ACIL ALLEN CONSULTING

REPORT TO
THE AUSTRALIAN RENEWABLE ENERGY AGENCY

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DRIVERS OF DOMESTIC PV UPTAKE

CHARACTERISTICS OF HOUSEHOLDS WITH SOLAR PHOTOVOLTAIC SYSTEMS

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Background and approach

The Australian Renewable Energy Agency (ARENA) commissioned ACIL Allen Consulting (ACIL Allen) to examine the relationship between the rate of uptake of solar photovoltaic (PV) systems and socio-economic or demographic characteristics in different areas of Australia. Consistent with ARENA's mandate to increase the level of renewable energy generation in Australia, this study is intended to assist ARENA and stakeholders to understand drivers of uptake of PV systems by Australian households.

Whilst the intent of the study is to understand the characteristics of individual households that have or have not adopted PV, existing data sources do not relate PV adoption and socio-economic factors at the individual household level, and so this question cannot be tackled directly. Rather, this study relies on aggregated PV uptake, socio-economic and demographic data at the postcode level, from the Clean Energy Regulator (CER), Australian Taxation Office (ATO) and Australian Bureau of Statistics.

The study employs multivariate linear regression techniques to find statistically significant correlations between socio-economic and demographic variables at the postcode level and PV uptake rates. Multivariate analysis simultaneously controls for the effect of a range of variables on PV uptake, and therefore provides more robust estimates of the effect of any single variable on PV uptake than if those variables were analysed in isolation.

The variables examined for their effect on PV uptake in this study were:

- Salaries, wages and business income per dwelling
- Australian government pensions per dwelling
- Superannuation and foreign pension income per dwelling
- The proportion of households with detached or semi-detached dwellings
- The proportion of households who own their dwelling
- Average number of bedrooms per dwelling
- Population density
- Average age
- Proportion of population that is above 53 years of age
- Proportion of population that is under 15 years of age
- English proficiency
- Measures of tertiary education attainment
- Proportion of households that lived at the same address five years ago
- Proportion of population identifying as Indigenous
- Unemployment rate.

Regressions examining PV uptake rates to both the end of December 2011 and from the end of 2011 until the end of August 2013 were undertaken to examine whether the drivers of PV uptake had changed over time. The change in PV uptake over time was also examined through maps illustrating the change in installation rates between those two periods.

Regression results

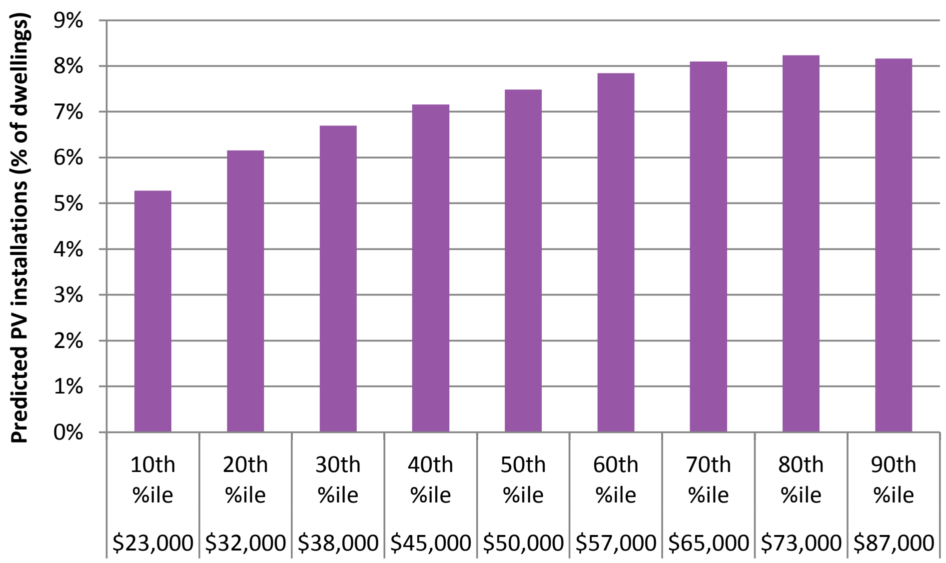
The core regression results of this study indicate that the socio-economic and demographic variables that have the strongest positive effects on PV uptake rates are:

- Owner occupation of dwellings
- The number of bedrooms per dwelling
- The proportion of people in a postcode that are over 53 years of age.

The study also found that where higher proportions of households were at the same address five years ago, PV uptake is lower. This might be because people who move to a new house are more motivated to consider various home renovations, including PV installation, than those who do not move. Alternatively, households that have been at the same address more than five years may consider themselves more likely to move in the near future, reducing the attractiveness of PV.

The relationship between household income levels and PV uptake rates has been widely discussed in Australia. Whilst this study finds that various measures of household income do have a statistically significant effect on PV uptake, this effect is relatively modest. Specifically, the level of salaries, wages and business income per dwelling, that is, the level of income generally sourced by economically active households, was positively correlated with PV uptake over a large range of incomes. Only after average salaries, wages and business income per dwelling reaches around $77,500 (or around the 84th percentile) do increases in average income result in lower predicted levels of PV uptake. This can be seen from Figure ES 1.

Figure ES 1 **Effect of varying income levels on PV uptake**



Note: PV uptake rates estimated as the predicted uptake rate from the multivariate regression model where each variable is held at its median value, other than salaries, wages and business income, which is varied between its 10th and 90th percentile values. The 'typical' postcode use for this analysis is located in Melbourne (i.e. Location type = Major Urban, State = VIC, SRES zone = 4). Figures below the respective percentiles are the approximate level of salaries, wages and business income per dwelling.
Source: ACIL Allen analysis

Income from Australian Government pensions was also positively correlated with PV uptake. However, income from superannuation and foreign pensions, generally associated with self-funded retirees, was not found to have a statistically significant effect on PV uptake. The overall results from this study indicate that retirees are likely to adopt PV more readily than other households (as increasing the proportion of people over 53 is predicted to increase PV uptake), but this effect is only mildly sensitive to retirement income levels and quite insensitive to income source.

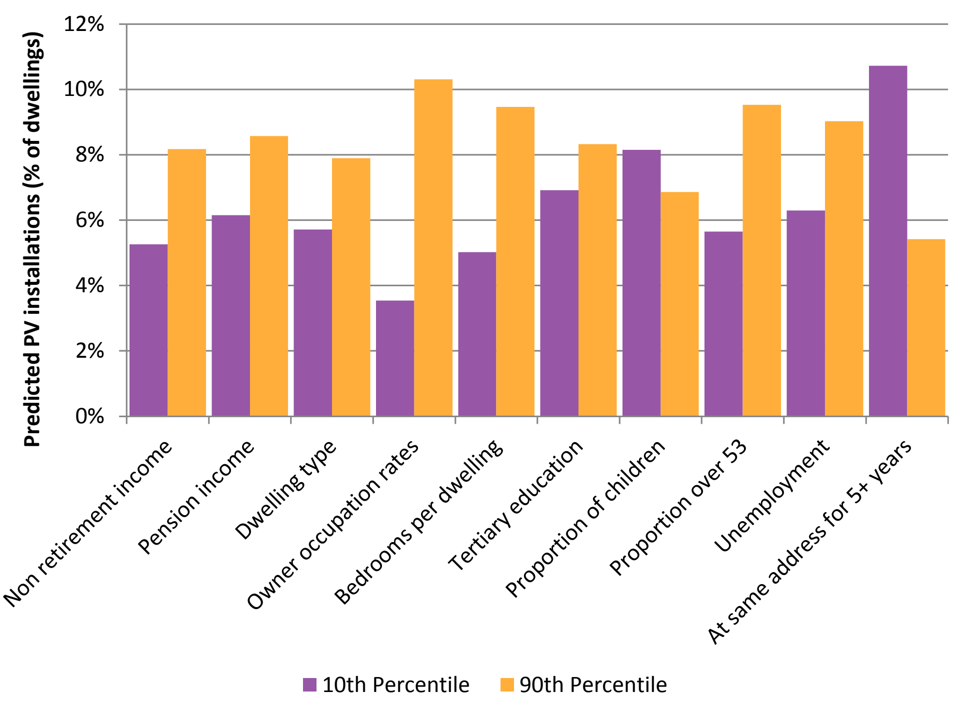
Other factors that had a statistically significant effect on PV uptake rates, albeit to a lesser degree than those listed above, were:

- Dwelling type (i.e. the proportion of detached and semi-detached dwellings in a postcode)
- Unemployment rates
- Rates of tertiary education qualifications
- The proportion of the people below 15 years of age.

Somewhat surprisingly, higher unemployment rates were associated with higher PV uptake rates. This may reflect that, as income levels are separately controlled, higher levels of unemployment are likely to imply a higher median income for a given average level of income. Another surprising result was that higher numbers of children below 15 were associated with lower levels of PV uptake.

The effect on PV uptake of changing in the range of socio-economic and demographic variables considered in this study are presented in Figure ES 2. This figure illustrates the predicted level of PV uptake for a household in the Melbourne metropolitan area with median values of all socio-economic variables, except that each individual variable is varied to its 10^{th} percentile (low) and 90^{th} percentile (high) values. Variables that are positively correlated with PV uptake will have a higher level of PV uptake at their 90^{th} percentile value than their 10^{th} percentile value, and the opposite will be true where there is a negative correlation. The absolute variation (expressed in percentage points) between the 10^{th} and 90^{th} percentiles is illustrated in Figure ES 3.

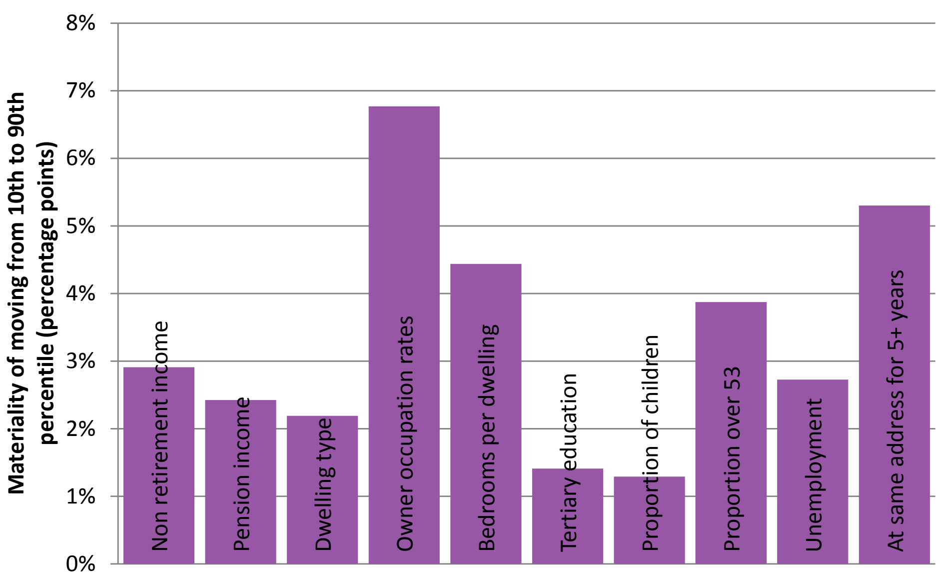
Figure ES 2 **Effect of socio-economic variables on PV uptake**



Note: PV uptake rates estimated as the predicted uptake rate from the multivariate regression model where each variable is held at its median value, other than the variable in question, which is varied to either its 10^{th} (low) or 90^{th} (high) percentile. The 'typical' postcode use for analysis of all variables is located in Melbourne (i.e. Location type = Major Urban, State = VIC, SRES zone = 4)

Source: ACIL Allen analysis

Figure ES 3 **Materiality of varying variables from 10^{th} to 90^{th} percentile as percentage points of PV uptake rate**



Note: PV uptake rates estimated as the predicted uptake rate from the multivariate regression model where each variable is held at its median value, other than the variable in question, which is varied to either its 10^{th} (low) or 90^{th} (high) percentile. The 'typical' postcode use for analysis of all variables is located in Melbourne (i.e. Location type = Major Urban, State = VIC, SRES zone = 4)

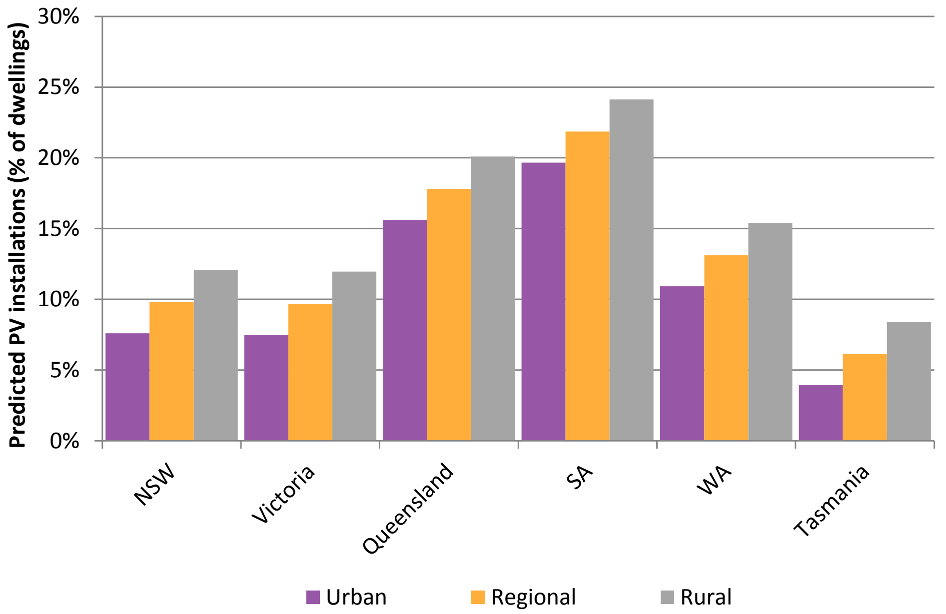
Source: ACIL Allen analysis

A simple analysis of CER data indicates that installation rates are generally higher in regional and rural locations than in urban locations. This study has confirmed that these differences exist independently of any socio-economic or demographic differences between urban and regional/rural locations. Dummy variables included in the regression to control for location type are statistically significant and positive for regional and rural locations (compared to urban locations), using a coding of postcodes developed by the ATO.

Further, there are statistically significant differences in uptake rates between various states and territories independently of socio-economic and demographic differences between those states. Compared to New South Wales, South Australia and Queensland have particularly high rates of PV uptake.

These differences are illustrated in Figure ES 4, which shows the expected rate of PV installation in urban, regional and rural locations in each state, for a hypothetical 'typical' postcode where all socio-economic and demographic variables are set at their national median levels.

Figure ES 4 **State/territory and location type effect on PV uptake**



Note: All estimates based on locations in SRES zone 3, except for Victoria and Tasmania which are in SRES zone 4. Estimates for regional locations based on the average for 'Regional (high urbanisation)' and 'Regional (low urbanisation)' locations.

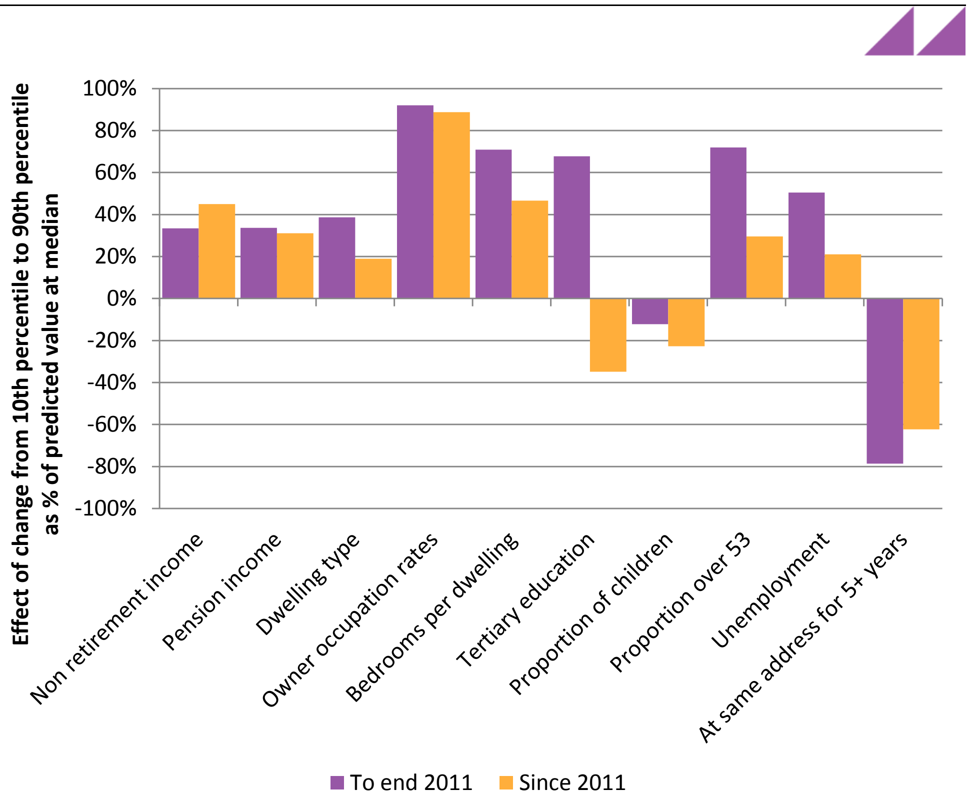
Source: ACIL Allen analysis

Another point of interest in this study is examining the dynamics of the substantial increase in PV uptake in Australia in recent years. To illustrate, the estimated PV uptake rate for Australia as a whole at the end of 2011 was around 7% of all dwellings, whereas at present the uptake rate is around 12% of all dwellings. This represents around 450,000 installations in just over 18 months.

To examine whether the drivers of PV uptake were different in the period to the end of 2011 than the drivers since that time, ACIL Allen compared regression analysis of PV uptake rates in those two periods. This analysis indicates that drivers of PV uptake are largely consistent over the two periods. The key difference is that the effect of tertiary education on PV uptake estimated by our regression modelling has gone from being positive (for the period to the end of 2011) to negative (since the end of 2011). This may reflect that postcodes with higher levels of tertiary education have experienced a level of saturation of PV uptake since the end of 2011, or simply that the PV industry has successfully marketed to a broader demographic since that time.

However, the effect of owner-occupation rates is largely unchanged between the two periods studied, and remains the largest effect on PV uptake rates. The effect of income levels is also largely unchanged. A comparison of the effect of different variables on PV uptake is show in Figure ES 5, which illustrates the change in PV uptake rates when moving from the 10th to the 90th percentiles for an individual variable (with all other variables held at their median value), expressed as a percentage of the predicted PV uptake rate where all variables are held at their median values.

Figure ES 5 **Comparison of materiality of varying variables – PV uptake rates to end 2011 and since 2011**



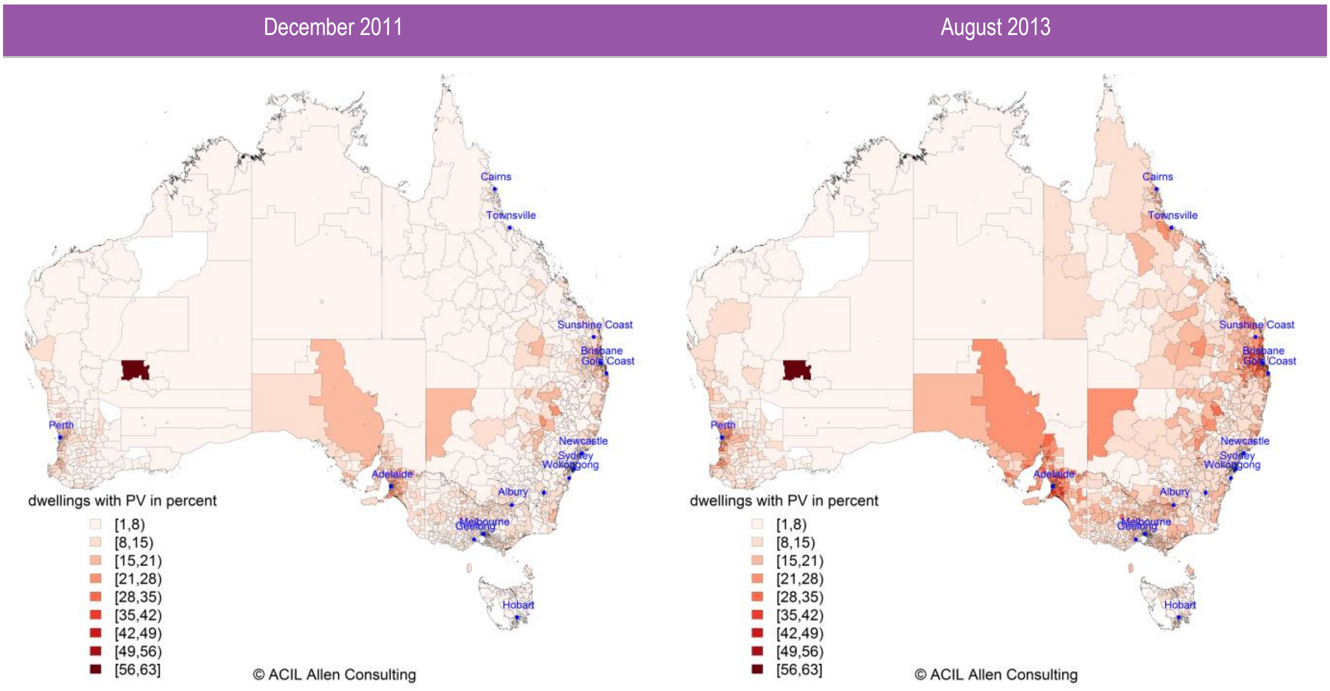
Note: Changes in PV uptake rates are estimated as the change in the predicted uptake rate from the multivariate regression model where each variable is held at its median value, other than the variable in question, which is varied to either its 10th or 90th percentile. The 'typical' postcode use for analysis of all variables is located in Melbourne (i.e. Location type = Major Urban, State = VIC, SRES zone = 4)

Source: ACIL Allen analysis

Mapping PV uptake

In addition to the core regression analysis described above, ACIL Allen mapped PV uptake rates by postcode for Australia as a whole and for specific regions. To capture the increase in PV installations since the end of 2011, all maps compare PV uptake rates to the end of 2011 and installation rates based on the most recent available data (to the end of August 2013) using the same colour coding for PV uptake rates. A map of Australia (Figure ES 6) is presented here to give a visual illustration of increases in PV uptake since 2011, and the strong regional distribution of PV uptake. A complete set of maps is provided in section 5 of the report.

Figure ES 6 **PV uptake rates in Australia**



Source: ACIL Allen analysis of ABS and CER data

1 Introduction

The Australian Renewable Energy Agency (ARENA) commissioned ACIL Allen Consulting (ACIL Allen) to examine the relationship between the rate of uptake of solar photovoltaic (PV) systems and socio-economic or demographic characteristics in different areas of Australia. Consistent with ARENA's mandate to increase the level of renewable energy generation in Australia, this study is intended to assist ARENA and stakeholders to understand drivers of uptake of PV systems by Australian households. In turn, understanding these drivers can assist in understanding the characteristics of households that have not yet adopted PV and therefore represent the market for future PV adoption. Overall, the study may contribute to both enhanced understanding of the effect of past and existing policies and programs supporting PV, and the design of future policies and programs.

Whilst the intent of the study is to understand the characteristics of individual households that have or have not adopted PV, available data does not allow this to be examined directly. There are no extensive data sources that match information on PV adoption and socio-economic factors at the individual household level. Undertaking surveys to obtain such information is time- and resource-intensive, and beyond the scope of this study. Accordingly, this study relies on the existence of information on aggregated levels of PV adoption, and aggregated or average socio-economic data, by geographic regions. However, this geographic information is available at sufficiently fine-grained level of disaggregation such that the inherent variability in socio-economic characteristics by geographic area, and in average PV uptake rates, allows broad inferences to be made about the likely characteristics of individual households that adopt PV.

This report is structured as follows:

- Section 2 outlines the methodology and key data sources for the study
- Section 3 provides a simple overview of the data analysed
- Section 4 examines the relationship between PV uptake and socio-economic indicators more formally through a multivariate linear regression model
- Section 5 complements the preceding analysis by mapping PV uptake rates as of the end of 2011 and at the present time by postcode.

2 Methodology

2.1 Data sources

Whilst the intent of the study is to understand the characteristics of individual households that have or have not adopted PV, available data does not allow this to be examined directly. There are no extensive data sources that match information on PV adoption and socio-economic factors at the individual household level. Undertaking surveys to obtain such information is time- and resource-intensive, and beyond the scope of this study. Accordingly, this study relies on the existence of information on aggregated levels of PV adoption, and aggregated or average socio-economic data, by geographic regions. However, this geographic information is available at sufficiently fine-grained level of disaggregation such that the inherent variability in socio-economic characteristics by geographic area, and in average PV uptake rates, allows broad inferences to be made about the likely characteristics of individual households that adopt PV.

Specifically, the core data sets used for this study are:

- Data on PV installation numbers and installed PV capacity collected and published by the Clean Energy Regulator (CER) in the course of managing the Australian Government's Small-scale Renewable Energy Scheme (SRES)
- Socio-economic and demographic data collected by the Australian Bureau of Statistics (ABS) through the 2011 Census
- Various income-related data collected by the Australian Taxation Office (ATO) in the course of administering the taxation system in Australia, and published in arrears as a taxation statistics summary.

The CER data used for this study is published at the postcode level, specifically the number of PV installations in a postcode and total capacity (in kilowatts) of PV systems installed in a postcode. Two 'snapshots' of PV installations were used in this study: installation data up to the end of 2011, and the most current public installation data from the CER capturing the period up until the end of August 2013. However, due to lags between PV installations and the creation of certificates under the SRES (at which point the installation is recorded in the CER data), this study does not capture all installations that have physically occurred up to the end of August 2013 but only those that had created certificates under the SRES.

Like the CER data, the ATO data used for this study is published at the postcode level. Amongst numerous measures relevant to the taxation system, the key variables of interest for this study were total taxable income, total wages and salaries, total business income, total Australian pensions, and total superannuation income for each postcode (see Table 4 for more detail). The ATO data used was the most recent available, published as part of the 2010-11 Australian taxation statistics summary.

The ABS data used is from the 2011 census (undertaken in August 2011). ABS census data is also provided by geographical area, but not by postcode. Formally, the ABS uses the Australian Statistical Geographical Standard (ASGS). To match with the CER and ATO data it is necessary for this study to convert all ABS geographic data into postcode regions. However, given the different purposes for the two geographic classifications there are some mismatches. The best concordance currently available is the ABS' own mapping of the 2011

Census data to 'Postal Areas' which was obtained by aggregating the ASGS Statistical Area Level 1 (SA1) regions to the best possible match to the Australia Post postcodes.

For this study we have used the ABS mapping of SA1 regions to 'Postal Areas' to link data from the ABS with that of the ATO and the CER. The data sets of the CER, the ABS and the ATO are however not entirely congruent.

There are 27 postal areas for which the ATO and ABS keep statistics in which no PV installations have occurred. The CER data set contains information on installations for a number of postcodes which are not included in the ATO and ABS data sets. Upon review of the data for these installations we have found that they are mostly listed in postcodes which are reserved for large businesses or government organisations. In total 1,359 installations are listed in postcodes which do not correspond to ABS or ATO data. We have not included the data on these installations in our analysis. Given that as of the end of August 2013 there were over 1,094,941 Solar PV installations in Australia we believe that omitting this data does not materially affect the results of our analysis.

Our analysis is focused on installations on a per dwellings[1] basis to explore the key drivers of uptake of PV systems in Australia. As dwellings do not include all built structures there are some smaller postcode areas which have rooftop PV installations but no or only very few dwellings, leading to uptake rates in excess of 100%. In general, postcodes with very low numbers of dwellings will exhibit large random variations in both PV uptake and socio-economic indicators. Accordingly, we have excluded 16 postcode areas which have less than 50 dwellings from this analysis. These areas include industrial areas such as the Lonsdale recycling plant in South Australia, the Malaga industrial area in Perth and the RAAF base in Edinburgh South Australia. Again, the level of households and PV installations affected by these exclusions is sufficiently small as to not materially affect the results of our analysis.

The ABS publishes a great range of socio-economic and demographic indicators. ACIL Allen considered which indicators had been found to have an effect on PV uptake in previous studies (see section 2.4), and other potential explanatory variables, when deciding to test the following indicators for their potential correlation with PV uptake:

- The proportion of households with detached or semi-detached dwellings
- The proportion of households who own their dwelling
- Average number of bedrooms per dwelling
- Population density
- Average age
- Proportion of population that is above 53 years of age.[2]
- Proportion of population that is under 15 years of age.
- English proficiency
- Measures of tertiary education attainment
- Proportion of households that lived at the same address five years ago
- Proportion of population identifying as Indigenous
- Unemployment rate.

[1] The ABS defines dwellings as structures that are intended to have people live in it and which are inhabited on census night.

[2] Based on ABS 2011, Multipurpose Household Survey

A more detailed explanation of the CER, ATO and ABS statistical measures used in this study is provided in Table 4.

For consistency across various data sources and ease of interpretation, various data sources were standardised to penetration rates or per household measures, e.g. the proportion of households with a PV system or the taxable income per household. These measures were calculated simply by dividing the relevant aggregate value by the ABS measure of the number of households in the relevant postcode. Given this, the core measure of PV adoption in this study is simply the proportion of households with a PV system.

This study adopted a static cross-sectional or ‘snapshot’ view of correlations between PV uptake and the socio-economic and demographic indicators examined despite the slight time differences between the data used: the ATO data is from the financial year 2010-11, the ABS data is from August 2011, and the CER data is from either December 2011 or August 2013. Implicitly, this approach assumes that the rate of change in socio-economic and demographic variables from the ATO and ABS data is sufficiently slow that these data sources still provide a meaningful picture of the characteristics of various postcodes when compared with solar uptake data from several months to several years later. In practice, this assumption seems reasonable and, in any case, census data is only available every five years and so the timing of the data sources for this study is relatively close.

The key data analysed in this study are summarised in section 3.

2.2 Multivariate linear regression

Our core approach to the study is to employ multivariate linear regression techniques to find statistically significant correlations between socio-economic and demographic variables at the postcode level and PV uptake rates.

This approach seeks a relationship that relates the level of a range of ‘explanatory variables’, being various socio-economic or demographic indicators for each postcode, to the level of a single ‘dependant variable’ for each observation (in this case, the proportion of households with a PV installation in each postcode). Formally, this approach postulates that the dependant variable for each postcode i, denoted y_i, is determined by a linear model with K explanatory variables such that:

$$y_i = \sum_{k=1}^{K} \beta_k x_{ik} + \varepsilon_i$$

where β_k is a coefficient explaining the effect of a change in the level of the kth explanatory variable for each observation i, x_{ik}, on PV uptake, and where ε_i is an idiosyncratic (unexplained) error term for observation i.

By combining all socio-economic and demographic variables with a statistically significant correlation with PV uptake, the multivariate model can estimate the marginal effect of one variable on PV uptake, whilst also controlling for the effects of other correlated effects on PV uptake. For example, we might expect that the proportion of households with a PV system increases as the proportion of households that own their own home increase. However, in estimating this effect, we might also need to take into account the fact that people who own their own home are more likely to live in a detached or semi-detached dwelling than in an apartment, and dwelling type also has an effect on PV uptake. A multivariate model capturing both variables is necessary to control for these related and potentially confounding effects on PV uptake.

2.3 Mapping analysis

Building on the regression analysis, this study includes use of mapping products to illustrate some relationships graphically. The primary use of mapping in this study is to capture the increase in PV installations since the end of 2011. Accordingly, all maps compare PV uptake rates to the end of 2011 and installation rates based on the most recent available data (to the end of August 2013) using the same colour coding for PV uptake rates. A complete set of maps for Australia as a whole and for various regions of Australia are provided in section 5 of the report.

2.4 Overview of similar studies

A range of organisations have undertaken analyses of PV uptake and socio-economic factors such as income using CER, ABS and/or ATO data. The key study in this area was analysis undertaken by Seed Advisory (Seed) for the Australian Energy Market Commission (AEMC) in early 2011 as part of the AEMC's review of the SRES. As with this study, Seed analysed correlations between PV installation rates and various socio-economic and demographic variables at the postcode level. Naturally, this study can take advantage of more recent data on PV installations (which have increased to over 1 million Australia-wide compared to around 625,000 at the time of the Seed study), 2011 census data (Seed used data from the 2006 census) and more up-to-date ATO data. Further, the methodology adopted here does not replicate that of Seed, and focuses more on multivariate rather than univariate analysis. Nevertheless, the fundamental questions examined by Seed, and the range of potential drivers of PV uptake investigated, are essentially the same as in this study.

Seed found, amongst other things, that solar uptake tended to be higher in areas where:

- There is a higher proportion of people in the 35-74 age group
- The share of detached and semi-detached housing is higher
- Dwellings have a higher number of bedrooms on average
- Density measured by people per square kilometre is lower
- A high proportion of people have income in the range of $1000 to $1700 per week
- Where the proportion of people with poor English is lower.

A comparison of Seed's findings with those of this study is provided in section 4.4.

A shorter study examining similar questions was undertaken by the REC Agents Association (RAA) in September 2012 (published on the association's website as a research note). Whilst not employing formal statistical techniques, the RAA studied the effect of income and dwelling location (using the ATO urban classification codes), finding a slight inverse relationship between income levels and solar penetration levels and generally higher rates of solar take up in rural and regional communities, and outer suburbs, than in central areas of capital cities.

The Alice Solar City project supported a household (as opposed to postcode) level examination of solar PV uptake using direct survey measurement. This study was published as a working paper presented at the 50th Annual Conference of the Australian Solar Energy Society. This paper found that 'early' PV adopting households tended to be from middle, rather than low or high, income groups. PV adopters tended also to live in detached dwellings and have relatively high levels of educational attainment.

Whilst this is not a comprehensive list of studies looking at the socio-economic and demographic characteristics of PV adopting households, this brief review indicates a clear focus of these studies on a range of factors, particularly:

- Household income (noting that strong linear relationships are not generally found)
- Dwelling type
- Dwelling tenure
- Dwelling location (e.g. urban, regional or rural) and/or population density
- Educational attainment and/or language skills.

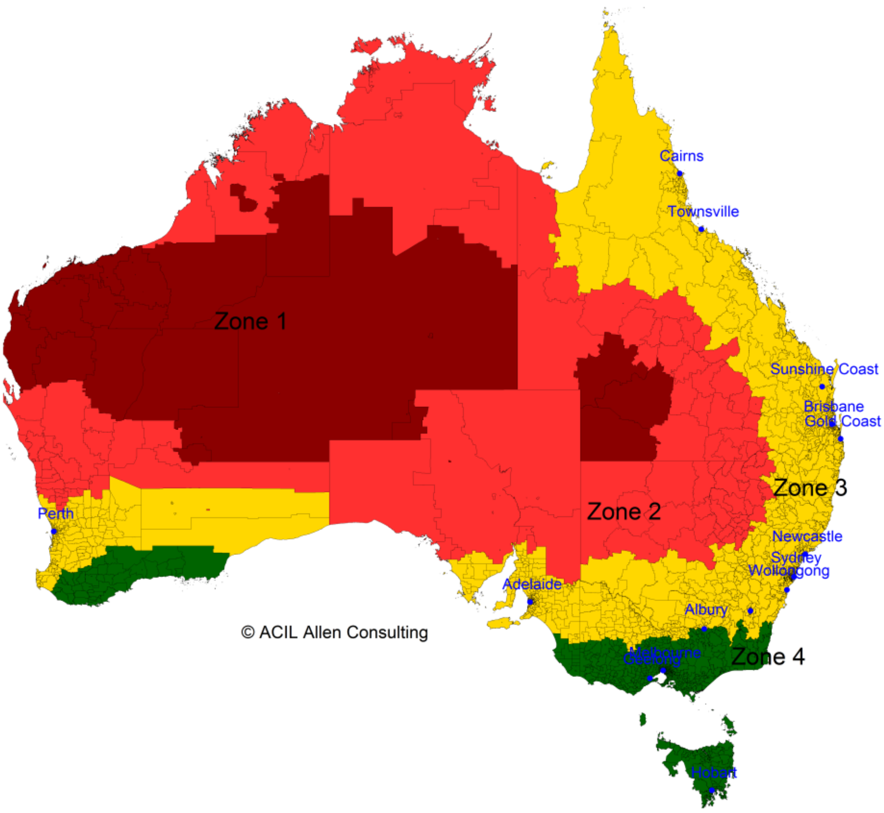
3 Data overview

3.1 PV installations

In this chapter we present key statistics of the uptake of roof-top photovoltaic (PV) across Australia. We also provide an overview of socio economic factors that we have used in our analysis.

To account for difference in solar insulation across Australia in the operation of the Small-scale Renewable Energy Scheme (SRES), regulations established under the *Renewable Energy (Electricity) Act* 2011 assign each postcode in Australia to one of four solar zones. For each solar zone a different factor applies when calculating the number of small-scale technology certificates an installation is eligible for. These solar zones are illustrated in Figure 1.

Figure 1 **SRES solar zones**



Source: *Renewable Energy (Electricity) Regulations 2001*, ABS

Table 1 compares the number of PV systems installed in each solar zone at the end of 2011 and in August 2013. Across Australia the penetration of PV systems as a percentage of dwellings that have a system installed has risen from around 7% at the end of 2011 to 12% in 2013. Most PV systems are installed in Zone 3 which is also the SRES Zone with the highest PV uptake rate.

Table 1 **PV installations by solar zone**

	2011 census	December 2011 data		August 2013 data		Since 2011	
Zone	Dwellings	Installations	PV uptake rate	Installations	PV uptake rate	Change in installations	% growth in installations
1	48,972	1,088	2.2%	1,635	3.3%	547	50.3%
2	207,632	15,998	7.7%	22,470	10.8%	6,472	40.5%
3	6,355,468	512,304	8.1%	864,634	13.6%	352,350	68.8%
4	2,520,369	113,233	4.5%	203,839	8.1%	90,606	80.0%
Total	**9,132,441**	**642,623**	**7.0%**	**1,092,578**	**12.0%**	**449,955**	**70.0%**

Note: This data does not include 1,359 installations which are listed in postcodes not used by the ABS
Source: *Renewable Energy (Electricity) Regulations 2001*, CER, ABS.

Table 2 shows the number of PV installation by state or territory. From 2011 to 2013 the state with the highest absolute number of PV system installations has shifted from New South Wales to Queensland. South Australia had the highest rate of PV uptake at the end of 2011 (13%) and retains this lead based on the most recent data. The uptake rate is lowest in the Northern Territory.

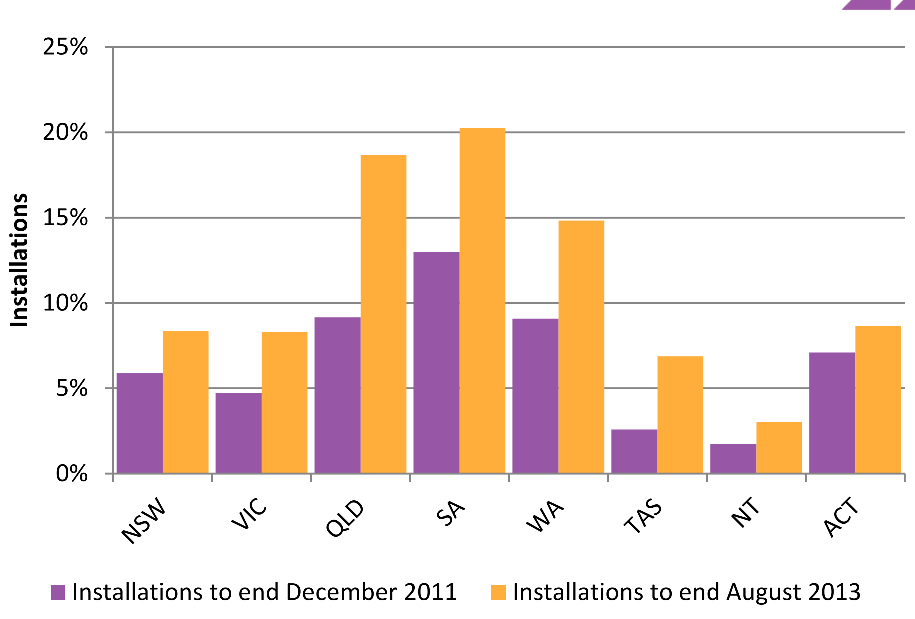
Table 2 **PV installations by state/territory**

	2011 census	December 2011 data		August 2013 data		Since 2011	
State/ territ-ory	Dwellings	Installations	PV uptake rate	Installations	PV uptake rate	Change in installations	% growth in installations
NSW	2,871,058	168,326	5.9%	240,211	8.4%	71,885	42.7%
VIC	2,290,840	107,713	4.7%	190,353	8.3%	82,640	76.7%
QLD	1,824,396	166,847	9.1%	340,858	18.7%	174,011	104.3%
SA	728,542	94,682	13.0%	147,532	20.3%	52,850	55.8%
WA	963,352	87,438	9.1%	142,795	14.8%	55,357	63.3%
TAS	233,026	6,022	2.6%	15,992	6.3%	9,970	165.6%
NT	76,091	1,314	1.7%	2,301	3.0%	987	75.1%
ACT	145,136	10,281	7.1%	12,536	8.6%	2,255	21.9%
Total	**9,132,441**	**642,623**	**7.0%**	**1,092,578**	**12.0%**	**449,955**	**70.0%**

Note: This data does not include 1,359 installations which are listed in postcodes not used by the ABS
Source: CER, ABS.

Figure 2 shows the change in the PV installation rate by state and territory from 2011 to 2013, as well as illustrating the significant variation in installation rates between different states and territories.

Figure 2 **PV installations by state/territory**



Note: This data does not include 1,359 installations which are listed in postcodes not used by the ABS
Source: CER, ABS.

The ATO classifies postcodes into six location types depending on the degree of urbanisation in the postcode. These location types are:

- Major urban (capital city)
- Other urban
- Regional (high urbanisation)
- Regional (low urbanisation)
- Rural
- Other.

The ATO's location classification of 'Other' mainly contains postal area that are reserved for large volume receivers and businesses. This location type also includes a number of new residential growth areas such as the suburb 'The Ponds', a newly developed suburb in Sydney's North West growth corridor, and Dawesville and Lakelands which are new suburbs in the Mandurah area of Western Australia.

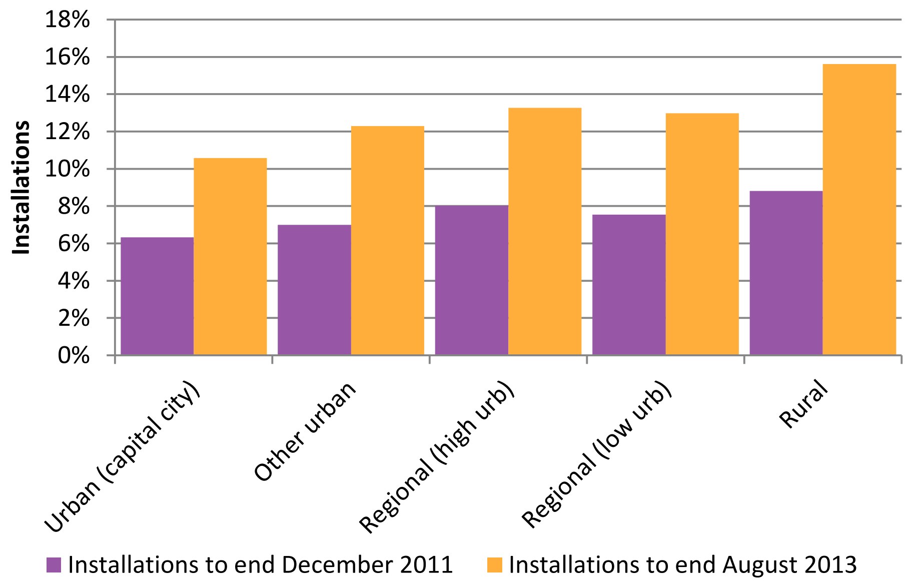
Table 3 lists the number of installations within each of these six location types in 2011 and 2013, and calculates PV uptake rates for each. This table and the subsequent Figure 3 illustrate that PV uptake rates are higher in regional and rural locations than in urban locations, as well as the substantial growth in PV installation rates since the end of 2011.

Table 3 **PV installations by location type**

	2011 census	December 2011 data		August 2013 data		Since 2011
Zone	Dwellings	Installations	PV uptake rate	Installations	PV uptake rate	% growth in installations
Major urban (capital city)	5,086,796	322,107	6.3%	538,296	10.6%	67.1%
Other urban	1,116,350	78,058	7.0%	137,153	12.3%	75.7%
Regional (high urbanisation)	1,047,698	84,084	8.0%	139,009	13.3%	65.3%
Regional (low urbanisation)	605,337	45,663	7.5%	78,525	13.0%	72.0%
Rural	1,266,829	111,749	8.8%	197,764	15.6%	77.0%
Other	9,431	962	10.2%	1,831	19.4%	90.3%
Total	**9,132,441**	**642,623**	**7.0%**	**1,092,578**	**12.0%**	**70.0%**

Note: This data does not include 1,359 installations which are listed in postcodes not used by the ABS
Source: CER; ABS; ATO

Figure 3 **PV installation rate by location type**



Note: This data does not include 1,359 installations which are listed in postcodes not used by the ABS. Other category excluded due to the small sample size and to avoid distorting scale of graph.
Source: CER; ABS; ATO

3.2 Socio-economic variables

We have tested a range of socio-economic variables for their ability to explain uptake rate of PV systems. Table 4 lists the socio-economic variables we have tested and what data source these variables are based on.

Table 4 **Socio-economic variables and source**

Variable	Unit	Data Source
PV uptake	Installations/per 1000 dwellings	CER PV installations to end of August 2013 and ABS 2011 Census
Taxable income per dwelling	$/dwelling	ATO Taxation Statistics 2011[3]
Salary, wages and business income per dwelling	$/dwelling	ATO Taxation Statistics 2011
Australian pensions income per dwelling	$/dwelling	ATO Taxation Statistics 2011
Super and foreign pensions income per dwelling	$/dwelling	ATO Taxation Statistics 2011
Proportion of detached and semi-detached dwellings	% of dwellings	ABS 2011 Census
Proportion of owner-occupied dwellings	% of dwellings	Outright ownership and ownership with a Mortgage ABS 2011 Census
Average bedrooms per dwelling	#/dwelling	Calculated based on ABS 2011 Census
Average age	years	Calculated based on ABS 2011 Census
Proportion of people under 15 years of age	% of population	ABS 2011 Census
Proportion of people over 53[4] years of age	% of population	ABS 2011 Census
Population density	Population/km^2	ABS 2011 Census, Australian Statistical Geography Standard 2011
People per dwelling	#/dwelling	ABS 2011 Census
Unemployment	% of population	ABS 2011 Census[5]
Indigenous proportion	% of population	ABS Census 2011
Proportion of people with poor English	% of population	ABS Census 2011 people who speak English not well or not at all
Proportion of people living at same address 5 years ago	% of population	ABS Census 2011
Proportion of people with tertiary qualifications	% of population	ABS Census 2011, postgraduate, bachelor, diploma or certificate level qualifications

Table 5 lists key statistics on the socio-economic variables across postcodes analysed in this report. We note that the statistics shown are based on the representation of each variable on a postcode basis. As postcodes are not uniform, the statistics shown are not representative of Australia as a whole. For example, the estimated PV uptake rate for Australia as a whole is around 12% (see Table 1, Table 2 or Table 3) whereas the average installation rate by postcode is around 12.8%.

[3] www.ato.gov.au/About-ATO/Research-and-statistics/In-detail/Tax-statistics/Taxation-statistics-2010-11/?default=&page=8#Individuals%27_tax

[4] Based on the average age at retirement from the 2011, ABS, Multi-purpose household survey

Table 5 **Summary of socio-economic variables by postcode**

Variable	Average	Min	10th percentile	Median (50th percentile)	90th percentile	Max
PV uptake	12.8%	0.0%	3.5%	11.0%	25.1%	62.9%
Taxable income per dwelling	$59,212	$1,562	$27,030	$54,215	$96,054	$235,842
Salary, wages and business income per dwelling	$53,364	$914	$23,038	$49,793	$86,733	$185,999
Australian pensions income per dwelling	$806	$0	$359	$812	$1,185	$8,579
Super and foreign pensions income per dwelling	$926	$0	$193	$757	$1,711	$12,661
Total retirement income per dwelling	$1,731	$0	$704	$1,619	$2,657	$13,277
Proportion of detached and semi-detached dwellings	88%	0%	69%	94%	99%	100%
Proportion of owner-occupied dwellings	57%	0%	37%	59%	74%	88%
Average bedrooms per dwelling	3.1	1.1	2.6	3.1	3.4	4.1
Average age	39	21	34	39	44	60
Proportion of people under 15 years of age	18%	0%	13%	18%	23%	35%
Proportion of people over 53 years of age	32%	0%	21%	31%	43%	81%
Population density	708	0	0	32	2,291	12,734
People per dwelling	2.2	0.3	1.6	2.2	2.8	26.2
Unemployment	3.2%	0.0%	1.8%	3.1%	4.8%	13.3%
Indigenous proportion	3.6%	0.0%	0.3%	1.5%	6.6%	93.2%
Proportion of people with poor English	1.6%	0.0%	0.0%	0.5%	4.8%	33.0%
Proportion of people living at same address 5 years ago	54%	3%	41%	56%	66%	82%
Proportion of people with tertiary qualifications	33%	10%	23%	32%	46%	63%

Note: All values are referencing postal areas and overall averages are the averages across postcode areas not across the nation

Source: ACIL Allen Analysis of CER, ATO and ABS data

4 Regression analysis

4.1 Approach

We tested the significance of socio-economic variables by evaluating the results of a multivariable regression model. The initial multivariate regression model used for this purpose uses all variables listed in Table 5 and a number of dummy variables. Dummy variables are binary variables that are set to either 1 or 0 and which control for intrinsic differences between postcodes that should be distinguished from the effect of other explanatory variables.

To illustrate the purpose of dummy variables, NSW postcodes are likely to have higher average incomes than many other states, but NSW also had a very generous feed-in tariff scheme for several years. A ‘NSW dummy’ controls for some of this policy induced variation whilst separately attributing the true effect of household income on PV uptake. Similarly, the SRES establishes four zones representing areas of higher or lower insolation, which in turn affects the financial return on a PV system. Allowing for differences in solar insolation through the use of dummy variables might, for example, allow a regression model to distinguish whether low PV installation rates in areas of Tasmania are due to low income levels or low levels of solar insolation, or both.

Dummy variables examined in this study were:

- Dummies for each state and territory
- Dummies for each SRES solar zone
- Dummies representing the ATO’s classification of postcodes into one of six categories: major urban (capital city); other urban; regional (high urbanisation); regional (low urbanisation); rural; and other.

The multivariate regression model also includes the square of salary, wages and business income, to pick up a non-linear (quadratic) relationship between this variable and PV uptake rates. A number of socio-economic variables were found to be statistically insignificant at the 5% level, and were progressively excluded from the multivariate analysis. These insignificant variables were superannuation and foreign pension income per dwelling, population density, people per dwelling, proportion of people with poor English proficiency, and the proportion of the population identifying as Indigenous. Dummies for the ‘other urban’ location type, the ACT, Northern Territory and Tasmania, for SRES solar zone 1 were also found to be insignificant and therefore excluded (SRES solar zone 3, the major urban postcode zone and NSW were the base locations compared, and therefore do not have dummy variables). Average age was also excluded from the regression, with the proportion of the population in the under 15 and over 53 categories preferred as explanatory variables to reflect the age distribution within postcode areas.

4.2 Core regression results

The results of the core multivariate regression model described in Table 6.

Table 6 **Results of multivariate regression analysis**

Variable	Estimate	Std. Error	t value	Pr(>|t|)
Intercept	-0.305	0.017	-17.95	0%
Salary, wages and business income per dwelling squared	0.000	0.000	-8.61	0%
Salary, wages and business income per dwelling	0.000	0.000	8.80	0%
Australian pensions income per dwelling	0.000	0.000	8.46	0%
Proportion of detached and semi-detached dwellings	0.072	0.013	5.39	0%
Proportion of owner-occupied dwellings	0.184	0.011	16.12	0%
Average bedrooms per dwelling	0.055	0.006	9.36	0%
Proportion of people with tertiary qualifications	0.063	0.019	3.34	0%
Proportion of people under 15 years of age	-0.139	0.042	-3.31	0%
Proportion of people over 53 years of age	0.175	0.021	8.35	0%
Unemployment	0.891	0.086	10.32	0%
Proportion of people living at same address 5 years ago	-0.212	0.016	-12.98	0%
Regional (high urbanisation) location	0.018	0.005	3.36	0%
Regional (low urbanisation) location	0.026	0.005	5.44	0%
Rural location	0.045	0.003	14.27	0%
Postcode classified by ATO as ‘other’	0.043	0.014	3.16	0%
SA	0.121	0.004	32.96	0%
VIC	0.035	0.004	9.70	0%
QLD	0.080	0.003	23.73	0%
WA	0.033	0.004	9.12	0%
SRES insolation zone 2	0.013	0.005	2.70	1%
SRES insolation zone 4	-0.037	0.003	-10.58	0%

Note: high t values and low Pr(>|t|) values indicate that a variable has a high degree of statistical significance.
Source: ACIL Allen analysis of ABS, ATO and CER data

The model shown above has an adjusted R^2 of 0.639, which, broadly speaking, indicates that 64% of the variation in PV uptake rates between postcodes can be explained by variation in the explanatory variables included here, whilst the remaining 36% is due to unobserved and/or random factors.

4.3 Interpretation of results

The sign on the regression estimates for the variables tested indicates whether or not they have a positive or negative effect on PV uptake. The exception to this is salaries, wages and business income, which were tested in the model in a quadratic form. In this case, the signs indicate that this variable has an ‘inverse U-shaped’ effect on PV uptake. However, further analysis of the coefficients indicates that the installation rates increase with income over the majority of income levels, with the ‘turning point’ above which PV uptake decreases with income being around $77,500 per dwelling, or is around the 84th percentile of the postcodes analysed. In other words, increasing salaries, wages and business income are associated with increasing PV uptake over a large range of incomes (up to the 84th percentile), but with the rate of increase slowing over that range. Above the 84th percentile, increasing salaries, wages and business income are associated with slightly decreasing levels of PV uptake. This can be seen by looking at the predicted level of PV uptake rate for a postcode with all socio-economic and demographic variables held at their national median level, whilst varying salaries, wages and business income from the 10th percentile (low) value to the 90th percentile (high) value. This analysis was done for a postcode assumed to be located in Melbourne, i.e. with the VIC state dummy, the Major Urban location code dummy and the

SRES solar zone 4 dummies set to 1. The results are illustrated in Figure 4, which shows the approximate level of salaries, wages and business income per dwelling alongside each percentile.

Figure 4 **Predicted PV uptake rates at various income percentiles**

Note: PV uptake rates estimated as the predicted uptake rate from the multivariate regression model where each variable is held at its median value, other than salaries, wages and business income, which is varied between its 10th and 90th percentile values. The 'typical' postcode use for this analysis is located in Melbourne (i.e. Location type = Major Urban, State = VIC, SRES zone = 4). Figures below the respective percentiles are the approximate level of salaries, wages and business income per dwelling.
Source: ACIL Allen analysis

The model confirms our expectations that postcodes with a high proportion of detached and semi-detached dwellings, and with a high proportion of owner-occupied dwellings tend to have higher PV uptake. Independently of dwelling type, locations where dwellings have a higher number of bedrooms also seem to have higher PV uptake rates.

Higher rates of tertiary education also are correlated with higher PV uptake. The results indicate that young families have lower takes of PV uptake, based on the negative coefficient on the proportion of people who are under 15 in a postcode. Conversely, older populations appear to be correlated with higher PV uptake, as indicated by the positive coefficient on the proportion of people over 53.

Surprisingly, a higher level of unemployment in a postcode is positively correlated with higher levels of PV uptake. This result is difficult to explain, but may reflect that income levels are separately controlled for and so higher levels of unemployment are likely to imply a higher median income for a given average level of income. However, it would be surprising if surveys at the household (rather than postcode) level found a positive correlation between unemployment and PV uptake.

Also somewhat surprising was that the proportion of households that have been at the same address for over five years is negatively correlated with PV uptake. This may reflect that when households move they consider a range of household renovation options, and PV installation is one of those options. It may also reflect that a household that has been in a given house for an extended period considers itself more likely to move in the near future, and therefore are less willing to invest in PV systems as it may not receive the full benefit of that system.

Whilst the signs of these coefficients indicate the direction of the predicted effect of the variable on PV uptake rates, the materiality of these effects cannot always be readily discerned from the estimated coefficients. Table 7 and Figure 5 illustrate the materiality of each of the main drivers we have identified in our multivariate regression analysis. We have assessed the materiality of each of the drivers by comparing the PV uptake rate predicted by our model when varying the variable in questions from the 10th percentile to the 90th percentile and keeping all other variables at their median values. Again, this analysis was done for a postcode assumed to be located in Melbourne, i.e. with the VIC state dummy, the Major Urban location code dummy and the SRES solar zone 4 dummies set to 1.

This analysis indicates that owner-occupation of dwellings has the largest effect on PV uptake, with the proportion of households at the same address five years ago having a substantial (negative) effect. Following this, the variables with the largest effect are the number of bedrooms per dwelling, the proportion of the population over 53, salaries, wages and business income, unemployment rates, income from pensions and the proportion of detached and semi-detached dwellings (in declining order). The proportion of the population under 15 and tertiary education rates have relatively small effects on PV uptake.

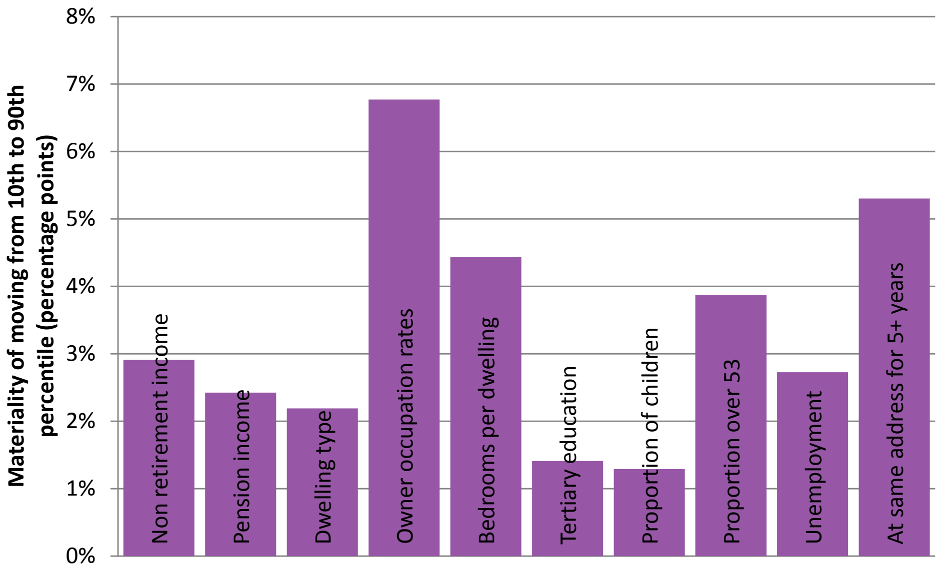
Table 7 **Materiality analysis**

Variable	10th Percentile	90th Percentile
All variables at median	7.5%	
Salary, wages and business income per dwelling	5.3%	8.2%
Australian pensions income per dwelling	6.2%	8.6%
Proportion of detached and semi-detached dwellings	5.7%	7.9%
Proportion of owner-occupied dwellings	3.5%	10.3%
Average bedrooms per dwelling	5.0%	9.5%
Proportion of people with tertiary qualifications	6.9%	8.3%
Proportion of people under 15 years of age	8.2%	6.9%
Proportion of people over 53 years of age	5.7%	9.5%
Unemployment	6.3%	9.0%
Proportion of people living at same address 5 years ago	10.7%	5.4%

Note: PV uptake rates estimated as the predicted uptake rate from the multivariate regression model where each variable is held at its median value, other than the variable in question, which is varied to either its 10th or 90th percentile. The ‘typical’ postcode use for analysis of all variables is located in Melbourne (i.e. Location type = Major Urban, State = VIC, SRES zone = 4)

Source: CER; ATO; ABS

Figure 5 **Materiality of varying variables from 10th to 90th percentile as percentage points of PV uptake rate**



Note: Changes in PV uptake rates are estimated as the change in the predicted uptake rate from the multivariate regression model where each variable is held at its median value, other than the variable in question, which is varied to either its 10th or 90th percentile. The 'typical' postcode use for analysis of all variables is located in Melbourne (i.e. Location type = Major Urban, State = VIC, SRES zone = 4)

Source: ACIL Allen analysis

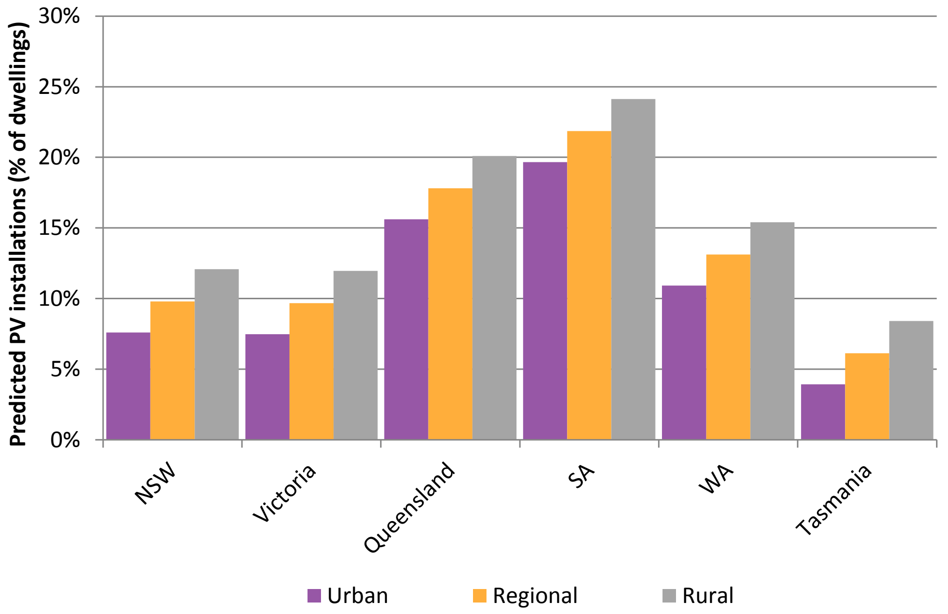
Unlike estimated coefficients for continuous variables, the coefficients on dummy variables can be used to directly estimate the effect of changing state/territory, location type (e.g. urban to rural) or solar zone.

The state/territory dummies were estimated with NSW as the reference location (i.e. NSW does not have a dummy attributed to it). The ACT, Tasmania and Northern Territory were not found to have statistically significant different uptake rates compared to NSW, once all other variables were controlled for. By contrast, South Australia and Queensland have substantially higher uptake rates, of 12 and 8 percentage points respectively. Victoria and Western Australia also have statistically higher uptake rates than NSW, of around 3.5 and 3.3 percentage points respectively (when differences in insolation rates and other relevant variables are accounted for).

With respect to location type, major urban (capital city) locations were the base location to which no dummy was assigned. Accordingly, the regression results indicate that regional and rural locations have a statistically higher rate of PV uptake, of between 1.8 and 4.5 percentage points. 'Other' locations also have a higher uptake, but this coefficient is hard to interpret given the miscellaneous nature of those locations. Other urban locations did not have a statistically significant difference in uptake rates to capital city locations.

To present the effect of moving between states and territories and different location types, ACIL Allen has analysed the variation in installation rates predicted for a postcode with all socio-economic and demographic variables set at their median values, but whether this hypothetical average postcode was moved between different states and different location types (e.g. urban or regional). The predicted installation rates were calculated using the relevant state/territory dummies and using SRES solar zone 3 for all states except Victoria and Tasmania (which use SRES solar zone 4). The estimated location type dummies were used in the following way: no dummy was assumed for urban locations, the average of the two regional dummies was used for regional locations, and the rural location type dummy was used for rural locations. These results indicate that both moving between states and moving between cities and rural or regional locations has a material and statistically significant effect on PV uptake independent of different socio-economic conditions in those different locations.

Figure 6 **State/territory and location type effect on PV uptake**



Source: ACIL Allen analysis

With respect to solar zones, SRES solar zone 3, the most common zone, was taken as the reference point and so did not have a dummy assigned. Surprisingly, SRES solar zone 1 (with the highest insolation level) did not have higher installation rates once all other factors were controlled for. SRES solar zone 2 has a small, but higher level of PV uptake of around 1.3 percentage points, whilst SRES solar zone 4 has a lower level of PV uptake by around 3.7 percentage points.

4.4 Comparison with other studies

The results described in sections 4.2 and 4.3 above can be compared with previous studies. Consistent with analysis by the REC Agents Association, this study finds higher levels of installation in regional and rural locations than in urban locations. However, unlike that study, our analysis indicates a positive relationship between household income and PV uptake across the majority of income levels (at levels below $77,500 per dwelling).

Like the Alice Solar City survey, our study indicates that households in detached dwellings and with higher levels of education are likely to have higher PV uptake rates. However, unlike that study, we do not find that middle income levels have the highest rate of PV uptake when analysed at the postcode level (noting that the Alice Springs study used data at the household level).

For comparison with the Seed Advisory study for the AEMC in 2011, Table 8 below describes the different and similar findings of that analysis and this study. This comparison focuses on the univariate rather than multivariate component of the Seed study, as the multivariate component was described by Seed as ‘preliminary’. It is also relevant to note that Seed was reliant on 2006 census data, whereas this study has benefitted from 2011 census data. In general the results of this study and those found by Seed are consistent, particularly for the key drivers of dwelling type and size, dwelling ownership, and dwelling location type. The most clearly contradictory results are not factors which have a large absolute effect on PV uptake.

Table 8 **Comparison with 2011 Seed study**

Variable	Effect in this study	Effect from Seed study	Comparison
Income	Generally increasing effect on PV uptake	Highest rates of PV uptake at middle income levels ($1000-$1700/week/household)	Somewhat consistent
Age	Higher proportions of older residents and lower proportions of children suggest higher PV uptake	Highest PV uptake where high proportions of people are aged 35-74	Somewhat consistent
Dwelling type	Both studies find PV uptake is higher where more dwellings are detached or semi-detached		Consistent
Dwelling size	Both studies find PV uptake is higher where dwellings have a higher number of bedrooms on average		Consistent
Dwelling ownership	Both studies find PV uptake is higher where more dwellings are owner occupied		Consistent
Population density and dwelling location type	Population density has no statistical effect, once location type is controlled for. Higher uptake in rural and regional locations	Lower population density suggests higher PV uptake. Location type not controlled for	Largely consistent
Proportion of children	Negative effect	Positive effect	Contradictory
English proficiency	No effect	Poor English proficiency reduces PV uptake	Somewhat contradictory
Tertiary education	Positive effect	No effect at the national level, positive effect in one state	Somewhat contradictory
Unemployment rate	Positive effect	Positive effect in some states	Somewhat consistent
Proportion of people who lived at the same address five years ago	Negative effect	No effect at the national level, negative effect in one state	Somewhat consistent

Source: Seed Advisory; ACIL Allen analysis

4.5 Regressions examining differences since 2011

To analyse whether the drivers of PV uptake have changed over time, we applied the same core regression model using the same socio-economic data to PV uptake data to the end of December 2011. The results for this regression are presented in Table 9.

Table 9 **Multivariate regression results using 2011 PV uptake data**

	Estimate	Std. Error	t value	Pr(>|t|)
(Intercept)	-0.222	0.012	-18.46	0%
Salary, wages and business income per dwelling squared	0.000	0.000	-7.36	0%
Salary, wages and business income per dwelling	0.000	0.000	6.95	0%
Australian pensions income per dwelling	0.000	0.000	6.50	0%
Proportion of detached and semi-detached dwellings	0.050	0.009	5.27	0%
Proportion of owner-occupied dwellings	0.098	0.008	12.14	0%
Average bedrooms per dwelling	0.035	0.004	8.28	0%
Proportion of people with tertiary qualifications	0.119	0.013	8.87	0%
Proportion of people under 15 years of age	-0.052	0.030	-1.74	8%
Proportion of people over 53 years of age	0.127	0.015	8.59	0%
Unemployment	0.646	0.061	10.57	0%
Proportion of people living at same address 5 years ago	-0.123	0.012	-10.66	0%
Regional (high urbanisation) location	0.009	0.004	2.55	1%
Regional (low urbanisation) location	0.014	0.003	3.98	0%
Rural location	0.024	0.002	10.90	0%
Postcode classified by ATO as ‘other’	0.012	0.010	1.26	21%
SA	0.076	0.003	29.28	0%
VIC	0.022	0.003	8.56	0%
QLD	0.022	0.002	9.28	0%
WA	0.021	0.003	8.11	0%
SRES insolation zone 2	0.019	0.003	5.57	0%
SRES insolation zone 4	-0.033	0.002	-13.49	0%

Note: high t values and low Pr(>|t|) values indicate that a variable has a high degree of statistical significance.

Source: ACIL Allen analysis of ABS, ATO and CER data

This model retains reasonable explanatory power despite the fact that we have not adjusted it to reflect changes in the data. This model has an adjusted R^2 value of 0.548, indicating that well over 50% of the variation in PV uptake rates in December 2011 is explained by this model, despite the fact that it was designed to explain observed PV uptake rates in August 2013.

More importantly, the signs on the coefficient estimates for each explanatory variable is the same as for the model presented in Table 6. In other words, no variables which had a positive effect on PV uptake in 2013 had a negative effect up to 2011, or vice versa. Further, only on variable (the ‘other’ location code) is not statistically significant at the 10% level in this model, and only one other variable (the proportion of children under 15) is not statistically significant at the 5% level.

To extend this comparison, we then applied the same regression model as set out in and to installation data focusing only on the period between the end of 2011 and the end of August 2013. In other words, this regression examined whether the same drivers were in operation in the period to the end of 2011 and the period since that time. The results for this regression are presented in Table 10.

Table 10 **Multivariate regression results using PV uptake data since end 2011**

	Estimate	Std. Error	t value	Pr(>|t|)
(Intercept)	-0.083	0.008	-9.84	0%
Salary, wages and business income per dwelling squared	0.000	0.000	-6.84	0%
Salary, wages and business income per dwelling	0.000	0.000	7.79	0%
Australian pensions income per dwelling	0.000	0.000	7.77	0%
Proportion of detached and semi-detached dwellings	0.022	0.007	3.34	0%
Proportion of owner-occupied dwellings	0.086	0.006	15.14	0%
Average bedrooms per dwelling	0.021	0.003	7.05	0%
Proportion of people with tertiary qualifications	-0.056	0.009	-5.90	0%
Proportion of people under 15 years of age	-0.088	0.021	-4.17	0%
Proportion of people over 53 years of age	0.048	0.010	4.57	0%
Unemployment	0.246	0.043	5.71	0%
Proportion of people living at same address 5 years ago	-0.089	0.008	-10.93	0%
Regional (high urbanisation) location	0.008	0.003	3.13	0%
Regional (low urbanisation) location	0.013	0.002	5.28	0%
Rural location	0.021	0.002	13.19	0%
Postcode classified by ATO as ‘other’	0.031	0.007	4.55	0%
SA	0.045	0.002	24.61	0%
VIC	0.013	0.002	7.32	0%
QLD	0.058	0.002	34.49	0%
WA	0.012	0.002	6.80	0%
SRES insolation zone 2	-0.006	0.002	-2.49	1%
SRES insolation zone 4	0.012	0.002	6.80	0%

Note: high t values and low Pr(>|t|) values indicate that a variable has a high degree of statistical significance.

Source: ACIL Allen analysis of ABS, ATO and CER data

Overall, this model has reasonable explanatory power, with has an adjusted R^2 value of 0.613. This indicates that the model calibrated to present installations levels has slightly greater ability to explain installations since December 2011 than those prior to that time.

At first glance, it is clear from Table 10 that the sign on the coefficient estimate for tertiary education is different when analysing installations since the end of 2011 and installations before that time. This means that the effect of tertiary education on PV uptake estimated by our regression modelling has gone from being positive (for the period to the end of 2011) to negative (since the end of 2011). This may reflect that postcodes with higher levels of tertiary education have experienced a level of saturation of PV uptake since the end of 2011, or simply that the PV industry has successfully marketed to a broader demographic since that time. However, all other variables and dummies have the same signs as in Table 9.

To compare the materiality of the effect of changes in any of these variables on PV uptake, Figure 7 illustrates the change in PV uptake rates when moving from the 10th to the 90th percentiles for an individual variable (with all other variables held at their median value), expressed as a percentage of the predicted PV uptake rate where all variables are held at their median values. It does so for both predicted installation rates using the model estimated based on data up until the end of 2011, and the model estimated using data since that time. This figure indicates that the effect of owner occupation, the variable with the largest effect on PV uptake, is essentially unchanged, the effect of income levels and staying at the same address for over five years is also quite consistent. By contrast, the effect of dwelling type, dwelling size (bedrooms/dwelling), unemployment and the proportion of people over 53 has decreased quite noticeably. As noted above, the effect of tertiary education on PV uptake has gone from positive (up until the end of 2011) to negative (since 2011).

Figure 7 **Comparison of materiality of varying variables – PV uptake rates to end 2011 and since 2011**

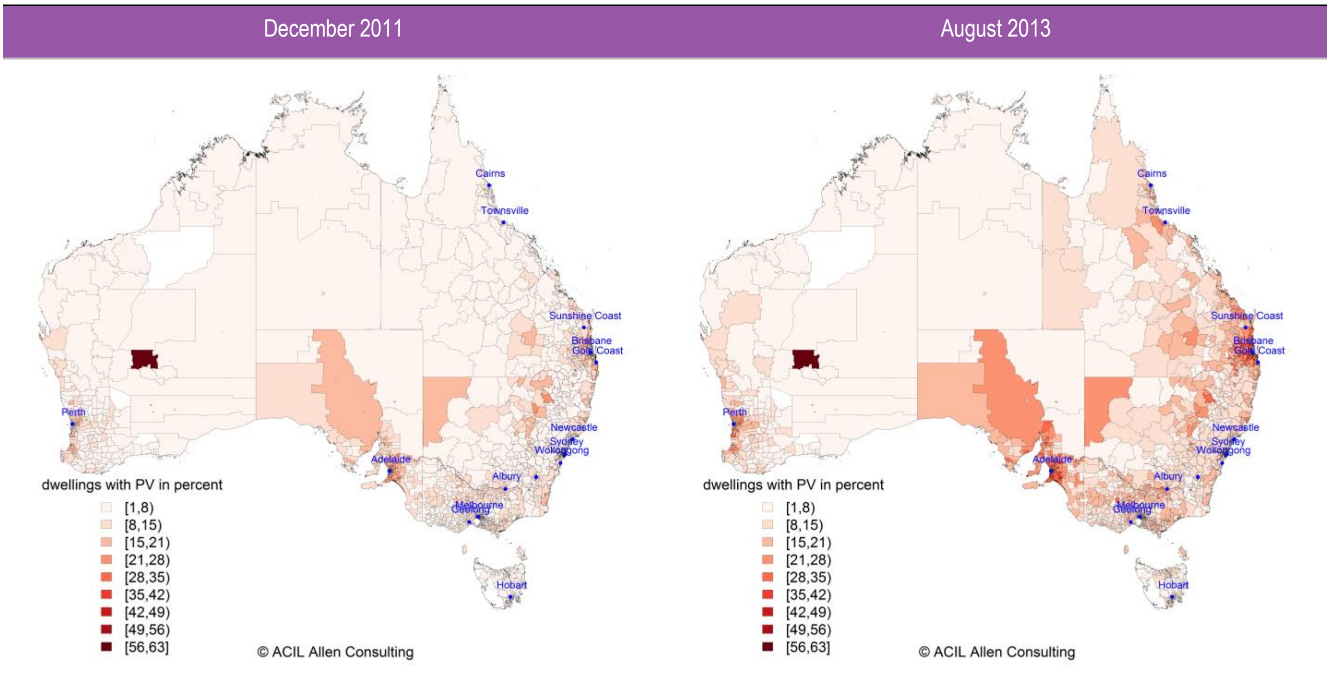
Note: Changes in PV uptake rates are estimated as the change in the predicted uptake rate from the multivariate regression model where each variable is held at its median value, other than the variable in question, which is varied to either its 10^{th} or 90^{th} percentile. The 'typical' postcode use for analysis of all variables is located in Melbourne (i.e. Location type = Major Urban, State = VIC, SRES zone = 4)
Source: ACIL Allen analysis

5 Mapping

The maps presented in this section compare uptake rates (as a percentage) between the end of December 2011 and the end of August 2013. All maps use the same colour coding to represent uptake rates so that visual comparisons over time and between areas can be readily undertaken. The maps use a colouring scheme where darker red colours represent a higher penetration of PV systems on a per dwelling basis in this postcode area. Postal areas are assigned one of 9 colours depending on the uptake rate of PV. To allow for an intuitive interpretation of the maps each increment of colour represents the same increment in penetration of roof-top PV in steps of 7 percentage points up to the maximum penetration rate in 2013 (63%).

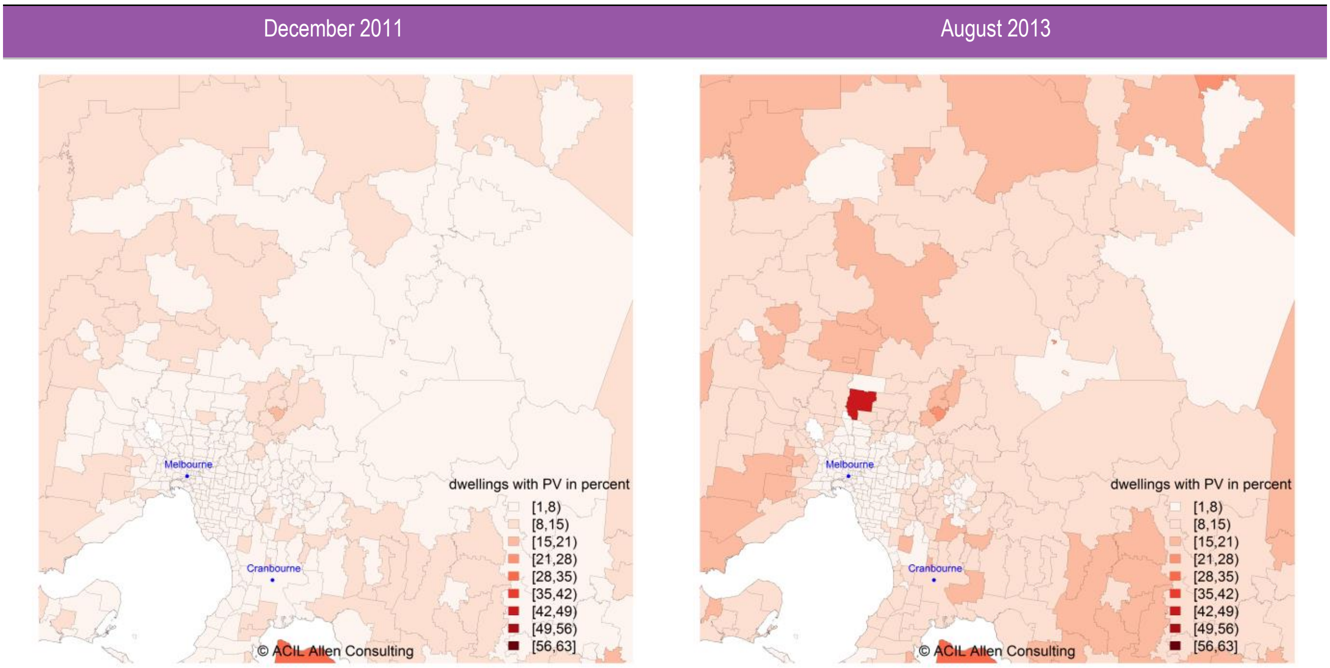
Maps are presented for: Australia; the six state capital cities (in the order of Melbourne, Sydney, Brisbane, Hobart, Adelaide and Perth); for most of Queensland (the state with the highest absolute levels of PV uptake); for most of South Australia (the state with the highest PV uptake rate); and for Tasmania.

Figure 8 **PV uptake rates in Australia**



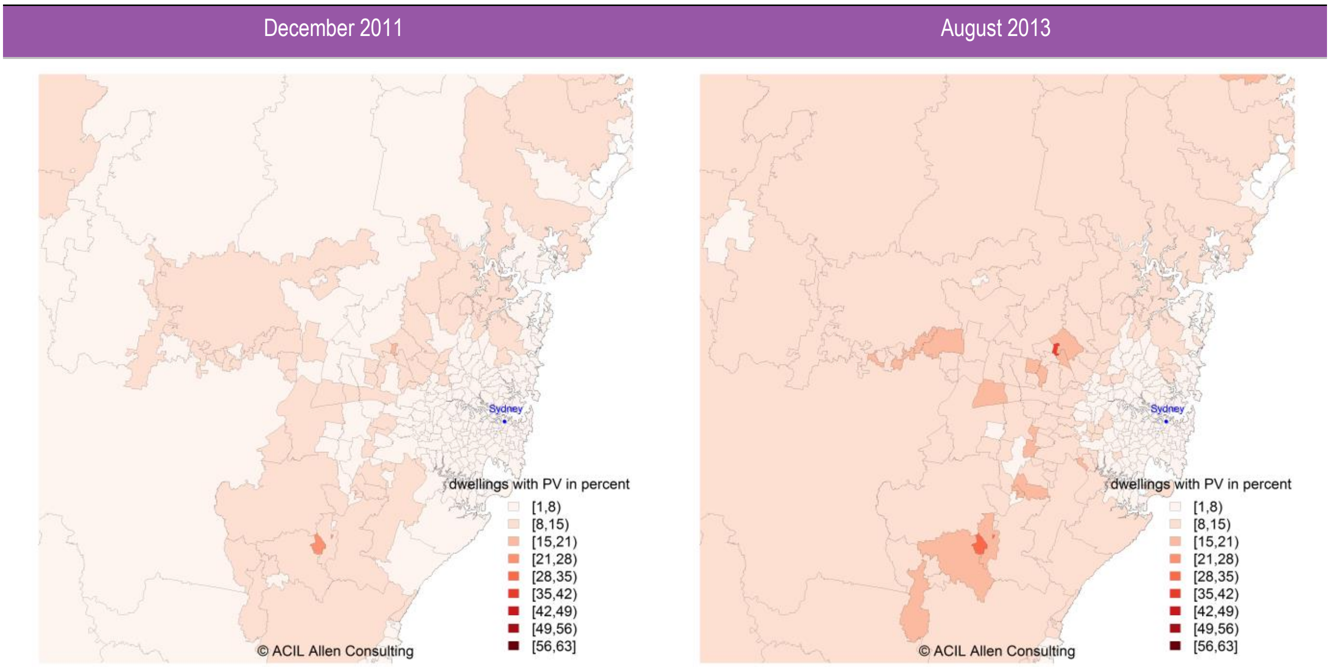
Source: ACIL Allen analysis of ABS and CER data

Figure 9 **PV uptake rates in Melbourne area**



Source: ACIL Allen analysis of ABS and CER data

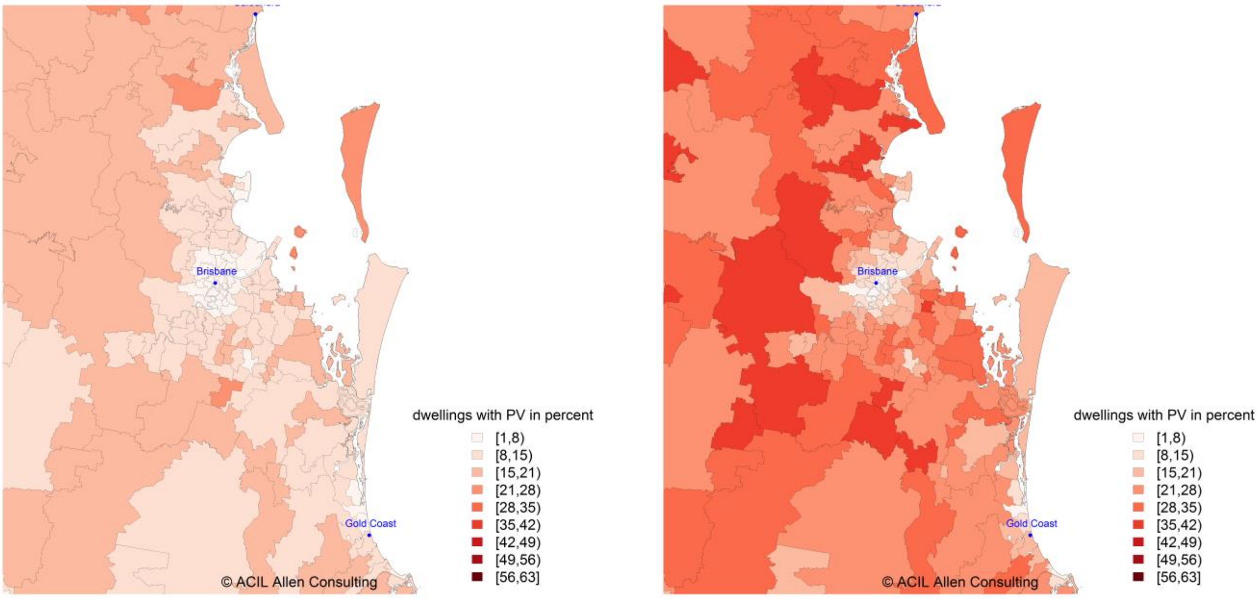
Figure 10 **PV uptake rates in Sydney area**



Source: ACIL Allen analysis of ABS and CER data

Figure 11 **PV uptake rates in Brisbane area**

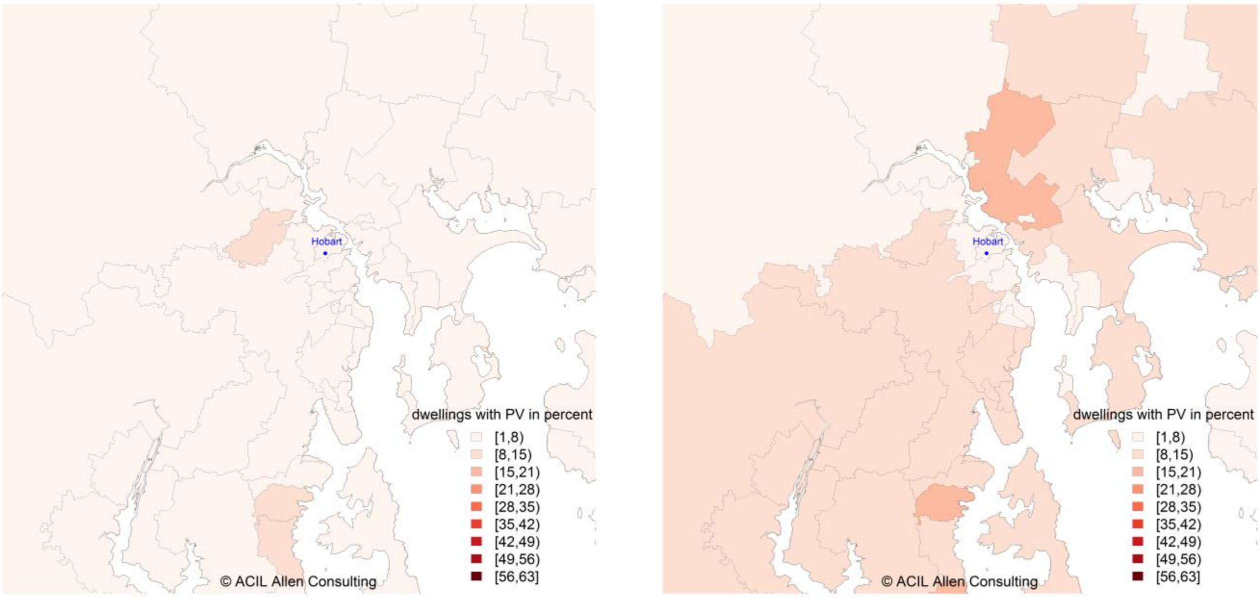
December 2011	August 2013



Source: ACIL Allen analysis of ABS and CER data

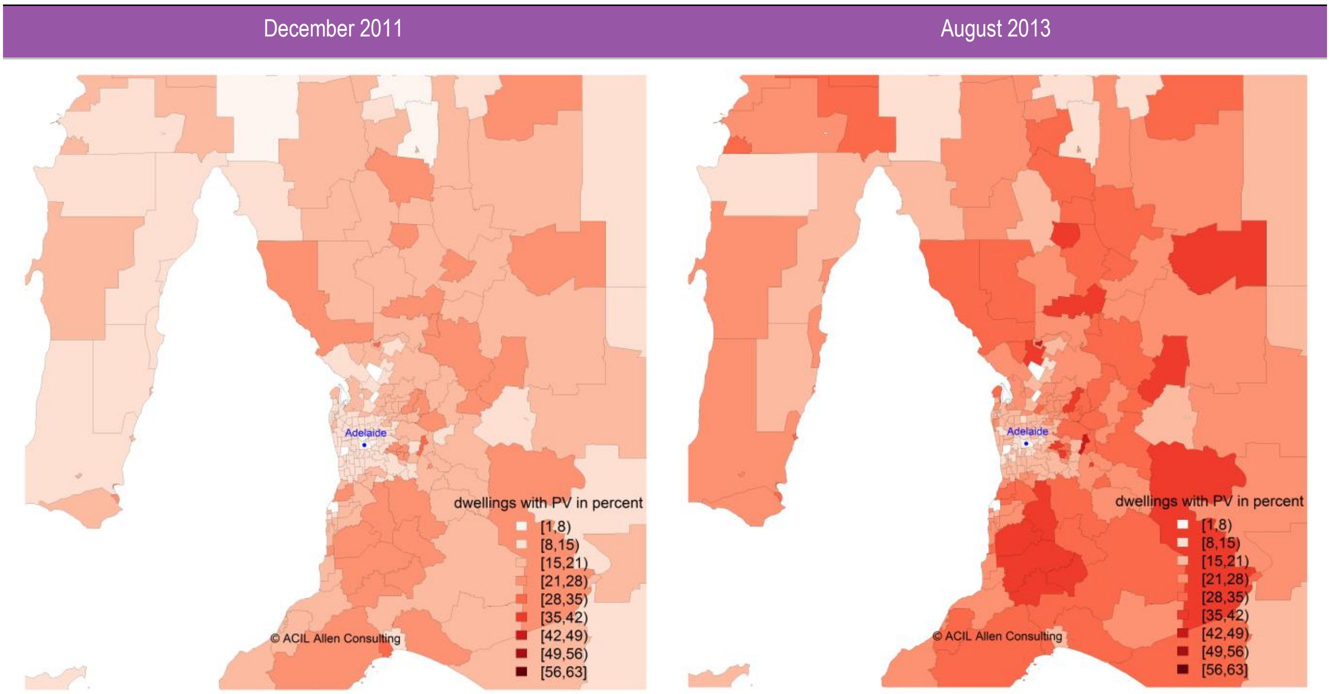
Figure 12 **PV uptake rates in Hobart area**

December 2011	August 2013



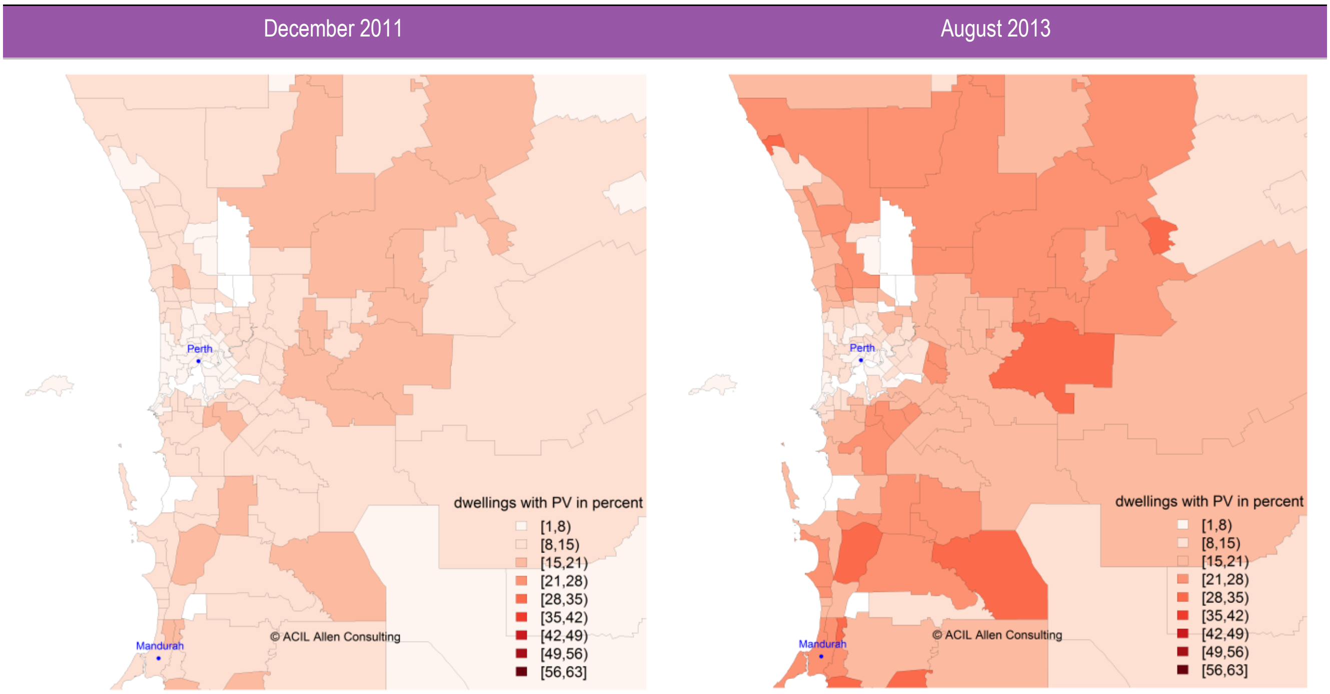
Source: ACIL Allen analysis of ABS and CER data

Figure 13 **PV uptake rates in Adelaide area**



Source: ACIL Allen analysis of ABS and CER data

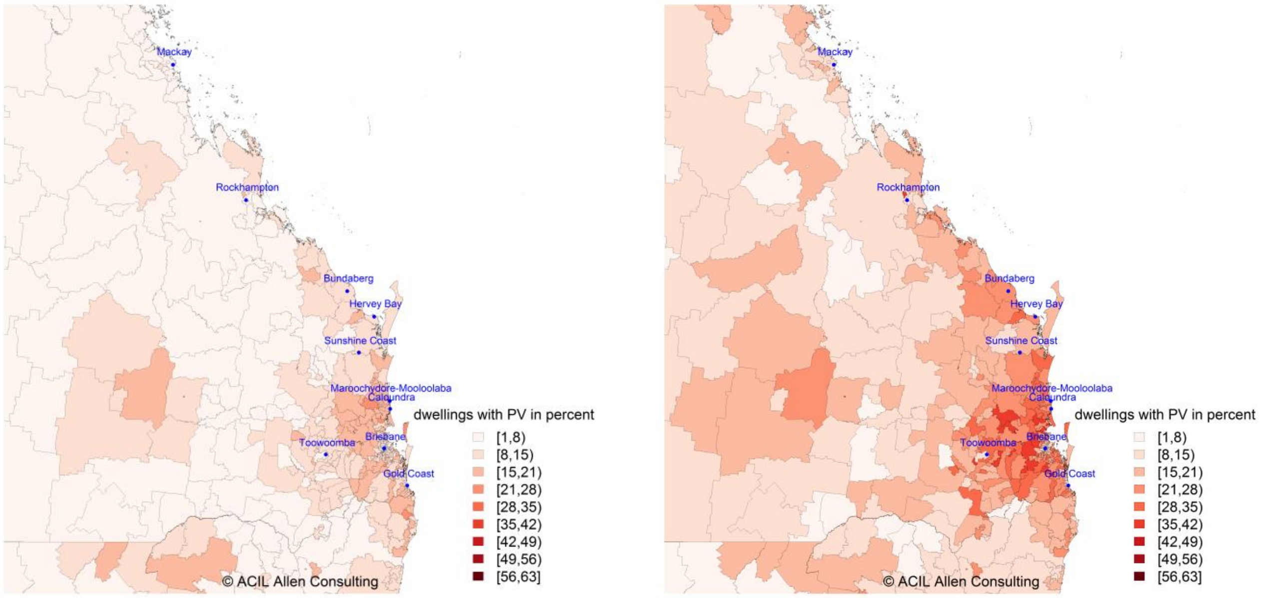
Figure 14 **PV uptake rates in Perth area**



Source: ACIL Allen analysis of ABS and CER data

Figure 15 **PV uptake rates in Queensland**

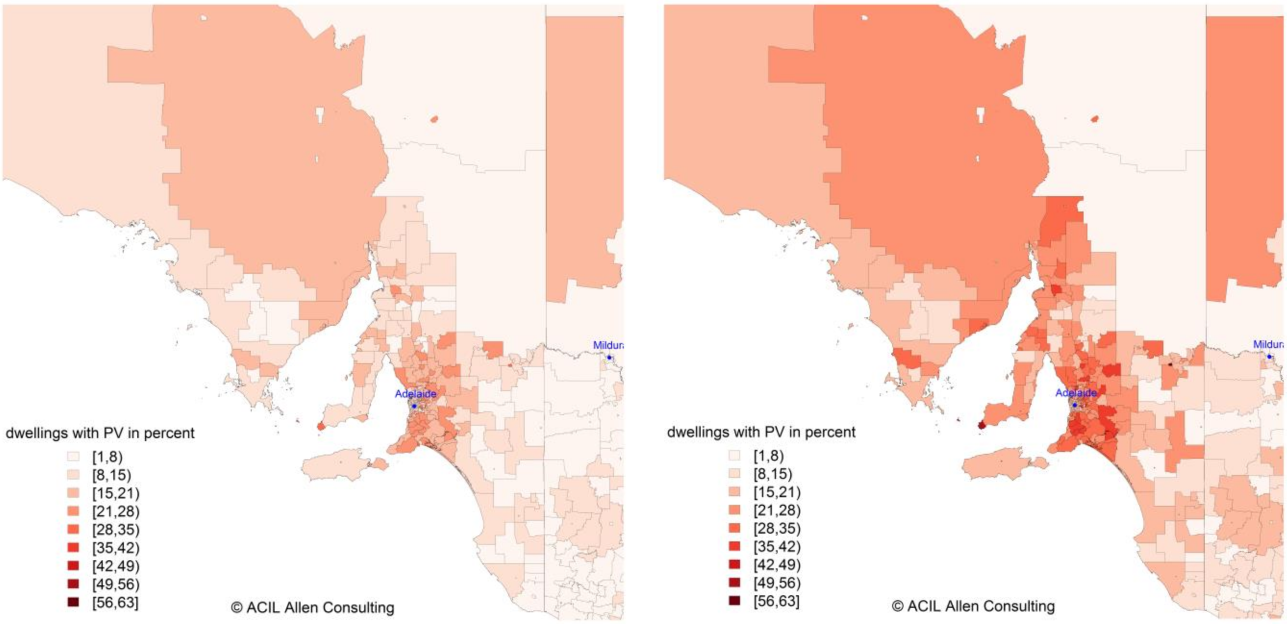
December 2011	August 2013



Source: ACIL Allen analysis of ABS and CER data

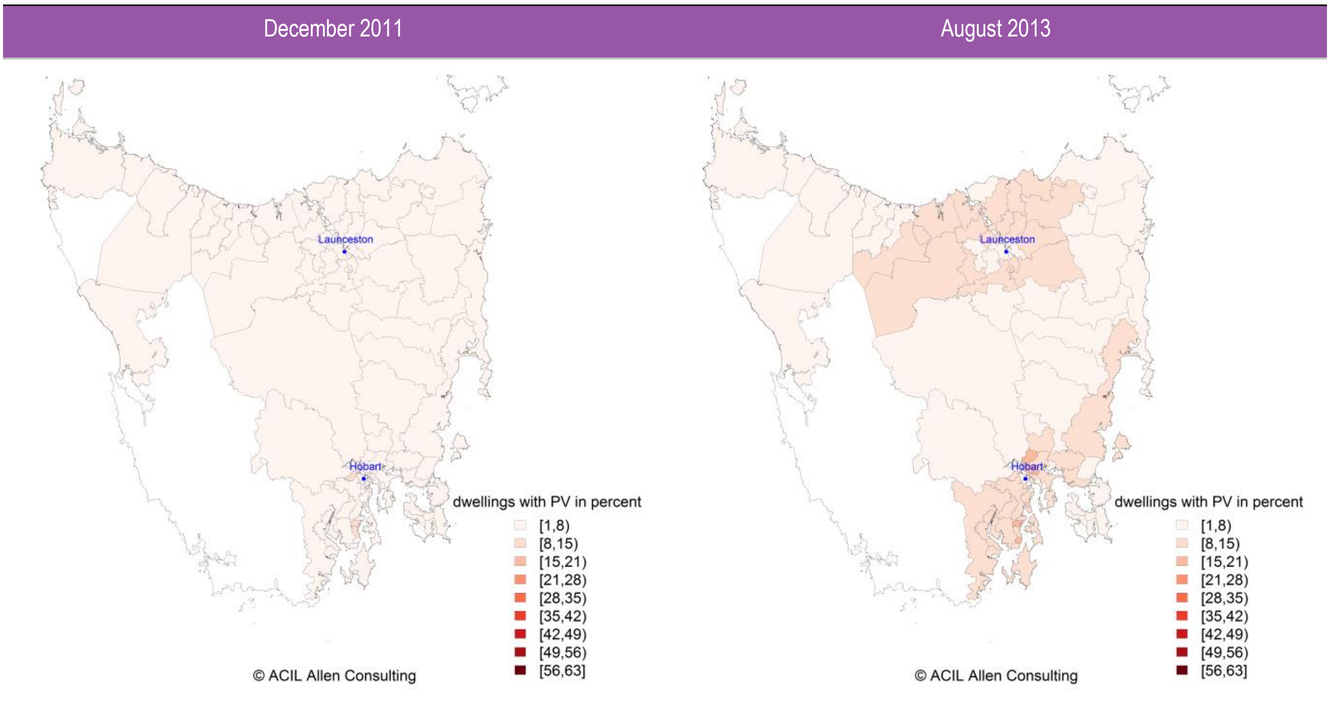
Figure 16 **PV uptake rates in South Australia**

December 2011	August 2013



Source: ACIL Allen analysis of ABS and CER data

Figure 17 **PV uptake rates in Tasmania**



Source: ACIL Allen analysis of ABS and CER data