Modelling of PV & Electricity Prices in the Australian Residential Sector

By

The Australian PV Association

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The model used to prepare the analyses for this report was developed with funding assistance predominantly from the Australian Solar Institute but also from the Australian PV Association, and with data sourced from APVA members and literature sources.

The model was initially developed in early 2010 and updated in mid 2011. However, since PV costs and performance continue to improve, values in the graphs should be read from the relevant current date.

About the Australian PV Association (APVA)

The APVA is an Association of companies, government agencies, individuals, university and other research groups with an interest in photovoltaic solar electricity research, technology, manufacturing, systems, policies, programs and projects. In addition to Australian activities, we provide the structure through which Australia participates in the International Energy Agency (IEA) Photovoltaic Power Systems program (PVPS).

Our work is intended to be apolitical and of use, not only to our members, but also to the general community. We are not a traditional lobby group, but instead focus on data analysis, independent and balanced information and collaborative research, both nationally and internationally.

Our reports, media releases and submissions can be found at www.apva.org.au.

Contents

Silex Solar panels installed in Epping, NSW by *Soltek Energy*

PV in the Residential Sector

The APVA has developed a set of techno-economic projection models to inform stakeholders as to likely changes in the cost of electricity generated by PV, compared to prevailing grid electricity prices. Three models were developed, one for residential systems, one for systems on commercial buildings, and another for systems designed for generation on a large scale. The residential and commercial systems are compared to the prices of grid electricity under standard electricity supply arrangements, whereas the large-scale model compares the cost of PV-electricity to wholesale electricity market prices.

Note that the residential and commercial comparisons implicitly assume that all electricity generated by the system is valued at the relevant retail tariff, whilst in practice PV system owners may receive little or no payment for electricity which is not used on site. Also, the life cycle cost of PV electricity is calculated over a 25 year period, while many householders expect a payback period on their investment of less than 10 years.

Each of these three models has the same functionality, but is structured to reflect the differing cost arrangements for each application. The models exclude government subsidy (eg. Solar Credits) and special tariff arrangements, so as to model the underlying economic case for current and future investments in PV. Achieving grid parity is a milestone now beginning to be reached for distributed PV systems, but it may not alone result in cost-effective or guaranteed deployment. Both technical changes to the grid and regulatory changes to the market are likely to be required before distributed PV systems can be widely deployed.

PV remains a relatively new technology, with much research and development still required. Nevertheless, it is one of the most versatile and promising of the renewable energy technologies now available. The results presented herein provide an indication of its prospects in Australia. The underlying data were sourced from APVA members and publically available information. The results presented are for the purposes of informing stakeholders and the interested public. They are general in nature and subject to a number of underlying assumptions. As such, readers should not take these results as representing financial or investment advice.

Background

There are approximately 8.5 million permanently occupied homes in Australia, accounting for 13% of Australian energy use. Residential electricity demand is expected to increase 55% from 1990 levels by 2020[1].

At the end of 2010 there was approximately 380 MW of PV installed on residential buildings, but the potential is much larger. For instance, if 25% of households each installed 2 kWp of PV, Australia could readily have 4 GWp installed on residential buildings, generating around 5.8 TWh per year or 12% of the Renewable Energy Target.

Historically Australian householders have been encouraged to install PV by a range of rebates, subsidies, and preferential feed in tariffs offered by various government jurisdictions. While these incentives have been successful in increasing deployment, the current environment of rapidly increasing residential electricity prices, combined with rapidly decreasing PV system costs, is changing the balance in such a way as to suggest the role of government may change from direct intervention (via rebates, subsidies, and other direct financial incentives) for residential PV to the provision of appropriate regulatory frameworks, so that householders can see an underlying economic incentive to source their energy from PV. Regulatory changes to ensure that PV electricity fed into the distribution network is appropriately valued , as well as technical changes to the grid itself to facilitate high levels of distributed generation, are now needed before a sustainable residential PV market can be created.

Description of the model

The results presented herein were obtained from the APVA's residential system cost projection model which is an integrated system cost and discount cash flow model implemented in Excel and controlled by VBA Macros. For detailed information regarding the methodology used, interested readers should consult *"A Manual for the Economic Evaluation of Energy Efficiency and Renewable Energy Technologies"* published by the US National Renewable Energy Laboratory[2].

Model Inputs

System Scenarios

The model operates via user definition of a system scenario. The variables selected by the user for this system then define the default cost, energy, and financial parameters from which the model produces its results. The user selects from a drop down table which provides the following choices for this purpose:

- Technology type: thin film, polycrystalline, monocrystalline and high efficiency silicon[3]
- Nominal system size: 1.5kW, 5kW or 10kW
- Location: Brisbane, Sydney or Melbourne[4]
- Financing: 100% Mortgage, 100% Savings, 50/50 Mortgage/Savings
- Development model: Standardised household systems, individually designed systems or Commercial investor systems.

[1] Dept of Environment, Water, Heritage & the Arts, 2008, Energy use in the Australian Residential Sector 1986-2020, ISBN: 978-1-921298-14-1
[2] Short W, Packey D, Holt T, *A Manual for the Economic Evaluation of Energy Efficiency and Renewable Energy Technologies*, National Renewable Energy Laboratory, 1995. www.nrel.gov/docs/legosti/old/5173.pdf
[3] These differ in terms of efficiency, cost, area, open circuit voltage (Voc) and weight.
[4] These differ in the annual average insolation and the performance ratio.

Once the system scenario has been specified, the model selects the relevant PV equipment data (module efficiency, module area, Voc, Module weight and average annual performance degradation) and financial data (landed module cost, inverter cost and BOS costs) from a set of default pre-programmed values contained within the model. Note that all models assume north-facing PV arrays at latitude angle with no shading.[5]

Key Cost / Financial Parameters

In addition to the system scenario, the model requires the user to define key financial and other input parameters. These parameters (listed below) are specified by the user for the present day (2011) and are calculated by the model for each of the next 20 years to 2031.

- Key financial parameters (cost of equity, cost of debt, CPI)
- Module Costs, Inverter Costs (factory gate / landed costs)
- Importer / Distributor system margins
- End system delivery margin (Installer margin)[6]
- Module Efficiency

Calculating investment returns relies on parameters which determine the value of money in future years. While the model provides the user with the flexibility to vary all parameters, the following defaults are applied in the modelling presented in this study:

- Inflation is taken to be 2.5% (the middle of the RBA target inflation band); and
- The interest rate on a loan and the opportunity cost of cash are both taken to be nominal 8.5% (this has been conservatively chosen to correspond to that available via a relatively high home equity loan).

The opportunity cost of cash and the loan interest rate are assumed to be the same for residential systems, as a householder with spare cash has the opportunity to use that cash to pay off their mortgage. The interest rate is used as the discount factor for all analysis presented herein.

To provide some indication of the impact of a change in the purchasing power of the Australian dollar (AUD) with respect to the currencies of countries that provide hardware, it is possible to alter the module and inverter costs by a percentage amount.

Input Electricity Price Projections

In order to establish the point of grid parity, the model takes two electricity price projections as key inputs. The electricity price projections (low and high) used in this modelling were updated in August 2011 and can be divided into two parts:

- Part 1 (to 2013): Electricity price increases expected as a result of the published small user retail price determination in NSW[7]; and
- Part 2 (2013 to 2031): Possible electricity price increases based on average historic annual price increases.

The high electricity price projection beyond 2013 is based on the annual average increase in the Australia wide electricity component of CPI[8] over the last 10 years of 3.76% p.a. in real terms. The Commonwealth Treasury's modelling of the impact of a carbon price[9] has been included in this projection.

[5] Note that this model does not attempt to duplicate what detailed PV performance models such as PVSyst offer. It is envisaged that data from such models can readily be inserted at the front end of this model if required.

[6] Although installers may not be paid a margin per se, and may in fact be paid a fixed amount per system, we have used a percentage margin for simplicity.

[7] IPART, Changes to regulated retail electricity prices from 1 July 2011 - Final Report (Table 1.2), June 2011

[8] Australian Bureau of Statistics 6401.0 - Consumer Price Index, Australia, Jun 2010

[9] Commonwealth of Australia 2011, Strong Growth Low Pollution Modeling a Carbon Price, Chart 5.28

The low electricity price projection is based on the annual average increase in the Australia wide electricity component of CPI over the last 20 years of 1.82% p.a. in real terms. No allowance for the impact of a carbon price has been factored into this projection.

Model Outputs

Once the system scenario has been defined and all key inputs specified by the user, the model automatically calculates the following values for the present day, as well as in respect of an investment in PV made in each year out to 2031. To emphasise the impacts over the next 10 years, the following graphs only cover the period to 2021.

- Total installed cost (as both 2011 A$/W and total 2011 A$), which consists of:
  - PV equipment cost (landed price)
  - Importer/Distributor margin
  - Structural CAPEX
  - BOS costs
  - Installation costs
  - End system delivery margin (Installer margin)
  - GST
  - Interest expenses (present value terms)
- Levelised Cost of PV Electricity (LCOE), in 2011 c/kWh
- Net present value Return on Equity (ROE) of the system including offset electricity, as 2011 $
- Net present value of offset electricity, as both 2011 $ and 2011 c/kWh
- Internal Rate of Return (IRR) of the investment.

Results

The Levelised Cost of Energy (LCOE) from a PV system is a metric used to understand the per-unit cost of the electricity generated by that system. It is the cost that, if assigned to every unit of energy produced by the system over its lifetime, will equal the net present value of the total lifetime system cost at the point of implementation[10].

In the results presented below, the LCOE is used as the metric which is compared to the cost of purchasing electricity from the grid to establish the point of 'grid parity', the point at which the LCOE from PV falls at or below the cost of purchasing electricity from the grid. This is an economic analysis and does not necessarily reflect the value of the PV electricity to a particular customer, since the latter will be determined not only by the LCOE, but also by the conditions of their grid supply, including the rate paid for electricity exported to the grid in excess of on-site requirements.

Base Case System

The following system configuration is taken as the base case system for the purpose of the analysis:

- Technology type: polycrystalline
- Nominal system size: 1.5kW
- Location: Sydney
- Financing: 100% Mortgage
- Development model: Standardised system

[10] Short W, Packey D, Holt T, p. 47, *A Manual for the Economic Evaluation of Energy Efficiency and Renewable Energy Technologies,* National Renewable Energy Laboratory, 1995. www.nrel.gov/docs/legosti/old/5173.pdf

Table 1 shows the key input parameters used in this case study. It also shows the annual changes in these parameters the purpose of establishing future year system costs.

Table 1: Base Case Input Parameters

Input Parameter	2011 Value	Base Case – Annual % Change
System lifetime	25 years	
Sydney generation	1,522 kWh/kW	
Brisbane generation	1,606 kWh/kW	
Melbourne generation	1,401 kWh/kW	
Cost of equity/debt (discount rate)	8.5%	
Inflation	2.5%	
Annual performance degradation	0.8% p.a.	
Module Efficiency	13.5%	2% p.a.
Module Cost (factory gate / landed)	1.30 ($/Wp)[11]	-4% p.a.
Inverter Cost (factory gate / landed)	0.90 ($/Wp)[12]	-2% p.a.
Importer / distributor margin	10%[13]	-2% p.a.
End System installation margin(s)	20%	-2% p.a.

System Capital Cost Breakdown

Figure 1 presents the capital cost breakdown for the base case system under two potential system delivery model options: individually designed, and a standardised 'bulk' supply. The majority of residential systems are now being installed under the standardised supply model and there are two main types of this model – company-based and council or community group-based. Company-based models seem to be the first to have been used widely and initially involved signing on 50 or so households willing to buy a system, then a rapid roll-out while the next 50 were signed on. Council or community group-based schemes may also be described as 'preferred supplier' models.

[11] Note that prices ranging from $1.05 to $2 have been seen on the market
[12] Prices on the market can vary significantly around this value and are currently falling
[13] 10% end system installation margin applies to systems delivered under standardised 'bulk supply' system delivery channels, which is used as the base case, 20% end system installation margin applies to systems individually designed and supplied.

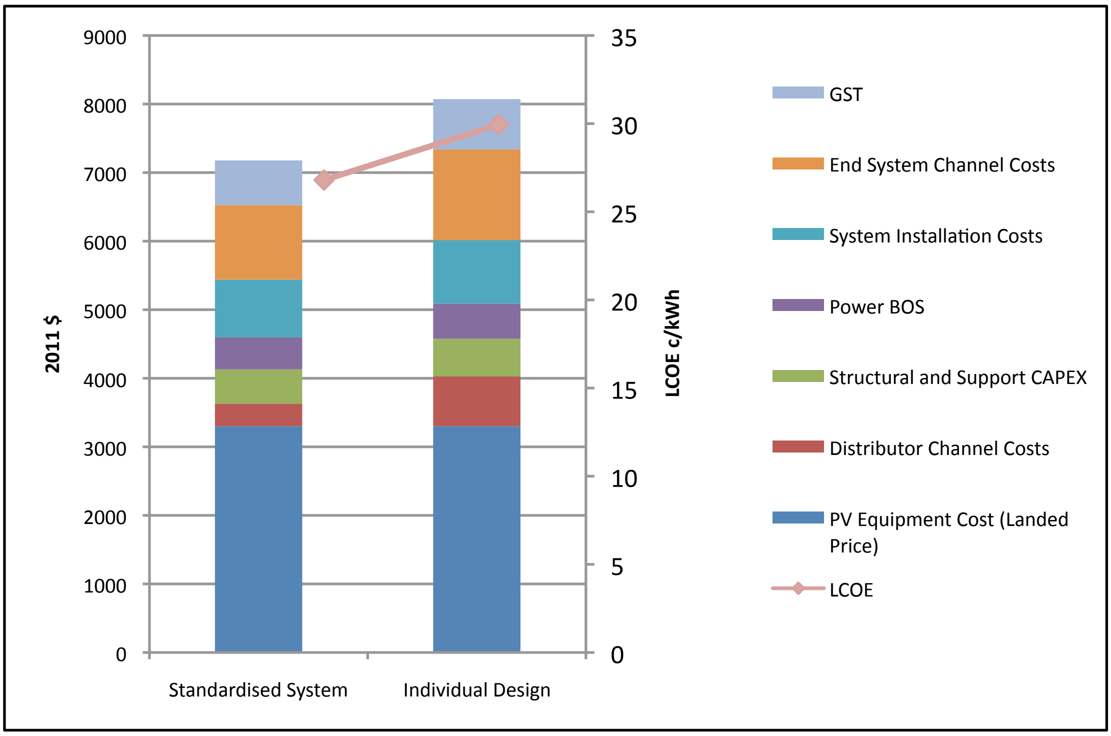

Figure 1: Base Case System (1.5kWp) Capital Cost Breakdown (Standardised System vs Individual Design) – excludes Solar Credits

The difference in cost is approximately 60 c/Wp with standardised systems costing approximately $900 less for a 1.5 kWp system at approximately $7200, or 4.80 $/Wp, compared with an individually designed system at $8100, or 5.40 $/Wp. This result illustrates the potential for innovative and efficient business models to drive system cost reductions. Figure 1 also shows that the (landed / factory gate) cost of the PV modules and inverters now represent under half of the end use system cost.

A standardised supply model has been chosen as the base case in the analysis herein, rather than the more conservative individual design option, as the standardised option has become the dominant business model available in the Australian residential PV market and is more reflective of installed PV system prices currently on the market.

Grid Parity

As described above, 'grid parity' is the point at which the LCOE from PV falls at or below the cost of purchasing electricity from the grid under standard electricity supply arrangements. Grid parity can be assessed in the following two ways:

- On the basis of the price of grid electricity paid in the year of system installation; or
- On the basis of the net present value of the electricity offset by the PV system over its 25 year life.

While comparing the LCOE from PV with the net present value of the electricity offset by the system over its lifetime may be an analogous comparison (apples with apples), it is more likely that consumer decisions, and the rate of system deployment, will be driven by the price of grid electricity paid in the year of system installation.

Figure 2 shows that, assessed on the basis of the net present value of the electricity offset by the PV system, the point of 'grid parity' has already been reached for base case systems located in Sydney, Melbourne, and Brisbane. As such, under the assumptions made in this modelling, a householder paying for a base case PV system in 2011 with a home equity loan at an 8.5% nominal interest rate is already likely to be better off over the life of the system than purchasing electricity from the grid.[14]

When grid parity is assessed on the more conservative basis of the price of grid electricity paid in the year of system installation, the point of 'grid parity' is likely to be reached between 2012 for a base case system located in Sydney and Brisbane and 2013 for the same system located in Melbourne[15][16]

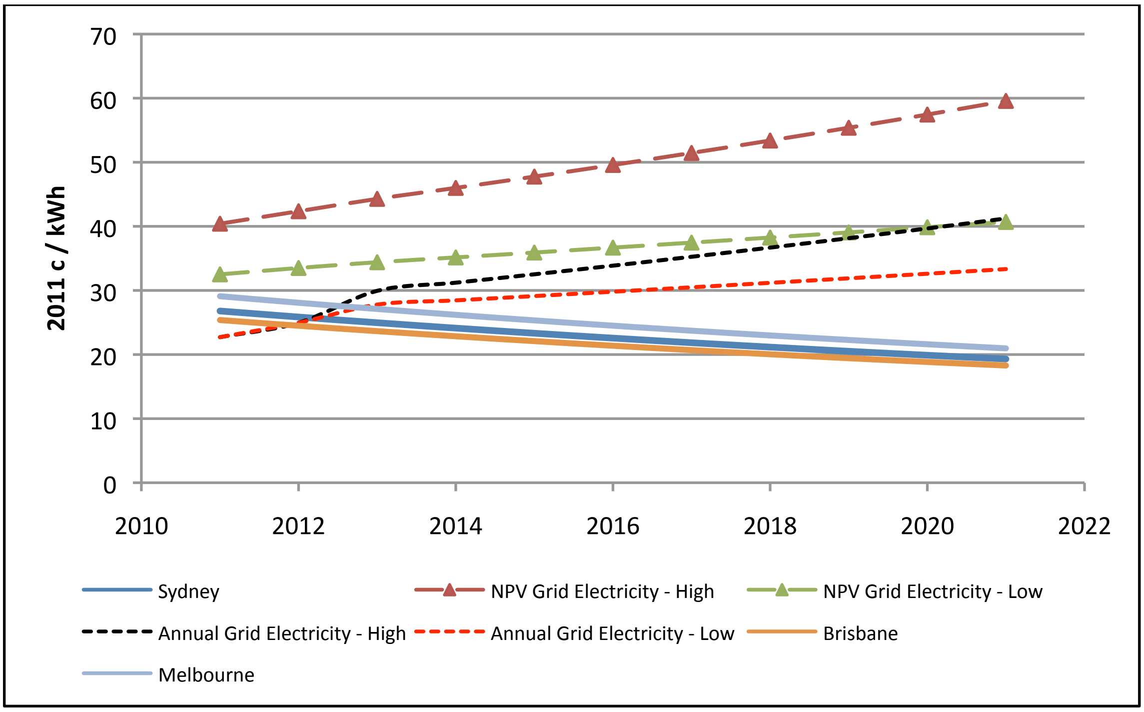

Figure 2: Projected base case PV LCOE vs high-low grid electricity price projection – excludes Solar Credits

As discussed in the section on Sensitivity Analysis below, these projections are entirely dependent on the assumptions made regarding various parameters. Figure 3 shows the possible ranges in LCOE if the most important parameters are varied: module efficiency, module cost, finance cost and the purchasing power of the AUD. See Table 2 for details of the sensitivity ranges assessed. The sensitivities provide bands of possible LCOE values over time. For the 'medium LCOE range' assessed, grid parity could be delayed by between 3 and 5 years compared to the base case, and for the 'maximum LCOE range', grid parity could be delayed by between 9 and 19 years.

[14] Note that implicit in this is the assumption that all electricity generated by the system is valued at the relevant retail tariff. However, PV owners may not receive this rate for electricity exported to the grid.
[15] It should be noted that the electricity price projections to 2013 have been based on small user regulated retail tariffs for NSW which will be different to those in Qld and Vic.
[16] Note that the capital costs used for these projections do not account for Solar Credits, so that the effective LCOE would be lower than shown by an amount dependent on location and REC value.

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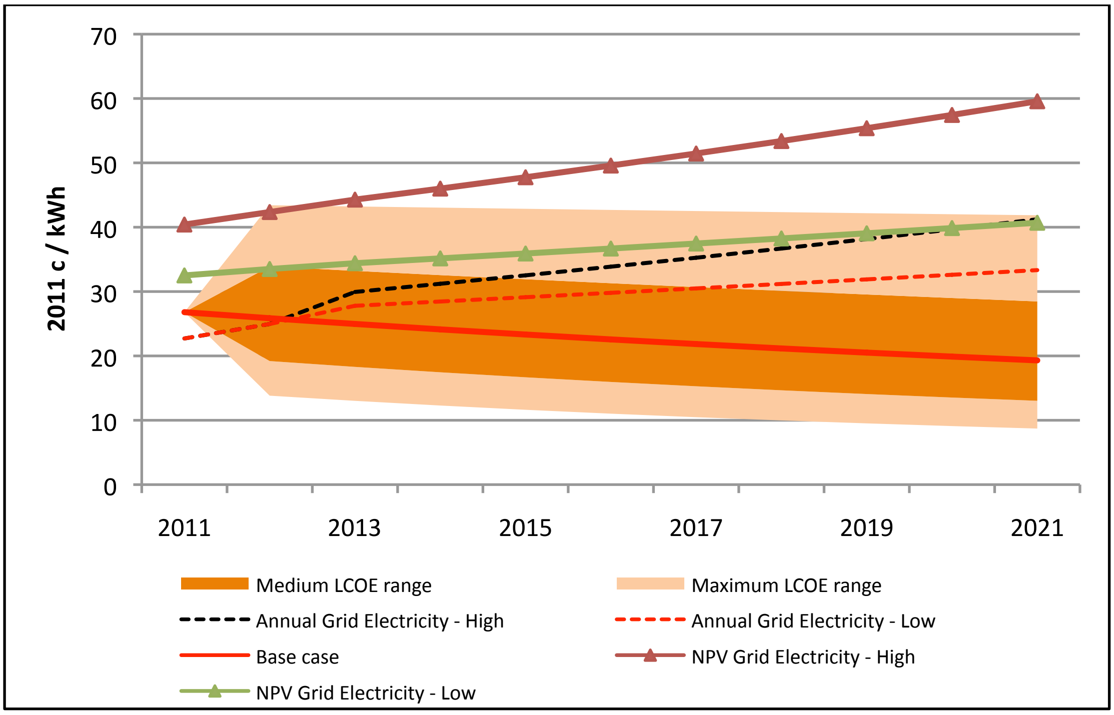

Figure 3: Effect of altering assumptions on projected base case PV LCOE – excludes Solar Credits

Table 2: Variation of Parameters for LCOE ranges in Figure 3

Input Parameter	**Max LCOE range lower bound**	**Med LCOE range lower bound**	**Med LCOE range upper bound**	**Max LCOE range upper bound**
Module efficiency	4% p.a.	3% p.a.	1% p.a.	0% p.a.
Module Cost	-8% p.a.	-6% p.a.	-2% p.a.	0% p.a.
Cost of debt	4.5%	6.5%	10.5%	12.5%
Purchasing power of AUD	25% higher	12.5% higher	12.5% lower	25% lower

Larger Systems

The system size has a significant impact, with the LCOE of a 10kW system being just over 80% that of a 1.5kW system. Note, however, that the standardised system model, and hence the price reductions available through them, may be more difficult to apply to larger system sizes[17].

[17] In addition, although Solar Credits are not included in the analyses shown here, it should be noted that the impact of Solar Credits per kW installed reduces for system sizes above 1.5kW, so that the effective capital cost for larger systems will be higher until 2013.

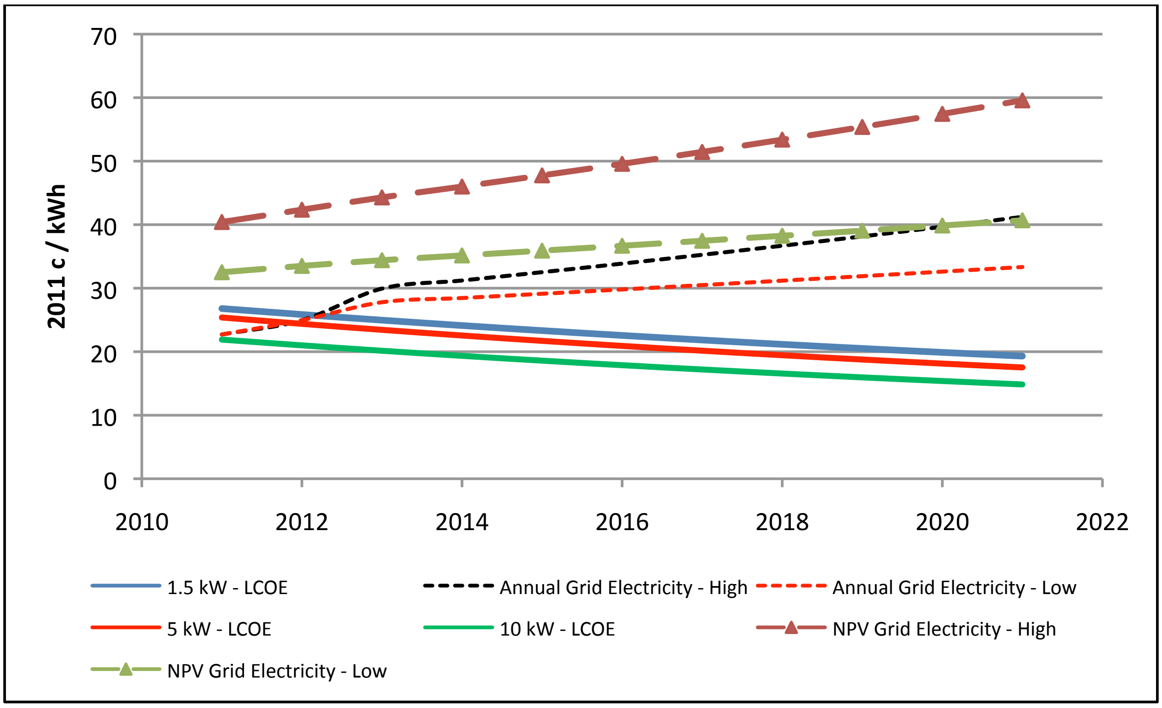

Figure 4: Effect of system size on base case LCOE over the period to 2031 – excludes Solar Credits

Figure 4 shows that, under base case assumptions, 10kW systems have not only achieved grid parity based on the net present value of lifetime electricity generated by that system but also on the basis of the price of grid electricity paid in 2011 at approximately 21 c/kWh with an installed cost of 4 $/Wp.

Sensitivity Analysis

The model allows for the variation of parameters to understand the sensitivity of the output and the resulting impact on the range of years over which grid parity is expected. Figure 5 shows the results of a sensitivity analysis undertaken by varying a selection of major input parameters by ± 25%.

From Figure 5 it can be seen that the LCOE is most sensitive to the following key input cost parameters:

- Module efficiency;
- Module cost;
- Finance cost (Interest rate); and
- The purchasing power of the AUD

Given the sensitivity of the LCOE to these parameters, the impact of variation in each will be investigated in more detail below.

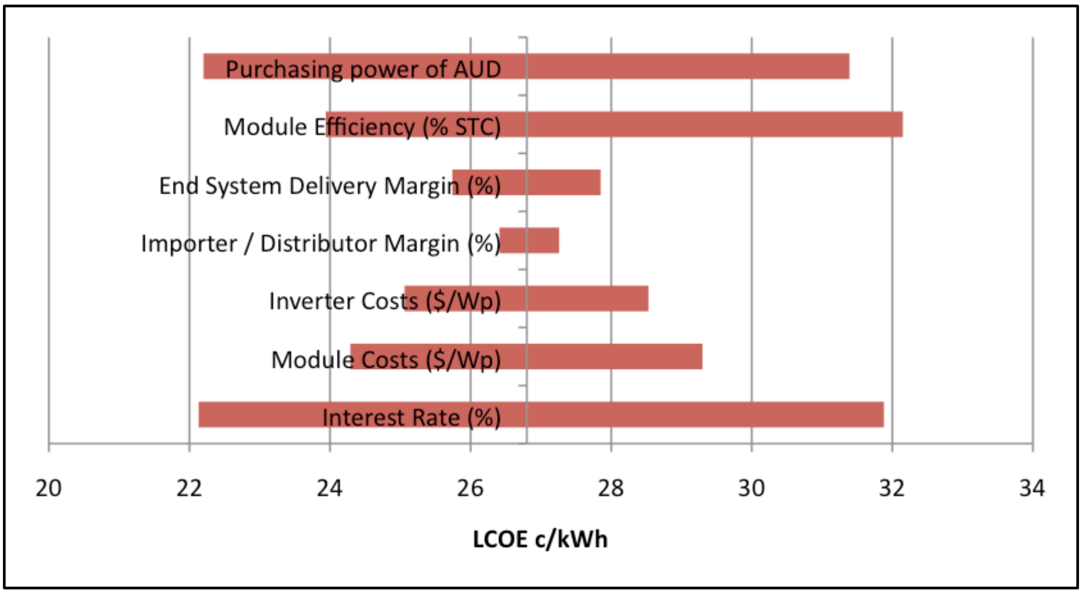

Figure 5: Impact on LCOE associated with variation of key parameters ± 25% – excludes Solar Credits

Module Efficiency

Variation in module efficiency is observed to impact significantly on the LCOE of the base case results. Increasing module efficiency by 25% (from 13.5% to 16.9%) decreases the LCOE by approximately 10.3%, assuming all other variables are held constant and no premium is charged for higher efficiency[18] - see Figure 6.

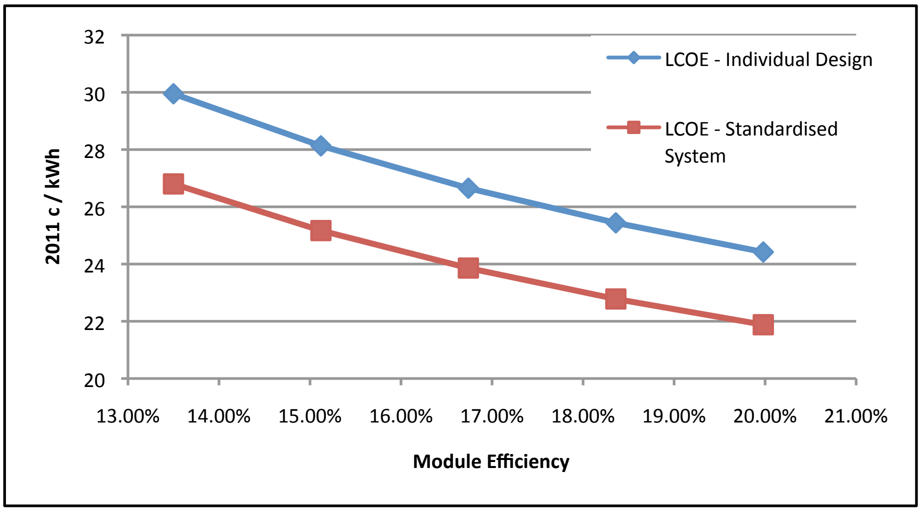

Figure 6: Effect of module efficiency on LCOE for the base case system – excludes Solar Credits

[18] Of course, there are already modules available at efficiencies as high as 20%, although at present they tend to be more expensive.

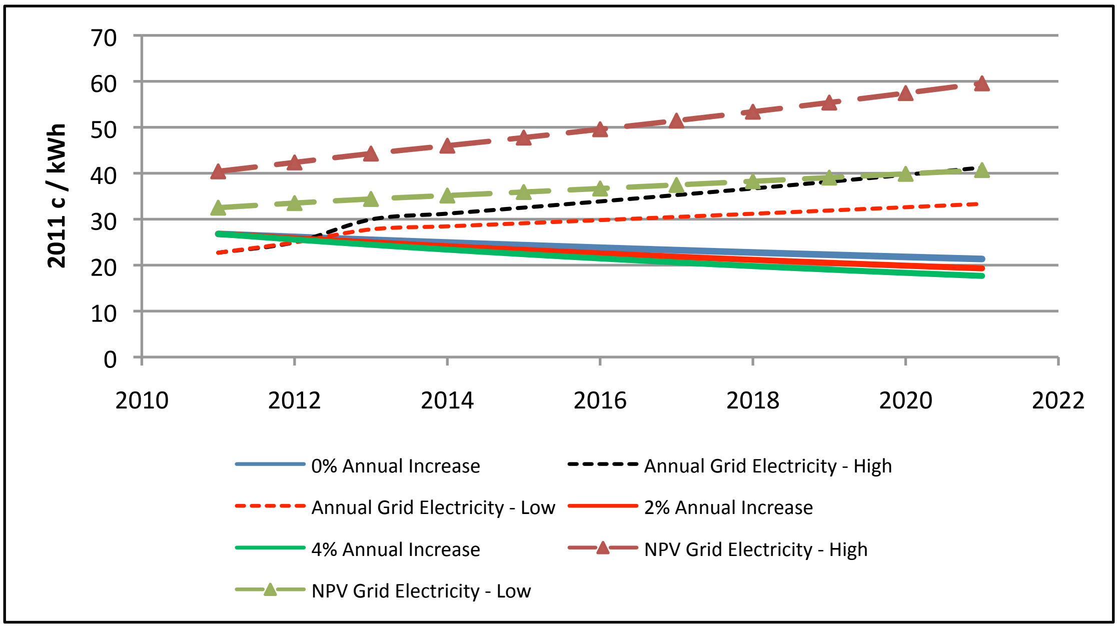

Figure 7: Projections of the impact of the rate of increase in module efficiency on base case LCOE over the period to 2031 – excludes Solar Credits

On the basis of anticipated price paid for electricity in the year of system installation, grid parity for all rates of efficiency improvement is achieved in 2013 with the benefits of higher rates of efficiency improvement accruing over time – see Figure 7.

Module Costs

As shown in Figure 8, decreasing the module costs[19] by 25% (from $1.30/W to $0.98/W) decreases LCOE by about 9.4%.

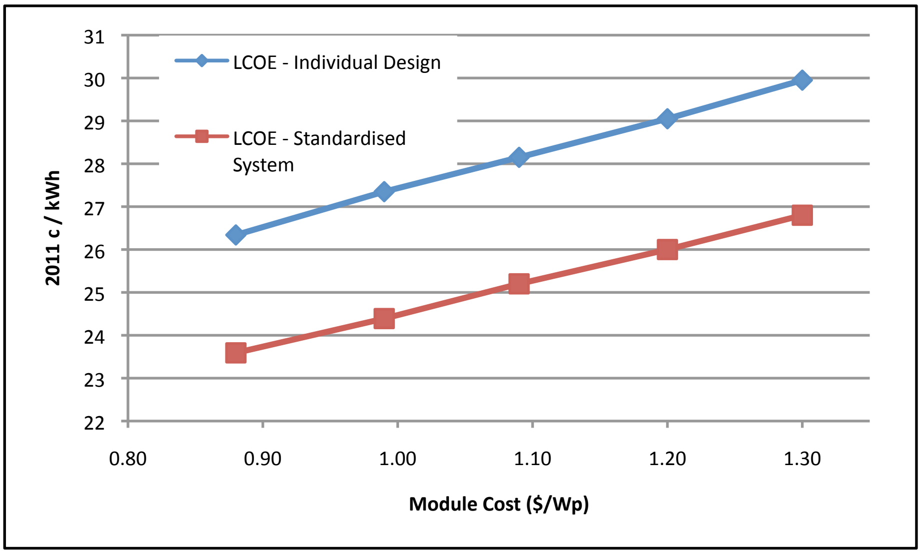

Figure 8: Effect of module cost on LCOE for the base case individual design and standardised system options – excludes Solar Credits

[19] Decreases in module costs on a $/Wp basis can result from module efficiency increases as well as improvements in other aspects of the market, such as manufacturing. For module purchasers, module costs can also be a function of volume purchase, the strength of the global PV demand and the exchange rate.

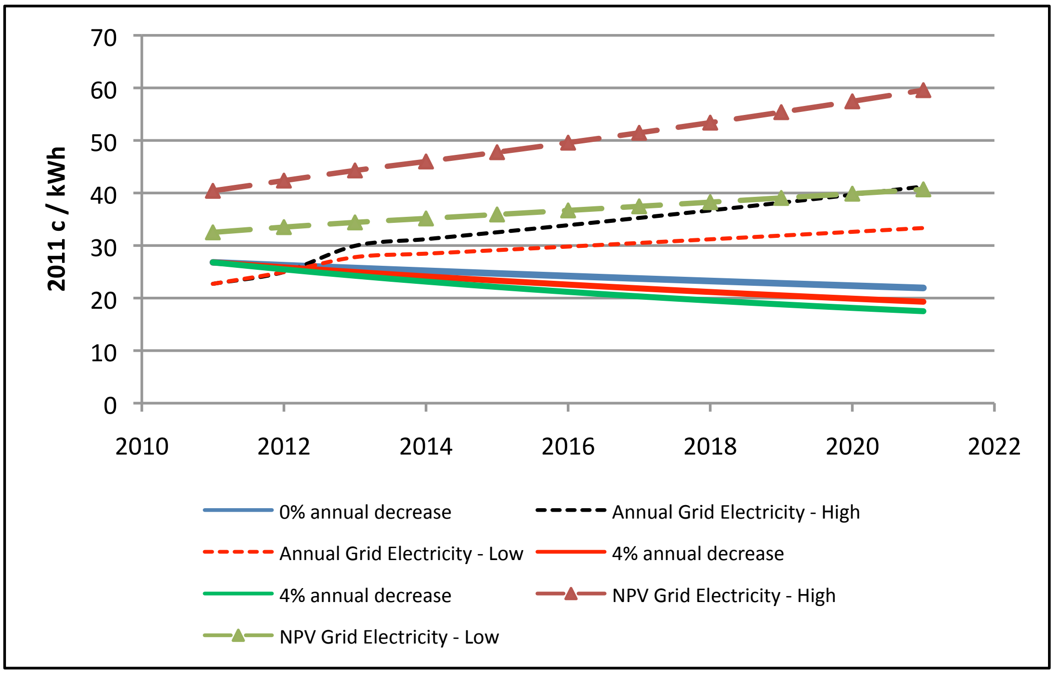

Figure 9: Effect of module cost decrease rates on LCOE for the base case system over the period to 2031 – excludes Solar Credits

Changes in the rate of decrease in module cost are seen to have minimal impact on the point of grid parity (when considered on the basis of annual electricity purchase costs), which is observed to occur in 2013 for all rates of module cost decrease – see Figure 9.

Finance Costs

Increasing the cost of financing a base case PV system by 25% (from 8.5% to 10.27%) is observed to increase the LCOE by approximately 16%. In addition to increasing the LCOE, increasing the interest rate also changes the discount rate applied to calculating net present values, which reduces the value of the electricity offset by the PV system over its life. Figure 10, Figure 11 and Figure 12 show the impact on grid parity from variations in interest rates.

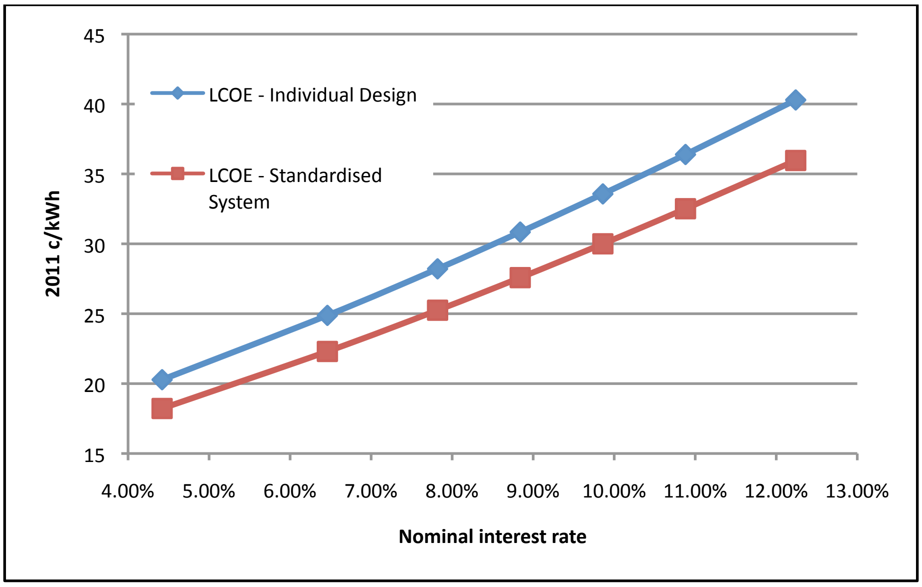

Figure 10: Effect of interest rates on LCOE for the base case system – excludes Solar Credits

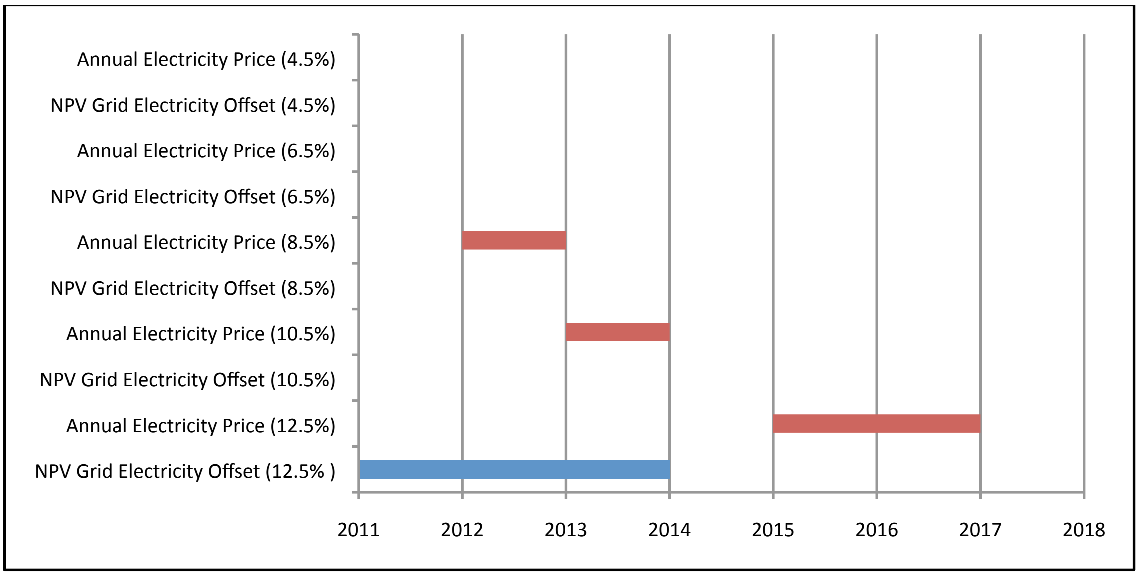

Figure 11: The range of years over which grid parity is achieved as a function of interest rates – excludes Solar Credits

Figure 11 shows the range of years over which grid parity is achieved as a function of the interest rate applied in the modelling. While the result obtained for the base case (using a nominal interest rate of 8.5%) showed that grid parity had been reached in 2011, as the interest rate is increased, the LCOE is observed to increase. For example, if an interest rate of 12.5% is applied, grid parity would be reached:

- Between 2011 and 2014 on the basis of net present value of electricity offset
- Between 2015 and 2017 on the basis of the price paid for grid electricity in the year of system installation.

Figure 12 illustrates the increase in LCOE and decrease in net present value of offset electricity as the interest rate is increased.

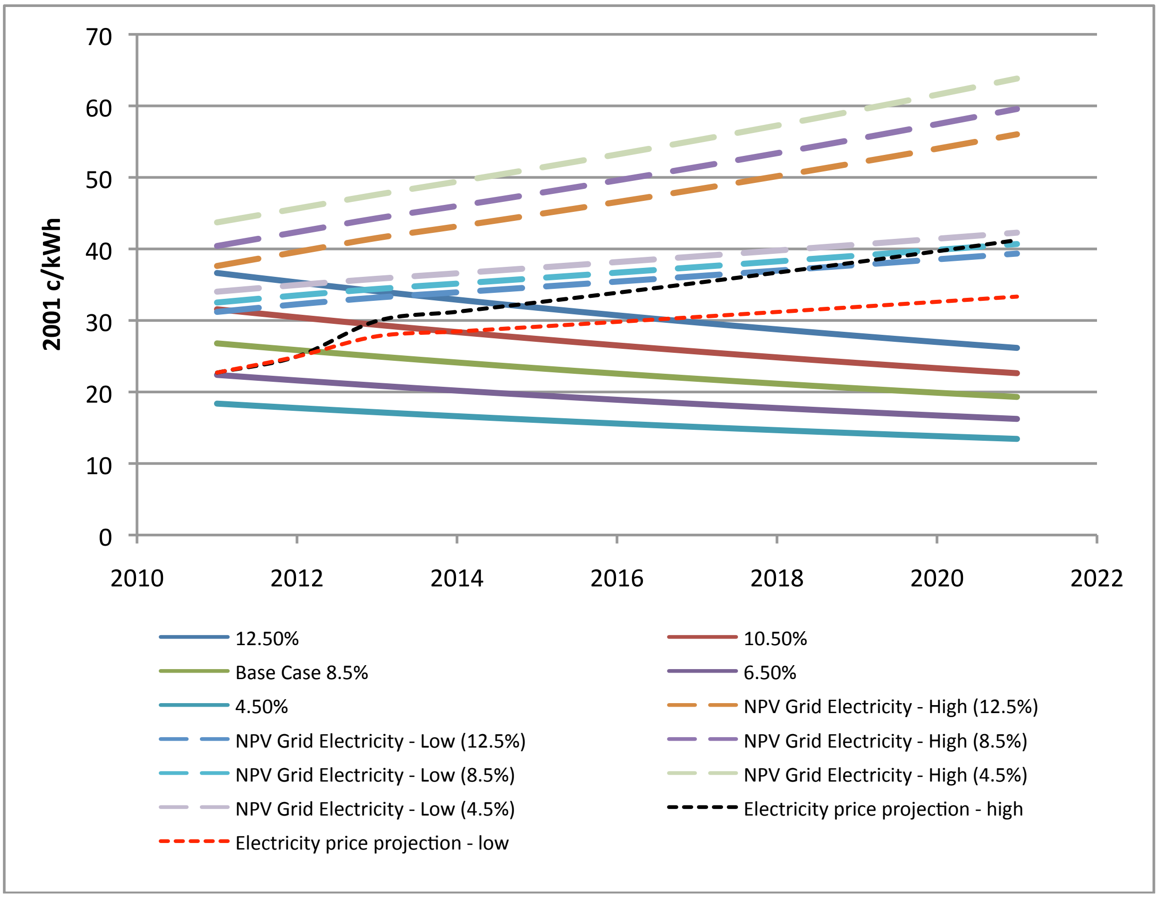

Figure 12: Change in LCOE and NPV of offset electricity for different interest rates over the period to 2030 – excludes Solar Credits

Purchasing power of the AUD

Much of the hardware of residential PV systems installed in Australia at present is purchased from overseas. The value of the AUD with respect to the currencies of countries that provide the hardware fluctuates daily and can vary by significant amounts in yearly timeframes. To provide some indication of how this might affect the LCOE, the module and inverter prices can be altered by a percentage amount. Thus, a 15% decrease in the purchasing power of the AUD increases module and inverter costs by 15%. Figure 13 shows that decreasing the purchasing power of the AUD by 15% increases the LCOE by approximately 10%, and vice versa.

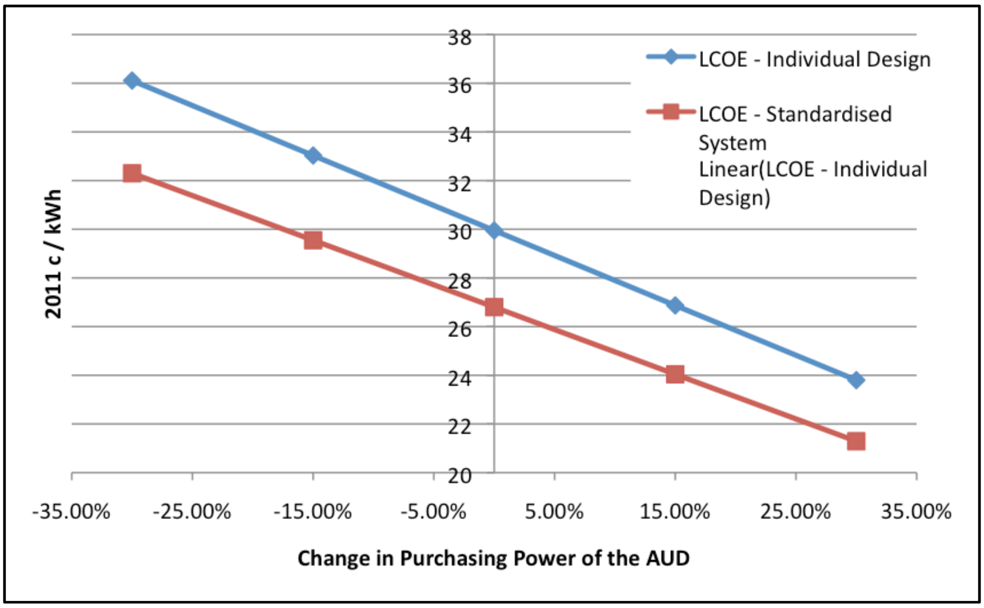

Figure 13: Effect of exchange rates on LCOE for the base case system – excludes Solar Credits

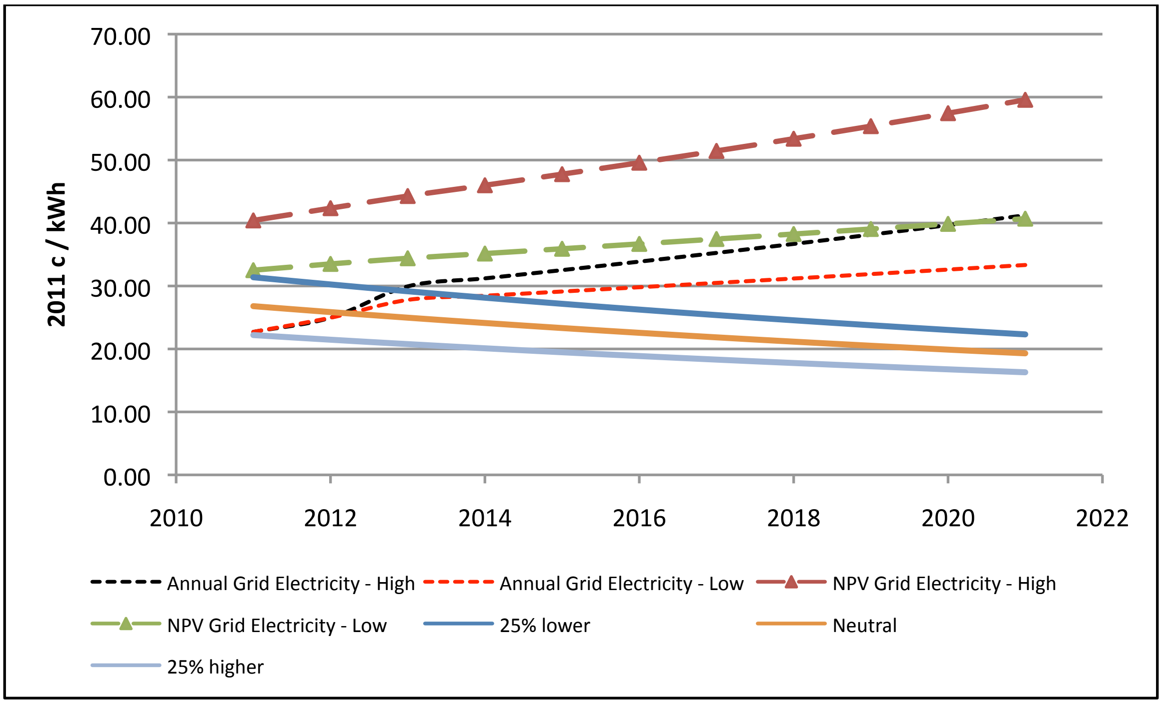

Figure 14: Effect of changes to the purchasing power of the AUD on LCOE for the base case system over the period to 2031 – excludes Solar Credits

As shown in Figure 14, decreasing the purchasing power of the AUD by 25% delays the year in which a certain LCOE is reached by 4 to 5 years. However, because electricity prices are expected to increase rapidly over the next few years, and as previous projections indicate that parity is expected to be reached during that time, a 25% decrease in purchasing power delays parity by only about 1 year.

Conclusions

The rate at which electricity prices are increasing, combined with the rate at which the cost of PV is decreasing, has seen the point of grid parity approach faster than was previously envisaged[20]. In particular, the point of grid parity has:

- been reached for base case residential systems (financed at a nominal interest rate of 8.5%) when assessed on the basis of the net present value of the electricity offset by the PV system over its lifetime;
- is expected to occur for a standardised residential system between 2012 and 2013, when assessed on the basis of the price of grid electricity paid in the year of system installation; and
- is expected to occur for a higher cost, individually designed residential system between 2015 and 2017, when assessed on the basis of the price of grid electricity paid in the year of system installation.

It should be noted that these results are independent of Solar Credits, feed-in tariffs or other government subsidies, and are being driven by dramatic reductions in module, inverter and system installation costs. The continued reduction in module and inverter costs is likely to see their cost as a proportion of total system cost continue to decline over the period to 2031.

Note that such projections are entirely dependent on the chosen assumptions. The variables that are most likely to change to an extent that could have a significant impact on PV LCOE in the short term are interest rates and the value of the AUD. For particular households, the actual value of PV electricity is also dependent on the amount paid for PV electricity exported to the grid. The latter is dependent on system size, timing and size of household electricity load, location and feed-in tariff rate and has not been modelled here.

While a nominal interest rate (discount rate) of 8.5% (broadly indicative of a relatively expensive average home equity loan) sees grid parity either having been achieved or to be achieved very shortly, if interest rates were to increase above this point, the point of grid parity would be delayed. The converse also applies.

A change in the value of the AUD with respect to the US dollar, which is typically used as the benchmark for PV prices, or against currencies of countries that supply hardware, has a significant impact on LCOE. The value of the AUD in 2010 and 2011 has been at historic highs relative to the US dollar, so any drop in AUD value would result in higher PV prices.

While the LCOE of PV electricity calculated here is independent of the retail tariff, grid parity is assessed on the basis of a comparison to that tariff. If exported PV electricity is paid less than the retail tariff, the effective point of parity for the individual householder would again be delayed, depending on the proportion of electricity exported. Also, many householders want a payback time for their investment to be shorter than the lifetime of the system. Hence, although parity may be reached over a 25 year period, further cost reductions are needed before the initial capital investment can be paid back in say 7 years.

In addition to continued improvements and cost reduction in PV technology, it is expected that opportunities still exist for system cost reduction via innovative and efficient business models which reduce importer/distributor and end system delivery costs. As the residential PV sector continues to mature and government subsidies around the world are progressively withdrawn, competitive pressures are expected to enhance innovation and improve the efficiency of system delivery models.

[20] The learning rate for PV has been consistently around 20% cost reduction for each doubling of production over the past 3 decades, so that significant increases in demand over the past 5 years have resulted in rapid cost decreases. For Australia, this has been exacerbated by the relatively high value of the AUD and by streamlining of the PV delivery chain.

While the results of the modelling presented herein are very positive for PV, its position may be further enhanced by:

- Reducing finance costs.
- Promoting the installation of larger systems
- Reducing the importer/distributor and installer costs, by the use of standardised system supply and installation, direct purchase from manufacturers or other means.
- Reducing module cost, which can occur through module efficiency improvements as well as through other activities, such as improvements to manufacturing processes.
- Likely reductions in inverter costs have a relatively small effect, but of course should not be overlooked as part of overall cost reductions. As PV module prices reduce, balance of system costs will become relatively more significant.

Uses for the Model

The model could be used for a range of policy or scenario analyses. These might include:

- Assessing impacts of:
    - State Feed-in Tariffs and Commonwealth support programs, such as Solar Credits
    - Alternative wholesale and retail price projections

- Modelling specific installations, systems & locations
- Adding an upfront interface to a more detailed PV module or system output model and to Australian solar radiation data to allow half hourly analyses for:
    - Time of Use tariffs and values
    - Building Integrated PV potential

Given the rapid growth of the PV market and the regular introduction of new technologies, the APVA anticipates regular updating of the model and the scenarios analysed.

Next Steps

The model outputs highlight the key requirements for PV to be cost effective against grid electricity for residential customers, but they also point to a range of wider issues, in addition to technical changes to the grid, which will need to be addressed in order to set appropriate regulatory frameworks for high PV penetration levels. These include:

- Finding ways to overcome the high initial capital cost of installing PV systems.
- Understanding how the fixed and marginal costs (wholesale, networks & retail) paid by electricity retailers are transferred through to consumers and what this means for distributed generation.
- Understanding the costs and benefits to electricity retailers of PV electricity exported to the grid – for instance, understanding whether current network standing charges that residential customers pay secure equitable access to marginal retail prices as reward for exported solar electricity.
- Establishing whether retail net metering is an appropriate price setting for distributed generation in a longer term, sustainable energy market without specific technology-based policy intervention.
- Reviewing any non cost-based barriers to solar electricity in the Australian electricity markets, including regulatory arrangements for distributed energy.