Mid-Scale PV Uptake Forecasts

Clean Energy Regulator

Final Report

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Contents

Executive Summary

In this report, there are forecasts of the capacity of mid-scale PV installations for the calendar years of 2019 up to and including 2023 for the Clean Energy Regulator (CER).

Mid-scale PV systems are defined by the capacity range of greater than 100 kW and less than 5 MW in size. 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 Clean Energy Regulator. 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 during 2018, which was over 3 times the capacity installed in 2017.

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 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 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 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 uptake to a mathematical 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 13,000 potential premises, only 872 units 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 been dropping steadily from over 12 years in 2012 to approximately 6 years currently. The payback period is expected to reduce further for the remainder of the projection period, primarily driven by a reduction in capital cost. This indicates that despite the decreasing LCG 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 successful 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. Larger 5 MW systems with the ability to procure discounted PV panels based on scale do 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.

A large rise in behind-the-meter mid-scale systems is projected with 347 MW estimated to be installed in 2023 alone. This is driven by the economic benefits and relatively low market saturation, the practical application of energy production and consumption at the same site and utilisation of excess rooftop space.

The education sector and remote community installations both see a consistent pattern of installations over the next 5 years, mainly driven by a state-based programs. A modest number of the front of meter grid connected systems was projected in line with expectations from the sector participants.

However, the forecasting of mid-scale PV systems is inherently difficult to project. 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.

Table 1: Summary of projected capacity of mid-scale PV installations 2019-2023, MW

	2019	2020	2021	2022	2023
Education Sector					
Northern Territory schools	1.20	0.90	0.75	0.90	-
Queensland schools	-	15	10	10	-
Victoria & NSW schools	4.40	4.40	4.40	4.40	4.40
WA and SA schools	2.96	2.96	2.96	2.96	2.96
Tasmanian schools	0.23	0.23	0.23	0.23	0.23
Universities	6.90	2.40	2.40	2.40	2.40
Remote community					
Queensland	0.30	0.70	-	0.70	0.70
South Australia	-	-	1.00	1.00	1.00
Western Australia	-	1.00	1.50	1.50	-
Main Grid Connection					
Redmud (SA)	10	20	20	20	-
Terregra (SA)	5	10	10	10	-
Remaining Industries					
Other industries	151	207	259	303	335
Total	**182**	**264**	**312**	**357**	**347**

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The sole purpose of this report and the associated services performed by Jacobs is to assist in the understanding of the mid-scale PV market in Australia in accordance with the scope of services set out in the contract between Jacobs and the CER (the Client).

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

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1. Introduction

The CER has engaged Jacobs to provide projections of uptake of mid-scale PV systems for 2019 to 2023.

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 2019 to 2023. These included projections for PV installations and installed capacity for commercial and industrial systems from 100 kW to 5 MW by various categories across state and territories in Australia[1];
- Review of the mid-scale solar PV market to identify key factors influencing the demand for and supply of mid-scale solar PV systems; and
- Analysis of the interplay between the small and large-scale schemes, including the expected behaviour as large-scale generation certificate prices fall.

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 June 2019 and included a total of 872 accredited and 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 June 2019 dollars.

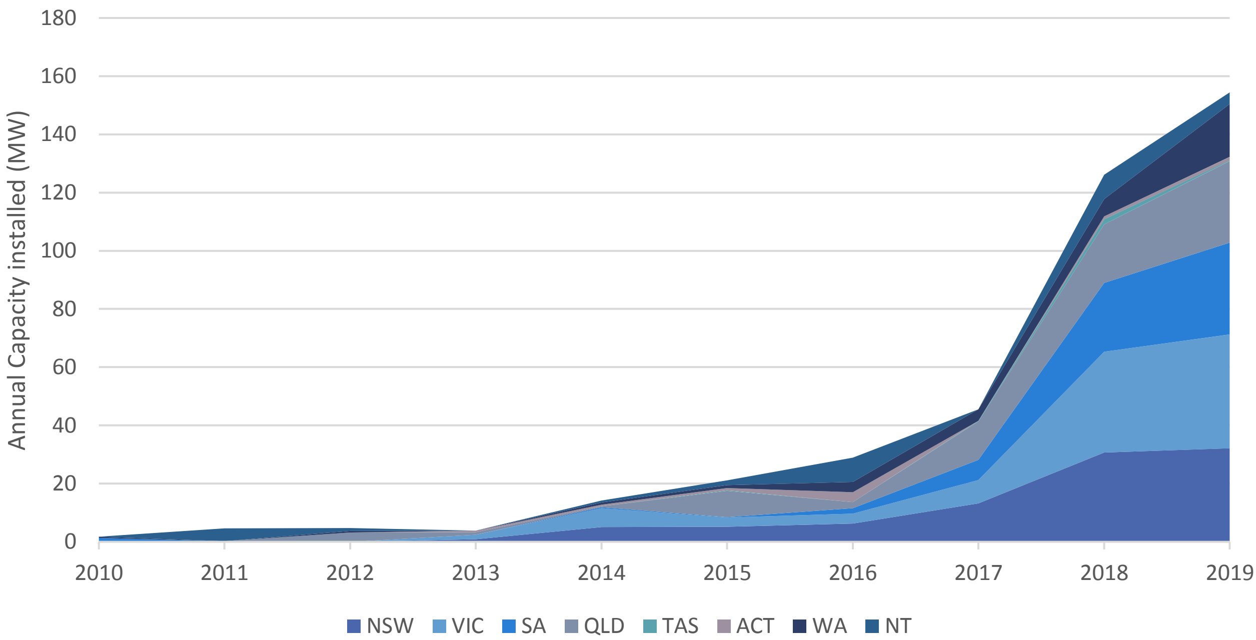
This report continues with an analysis of the trends in uptake in section 2, followed by a description of the current Federal Government Renewable Energy Incentive Scheme in section 3. Then in section 4 the methodology is outlined, and the market sizing analysis is provided in section 5. Section 6 discusses the payback period of different mid-scale PV systems. The projections of solar PV uptake by sector are discussed in section 7, and a summary of all results is provided in section 8. The appendices include detailed data tables and references.

[1] All systems ⩽100kW are included in the small-scale modelling report.

2. Trends in Uptake of Mid-Scale PV systems

Mid-scale PV installations 100 kW to 5 MW in size have recently experienced a growth in installation rate. Figure 1 highlights the trends for the installed capacity of these mid-scale systems by state. The installed capacity tripled from 40 MW in 2017 to 130 MW in 2018, and 2019 also shows strong growth.

Figure 1: Installed capacity of mid-scale systems by state, 2010-2019

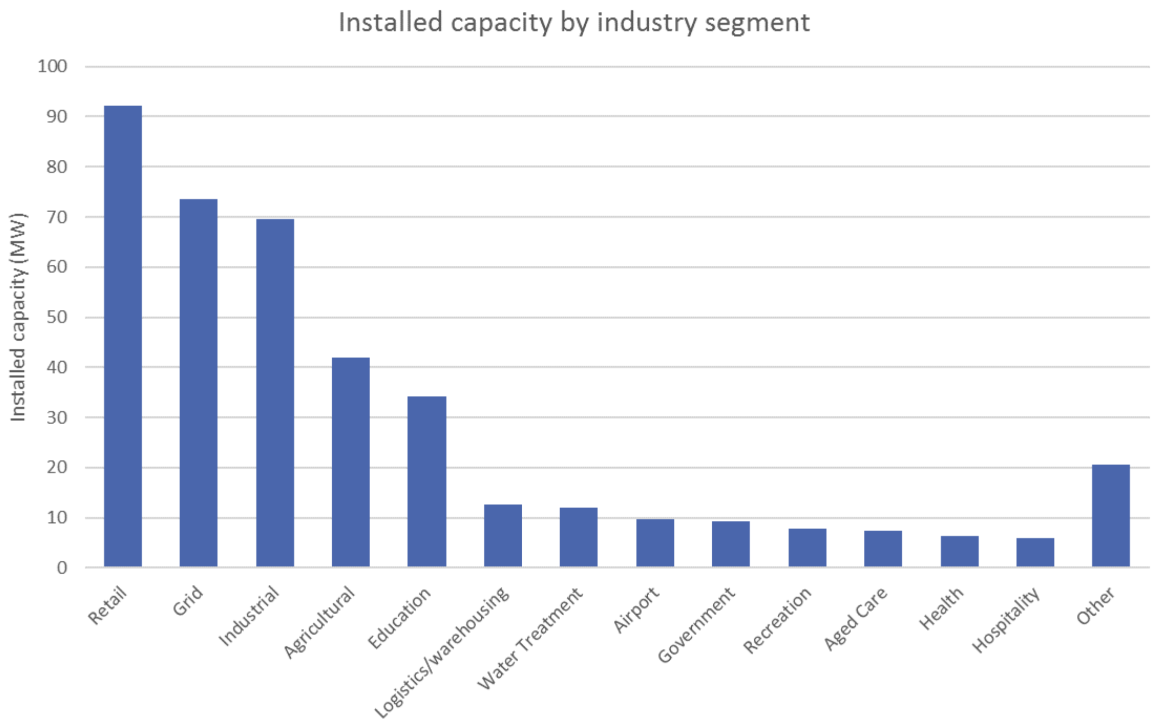


Source: CER data, 2019 is incomplete and includes installations under application

Figure 2 shows the breakdown in installed capacity across various identified segments. With over 90 MW installed, the retail segment has the greatest contribution to PV installations in the mid-scale category. Community and other ground-mounted systems make up the next greatest contributor with around 80 MW installed across Australia. The manufacturing sector with around 65 MW is the next largest contributor, followed by the agricultural (40 MW) and education (30 MW) sectors.

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.

Figure 2: Installed mid-scale capacity in market segments, Australia



Source: Jacobs' analysis of CER data

There are several potential drivers for the increase in installations of the mid-scale PV systems, these include:

- Recent increase in electricity prices and wholesale gas prices.
- Continued reduction in capital cost of PV systems.
- Government incentive schemes.
- Good correlation between solar output generation and commercial/industrial demand.
- Increasing environmental awareness, social pressure and increased education on renewable energy.
- Opportunistic utilisation of rooftop space.
- Avoidance of complex AEMO grid connection requirements for large scale systems.
- Provision of electricity to remote communities, displacing expensive diesel fuelled generation.

3. Federal Government Renewable Energy 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.

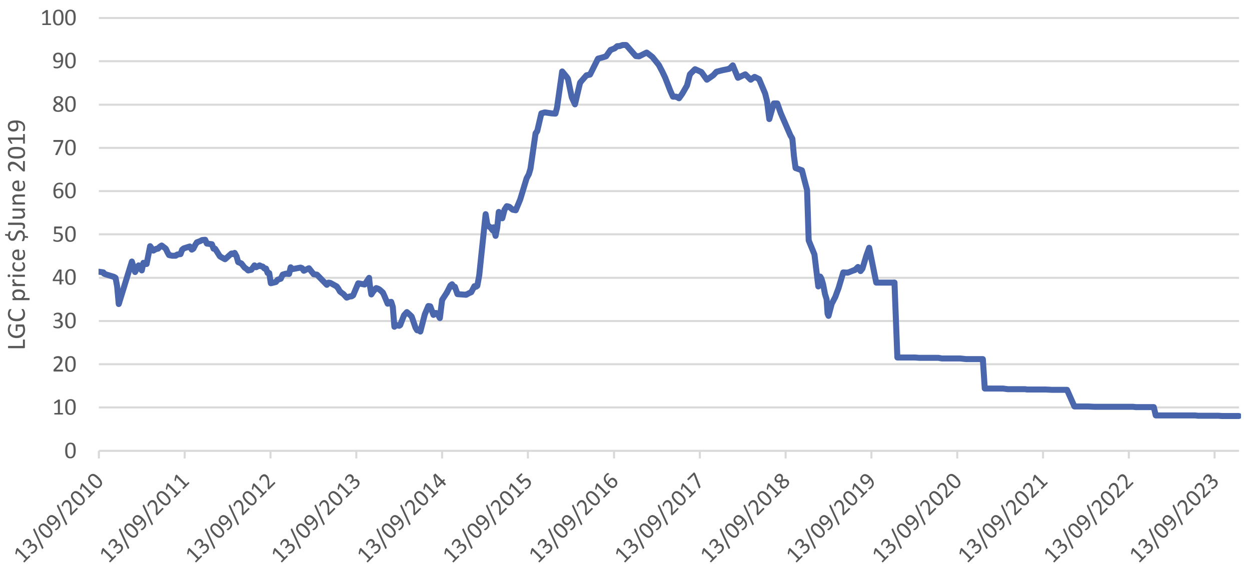
The renewable energy target of 33,000 GWh by 2020 is likely to be met. This target is legislated to remain constant until 2030.

Figure 3 show 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 drop even further after meeting the RET target in 2020. 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.

With the projected decline in LGC prices, there is a possibility that commercial installations are occurring at a faster rate than what would otherwise occur. However, this increase in rate of installations due to the influence of these incentive scheme is difficult to quantify.

Figure 3: Historical and projected LGC price, $June 2019



Source: Green Energy Markets, EcoGeneration and other sources. Data is generally wholesale spot prices for parcel sizes of 5000 certificates or more.

4. Method

The incentives for the stakeholders within this category 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 PPA agreements (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 larger segments with more homogenous incentives.

4.1 Market sizing

Potential 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 potential market size of the 12 largest segments were then estimated based on relevant market information. The 12 largest segments formed 97% of the total mid-scale capacity.

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 is 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 profile 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

The majority of mid-scale installations in the CER dataset have been identified as behind-the-meter solar PV systems. Based upon the assumption that these systems are subject to the projected economic benefits outlined in section 6.2.1, 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 growth of technology[2] 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)[1]. 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 and c were selected based upon fitting to trend of PV installations via the sum of least squares. All mid-scale installations with exception of the education sector 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 achieve 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.

[2] https://www.dst.defence.gov.au/sites/default/files/publications/documents/DST-Group-TN-1881.pdf

5. Market Sizing

To assist in projections of the number of mid-scale size PV installations that will occur over the next 5-year period, an evaluation of the potential market size was conducted. We consider this an important step in the projection of mid-scale systems as it not only provides boundaries for our projections, but also allows for an indication of the saturation of the sector and any potential for growth.

This exercise was conducted on the top 12 behind-the-meter categories identified by installed capacity, which represents 97% the installed capacity within the mid-scale range. Table 2 summarises the estimates on market sizes of suitable locations for these categories, along with an indication of the current level of uptake within each segment.

Table 2: Summary of market size estimates against current number of installations for identified market segments

Segment	Sub-sector	Estimated market size	Current number of installations
Retail	Shopping centres	1,752	144
Education	Schools	9,463	90 +2 small scale installations
Education	University campuses	171	37+10 small scale installations
Airports	>400,000 passengers/year	20	8
Aged Care	>100 residents	738	42 +16 small scale installations
Hospitals	Public and private hospitals	486	20
Recreation	Public swimming pools	877	24
Hospitality	Social clubs (e.g. RSLs)	2,106	24
Manufacturing	>$5 million turnover	4,704	163
Agricultural	>$5 million turnover	1,153	92
Logistics/Warehousing	>$10 million turnover	485	37
Water Treatment Plant	Water treatment plant	142	18
Government	Council buildings	268	30

Source: Various market information, Jacobs' analysis of CER dataset

5.1 Assumptions

5.1.1 Retail assumptions

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 trends. 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 on their retail stores including Ikea, Wesfarmers retail chains (e.g. Bunnings, Coles) and Woolworths supermarkets.

According to the Urbis Australian Shopping Centre Industry report (August 2015), there were 1,752 shopping centres in Australia that exceeded 1,000 square metres of gross lettable areas. These include:

- 67 regional shopping centres with at least one department store;
- 286 sub-regional centres, which include at least one discount department store;
- 1,104 neighbourhood or supermarket-based shopping centres, which include at least one supermarket as the major anchor
- 107 CBD centres

There are a total of 214 CBD centres of which only 50% were considered suitable for rooftop PV installations. Thus, 107 of these shopping centres will be considered as potential candidates for mid-scale rooftop PV systems. We assume that these include all suitable supermarkets in CBD areas and therefore we will not make additional inclusions for supermarket chains.

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

This results in a total of 1,752 retail premises that are considered suitable for the installation of a mid-scale PV system and represents the estimated market size for this segment.

5.1.2 Water treatment plant

We have used information published by Sydney Water, one of the largest water companies in Australia, to determine the market for water treatment. Sydney water provides helpful details on their water treatment plants including information on the size of the operations at their sites. 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.

The (greater) Sydney Water network includes 9 water filtration plants, 16 wastewater treatment plants and 14 water recycling plants[3]. We assume that all water filtration plants, and the treatment and recycling plants with a discharge of more than 10 million litres per day are suitable sites for mid-scale solar PV plants. The latter category includes seven of the recycling plants and eight of the wastewater plants, which amounts to a total of 24 suitable sites in the greater Sydney area. As this area represents approximately 4.3 million people, we can extrapolate to a total Australian population of 25.4 million, which equates to an estimate of approximately 142 suitable water treatment sites nationwide.

5.1.3 Airports

Airports are another sector which has seen growing installation rates of solar PV. Appendix A lists of the top twenty busiest airports in Australia. With over 400,000 passengers per year, we assume these are all potential candidates for mid-scale PV installation and therefore contribute to the total market size.

5.1.4 Manufacturing, agricultural and warehousing/logistic industries

Table 3 shows the NSW industrial sector by energy utilisation for the year 2018. With the exclusion of the electricity generation industry, the major industrial consumers of electricity are in the mining, manufacturing and agriculture sectors in NSW.

[3] http://www.sydneywater.com.au/SW/water-the-environment/how-we-manage-sydney-s-water/wastewater-network/index.htm

Table 3: Energy consumption in the industrial sector NSW, 2017

Industry sector	Total energy usage (PJ)	Electricity usage (PJ)
Agriculture, forestry and fishing	31.3	2.0
Manufacturing	247.8	64.7
Transport, postal & warehousing	536.8	>1.0

Source: ABS

The manufacturing industry has the greatest electricity usage of all industry sectors in NSW. 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 3.2 MW at a food processing plant in Queensland. This highlights the potential for this sector to adopt rooftop PV technology.

Table 4 shows the number of manufacturing businesses in Australian states and territories with a turnover of greater than $5 million. We assume that these businesses would have both the financial and rooftop capacity to host a medium-size PV system.

The electricity usage of the agricultural sector is limited. However, 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. Therefore, we have assumed that agricultural businesses are most likely to host ground mounted mid-scale PV systems. The number of suitable locations in Australia is 1,287 as per table below.

According to Table 3, the transport, postal and warehousing industry has the lowest usage of electricity in the industrial sector. 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 such as Australia Post, Amcap, DHL logistics and Country Road Group logistics. For these reasons, we have assumed that transport, postal and warehousing companies with an annual turnover of greater than $10 million would be suitable for the installation of a PV system.

The ABS also provides the survival rate of businesses that existed in 2014 and are still operating in 2018. 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 percentage as included in the table below.

Table 4: Market size assumptions for manufacturing, agricultural and warehousing/logistics sectors

	Number of business	2014-2018 survival rate	Market Size Assumption
Manufacturing >$5m	5436	89.4%	4857
Agricultural >$5m	1287	89.6%	1153
Warehousing/logistics >$10m	558	86.9%	485

Source: ABS

5.1.5 Government

Of the 23 government buildings identified in the CER dataset as having mid-scale solar PV installed, over half of these were council buildings (Appendix B). 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[4]. 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 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%. The final estimate of total market size for council buildings is 268.

5.1.6 Recreation – aquatic centres

There are approximately 1,077 public swimming pools in Australia[5]. 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.

The four-year survival rate for businesses classified in the Sports and Recreational sector with an annual turnover greater than $2 million for the period of 2014 to 2018 is 81.4%[6]. After applying this survival rate to the total estimated number of public swimming pools, the total market size for this sector is assumed to be 877.

5.1.7 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 25 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 2019 are estimated at 5,074.[7] 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.

The estimates on the number of businesses within the sports and social clubs sector are further adjusted based on the percentage business survival rates as defined by the hospitality sector in the ABS. The ABS estimated four-year survival rate for hospitality businesses with an average turnover greater than $2 million is 83%. Furthermore, upon evaluation of Todae Solar's portfolio of PV installations on social clubs, approximately 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 2,106 suitable locations.

5.1.8 Aged care industry

As of June 2019, there are 2,718 residential aged care facilities in Australia[8]. 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 aged-care facilities with more than one hundred beds is 738, which is assumed as the total market size of suitable aged-care facilities for a mid-scale system.

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4 https://alga.asn.au/facts-and-figures/
5 https://www.royallifesaving.com.au/__data/assets/pdf_file/0003/21945/RLS_FactSheet_33_SWIMMING_PARTICPATION-2.pdf
6 Based on ABS data
7 https://www.ibisworld.com.au/industry-trends/market-research-reports/accommodation-food-services/social-clubs.html
8 https://www.gen-agedcaredata.gov.au/Resources/Access-data/2019/September/Aged-care-service-list-30-June-2019

5.1.9 Hospitals

Due to the nature of services provided, hospitals are very energy intensive. A study conducted by VicHealth estimated that in the year 2016-2017, Victorian Public health services consumed 2,341 terajoules of electricity. This amounts to an average of 11,870 MWh of electricity consumed per day per public hospital in Victoria[1].

Despite large hospitals being a significant consumer of energy, only 13 of the 695 public and 497 private hospitals across Australia were identified from the list supplied by the CER as having mid-scale systems installed. Additionally, only two of these defined as major city principal referral hospitals according to the ABS classifications[2]. 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 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 with less than 200 beds. Similarly, we have excluded hospitals with 10 or fewer beds under the assumption that these would not have a suitable rooftop to house a mid-scale system. This brings the assumed market size of the public hospital sector to 63% of the total number or 435 potential premises, as per details provided in Table 5.

The same logic and percentages were applied to private hospitals. While private hospitals are not expected to host as many beds as the major public hospitals, it provides a proxy to the number of inner-city locations, which would be less suitable for rooftop installations than suburban or regionally based centres. We therefore estimated that a further 311 of 497 private hospitals will likely be suitable for mid-scale PV installations.

Table 5: Number of Australian public hospitals by bed size

Public hospitals by size	Number of hospitals	Percentage
10 or fewer beds	171	25%
More than 10 to 50 beds	302	43%
More than 50 to 100 beds	72	10%
More than 100 to 200 beds	61	9%
More than 200 to 500 beds	63	9%
More than 500 beds	26	4%
All hospitals	**695**	100%

Source Hospital Resources 2016-17: Australian hospital statistics

[1] https://www2.health.vic.gov.au/hospitals-and-health-services/planning-infrastructure/sustainability/energy/energy-use
[2] ABS catalogue 14825 appendix C: Australian hospital peer groups

6. Payback period of mid-scale PV systems

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 5 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 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 5: Summary of assumptions utilised for net economic benefit calculations

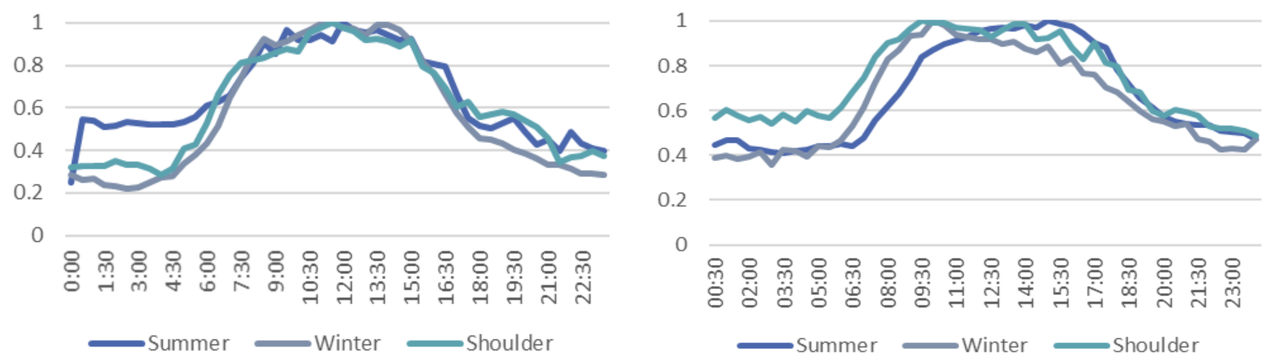
	Commercial	Industrial	Ground mounted
Capacity	250 kW	850 kW	200 kW
Solar profile	NSW rooftop, AEMO	NSW rooftop, AEMO	NSW rooftop, AEMO
Solar degeneration	0.4% / year	0.4% / year	0.4% / year
Capacity Factor	16%	17%	19%
Demand profile	CSIRO commercial demand profiles	CSIRO industrial demand profiles	N/A
Real WACC	7.5%	7.5%	7.5%
NPV time period	10 year	15 years	15 year
Electricity prices	Commercial	Industrial	Wholesale

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.

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



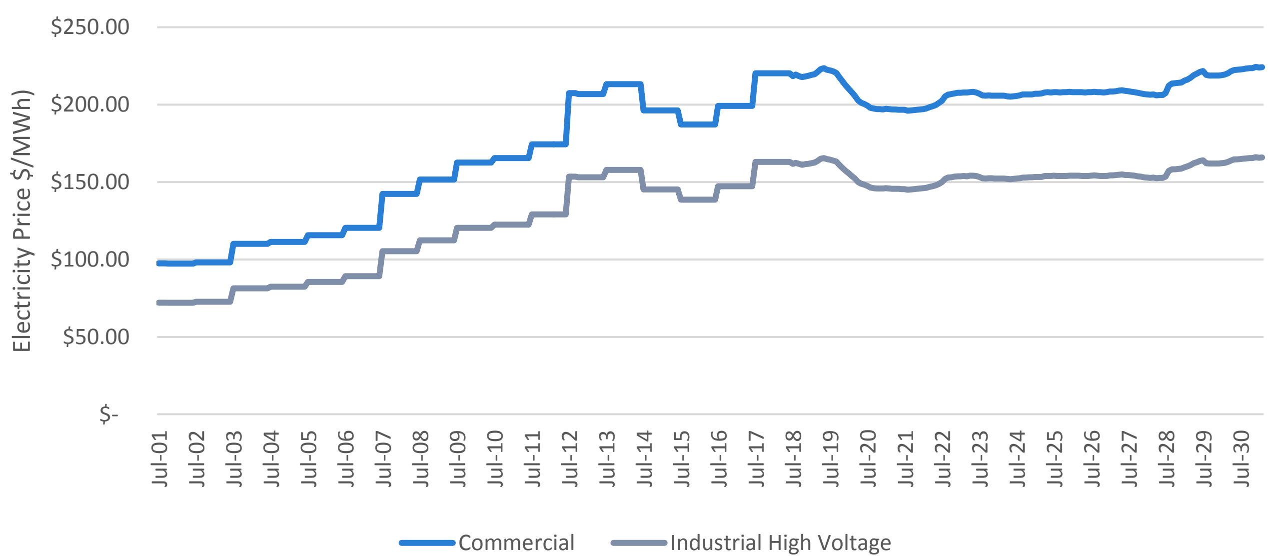
Source: CSIRO technical report: Load and solar modelling for the NFTS feeders, 2015

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, 2010 – 2030, $ June 2019



Source ABS index, Jacobs' analysis

6.1.3 LGC & STC scheme assumptions

Table 6 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. The marginal loss factor (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:

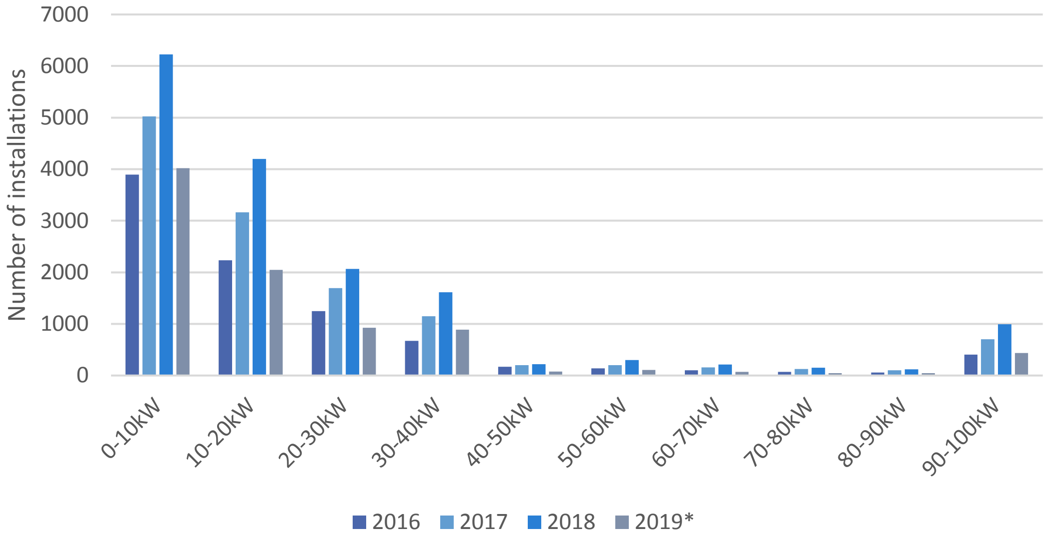
Annual benefits = capacity of system x capacity factor x 24 hours/day x 365 days/year x LGC price

Table 6: Historical and projected annual LGC price, $ June 2019

Year	LGC price ($June 2019)	STC price ($June 2019)
2012	42.7	32.5
2013	38.3	35.6
2014	32.7	40.8
2015	55.0	40.6
2016	88.2	41.2
2017	86.2	38.5
2018	76.3	38.3
2019	39.2	37.5
2020	30.0	40.0
2021	23.0	39.0
2022	20.0	38.1
2023	17.0	37.1

Figure 6 shows the number of small-scale PV installations by size bracket. In 2019 there were 997 installations within the 90-100 kW bracket, which is more than the entire number of mid-scale PV installations 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.

Figure 6: Number of small-scale installations by capacity bracket, 2016 to 2019



*Source Jacobs' analysis CER data, *2019 data is incomplete*

With the STC rebate paid as a once off lump sum and LGC payments dependent on the amount of electricity generated, we levelized the future LGC payments so that an appropriate comparison between the schemes could be made. Table 7 shows the estimated STC benefits against a series of 10 years of levelized LGC benefits. 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 6. 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 LGC prices, the difference between benefits from the STC certificates is only expected to be greater during 2020. 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.

Table 7: Comparison of estimated levelized LGC and STC rebates based upon a 100 kW PV system, 2016 to 2023, $

Year of installation	STC Rebate	Levelized LGC benefit (10 payments)	Difference between STC and LGC levelized benefits
2012	67,137	53,121	14,016
2013	73,606	52,128	21,478
2014	84,290	51,499	32,792
2015	84,033	50,440	33,593
2016	85,157	45,933	39,224
2017	74,312	36,084	38,227
2018	68,718	25,801	42,917
2019	62,080	16,242	45,839
2020	60,649	11,547	49,102
2021	53,780	7,893	45,887
2022	47,211	5,020	42,191
2023	40,932	2,383	38,549

6.1.4 Capital Cost

Capital cost assumptions for the NPV and payback period calculations were based upon analysis of the data supplied by CER.

It is assumed that the capital cost includes costs associated with grid connection as well as any network infrastructure upgrades that may be required. We have also assumed that no subsidies are included in these figures.

The historical capital cost since 2015 was derived from the median cost per kW of the supplied CER data for each respective year. Capital cost projections were based upon CSIRO’s Gencost 2018 rooftop cost forecasts.

Table 8 provides the assumptions used for the capital cost of mid-scale ground mounted PV systems installed. This is based on the median cost of mid-scale ground mounted systems identified in the data supplied by CER.

Table 8: Capital cost assumptions for ground mounted mid-scale PV systems, $ June 2019

Year	Capital Cost ($/kW)	Source
2012	3,602	Solar Choice
2013	3,001	Solar Choice
2014	2,479	Solar Choice
2015	2,380	CER
2016	2,242	CER
2017	1,893	CER
2018	1,744	CER
2019	1,649	CER
2020	1,479	CSIRO
2021	1,407	CSIRO
2022	1,353	CSIRO
2023	1,299	CSIRO

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 Net Present Value 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 output approximately 350 MWh per year.

Based on the assumed parameters, the payback period for a commercial 250 kW rooftop system is outlined in Table 9. Payback periods have dropped steadily since 2012 until just over 6 years in 2019, driven by a continual drop in capital cost and high LGC prices. The payback period is projected to continues to decline for the remainder of the forecasting period despite a reduction in LGC and electricity prices. Since 2017 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 within this sector observed since 2017.

Table 9: Payback period assumptions of 250 kW commercial system scenario

Year	Capital cost	1st year energy Savings	NPV (10 Year)	Payback (years)	IRR
2012	$900,500	$62,594	-$315,850	12.1	-1%
2013	$750,250	$65,521	-$163,476	10.2	2%
2014	$619,750	$63,860	-$ 32,567	8.5	6%
2015	$595,000	$62,348	-$ 6,709	8.2	7%
2016	$560,500	$66,969	$ 22,083	7.8	8%
2017	$473,250	$72,799	$ 86,068	6.8	11%
2018	$436,000	$71,722	$ 93,231	6.5	12%
2019	$412,250	$69,966	$ 89,443	6.3	12%
2020	$369,750	$65,764	$118,048	5.7	14%
2021	$351,750	$65,679	$128,797	5.5	15%
2022	$338,250	$68,127	$137,229	5.3	16%
2023	$324,750	$68,027	$143,962	5.2	17%

6.2.2 Industrial 850 kW behind-the-meter system

The key differentiating factor between the economic analysis of industrial systems outlined in Table 10 is based on the retail price assumption. The industrial electricity price is considerably less than the retail price for commercial businesses. With a significantly lower electricity price, similar returns as for commercial systems can be realised only by extending the NPV periods to 15 years and thus including benefits for 5 extra years.

Currently industrial systems are projected to have a 10% internal rate of return and a payback period of just over 8 years. Resulting from the anticipated decline in the capital costs the IRR is expected to increase to 14% by 2023, while the payback period is projected to fall below 7 years.

Table 10: Payback period assumptions of 850 kW industrial high voltage system scenario

Year	Capital cost	1st year energy savings	NPV (15 Year)	Payback (years)	IRR
2012	$3,061,700	$158,119	-$1,136,186	15.8	0%
2013	$2,550,850	$172,097	-$ 634,887	13.3	3%
2014	$2,107,150	$166,230	-$ 209,305	11.2	5%
2015	$2,023,000	$156,147	-$ 129,075	10.8	6%
2016	$1,905,700	$158,712	$ 33,572	10.3	7%
2017	$1,609,050	$172,809	$ 195,000	9.0	9%
2018	$1,482,400	$179,241	$ 236,962	8.5	10%
2019	$1,401,650	$179,097	$ 232,939	8.3	10%
2020	$1,257,150	$163,552	$ 333,896	7.6	12%
2021	$1,195,950	$160,762	$ 375,693	7.3	12%
2022	$1,150,050	$166,175	$ 412,524	7.0	13%
2023	$1,104,150	$169,101	$ 447,129	6.7	14%

6.2.3 Ground mounted 200 kW front of the meter system

With over 60 mid-scale ground mounted PV installations in South Australia since 2016, Redmud has developed a business model by offering land-owners opportunities to re-purpose their properties for the construction and implementation of small solar farms. Redmud engages with farmers, primary producers and investors and claims to offer a high return on investment for client's by selling the energy and LGCs on the NEM. With the success of Redmud's business model in South Australia, we decided to investigate the possibility of a similar investment proposition across another state.

The assumptions for this case 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 dependable on the life of the business. The NPV was calculated as the present value of 15 years of energy sales plus 15 years of LGC payments at a real discount factor of 7.5%.

The results of the NPV and payback period assumptions are outlined in Table 11. With negative NPV rates for the entire forecasting period, 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 without any behind the meter application.

This indicates that for these 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 reasonably lucrative 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 11: NPV and Payback estimates of 200 kW, fixed angle ground mounted system

Year	Capital Cost	NPV	Payback (years)	IRR
2012	$720,400	-$425,331	24.5	-5.2%
2013	$600,200	-$303,813	20.7	-3.3%
2014	$495,800	-$200,281	17.3	-1.0%
2015	$476,000	-$175,327	16.7	-0.5%
2016	$448,400	-$147,690	16.0	0.1%
2017	$378,600	-$ 94,897	14.2	2.0%
2018	$348,800	-$ 95,591	14.3	1.8%
2019	$329,800	-$100,266	14.5	1.5%
2020	$295,800	-$ 81,525	13.6	2.3%
2021	$281,400	-$ 72,480	13.2	2.8%
2022	$270,600	-$ 65,318	12.8	3.1%
2023	$259,800	-$ 60,090	12.5	3.4%

7. Projections

7.1 Education sector

The education sector has seen strong uptake of rooftop PV installations in the 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 the majority of segments and a bottom up approach to forecasting was utilised. Table 12 summarizes our estimates on the projections of solar installations in the education sector.

Table 12: Summary of mid-scale solar PV installation capacity projections for the education sector, MW

State	2019	2020	2021	2022	2023
Northern Territory	1.20	0.90	0.75	0.90	-
Queensland	-	15	10	10	-
Victoria & NSW schools	4.40	4.40	4.40	4.40	4.40
WA and SA	2.96	2.96	2.96	2.96	2.96
Tasmania	0.23	0.23	0.23	0.23	0.23
Universities	6.90	2.40	2.40	2.40	2.40

7.1.1 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 prohibitively expensive, and most of the systems installed were less than 10 kW. This accounts for only around 2% of a daily school's requirements[9].

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. Eight schools have been selected under the plan and are expected to have solar PV installations completed by the end of 2019. A further 6 schools are scheduled for the second round in 2020 and 5 more in 2021[10].

[9] https://www.pv-magazine-australia.com/2019/01/28/tomorrow-back-to-solar-empowered-schools/
[10] https://www.pv-magazine-australia.com/2019/06/28/first-tenders-awarded-in-5-million-rooftop-solar-schools-program/

The funding of $5 million for 25 schools equates to approximately $200,000 per school. The assumption is that these schools would install an average of 150 kW of solar PV capacity each.

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[11]. The government acknowledged that the majority of Queensland's 1,241 state schools already offset energy costs with small PV systems installed under the NSSP, however noted that more could be achieved as a result of recent developments in new technologies.

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.

Phase 1 of the program is expected to commence in financial year 2020 and will involve $40 million allocated to the installation of 35 MW of PV systems on up to 30 schools. The remaining $57 million is to be invested in making schools more energy efficient.

Victoria and New South Wales

In 2018, the Australian Youth Climate Coalition and Community Power Agency published a comprehensive plan to power New South Wales and Victorian high schools with 100% renewable energy. This plan proposed to install 100 kW of solar PV panels on all 519 NSW and 418 Victorian public high schools at a combined cost of $128 million[12].

Many schools across Victoria and NSW have small solar systems installed as a result of the Federal Government NSSP (July 2008 to June 2013) and various state government initiatives. But these systems have an average capacity of around 5 kW per school in NSW and 7 kW in Victoria and are not sufficient to cover their needs. While at this stage this is a proposal and neither state government has committed to these plans, it does provide guidance on the potential for additional solar to be installed in schools.

A total of 26 schools in Victorian and NSW have been identified as having mid-scale PV installations, which includes both public and private schools. In the first half of 2019, 11 of these schools were accredited with having solar installations at a median capacity of 200 kW. Without any overriding state based polices, the assumption is that this rate of installations will continue for the remainder of the forecasting period.

South Australia, Western Australia and Tasmania

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 first 6 months of 2019 in these states.

In Western Australia, four schools had accredited mid-scale solar installations with a median capacity of approximately 250 kW and in South Australia there were three schools with a median capacity of 160 kW for the first 6 months of 2019.

In Tasmania there were two schools identified in 2017 and 2018, with an average of 225 kW. It is assumed that mid-scale installations in Tasmania will occur at a rate of one per year at an estimated 225 kW per installation.

7.1.2 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 35 university campuses are identified on the CER database, however only 72% of these are greater than 100 kW in size. For this reason, the assumption is that 72% or a total of 121 university

[11] https://www.queenslandlabor.org/media/20293/alpq-powering-queenslands-future-policy-document-final.pdf
[12] https://www.pv-magazine-australia.com/2019/01/28/tomorrow-back-to-solar-empowered-schools/

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.

Plans are already underway for a 4 MW system to be installed at Monash University Clayton campus[13]. The assumption is that the Monash system will be completed by the end of 2019 and the remaining 96 university campuses will have a 250 kW system installed over the next 10-year period at a total of 2.4 MW per year.

7.2 Ground mounted community installations

Of all the segments, these systems have the widest range in system size, varying from 100 kW right up to 5 MW. There are also varying incentives. 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 this segment.

This section outlines the assumptions surrounding our estimates on these remote community and front-of-meter system projections. Table 13 summarizes the projections based on these assumptions.

Table 13: Summary of ground-mounted community and grid connected mid-scale PV installation assumptions, MW

State	2019	2020	2021	2022	2023
Remote community					
Queensland	0.3	0.7	-	0.7	0.7
South Australia	-	-	1.0	1.0	1.0
Western Australia	-	1.0	1.5	1.5	-
Main Grid Connection					
Redmud (SA)	-	25	20	20	-
Terregra (SA)	5	10	10	10	-

7.2.1 Solar Energy Transformation Program (SETuP)

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[14]. 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 in the future. 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.

[13] https://www.pv-magazine-australia.com/2018/11/10/long-read-from-rooftops-to-innovative-ppa-structures-australias-universities-go-solar/

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

7.2.2 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[15].

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[16]. These will not be considered as mid-scale solar installations. A further 700 kW is assumed to be installed at the Pormpuraaw and Northern Peninsula regions during 2020.

Ergon Energy owns and operates 33 standalone power stations in Queensland that supply 38 remote communities, typically operated by diesel generators[17]. This opens the opportunity for further solar PV installations to partially offset diesel generation at these communities. In this study, it is assumed that another four of these generators will be supplemented by solar PV at 350 kW each, for the last two years of the projected period.

7.2.3 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 located in additional aboriginal communities.

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

Similar with what has been implemented in other remote communities around the country, the assumption will be that 2 of these sites per year will receive a 350 kW solar system installed from 2021 until the end of the forecasting period.

Through the Renewable Technology Fund, RenewablesSA is helping fund the deployment of a modular and relocatable 1 MW Solar PV and 0.5 MWh battery storage facility at the Heathgate Resources' Beverley Uranium Mine. The solar and storage facility will be integrated with the existing on-site gas power plant and it is assumed that the construction of this will be completed by the end of 2019.

7.2.4 Western Australia remote communities centralised 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[18].

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 large east Kimberly remote communities of Warmun and Kalumburu in 2020. It is assumed that 500 kW will be installed at each of these sites during 2020.

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15 https://www.dnrme.qld.gov.au/energy/initiatives/solar-remote-communities

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

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

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

Construction is scheduled for solar farms in the west Kimberley communities of Ardyaloon, Beagle Bay, Djarindjin-Lombadina and Bidyadanga in 2021. It is assumed that these communities will also have 500 kW of solar installed during 2021.

7.2.5 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[19]. Returns are generated by utilising vacant land titles with a foot print of approximately 0.5 hectare, 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 coal fired power station in South Australia in 2016, wholesale electricity prices increased for the period of 2017 and 2018. 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 competing on the wholesale market in South Australia.

However, according to our NPV and payback period analysis in Section 6.2.3, 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.

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. Supply chains are set up directly from overseas factories to the Adelaide port[20].

The assumption is that the “Redmud - Green Gold Energy” joint venture will develop their stated pipeline over the next three years, with 25 MW developed in 2020, 20 MW in 2021 and another 20 MW in 2022.

7.2.6 Mid-scale ground mounted solar farms

Finalising grid connection amid the regulations imposed by the Australian Energy Market Operator have delayed a number of large-scale projects across the country, undermining their economic viability. This has caused some developers to walk away from projects, or bear additional expenses to install components, such as synchronous condensers, in order to improve grid strength.

Mid-Scale generators (<5 MW) can be classified as non-scheduled generators, which do not need to participate in the central dispatch process and do not require AEMO’s strict grid connection requirements. Local distribution network service providers have less stringent requirements and a faster turnaround, there is a lower chance of curtailment due to network overload considering their size and less project lead-time involved between connection agreement and commissioning of plant.

This opportunity for developing mid-scale plant may be relatively short lived for the reasons outlined below:

1. Planned transmission upgrades will alleviate congestion concerns allowing large scale solar developments to become more economic, causing saturation of the market and reducing the dispatch weighted value of solar generation.

2. An increasing percentage of embedded generation may eventually cause AEMO/network service providers (NSPs) to impose more stringent connection requirements on small-scale systems.

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

3. An increasing percentage of small-scale embedded generators connecting to HV distribution networks may eventually be the cause of additional network augmentation costs being required for new developments of the same kind. This especially applies to connections in rural (typically low demand networks).

Terregra Renewables is one firm that is taking advantage of the benefits in the construction of mid-scale utility PV generators. The $8.5 million 5 MW Mobilong Solar Farm in South Australia began operating in July 2019 and is the first in a series of five megawatt solar farms that the developer is planning to deliver across Australia.[21] The company has a second 5 MW plant under construction, the Moyhall Solar Farm in South Australia, and intends to develop a total 35 MW Australian portfolio of these sized plant. For this study, it is assumed that the Moyhall Solar farm plus an additional 5 MW solar farm will commence generation in 2020. Followed by two further 5 MW farms per year until the 35 MW size portfolio is reached.

[21] https://www.pv-magazine-australia.com/2019/07/15/terregra-switches-on-its-first-merchant-solar-farm-in-south-australia/

8. Result Summary

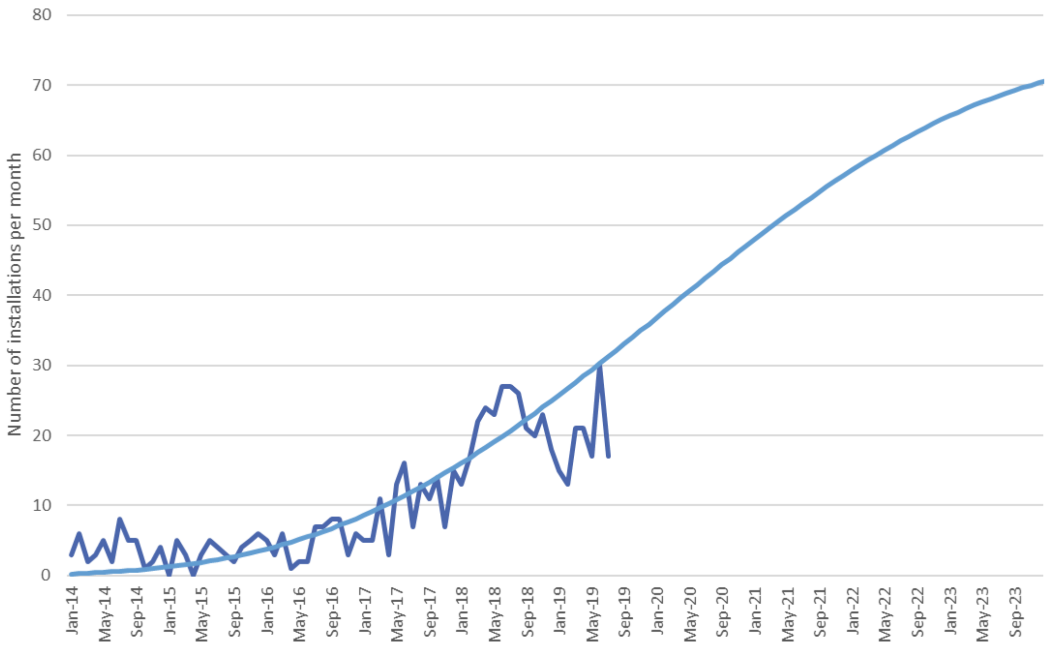
This section presents the results of the mid-scale PV projections. All results are presented in calendar years.

8.1 Uptake

Figure 7 shows the monthly historical and fitted data for the number of installations of mid-scale PV systems in Australia for all segments except the remote community and front-of-meter ground mounted segments and the education sector. The installations of these behind-the-meter PV systems are projected to grow throughout the forecasting period and reach approximately 70 installations per month by the end of 2023. This is fuelled by clear economic benefits, despite a reduction in government LGC incentives and room for growth in a relatively large market.

The average capacity of these behind-the-meter systems was found to be 410 kW. This was used to calculate the estimated installed capacity of these systems, as outlined in Table 14.

Figure 7: Historical and projected monthly number of mid-scale PV installations



Source CER data, Jacobs' analysis

8.2 Capacity installed

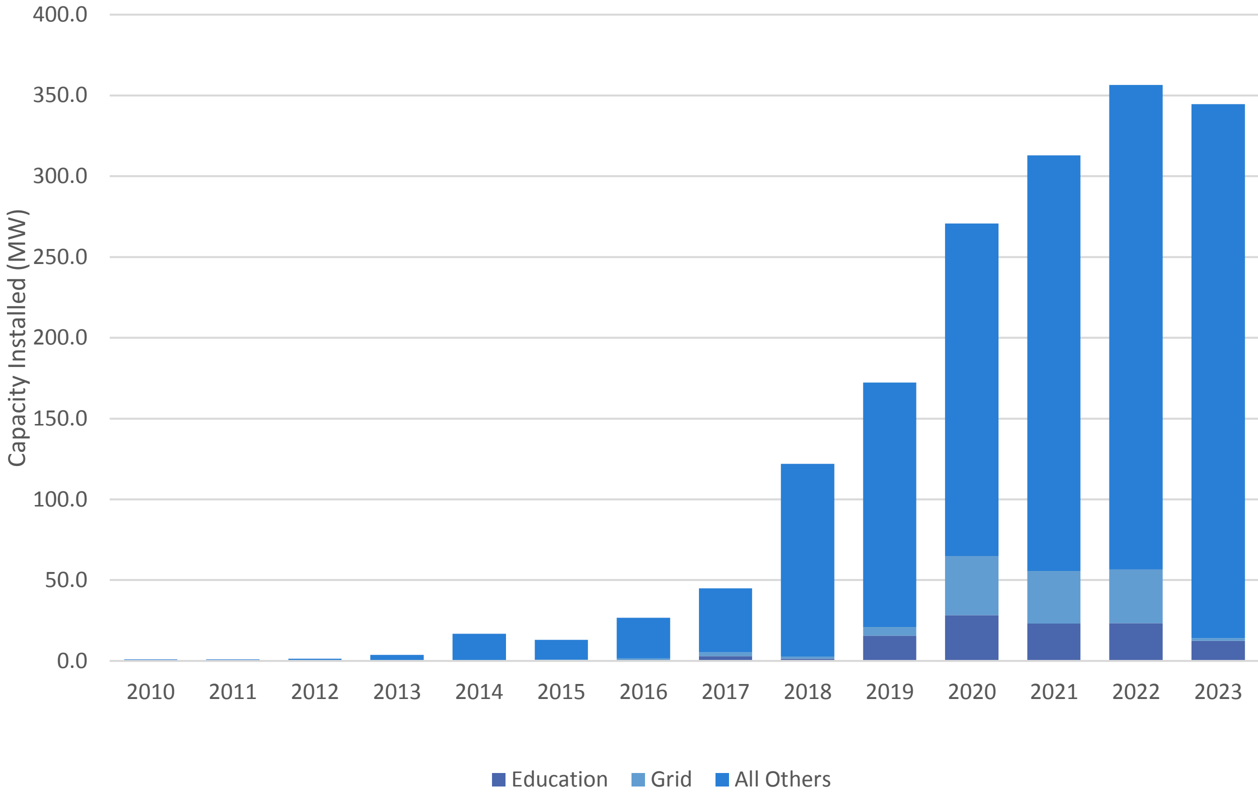
With only 872 recorded installations out of a total estimated market size of 13,162 suitable premises (excluding the education sector and in front of the meter systems), there is still substantial room for growth within the mid-scale PV sector.

Figure 8 shows the historical and projected capacity of mid-scale systems installed.

Returns on investment for commercial businesses for the installation of a mid-scale system are estimated to be approximately 10% in 2019 and are expected to improve over the forecasting period to 16% in 2023, driven by the continued expected decline in capital cost of solar panels. This is despite the predicted decline in LGC prices.

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.

Figure 8: Historical and projected installed capacity of mid-scale PV systems



Source CER data, Jacobs' analysis

Table 14 summarizes our estimates of the projected installed capacity of mid-scale systems over the 5-year forecasting period. Table 18 in Appendix D outlines the number of installations estimated over this period.

The education sector contributes a modest amount with a total of 103 MW expected to be installed from 2019 to 2023. This is based primarily upon government initiatives aimed at public schools.

With recent connection issues regarding large scale solar projects, the collapse of the EPC contractors, deteriorating marginal loss factors and recent extensive curtailing of large-scale solar generation, 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. Terregra Renewables is one firm that is taking advantage of the benefits in associated with this niche and their 35 MW of expected portfolio is assumed to contribute to the mid-scale PV installations over the next 5-year period.

Redmud Energy has been successful on the back of high South Australian wholesale prices coupled with high LGC prices in 2017-2018. However, this model has not shown to be profitable in other states where wholesale prices are lower. With both LGC prices and wholesale prices expected to fall across all states in the NEM over the forecasting period, this business model is not expected to become economically viable in other states, and as such our projections remain conservative and no expansion of this business model is expected to other states.

Table 14: Summary of projected capacity of mid-scale PV installations 2019-2023, MW

	2019	2020	2021	2022	2023
Education sector					
Northern Territory schools	1.20	0.90	0.75	0.90	-
Queensland schools	-	15	10	10	-
Victoria and NSW schools	4.40	4.40	4.40	4.40	4.40
WA and SA schools	2.96	2.96	2.96	2.96	2.96
Tasmanian schools	0.23	0.23	0.23	0.23	0.23
Universities	6.90	2.40	2.40	2.40	2.40
Remote community					
Queensland	0.30	0.70	-	0.70	0.70
South Australia	-	-	1.00	1.00	1.00
Western Australia	-	1.00	1.50	1.50	-
Main grid connection					
Redmud (SA)	10	20	20	20	-
Terregra (SA)	5	10	10	10	-
Remaining industries					
Other industries	151	207	259	303	335
Total	**182**	**264**	**312**	**357**	**347**

Appendix A. Australian airports by passenger number

Table 15: Australian airports by passenger number

Airport Location	Total Passengers for year ended June 2019	Current installed PV capacity
SYDNEY	44,375,769	550 kW
MELBOURNE	37,058,820	
BRISBANE	23,625,829	
PERTH	12,405,796	
ADELAIDE	8,368,177	1,283 kW
GOLD COAST	6,414,536	
CAIRNS	4,858,809	
CANBERRA	3,217,791	
HOBART	2,725,559	
DARWIN	1,950,602	4,000 kW + 1,524 kW
TOWNSVILLE	1,596,023	
LAUNCESTON	1,390,509	
NEWCASTLE	1,264,335	
SUNSHINE COAST	1,257,561	
MACKAY	821,936	
ALICE SPRINGS	603,966	235 kW + 651 kW
ROCKHAMPTON	552,623	
BALLINA	534,073	
KARRATHA	447,906	1,000 kW
PROSERPINE	429,988	

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

Appendix B. Government buildings with mid-scale solar PV

Table 16 shows the list of currently accredited mid-scale buildings identified under the Government segment, the majority of these are council-based buildings. This category is dominated by council buildings, suggesting that these buildings provide a good platform for the installation of mid-scale PV systems.

Table 16: Mid-scale PV installations identified as Government owned premises

Sub-category	Name of building
science/research	Tamworth Agricultural Institute Calala Solar - NSW
council buildings	Todae Solar - Nillumbik - Solar - VIC
council buildings	Rigby House Coffs Harbour Solar - NSW
science/research	Symonston Solar - ACT
council buildings	LMCC - Works Depot Power Station - Solar NSW
council buildings	Central Highlands Regional Council Solar - QLD
Library	Nerang Library Solar - QLD
Museum	Moreland Annex - Solar - VIC
council buildings	St Kilda Town Hall - Solar - VIC
council buildings	LMCC Administrative Centre – Solar – NSW
Library	Broadbeach Library Mermaid Waters Solar - QLD
council buildings	Banyule City Council Greensborough Solar - VIC
Museum	Australian National Maritime Museum Solar - NSW
Council buildings	Nerang Administration Centre - QLD - Solar
Other	Royal Australian Mint – Solar – ACT
Science	Australian Antarctic Division HQ Solar
council buildings	Parkes Shire Council STP - Solar - NSW
council buildings	Wyndham Civic Centre Solar - VIC
council buildings	Rouse Hill Town Centre -Solar -NSW
science/museum	Scienceworks - Solar [w SGU] – VIC
council buildings	Ripley Town Centre – Solar – QLD
Museum	Melbourne Museum - Solar - VIC

Source CER dataset

Appendix C. Hospitals

Table 17 shows the list of currently accredited mid-scale buildings identified as hospitals. This category is dominated by regional hospitals and smaller city hospitals.

Table 17: Mid-scale PV installations identified as hospitals

Sub category	Power Station Name	ABS Remoteness area
Hospital	Todae Solar SV - Mater Clinic - NSW	Major cities
Hospital	Yarram District Health Service - Solar - VIC	Inner regional
St Vincents private hospital	Todae Solar SV - Griffith – Solar - NSW	Major cities
Hospital	KOOWEERUP REGIONAL HEALTH SERVICES – Solar w SGU - VIC	Inner regional
Hospital	Burnside War Memorial Kensington Solar - SA	Major cities
St Vincents private hospital	Todae Solar SV - Private Brisbane – Solar – QLD	Major Cities
Private hospital	Todae Solar SV - Toowoomba – Solar - QLD	Inner regional
Hospital	Todae Solar SV - Mater Hospital - Solar - NSW	Major cities
Hospital	GL Prince Charles - Solar - QLD	Major cities
Hospital	Canberra Hospital Building 26 Solar ACT	Major cities
Hospital	Friendly Society Private Hospital Bundaberg - Solar - QLD	Inner regional
Hospital	Port Macquarie Base Hospital - Solar - NSW	Inner regional
Hospital	SALE HOSPITAL - SOLAR - Vic	Inner regional
Hospital	Bairnsdale District health Services - Solar - VIC	Outer regional

Source CER data, ABS Catalogue 14825 appendix-c hospitals

Appendix D. Number of mid-scale PV installation projections

Table 18 lists the number of mid-scale PV installations projected over the forecasting period.

Table 18: Mid-scale PV installation projections

State	2019	2020	2021	2022	2023
Education Sector					
Northern Territory schools	8	6	5	6	-
Queensland schools	-	12	9	9	-
Victoria & NSW schools	22	22	22	22	22
WA and SA schools	14	14	14	14	14
Tasmania schools	1	1	1	1	1
Universities	11	10	10	10	10
Remote community					
Queensland	1	2	-	2	2
South Australia	-	-	3	3	3
Western Australia	-	2	3	3	-
Main Grid Connection					
Redmud (SA)	-	5	4	4	-
Terregra (SA)	1	2	2	2	-
Remaining Industries					
	369	504	632	740	818
Total	**427**	**580**	**705**	**816**	**870**

Appendix E. References

https://www.afr.com/politics/agl-future-fund-qic-cop-haircut-in-grid-anarchy-fallout-20190312-h1carb

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