"We can either hide from grid parity or we can embrace the challenges… All we ever hear is that [PV] is expensive, can't deliver, or is not worth investing. We rarely hear of the opportunities."

- Mike Sandiford, Melbourne Energy Institute.

Solar PV Forecast for AEMO 2012-2022

Considerations for the Australian Energy Market Operator

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change your position in the renewable energy market

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SolarBusinessServices and SunWiz have made every attempt to ensure the accuracy of its forecast. As it is beyond the ability of any forecaster to predict every future event, SolarBusinessServices and SunWiz do not warrant the accuracy of its prediction. The trends depicted in this report are forecasts only and do not necessarily indicate the extreme range of the trends. In actuality, the top and bottom range may be higher or lower than indicated.

1 Executive summary

Solar Power Can No Longer Be Overlooked

Within Australia, the deployment of solar power has been up until now largely overlooked by parties modelling Australia's energy mix. However, with over 1.3GW of photovoltaic (PV) solar panels now installed in Australia[1], PV is already having an impact upon the electricity industry. Though PV rollout has recently been slowed by a cutback in government support levels, this Solar Forecast for AEMO clearly shows that continued deployment of substantial volumes of PV will continue to occur.

Within a decade, a conservative forecast predicts six gigawatts of solar PV will have been deployed, which could represent 11% of Australia's generation capacity and over 3% of its electrical energy consumption. Under less conservative assumptions, the Internal Rate of Return (IRR) from residential and small commercial systems are predicted to exceed 15% for most of the coming decade, with IRRs exceeding 25% in all states by 2020 in a more optimistic scenario. At the high end, the installation of 15GW over the next ten years is entirely plausible, and would be equivalent to 30% of forecast generation capacity and 7% of electrical energy production, Australia-wide.

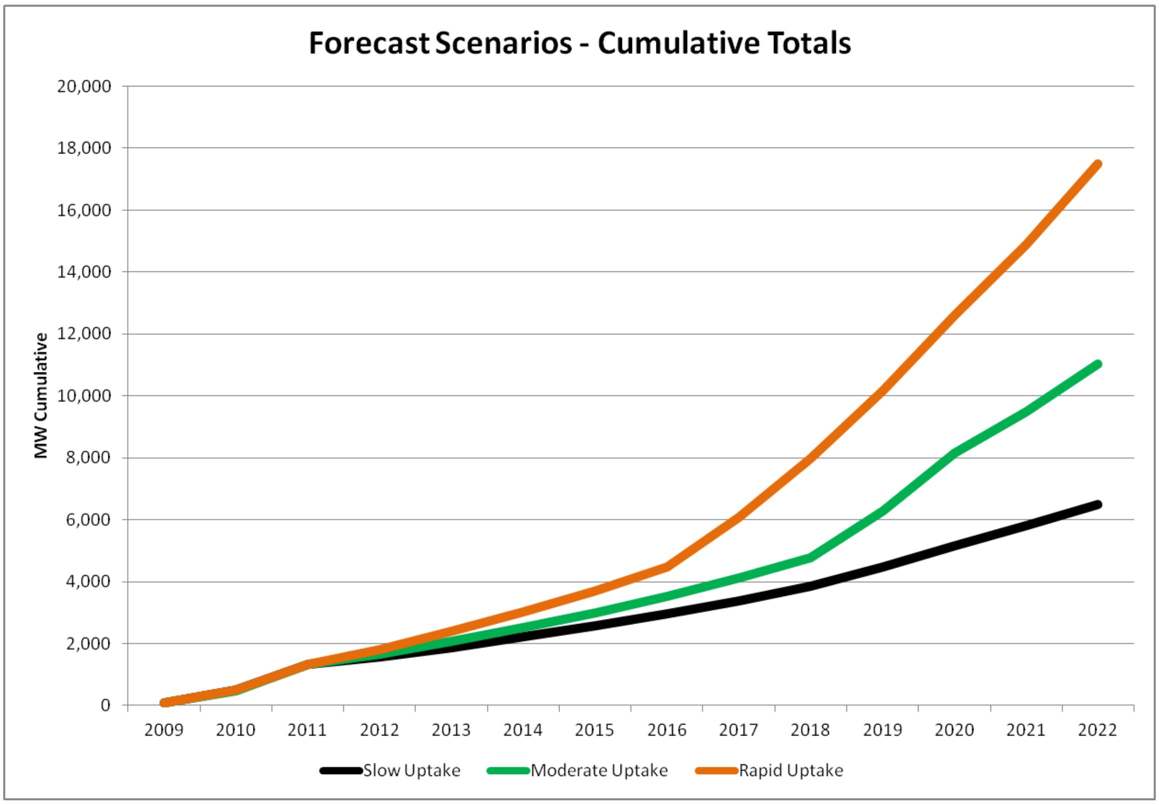

Figure 1: Total PV installed Capacity, Nationwide, cumulative

Such levels of installations have the potential to significantly impact Australia's electricity industry. Issues associated with high levels of low voltage network penetration have already arisen, particularly in long rural feeders. Though technical solutions already exist internationally, without a proactive facilitation strategy by Distribution Network Operators such issues will increase in their

[1] www.orer.gov.au/publications/data.html

range. The impact will also be felt by generators and retailers as generation merit order is changed, transported volumes decrease, and peak pricing events alter in their timing and frequency of occurrence.

Deployment of such a large volume of unregistered, non-scheduled generation could present challenges for AEMO. Not all of this capacity will be connected to the NEM, with a large fraction occurring in Western Australia and in remote mines. However, the economics of solar power dictate that the vast majority is expected to be installed 'behind the meter', i.e. on premises where solar generation primarily reduces grid consumption – rather than being a dedicated solar generator directly connected to the grid and exporting 100% of its energy. Indeed, it is likely that only a small proportion will be a pure power station exporting, potentially complicating AEMO's task of energy forecasting.

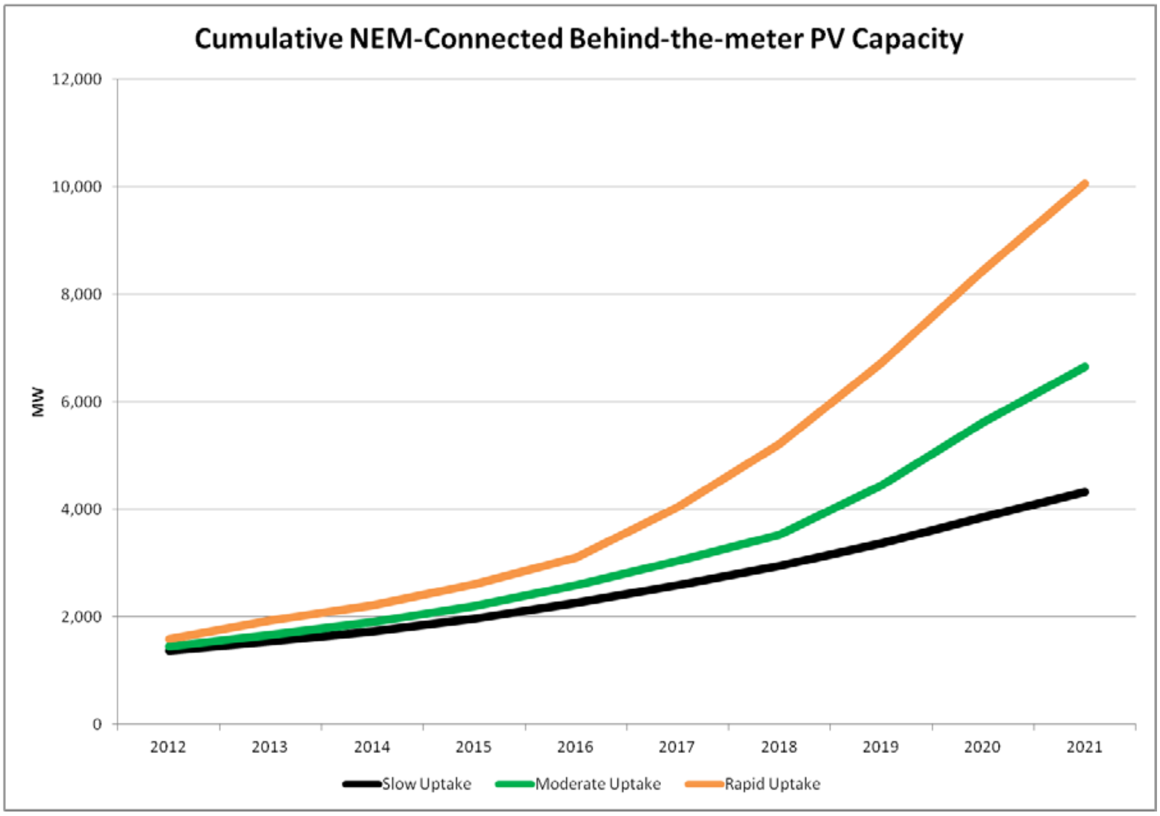

Figure 2: PV Capacity connected to the NEM behind a consumption meter, cumulative

Such deployment of PV has previously been beyond comprehension for many energy forecasters. Overlooking the fact that PV prices are today lower than 2020 modellers' assumed prices, forecasters have predicted that there will be 1.9GW on the grid by 2030[2], perhaps without reference to the 1.3GW to date[3] (0.8GW of it installed in 2011). However, three private consulting firms agreed that there will be 1.2-1.4 GW of small-scale (i.e. <100kW) PV installed over the period 2012-2014[4], though this forecast takes a more conservative line (See Figure 23 in the main document). Bloomberg New Energy Finance predicts 2-5GW of PV systems larger than 100kW will contribute to the later years of the Renewable Energy Target (RET)[5]. In this light, this forecast is entirely credible and could be even considered somewhat conservative.

The sensibility of the forecast can be confirmed by applying a simple 10%-20% CAGR to the prediction of 2012's results, the year about which most is known. Prior to the period when government incentives caused boom years of successive trebling, quadrupling, and doubling of industry size, the PV industry averaged between 10%-25% annual growth (see Figure 25 in main body of document); the forecasts in this document fall within this range, as illustrated by Figure 3.

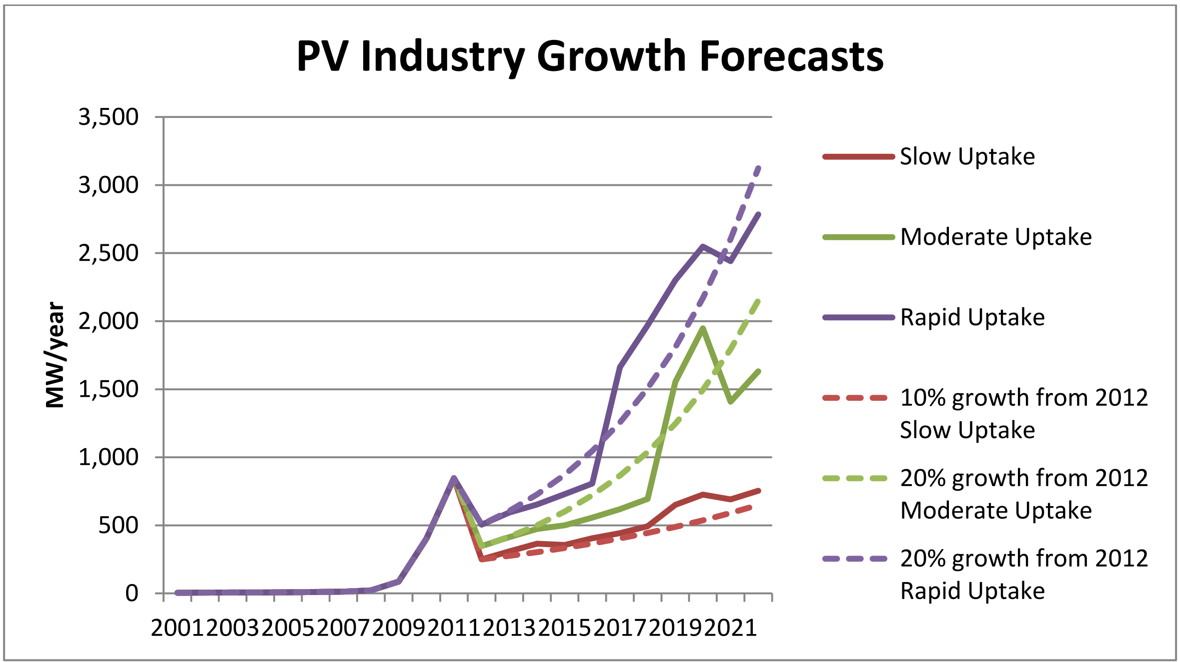

Figure 3: PV Industry Growth Forecasts

It should be noted that these scenarios do not represent the extremes – e.g. a ban on PV installations, or a return to premium gross feed-in tariffs.

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[2] http://www.ret.gov.au/energy/Documents/ewp/draft-ewp-2011/Draft-EWP.pdf, p273, assumes 3.6kWh/kWp/day to convert from TWh to GWp.

[3] www.orer.gov.au/publications/data.html

[4] http://www.orer.gov.au/About-ORER/Reports/reports#modelling

[5] Seb Henbest, "SIGNALS FOR TRANSITION - THE CARBON PRICE & THE LRET", Bloomberg New Energy Finance, EcoGen 2011, 5/9/2011

Organisation-wide Implications for AEMO

[6]

PV deployment of this scale has the potential to impact many areas of AEMO's operations in the electricity market. **Forecasting and planning** will be strongly impacted by PV, which could contribute 50-150% of the forecast growth in generation capacity over the coming ten years[7]. PV is likely to impact upon **loss factors**, and create additional requirements for **Ancillary Services**. **Dispatch** (and its forecasting) will be affected by weather-related factors across a wide area due to the broad swathe of PV installations. Managing a variable non-dispatchable power source will require careful **reserve management**. PV may impact upon the **metering requirements**, and particularly in **network connections**. AEMO's experience integrating wind power into the NEM will service it well, though there will be major differences with a distributed generation on an equivalent scale.

The Economics of the Inevitable

What drives such levels of deployment? Over the coming years, government policy will continue to contribute a great deal through such actions as the solar multiplier, Solar Flagships, the ACT solar Auction, the Large-scale Renewable Energy Target, and possibly the Clean Energy Finance Corporation. However, these policies merely accelerate deployment of solar, which (due to its economics and simplicity) will in the medium-term will inevitably be popular as a simple way of reducing the high costs of residential and commercial power. Further, the rapid deployment scenario sees solar electricity as being cost competitive with the wholesale price of generation by 2022 when reduced transport losses and time-of-day value are accounted for.

> *"[US Energy Secretary] Chu's predictions means that the government's of the world's three biggest energy users, China, the US and India, each believe that the cost of utility scale solar will be cheaper than fossil fuels by 2020 at the latest."*[8]

The fundamental drivers of increasingly favourable financial returns for solar power are the ever increasing residential electricity price and the ever-decreasing price of solar power systems. Figure 4 demonstrates the financial returns available from a 5kW system (assumed to export 50% of its power), under a range of electricity price forecasts. The reduction in solar multiplier and anticipated end to feed-in tariffs notwithstanding, solar power is clearly attractive to the end user.

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[6] http://www.aemo.com.au/corporate/org.html

[7] Assumes 61GW of generation by 2022 from a starting point of 49GW, with PV deployment of 6.7-18.1GW by 2022 from 1.2GW by end 2011

[8] http://reneweconomy.com.au/2012/now-us-says-solar-pv-to-be-cheaper-than-fossil-fuels-by-2020-2020

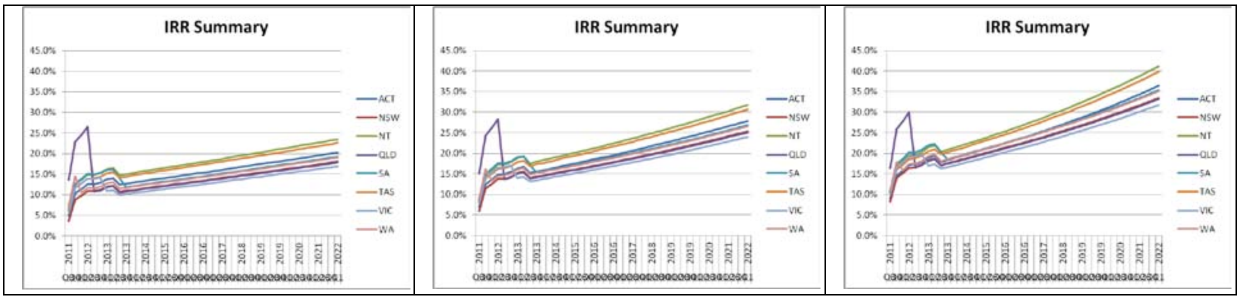


Figure 4a, b, c: IRR of a 5kW system with residential electricity price indexed at 0%, 2.5% and 5% and wholesale prices as per Carbon Price Modelling[9], adjusted for time-of-generation and loss-reduction.

Slow Uptake: Indeed, it would take a dramatic fall in the Australian Dollar, turnaround in recent trends in electricity prices, breakthrough in other renewable energy technologies, or an act of deliberate market protectionism to withhold Australian PV installations to 6 GW over the next decade.

Moderate Uptake: A more likely scenario is steadily increasing demand from the residential and commercial sectors, and a considerable contribution to the RET in its later years, resulting in 10 GW over the coming decade. Such levels of demand could force gentailers to embrace PV, in order to continue to sell energy of some form.

Rapid Uptake: It is well within the realms of possibility that, should current electricity prices trends continue (for any number of reasons), PV being as cheap as wholesale time-of-day power by the end of the decade would result in surging demand for PV on all commercial buildings, households doubling their system size, and CEFC assistance resulting in a previously unthinkable contribution to the RET resulting in 15 GW over the coming decade. With financial returns in all sectors equivalent to those seen in NSW's solar heyday, such demand for solar would have an unprecedented impact upon the electricity sector – with 30% of standing capacity, solar would have the potential to cause frequent shutdowns of gas turbines.

Scenario	GW cumulative by end 2021	NEM Connected behind the meter 2021	Percentage of National Generation Capacity, 2021	Percentage of NEM Generation 2020[10]	Percentage of owned homes with PV 2020
Slow Uptake	5.8	4.3	8.3%	2.0%	23%
Moderate Uptake	9.5	6.6	13.5%	3.0%	28%
Rapid Uptake	14.9	10.0	21.4%	4.5%	36%

Table 1: Summary of various scenario components

[9] "Strong Growth, Low Pollution - Modelling a Carbon Price", Chart 5.27

[10] Behind the meter, does not include solar farms

Such figures suggest the PV industry has a remarkable contribution to make to the Australian energy mix. However, government support remains essential in the medium term to sustain a solar industry until the point at which it can deliver such results without additional assistance - Figure 4a shows the solar multiplier and retail-equivalent feed-in tariffs just manage to keep IRR above 10% in the larger Australian states. However, should recent electricity price trajectories continue, PV financials become so attractive as to pose the question: how effectively the inevitable wave of PV deployment can be managed?

Indeed, though deployment on this level may threaten current vested interests, PV can (in the authors' opinion[11]) deliver outstanding benefits to the Australian community, environment, and economy. On the basis of PV's inevitable financial favourability within a decade, it is likely that today's owners of fossil fuel generators will be heavily invested in the deployment of solar power in the not too distant future. Furthermore, rather than relying entirely upon government or the top 500 Australian energy users to address climate change, most of the investment in solar electricity generation (and associated emissions reductions) entailed in the forecast would come from home and business owners, leveraging billions of private dollars to mitigate climate change and improve the financial sustainability of businesses. In the long run, the fewer barriers there are to solar power, the sooner solar power can distribute its benefits, to the betterment of current and future generations.

This document describes a range of modelled outcomes based on the latest available data.

A material solar generation sector results, regardless of the assumption set.

This means a significant contribution of PV to Australia's energy mix is inevitable.

The energy industry must now plan for a future that will be materially impacted by solar energy.

Reducing barriers to deployment will accelerate benefits for current and future generations.

[11] As is the rest of this paragraph

Contents

2 Australian PV industry summary/history

From not-so-humble beginnings, Australia's worldwide-leading PV sector of the 1990s was squandered in the first six years of the millennium. Historically sustained by an off-grid market unparalleled in any developed economy, Australia was late to catch onto the opportunities presented by grid-connected PV. Once policy settings changed in 2007, Australia's grid-connected PV industry exploded; with residential-focussed policies meaning Australia installed more systems in 2010 than Germany in the 1-10kW range[12].

Ironically, the phase-out of support for solar power created a surge of demand in 2011, with the result that more than 800MW was installed in a single year[13], almost ten times the amount installed two years prior, and doubling the 400MW installed in the previous year (See Figure 5). A spike in installation activity occurred in the months running up to the wind-back of the solar multiplier; the aftermath saw installation levels fall back to levels similar to those of late 2010. (See Figure 6a). The absence of a feed-in tariff left the ACT and NSW markets reeling after the backlog of applications was installed, though changes to feed-in tariffs in SA, VIC, and WA eased the blow nationally (See Figure 6b). However, the replacement support levels are significantly lower in SA and VIC (exported energy attracts approximately the retail price of electricity), and all but absent in WA, so further declines are expected in these key states. In spite of this, there is now over 1.3GW of PV in Australia and 2012 sales and installation activity has recovered somewhat in some states, though market consolidation is expected in the coming years.

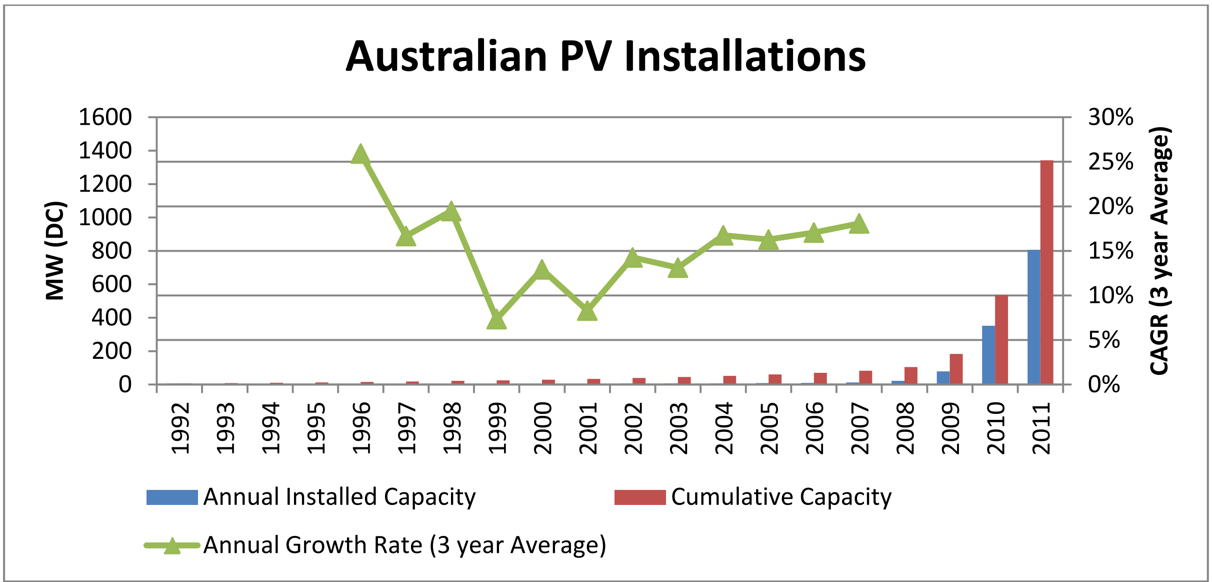
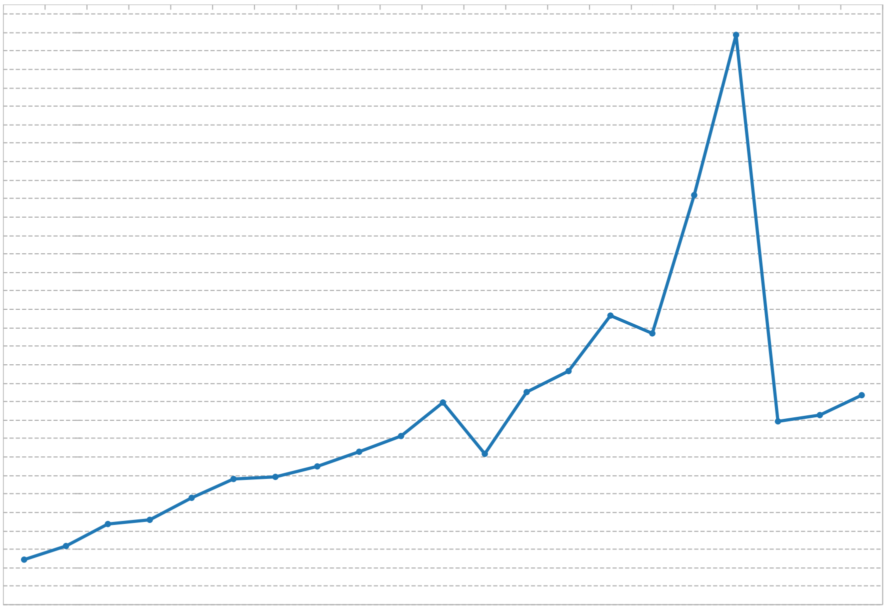


Figure 5: kW installed annually[14]

[12] http://www.renewableenergyworld.com/rea/blog/post/2011/03/australian-solar-industry-installs-more-small-pv-than-germany-in-2010

[13] www.sunwiz.com.au/index.php/interactive-hot-spots.html, based on data from http://www.orer.gov.au/publications/data.html

[14] http://www.apva.org.au/sites/default/files/documents/APVA%20Status%20Reports/PV%20in%20Australia%202010.pdf and 2011 data sourced from ORER.



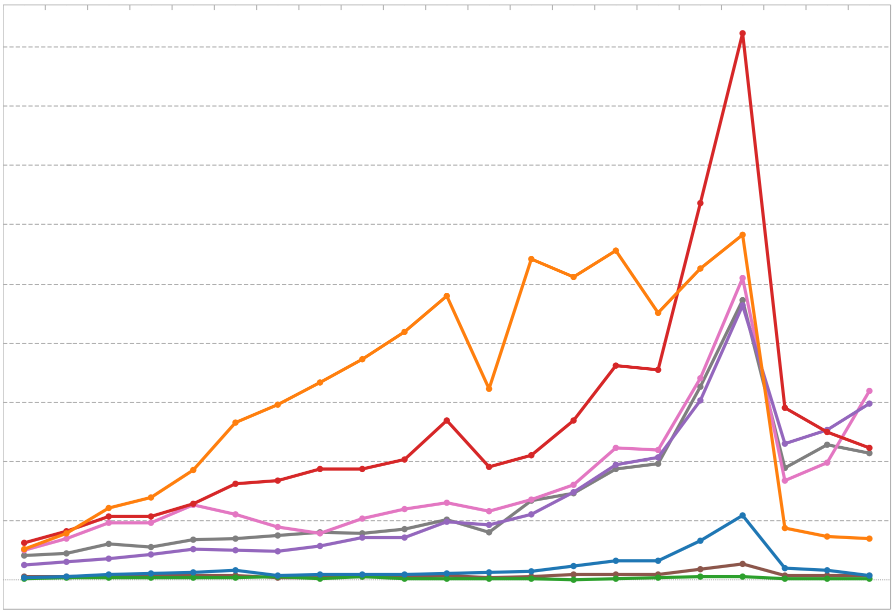


Figure 6 (a & b): Changing state of the Australian PV industry (Above: National, Below: by State)[15]

[15] www.sunwiz.com.au/index.php/interactive-hot-spots.html, based on data from http://www.orer.gov.au/publications/data.html

It is worth noting that nationally, it is estimated that 8% of all suitable homes are fitted with one of nearly 400,000 PV systems (See Figure 7). Despite NSW having the highest number of PV systems in Australia, SA continues to lead in market penetration with over 12% of residential roofs fitted with PV. In contrast, only one in twenty non-rented homes in Victoria host a PV system.

Therefore, a vast potential market of 4.2 million residential dwellings remains available across Australia. Assuming an installed cost of A$4/W and an average system size of 2kW, this represents a potential market value in the order of $33 billion dollars in present terms, with system upgrades and 173,000 new dwellings per year[16] providing further room for market expansion.

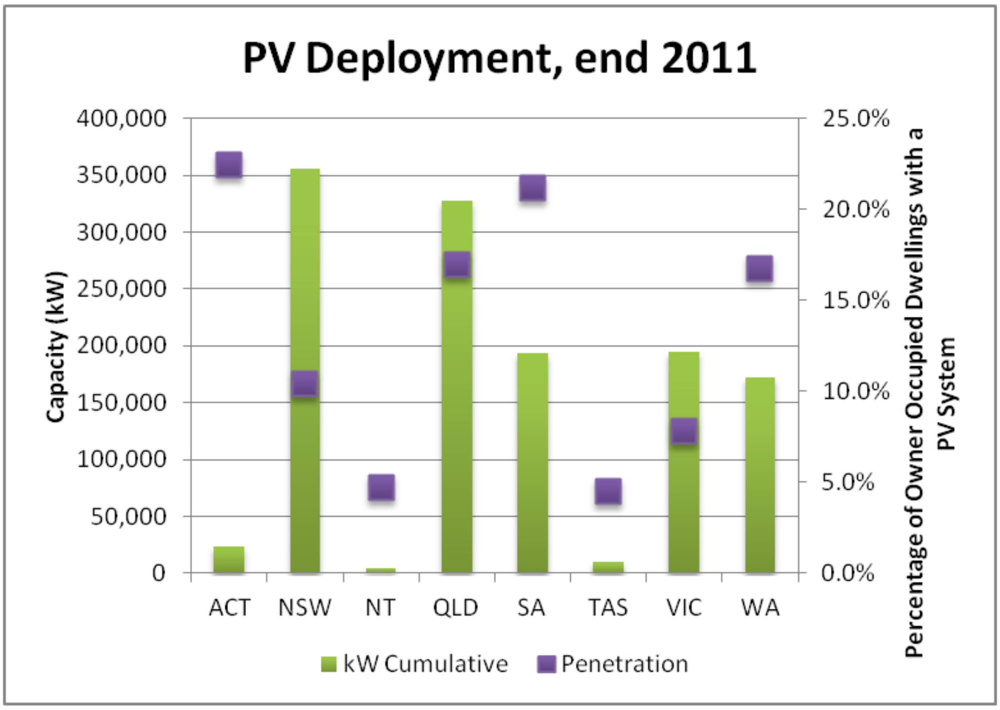


Figure 7: Penetration of grid-connect PV into owner-occupied homes[17]

[16] IES, "Modification Of The Solar Credits Multiplier" - Report for the Clean Energy Council, 31 March 2011

[17] Source: ABS 2006 Census, ORER

3 Key market drivers and issues

3.1 Key market Drivers

3.1.1 Government Policy

There have been a number of drivers of solar power in Australia. Those that remain relevant in the period of the forecast include feed-in tariffs, the Renewable Energy Target (RET), and the solar multiplier that applies in the Small-scale Renewable Energy Scheme (SRES). These policy drivers are now declining: the popularity of feed-in tariffs as a policy support mechanism is on the wane, and the solar multiplier will reduce over the coming years, though the RET is expected to support a significant number of solar projects over 100kW. Policy can also affect solar indirectly: for example the vocal resistance to wind farms, their new exclusion zones and deployment time frames are likely to lead to a greater requirement for solar power to meet the RET. In addition the Clean Energy Finance Corporation will likely act to stimulate the uptake of large-scale PV by reducing the project risk, thereby providing access to lower-interest finance.

3.1.2 Electricity prices

Electricity prices are one of the greatest drivers of PV uptake. A great deal of PV uptake may have been subsidy-driven, but electricity prices are now approaching levels equivalent to feed-in tariffs in some locations. Electricity prices are already impacting consumer's habits[18], reducing electricity consumption. In an effort to continue to sell energy, many of Australia's major electricity retailers, such as Origin Energy, AMU Solar, and TRUenergy, now sell PV systems.

Network expenditure to meet peak demand is responsible for the majority of the energy price increases[19]. The reduction in the amount of energy transported, both due to energy efficiency and distributed generation[20], is likely to exacerbate this situation. Additionally, electricity prices are set to rise on the back of a carbon price, and electricity prices for small businesses are already often higher than residential tariffs.

3.1.3 Carbon price

The carbon price is keenly focussing the attention of residents and businesses upon their electricity consumption. Though the carbon price has marginal impact upon financial outcome from an investment in PV on residential buildings, the carbon price has a disproportionately greater impact on the lower prices paid by the commercial sector. The threat of the carbon price and the ease with which PV can reduce businesses emissions has already driven strong levels of interest, and is expected to do so for years to come.

3.1.4 Grid parity and levelised cost of electricity

In simple terms, grid parity is reached when the effective price of purchasing one unit of PV energy is the same or lower than the cost of buying one unit of energy from the grid. At this point, PV

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[18] AEMO, "2011 ELECTRICITY STATEMENT OF OPPORTUNITIES For the National Electricity Market", 2/3/2012

[19] http://www.aemc.gov.au/market-reviews/completed/future-possible-retail-electricity-price-movements-1-july-2010-to-30-june-2013.html

[20] AEMO, "2011 ELECTRICITY STATEMENT OF OPPORTUNITIES For the National Electricity Market", 2/3/2012

becomes economically viable in broad terms. The effective price of purchasing PV is best described by its levelised cost of electricity (LCOE). Several analyses by the Australian PV Association demonstrate that PV is often already a cheaper option than residential and small-business tariffs[21] – a situation that will almost certainly apply to commercial and wholesale electricity prices in the coming decade.

3.2 Key market issues

3.2.1 Market regulations

The current structure of the Australian electricity market presents barriers to the deployment of distributed energy in the absence of a mandated feed-in tariff[22]. As network charges (transmission use-of-service and distribution use-of-service) are payable on any power that is exported to the grid, no matter how far it travels, the economics of exported power are penalised to the point of being unfavourable. This inhibits the ability for one PV system to sell power to a neighbouring site, constraining system size to meet a site's minimum daytime demand and preventing development of distribution network-connected small PV farms. This barrier might be reduced in a few years' time, should the Australian Energy Regulator heed many stakeholders' calls to reform the market[23].

The impact of this barrier is to favour small PV systems in order to avoid power exports in states without a mandated value on power fed into the grid. While a 1.5kW system may generate one-third of the average household's energy needs, as household consumption is typically low during the middle of the day, a significant proportion of solar generation is exported to the grid. In Western Australia and New South Wales, this power is valued at far less than the price of imported electricity, effectively acting as a disincentive for larger systems. However, towards the end of the decade, this forecast predicts that the value of exported electricity may equal PV's LCOE, meaning that power exports can be profitable (see Figure 14). This would result in larger systems (and upgrades of existing systems).

3.2.2 Industry capacity

The PV industry in Australia comprises more than 2,000 companies and an estimated 15,000 individuals with a wide variety of expertise. These companies have successfully built business models delivering a high volume of standardised residential systems. However the feed-in tariffs have supported business inefficiencies and market consolidation is expected to occur.

The capacity of these companies to adequately manage the requirements of *commercial* PV opportunities varies depending on the market segment. However, it is fair to say that almost all are considering the commercial market and many have successfully conducted commercial PV projects

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21
http://apva.org.au/sites/default/files/documents/APVA%20Reports/Residential%20Sector%20Modelling%20of%20PV%20and%20Electricity%20Prices%20-%20APVA%20Nov%202011.pdf
http://apva.org.au/sites/default/files/documents/APVA%20Reports/Commercial%20Sector%20Modelling%20of%20PV%20and%20Electricity%20Prices%20-%20APVA%20Nov%202011.pdf

22 http://www.ipart.nsw.gov.au/Home/Industries/Electricity/Reviews/Retail_Pricing/Solar_feed-in_tariffs/14_Mar_2012_-_Final_Report/Final_Report_-_Solar_feed-in_tariffs_-_March_2012

23 http://www.ipart.nsw.gov.au/Home/Industries/Electricity/Reviews/Retail_Pricing/Solar_feed-in_tariffs/14_Mar_2012_-_Final_Report/Final_Report_-_Solar_feed-in_tariffs_-_March_2012

over recent years[24]. The majority of experience has been at the smaller end of the size range, and only a few companies have the capacity and capability to conduct very large projects. Like most major project markets, consortia or joint ventures are increasingly common for commercial PV projects and (arguably) essential for large projects due to the diverse requirements necessary to implement complex engineering and financial project management.

3.2.3 Network connection

The connection of PV systems to grid networks is rapidly becoming a significant barrier and a potential opportunity at the same time. Grid networks were not historically designed to cater for distributed generation and the characteristics of PV are unique. Grid network operators and the regulatory environment they operate within are also poorly suited to PV at scale and as a result a significant overhaul of the network rules and regulations is required to adequately and more efficiently cater for increasing amounts of PV.

Network issues have arisen in areas with large volumes of residential PV installations on weak areas of the grid such as in remote or rural networks. This voltage control problem is less significant in the commercial PV segment where generation more closely matches load profile. However, phase balancing and management of active and reactive power become more important in commercial installations, as do network obligations to ensure quality and safety of the existing electricity network. This can result in onerous requirements being placed on PV installations, which can include additional equipment to ensure anti-islanding, phase balance, harmonic distortion, and avoidance of power exports.

There are a number of technological possibilities to assist in overcoming these issues including smart inverters and energy storage with a number of trials already underway. There is a distinct likelihood that even small commercial PV could require active and or intelligent control mechanisms in the near future and large project proponents should consider it a prerequisite.

3.2.4 Upfront cost and finance

Upfront cost has been identified as a major barrier to the greater uptake of PV for decades. In a residential market it has proven itself to be less of a barrier when it is below a certain threshold that makes it a discretionary purchase decision– hence the proliferation of "sub-$3,000" offers.

However, in commercial markets a much more rigorous approach needs to be taken to potentially satisfy shareholders, accountants and other stakeholders who have clearly defined expectations of internal rate of return (IRR) on capital used. In this case, up-front cost remains an issue but its costs and benefits must be translated into IRR and take into account taxation, depreciation and finance costs if applicable. The Australian experience with finance has logically been focused on the residential segment (as the largest market segment) although this is slowly changing.

Ultimately, at the larger end of the projects spectrum, the issue of finance tends to become blended as one of many elements in the ultimate project agreement. Power purchase agreements (PPA) are increasingly the front end of the deal, becoming a means to fund the repayment of finance and costs through guaranteed PV energy sale prices. However, due to oversupply of LGCs and given the

[24] http://www.sunwiz.com.au/index.php/large-system-list.html

electricity ‘gentailers’ stranglehold on the market, offers for PPAs are generally currently unfavourable to third-party developers.

3.2.5 Bankability

A final factor also weighs into the international mix of risks for the Australian PV market: bankability – the willingness of banks to fund only equipment from proven manufacturers. Crucially, a relatively small number of the many hundreds of PV manufacturers around the world are considered bankable, and which manufacturers appear on such lists varies with time. Those companies who are not considered bankable target markets where large scale finance is not required. Historically, Australia has been just such a market. With a primarily residential market, bankability is not an issue here. As a result, a proliferation of small, new, and almost completely unknown companies supplying the majority of product in our market has occurred. Typically non-bankable product sells at a discount to bankable product, driving price down.

As Australian commercial PV market opportunities grow, the issue of bankability will become increasingly important and non-bankable PV manufacturers are likely to see increasing pressure to comply or exit the market. Furthermore, project financiers will only lend to strong stable project owners with projects built by reputable installers, and whose power is guaranteed to be purchased by reliable customers. Thus, bankability will extend its influence down through the industry whenever large sums of finance become involved. Given the precariousness of many PV integration businesses, stable and experienced PV integrators are most likely to be able to service the market, but only if they can compete with experienced foreign companies backed by international financiers with greater confidence in PV than Australia’s banks.

3.2.6 Merit Order Effect

The potential for PV to impact wholesale electricity prices through the Merit Order Effect (MOE) has intensified recently in Australia. This follows recent analysis from Germany (amongst other countries) where the high penetration of Wind and PV has now been demonstrated to have lowered wholesale electricity prices through the MOE[25], particularly in 2011.

The University of Melbourne, through its Melbourne Energy Institute, has recently completed a draft report titled “Retrospective modeling of the merit-order effect on wholesale electricity prices from distributed photovoltaic generation in the Australian National Electricity Market”. Arguably this is the most current and comprehensive modelling study conducted to date on the potential for PV to reduce wholesale prices through the MOE and its findings have significant ramifications for the future make up of our electricity industry and the options and impacts of incentivising PV.

Whilst the report is subject to final reviews, its draft findings found that in summary “For 5GW of capacity, it was found that the value of the Merit Order Effect would have been $1,229 million in 2009 and $628 million in 2010.”[26] The impact of the installation of 1, 3, and 5 GW of PV upon the demand pool in summer, and the bidding stack, is shown in Figure 8.

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[25] http://reneweconomy.com.au/2012/merit-order-how-solar-fits-could-cut-energy-bills-for-all

[26] Source: http://www.centralvictoriasolarcity.com.au/wp-content/uploads/2011/12/Energy-Matters.pdf

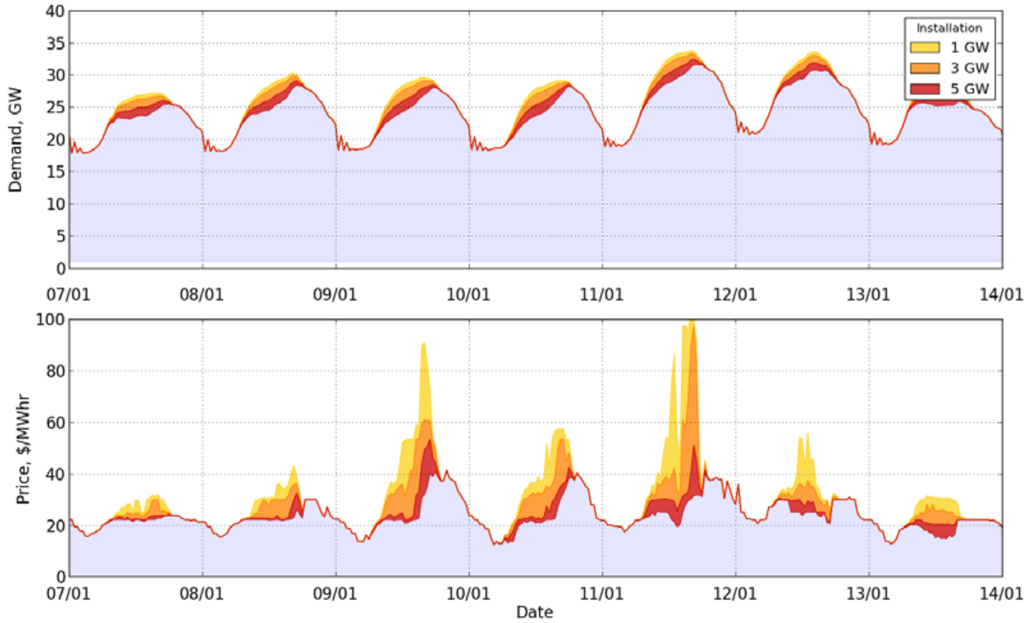

Figure 8: Merit Order Effect[27]

[27] Dylan McConnell; Patrick Hearps; Dominic Eales; Rebecca Dunn; Lachlan Bateman, "Retrospective modeling of the merit-order effect on wholesale electricity prices from distributed photovoltaic generation in the Australian National Electricity Market", Melbourne Energy Institute, Draft, September 2011

4 Methodology and definition of scenarios

4.1 Methodology

A two-stage process was taken for this forecast. The first stage involved performing detailed modelling of the financial attractiveness of an investment in solar power for each quarter out to Q1, 2022. The second stage involved translating the economic attractiveness of a solar investment into a forecast amount of uptake in the relevant quarter. At each stage, three scenarios were developed representing conservative, moderate, and optimistic assumptions.

The forecasting process utilises the authors' knowledge and more than 20 years combined experience in the PV industry. Over 2012-2016, the national forecast for AEMO is closely aligned with a forecasts prepared each year for the industry itself[28], but have been adjusted to meet AEMO's needs by considering only NEM-connected systems situated behind the meter (i.e. excluding solar farms).

It must be noted that the second stage of the process is based upon a subjective interpretation of the results from the first stage. A "rational agent" model of PV demand, in which demand is directly linked to financial return, has repeatedly proven inaccurate due to complicating factors including boundary events when government incentives drop, upfront pricing, consumer sentiment, and (in future) network constraints. As such, the second stage of forecasting is not mechanically linked to the financial returns forecast from the first stage, but rather an interpretation of the first-stage results implications for uptake.

It should also be noted that second-order affects are not considered. For example, the time-of-generation value of PV exports, which is currently significantly higher than average NEM pool price, may reduce as PV penetration on the grid increases. So too, a high carbon price may have affect the exchange rate, which would affect the price of PV systems.

Finally, it must be noted that the forecast scenarios do not correspond to the extremes of all scenario inputs occurring coincidentally. Such 'perfect storms' can and do occur, such as in 2011 in which cuts to feed-in tariffs and an accelerated reduction in solar multiplier acted to massively increase demand for PV. The forecasts do not consider events such as a ban on PV installations, nor a return to return to premium gross feed-in tariffs. The scenarios are based upon keeping PV price reductions at

4.1.1 Data sources

SunWiz and SolarBusinessServices monitor key industry indicators on a daily basis. E.g.:

- SunWiz's Market Insights[29] tracks monthly REC Registry registrations to assess performance of PV retailers, identify system size trends, and track large-scale systems
- SunWiz's Solar Hot Spots[30] tracks quarterly installation metrics at a postcode level, identifying trends in market demographics that influence solar uptake

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[28] SunWiz, Solar Business Services, "Australian PV Market Forecast 2011-2016", November 2011 - http://www.sunwiz.com.au/index.php/industry-services/market-forecast.html

[29] http://www.sunwiz.com.au/index.php/australian-pv-market-data-insights.html

- SolarBusinessService's PV Price Tracker constantly monitors retail, wholesale and factory gate PV prices
- SolarBusinessService's Channels Report constantly monitors channel activity, strategic changes and volumes
- Regular policy analysis both internally and for clients
- Attendance at major conferences
- Membership on the PV Directorate, and through memberships with the Clean Energy Council (CEC), Australian PV Association (APVA), Solar Energy Industry Association(SEIA), and the Australian Solar Energy Society (AuSES)

4.2 Forecasting Financial Attractiveness

The electricity price for offset consumption was obtained by researching and averaging current market offers in each state. The 2012 electricity price in each state is presented in Table 2. The electricity in subsequent years was raised on the 1st of July of each year by a variable amount: 0%, 2.5%, and 5% above inflation (2.5%), depending on the scenario – with the exception of the first year in which a price rise summarised by the Australian Energy Market Commission[31] was used, as shown in Table 2. The resultant electricity prices are shown in Figure 9.

	ACT	NSW	NT	QLD	SA	TAS	VIC	WA	ACT
1/1/2012 Price of electricity (offset consumption)	15.0	21.2	19.2	20.7	23.7	20.8	23.1	21.0	15.0
Price index on 1/7/2012	13.6%	8.2%	2.5%	9.4%	5.5%	3.4%	8.1%	13.7%	13.6%

Table 2: Electricity price and price index for each state

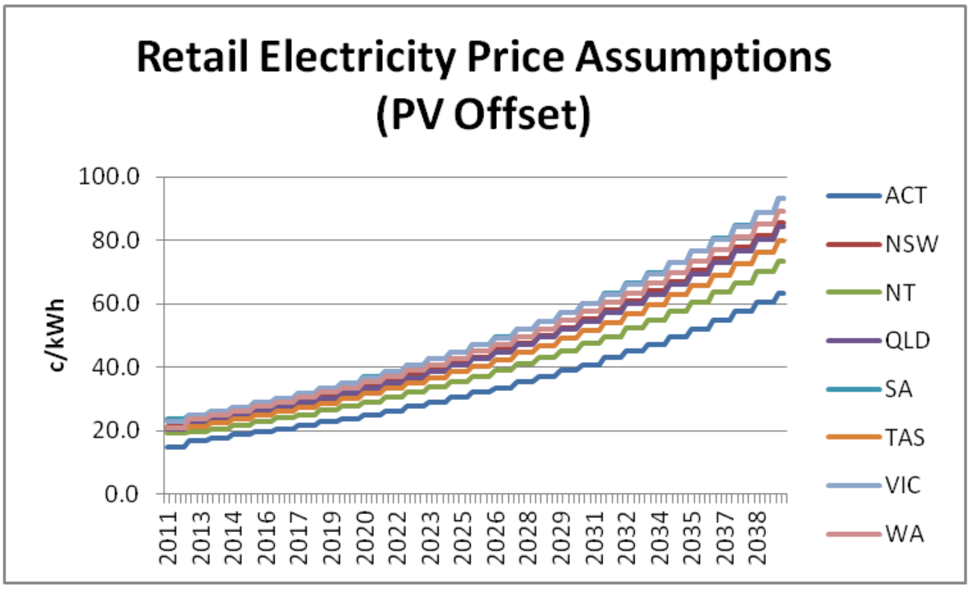


Figure 9: Retail price assumptions (PV offset) – for Moderate Uptake Scenario.

[30] www.sunwiz.com.au/index.php/industry-services/solar-hot-spots-target-suburbs.html
[31] http://www.aemc.gov.au/market-reviews/completed/future-possible-retail-electricity-price-movements-1-july-2010-to-30-june-2013.html

The price of electricity export was assumed to be equal to the feed-in tariff currently in force in each state or territory. Following the conclusion of the feed-in tariff, the value of exported energy was assumed to be the predicted price of electricity in the wholesale market, plus 10% (accounting for avoided losses in distributed generation), plus 50% (accounting for time of day premium on production). The base level for wholesale electricity prices was sourced from the Carbon Price modelling[32], in which the global action price was associated with the low scenario, the Clean Energy Future associated with the medium scenario, and the high price associated with the high scenario. This set of assumptions brings export values into line with those currently offered voluntarily or regulated. The summary of settings are shown in Table 3.

	Export Value
ACT	Equal to the retail price of electricity
NSW	Equal to the wholesale price of electricity, adjusted for losses and time-of-generation value
NT	Equal to the retail price of electricity
QLD	Equal to the wholesale price of electricity, adjusted for losses and time-of-generation value, assumed, plus (for systems <5kW) 44c/kWh until Q3 2028 for entrants prior to 1/7/2012
SA	Equal to the wholesale price of electricity, adjusted for losses and time-of-generation value, assumed, plus 16c/kWh until Q4 2016 for entrants prior to 1/10/2013
TAS	Equal to the retail price of electricity
VIC	For systems less than 5kW: Equal to the wholesale price of electricity, adjusted for losses and time-of-generation value, assumed, plus 25c/kWh until Q1 2017 for entrants prior to 1/1/2013. For systems above 5kW, equal to the retail price of electricity for entrants prior to 1/1/2013, and the adjusted wholesale price for later entrants.
WA	Equal to the wholesale price of electricity, adjusted for losses and time-of-generation value, plus 10% to account for more expensive generation mix in WA.

Table 3: Summary of scenario settings

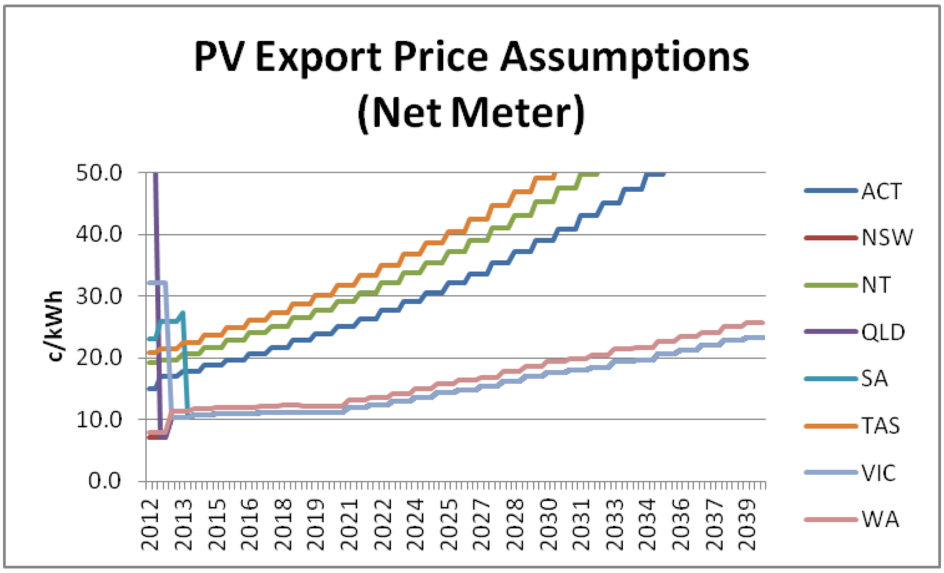


Figure 10: PV export price assumptions (net meter) – for Medium scenario

[32] "Strong Growth, Low Pollution - Modelling a Carbon Price", Chart 5.27

4.2.1 System Pricing:

System pricing is based upon a deep understanding of the make up of the global PV industry, and takes into account historical trends and the physical nature of panels, inverters, framing equipment, and labour. Some inputs are expected to continue to decline in price in line with historical trends, as efficiencies, scale, and innovation continually drive down prices, whereas gains in labour efficiency are expected to be largely balanced by inflation.

System pricing is based upon a pricing forecast for system input components (including labour) and profit margin.

- Initial prices are set at median prices observed on the market, for both components and systems. For the foreseeable future (12-24 months), these are reduced in line with expectations – which include a period of price stability for panels to account for forecast global trends – after which prices of inverters and panels are reduced by 7% annually in line with long-term historical trends, offset by 2.5% p.a. inflation.
- Prices of 1, 1.5, 2, 2.5, 3, 5, 7.5, and 10 kW systems are tracked out to 2022, and economies of scale apply to inverter and installation pricing.
- The price of balance of system components is held steady, meaning that cost savings are expected to be in line with inflation.
- After falling slightly from current levels, the price of framing is assumed to increase with inflation from 2015.
- The cost of installation is expected to be reasonably stable, as inflation and increasing regulation balance out improving efficiencies.
- Margins (which vary by system size and initially average 17.5%) are expected to increase over the period (to average 30% by 2022) as the industry is forced to improve its long-term profitability and to make an equivalent amount of money from reduced volumes of sales.

Results of sensitivity analyses in which PV prices vary above and below this amount, independent and in conjunction with varying electricity price rises are provided in the Appendices. These show that outcomes for the base case (varying electricity price escalation with fixed (mid-range) PV price reductions) are comparable for an alternative case (varying PV price reductions with fixed (mid-range) electricity price escalations)). However, should both occur in combination (i.e. high electricity price rises in combination with rapid decreases in PV system price, or low electricity prise rises in combination with slow decreased in PV system price) widely variant outcomes could occur – ranging from runaway solar industry to an industry that languishes then stagnates. The scenarios thus depicted in this report should be considered most likely possible alternatives rather than the extremes of what could occur.

The Australian Dollar is assumed to be constant over the period at US$1.05. Sensitivity analysis reveals that the value of the Australian dollar has a significant bearing on financial outcomes over the coming years and is a major (positive and negative) risk to deployment levels. However, predicting the exact nature and level of future foreign exchange rates is beyond the scope of this document and hence, a constant rate has been assumed.

4.3 Forecasting Installations: Overview

A forecast was prepared for each calendar year 2012-2022. The forecast accounts for known and predicted changes to feed-in tariffs over the foreseeable future (12-24 months). Beyond this horizon, annual rates of growth are applied to figures, with specific adjustments made for considerations such as network penetration, shifting tendencies towards commercial installations, and the effect of the RET. The forecast for 2012-2016 is equivalent to a forecast prepared for the industry, "Australian Solar Market Forecast 2011-2016"[33]. Beyond 2016, growth factors are used for the residential and small commercial sectors; for installations above 100kW growth factors are used in combination with Bloomberg analysis.

The annual forecast was then broken down into quarterly periods that account for the timing of the end of state feed-in tariffs, reductions in solar multiplier until Q3 2013, and on a linear basis thereafter. The sub-forecast amount of NEM-connected capacity installed behind the meter was then calculated as all of the sub-100 kW installations in states other than WA and NT, and a proportion varying by scenario and year of 100+kW installations in NEM-connected states, with 50% of commercial installations expected behind the meter in boom years, and 50% in other years.

4.4 Segmentation

4.4.1 Grid-connect distributed segment

This segment includes all grid-connect installations less than 100kW. This includes installations in the range of 10-30kW on small-commercial premises (which currently face higher electricity prices than the residential sector), and in the range of 30-100kW on medium-commercial premises.

4.4.2 Grid-connect centralised segment

This sector considers large commercial systems larger than 100kW that are installed behind-the-meter. It is expected that AEMO independently tracks utility-scale installations. As such the forecast excludes installations under the ACT Solar Auction, Solar Flagships, and other solar farms. The forecast also excludes installations not connected to the NEM, such as Western Australia, Northern Territory, Mt Isa, and other off-grid areas.

The number of large systems in Australia continues to grow each year and the installed projects, press releases, tenders and enquiries for large projects continues to grow. Underlying this growth are a range of factors including increasing commercial electricity prices, the green building program and the carbon price.

The forecast for the GCC segment is not based upon detailed financial modelling but rather a projection of historical uptake and recent interest at current prices.

[33] SunWiz, Solar Business Services, "Australian PV Market Forecast 2011-2016", November 2011 - http://www.sunwiz.com.au/index.php/industry-services/market-forecast.html

4.5 Forecast scenario definitions

4.5.1 Slow Uptake

The Slow Uptake (SU) scenario is the most conservative of our scenarios and is considered 100% bankable. It generally assumes poor-case outcomes across the board and is based only on known programs or market activity. It does not correspond with a 'perfect storm' of bad events, and there is still a possibility for downside in the event that every state and sector experienced worst-case outcomes, but this is considered highly unlikely. However, this should serve as a bankable minimum upon which to base internal forecasts.

Examples of drivers in this scenario include:

- An early termination to the Queensland Solar Bonus Scheme.
- Transitional Feed-in Tariffs are cut after their stated period.
- Substantial fall in residential installations in 2012.
- Modest pick-up in small-commercial installations in all states but NSW in 2012.
- Minor recovery in some states' residential sectors in 2013 offset by wind backs in QLD, SA and Victoria.
- Market stabilisation in 2014 followed by slow growth in residential sector in subsequent years and improved by still modest growth in small commercial.
- 10% growth in GCD systems beyond 2016, as uninspiring financials start to ease, but barriers to deployment hold back solar.
- 20MW ACT Solar Auction deployed in 2012, and only 70 MW more PV in subsequent years, none of which is connected behind-the meter.
- One round of Solar Flagships proceeds, encompassing 150 MW over four years, none of which is connected behind-the meter.
- Modest market for GCC, much of which deployed in mines, but some of which occurs (Green Buildings etc) in grid connected regions. The CEFC directs only small amounts of funding towards PV, which assists in minor amounts of deployment in the latter years of the RET.
- 100% of GCC installations in Victoria and ACT (non-Solar Auction) being NEM-connected behind the meter.
- 80% of GCC installations in NSW, SA, and QLD being NEM-connected behind the meter in all years other than 2019-2020, during which time the RET causes 50% of installations to be either on remote mine sites or solar farms[34].

[34] In line with US patterns: http://www.seia.org/galleries/pdf/SMI-YIR-2010-ES.pdf

4.5.2 Moderate Uptake scenario (moderate)

The Moderate Uptake (MU) scenario consists of a set of less-conservative assumptions than our SU forecast. Positive outcomes are likely but tougher to achieve. The relative position this scenario occupies between the SU and Rapid Uptake forecasts provides some indication as to which end the market is more likely to lie. For example, if the MU scenario lies closer to the SU scenario than the Rapid Uptake scenario, then actual installed capacity is forecast to be on the lower side.

Examples of drivers in this scenario include:

- Termination of the Queensland Solar Bonus Scheme in late 2012.
- Transitional Feed-in Tariffs cut after their stated period.
- Substantial fall in residential installations in 2012, though less severe than SU.
- Modest pick-up in small-commercial installations in all states but NSW in 2012.
- Continued reductions across all states' residential sectors in 2013, offset by healthy expansion of the small commercial sector.
- Stable growth from 2016-2019 in the GCD sector, though the emergence of highly favourable economics in 2019 accelerates installations in the residential and small commercial sectors from 2019 onwards. Current barriers to solar deployment addressed with existing and new technologies.
- 20MW ACT Solar Auction deployed in 2012, and 120 MW more PV in subsequent years, none of which is connected behind-the meter.
- A second round of Solar Flagships proceeds, resulting in 250 MW of PV over five years, none of which is connected behind-the meter.
- Until 2019, a modest market for GCC exists, much of which deployed in mines, but some of which occurs (Green Buildings etc) in grid connected regions. However, meeting a 20% RET by 2020 requires deployment of 2 GW of PV (both medium-scale and large-scale) across 2019-2020, in line with analysis by Bloomberg New Energy Finance[35] - see Figure 11 and Figure 12).
- After the RET is met in 2020, GCC installations fall substantially as economics of PV do not stack up in the absence of demand for RECs. However, big businesses continue to install large amounts of rooftop solar.
- 100% of GCC installations in Victoria and ACT (non-Solar Auction) being NEM-connected behind the meter.
- 80% of GCC installations in NSW, SA, and QLD being NEM-connected behind the meter in all years other than 2019-2020, during which time the RET causes 50% of installations to be either on remote mine sites or solar farms.

[35] Seb Henbest, "SIGNALS FOR TRANSITION - THE CARBON PRICE & THE LRET", Bloomberg New Energy Finance, EcoGen 2011, 5/9/2011

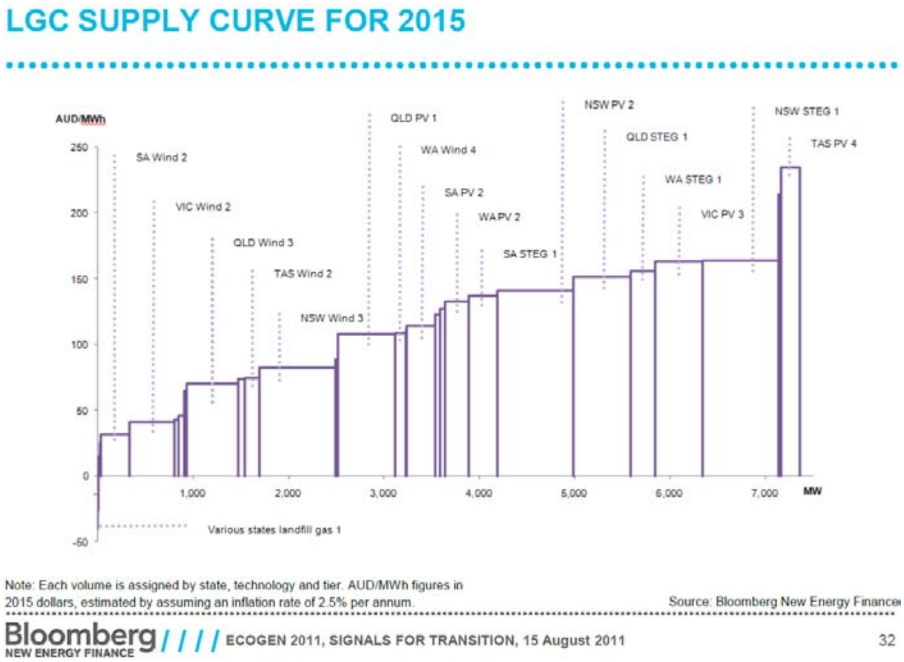


Figure 11: Volume and Price of Renewable Energy Supplies [36]

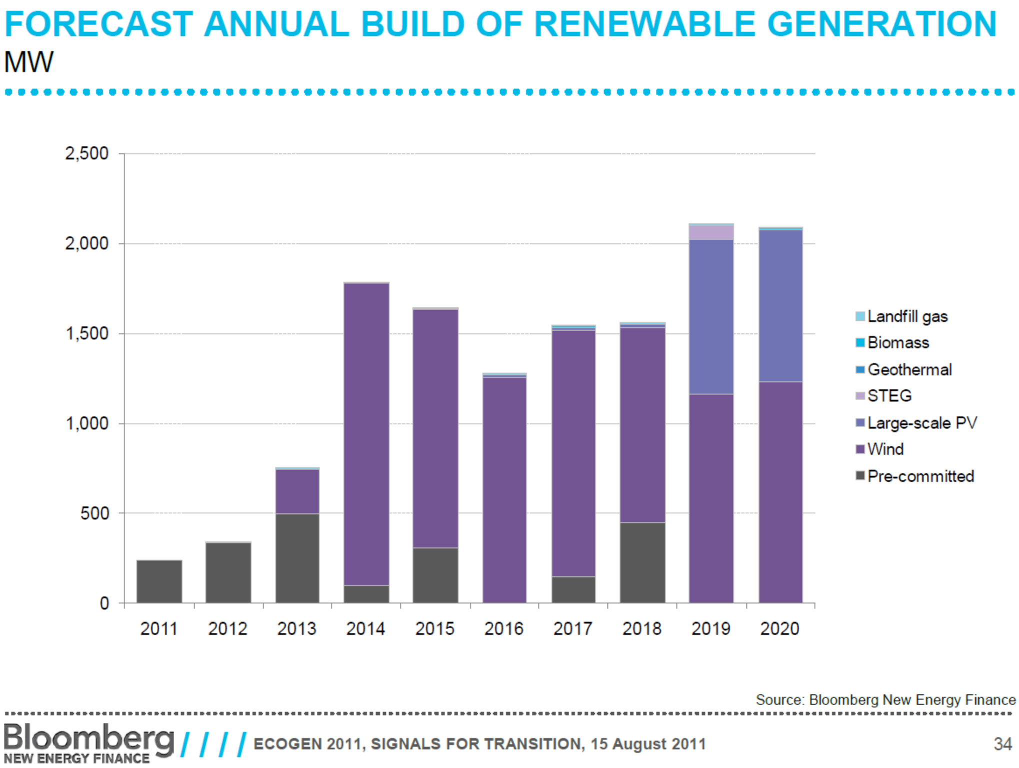


Figure 12: Forecast Annual Build of Renewable Generation [37]

[36] Seb Henbest, "SIGNALS FOR TRANSITION - THE CARBON PRICE & THE LRET", Bloomberg New Energy Finance, EcoGen 2011, 5/9/2011

[37] Seb Henbest, "SIGNALS FOR TRANSITION - THE CARBON PRICE & THE LRET", Bloomberg New Energy Finance, EcoGen 2011, 5/9/2011

4.5.3 Rapid Uptake scenario (aggressive)

The Rapid Uptake (RU) scenario consists of a set of more ambitious or optimistic assumptions driven at the type of growth levels that the PV industry might hypothetically prefer. This does not represent a situation in which the heavens align, but does illustrate the upper levels of likely installations given an optimistic extension of current knowledge. The RU scenario does not assume (for example) that every state and territory (re-)introduces $0.60/kWh gross feed-in tariffs, but rather (for example) that network connection issues turn out to be easily addressable and unlock a wave of residential PV installations on the basis of the continually improving financial proposition of PV. Examples of drivers in this scenario include:

- In late 2012, Queensland Solar Bonus Scheme wound back to a two-year transitionary value equivalent to retail electricity price (for which South Australia and Victoria are examples).
- Transitional Feed-in Tariffs cut after their stated period.
- Substantial fall in residential installations in 2012, though less severe than MU; Queensland transitionary FiT delays some of the wind-back to 2013. A rebound in residential installations in 2015 followed by an accelerating surge of demand from 2018 onwards.
- Healthy pick-up in small-commercial installations in all states in 2012, with very favourable financial outcomes accelerating such installations substantially from 2015 onwards.
- Consequentially, continued growth in the GCD sector occurs, with 2019 representing the year that this sector returns to an 800 MW market. Solar economics sufficiently favourable to address barriers to increasing network penetration in conjunction with other grid management technologies.
- 20MW ACT Solar Auction deployed in 2012, and 160 MW more PV in subsequent years, none of which is connected behind-the meter.
- A second round of Solar Flagships proceeds, all of which goes to PV, resulting in 525 MW of PV over six years, none of which is connected behind-the meter.
- The GCC market grows substantially, particularly in off-grid situations until 2017, at which time solar becomes the least-cost renewable energy technology due to CEFC support. In line with analysis by Bloomberg New Energy Finance[38], this measure increases deployment of large-scale PV to 5 GW over the period 2017-2020.
- After meeting the RET, the cost of wholesale electricity is sufficiently high to justify utility-scale PV on its own merits, albeit with a drop in installations due to lower demand for LGCs.
- 100% of GCC installations in Victoria and ACT (non-Solar Auction) being NEM-connected behind the meter.
- 80% of GCC installations in NSW, SA, and QLD being NEM-connected behind the meter in 2013-2016 reflecting some mining installations, after which time the RET and the wholesale electricity price causes 50% of installations to be either on remote mine sites or solar farms.

[38] http://www.climatespectator.com.au/commentary/cefc-will-help-big-solar-displace-wind

5 Forecast Financial Outcomes

5.1 Forecast Prices

The unit price of systems over the forecast period is shown in Figure 13. Considering that PV system prices were $12/W only a few years ago, and relatively stable at $6/W for the past year[39], Figure 13 illustrates the rapid price decline that has occurred in the previous six months. It also shows which demonstrates the available economies of scale. The net system price after an STC discount (assuming a price of $30 rises to $37 at which point it stabilises) is shown in Figure 13 – which assumes the solar multiplier reduces to 2x on 1/7/2012 and to 1x on 1/7/2013, and assumes the number of STCs and their price remains unchanged by ministerial decision or any review of the RET. The reduction in the solar multiplier has obvious effect on the net price paid, which rises over the coming 18 months for systems less than 5kW. Though the impact of the final reduction in multiplier is significant across the board, systems 5kW and above are still expected to reduce in price faster than the effect of the reduction in multiplier.

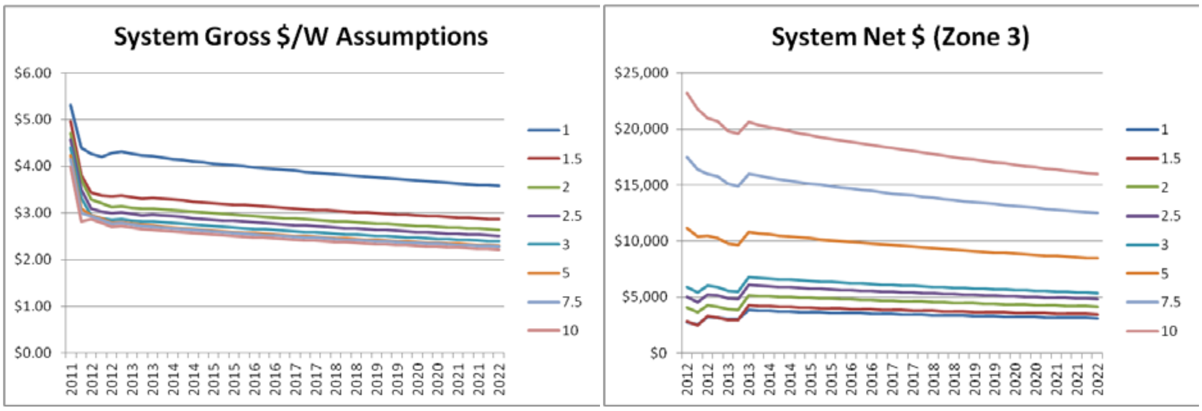


Figure 13: System price per watt over time

The forecast levelised cost of electricity (LCOE) from a PV system after STC discount is shown in Figure 14. It can be seen that the effective cost of a PV system when amortised over its lifetime (assuming a 10% discount rate) is currently below 16c/kWh, but is expected to rise somewhat (depending on system size) as the solar multiplier is reduced. In spite of this, the cost of solar is shown to remain below the cost of retail electricity, such that – to the extent that power is consumed on site – a favourable proposition for small PV systems can continuously be made. Larger systems are less affected by the multiplier drop, and due to their economies of scale appear to be cost competitive with commercial energy mid way through the period. Considering that the price of exported energy is calculated to be 12.4c/kWh by the end of the study period under the MU scenario, PV appears to be able to compete with wholesale electricity prices (adjusted for losses and time-of-generation value) by 2022[40]. In such cases, exporting energy in the absence of a feed-in tariff could make financial sense towards the end of the decade – which has considerable flow-on effects, as discussed in Section 8.

[39] www.apva.org.au/sites/default/files/documents/APVA Status Reports/PV in Australia 2010.pdf

[40] This factors in a small discount from STCs (without multiplier) is factored in.

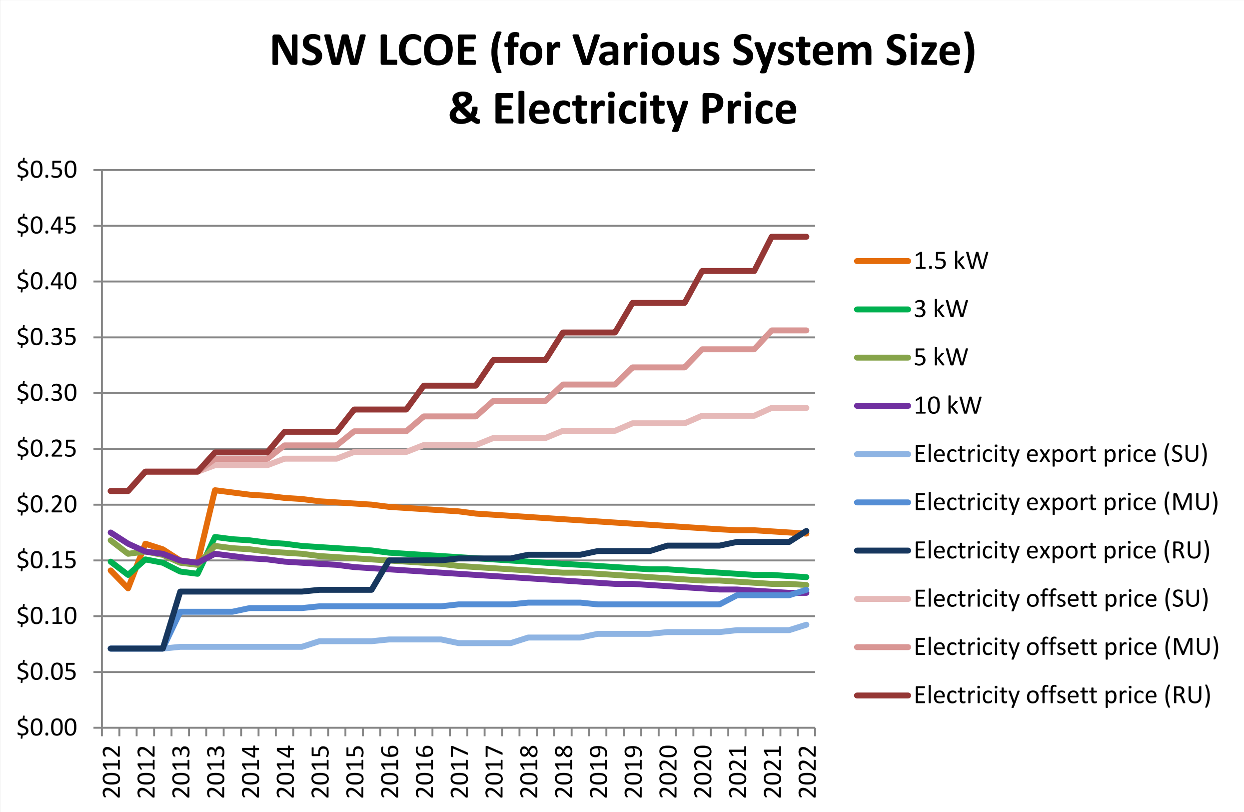


Figure 14: NSW LCOE and electricity price

5.2 Payback and Internal Rate of Return

The financial outcomes from investment are shown in Table 4. These illustrate the following important points for 5kW systems, which exclude any changes to the exchange rate or unforeseen events:

- Simple paybacks of under 10 years, needed for industry survival, are almost certain.
- With the exception of 2013, simple paybacks of 7 years, which result in a thriving industry, occur in more than two major states for all of the period under medium scenarios.
- Simple paybacks of under 5 years, which result in a booming industry, begin to occur in the second half of the decade in the high scenario.
- The internal rate of return is below 10% once feed-in tariffs end in the major states under the low scenario, a situation that persists until the middle of the decade.
- The internal rate of return remains above 10% for the entire period, regardless of feed-in tariff settings, under a medium scenario.
- The internal rate of return is above 15% from 2014 onwards in all states under a high scenario, and from 2015 in the medium scenario.
- 1.5kW systems are only most favourable while the solar multiplier persists and while the value of export energy is low. After this time, larger systems' economies of scale of make them a more favourable investment. This has implications for distribution networks.

A sensitivity analysis is presented in the Appendices.

Table 4: Financial Returns on 5kW Systems

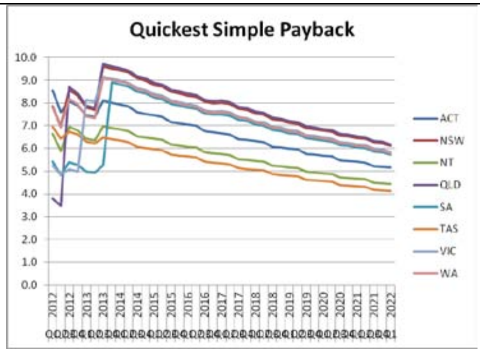
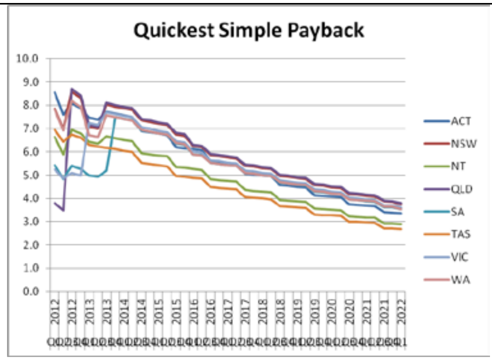
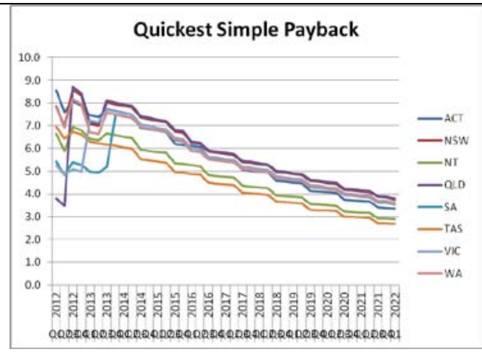
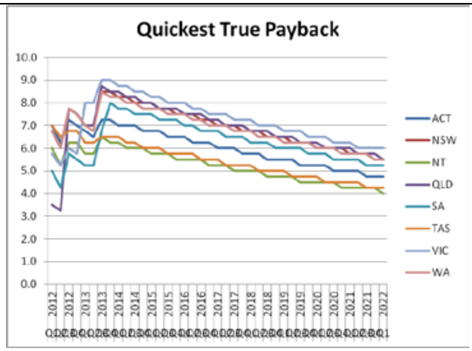
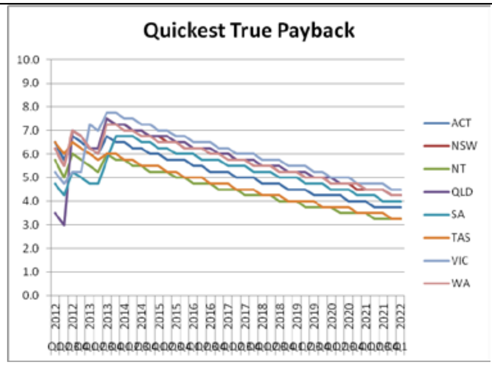
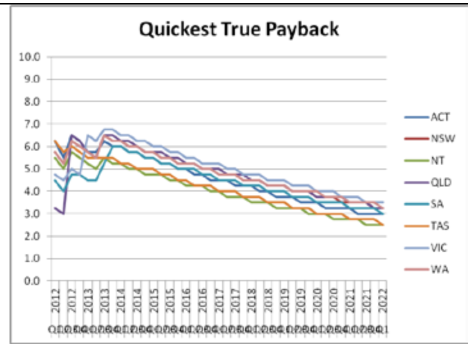
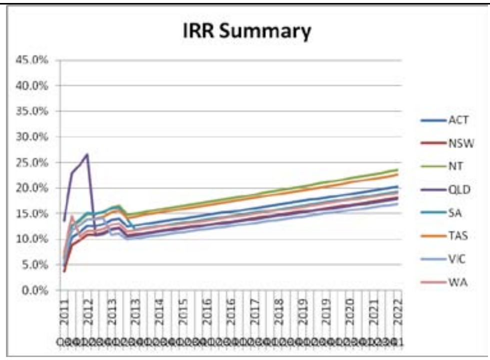
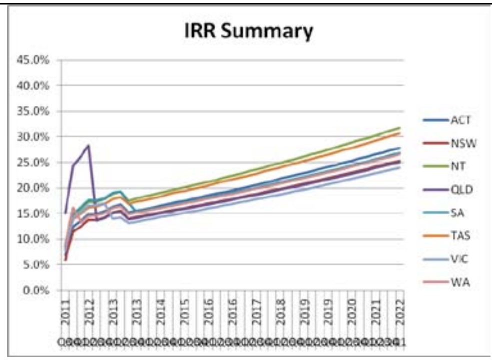
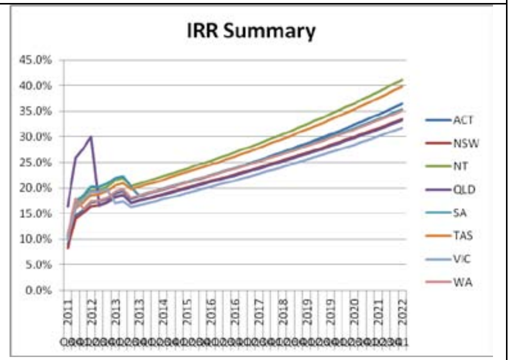
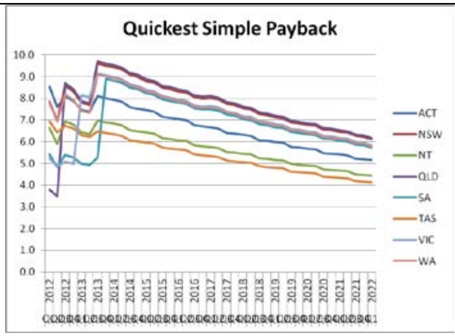
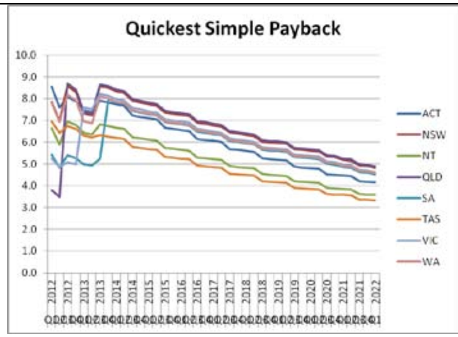
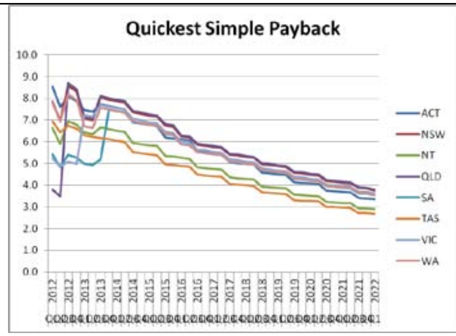
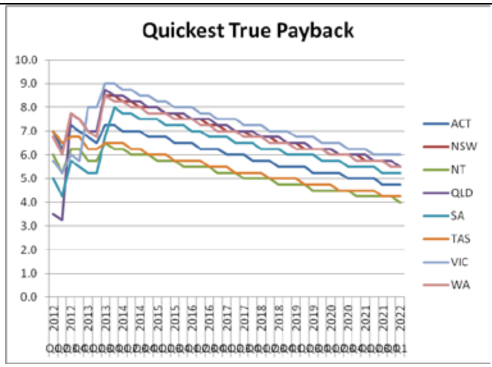
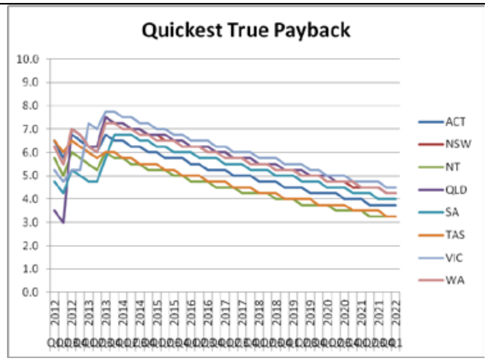
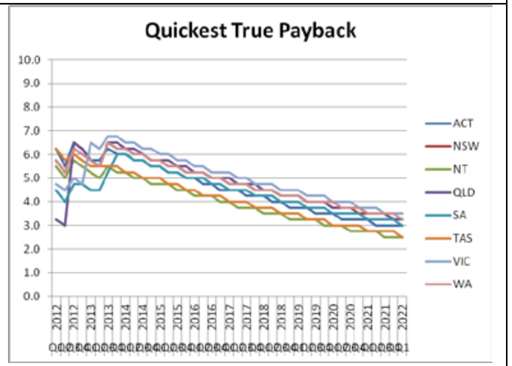
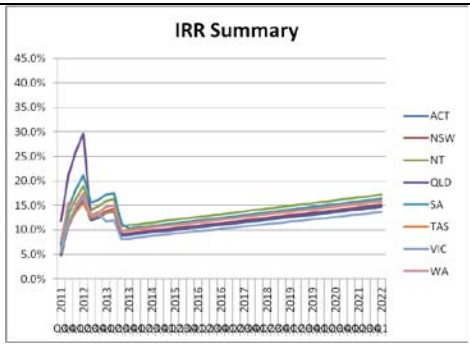
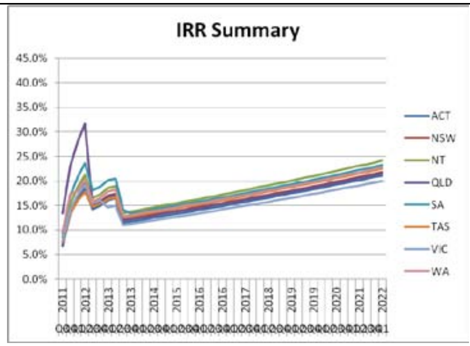
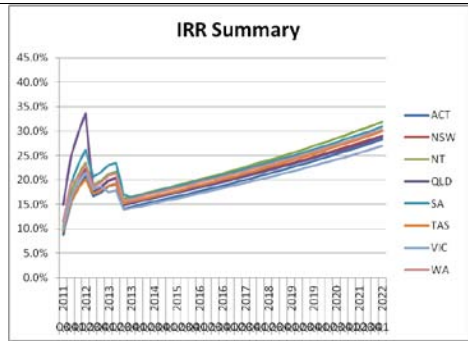
Scenario	SU	MU	RU
Simple Payback			
True Payback			
Internal Rate of Return			

Table 5: Financial Returns on 1.5kW Systems

Scenario		SU	MU	RU
Simple Payback				
True Payback				
Internal Rate of Return				

5.3 Effect of Government Support

Figure 15 shows the financial return under a MU electricity price scenario of a 1.5kW system in the absence of government support from STCs, with each state illustrating the effect of export value. It can be seen that the premium feed-in tariff on offer in Queensland has a large impact upon IRR. The transitional feed-in tariffs in Victoria and South Australia also act to sustain somewhat the PV industry in those locations. However, at the end of their transitionary period, should they join NSW and WA in only offering a wholesale electricity price (adjusted for loss and time of production) for PV exports, the financial return available on PV investment will not reach 10% (the level required to sustain a reasonable amount of demand) before 2015. This serves to illustrate that the PV industry will rely upon STCs to bridge the gap to 2015, suggesting that continued support for small-scale PV is required in order to sustain the industry.

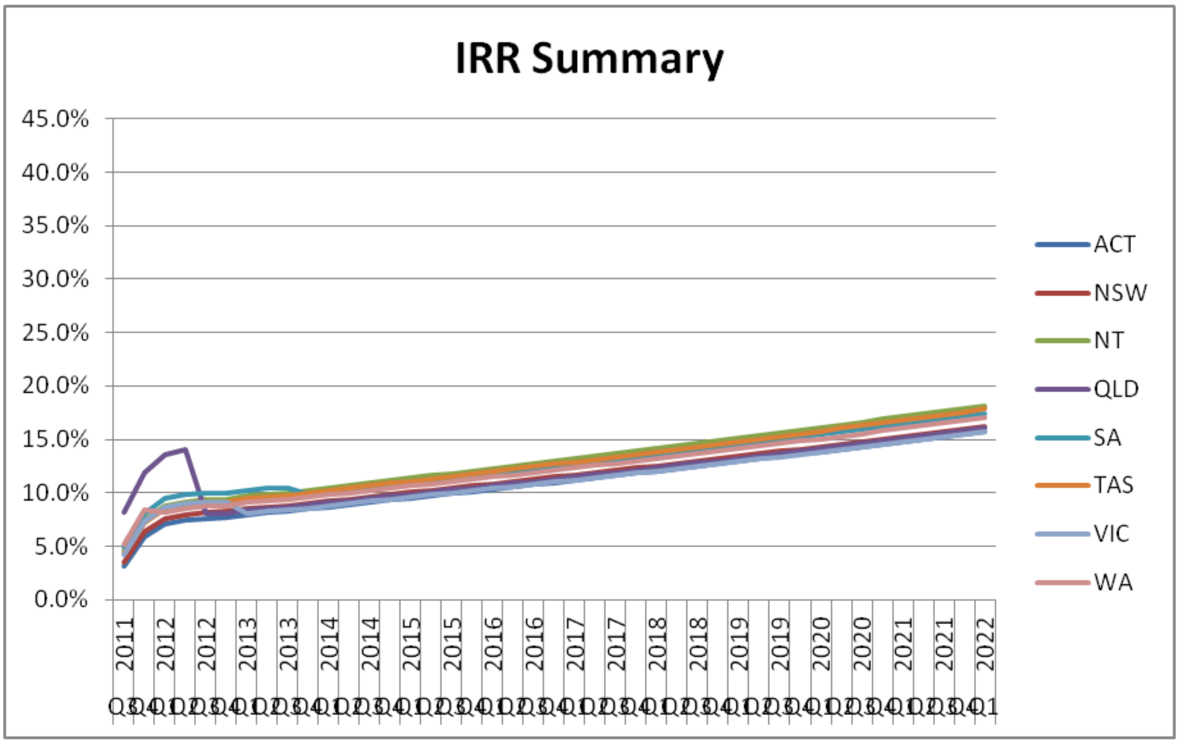


Figure 15: IRR for 1.5kW system without STCs

PV has previously been considered an expensive means of abating emissions. This has largely resulted from incorrect PV price projections (See Section 7.2) and from treatment of PV as offsetting wholesale electricity prices (i.e. assuming PV is installed as a solar farm). However, a PV system that does not export power can be considered in a similar way to an energy-efficiency device such as a light-bulb, which saves money at the prevailing retail tariff.

Figure 16 shows that in the absence of STCs and feed-in tariffs, a 1.5kW residential or small-business system that consumes all of its generation on site has a positive Net Present Value in most Australian states. Largely a result of PV recently reaching grid parity, this demonstrates that as an emissions abatement measure, it can be argued that non-exporting PV systems have a negative cost of emissions abatement, like most energy efficiency initiatives. Seen in this light, PV is no longer an expensive form emissions abatement. However, Figure 15 shows that existing government support of a transitionary nature continues to be required to sustain PV demand over the coming two-to-three years.. As will be seen in the coming sections, solar power can make a significant contribution to the Australia's electricity mix, though the coming years are expected to be years of consolidation. It can therefore be argued that such support will ensure the PV industry is ready and able respond to escalating demand in the later half of this decade

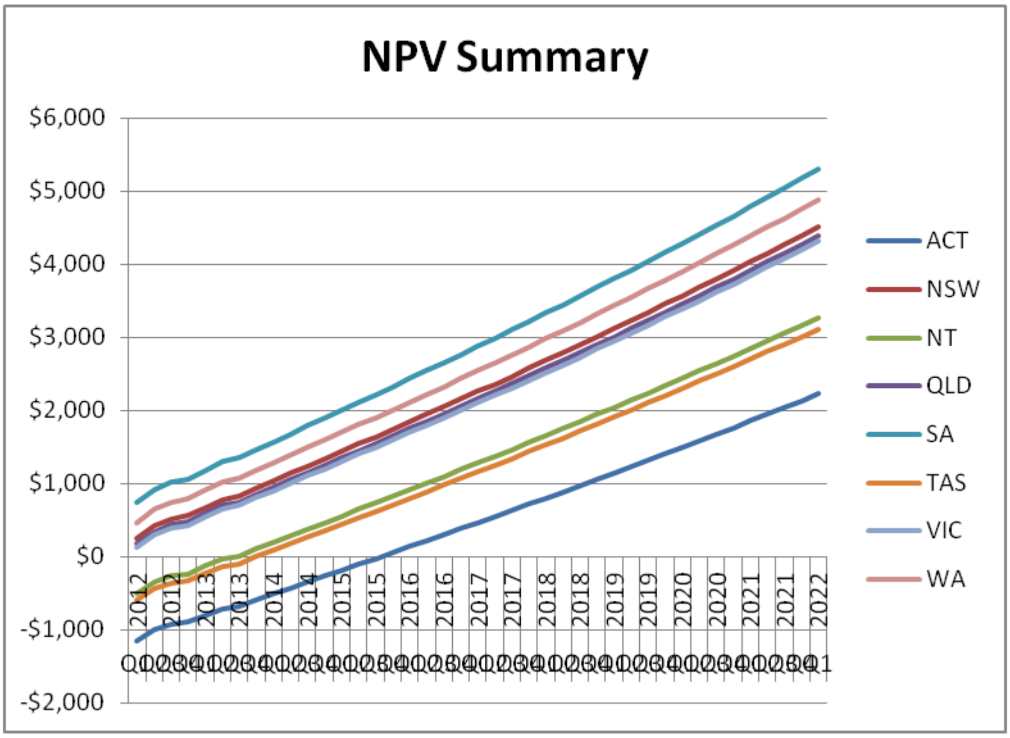


Figure 16: NPV of a 1.5kW non-exporting system in the absence of STCs[41]

[41] Assumes 10% discount rate

6 Installation Forecast

6.1 Overall

Slow Uptake: Under a conservative set of assumptions, the current market contraction persists for many years, offset somewhat by the GCC market comprising solar flagships and the ACT Solar Auction, and some spill over from the RET. In later years of this scenario, the residential market declines due to difficulty of connection, but in its place arises a healthy market for small commercial systems.

Moderate Uptake: Under a moderate set of assumptions, the residential market slowly recovers before accelerating towards the end of the decade, and the small-commercial sector grows continuously. After Solar Flagships and the ACT Solar Auction play out, the GCC market makes a sizeable contribution to the RET though in intervening years the market is driven primarily by the economics of large commercial rooftops.

Rapid Uptake: Under a more optimistic scenario, the CEFC and the LRET combine to increase the amount of GCC PV deployed to meet the RET. Beyond this point, the economics of large-scale solar stack up without need for subsidy, and the market stabilises at high levels. The small commercial market has the most favourable economics owning to the least amount of power exports, though exported power has a similar price to solar LCOE, making solar favourable in plenty of new locations. As a consequence, the residential market is aided by system expansion, which offsets the effects of a maturing market sector.

As seen in Figure 17, the scenario show the PV industry will install between 250-800 MW a year until the latter years of the Renewable Energy Target (RET). Though the SU scenario does not see a return to 2011 installation levels (800+MW) within the next 10 years, there will still be at least 6 GW in Australia by that time. However, it is entirely foreseeable that over 1 GW per year will be added towards the end of the decade, resulting in as much as 18 GW installed in Australia by the end of 2022 in the RU scenario[42].

[42] Annual installation figures, broken down by system size, application, and location are available upon request from the authors.

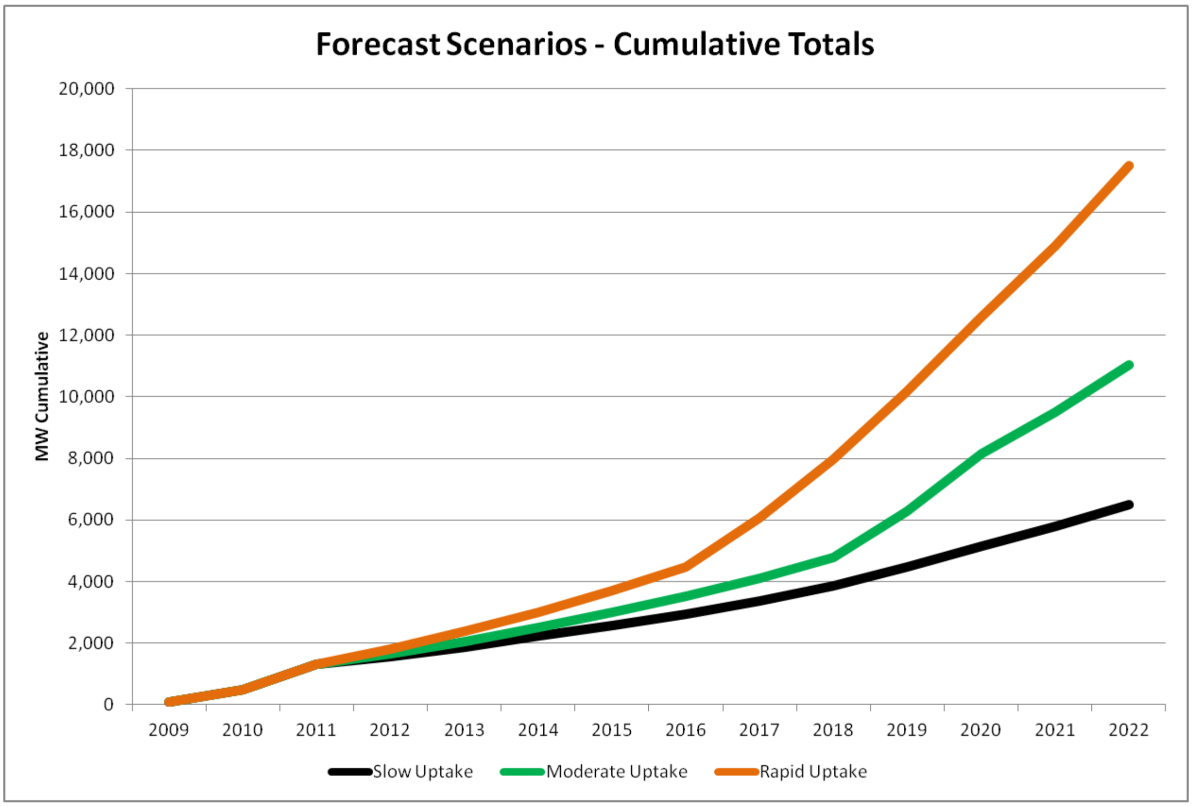


Figure 17: Forecast scenarios - cumulative

6.2 NEM-connected Behind-the-meter Sub-segment

AEMO has requested a forecast of NEM-connected systems installed behind the meter. Of the total amount of capacity described in Section 6.1, not all will be grid connected, and a significant amount will be solar farms exporting all their generation. The following graphs present the amount of capacity likely to be NEM-connected behind-the-meter installations, for the purpose of AEMO's tracking. Within this data is contained a residential and small-commercial PV market that is stable or contracting for the coming two years before entering a period of expansion on the basis of steadily improving economics. The major determinant of growth in the second half of the decade is the extent to which the RET drives rooftop installations on commercial premises, and the extent to which the CEFC directs funding towards PV.

As shown in Figure 18, this results in NEM-connected behind-the-meter installation volumes of less than 400 MW a year until the end of 2015, which are seen to be years of market consolidation (down from the 800MW installed in 2011). By the end of the decade, installation is forecast to ramp up to 0.5-1.4GW of un-registered generation. This will bring total generation that is non-registered to between 4-8GW, as shown in Figure 19.

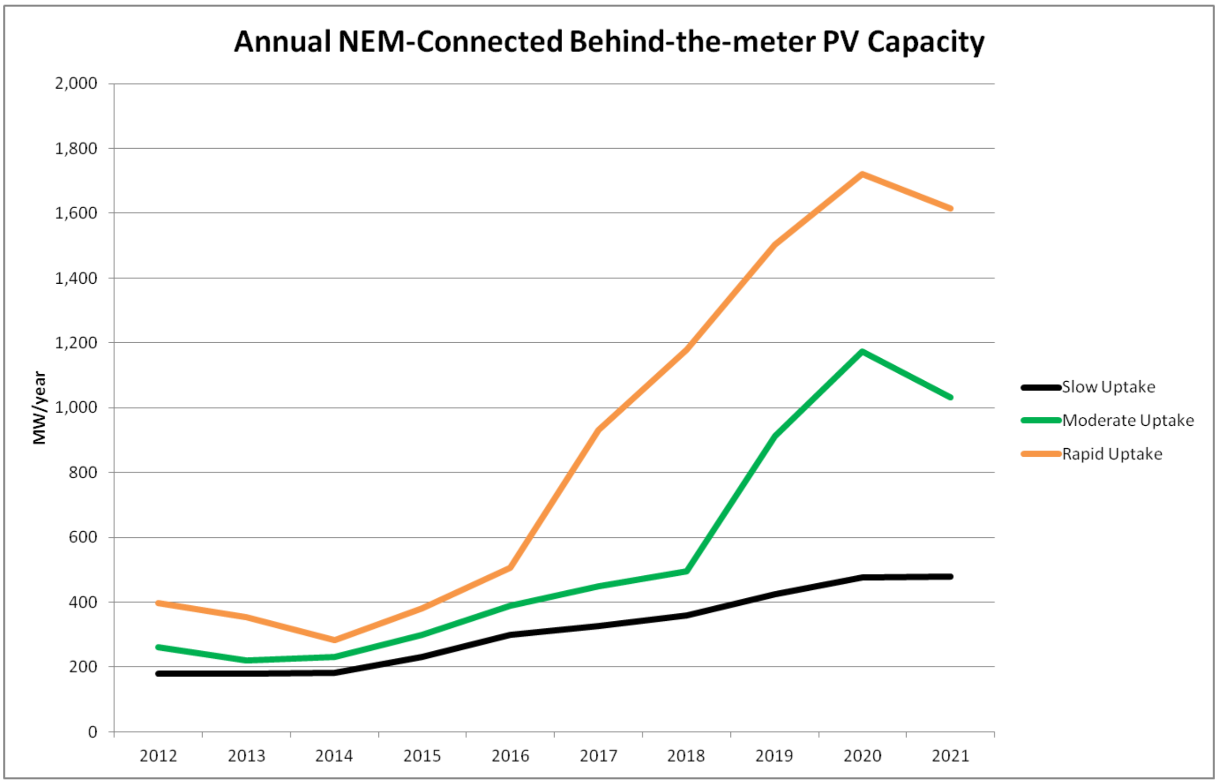


Figure 18: Annual NEM-connected behind-the-meter PV capacity

Note that these installation figures are lower than ORER forecast levels as they account non-rational factors including an industry that is currently struggling to survive – with many solar businesses closing down and installations that are proceeding doing so with low margins. Regardless, the fast start to 2012 indicates it will lie more towards the RU scenario than SU.

Additional tables of installations by sector (GCC and GCD) and by state have been provided to AEMO in a separate spreadsheet.

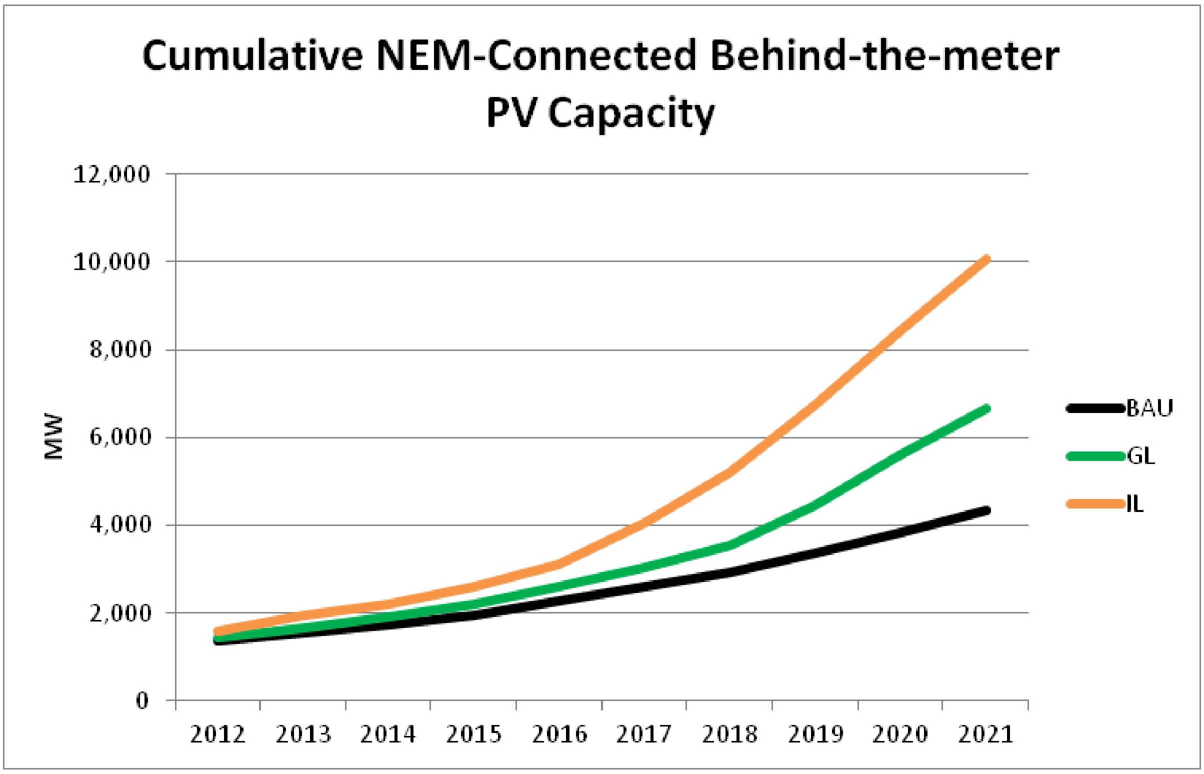


Figure 19: Cumulative NEM-connected behind-the-meter PV capacity

7 Credibility of Forecast

Deployment of PV on the scales described in Section 5.3 has previously been beyond comprehension for many energy forecasters. Hence the forecast 6-18 GW of PV deployment may come as a surprise to many. However, history has repeatedly demonstrated that PV uptake will exceed wildest expectations given favourable financial outcome. Having demonstrated the financial outcomes that are expected over the coming decade, this section will demonstrate that although the *Solar Forecast for AEMO 2012-2022* is entirely credible, and identify the principle reason previous forecasts have been misleading. Section 8 will then consider the implications of such previously unconsidered levels of PV deployment, which present major promise but not without challenges.

7.1 Other forecasts

In its modelling of a carbon price, Treasury (with input from SKM MMA and ROAM consulting) predicted solar (combined PV and concentration solar thermal power) would comprise 0.8-0.9% of Australia's energy mix by 2030, and 3.2-3.3% by 2050[43], as illustrated in Figure 20. Translated into installed capacity, these indicate at most 1.9GW PV by 2030[44] and 9.2GW PV by 2050, but in all likelihood these numbers must be reduced by the contribution allocated for solar thermal power.

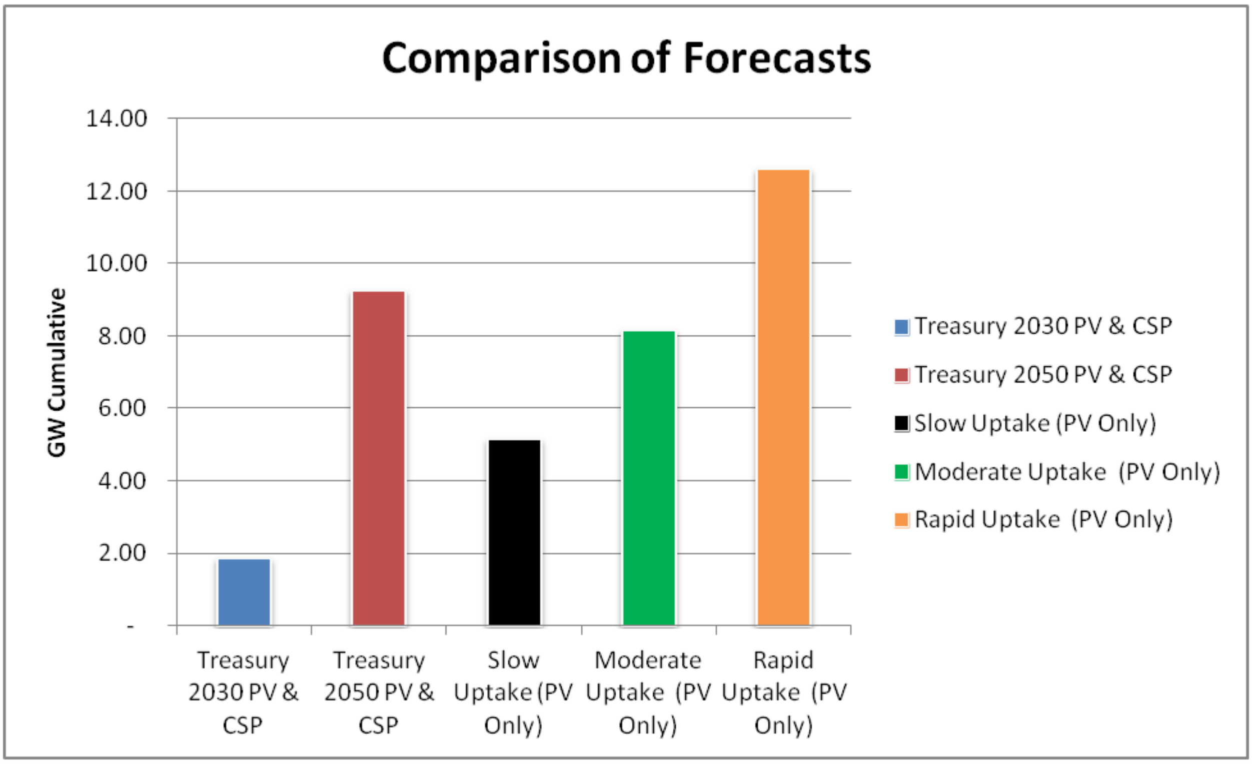


Figure 20: Comparison of forecasts

The *Solar Forecast for AEMO 2012-2022* shows that Treasury's forecast underestimates PV's potential by three decade's worth of installations. Considering there is already 1.3GW of PV installed to date (0.8GW of it installed in 2011)[45], a 2 GW forecast by 2030 massively understates PV's

[43] http://www.ret.gov.au/energy/Documents/ewp/draft-ewp-2011/Draft-EWP.pdf, p 273

[44] Average of SKM/MMA and ROAM figures, assumes average PV production of 3.6 kWh/kWp/day to convert between TWh and GWp.

[45] Source: ORER, http://www.sunwiz.com.au/index.php/interactive-hot-spots.html

potential. Even under the lowest case scenario, 395% more PV will be installed than Treasury modelling suggests by 2022.

Another example of underestimation of the PV industry is provided by the revised Queensland Renewable Energy Plan[46] (QREP) which saw PV in 2011 exceed its original 2020 forecast by 800%, as shown in Figure 21. Even the revised QREP forecast (a doubling of industry size by 2020) implies that the remainder of the decade will see a return to cottage industry installation levels.

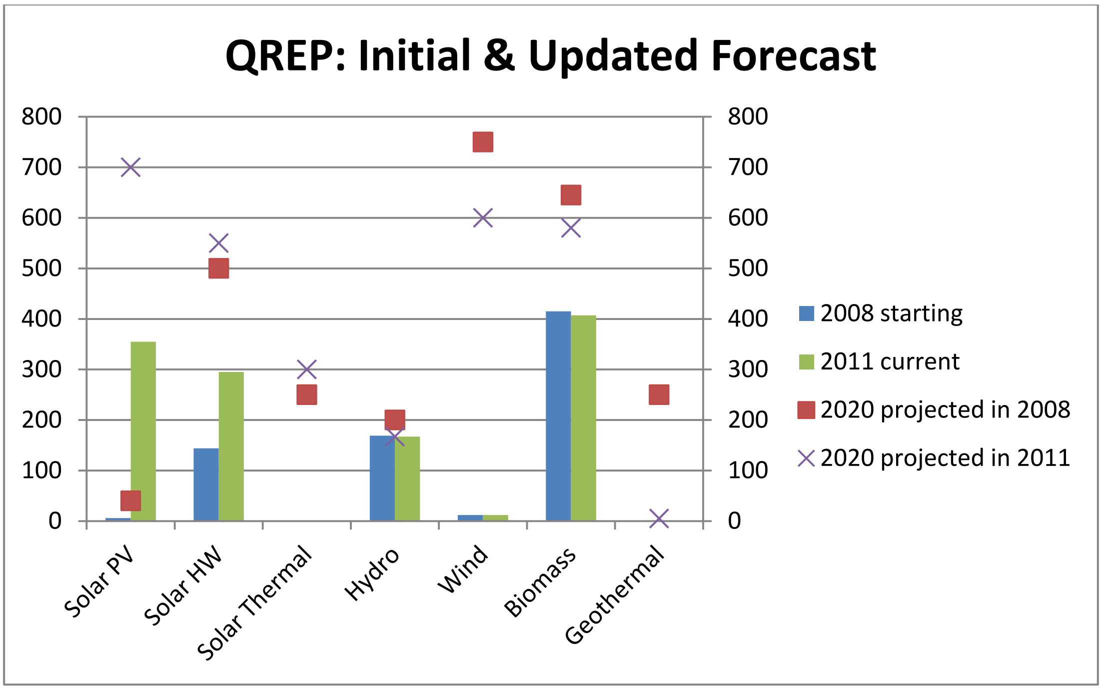


Figure 21: QREP – Initial and updated forecasts

[46] http://www.cleanenergy.qld.gov.au/renewable-energy/renewable-energy-plan.htm

7.2 PV Pricing

In a paper commissioned by the Garnaut Review, the Melbourne Energy Institute[47] demonstrated that Department of Resources Energy and Tourism is using outdated, overconservative presumptions of PV Prices[48,49]. These have the potential to blindfold decision makers to the true potential of PV, and the upcoming market shifts that will result from its continued deployment.

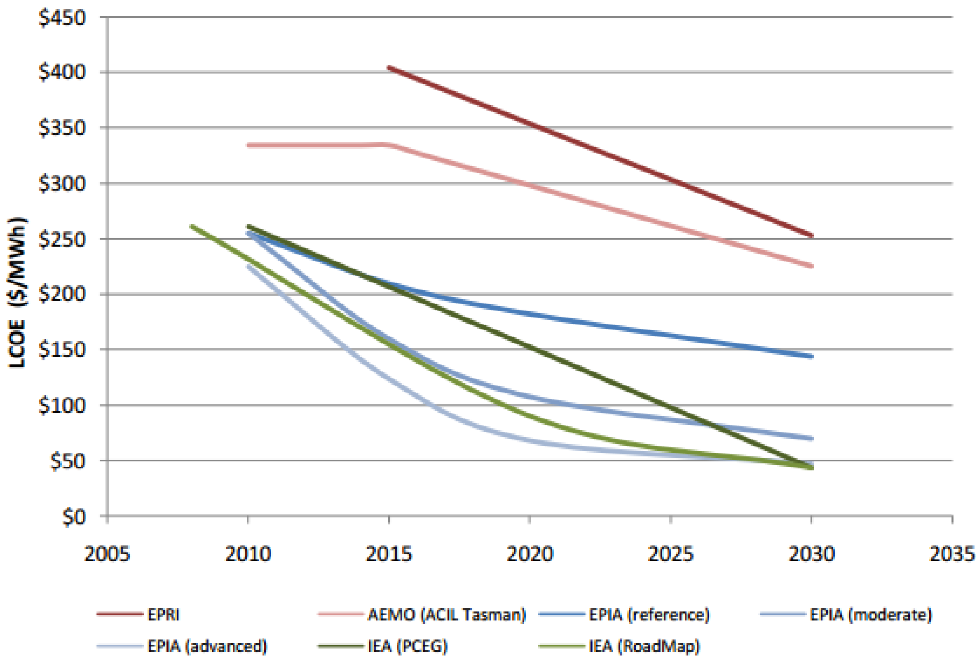


Figure 22: Previous forecasting[50]

7.3 Credible Benchmarks

Solar Forecast for AEMO 2012-2022 is entirely credible, if perhaps slightly conservative. The Office of the Renewable Energy Regulator (ORER) commissioned three respected consultants to perform a forecast of the small-scale renewable energy scheme certificate creation in coming years[51]: ACIL Tasman, SKM-MMA, and Green Energy Markets (to which SunWiz and Solar Business Services contributed). The figure below compares the (GCD) forecast scenarios contained within this document to the installation levels predicted by other consultants. It can clearly be seen that if anything this report's forecasts are conservative, predicting 0.6GW-1.1GW of small-scale PV to be deployed in the next three years, compared to the 1.1-1.4GW predicted by other consultants. Notably, such installation levels will bring Australia's total PV capacity by 2014 to above 2 GW (the 2030 PV & CSP level predicted by Treasury modelling), even before deployment of large-scale systems are factored in.

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[47] http://www.garnautreview.org.au/update-2011/commissioned-work/renewable-energy-technology-cost-review.pdf

[48] http://www.ret.gov.au/energy/Documents/AEGTC%202010.pdf

[49] E.g. Figure 6.29 shows $1/W panel price being reached in 2020-2025; Such prices are commonly available in 2012

[50] http://www.garnautreview.org.au/update-2011/commissioned-work/renewable-energy-technology-cost-review.pdf, Figure 1

[51] http://www.orer.gov.au/About-ORER/Reports/reports#modelling

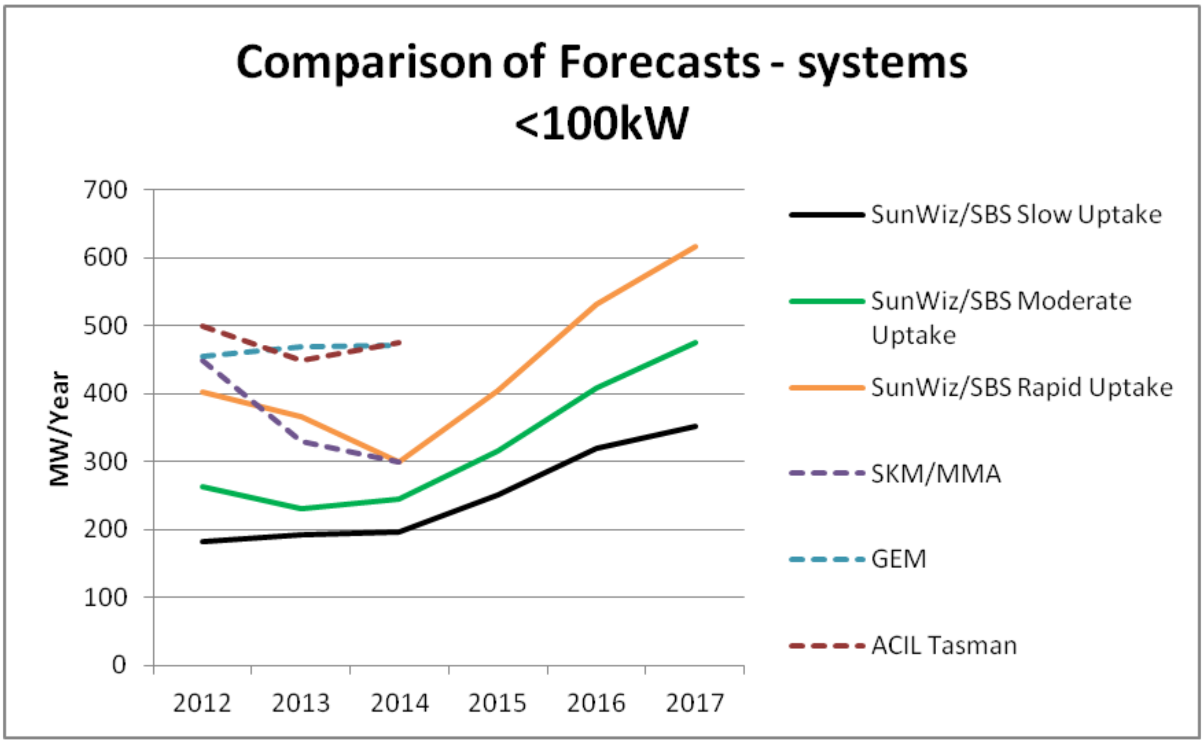

Figure 23: Comparison of forecasts – systems <100kW

The sensibility of this report's forecast can also be confirmed by applying a simple annual growth rate to the prediction of 2012's results, the year about which most is known. As seen in Figure 24, the forecast scenarios average out to 10-20% annual growth rate from 2012 predicted figures. There is a strong precedent for such growth rates: prior to the period when government incentives caused boom years of successive trebling, quadrupling, and doubling of industry size, the PV industry averaged between 10%-25% annual growth (see Figure 25).

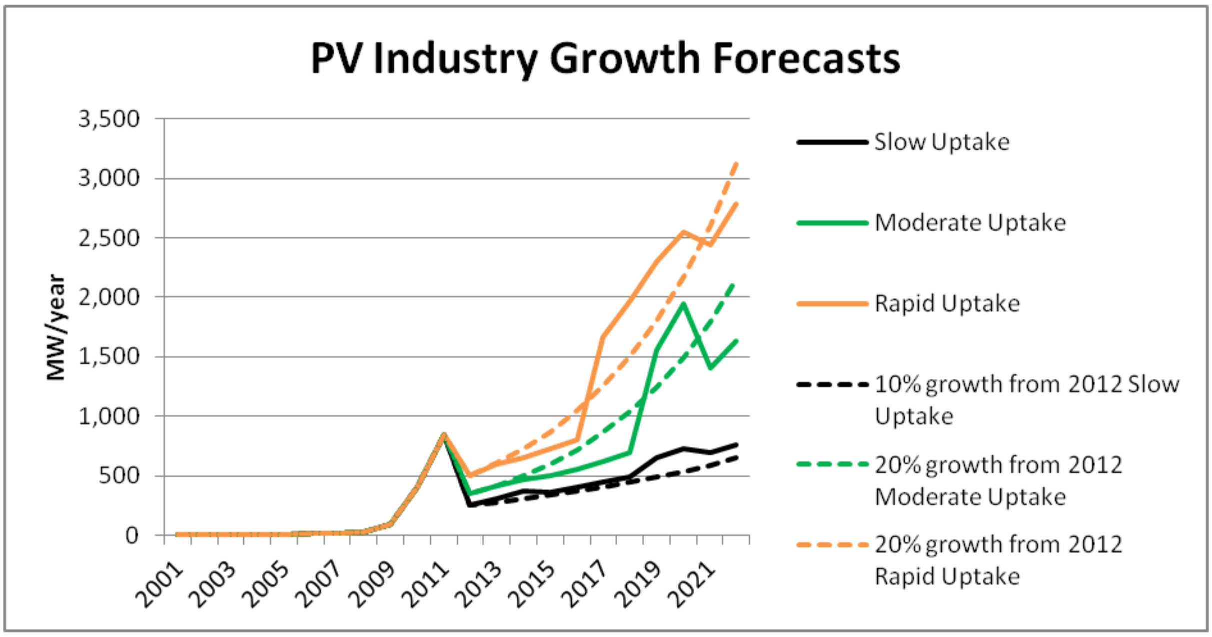

Figure 24: PV industry growth forecasts

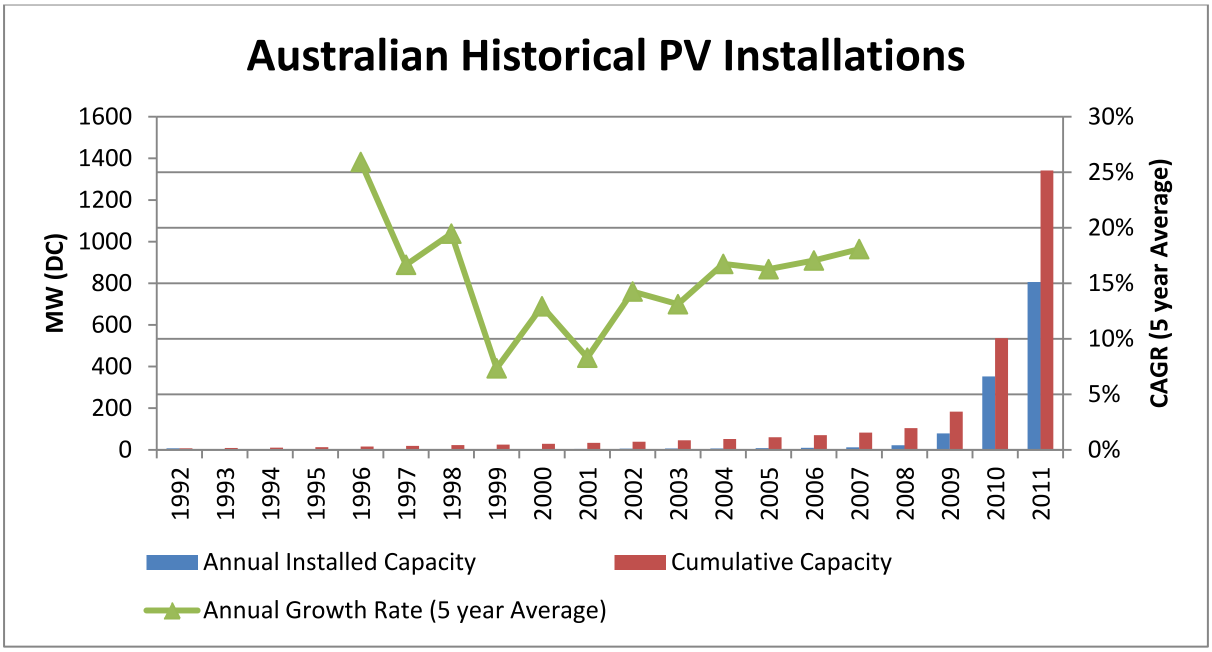

Figure 25: Australian historical PV installations

In summary, the *Solar Forecast for AEMO 2012-2022* is not only highly plausible, it is quite possibly conservative. The AEMO and the entire electricity industry should carefully consider its implications, as is done in the next section.

8 Context and Implications

To contextualise these results, such deployment of PV could by 2022 result in PV contributing to at least 9% of Australia's predicted generation capacity, and potentially over 20%. Indeed, according to Clean Energy Future modelling, stationary generation is predicted to grow from a current 57 GW to about 72 GW over the coming ten years[52] – PV could make up at least 36% of this growth (SU: 4 GW), and possibly 110% (RU: 17 GW). At these levels, PV will at least influence the generation mix of future deployed conventional generators – a sentiment echoed by Origin Energy CEO Grant King[53], and will also impact upon the manner in which the Renewable Energy Target is met.

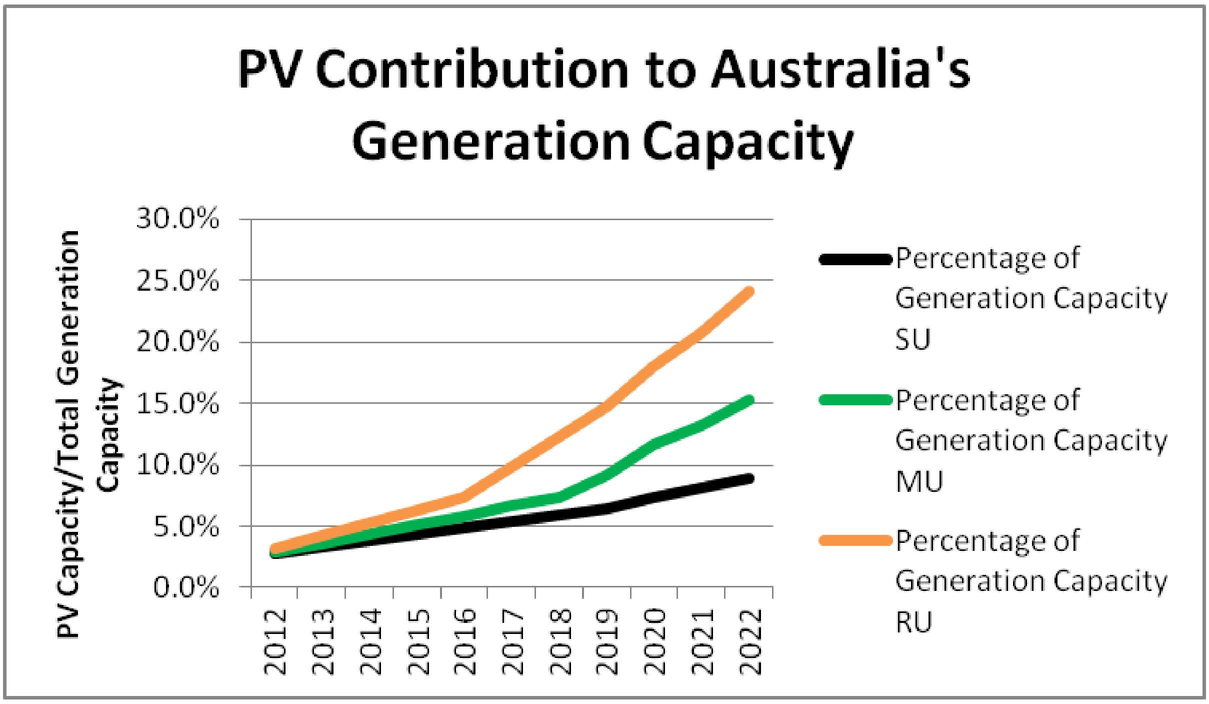

Figure 26: PV Contribution to Australia's Generation Capacity

However, PV is also likely to have an impact upon existing generators. As noted by AEMO, "The changing economic landscape, a more energy-conscious public, the impact of rooftop PV installations and milder weather have all contributed to lower than forecast annual energy demand across Eastern and South Eastern Australia."[54] Indeed, expressed in terms of total electricity consumption, NEM-connected PV (excluding solar farms) could contribute 2.0%-4.5% of AEMO's forecast NEM electricity generation by the end of the decade, up from about 0.9% by the end of 2012 – See Table 6. PV's total percentage of energy production would be raised significantly by the inclusion of solar farms (including those under the Solar Flagships and the ACT Renewable Energy Auction) – alternatively, should consumption stabilise at 2011 levels (191 TWh), PV's contribution could be as much as 5.8% by 2020.

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[52] Core Policy scenario, figure 5.3 of http://www.treasury.gov.au/carbonpricemodelling/content/consultants_reports/ROAM_Projections_of_Electricity_Generation_in_Australia_to_2050_20110803.pdf

[53] http://reneweconomy.com.au/2012/why-australia-needs-no-new-coal-or-gas-baseload-15623

[54] AEMO, "2011 ELECTRICITY STATEMENT OF OPPORTUNITIES For the National Electricity Market", 2/3/2012

	AEMO Forecast TWH Consumed	PV TWh Produced (Forecast for AEMO, NEM-connected running total incl. solar farms)			Percentage of Consumption (Forecast for AEMO)		
		SU	MU	RU	SU	MU	RU
2012	210	1.8	1.9	2.1	0.9%	0.9%	1.0%
2013	215	2.0	2.2	2.5	0.9%	1.0%	1.2%
2014	220	2.3	2.5	2.9	1.0%	1.1%	1.3%
2015	225	2.6	2.9	3.4	1.1%	1.3%	1.5%
2016	230	3.0	3.4	4.1	1.3%	1.5%	1.8%
2017	234	3.4	4.0	5.3	1.5%	1.7%	2.3%
2018	238	3.9	4.6	6.9	1.6%	1.9%	2.9%
2019	242	4.4	5.8	8.8	1.8%	2.4%	3.7%
2020	248	5.1	7.4	11.1	2.0%	3.0%	4.5%

Table 6: Percentage of NEM-connected energy generation out to 2020[55]

While PV deployment on this level may not unseat fossil fuels from their primacy in the Australian electricity mix, it may have a disproportionate impact upon wholesale electricity prices. PV generation is presently highly-coincident with peak pricing events, which commonly arise in response to peak demand within a NEM region. Should sufficient PV be deployed, the requirement for conventional generation at peak times will be reduced, which will reduce the frequency and duration of peak pricing events in what's known as the Merit Order Effect. This will undoubtedly have "a significant impact on the business models of generators, who rely on these peak periods, when prices paid for all generators can surge to $10,000/MWh or more"[56], known as =the Merit Order Effect as discussed in Section 3.2.6.

On the flip side, excessive amounts of solar generation could reduce daytime electricity prices to below night time levels, as has already occurred on occasion in Germany[57]. This could impact the value of exported solar energy, affect tariff structures, and play havoc with the business models of previously-deployed PV. However, society (not just those with PV but all electricity consumers) could benefit from the reduction in electricity prices caused by solar.

[55] Assumes 3.6kWh/kWp/day average PV production. Compares financial and calendar years and does not account for progressive deployment across the year. Uses total production from AEMO, "2011 ELECTRICITY STATEMENT OF OPPORTUNITIES For the National Electricity Market", 2/3/2012

[56] http://reneweconomy.com.au/2012/smart-energy-how-to-profit-from-falling-demand-13396

[57] http://reneweconomy.com.au/2012/euro-utilities-declare-war-on-solar-pv-57935

Figure 27: Summary of AEMO's operations[58]

Deployment of such a large volume of unregistered, non-scheduled generation could present challenges for AEMO, indeed PV deployment of this scale has the potential to impact many areas of AEMO's operations in the electricity market. **Forecasting and planning** will be strongly impacted by PV, which could contribute 50-150% of the forecast growth in generation capacity over the coming ten years[59]. PV is likely to impact upon **loss factors**, and create additional requirements for **Ancillary Services**. **Dispatch** (and its forecasting) will be affected by weather-related factors across a wide area due to the broad swathe of PV installations. Managing a variable non-dispatchable power source will require careful **reserve management**. PV may impact upon the **metering requirements**, and particularly in **network connections**. AEMO's experience integrating wind power into the NEM will service it well, though there will be major differences with a distributed generation on an equivalent scale.

There are other technical impacts that will need to be managed. Issues associated with high levels of low voltage network penetration have already arisen from currently deployed PV, particularly in long rural feeders. Figure 28 shows that household penetration of PV into owner-occupied[60] homes, which currently stands at 11%, is likely to double or treble, to the point where between 23% and 35% of owned homes could host a PV system by 2020. Though such penetration levels reduce the remaining market for residential PV sales – in effect making selling PV more difficult – they do not represent saturation of the residential market, as there will be ample opportunities to expand existing systems, sell into commercial premises, and focus upon the rental market. However, penetration of such scale is likely to present challenges for distribution network operators in some areas of the network.

Technical solutions already exist to such challenges. These include adaptive reactive power control on inverters and network-controlled peak output shaving – both of which are now mandated by new German electricity network regulations. Energy storage is another technical solution, one whose costs have prevented broad scale application in residential settings, though tariff changes may soon justify distributed energy storage. Uptake of electric vehicles will also present issues of their own, issues that may be coupled and addressed through distributed generation. Regardless, distribution

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[58] http://www.aemo.com.au/corporate/org.html

[59] Assumes 61GW of generation by 2022 from a starting point of 49GW, with PV deployment of 6.7-18.1GW by 2022 from 1.2GW by end 2011

[60] The number of owner occupied homes in 2011 is assumed to be 4,926,469 as per 2006 Census QuickStats : Australia, growing by 50,000 in each subsequent year. The housing penetration is obtained by summing the capacity installed in the GCD < 10kW sub-sector, then dividing by an average system size of 2.4kW.

network operators will need to take a greater proactive role in energy management at greater granularity in order to cost-effectively address the challenges posed by peak demand, electric vehicles, and PV. Fortunately it has already been shown that combined PV-storage can have a superior value proposition to network augmentation[61]. Finally, the smart grid should also assist in monitoring, measuring, and addressing these challenges.

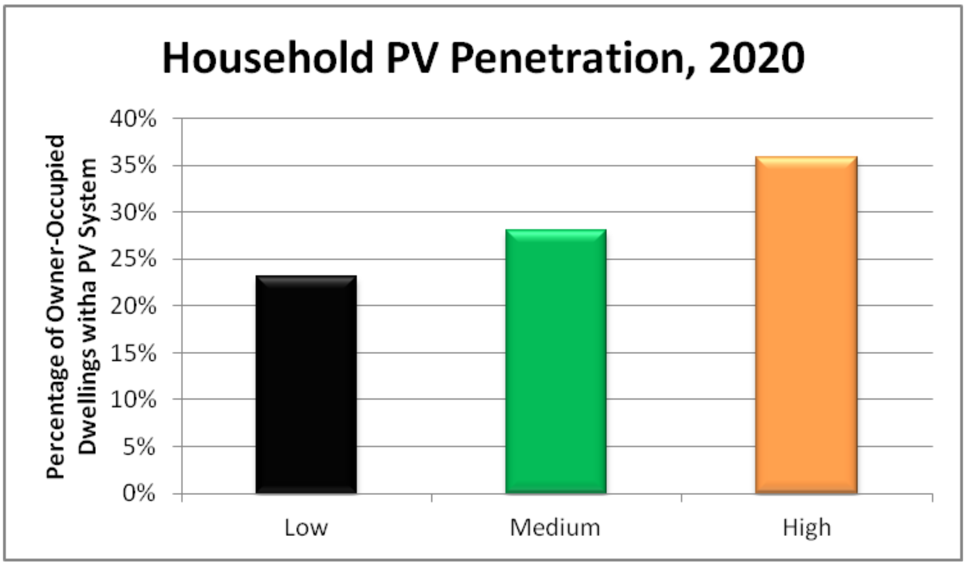

Figure 28: PV penetration into owned homes - 2022[62]

[61] http://www.climatespectator.com.au/commentary/its-time-smarter-grid

[62] http://www.censusdata.abs.gov.au/ABSNavigation/prenav/ProductSelect?newproducttype=QuickStats&btnSelectProduct=View+QuickStats+%3E&collection=census&period=2006&areacode=0&geography=&method=&productlabel=&producttype=&topic=&navmapdisplayed=true&javascript=true&breadcrumb=LP&topholder=0&leftholder=0&currentaction=201&action=401&textversion=false#Dwelling%20Characteristics

9 Conclusions and Opinion

The following text represents the opinion of the authors.

History has repeatedly demonstrated that the uptake of PV around the world has on average exceeded industry's wildest expectations, and indeed, Australia is no exception. The potential market opportunity is enormous and remains largely untapped.

The majority of energy market forecasters have dramatically underestimated the cost reductions, demand and probable uptake of PV in Australia. The unfortunate effect of this has been to blind government and the industry to the inevitable changes that will occur in the electricity industry as a result of the financial attractiveness of a simple rooftop technology for which the Australian public has shown unprecedented enthusiasm.

This presents some challenges for the electricity industry. Current and future business models of the generators and retailers will be impacted even by conservative deployment of PV. In order to survive, many gentailers will resort to an embrace of PV, however unwilling. Those that incorporate this inevitability into their strategic planning are likely to outperform those that don't. So too, challenges of increasing PV penetration will arise for the Distribution Network Operators. Considering the length and funding cycle of the network operators and its immediacy, harnessing the opportunities provided by PV – and similarly, electric vehicles and peak demand – whilst managing its impacts will require a sophisticated network control strategy. It is essential that all stakeholders are well informed.

As for AEMO, PV deployment of this scale has the potential to impact many areas of AEMO's operations in the electricity market. AEMO will be affected organisation-wide: Forecasting and planning, loss factors, Ancillary Services, Dispatch (and its forecasting), reserve management, metering requirements, and network connections. AEMO's experience integrating wind power into the NEM will service it well, though there will be major differences with a distributed generation on an equivalent scale.

In spite of the challenges PV poses to the electricity industry, it also creates substantial benefits. As PV will be profitable for residential and commercial electricity users, its emission abatement cost will be negative. Previously viewed as an expensive way to abate carbon emissions, PV's impending self-sufficient profitability will unleash billions of dollars of private investment in carbon abatement. By lowering electricity bills both due to the Merit Order Effect and for system owners directly, PV could improve the business competitiveness and provide some relief from rising electricity costs.

This is not to say that PV support should be removed just yet; to the contrary, support is absolutely essential in the short term. The PV industry is expected to just survive the next three years as reductions in solar multiplier take effect. However, it does suggest that the PV industry has a remarkable contribution to make to the Australian energy mix. The real question then becomes how effectively the inevitable can be managed. In the long run, the fewer barriers there are to solar power, the sooner solar power can distribute its benefits, to the betterment of current and future generations.

10 Appendices: Sensitivity Analysis

10.1 Adjusting PV price declines with consistent electricity price rises (moderate scenario)

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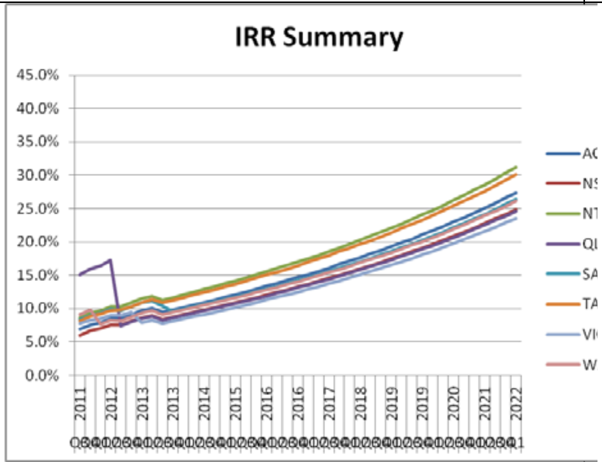
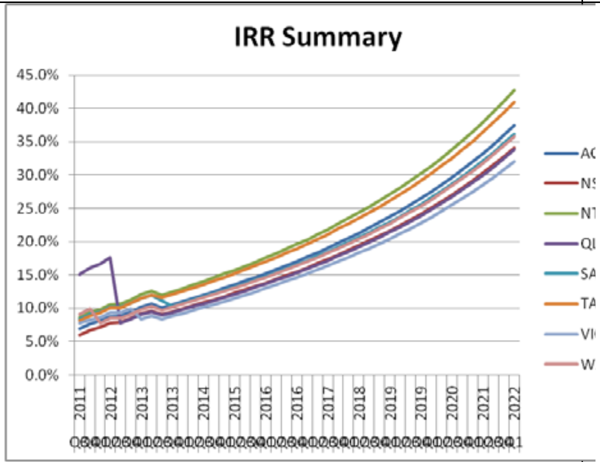
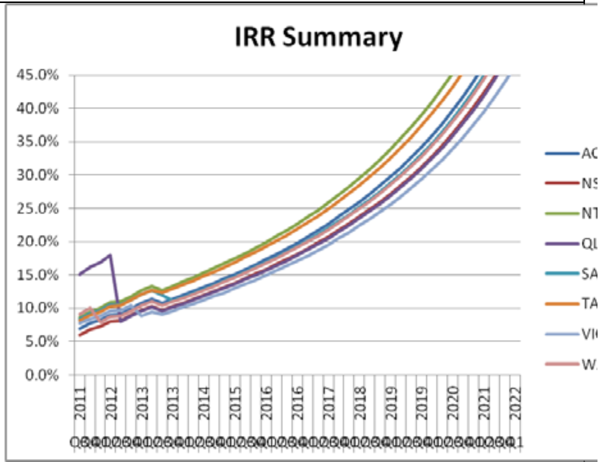
<tr><td>5kW</td><td>
</td><td>
</td><td>
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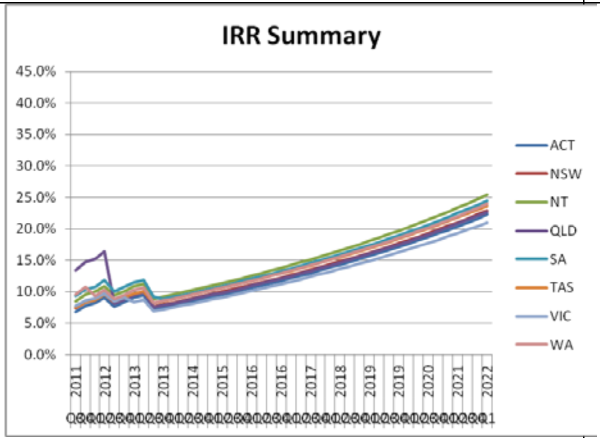
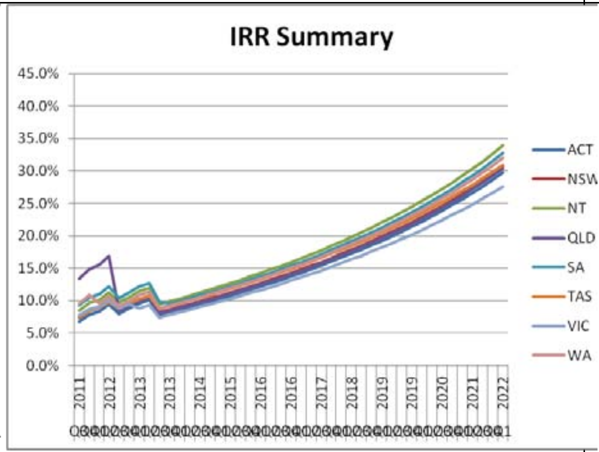
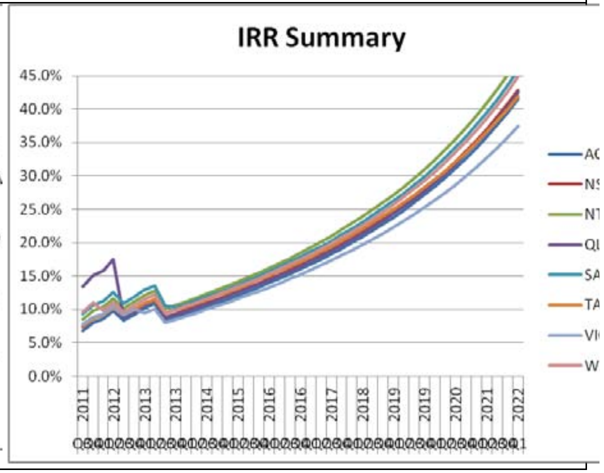
<tr><td>1.5k W</td><td>
</td><td>
</td><td>
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10.2 Varying both electricity prices and PV price declines

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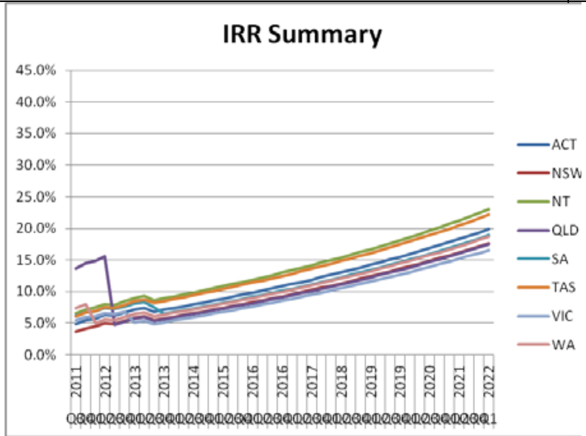
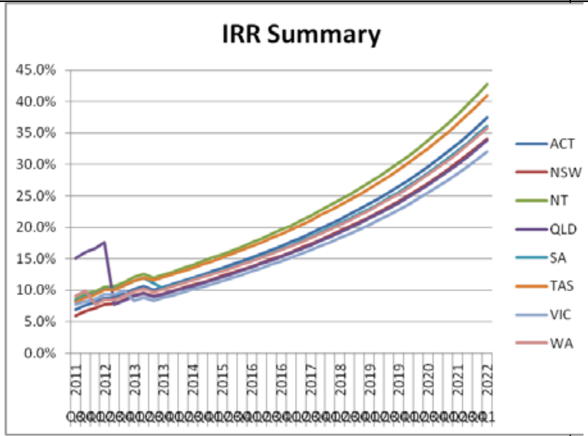
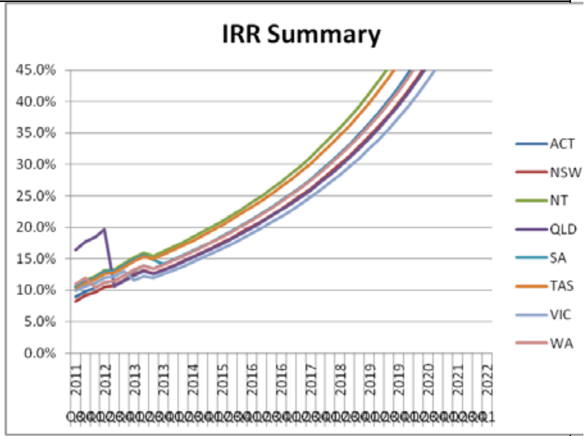
<tr><td>5kW</td><td>
</td><td>
</td><td>
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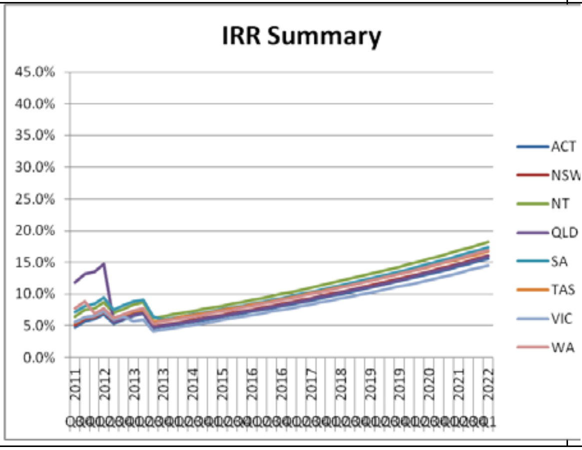
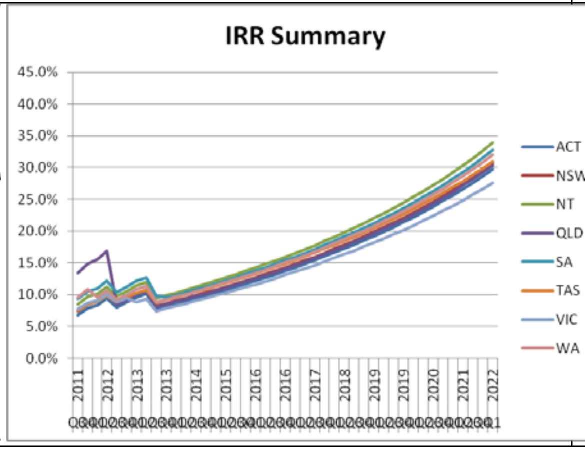
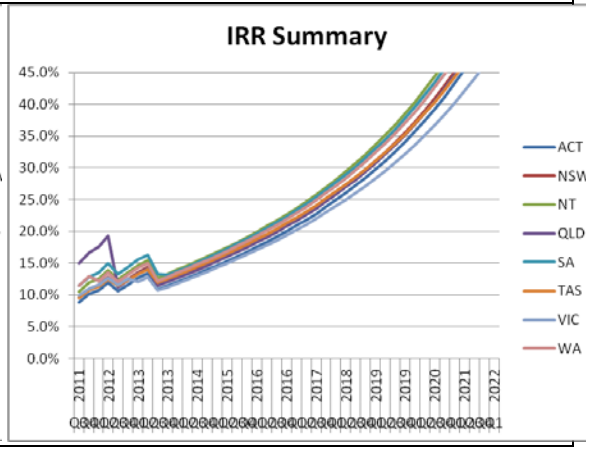
<tr><td>1.5kW</td><td>
</td><td>
</td><td>
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Note that these sentitivity analyses use a PV price decline across the entire PV price, whereas PV price declines in the scenarios in the main body of the document are based upon varying declines across individual components of the PV system price.