# Small-scale Technology Certificates Data Modelling for 2012 to 2014

FINAL DRAFT REPORT

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# 1. Abbreviations

| | |
|---|---|
| ACT | Australian Capital Territory |
| ARIMA | Autoregressive Integrated Moving Average |
| CPI | Consumer Price Index |
| CPRS | Carbon Pollution Reduction Scheme |
| DOGMMA | Distributed Generation Market Model of Australia |
| EPIA | European Photovoltaic Industry Association |
| FiT | Feed-in Tariff |
| HPWH | Heat Pump Water Heaters |
| kW | Kilowatt |
| kWh | Kilowatt hour |
| LRET | Large-scale Renewable Energy Target |
| NSW | New South Wales |
| ORER | Office of the Renewable Energy Regulator |
| PV | Photovoltaic |
| PVRP | Photovoltaic Rebate Program |
| REC | Renewable Energy Certificate |
| RET | Renewable Energy Target |
| SGU | Small Generation Unit |
| SHCP | Solar Home and Communities Plan |
| SKM MMA | Sinclair Knight Merz - McLennan Magasanik Associates, the strategic consulting group within Sinclair Knight Merz resulting from the merger with McLennan Magasanik Associates in 2010 |
| SRES | Small-scale Renewable Energy Scheme |
| STC | Small-scale Technology Certificate |
| SWH | Solar Water Heaters |

# 2. Executive Summary

This report has been prepared for the Office of the Renewable Energy Regulator (ORER) and presents SKM MMA's projections of the number of Small-scale Technology Certificates (STCs) expected to be created in the 2012, 2013 and 2014 calendar years.

Two modelling approaches were used to formulate the projections. The first approach used SKM MMA's DOGMMA model, which is a structural model of distributed and embedded generation for all of Australia. It determines the uptake of small-scale renewable technologies based on comparing the net cost of generation against the net cost of grid delivered power. The second approach was through the construction of a time series model, which would determine the uptake of renewable technologies based on trends in historical data, also having regard to the historical and projected evolution of the net cost of system installation.

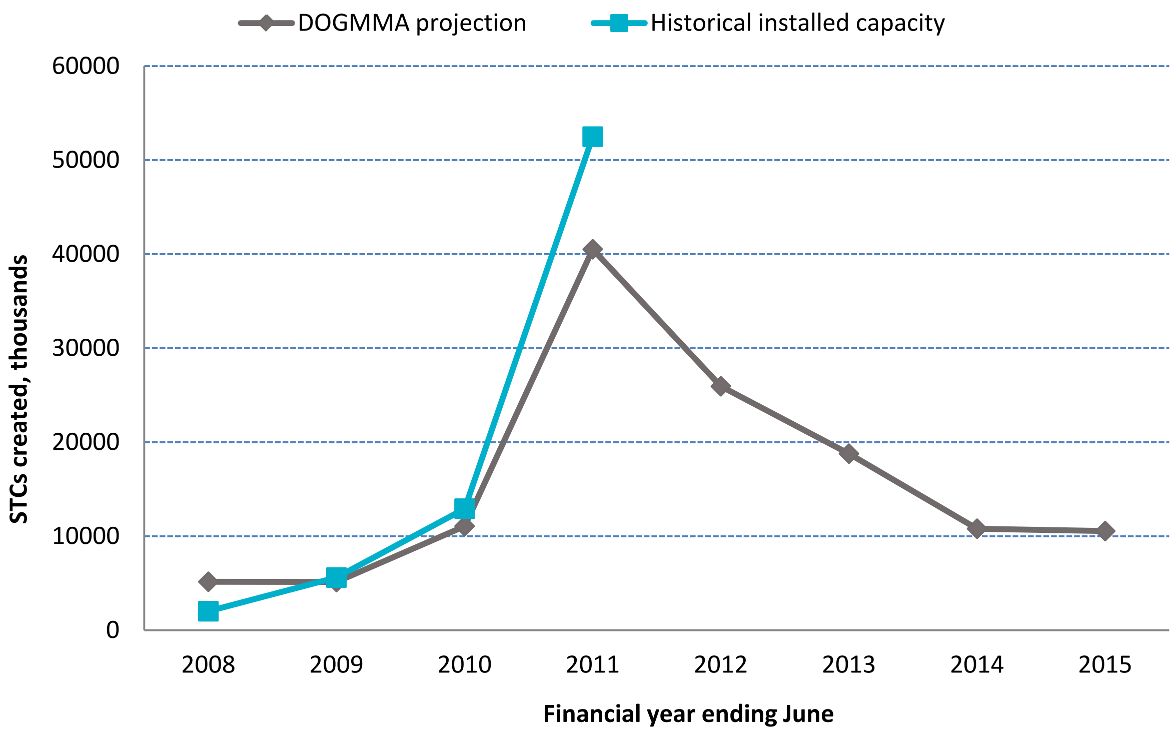
The time series modelling was conducted for two scenarios, a Base scenario and a Low scenario. This approach was adopted because the ORER confirmed that a seemingly consistent trend has emerged over the last six weeks, where PV uptake levels have fallen dramatically. There has not been any fundamental change in the market over that time frame, so it appears that this trend signals a change in consumer sentiment to PV, which may have been brought about by the cessation of feed-in tariff schemes in various states coupled with the reduction of the Solar Credits multiplier from 1 July 2011. The Base scenario assumes that consumer sentiment has not changed and projections are based around the current monthly trend. The Low scenario captures the potential impact of changing consumer sentiment, by reflecting the recent trends of reduced uptake. The Low scenario adjusts for this changing sentiment by lowering the starting point of the projection, thus better aligning it with the most recent uptake levels.

Analysis of the dataset provided by ORER detailing the historical creation of all STCs by small-scale technologies revealed that the majority of STCs were created by PV systems, solar water heaters (SWHs) and heat pump water heaters. STC projections from small-scale wind and hydro systems were therefore not considered in the analysis since they constitute a small fraction of the total.

Exec Figure- 1 shows the projection of PV uptake capacity across Australia derived from the DOGMMA model, and also includes the results of the calibration over the last three years. The fit of the model to the historical data is quite good, although 2010/11 has been underestimated. This has arisen because DOGMMA could not predict the extraordinary 'rushed buying' of PV systems that occurred in NSW and the ACT in 2010/11 when the feed-in tariff schemes for PV were announced to end in both of those markets.

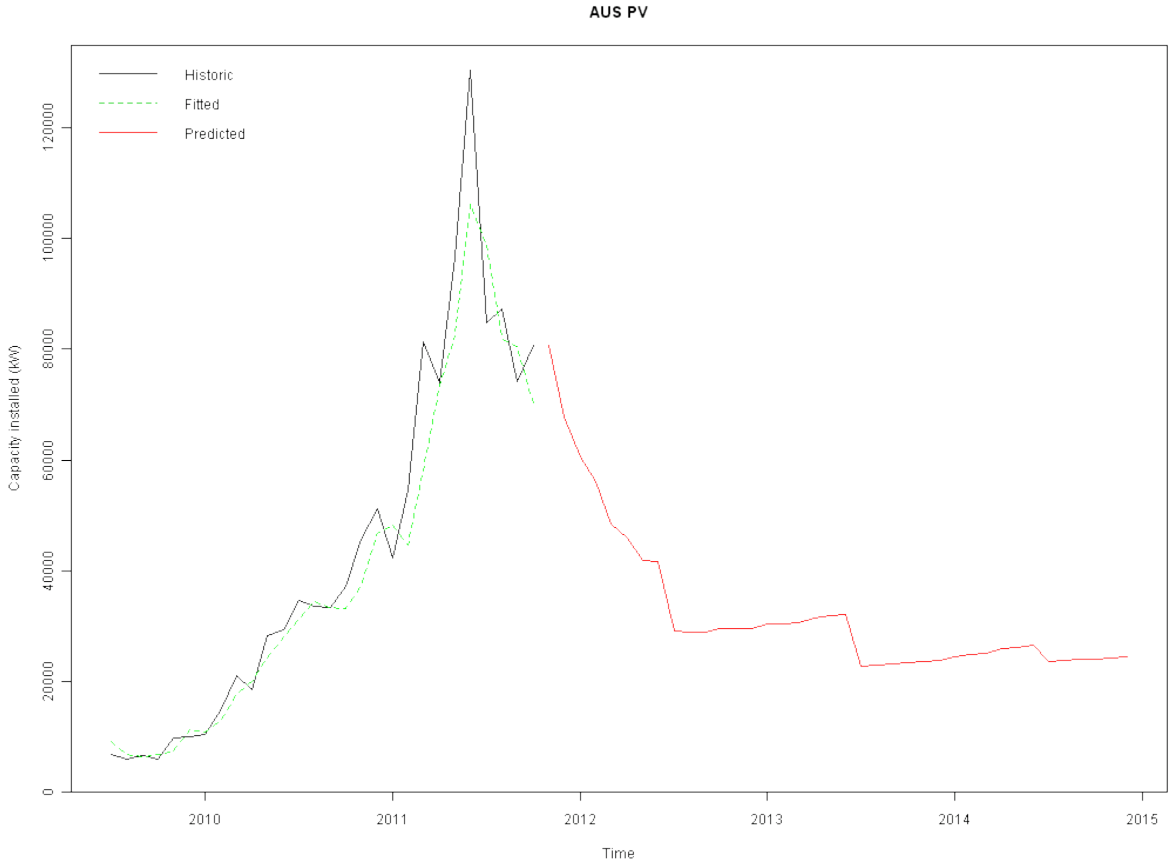
Looking forward, DOGMMA predicts a reduction in the number of STCs created, which is driven by the progressive reduction in the Solar Credits multiplier, and the ending of the PV feed-in tariffs in most states. Certificate production is projected to stabilise in 2014/15, which is the first year in which the multiplier no longer reduces.

Exec Figure- 1 PV uptake capacity for Australia using DOGMMA




Exec Figure- 2 shows the projection of monthly PV uptake capacity across Australia for the Base scenario derived from the time series model. The solid black line on the left is the historical monthly PV capacity uptake, and the solid red line on the right is the projection. The green dotted line is the time series model's fit to the historical uptake capacity, which appears to be quite good. According to the time series model, the monthly PV uptake has already peaked and the model is projecting decreasing PV uptake over the next three years. The stark jumps evident in the monthly projections occur every July from July 2012 onwards. These are driven by the monthly PV net cost projection, and reflect the steps down in the Solar Credits multiplier. The positive slope in between these steps reflects a gradual lowering of costs through the assumed decline in PV capital costs and through an increase in the avoided costs of electricity, which is driven by rising wholesale and retail costs.

■ Exec Figure- 2 PV uptake capacity for Australia using time series model – Base scenario

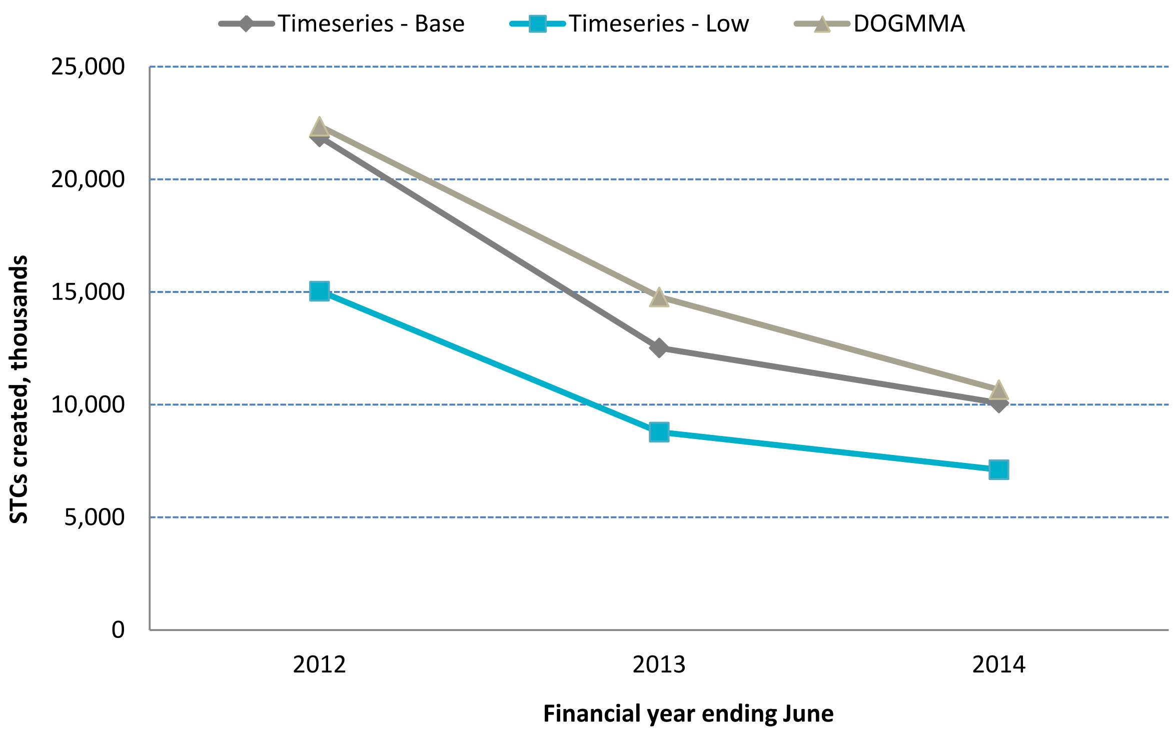



Exec Table- 1 shows the projected number of STCs from the time series modelling for the Base and Low scenarios, as well as the results from DOGMMA. These results are also presented visually in Exec Figure- 3.

■ Exec Table- 1 Summary of projected STC creation

| | 2012 | 2013 | 2014 |
|---|---|---|---|
| Time series - Base | 21,886,000 | 12,523,000 | 10,076,000 |
| Time series – Low | 15,041,000 | 8,786,000 | 7,116,000 |
| DOGMMA – Base | 22,362,000 | 14,785,000 | 10,671,000 |

Exec Figure- 3 STC projections using both methodologies




The time series based STC projection is almost 20% lower than that produced by the DOGMMA model in 2013, although the difference in projections for 2012 and 2014 are much lower. The Low scenario which assumes that the subdued consumer sentiment towards PV, persists over the next three years, are lower by a range of 30%-40% compared to the Base scenario projections.

The reduction of STCs produced in 2013 relative to 2012 is due to the reduction in the Solar Credits multiplier and the projected decline in installed capacity across all states. STCs sourced from water heaters are projected to make up from 14% to 30% of total number of certificates produced for the next three calendar years for the Base scenario, and 22% to 43% for the Low scenario.

In providing these projections of STC volumes over the 2012, 2013 and 2014 calendar years, SKM MMA would like to underline the large level of uncertainty surrounding them. This is evident in the variation of the projections between the Base and Low scenarios, which are essentially differentiated by just six weeks of additional uptake data. The fundamental source of the uncertainty underlying the PV uptake predictions is the lack of market history at the current level of net installation cost, particularly resulting from large changes in Government incentives and rapidly declining capital costs of PV systems in recent times.

SKM MMA has more confidence in the STC volume projections for water heaters produced by both models. The time series model in particular used almost six years of market history to make the predictions. However, these projections only form 14% to 30% of the annual number of STCs expected to be created over the next three years for the Base scenario, and therefore have a smaller weighting than the PV projections.

# 3. Background

The Department of Climate Change and Energy Efficiency through the Office of the Renewable Energy Regulator (ORER) is responsible for the implementation of the Australian Government's Renewable Energy Target (RET). The specific aim of the target is to assist the government with its commitment to achieving 20 percent of its electricity supply from renewable sources by 2020.

The RET legislation places a legal liability on wholesale purchasers of electricity to contribute towards the government's yearly targets. Wholesale purchasers meet this requirement by surrendering eligible certificates. A certificate is generally equivalent to 1MWh of renewable electricity and wholesale purchasers may create certificates through their own power stations or purchase them from the market.

Since the start of the RET, the government has announced a change which has seen the RET scheme split into two parts; the Small-Scale Renewable Energy Scheme (SRES) and the Large-Scale Renewable Energy Target (LRET). These schemes became effective on the 1st January 2011.

The SRES scheme offers small-scale technology certificates (STCs) at a fixed price of $40 per certificate to purchasers of eligible solar water heaters (SWH), air source heat pump water heaters (HPWH) and small-scale photovoltaic (PV), wind and hydro systems. There is no cap to the number of STCs that can be created, which means that liable entities, through whom the scheme is funded, could potentially have significant costs to cover if there is a large uptake of these technologies.

The purpose of this report is to forecast the number of STCs that will be generated in the calendar years of 2012, 2013 and 2014. This will assist liable entities to anticipate the extent of their liability over the coming years.

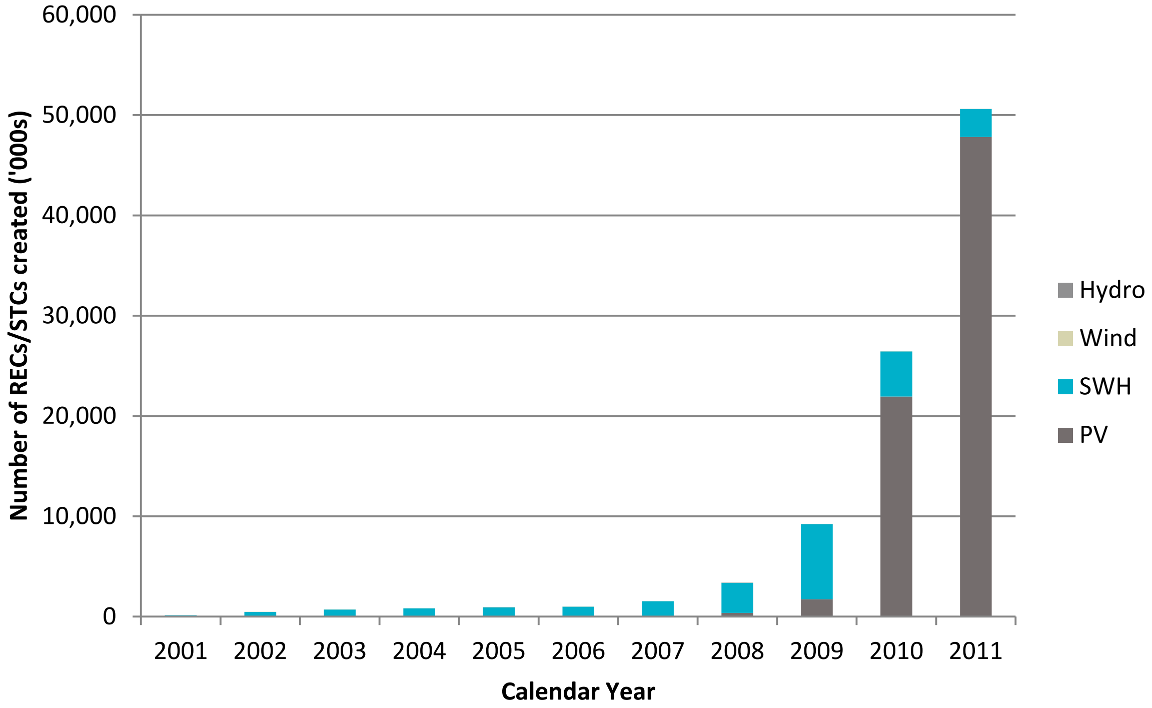
The number of RECs and STCs created historically by each of the small-scale technologies is shown on an annual time scale in Figure 3-1. REC creation was historically dominated by solar water heater (SWH) installations, although this changed in 2010, where photovoltaic systems are now making the largest contribution, and continue to contribute the greatest proportion of STCs created.

The two stand-out trends are: (i) the large volume of SWH RECs created in 2009, which was one factor responsible for the fall of the spot REC price at the time; and (ii) the even larger volume of photovoltaic STCs created in 2010 and thus far in 2011. The large increase in SWH RECs was driven by a change in the incentives offered to home owners by means of the Solar Hot Water Rebate, which commenced from 1 July 2009 and ended on 19 February 2010. This offered a rebate of up to $1600 to eligible householders for installing a SWH that replaced an electric hot water storage system.

From 2010 onwards, PV became the dominant small-scale renewable technology, and installations grew at an exponential rate. There are a number of factors explaining the rapid uptake of PV systems over the last two years. Firstly, the installed cost of PV systems plummeted in 2009 and 2010. Over about one year, the cost of these systems halved. At the same time, their affordability was aided by the rising Australian dollar, and the government incentives that were offered.

Secondly, the Federal Government's Photovoltaic Rebate Program (PVRP) increased from $4000 to $8000 as of November 2007, and this was followed by the subsequent issuance of Solar Credits for SGUs under the expanded RET scheme, from 9 September 2009 (superseding the PVRP). Thirdly, various state governments introduced feed-in tariffs (FiTs). Queensland was the first, offering a net FiT of 44 c/kWh in July 2008, and WA was the last, offering a net FiT of 40c/kWh in August 2010. The popularity of these schemes was evident in the fact that they were fully subscribed in a short period of time. The price level of the FiTs were subsequently cut in NSW and the ACT, and the WA scheme was closed to new applications from 1 August 2011.

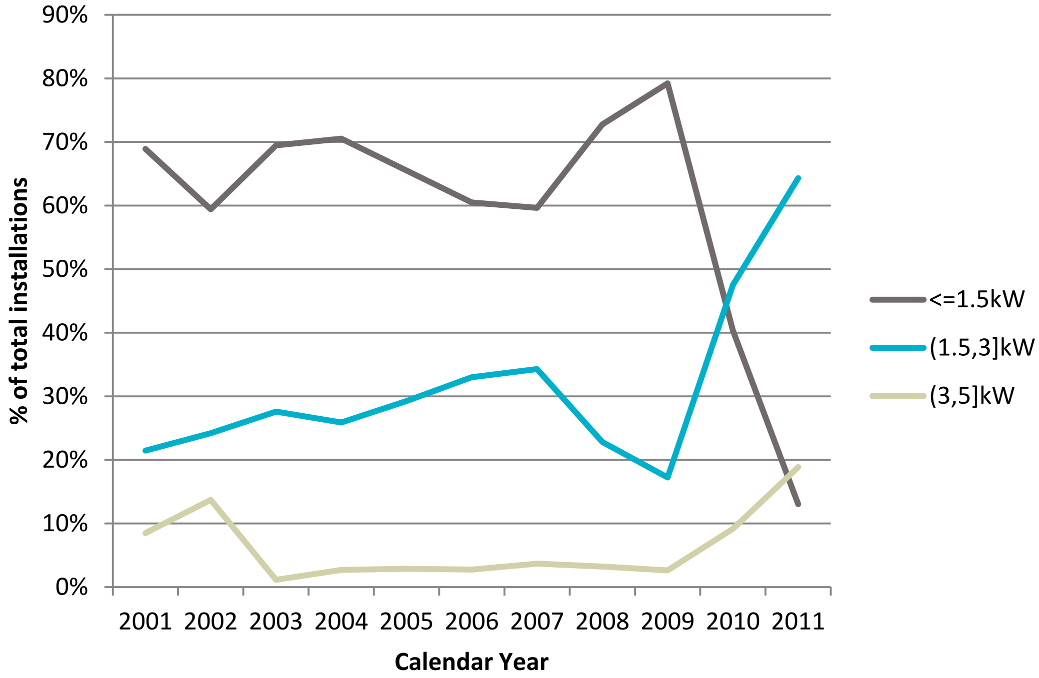
■ Figure 3-1 RECs/STCs created historically from small-scale technologies – Calendar years




The proportion of different PV system sizes being installed in the market is shown in Figure 3-2. The graph shows an increasing proportion of installation of system sizes of 1.5kW or less between 2008 and 2009, whereas from 2010 onwards there is a rapid decline in the installation of small PV systems[1]. This change in trend from 2010 onwards is mirrored by an increase in the proportion of system sizes between 1.5kW and 3kW, and a gradually increasing proportion of sizes 3kW to 5kW.

[1] As at November 2011.

Figure 3-2 Proportion of system sizes installed




The sharp increase in the proportion of 1.5kW system between 2008 and 2009 is likely reflective of the introduction of the 5x solar credits multiplier in 2009. The declining proportion of smaller system sizes since then is assumed to have occurred for a number of reasons:

- The solar credits multiplier is likely to have increased the affordability of larger systems, since the multiplier still applies to the first 1.5kW (the fact that the multiplier reduces over time is likely to have induced additional demand for PV prior to 2013);
- Uncertainty surrounding the impact of the carbon tax on retail electricity prices is likely to have induced ‘rushed buying’ of larger systems to offset the expected increase in electricity charges through avoided costs of future electricity consumption. This trend is expected to continue but at a relatively slower rate until 2014, with systems between 1.5kW and 3kW projected to reach approximately 80 percent of total annual installations; and
- Changes in FiT schemes in some states from a gross scheme to a net scheme, stimulating demand for larger systems to generate more electricity for export to the grid.

The remainder of this report has been set out as follows:

- **Government incentives:** A discussion of federal and state incentives and FiTs that may influence a users’ decision to take up small-scale renewable technologies, and which form underlying assumptions for net cost calculations in the modelling
- **Methodology:** Presents the key modelling assumptions and the methodologies underlying both SKM MMA’s DOGMMA model and the time series model utilised in this assignment; and
- **Modelling results:** Presents the results of the modelling using both models and then translates these into projected STC volumes for the 2012, 2013 and 2014 calendar years.

# 4. Government incentives

The number of STCs that will be generated in 2012, 2013 and 2014 is dependent on individuals' and households' uptake of eligible technologies which is in turn influenced by financial incentives such as federal and state rebates and the state-based FiT schemes.

Additional factors impacting the perceived cost or net cost of renewable technologies including the avoided cost of electricity consumed are discussed in Section 5.3.3.

## 4.1. Rebates

In order to address the high up-front cost of installation and encourage individuals and household to adopt renewable technologies, Australian governments have initiated a number of Federal and State rebates. This section provides an overview of historical rebates pertaining to solar PVs, SWHs and HPWHs as well as current incentives for installers.

The Australian Government through the Department of Climate Change and Energy Efficiency launched the Photovoltaic Rebate Program (PVRP) in 2000 where individuals and households, regardless of income received a rebate of $4,000 for installing solar PVs. In October 2007 the program was replaced by the Solar Home and Communities Plan (SHCP). This plan assisted with the installation of more than 100,000 systems and since then it has been replaced by the Solar Credits program.

In addition to the solar PV rebates, the Australian Government also provided support to individuals and households through the solar hot water rebate program. The program offered $1,600 and $1,000 in rebates for solar water heaters and heat pump water heaters respectively. The program has since been replaced by the Renewable Energy Bonus Scheme.

In addition to the federal rebates, a number of state initiatives also provide assistance.

- Table 4-1 provides a summary of Federal rebates; and
- Table 4-2 provides a summary of solar water heater and heat pump water heater rebates by state.

Table 4-1 Historical rebates offered by the Federal Government

| Historical | | |
|---|---|---|
| **System** | **Information** | **Description** |
| Solar PVs | **Name:** Photovoltaic Rebate Program (PVRP)<br>**Valid:** From 2000 to October 2007 | A rebate of $4,000 and not subjected to a means test. |
| | **Name:** Solar Homes and Communities Plan (SHCP)<br>**Valid:** November 2007 to 6 July 2009 | The SHCP started out as the PVRP and provided support to households through a solar panel rebate. For the greater part of the plan, it was subjected to a means test of $100,000 or less. The SHCP offered the following rebate:<br>▪ For new systems - Up to $8,000 ($8 per watt up to one kilowatt); and<br>▪ For extensions to old systems - Up to $5,000 ($5 per watt up to one kilowatt) |
| SWH | **Name:** Solar hot water rebate program<br>**Valid:** Until 19 February 2010 | A rebate of $1,600 and not subjected to a means test. |
| HPWH | **Name:** Solar hot water rebate program<br>**Valid:** Until 19 February 2010 | A rebate of $1,000 and not subjected to a means test. |
| **Current** | | |
| **System** | **Information** | **Description** |
| Solar PVs | **Name:** Solar credits<br>**Valid:** From 9 June 2009 to current | This scheme replaced the SHCP and the extent of the rebate is dependent on the size of the system and the date of installation.<br><br>A multiplier is applied to the first 1.5kW of eligible systems where the balance receives no multiplier. The multiplier will be gradually stepped down to reflect technological advances. The multipliers pertaining to each year are as follows: |

| Date Installed | 9 June 2009- 30 June 2011 | 1 July 2011 – 30 June 2012 | 1 July 2012 – 30 June 2013 | From 1 July 2013 onwards |
|---|---|---|---|---|
| Multiplier | 5 | 3 | 2 | No multiplier (1) |

| | | |
|---|---|---|
| SWH | **Name:** Renewable Energy Bonus Scheme - Solar hot water rebate program<br>**Valid:** From 20 February 2010 to current | A rebate of $1,000 and not subjected to a means test.<br>From 1 November 2011, only systems that are able to generate 20 or more STCs are eligible for the rebate. |
| HPWH | **Name:** Renewable energy bonus scheme - Solar hot water rebate program<br>**Valid:** From 20 February 2010 to current | A rebate of $600 and not subjected to a means test. From 1 November 2011, only systems that are able to generate 20 or more STCs are eligible for the rebate. |

■ Table 4-2 Summary of solar water heater and heat pump water heater rebates by State governments

| **Historical** | | |
|---|---|---|
| **State** | **Information** | **Description** |
| New South Wales | **Name:** NSW hot water system rebate<br>**Valid:** From October 2007 to 30 June 2011 | A rebate of $300 for a solar or heat pump hot water system |
| Northern Territory | **Name:** Solar hot water retrofit rebate<br>**Valid:** From 1 July 2009 to 30 June 2010 | Northern Territory households may be eligible for a Solar Hot Water Retrofit Rebate of up to $1,000 to help with the costs of installing a solar hot water system. |
| **Current** | | |
| Victoria | **Name:** Victorian solar hot water rebate<br>**Valid:** From July 2008 until 30 June 2012 | A rebate from $400 to $1600 and from $300 to $1500 for regional Victoria and metropolitan Melbourne respectively for both solar water heaters and heat pump water heaters. |
| Queensland | **Name:** Queensland government solar hot water rebate<br>**Valid:** From 13 April 2010 to current | ▪ A $600 rebate for the installation of a solar or heat pump hot water system; or<br>▪ A $1000 rebate for pensioners and low income earners who install a solar or heat pump hot water system. |
| Australian Capital Territory | **Name:** HEAT Energy Audit<br>**Valid:** From December 2004 to current | A $500 rebate is available for expenditure of $2,000 or more on the priority recommendations in the ACT Energy Wise audit report - which can include installing solar or heat pump water heating. |

| | | |
|---|---|---|
| Western Australia | **Name:** Solar water heater subsidy<br>**Valid:** From July 2010 to 30 June 2013 | ▪ A rebate of $500 for natural gas-boosted solar or heat pump water heaters; and<br>▪ A rebate of $700 for bottled LP gas-boosted solar or heat pump water heaters used in areas without reticulated gas. |
| South Australia | **Name:** South Australian Government's Solar Hot Water Rebate scheme<br>**Valid:** From 1 July 2008 to current | A rebate of $500 for a new solar or electric heat pump water heater system. In order to be considered for this rebate, applicants must hold at least one of the following Australian government concession cards:<br>▪ Centrelink Health Care Card;<br>▪ Centrelink or Department of Veterans' Affairs Pensioner Concession Card;<br>▪ Department of Veterans' Affairs Gold Card - Totally and Permanently Incapacitated;<br>▪ Department of Veterans' Affairs Gold Card - War Widow; and<br>▪ Department of Veterans' Affairs - Extreme Disablement Adjustment. |
| Tasmania | **Name:** Solar and Heat Pump Hot Water Rebate Scheme<br>**Valid:** 1 July 2007 to 31 December 2011 (solar hot water systems)<br>**Valid:** 1 November 2008 to 31 December 2011 (heat pump water systems) | This scheme offers Hobart ratepayers a $500 incentive to install a solar or heat pump hot water system into their homes. |

Where a range of possible rebates were available, SKM MMA generally assumed a rebate at the lower range of the scale. No rebate was assumed to apply for a typical SWH or HPWH installer in South Australia since the rebates in that state are only available to low-income earners.

## 4.2. Feed-in tariff

Feed-in tariffs in Australia for small-scale renewable energy generation are offered by the state governments. Table 4-3 presents a summary of the FiTs offered by state. For states where Government schemes are due to cease prior to the end of the forecast period, SKM MMA has assumed a default FiT of 7c/kWh[2].

[2] This represents the average FiT payment currently offered by the large electricity retailers over and above the state based FiT.

▪ Table 4-3 Summary of feed-in tariffs

| State | Description |
|---|---|
| Victoria | Net feed-in tariff of 60c/kWh commenced in November 2009 and ended in 30 September 2011. A net transitional feed-in tariff of 25c/kWh is planned to replace this and is expected to be available from 1 January 2012, additionally only systems up to 5kW in size are eligible. |
| New South Wales | Gross feed-in tariff of 60 c/kWh commenced in January 2010. The feed-in tariff was reduced to 20 c/kWh in 27 October 2010 and has since closed to new applicants as of 28 April 2011. |
| Queensland | Net feed-in tariff of 44 c/kWh commenced in July 2008. As of 8 June 2011, only systems up to 5kW in size are eligible. |
| Northern Territory | All PV-generated electricity receives the retail marginal cost of 19.77 c/kWh, which effectively makes this a gross feed-in tariff.<br>Customers on the Alice Springs grid receive 52.08 c/kWh for all PV-generated electricity through the Alice City Solar Program. |
| Australia Capital Territory | Gross feed-in tariff of 50.5 c/kWh commenced in March 2009. The scheme was revised in April 2010, and the feed-in tariff was reduced to 45.7 c/kWh. This revised scheme ended on 31 May 2011.<br>On 1 July 2011, small scale units were allowed to receive credits under the medium scale program. This scheme commenced on 12 July 2011 for a rate of 30.16/kWh.<br>Due to overwhelming demand, the available cap was quickly taken up and the scheme closed the day after on 13 July 2011. |
| Western Australia | Net feed-in tariff of 40 c/kWh commenced from August 2010. As of August 2011 the scheme was closed to new applicants. |
| South Australia | Net feed-in tariff of 44 c/kWh commenced in July 2008. The scheme was revised on 1 October 2011, and the feed-in tariff was reduced to 16 c/kWh. This will be available until the 30 September 2013. |
| Tasmania | Net feed-in tariff of 20c/kWh, which is administered by Aurora Energy and is called the Net Metering Buyback Scheme. Households need to be Aurora Energy customers to be eligible. |

# 5. Methodology

## 5.1. General methodology

The forecast of STC creation for calendar years 2012, 2013 and 2014 has been undertaken using SKM MMA's structural model of distributed and embedded generation (called DOGMMA), as well as a time series model. The structural model determines the uptake of small-scale renewable technologies based on comparing the net cost of generation against the net cost of grid delivered power. The time series model determines the uptake of renewable technologies based on trends in historical data, also having regard to the historical and projected evolution of the net cost of installation.

The factors considered in both models are as follows:

- State and Commonwealth incentive schemes influencing uptake, such as the applicable state-based feed-in tariff for generating units, the Renewable Energy Bonus Scheme, any other rebates that may be on offer;
- Impact of the Solar Credits multiplier and/or the 1.5kW PV threshold to which the multiplier is applied;
- Impact of June 2010 RET legislative changes to eligibility;
- Impact of building codes, regulations and energy efficiency measures;
- Capital cost trends of eligible systems for each renewable technology, due to new technological and manufacturing improvements; and
- Global financial conditions and changes to cost of raw materials.

## 5.2. Historical data set supplied by ORER

ORER supplied a comprehensive historical data set of small-scale renewable generation installations as well as installation of solar water heaters and heat pump water heaters. There were over 610,000 records in the SGU dataset, with the data spanning 2001 until October 2011[3]. The information supplied included:

- date of installation;
- date of REC/STC registration;
- post code of installation address;
- state of installation address;
- technology type (PV, wind or hydro);
- capacity of the system;
- number of RECs/STCs registered by the system;
- number of RECs/STCs that passed/failed the validation audit

The data showed that the number of STCs created by small-scale PV systems was significantly greater than STCs produced by small-scale wind and hydro. As such, certificate

[3] Data from part of November 2011 was also supplied.

projections for small-scale wind and hydro will not be carried out as their contribution to the total would be negligible.

The dataset comprising SWHs and HPWHs contained over 714,000 records covering the same time span as the SGU dataset. Supplied information included:

- date of installation;
- date of STC registration;
- post code of installation address;
- state of installation address;
- technology type (SWH or HPWH);
- number of STCs registered by the system; and
- whether the system capacity was over 700 litres.

These data were primarily used to construct the historical time series data, thus enabling the utilisation of time series analysis. The SGU capacity data were also summarised in a form to allow the calibration of the DOGMMA model.

## 5.3. General assumptions

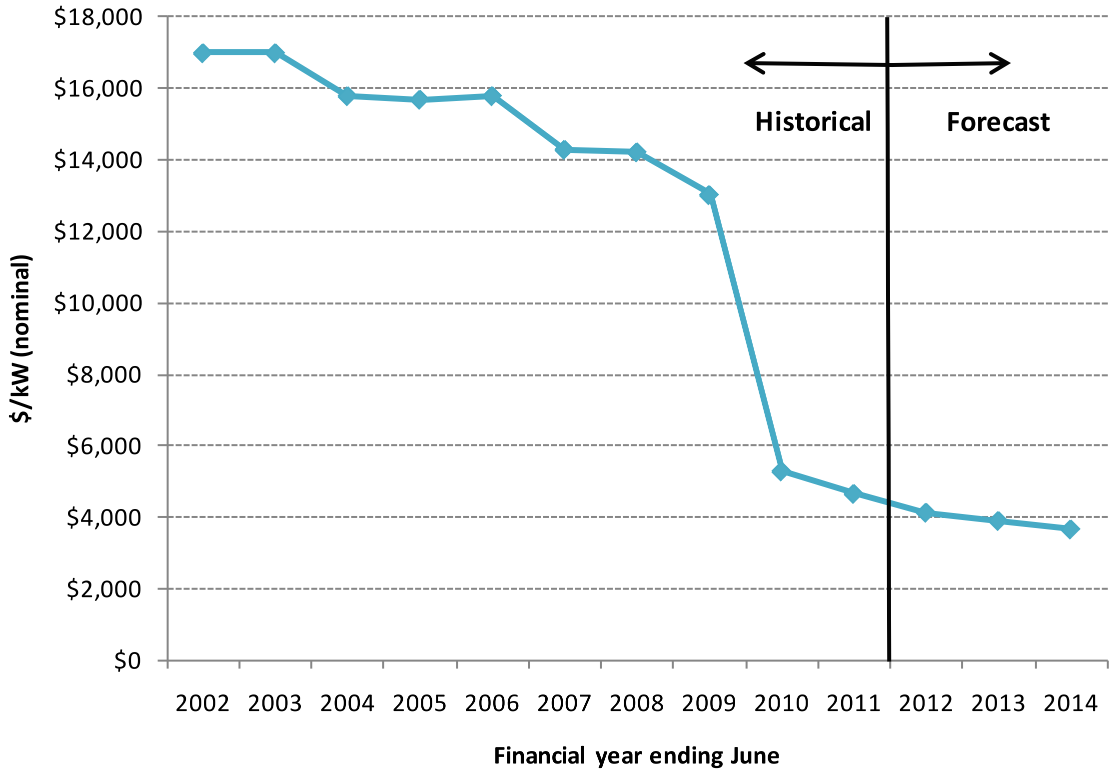
The following section presents our key modelling assumptions. Capital cost assumptions for 2011 are based on market research conducted by SKM MMA for a range of suppliers across Australia, and represents an average cost per kW including installation and before any Government rebates or credits.

### 5.3.1. Capital cost assumptions for solar PVs

Figure 5-1 shows the assumed capital costs for an installed PV system in nominal dollars. This was converted into real dollars for the modelling using historical CPI and assuming CPI of 2.5% p.a. for projections. The most notable feature of the graph is the significant reduction in the capital cost which occurred during the 2009/10 financial year. Capital cost is assumed to further decline at a rate of 7 percent in real terms between 2011 and 2014, based on projections from the EPIA for an advanced scenario which foresees the ability to deploy PV faster in line with market developments, and can be interpreted as a continuation of current support measures[4]. The DOGMMA model also incorporates a decreasing capital cost as the system size increases, reflecting certain available economies of scale. These cost assumptions are further described in Appendix A.

[4] Source: Hearps, P. and McConnell, D. reviewed by Sandiford M. and Dargaville, R. (2011) Renewable Energy Technology Cost Review, Energy Research Institute, The University of Melbourne.

▪ Figure 5-1 Capital costs assumed for solar PVs – ($ nominal/kW)



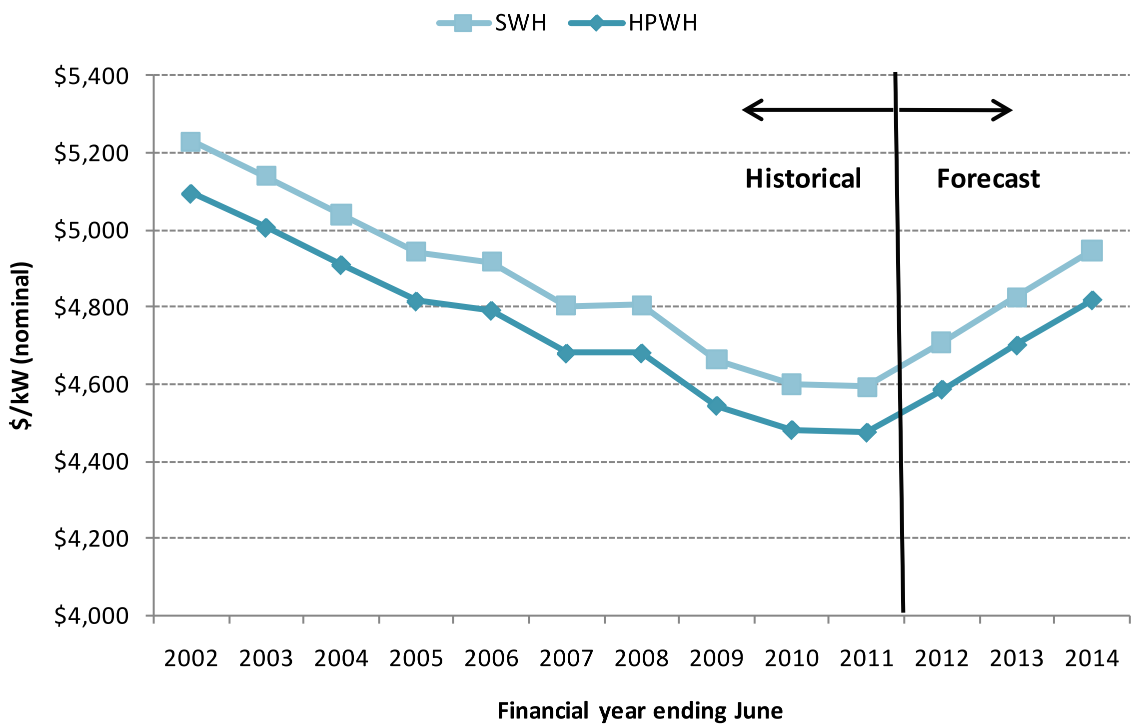

Source: SKM MMA market analysis with historical prices based on AECOM report to Industry and Investment NSW, *Solar Bonus Scheme: Forecast NSW PV Capacity and Tariff Payments*, October 2010

## 5.3.2. Capital cost assumptions for solar water heaters and heat pump water heaters

Figure 5-2 shows the assumed capital costs for solar water heaters and heat pump water heaters in nominal dollars for a typical domestic unit[5]. Capital cost is assumed to remain constant in real terms between 2011 and 2014 which is reflective of the relatively mature technologies compared with PV systems.

[5] With a capacity of 315 litres

■ Figure 5-2 Capital costs assumed for typical domestic SWH and HPWH unit – (nominal dollars)




## 5.3.3. Net cost model

The net cost for SGUs, SWHs and HPWHs is a key variable in explaining the uptake of these systems for the time series and analysis, and was central to the uptake forecasts using the time series model. It also drives the output of the DOGMMA model, which is a forward looking optimisation model that seeks to minimise total energy supply costs. The net cost is defined as follows:

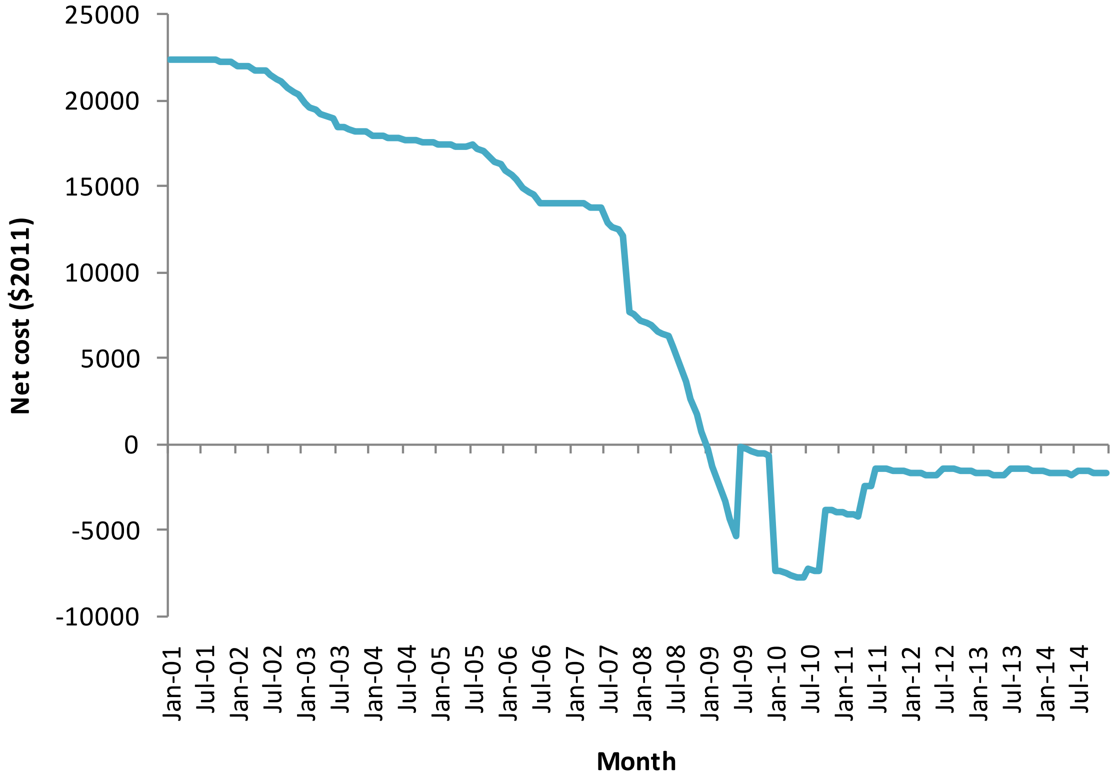
- Sum of capital cost including installation
- Less
  - Value of any available government rebates
  - Revenue from the sale of RECs[6] and/or STCs, including the effect of the Solar Credits multiplier
  - Net present value of future feed-in tariff payments
  - Net present value of the avoided cost of electricity

## 5.3.4. Net cost for PV

Figure 5-3 shows the net cost for a 1.5 kW PV system installed in NSW. Movements in the net cost are representative of trends in all Australian States and Territories, although these may occur at different time periods as they are dependent on the timing of the various schemes and rebates applicable to PV systems.

[6] Prior to 2011

■ Figure 5-3 Net cost for typical PV system installed in NSW




The net cost represents the cost of a 1.5kW system, however it is based on a net cost per kW which incorporates the increasing trend of systems installed with size greater than 1.5kW (see Figure 3-2). As such, net cost assumptions including the solar credits multiplier and estimated FiT revenue have been adjusted to reflect the proportion of systems greater than 1.5kW.

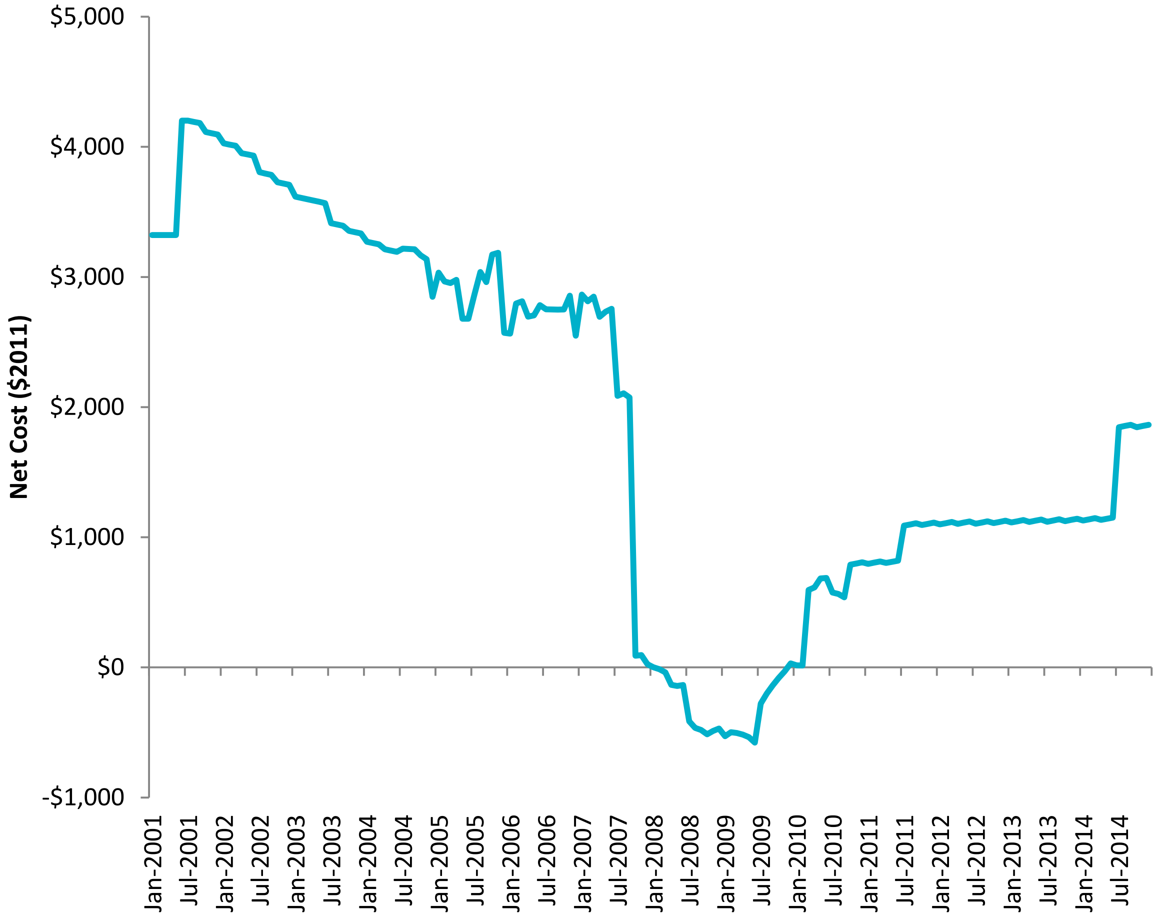
The historical net cost reduces gradually from 2001 until 2007, and then there is a significant drop in the net cost in late 2007, which corresponds to the increase in the Federal government's PVRP rebate from $4,000 to $8,000. The sudden increase in net cost in mid 2009 represents the abolition of the PVRP rebate and its replacement by the Solar Credits multiplier. This is followed by another steep decline in the net cost, which reflects the rapid reduction in PV capital costs, and in the NSW context it also reflects the introduction of the gross feed-in tariff. The subsequent increase in late 2010 corresponds to the reduction in the NSW gross feed-in tariff from 60 c/kWh to 20c/kWh, and the subsequent closing of the scheme to new applicants on 28 April 2011. This is followed by a series of line segments with negative slope but these are interspersed with step increases in the net cost. The step changes reflect the progressive reduction of the Solar Credits multiplier, the last of which would occur in July 2013, when the multiplier is finally removed.

The negative slope is important and it persists beyond 2015, so that eventually net costs do exhibit a long-term downtrend. The two drivers underlying the decreasing long term cost trend are the decreasing capital cost (see Figure 5-1) and the increasing avoided cost of electricity, including the impact of the carbon price.

### 5.3.5. Net cost for water heaters

Figure 5-4 shows the net cost for a typical domestic SWH system installed in NSW, which is representative of the net cost trends in all Australian States and Territories. The historical net cost reduces gradually from 2001 until 2007, and then there is a significant drop in the net cost in late 2007, which corresponds to the introduction of the Federal government's solar hot water rebate program. The increase in the net cost in early 2010 corresponds to the reduction in the Federal government's SWH rebate from $1,600 to $1,000. From 2010 onwards, the net cost continues to exhibit an upward trend, which is reflective of the assumed flat projected capital cost and the cessation of the state-based rebate.

■ Figure 5-4 Net cost for typical domestic SWH installed in NSW




### 5.3.6. Wholesale electricity price assumptions

SKM MMA's base case wholesale electricity prices were used as the basis for estimating retail electricity prices, which in turn were used in calculating future electricity savings and/or revenues for SGUs, SWHs and HPWHs. The base case assumes medium economic growth, and includes the impact of carbon pricing.

## 5.4. Scenario assumptions

After examining the historical data for PV capacity installed, the ORER data indicate a reduced uptake in the capacity installed in some of the states for the last couple of weeks of October. SKM MMA sought further advice from the ORER and it was confirmed that this trend has continued at least until the end of November. This does not seem to coincide with any major change in the market and without further analysis can only be attributed to changing consumer sentiment with respect to the purchasing of PV.

This emerging trend was not fully captured by the time series model, which is a monthly model, since it only appears as a downward deviation of the last data point. Thus, this recent change in trend has not been fully captured in the data and could potentially affect the projections going forward.

In order to allow for this emerging issue, SKM MMA prepared the projections for PV from the time series model under two scenarios. The Base scenario assumes that consumer sentiment has not changed and the projection is based around the current monthly trend. The Low scenario adjusts for this sentiment by lowering the starting point of the projection (November 2011) based on the percentage change in the average uptake of the last two weeks of October 2011 compared to the average uptake of September 2011. The adjustment had to be made this way because there were not enough data points in November 2011 to capture this effect. Details are presented in Table 5-1.

▪ Table 5-1 Adjustment to PV uptake for November 2011 projection for Low scenario

| State | Adjustment | Comment |
|---|---|---|
| ACT | -83% of September 2011 | |
| New South Wales | -65% of September 2011 | |
| Northern Territory | No adjustment | The reduced uptake occurred at the start of October 2011, thus the reduction is already captured in the monthly data |
| Queensland | No adjustment | ORER advised that uptake has started to recover towards the September 2011 average |
| South Australia | No adjustment | ORER advised that uptake has started to recover towards the September 2011 average |
| Tasmania | -64% of September 2011 | |
| Victoria | -70% of September 2011 | |
| Western Australia | -62% of September 2011 | |

This scenario is not modelled in the structural model, DOGMMA, which is a longer term model that operates on a yearly basis. Additionally, since this change in trend seems to be driven by sentiment rather than fundamental market factors, the model is not likely to capture the variation.

## 5.5. Structural model

### 5.5.1. Overview of model

DOGMMA is a structural model that recognises that the uptake of renewable technologies is affected by a number of factors. It determines the uptake of renewable technologies based on net cost of generation versus net cost of grid delivered power. Because the cost of renewable generation varies by location and load factors, the model attempts to calculate uptake based on renewable resources and load levels within distribution regions. Other factors that may impact on the decision are modelled as a premium prepared to be paid for small scale renewable generation. The premium currently assumed is based on market survey data and other published market data. The premium is assumed to decrease as the rate of uptake increases (reflecting the fact that the willingness to pay will vary among customers).

The cost of small scale renewable energy technologies is treated as an annualised cost where the capital and installation cost of each component of a small scale generation system is annualised over the assumed lifespan of each component, discounted using an appropriate weighted average cost of capital. Revenues include sales of electricity using time weighted electricity prices on the wholesale and retail market (which may be affected by emissions trading), avoidance of network costs including upgrade costs if these can be captured, and revenues from other Government programs such as the Solar Credits multipliers and the SRES scheme.

### 5.5.2. DOGMMA Methodology

The model was calibrated to reasonably fit the historical time series data by state on a financial year basis. The parameters that were adjusted to facilitate the calibration included constraints on the uptake by state of any particular technology type and size (domestic or commercial) and also the assumed net export of electricity into the grid by state, technology type and size. Adjusting these parameters proved to be enough to obtain a reasonable fit for all states. The results of the calibration are presented alongside the model projections in section 6.1.

The uptake projection was based on SKM MMA's base case electricity market forecast, based on the Federal Treasury's Government Policy scenario[7]. The market scenario provided a forecast of the electricity market component of the small scale generation's revenue.

### 5.5.3. Key model assumptions

The key model assumptions for the DOGMMA model are provided in Appendix A. These include assumptions about SGU uptake constraints, SGU capital cost assumptions and other technical assumptions.

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[7] SKM MMA, *Carbon Pricing and Australia's Electricity Markets: Additional scenarios*; available at http://www.treasury.gov.au/carbonpricemodelling/content/consultantreports.asp

## 5.6. Time series model

### 5.6.1. Overview

A time series is a sequence of data points measured at different points in time, and its analysis comprises methods for extracting meaningful characteristics of the data (e.g. trend, seasonality, autocorrelation). Forecasting using time series techniques involves predicting future events based on a model of the data built upon known past events. Unlike other types of statistical regression analysis, a time series model accounts for the natural order of the observations and will reflect the fact that observations close together in time will generally be more closely related than observations further apart.

### 5.6.2. Data preparation

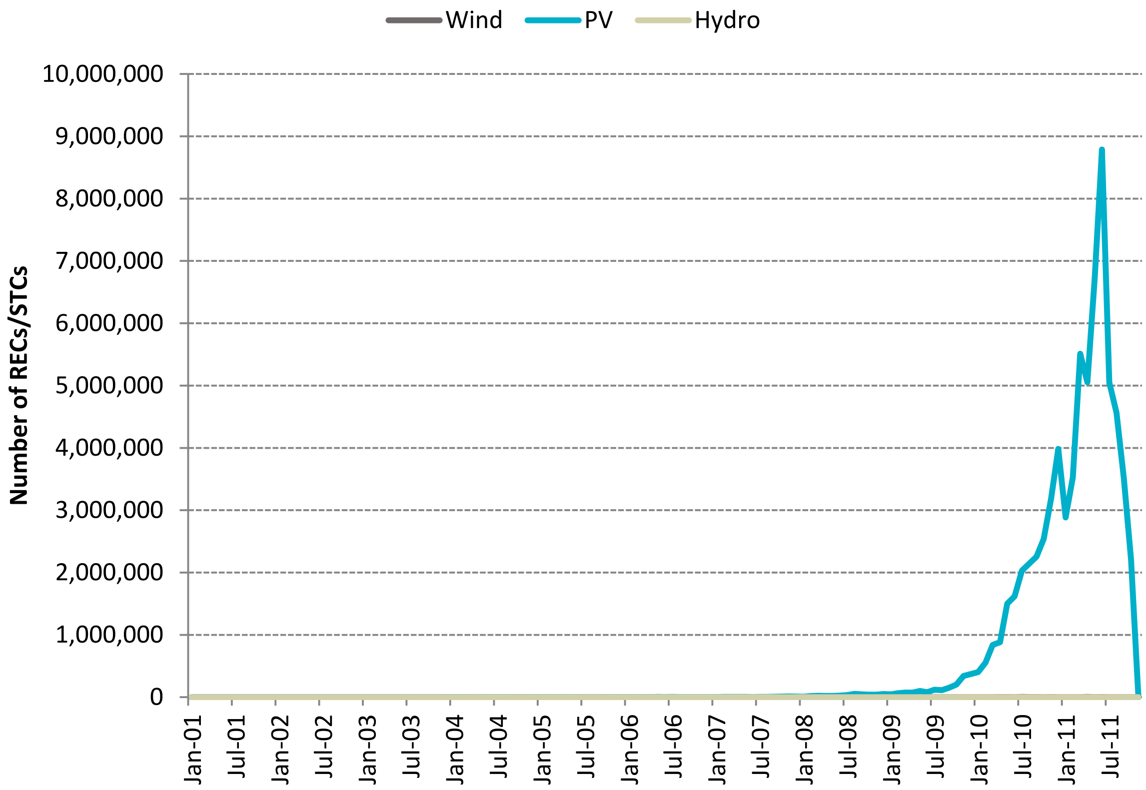
As detailed in Section 5.2, ORER provided SKM MMA with data on all SGU and water heater installations for Australia. For the purposes of the time series modelling, the data was processed and aggregated into monthly steps to create time series by technology for each state. It was important to separate the time series by state since each state has its own feed-in tariff arrangement, which is a critical component of the economics of installing an SGU. In the case of SWHs and HPWHs, the assumed STC creation cut-off point distinguishing a commercial system from a domestic system was refined throughout the modelling to achieve the best results (see section 5.6.4.4). The modelling for SWHs and HPWHs were not done on state level because it was found that this increased the error in the predictions.

All time series modelling was conducted in R, a programming language and software environment for statistical computing. Among many other features, R provides a wide variety of time-series analysis algorithms, and its programming language allows users to add additional functionality as needed.

### 5.6.3. Time series model for SGUs

Figure 5-5 shows the time series corresponding to the total number of RECs/STCs registered per month for the different SGU technologies. As previously noted, the RECs/STCs are largely dominated by PVs, with RECs/STCs registered by small wind and small hydro projects being several orders of magnitude smaller than PVs. The number of STCs generated by small wind and small hydro are expected to continue as insignificant relative to those generated by PVs, and therefore are neglected in the modelling.

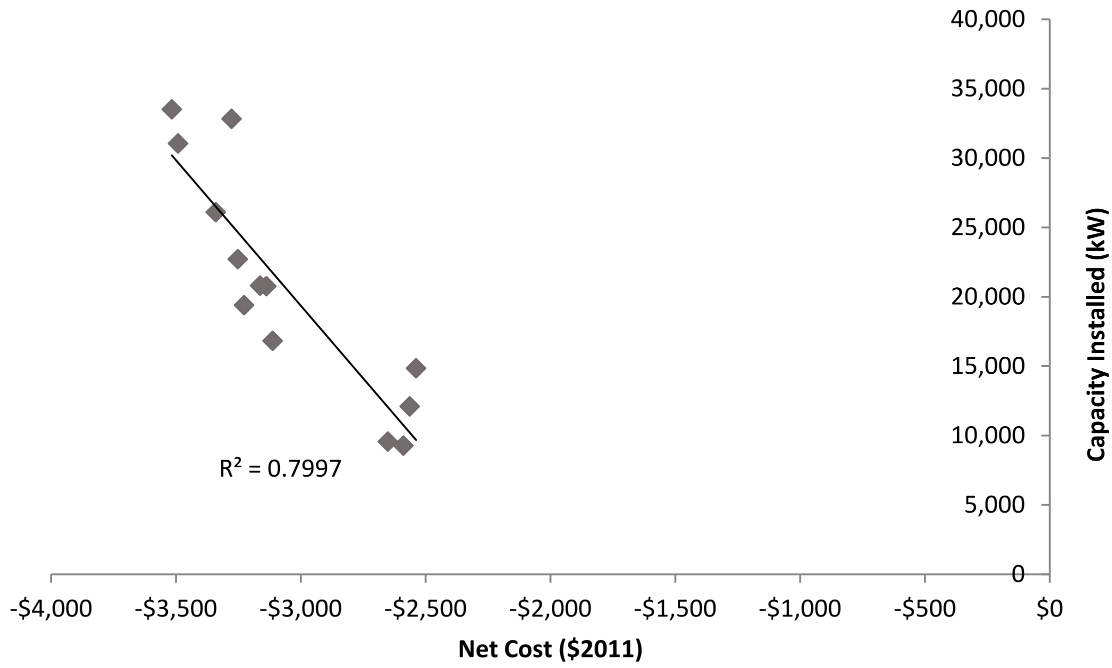
■ Figure 5-5 Number of RECs registered for SGUs




#### 5.6.3.1. Choosing the external regressor

One may reasonably assume that there is an inverse relationship between the uptake of PV technology and its cost. The estimated historical net cost for a new PV installation by state was therefore trialled as an external regressor to fit the obvious trend displayed by the installation data. Since the only purpose for the net cost was to act as an external regressor, the main point of interest was its shape and relativity to the costs for other states and technologies, rather than its absolute value. Figure 5-6 displays the relationship between capacity installed and net cost for NSW for the 12 month period from October 2010. Previous analysis has indicated that the net cost provides a better fit to the data than the upfront cost, which is intuitively reasonable since consumers would be expected to consider the whole-of-life costs in investment decisions.

■ Figure 5-6 PV installed capacity versus net cost for NSW




### 5.6.3.2. Choosing the dependent variable

Analysis previously conducted to determine the most appropriate way of aggregating the PV data to predict future uptake found that net cost was most strongly correlated to capacity installed, as opposed to the number of installations. Additionally, the use of installed capacity as the dependent variable avoids having to convert from number of installations to installed capacity. This would have required the prediction of the average installation size which, according to the historical data, is quite variable over time especially for the smaller states with the sparser datasets.

Given that the main determinant for forecasting future trends of certificates produced from PVs is the future cost, it is important for there to be a high correlation between capacity installed[8] and net cost.

#### 5.6.3.2.1. Limiting the amount of data points in the regression

As mentioned in Section 5.3, ORER provided historical data of PV installed capacity up to October 2011, which is an update to the data provided to the previous study[9]. SKM MMA has re-examined the relationship (through correlation and regression $R^2$) between net cost and PV installed capacity to ensure reasonable projections were produced.

Figure 5-7 shows the correlation between the net cost and the capacity installed between July 2009 (when the Solar Credit Multiplier started) and October 2011. It can be seen that

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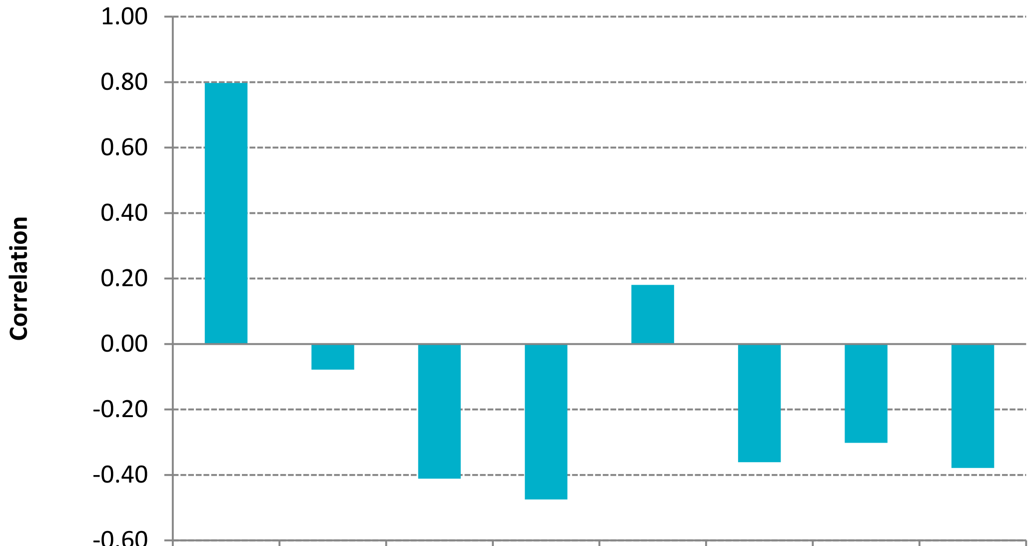
[8] Since the capacity installed determines the number of eligible STCs when accounting for incentive schemes such as the Solar Credits multiplier.

[9] SKM MMA, *Small-scale Technology Certificates Data Modelling for 2011 to 2013*; available at http://www.orer.gov.au/Forms-and-Publications/?retain=true&PagingModule=647&dfaction=search&dfname=&dfdtitle=stc%20modelling

the relationship between net cost and capacity installed are quite poor for each state and of special note is ACT and SA where the correlation has become positive.

Figure 5-7 Correlation between net cost and capacity installed, July 2009-October 2011

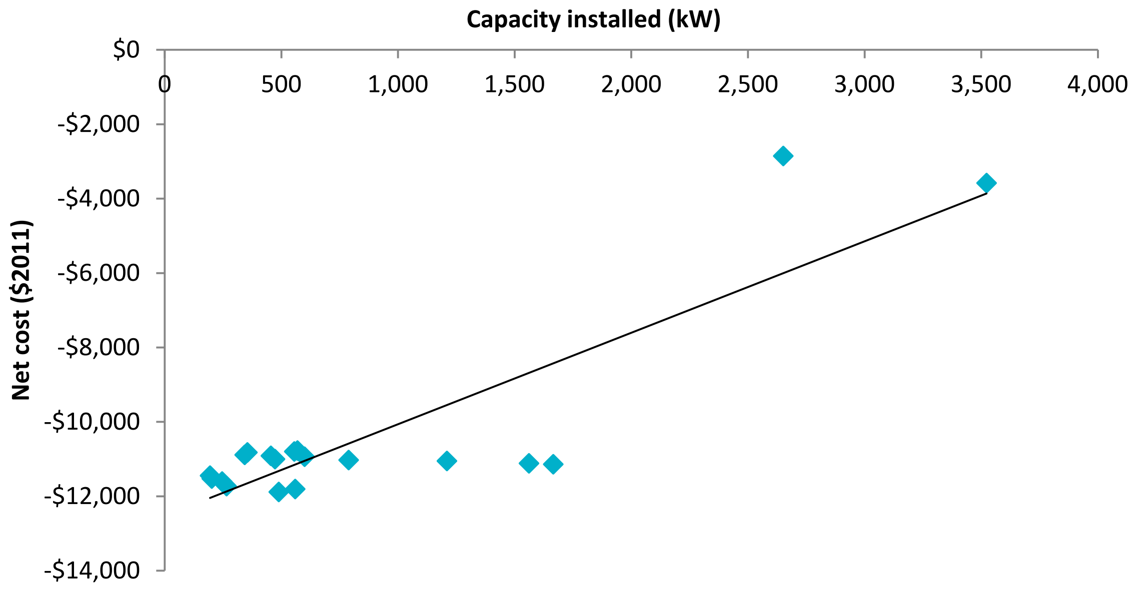



| | ACT | NSW | NT | QLD | SA | TAS | VIC | WA |
|---|---|---|---|---|---|---|---|---|
| Correlation | 0.80 | -0.08 | -0.41 | -0.47 | 0.18 | -0.36 | -0.30 | -0.38 |

For all states the main factor explaining the breakdown in correlation is the unexpected announcement of a change in the initially anticipated reduction to the Solar Credits multiplier. Originally the multiplier was planned to decrease from 5 to 4 in July 2011, however the multiplier was reduced to 3 from July 2011. The data indicates that this has resulted in some 'rushed' buying of PV systems to take advantage of the higher multiplier before the scheduled reduction in June 2011 (see Figure 5-5).

In the case of the ACT, where solar PV has been exceptionally popular, the relationship showed signs of breaking down in May 2010 due to an unexpected announcement that the feed-in tariff would be reduced. Following this, was an announcement that the feed-in tariff would end in May 2011. As a result of consumers rushing to obtain the rebate, it can be seen that in some instances PV capacity installed increased even when net cost had also increased. Figure 5-8 provides the relationship between net cost and capacity installed between January 2010 and July 2011, where this behaviour is evident.

Figure 5-8 Capacity installed versus net cost - ACT January 2010-July 2011




The subsequent low level of correlation across a number of states between net cost and uptake compromised the predictive value of the net cost as the external regressor. SKM MMA used the following approach to address this issue:

- It was assumed that the anomalously high demand leading up to July 2011 was driven by impending changes to the Solar Credits multiplier and the state feed-in tariffs, which created an atmosphere of 'rushed buying', where consumers made the decision to take up PV based on the fear of missing out on the maximum available subsidy. During this time, the relationship between uptake and net cost temporarily broke down, but now that the rushed buying has ceased, it should be valid again;
- The rushed buying will not be repeated in the forecast period because there is no trigger for it since the best subsidies that were on offer have now ceased;
- The time frame for performing the regression characterising the relationship between uptake and net cost has been limited for each state. The starting date is from July 2009, which corresponds with the introduction of the Solar Credits multiplier, but the end date is based on the time frame of the rushed buying, which is different for each state. These end dates are outlined in Table 5-2 below.

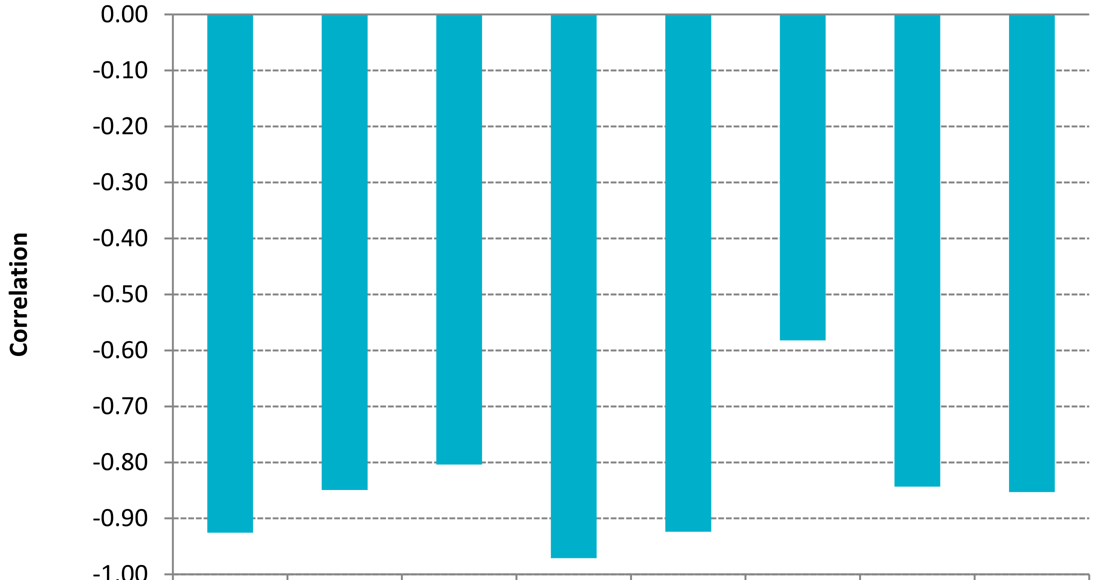
Table 5-2 End dates for regression

| State | Regression end dates |
|---|---|
| ACT | May 2010 |
| NSW | September 2010 |
| NT | December 2010 |
| QLD | November 2010 |
| SA | September 2010 |
| TAS | June 2011 |

| State | Regression end dates |
|---|---|
| VIC | February 2011 |
| WA | January 2011 |

The resulting correlation for each state is shown in Figure 5-9, which has significantly improved and shows strong correlation between net cost and capacity installed.

Figure 5-9 Correlation of net cost and installed capacity of PV excluding rushed buying periods




| | ACT | NSW | NT | QLD | SA | TAS | VIC | WA |
|---|---|---|---|---|---|---|---|---|
| Correlation | -0.93 | -0.85 | -0.80 | -0.97 | -0.92 | -0.58 | -0.84 | -0.85 |

### 5.6.3.3. Choosing the level of aggregation

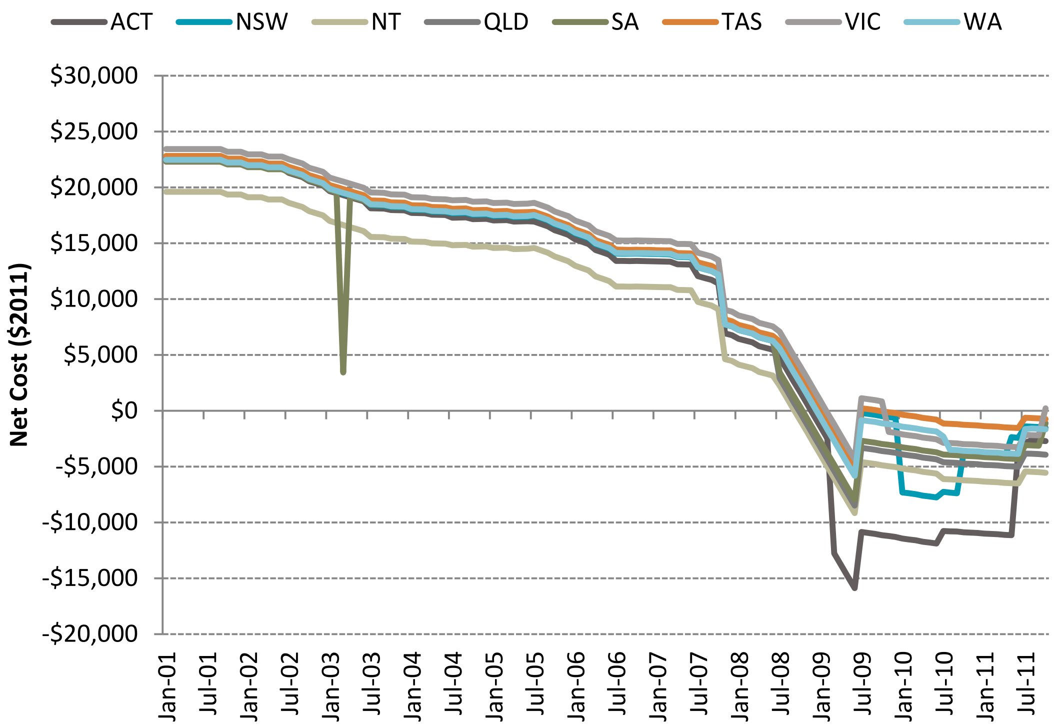
It was hypothesised that separating the PV data according to the 1.5 kW multiplier size limit may reduce the noisiness of the data since it was thought that the behaviour of the two groups (below 1.5 kW and above 1.5 kW) may be significantly different. Separate models were therefore trialled for small and large PV systems, but the disaggregation increased the variance of the respective time series and therefore prediction error also increased. The expected benefit of separately modelling the installations in this way was therefore not enough to compensate for the increased prediction error.

As previously noted, while the data were aggregated to reflect an average system size of 1.5kW, the average net cost is reflective of a changing trend towards a greater proportion of installed systems greater than 1.5kW. The predicted installed capacity was thus adjusted by the assumed proportion of system sizes when allocating installed capacity to the relevant solar credits multiplier.

### 5.6.3.4. Form of the time series model

The time series at the state level were clearly non-stationary, showing both a changing mean and changing variance over time (technically known as heteroskedasticity). However, the logarithm of the original time series was found to be stationary after the trend was removed. Analysing the logarithm of the time series revealed that it had no significant level of seasonality, and thus the data lent itself nicely to an ARIMA model accompanied with an external regressor.

■ Figure 5-10 Historical PV net cost by state




In summary, the time series analysis of the data for the SGUs was carried out by fitting univariate ARIMA models to the logarithm of the monthly PV installed capacity by state with the use of the net cost in each state as an external regressor. The historical PV net cost for small systems are is shown in Figure 5-10, and appears to be reducing gradually until 2007. The significant drop in net cost in late 2007 corresponds to the increase in the Federal government's PVRP rebate from $4,000 to $8,000. The sudden increase in net cost in mid 2009 represents the abolition of the PVRP rebate and its replacement by the Solar Credits multiplier. This is followed by a gradual increase in net cost reflective of a reducing multiplier and the end of the mandated feed-in tariff in some states. In some states this has effectively change the scheme from gross to net.

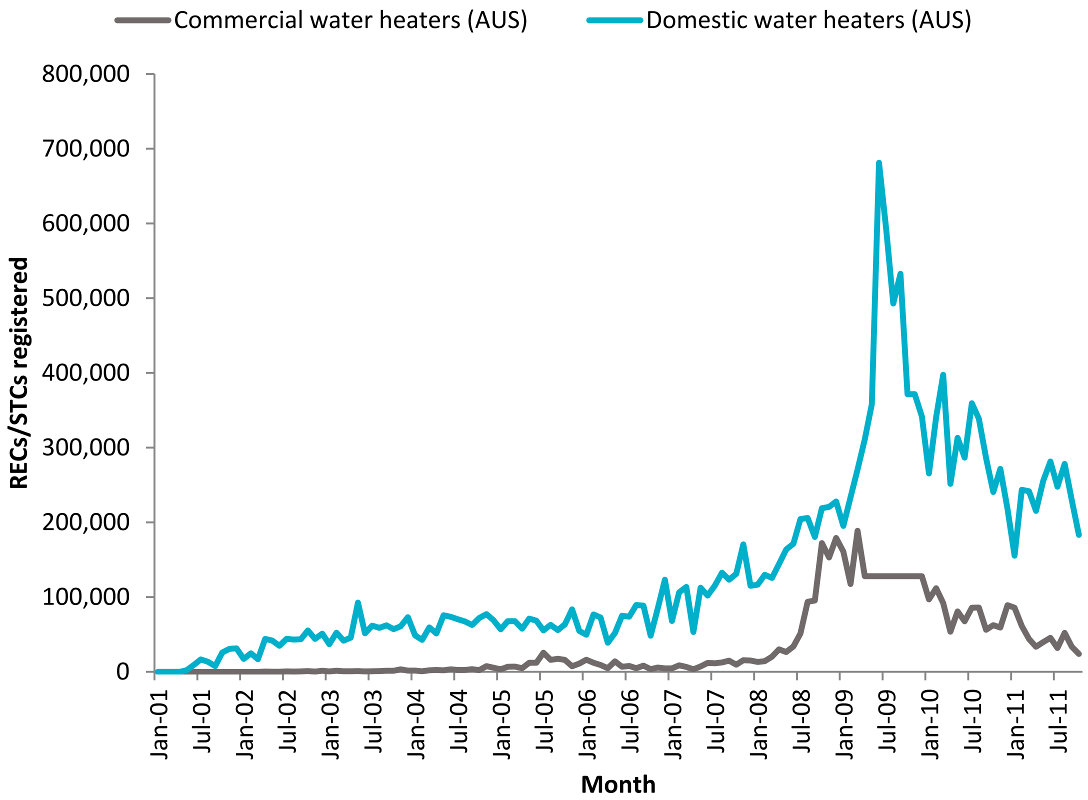
The results of the time series modelling for SGUs are presented in Section 6.2.

## 5.6.4. Time series model for water heaters[10]

Figure 5-11 shows the time series corresponding to the total number of RECs registered per month for both commercial and domestic water heaters. Water heaters were defined as commercial if they received more than 40 RECs/STCs, which was a cut-off determined by trial and error (see section 5.6.4.4).

[10] The tern "water heaters" refers to solar water heaters and heat pump water heaters.

Figure 5-11 RECs/STCs registered by water heaters



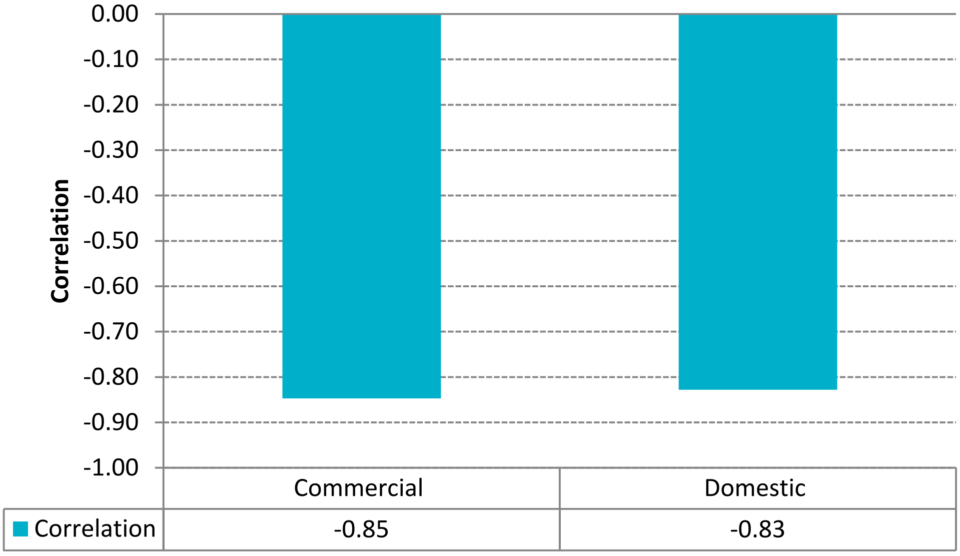

### 5.6.4.1. Choosing the external regressor

As with the SGU analysis, it was assumed that the net cost would be the main explanatory variable underlying the distinct trend in water heater uptake. The data were examined and the historical net cost was used as an external regressor to fit the trend in the data.

### 5.6.4.2. Choosing the dependent variable

The water heater data were aggregated by number of RECs/STCs registered. A strong correlation was observed between net cost and RECs/STCs registered for both commercial and domestic installations, as displayed in Figure 5-12.

Figure 5-12 Correlation between number of RECs/STCs versus net cost for water heaters

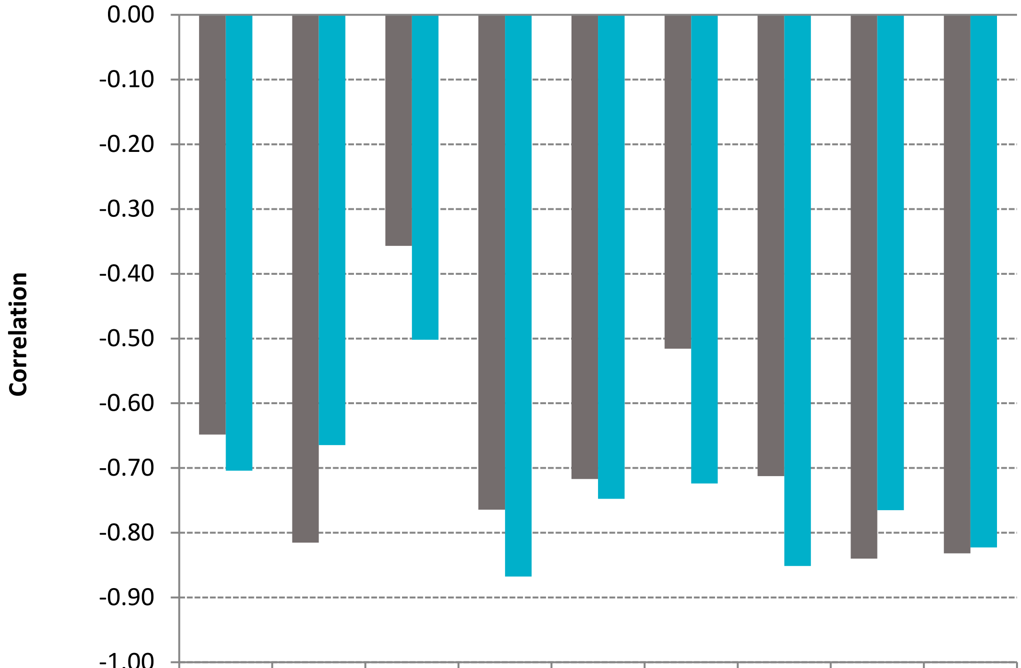



### 5.6.4.3. Choosing the level of aggregation

Separate models were initially trialled for water heaters by state. However, it was found that this level of disaggregation significantly increased the variance of the time series and hence the error in the predictions. Figure 5-13 shows that the correlation of RECs registered with the respective net cost[11] (for all water heaters independent of technology) is quite variable depending on the state, and is especially low in states with low installation numbers.

[11] The net cost used for each state was the weighted average of the net costs across the technologies.

■ Figure 5-13 Correlation of water heater categories versus net cost by state

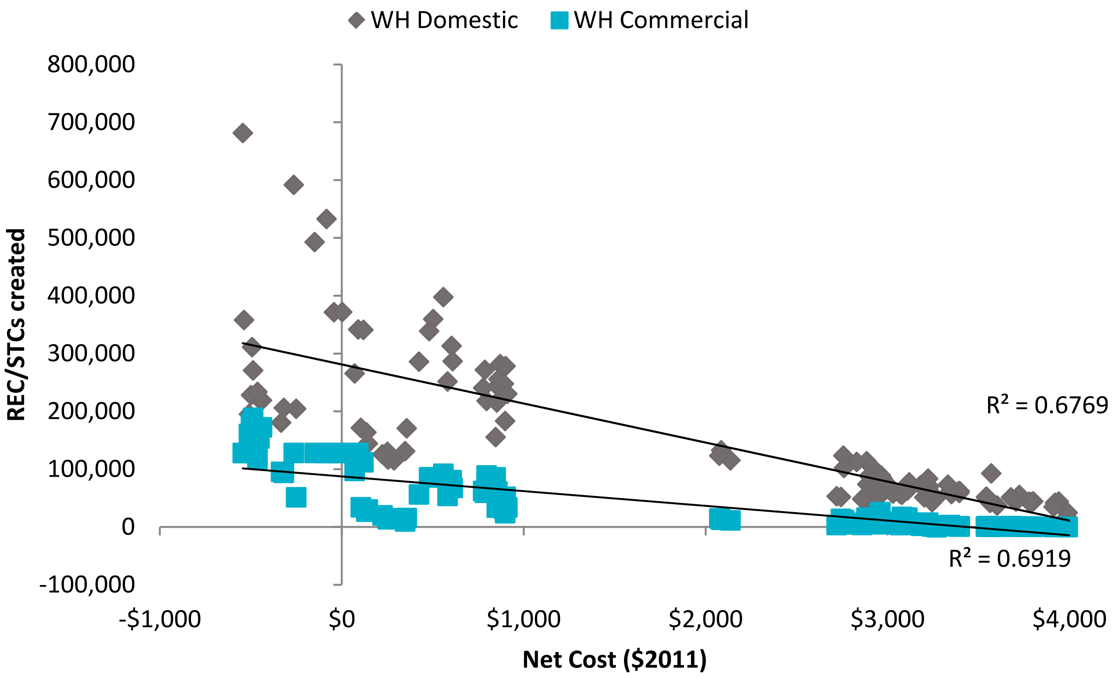



| | ACT | NSW | NT | QLD | SA | TAS | VIC | WA | AUS |
|---|---|---|---|---|---|---|---|---|---|
| WH Commercial RECs/STCs | -0.65 | -0.82 | -0.36 | -0.76 | -0.72 | -0.52 | -0.71 | -0.84 | -0.83 |
| WH Domestic RECs/STCs | -0.70 | -0.66 | -0.50 | -0.87 | -0.75 | -0.72 | -0.85 | -0.77 | -0.82 |

Further analysis of the data showed that the correlation of RECs/STCs with the net cost[12] for all Australia varies depending on the technology. After trialling a number of combinations of aggregation and disaggregation, it was found that the best results with respect to the correlation with net cost were obtained by aggregating across all states and both technologies, but retaining the distinction between commercial-sized systems and domestic-sized systems, see Figure 5-14. The importance of maintaining the split between commercial and domestic systems will become apparent in the following section.

[12] The net cost used for each technology was a weighted average of the net costs across the states.

Figure 5-14 REC/STCs creation versus net cost - AUS



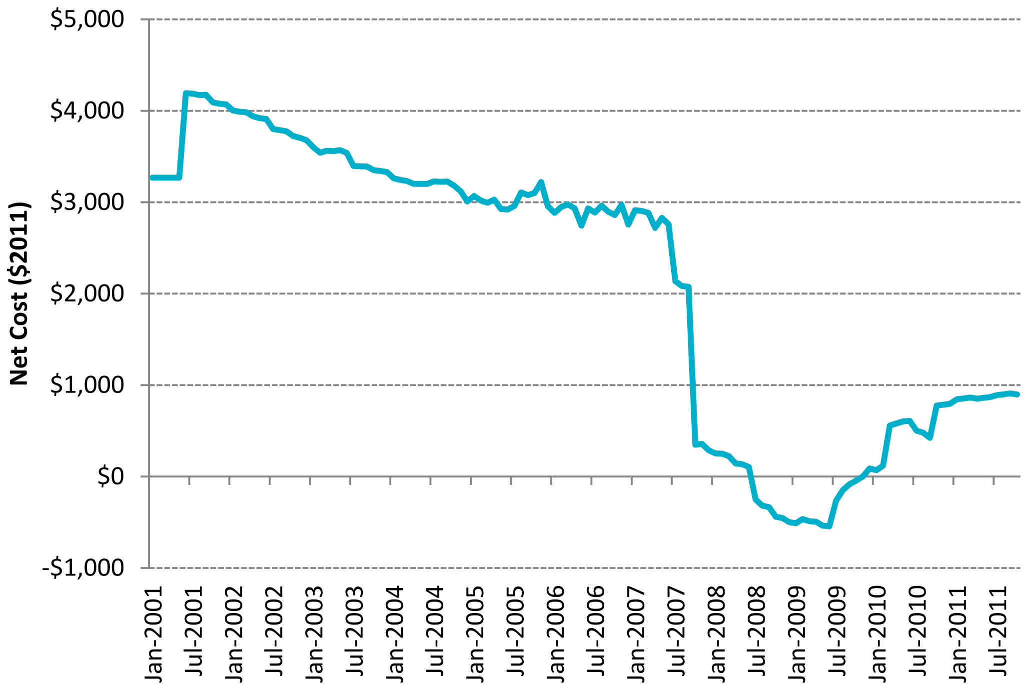

### 5.6.4.4. Correcting for SWH data distortion

SKM MMA is aware of an issue with the historical SWH uptake numbers for commercial systems, in that they appear to be inflated by provisions which allowed consumers to reduce their upfront cost by installing larger systems than they actually required, thereby claiming more RECs. This effect was corrected by the statutory declaration requirement, introduced in legislation from 9 September 2009, for SWHs with a volumetric storage capacity greater than 700 litres.

This anomaly, which is clearly present in the uptake data, was compensated for by grouping systems into a domestic and commercial category, with 55 RECs set as the initial cut-off point defining the two data sets. However, visual inspection of the data split up in this way showed that the inflation in uptake was still present in the domestic category. Trial and error revealed that the bump in uptake could be reduced, but not entirely eliminated, by changing the cut-off between domestic and commercial categories. As there was no objective way of choosing the cut-off based on the visual inspection, the best cut-off was chosen to be the one that maximised the correlation between the net cost and the uptake, since this would produce the least prediction error. Trial and error revealed that this could be achieved with a cut-off of 40 RECs/STCs.

The aforementioned distortion present in the time series for commercial water heaters was compensated for by replacing the number of RECs registered from March 2009 to December 2009 by the average of the three months preceding and following this time period, which is when the water heater uptake peaked.

Figure 5-15 Historical average water heater net cost




### 5.6.4.5. Form of the time series model

The original water heater time series were non-stationary, showing both a changing mean and changing variance over time. However, the logarithm of the original time series was found to be stationary after the trend was removed. Seasonality in the time series was insignificant and the data lent itself nicely to an ARIMA model with an external regressor.

In summary, the time series analysis of the data for the water heaters was carried out by fitting univariate ARIMA models to the logarithm of the monthly number of registered RECs by water heaters, split into domestic and commercial categories, for all of Australia. The weighted average of the net cost in each state was used as an external regressor (illustrated in Figure 5-15). All of the modelling was carried out in R and the results are presented in Section 6.2.

# 6. Modelling results

This section presents the results of the modelling for the structural model and the time series model under Base scenario. The results from the DOGMMA model are presented as the total number of STCs created from SGU and water heaters for financial years 2007/08 to 2014/15. The results from the time series modelling of PV are in the form of projected installed capacity, which are then translated into STC volume projections for the 2012, 2013 and 2014 calendar years for both scenarios. The modelling of water heaters from the time series are presented as the number of STCs created.

## 6.1. DOGMMA calibration results and projections

The results presented in this section are for the total STCs created from PV and water heaters, however since PV makes up the majority of the units creating STCs, the variations in trend are nearly entirely attributable to the variation in PV uptake. Additionally, water heaters are at a more mature stage of market development and the uptake is projected to be relatively stable.

Figure 6-1 shows the historical and projected total STCs created for Queensland in financial years. The fit to the historical data is very good. DOGMMA predicts that the peak was reached in 2010/11 and the numbers of STCs created over the next three years are projected to decrease steadily. The steady decrease corresponds to the progressive reduction of the Solar Credit multiplier at the end of each financial year to 2013/14.

▪ Figure 6-1 Historical and projected installed PV capacity for Queensland

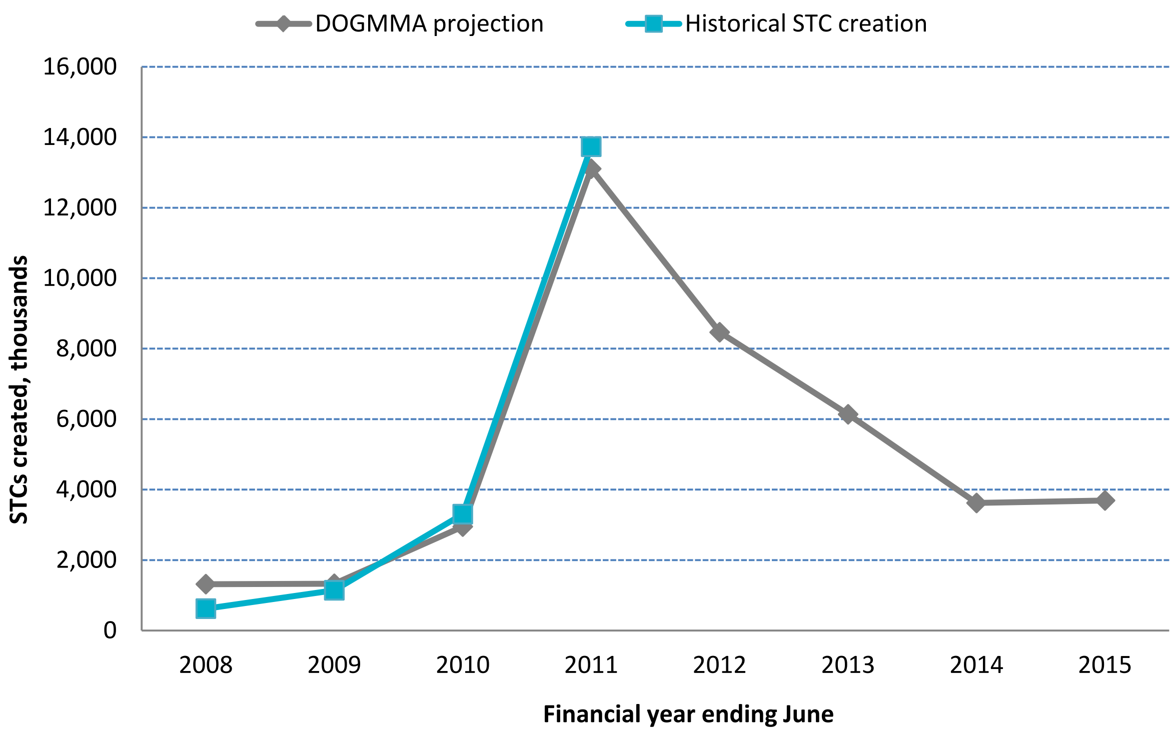


Figure 6-2 shows the historical and projected total STCs created for New South Wales, and includes the ACT. The fit to the historical data is reasonably good, although the model fit for 2010/11 is considerably lower than the historical uptake. This is due to the ‘rushed buying’ that occurred in both of these markets when the feed-in tariffs for PV were announced to end. NSW and ACT both offered very generous gross feed-in tariffs and when it was announced that these would end, there was ‘rushed’ buying to take advantage of these incentives. Consequently, the uptake of PV was inflated in this period, and beyond the predictive scope of the DOGMMA model. Looking forward, DOGMMA projects a decrease in uptake, which corresponds to the progressive reduction in the Solar Credit multiplier.

■ Figure 6-2 Historical and projected installed PV capacity for New South Wales

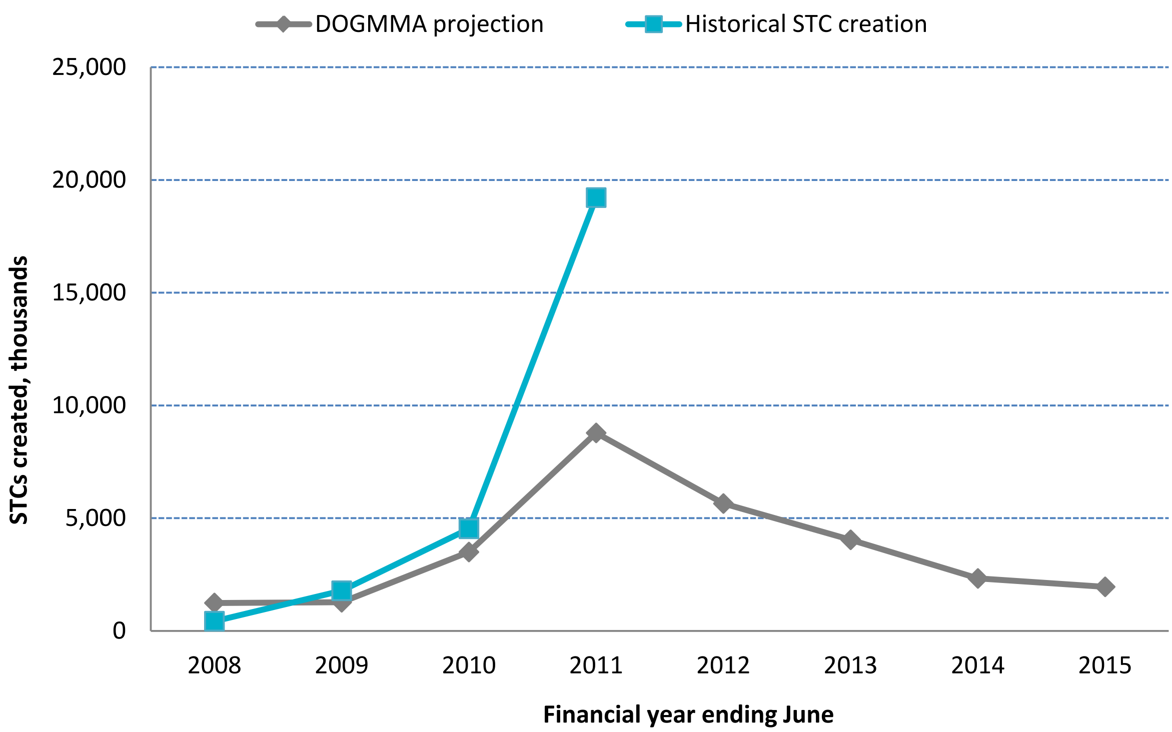



Figure 6-3 shows the historical and projected total STCs created for Victoria. The fit to the historical data is quite good. DOGMMA is projecting a reduction in certificate production for the next few years, which is consistent with the other states and the reduction in the Solar Credit multiplier

▪ Figure 6-3 Historical and projected installed PV capacity for Victoria

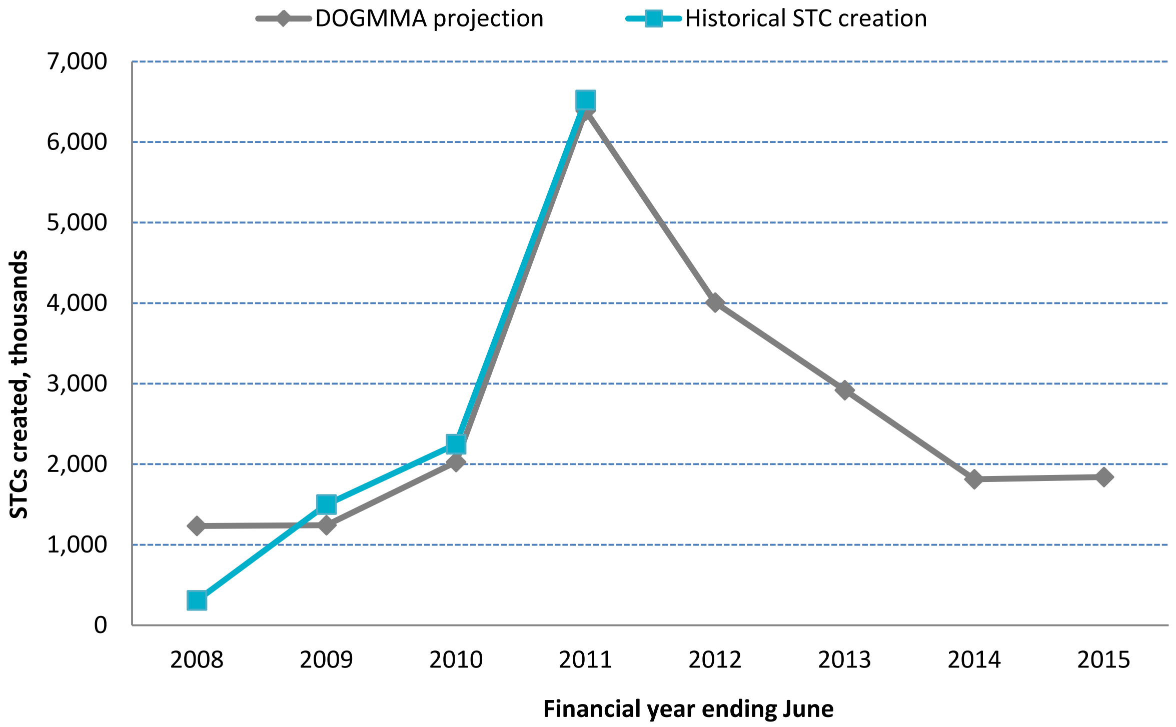



Figure 6-4 shows the historical and projected total STCs created for Tasmania. The fit to the historical data is reasonable. The model is projecting a decrease in the next three years, but at a more moderate rate compared to the other states.

▪ Figure 6-4 Historical and projected installed PV capacity for Tasmania

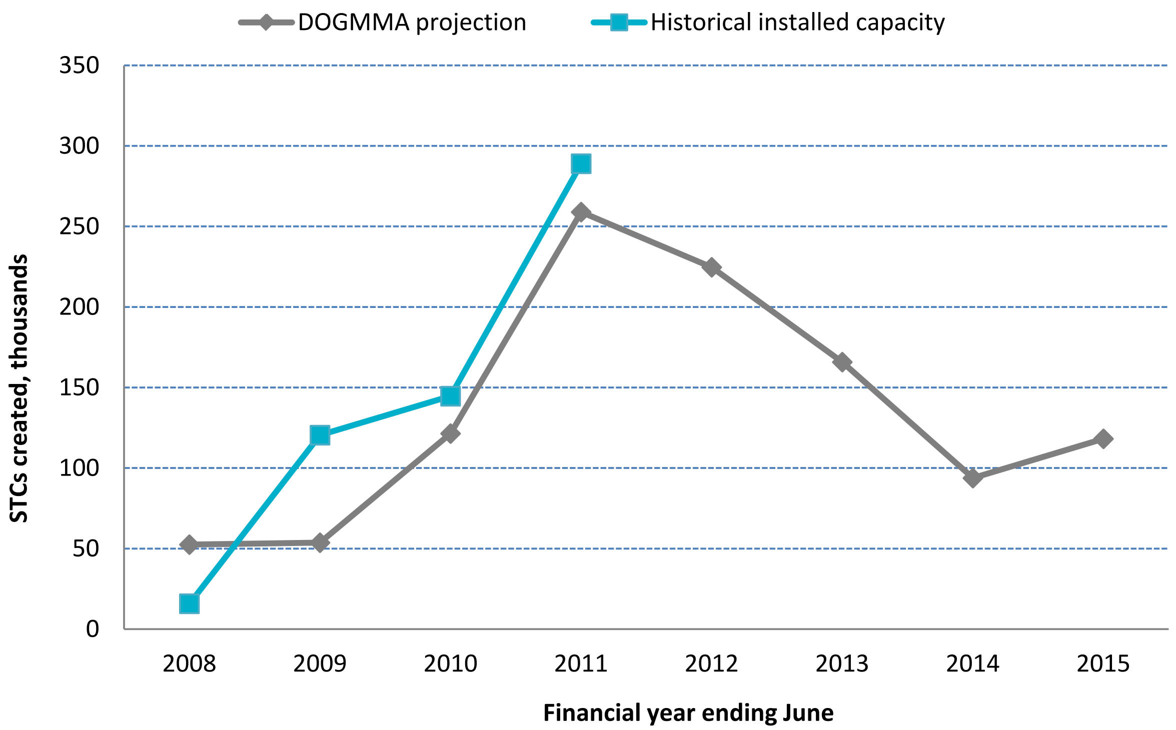


Figure 6-5 shows the historical and projected total STCs created for South Australia. The fit to the historical data is very good. Looking forward, the projection is similar to the other states in that it decreases over the next three years.

■ Figure 6-5 Historical and projected installed PV capacity for South Australia

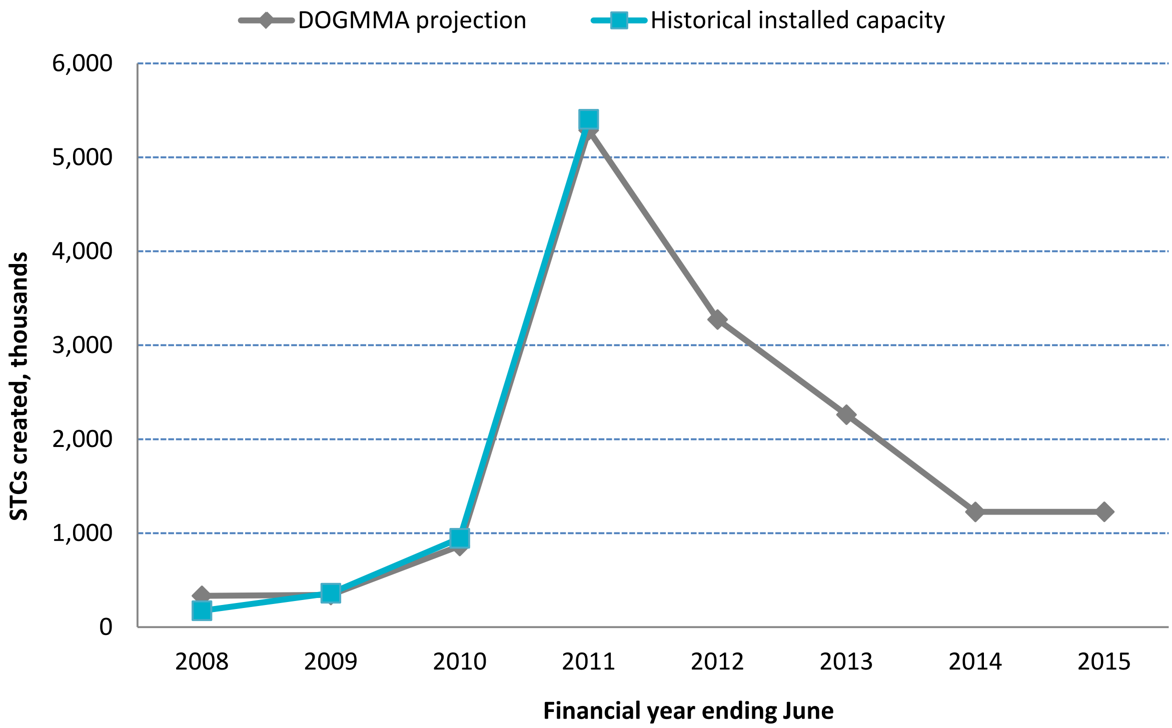



Figure 6-6 shows the historical and projected total STCs created for Western Australia. The fit to the historical data is quite good although a bit on the low side in the earlier years. DOGMMA predicts a decrease in STCs created over the next three years, which is similar to the results for the other states.

■ Figure 6-6 Historical and projected installed PV capacity for Western Australia

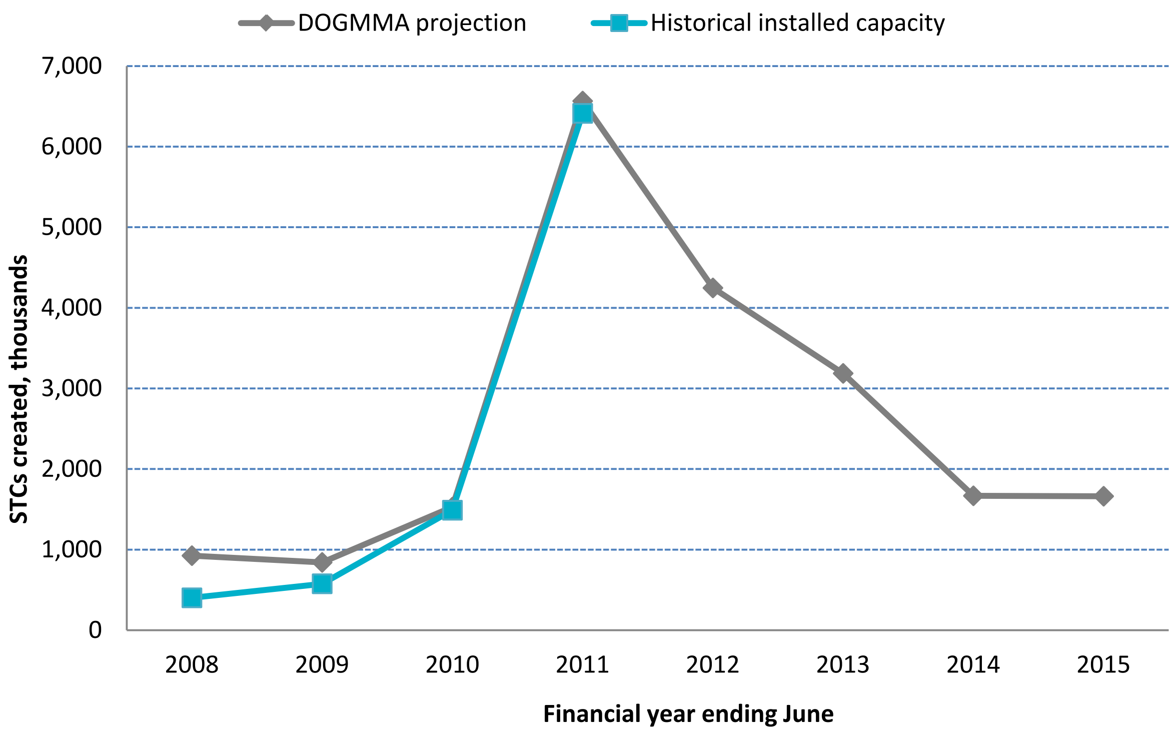



Figure 6-7 shows the historical and projected total STCs created for the Northern Territory. The model fit is good for 2010/11 but a little low for the early years. The forecast for the next three years is consistent with the other states in that it decreases steadily.

■ Figure 6-7 Historical and projected installed PV capacity for Northern Territory

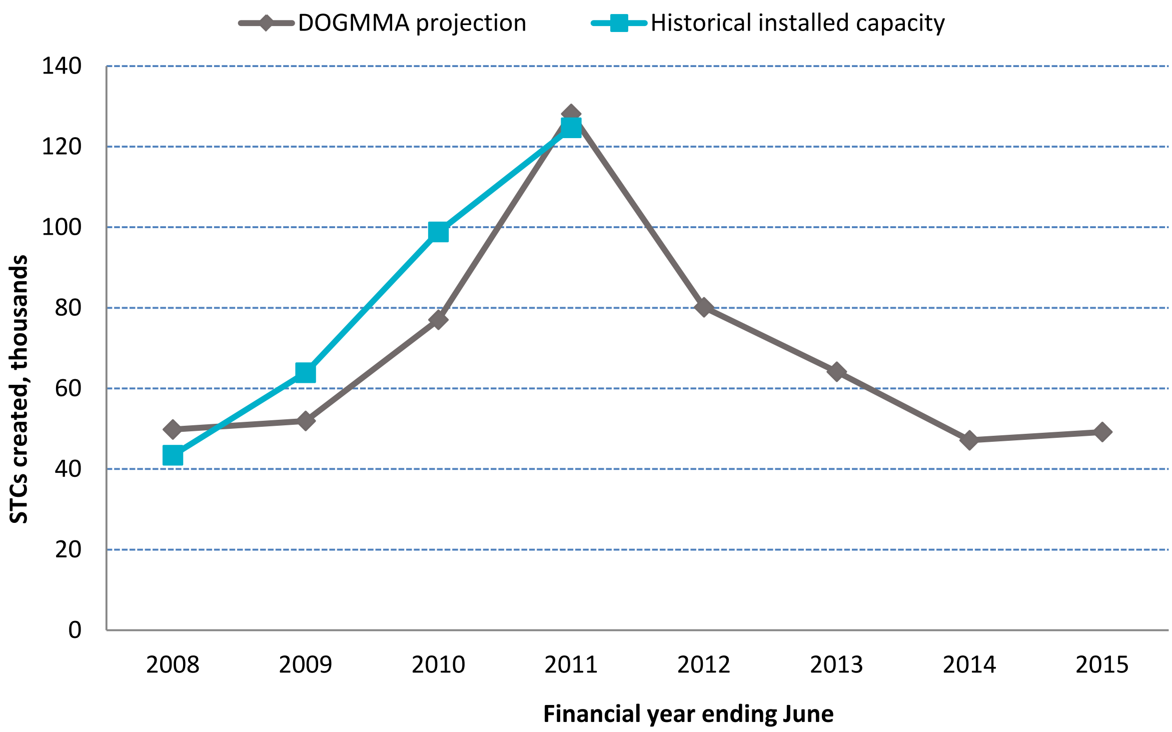
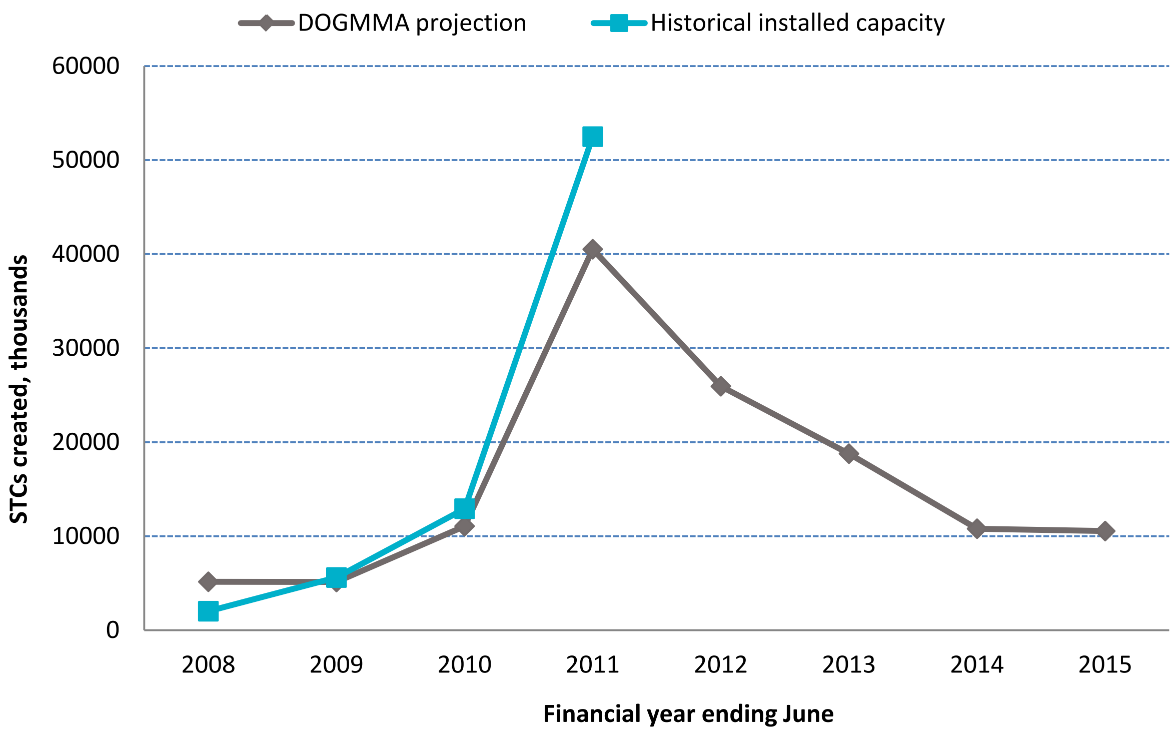



Figure 6-8 shows the historical and projected STCs created in aggregate across Australia. The fit to the historical data is quite good, although the fit in 2010/11 has been underestimated and this is due to the issue with NSW/ACT. Looking forward, DOGMMA predicts a reduction in the number of STCs created, which is driven by the progressive reduction in the Solar Credits multiplier, and the ending of the PV feed-in tariffs in most states. Certificate production is projected to stabilise in 2014/15, which is the first year in which the multiplier no longer reduces.

■ Figure 6-8 Historical and projected installed PV capacity for Australia




## 6.2. Time series projections for Base scenario

### 6.2.1. Installed PV Capacity

The results of the time series modelling for all states are presented below. The solid black line on the left of the graphs represents the historical monthly time series, extending to October 2011 upon which the projection is based. The radical change to the incentives for installing PV which occurred in June 2009[13] threw out the time series model, and sensible projections could only be achieved by including data from July 2009 onwards, when the Solar Credits scheme took effect. The green dotted line on the left gravitating around the solid black line is the model's fit to the historical data. The model's predicted monthly PV uptake capacity is represented by the solid red line on the right hand side of the graphs, and the two dotted lines encompassing the projection represent the prediction plus and minus the standard error.

Figure 6-9 shows the time series projection for the installed monthly PV capacity in Queensland. The model's fit to historical data is quite good. According to the projection, the monthly installed capacity of new PV systems has peaked in Queensland and will be trending downwards in steps over the next three years. The stark jumps evident in the monthly projections occur every July from July 2012 onwards. These are driven by a combination of the monthly net cost projection, as well as a step down in the Solar Credits

[13] That is, the abolition of the $8,000 PVRP rebate and the introduction of the Solar Credits scheme.

multiplier until 2013. The positive slope in between these steps reflects a gradual lowering of costs through the assumed decline in PV capital costs, and through an increase in the avoided costs of electricity, which is driven by rising wholesale and retail prices.

■ Figure 6-9 PV installed capacity projections for Queensland

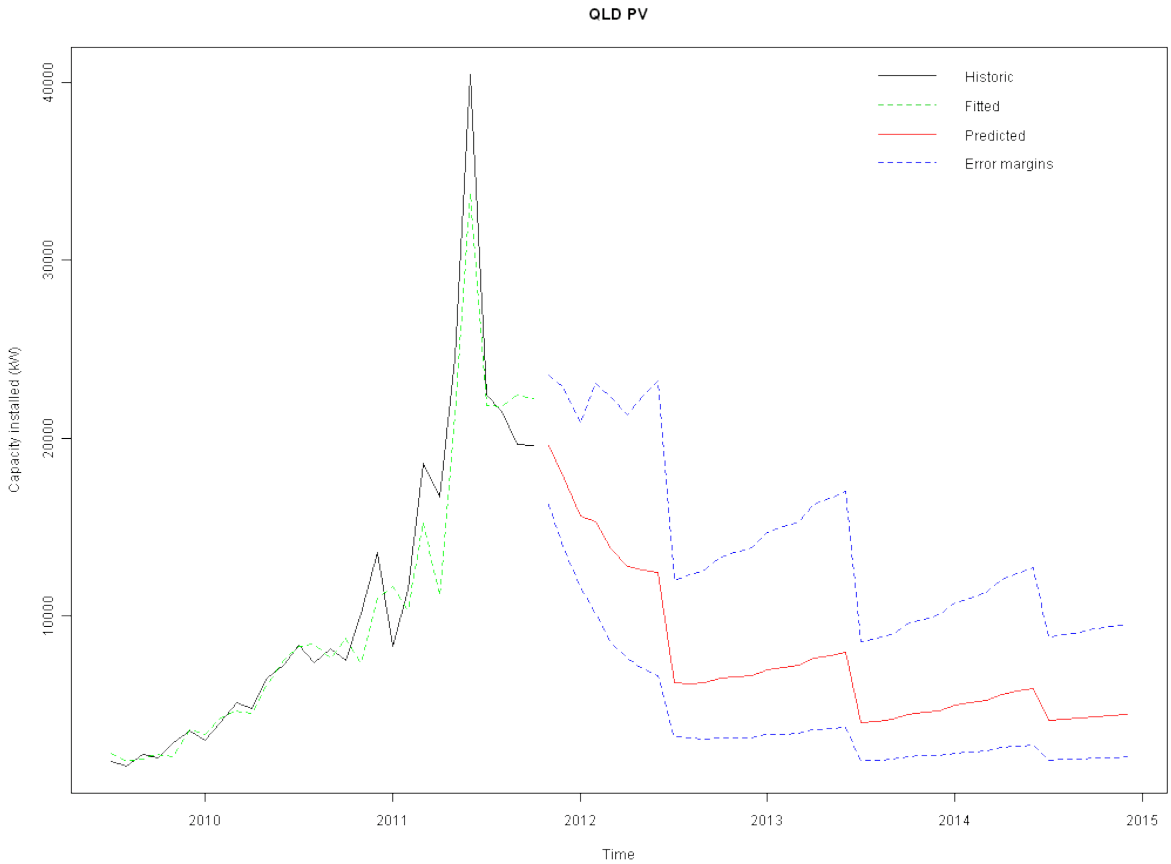



Figure 6-10 shows the time series projection for the installed monthly PV capacity in New South Wales. A key feature of the projection is the large decline in uptake in 2011. This reflects the recent reduction in the NSW gross feed-in-tariff from 60c/kWh to 20c/kWh and the subsequent change to a net scheme. The projection is otherwise similar to that of Queensland in that the multiplier reductions in July 2012 and 2013 effect a shallow down-trend in uptake capacity, however the jumps in projections between years is not as obvious as for Queensland.

Figure 6-10 PV installed capacity projections for New South Wales

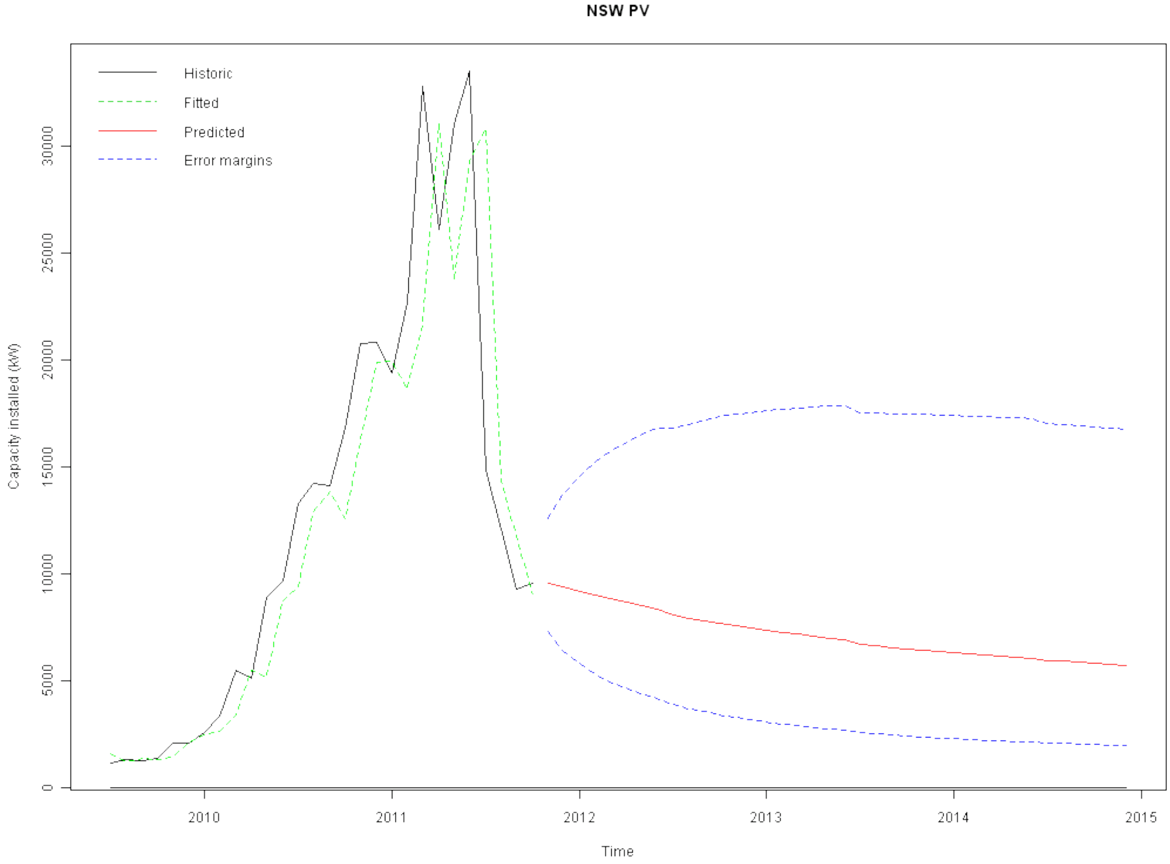



Figure 6-11 shows the time series projection for the installed monthly PV capacity in Victoria. Unlike the projections for Queensland and NSW, there is no immediate reduction in uptake capacity, but rather a slight uptrend is in place until July 2011, when the first multiplier reduction occurs. The projected uptake declines sharply in 2012 indicating that capacity installed will have reached a second peak before trending downwards in the medium term. Although negative and exhibiting similar stepped behaviour, the trend is flatter than the Queensland projections.

■ Figure 6-11 PV installed capacity projections for Victoria

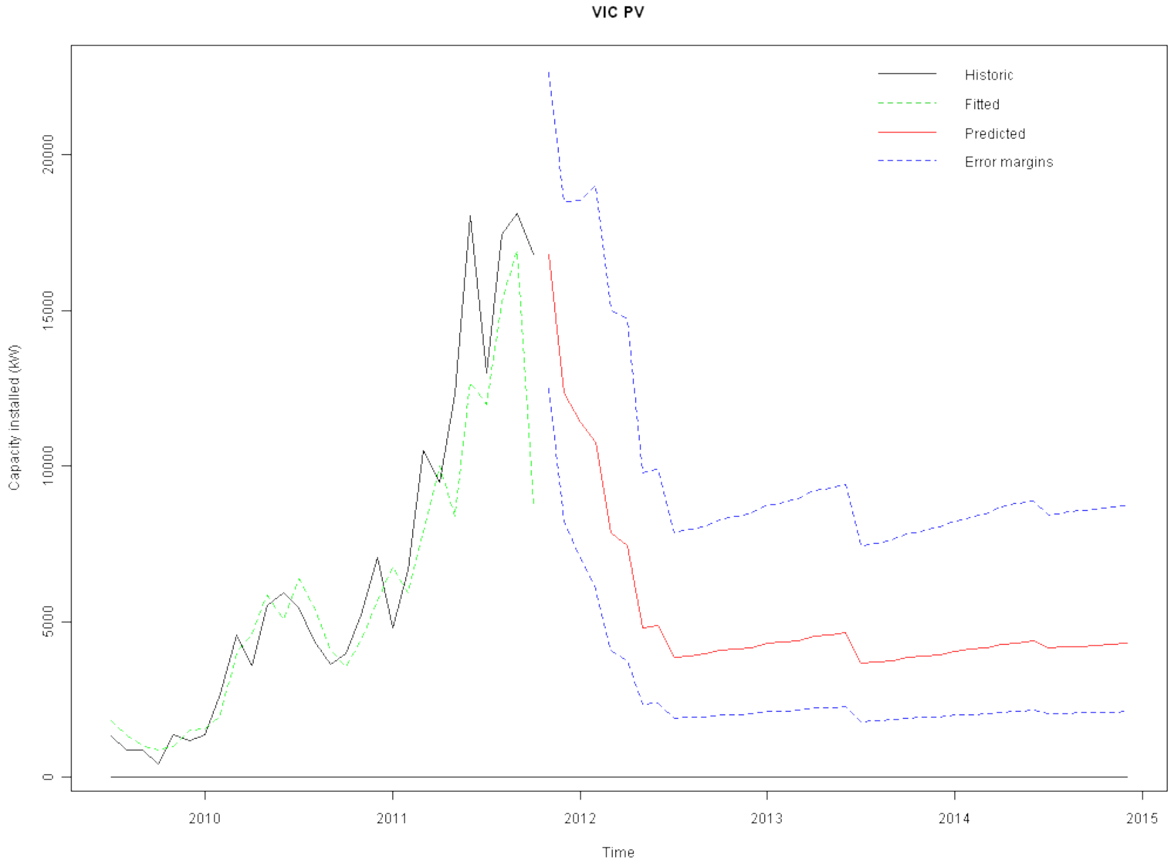



Figure 6-12 shows the time series projection for the installed monthly PV capacity in Tasmania. The historical monthly uptake time series is not as steep as that observed for the mainland states, which is what one may have expected, given that Tasmania has the lowest insolation levels of the Australian states and territories. The projection exhibits similar trends to the other states, with stepped decreases in uptake each financial year reflecting the net cost projection and reduction in the solar credits multiplier.

▪ Figure 6-12 PV installed capacity projections for Tasmania

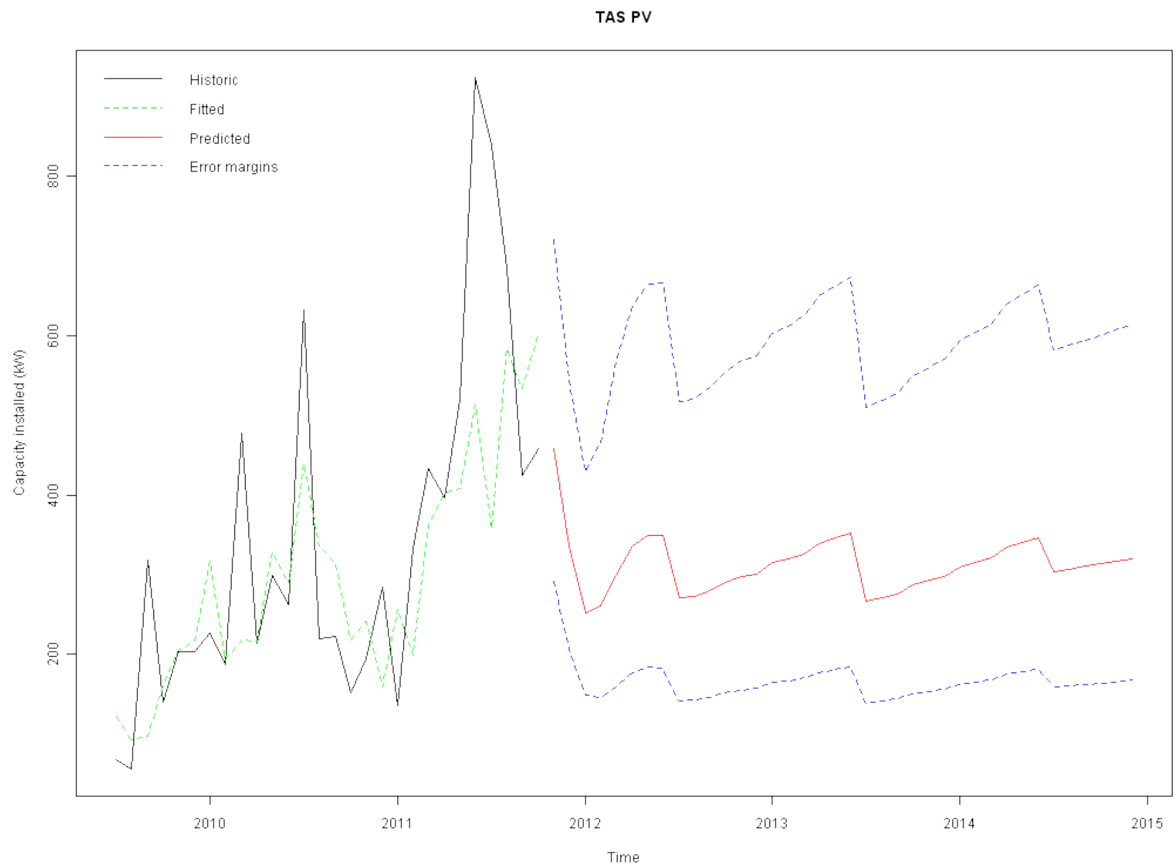



Figure 6-13 shows the time series projection for the installed monthly PV capacity in South Australia. The model fit to the historical time series appears to be quite good. The projection has decreased sharply with the reduction of the feed-in tariff at the end of September 2011. The trend has similar characteristics to Victoria.

■ Figure 6-13 PV installed capacity projections for SA

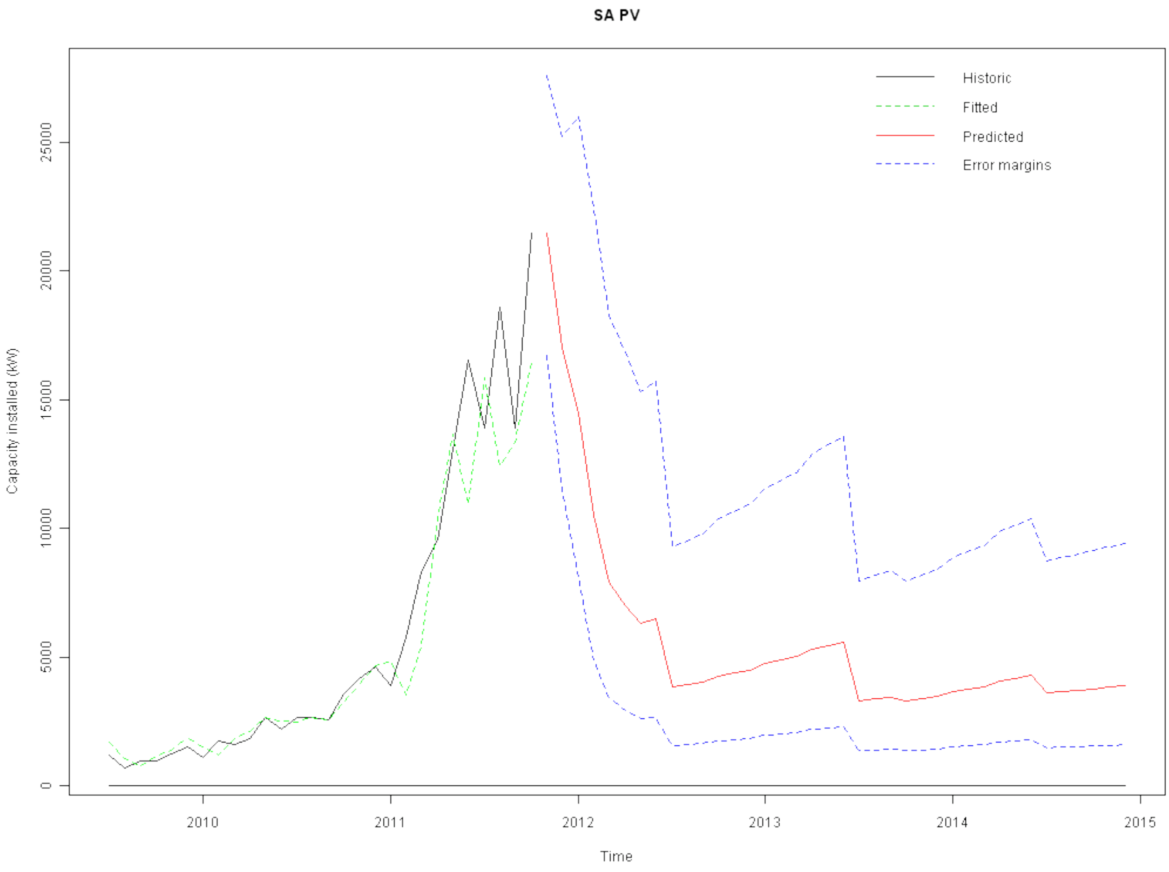



Figure 6-14 shows the time series projection for the installed monthly PV capacity in Western Australia. The model fit to the historical time series is reasonably good, and the historical data shows that capacity has peaked in late 2011. Subsequent years show a forecasted decline in uptake with stepped decreases at the end of each financial year, which do not appear to be as prominent as other states.

■ Figure 6-14 PV installed capacity projections for Western Australia

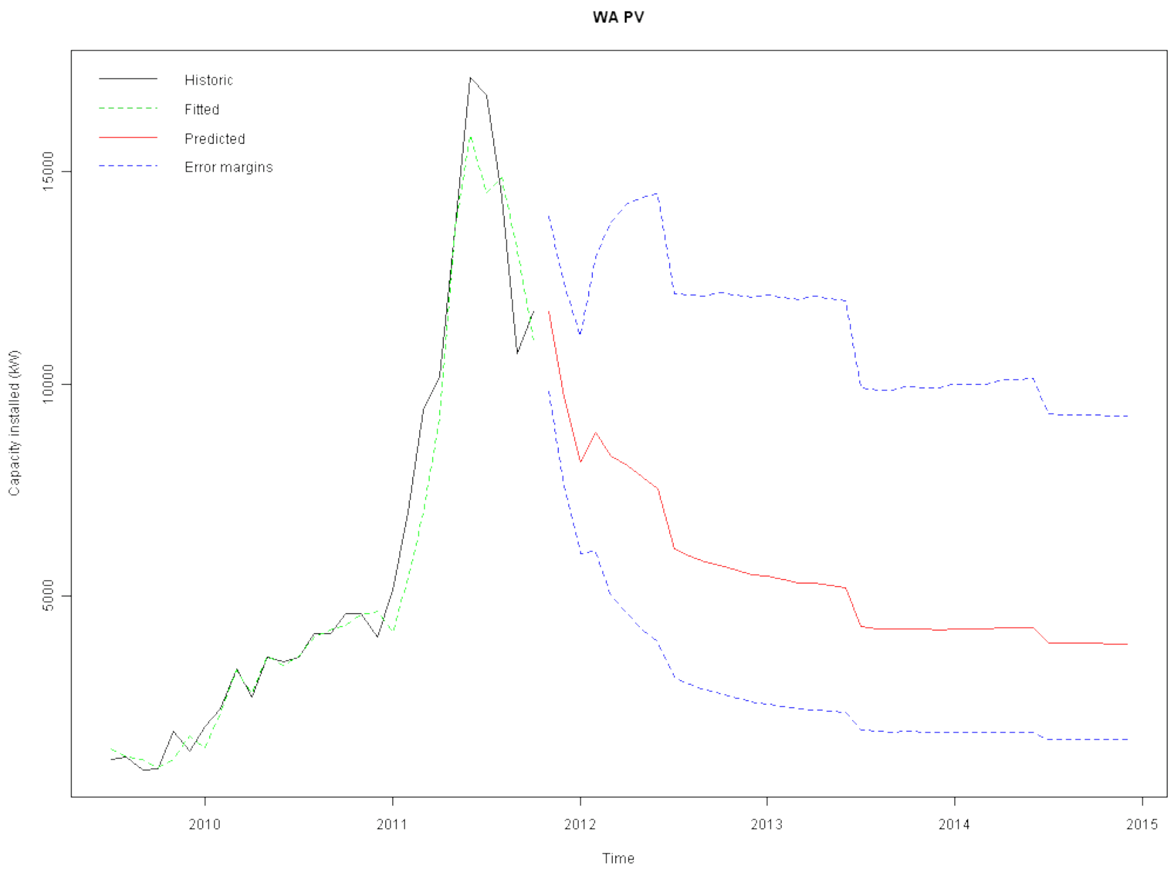



Figure 6-15 shows the time series projection for the installed monthly PV capacity in the Northern Territory, with the model fit appearing reasonable. The historical uptake does not appear to have been as rapid as in the mainland states. The time series model is predicting that the monthly uptake has already peaked, and is projecting a decline in uptake in late 2011, followed by a shallow down-trend if not stable uptake in the medium term. The large standard error is reflective of the relatively lower installations compared to other states.

■ Figure 6-15 PV installed capacity projections for Northern Territory

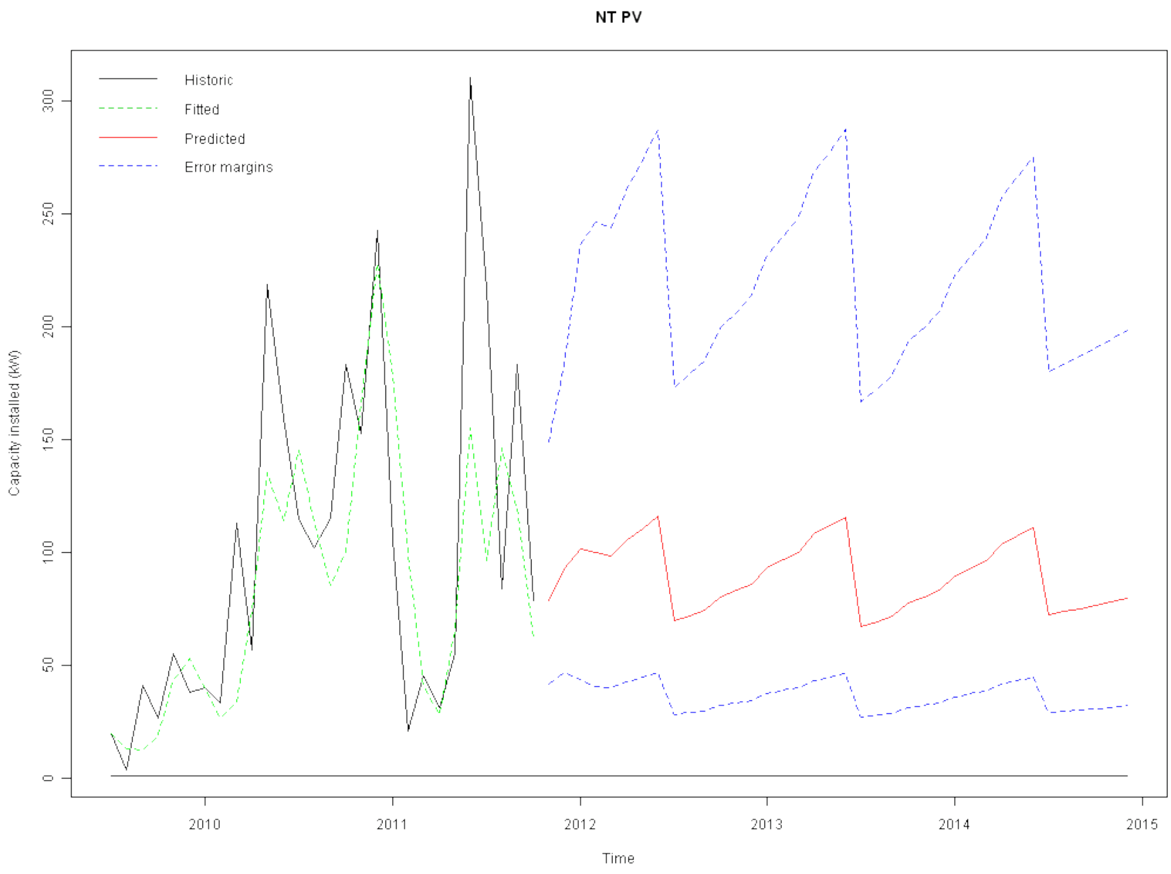



Figure 6-16 shows the time series projection for the installed monthly PV capacity in the Australian Capital Territory. The model fit to the historical time series is very good. Both the historical time series and the model projections indicate that the peak uptake of capacity has already occurred in late 2011. As with other states and territories, the model is predicting a reduction in uptake but with relatively stable uptake across the financial years.

■ Figure 6-16 PV installed capacity projections for Australian Capital Territory

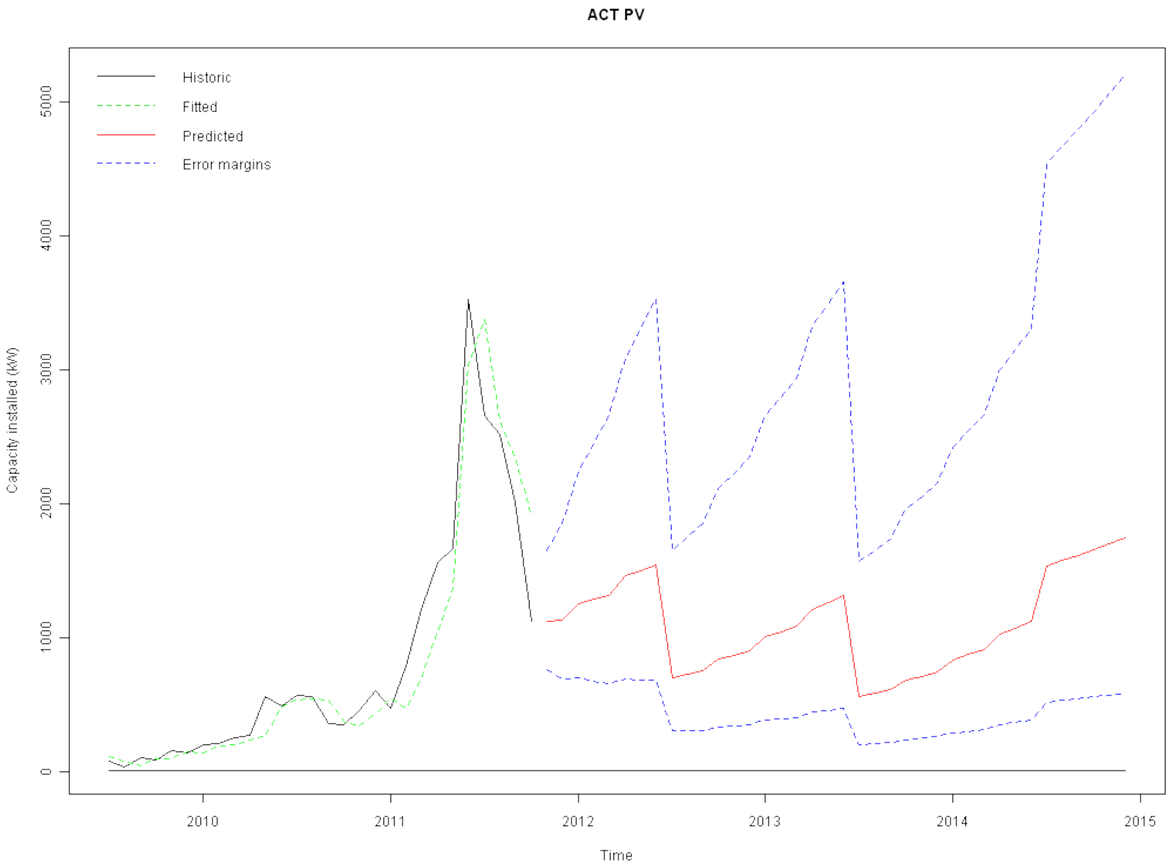
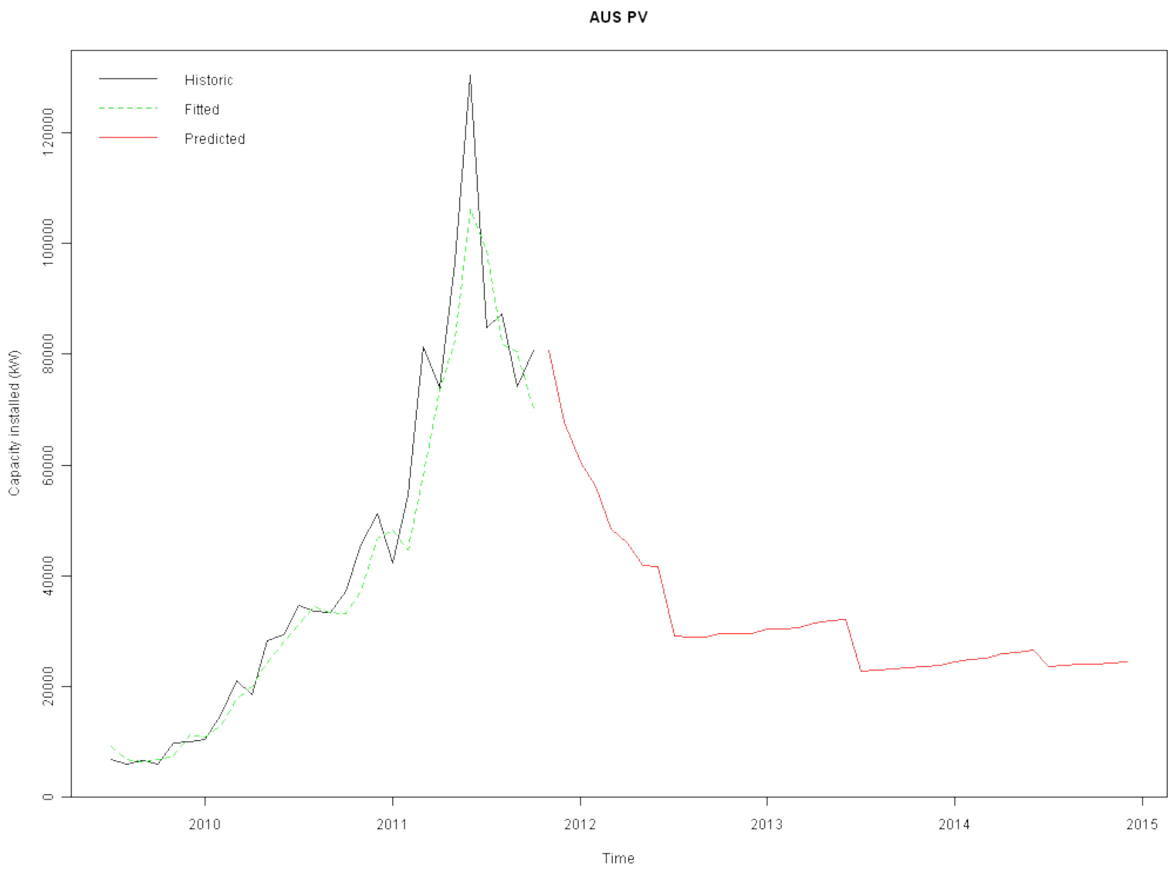



Figure 6-17 shows the sum of the state projections, which is effectively the projected PV installed capacity across Australia. The common trends across all states including the drop in capacity installed as well as 'steps' coinciding with reductions in the Solar Credits multiplier are evident in the chart.

▪ Figure 6-17 PV installed capacity projections aggregated for all Australia




## 6.2.2. Water heater STC projections

The results of the time series modelling for domestic and commercial water heater STCs projections are presented below. Unlike the time series modelling for PV systems, most of the historical time series was able to be employed in projecting water heater STC volumes. This is because the changes to the government-based financial incentives driving the uptake of water heaters were not as pronounced as those for SGUs.

Figure 6-18 shows the time series projection for STC volumes created by commercial water heaters for the whole of Australia. The time series model's fit to the historical time series appears to be reasonably good, although the uncertainty surrounding the projection indicates that the fit is uncertain, which is likely attributable to the relatively smaller uptake of commercial systems compared with domestic. It should be noted that the flat portion of the historical time series data just prior to 2010 corresponds to the data adjustment described in section 5.6.4.4.

The projection of monthly STC creation from commercial water heaters indicates a reduction in uptake across Australia from current levels which is quite stable from mid 2012. This is broadly consistent with the cessation of the various state based rebates between now and December 2013, although no state rebates cease in mid 2012, which is the point at which the uptake levels off. This latter effect is probably driven by a levelling of the real cost of installation post 2011.

■ Figure 6-18 Commercial water heater STC volume projections for Australia

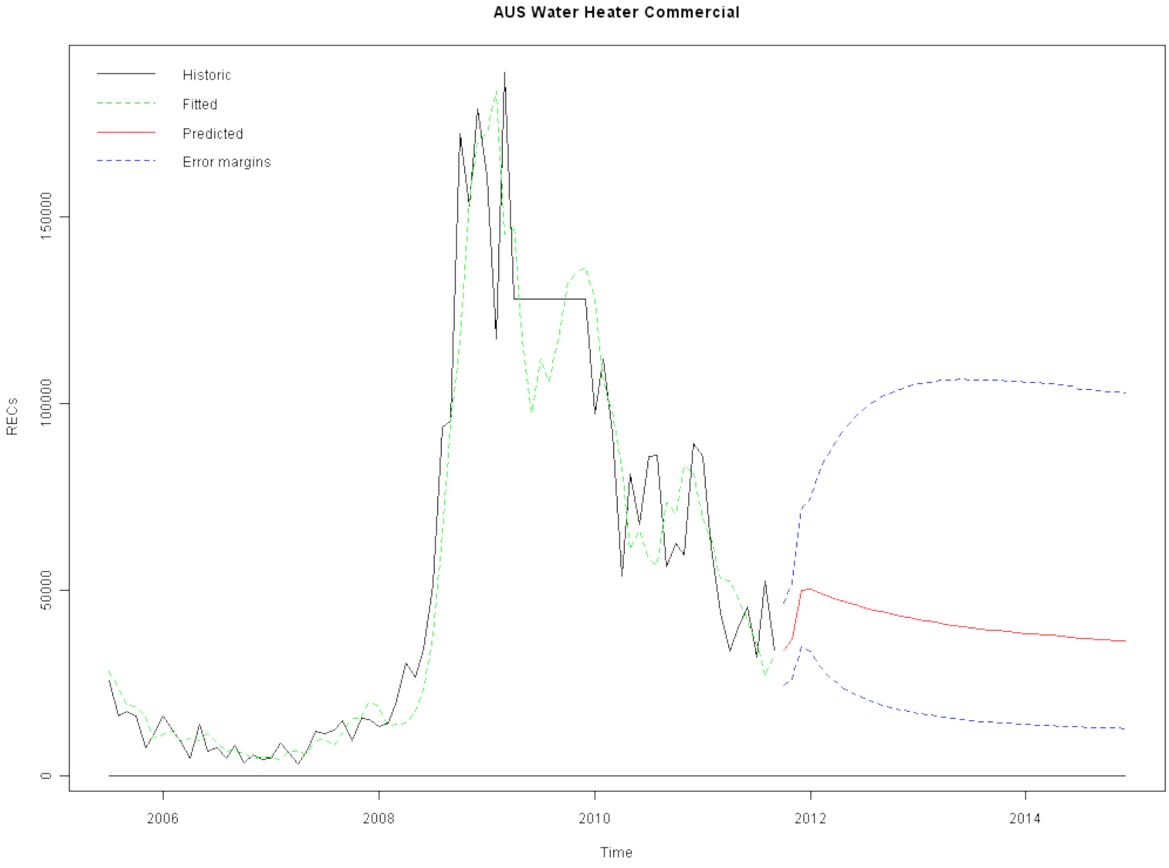
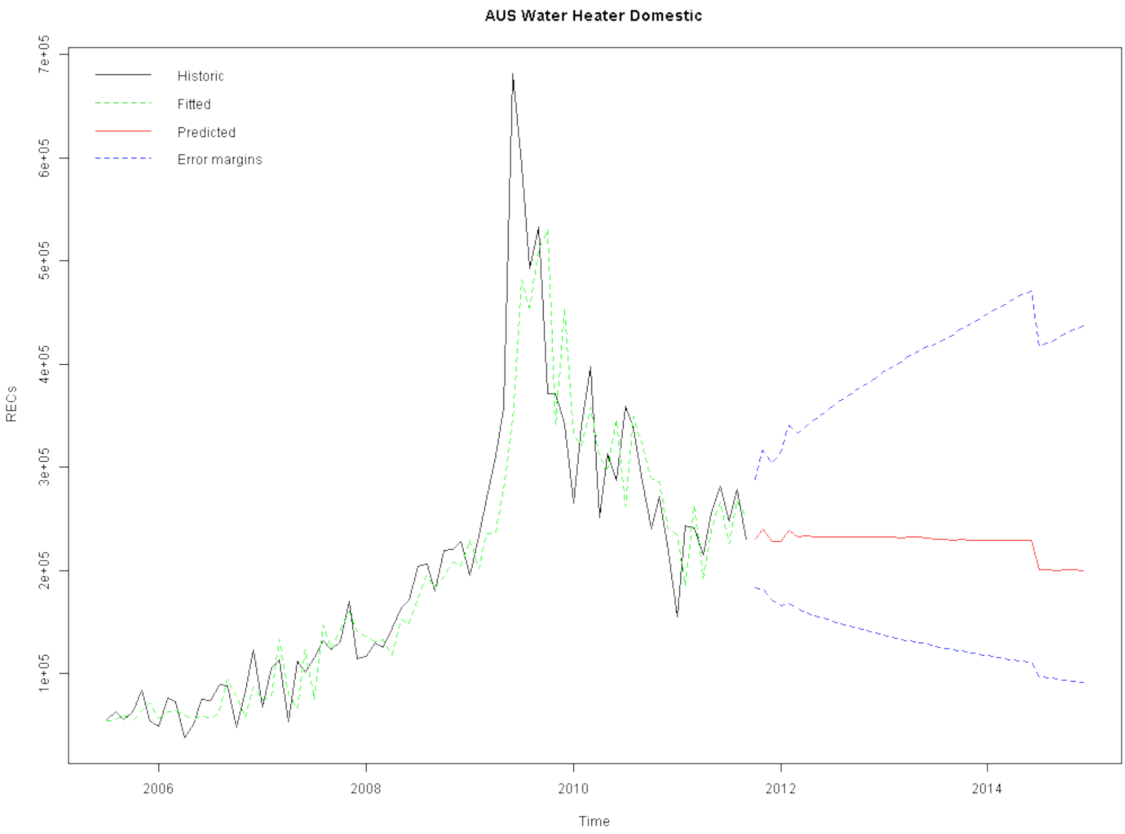



Figure 6-19 shows the time series projection for STC volumes created by domestic water heaters for the whole of Australia. The peak in the historical time series around mid 2009 coincides with the pronounced peak exhibited in the corresponding time series for commercial water heaters (see section 5.6.4.4), and is therefore considered to be somewhat artificially inflated. However, testing has shown that the effect of this peak does not lead to a large distortion in projected volumes, and so it was left in the time series unadjusted.

The model's fit to the historical time series is quite good and the STC volume projections for domestic water heaters are similar to those for the commercial category in that there is a gradual reduction in uptake from current levels, and then a levelling off of uptake from about mid 2012. The drivers behind this behaviour would be identical to those described for the commercial category. The forecast standard error also appears to be better than for commercial systems, likely due to a greater installed capacity.

■ Figure 6-19 Domestic water heater STC volume projections for Australia




## 6.3. Certificate projections for time series model

Table 6-1 shows the projected number of STCs created by small-scale PV technology by state for the next three calendar years using the time series model under the Base scenario. The reduction of STCs produced in 2013 relative to 2012 is partly due to the reduction in the PV multiplier and the projected decline in installed capacity across all states with most having peaked by 2012. Most of STC reduction occurs in Queensland, Victoria, South Australia, New South Wales, Western Australia and ACT, all of which have a drop in certificate creation of at least 40%. The trend continues to 2014, although at a relatively lower rate.

The projections resulting from the Low scenario are shown in Table 6-2. Projections for all states and territories apart from Queensland, South Australia and Northern Territory start from a much lower base relative to the Base scenario projections. This assumes that the subdued consumer sentiment towards PV, which has become apparent through much lower uptake over the last six weeks, persists over the next three years.

■ Table 6-1 Projected STCs created from PV using time series model – Base scenario

| | 2012 | 2013 | 2014 |
|---|---|---|---|
| ACT | 475,000 | 293,000 | 362,000 |
| Queensland | 5,105,000 | 2,136,000 | 1,422,000 |
| New South Wales | 3,776,000 | 2,265,000 | 1,668,000 |
| Victoria | 2,661,000 | 1,313,000 | 1,124,000 |
| Tasmania | 116,000 | 91,000 | 84,000 |
| South Australia | 3,090,000 | 1,498,000 | 1,144,000 |
| Western Australia | 3,286,000 | 1,665,000 | 1,207,000 |
| Northern Territory | 40,000 | 30,000 | 26,000 |
| **Total** | **18,549,000** | **9,293,000** | **7,037,000** |

Table 6-2 Projected STCs created from PV using time series model – Low scenario

| | 2012 | 2013 | 2014 |
|---|---|---|---|
| ACT | 143,000 | 88,000 | 106,000 |
| Queensland | 5,105,000 | 2,136,000 | 1,422,000 |
| New South Wales | 1,269,000 | 762,000 | 561,000 |
| Victoria | 868,000 | 429,000 | 367,000 |
| Tasmania | 39,000 | 31,000 | 28,000 |
| South Australia | 3,090,000 | 1,498,000 | 1,144,000 |
| Western Australia | 1,150,000 | 583,000 | 422,000 |
| Northern Territory | 40,000 | 30,000 | 26,000 |
| **Total** | **11,704,000** | **5,556,000** | **4,077,000** |

Table 6-3 shows the projected number of STCs created by water heaters by domestic/commercial classification from the time series model. The water heater forecast does not vary as much as the PV projection per year since there is no STC multiplier effect.

There is less than a 10% variation in projected certificate creation over the next three years, although the trend in creation is down. This result is consistent with the cessation of the various state rebates for SWH and HPWH technologies over the next three years.

■ Table 6-3 Projected STCs created from water heaters under Base scenario using time series model – Calendar years

| | 2012 | 2013 | 2014 |
|---|---|---|---|
| Commercial | 512,000 | 422,000 | 419,000 |
| Domestic | 2,826,000 | 2,808,000 | 2,620,000 |
| **Total** | **3,337,000** | **3,230,000** | **3,039,000** |

## 6.4. Certificate projections for DOGMMA

Table 6-4 shows the projected number of STCs created by PV for each state for the next three calendar years according to the DOMMA model. The reduction of STCs produced in 2013 relative to 2012 is due to the PV multiplier dropping from 3 to 2 on 1 July 2012. The subsequent drop in STC creation in 2014 is the result of the PV multiplier dropping from 2 to 1 on 1 July 2013.

- Table 6-4 Projected STCs from PV using DOGMMA – Calendar years

| | 2012 | 2013 | 2014 |
|---|---|---|---|
| Queensland | 6,351,000 | 3,928,000 | 2,706,000 |
| New South Wales (inc. ACT) | 3,895,000 | 2,291,000 | 1,489,000 |
| Victoria | 2,777,000 | 1,693,000 | 1,145,000 |
| Tasmania | 155,000 | 89,000 | 64,000 |
| South Australia | 2,593,000 | 1,565,000 | 1,045,000 |
| Western Australia | 3,373,000 | 2,169,000 | 1,483,000 |
| Northern Territory | 47,000 | 29,000 | 20,000 |
| **Total** | **19,191,000** | **11,764,000** | **7,952,000** |

Table 6-5 presents the aggregated projections of STCs created from water heaters for the next three calendar years according to DOGMMA. The numbers are decreasing over the three years.

- Table 6-5 Projected STCs from water heaters using DOGMMA – Calendar years

| | 2012 | 2013 | 2014 |
|---|---|---|---|
| Total | 3,171,000 | 3,022,000 | 2,719,000 |

## 6.5. Combined STC volume projections

### 6.5.1. Summary of STC projections

Table 6-6 shows a summary of the STC volume forecast produced by the DOGMMA model and the two forecasts produced by the time series model. This is also illustrated in Figure 6-20, which shows that the Base scenario projections are quite similar between the two models, although the DOGMMA projections are consistently higher. The Low scenario projections from the time series modelling are consistently below those of the Base scenario.

- Table 6-6 Summary of Australia-wide total STC projections

| | 2012 | 2013 | 2014 |
|---|---|---|---|
| Time series - Base | 21,886,000 | 12,523,000 | 10,076,000 |
| Time series - Low | 15,041,000 | 8,786,000 | 7,116,000 |
| DOGMMA - Base | 22,362,000 | 14,785,000 | 10,671,000 |

■ Figure 6-20 Australia-wide STC projections for both models

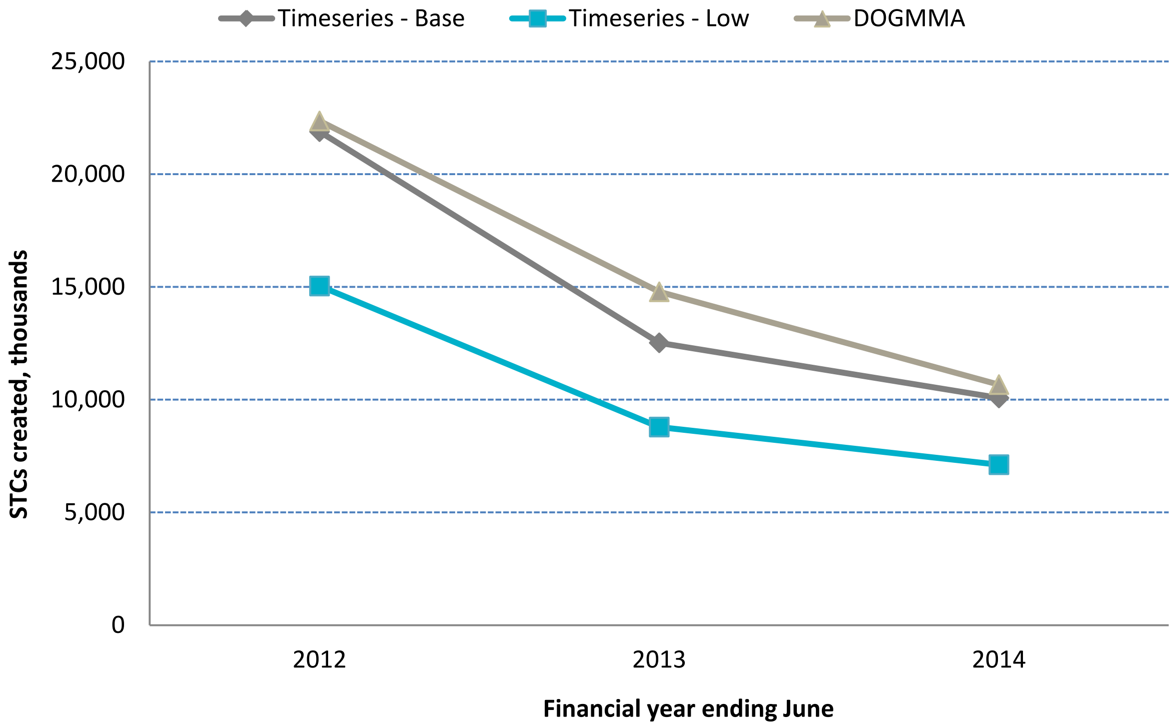



Table 6-7 shows the difference between the total STC projection created by PV and water heaters produced by DOGMMA and that of the time series model under Base scenario. The predictions from DOGMMA are consistently higher than the time series model under Base scenario. The greatest difference between the models occurs in 2013 with the DOGMMA predicting the creation of 18.1% more certificates relative to the time series model. The forecasts are quite comparable for 2012 and 2014.

■ Table 6-7 Difference between DOGMMA and time series total STC forecast under Base scenario

| | 2012 | 2013 | 2014 |
|---|---|---|---|
| Difference | 475,000 | 2,263,000 | 594,000 |
| % Difference | 2.2% | 18.1% | 5.9% |

The projections under the Low scenario from the time series modelling are lower by a range of 30%-40% compared to the Base scenario projections.

# 7. Concluding remarks

In providing these projections of STC volumes over the 2012, 2013 and 2014 calendar years, SKM MMA would like to underline the large level of uncertainty surrounding them. This is evident in the variation of the projections produced for the Base scenario and the Low scenario.

For the Base scenario, both DOGMMA and the time series model predict a down trend in STC creation from 2012 to 2014, mainly driven by the reducing Solar Credits multiplier over this time frame, although installed capacity also falls over this time period. The two models are in fairly close agreement with each other, although there is an 18% difference in the 2013 projection.

The time series model is much more sensitive to short-term trends than the DOGMMA model since it's primarily driven by the immediate net cost. As a result, meaningful projections for PV uptake could only be achieved by limiting the time frame over which the regression to the net cost was performed. This process excluded the extraordinary levels of uptake witnessed in the market, which generally began in the last months of 2010. During this time period, the relationship between net cost and uptake broke down as there was a rush to purchase PV systems in anticipation of the end of various Government incentive schemes. In addition, the recent trend towards installation of systems larger than 1.5kW has made the time series modelling even more uncertain. Therefore the PV installed capacity projections tend to exhibit large standard errors, with the fundamental source of uncertainty being the lack of market history at the current level of net installation cost.

Apparent changes in consumer sentiment towards PV over the last six weeks, characterised by very low uptake levels, led SKM MMA to model a Low uptake scenario, which assumes this subdued sentiment persists for the next three calendar years. The resulting projections are 30% to 40% lower than the Base scenario projections, thus highlighting the large level of uncertainty surrounding STC uptake projections, especially in modelling PV uptake.

SKM MMA has more confidence in the STC volume projections for water heaters produced by both models. The time series model in particular used almost six years of market history to make the predictions. However, these projections only form 14% to 30% of the annual number of STCs expected to be created over the next three years for the Base scenario, and therefore do not carry as much weight as the PV based projections.

With respect to predictions by the time series model for water heater uptake, it should be noted that no account was taken of any structural changes that are not incorporated in the net cost variable. One example not captured in the modelling is that electric water heaters will be phased-out in 2012 and they will no longer be able to be installed in any existing detached, terrace or town house in all states and territories except Tasmania. This development would see a shift in demand towards solar water heaters, which would potentially result in the creation of additional STCs.

# Appendix A DOGMMA model assumptions

## A.1 Constraints

A number of constraints that limit the uptake of distributed generation are included in the model:

- *Economic constraints.* As the capacity of distributed generation in a region increases, the unit cost of generation also increases[14]. This is modelled as reduced capacity factor for all small-scale technologies as more uptake occurs (in the case of wind, this reflects the fact that as more wind farms are built, they are likely to locate in less windy areas).
- *Technical and regulatory constraints.* A number of maximum capacity limits are imposed to mimic the impact of technical limits to uptake in a region or regulatory impediments. The maximum capacity limits can also be used to model the effect of social issues such as the amenity affect of wind generation in residential areas and some sensitive sites.
- *Geographic constraints.* The off-take nodes have been divided into metropolitan and rural nodes and have been utilised to assign the availability of potential capacity in a region for wind and hydro resources.
- *General constraint.* The capacity of distributed generation is not allowed to exceed the local peak demand (as this would entail the need to export power to other regions which would incur additional costs not modelled).

## A.2 Local demand

Forecasts of local demand at each node were derived by taking the actual peak demand for 2006/07, as published by state based transmission planners, and then applying the state-wide peak demand growth rate as forecast by the latest Electricity Statement of Opportunities. The larger states were represented by multiple nodes, whereas South Australia and Tasmania were each treated as single node regions.

Energy consumption for each region was calculated from peak demand by using the state-wide load factor. A correction factor was applied to ensure that the sum of energy consumption at each node equalled state-wide energy consumption.

## A.3 Technical assumptions

Assumed technical parameters for each of the distributed generation options are shown in Table A.1 . Although the model can handle variations in the assumptions by region, we assumed that the technical assumptions for each generation technology were the same in each region. However, the capacity factor for wind generation shown in the table represents the maximum capacity factor achievable in the region. The actual capacity factor decreases as the level of wind generation increases within a region.

[14] This is done to represent the actual likelihood of rising costs as supply increases, and to avoid what is known as the “flip flop” effect that occurs with average cost assumptions, where the model chooses nothing but distributed generation once the cost of distributed generation is lower than the cost of grid supplied electricity.

▪ Table A- 1 Technical assumptions for distributed generation options

| Parameter | Rooftop PV | Small Wind | Small Hydro | Solar Water Heater | Heat Pump Water Heater |
|---|---|---|---|---|---|
| Annual uptake limit as maximum proportion of total demand, % | 0.05 – 0.55 | 0.001 | 0.0001 | 0.1 – 0.3 | 0.1 – 0.3 |
| Maximum plant size | 0.001 – 0.01 MW | 0.003 – 0.03 MW | 0.001 MW | 315 litres | 315 litres |
| Capacity factor, % | 15 - 18 | 16 - 38 | 30 | 20 - 23 | 20 - 23 |
| Outage rates, % of year | 3 | 3 | 3 | 3 | 3 |
| Emission intensity of fuel, kt of $CO_2$e/PJ | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |

Note: PV capacity factors vary by region according to solar insolation levels. Wind capacity factor varies by the amount of wind generation in a region. Source: SKM MMA analysis.

It is assumed that in each region, the actual plant size will be equal to maximum allowed size except for the last plant chosen, which may have a lower capacity.

Unit capital costs are also assumed to decrease over time, reflecting long-term trends. Wind capital costs are assumed to decline 2% per annum by 2020 and 1% per annum thereafter. Photovoltaic system capital costs are assumed to decline by 7% per annum until 2014 and then at 6%, mini hydro systems are assumed to decline at 1% per annum, whereas SWHs and HPWHs are assumed to be flat in real terms since they are more mature technologies.

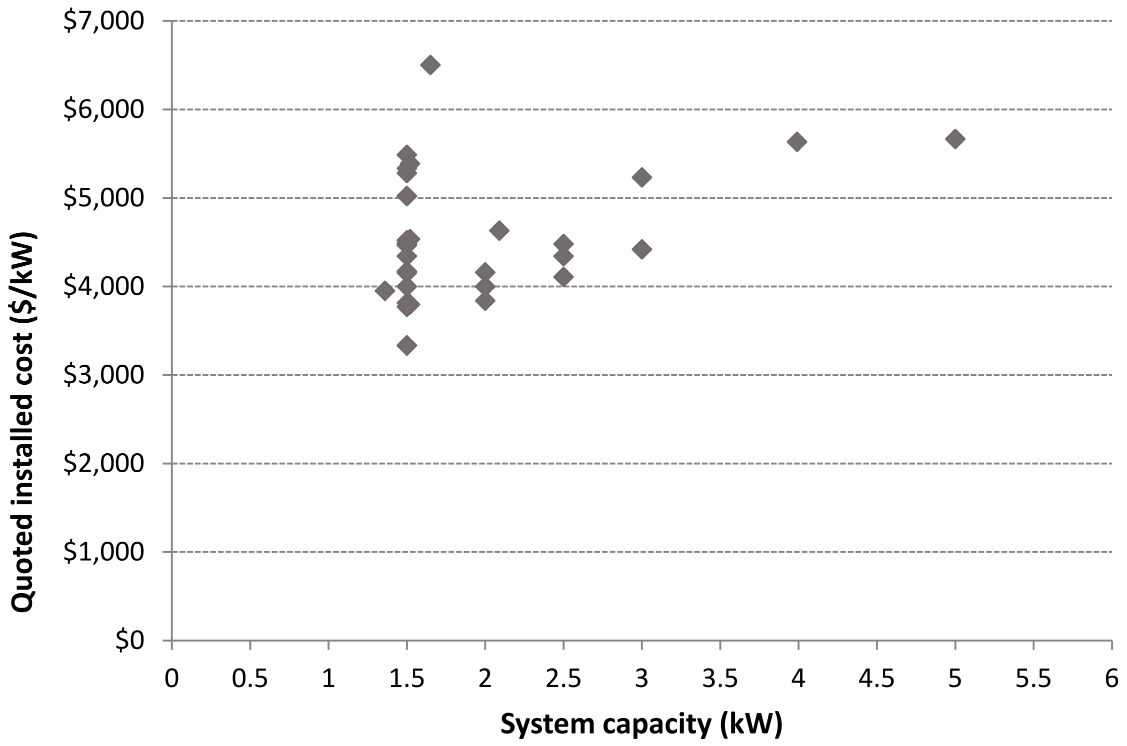
Capital costs are annualised over the life of the plant, assumed to be 15 years for all plants. Costs are annualised using a real weighted average cost of capital set at 5% above the risk-free long-term bond rate (which, based on latest 10 year treasury bond rates, is about 2.1% per annum in real terms).

## A.4 Photovoltaic system parameters

### A.4.1 Costs

The average installed system cost for residential PV has dropped dramatically over the last 24 months and is now around $4,500 per kW in Australia for a typical roof top system. Figure A- 1 shows the results of some market research conducted by SKMA MMA, where the quoted installed costs for PV systems excluding subsidies have been plotted against system size. Smaller systems cost a little more and larger system a little less by achieving some economies of scale and bulk purchase of panels; however installation cost tends to be higher for the larger systems making the total installed cost per kW for larger systems greater than smaller ones.

■ Figure A- 1 Quoted installed cost for PV systems by system capacity, excluding subsidies




There is an international market for PV modules, which keeps pricing in individual countries reasonably linked. Module prices increased from 2003 to 2008 due to very strong demand for PV, driven by strong government incentive programs in countries such as Germany, Japan and California and a shortage of crystalline silicon feedstock. Manufacturers have responded by investing heavily in more manufacturing capacity at larger scale to achieve economies of scale of production. Combining this with a drop in demand due to the financial crisis and falling subsidy support led to 30% decrease in prices in 2009, with a further fall of 20% in 2010.

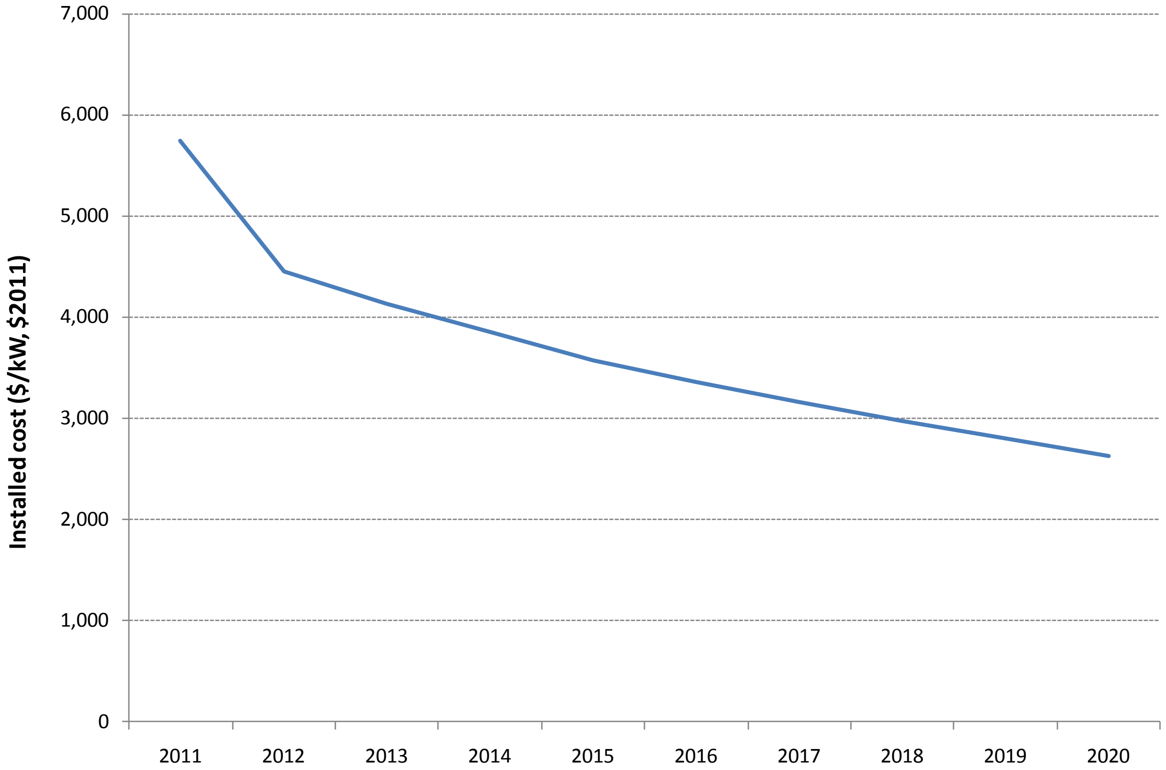
Predicting the future price of any product is difficult and subject to large uncertainties. The key parameters that will determine the future cost of PV cells include:

- Raw material cost.
- Other input costs.
- Economic conditions.
- Demand and production levels.
- Technology.

Many of these parameters are interlinked and improvement in one may force higher costs in another. For example, as costs fall due to increased economies of scale in manufacturing, upward cost pressure may result from the increased demand forcing up raw material costs. However, technology improvements may reduce the quantity of raw material required or the type of material necessary.

Data over the past 25 years have revealed that there has been a 20% cost reduction for every doubling of the cumulative production of PV cells. This linear behaviour of cost with cumulative volume is typical of most manufacturing, and is expected to continue at the historical rate of 20% for each doubling of cumulative production volume. Prices are projected by the EPIA to fall by 7 percent each year in real terms between 2010 and 2015 under their advanced scenario, which is essentially a continuation of current support measures. This also assumes that global demand continues to rise to encourage technology improvements and that manufacturing capacity can keep pace with this demand. SKM MMA's assumed installed cost for PV systems over the next ten years is shown in Figure A-2.

- Figure A- 2 Assumed installed cost for PV systems, 1 kW capacity




### A.4.2 Capacity factors

Photovoltaic cell output is directly related to the intensity of the sunlight falling on the panel. The sunlight intensity or solar insolation varies with global position (effectively distance from the equator), and local climate, such as cloud cover. Across Australia the solar insolation varies significantly and the output of a given solar array is dependent on its location. To account for these variations we have estimated the PV system capacity factors at each of the transmission nodes employed in the analysis using the RET Screen PV Energy Model[15]. The key inputs for this analysis are the geographic coordinates of the locations involved, the orientation, configuration, and tracking of the panel, and the monthly average temperature

[15] RETScreen Energy Project Analysis Software, Clean Energy Decision Support Centre, www.retscreen.net

and solar radiation. The climate data are available from the NASA Surface Meteorology and Solar Energy Data Set[16].

The resulting system capacity factors range from 15% (Tasmanian location) to 18% (northern Australia).

## A.5 Solar water heater and heat pump water heater parameters

### A.5.1 Costs

Installed costs for solar water heaters and heat pumps were estimated by a survey of suppliers for the most popular products. It was found that the most popular residential systems had capacities in the order of 300 litres, with an average installed cost of about $4600 for solar water heaters and $4500 for heat pump water heaters, excluding rebates. Since these are mature technologies, it was assumed that projected installed costs would be flat in real terms.

### A.5.2 Energy displaced

SWHs and HPWHs do not actually generate electricity, but rather they displace either electricity or gas demand (depending on the system they've replaced) by heating water directly. The amount of energy displaced by these systems was estimated from the typical number of STCs such systems are entitled to claim, assuming a 15 year life. This ranged from 1.7 MWh per annum for solar water heaters in Tasmania to 2.0 MWh per annum for solar water heaters in the northern states. A similar range was also applicable to heat pump water heaters.

## A.6 Small wind parameters

### A.6.1 Costs

Distributed wind generation at a scale greater than 0.5 kW has reached a reasonable level of maturity in the market for off-grid power, and is now becoming available and installed in grid-connected applications.

Based on available systems in the 0.5 kW to 20 kW size range, and including all ancillary equipment and installation costs, a correlation between system size and cost has been developed. These costs are based on retail equipment prices and include GST but do not include any government rebates or incentives. Costs for grid-connected wind turbines have become relatively constant over a capacity range of 0.5 kW to 20 kW and are in the vicinity of $6,500/kW but may increase to around $15,000/kW for sub 0.5 kW units.

### A.6.2 Capacity factors

The capacity factor of a wind turbine is a function of the local wind regime and the generation characteristics of the turbine. As an example we have determined average annual wind speeds at each of the regional locations utilised in the modelling of the Victorian nodes using the interactive wind map on the Sustainability Victoria website[17]. For other states, we have used data provided by Government authorities or prorated to available wind generation capacity factors.

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16 http://eosweb.larc.nasa.gov/sse/RETScreen/

17 http://www.sustainability.vic.gov.au/www/html/2123-wind-map.asp?intSiteID=4

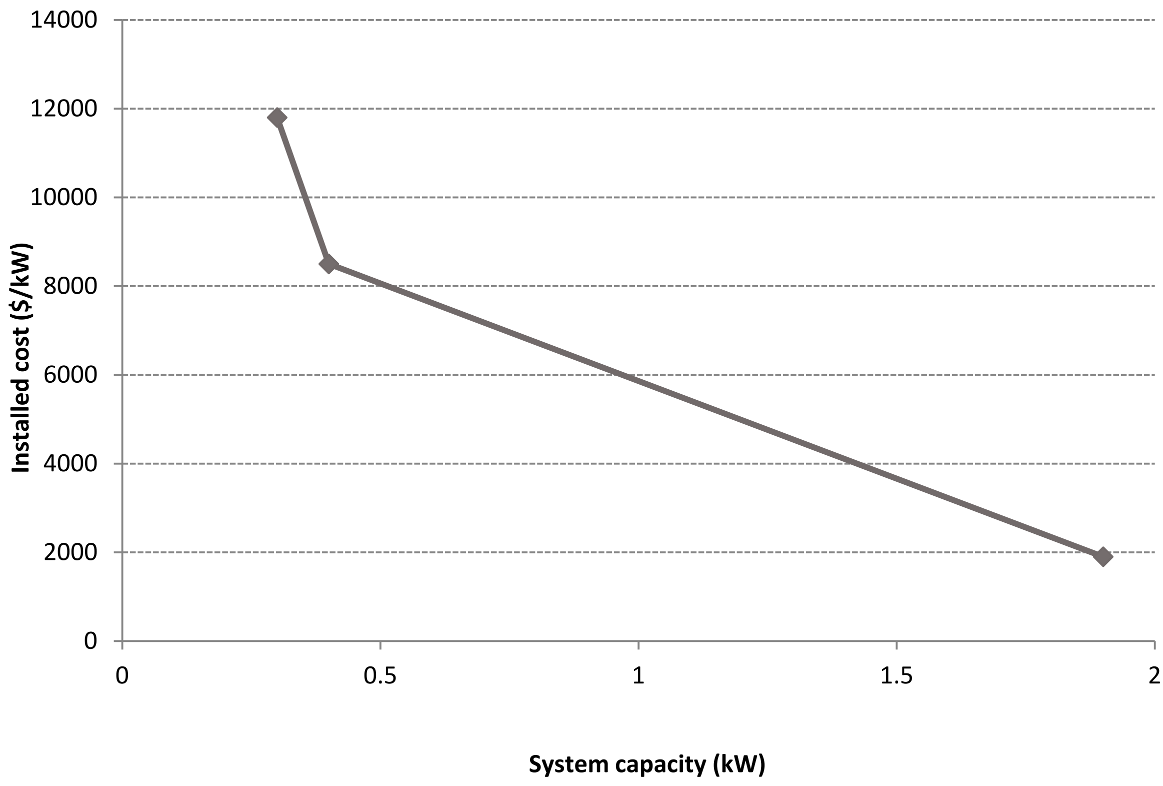
The capacity factors for wind turbines have been adjusted for the fact that they operate at lower altitudes than were measured for the wind maps and available wind farm data. Most wind turbine manufacturers publish the wind speed to power output relationships of their turbines, and these allow the average wind speed to be transformed into an annual energy output that allows the capacity factors to be calculated in each region. We have based the wind-to-energy conversion on the data for a 1.8 kW grid connected turbine manufactured by Southwest Wind Power, but have reduced the outputs by 20% to account for the lower output one would expect in siting conditions that are likely to be less than the ideal. Capacity factors are assumed to range from 15% to 25% throughout Australia.

Note that the capacity factor estimates for each state represents maximum estimates for each region. As small scale wind generation capacity increases, the capacity factors decrease.

## A.7 Mini Hydro

The application of mini and micro hydro systems is rather limited depending on location, and these systems depend on a flowing stream of water. We have determined the costs of mini hydro based on a small number of these systems we have identified. The costs appear to be highly sensitive to size as shown in Figure A- 3.

■ Figure A- 3 Installed cost of mini-hydro systems



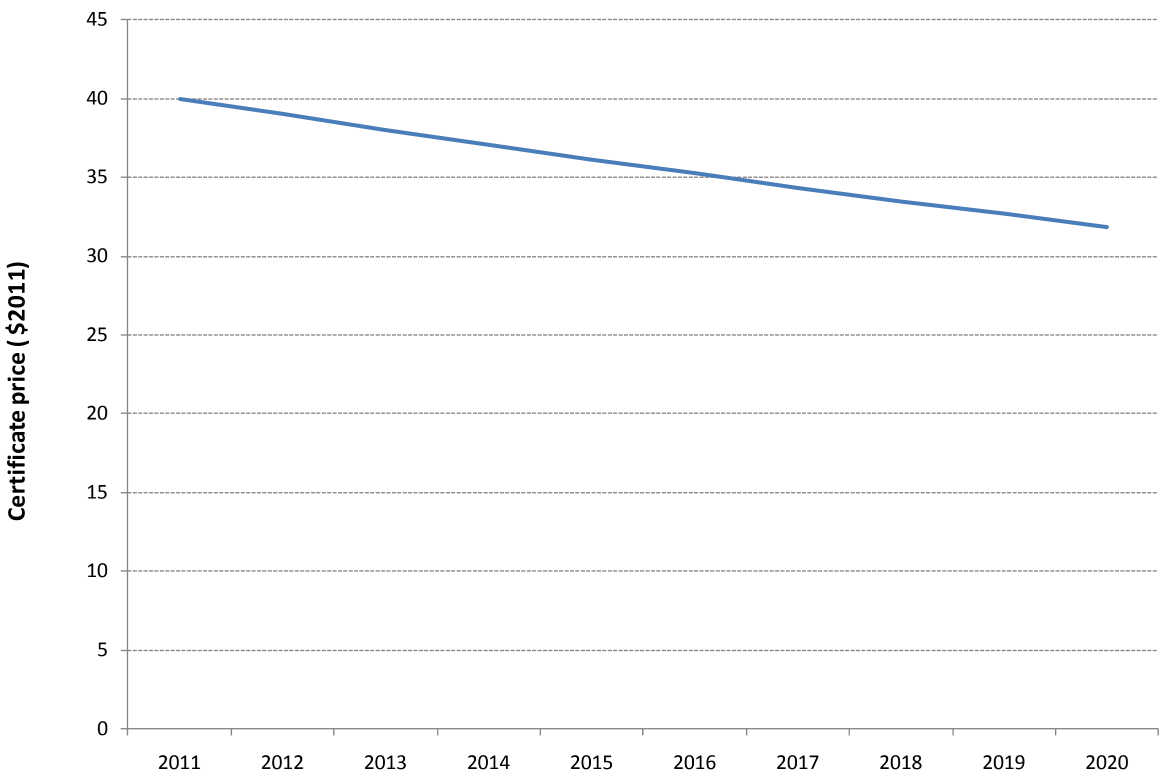

## A.8 Other revenues

Small scale renewable generators are assumed to earn revenue from the sale of STCs. An average system was assumed to be deemed to earn certificates equivalent to their generation levels over a 15 year period. The value of each STC is assumed to be $40/MWh in nominal terms, at thus it deescalates by the inflation rate in real terms as shown in

Figure A- 4. It was assumed that the current oversupply in the STC market, which is depressing the STC price, is only a short term deviation that will correct itself when lower STPs are published in subsequent years to compensate for the oversupply.

In addition, some customer groups are willing to adopt PV systems at above the equivalent cost of grid-supplied electricity. The value of this premium was assumed to be around $2,000.[18] This applied to additional cumulative systems installed up to 30,000, after which no premium was applied.

■ Figure A- 4 STC price projections




[18] This was estimated by adjusting the premium until historical sale numbers are achieved.