Tariff Implications for the Value of PV to Residential Customers

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Abstract

Under the Commonwealth Government's PV Rebate Program (PVRP), over 2000 grid-connected PV systems have been installed. It is useful to assess the cost-effectiveness of the systems, as well as how customers might maximize their return on investment. This paper reports on a study of rooftop PV system value to residential customers, depending on the electricity tariff chosen. For a 1 kWp PV system, for the household studied, electricity bills can be reduced by around 15%-23% under currently available tariffs. Nevertheless, the return on investment with current PV costs and electricity prices is not positive, even with Government subsidies. PV prices would need to fall by at least one third for PV to begin to be economically viable for residential use. Without the PVRP, PV prices would need to fall by up to two thirds. Given that such price reductions require industry scale-up and are not expected for another decade, consideration is now being given to the option of feed-in tariffs as an alternative to capital grants. These tariffs aim to offer customers who invest in PV, or other renewable energy technologies, an electricity buy-back rate which facilitates an economic payback within the life of the PV system. This approach has been tried in a number of other countries and found to be far more effective than government grants in attracting the investment required to drive down PV prices. The appropriate tariff for PV in Australia may need to start at around 85c/kWh and decrease over 15 years. If the cost is spread across all residential and commercial users it would add less than 2% to electricity bills yet could result in the Australian PV Industry Roadmap target of 350MW installed capacity by 2010.

1. INTRODUCTION

In earlier work (Watt et al, 2003; Watt et al, 2005) the potential for photovoltaics to contribute to meeting peak summer loads was examined for sites in South Australia, New South Wales and Victoria. Good correlations were found between PV output and system load, as measured at State nodes, and between PV output and commercial loads. Peak summer residential loads tend to lag PV output, particularly where the penetration of air conditioners is high, although PV can nevertheless make a significant contribution to meeting overall summer residential load, especially if west-facing.

Under the Commonwealth Government's PV Rebate Program, over 2000 grid-connected PV systems have been installed. Although most installations have been for environmental reasons (SEDA, 2003), it is nevertheless useful to assess the cost-effectiveness of the systems installed, as well as how customers might maximise their return on investment. The key parameters in this calculation are the system cost, how it is financed, the location (and hence the solar radiation pattern), the electricity tariffs available to the customer and their electricity usage pattern. This paper reports on a study of rooftop PV system value to residential customers, depending on the electricity tariff chosen (Pop, 2005). In the complete study, normal residential, time-of-use and green tariffs available from a number of retailers in South Australia, New South Wales and Victoria were examined. The load pattern of a household in Adelaide was used to assess the value of 1, 3, 5 and 7 kWp rooftop PV systems. PV data was supplied from a Country Energy system located in Queanbeyan. In this paper, only the results for a 1 kWp PV system under Energy Australia tariffs are reported. A separate analysis is provided of a possible feed-in tariff option.

2. THE HOUSEHOLD LOAD PATTERN

The household load used for the analyses was provided by a reasonably new, 180 m^2 fully air conditioned Adelaide house which includes some energy efficiency measures, such as insulation and efficient appliances. All appliances were separately monitored. The residents of the home are a family of two adults and two children. They are of medium income with one adult working full-time and one part-time. The data covered the period April 2002 to March 2003. The household monthly average load ranges from 255 kWh in April to 1043 kWh in January. The total annual household electricity use was 6496 kWh, or about 18 kWh per day.

The summer load (December to February) accounted for about 40% of the annual load, with average daily load of around 30 kWh. It is dominated by air conditioner use. This in turn reflects the family's work patterns. Loads are high when adults are home, including on weekends. The air conditioner often cuts in as early as 5:30am and can keep operating well into the evening. Figure 1 shows the load pattern over a typical summer week. The total load, as well as the air conditioner load is shown, as is PV output (scaled to 3 kWp) and the National Electricity Market price for South Australia. All times have been shown as Eastern Standard Time. Where necessary, adjustments have been made for daylight saving and Central Standard Time.

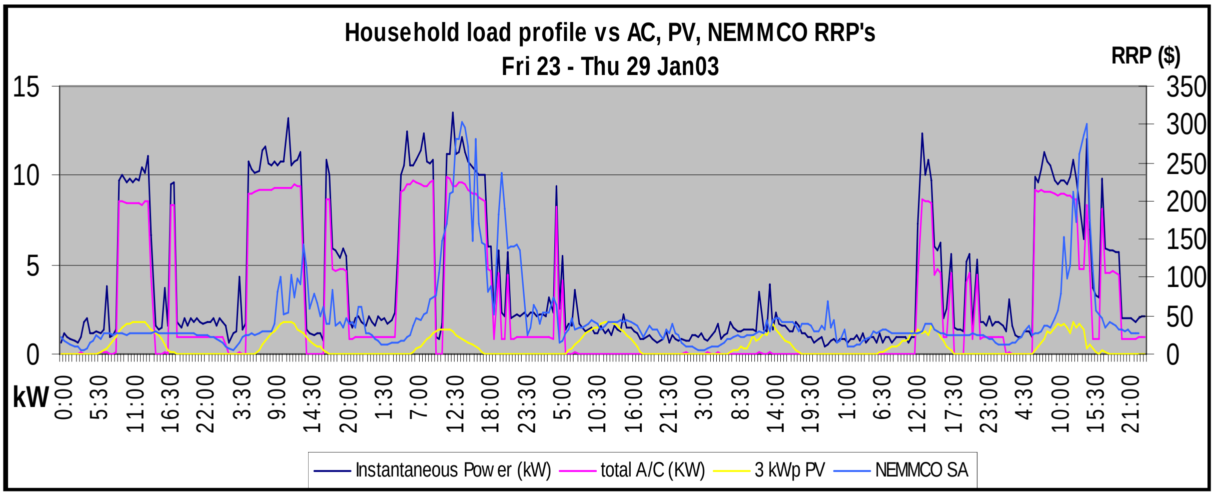

Figure 1: Household load shown with PV output and NEM prices for a week in Summer.

3. THE PHOTOVOLTAIC SYSTEM

The PV data for the period April 2002 to March 2003 was taken from Country Energy's Queanbeyan power station (Latitude 35.45, Longitude 148.56). This consists of 720 multi-crystalline modules arranged into 9 arrays with 9 x 6kW multi-string inverters. The total system capacity is 50 kilowatts. All data has been normalised to 1 kWp.

The minimum system output was in June, at around 2.8 kWh/kWp per day, and the maximum in October, at 4.3 kWh/kWp per day. The average summer (Dec-Feb) output was 4.2 kWh/kWp per day.

4. DESCRIPTION OF TARIFF OPTIONS

Continuous tariffs are set at a constant rate, regardless of time. They are the most commonly used residential tariff in Australia. Time-of-Use-tariffs (TOU) are characterised by differentiated rates, usually by the categories off-peak, shoulder and peak periods. Green tariffs are available through almost all Australian electricity retailers and refer to a supply option that guarantees the retailer will purchase an equivalent amount of electricity from a renewable energy generator (eg. Wind, Solar, Hydro). These tariffs are typically higher than the standard continuous tariffs.

Although a variety of tariffs were examined, only those which were available through Energy Australia at the time the load data were obtained are reported here. These are the Domestic All Time (continuous), the Power Smart Home (TOU) and the Pure Energy 100% (Green) tariffs. For the TOU tariff, calculations have taken into account weekend and public holiday rates. Net metering has been assumed and, to avoid complexity, GST has not been included in the calculations. It should be noted that tariffs vary widely between retailers, both by rates and by access charges, as illustrated in Figure 2, and customers may in some cases be able to save considerable amounts by switching retailers or tariffs, regardless of whether they own a PV system.

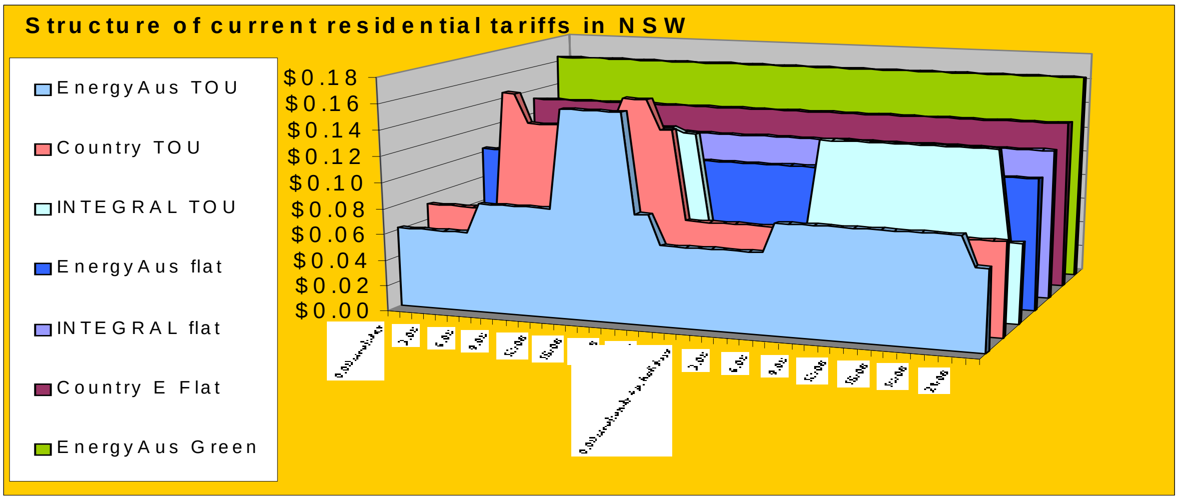

Figure 2: Structures of Tariffs available from NSW Electricity Retailers in 2004.

5. ANALYSES OF PV VALUE FOR HOUSEHOLDS

5.1. Value of electricity generated

Naturally, the highest PV revenue can be raised from the highest available tariffs, if net metering is applied. For this reason, Green tariffs can be a good option, although a particular retailer may not pay the Green tariff for net export. Also, according to the data presented here, these higher tariffs don't result in the lowest overall electricity bills. Around 25% of the PV output over the year would be exported to the grid due to load being less than the PV output at the time. This latter figure indicates the importance of the buy-back rate being offered to the PV owner.

For the household studied here, a 1 kWp PV system would contribute 22% of the annual load and reduce the household's annual electricity bill from $775 under Energy Australia's domestic continuous tariff to $627 (a 19% reduction). The impacts on Continuous, Time-of-use and Green tariff options are shown in Table 1. For a net metered residential customer with a 1 kWp PV system and the household load examined here, the lowest bill ($593) is achieved via the TOU tariff, although the largest saving ($235) is via the Green tariff (assuming the Green tariff is paid on net export). A typical customer on a continuous tariff would save $182 (23%) per year if they switched to a TOU tariff when they installed their PV system. The Green tariff option becomes more favourable as the PV system size increases.

Table 1: Household annual electricity bill including supply charges with and without a 1 kWp PV system using Energy Australia's tariff options

	Continuous	TOU	Green
Annual Bill	$775	$732	$1170
Bill with 1 kWp PV	$627	$593	$935
Saving	$148	$139	$235

5.2. Investment Value

The 1 kWp PV system is assumed to have a capital cost of $13,750, including installation, inverter and metering. This compares with the average 2004 cost of $13,100 per kWp for grid connected systems installed under the Commonwealth Government's PV Rebate Program (PVRP). At present, residential customers would be eligible for a $4,000 grant from the PVRP. In addition, Renewable Energy Certificates (RECs) through the Mandatory Renewable Energy Target (MRET) mechanism may also be available, although prices vary. In the analyses below an upfront REC payment of $500 is assumed, which is similar to the Enviro-Cash Back offer currently available for BP Solar systems.

The net present value of the PV system, with and without the Government rebate, with and without RECs and with 25 and 30 year lifetimes is shown in Table 2. Electricity tariffs are as previously described and prices are assumed to rise at 3% per annum with inflation at 2.5%.

Table 2: Net Present Value of a 1 kWp PV system

	Continuous	TOU	Green
25 Years	-$9,800	-$10,050	-$7,520
30 Years	-$8,950	-$9,260	-$6,180
25 Years + PVRP	-$5,800	-$6,050	-$3,520
30 Years + PVRP	-$4,950	-$5,260	-$2,180
25 Years + PVRP + RECs	-$5,300	-$5,550	-$3,020
30 Years + PVRP + RECs	-$4,450	-$4,760	-$1,680

5.3. Analysis

The results of this analysis are indicative only, since the PV system was located in NSW and the household was in Adelaide. This would result in a lag between the solar output and the load. Were the PV located on the house, the match would be better. Also, both load and PV output are weather and temperature dependent. Cloud cover and temperature data at the two sites were not available for this study, so that the impact of any differences could not be assessed. Nevertheless, some general conclusions can be drawn.

TOU tariffs can provide the best returns for PV system owners, if net metering is allowed. As discussed in previous papers (Watt et al, 2003), orienting PV arrays further towards the West can enhance summer afternoon output and so could be worthwhile, if the TOU tariff offered returns sufficient to compensate for the lower annual PV system output. However, based on current prices, lifetimes, tariffs and the PVRP, PV prices would need to fall by at least one third for PV to begin to be economically viable for residential use. Without the PVRP, which will finish in 2007, PV prices would need to fall by up to two thirds. The MRET has not been a particularly useful mechanism for increasing PV uptake. However, the Commonwealth Government is currently considering the extension of the deeming period for PV systems from 5 to 15 years, in line with the MRET Review recommendations. In the short term, this could see the value of RECs available at PV system installation rise to say $1,500, which would offer a useful up front price reduction. However, REC prices have already begun to fall as liable parties secure their requirements to 2010, so the REC value for PV systems may not remain at useful levels for very long. Unless MRET is increased and extended in some way by the State Governments, it will most likely remain a measure of peripheral interest for small PV systems.

6. FEED-IN TARIFF OPTIONS

Given that PV price reductions are not expected to result in cost-effective grid-connected systems in Australia for another decade, consideration is now being given to the option of feed-in tariffs as an alternative to capital grants. These are now available in several European countries and aim to offer customers who invest in PV, or other renewable energy technologies, an electricity buy-back rate which facilitates an economic payback within the life of the system. The tariff for the year of installation is guaranteed to the installer for a set period, typically 15 to 20 years, allowing a sufficiently attractive economic return to be made. Such returns have attracted huge investment in PV in the European nations that have implemented feed-in tariff policies; far greater than the penetration achieved to date in Australia using PV-specific capital grants or the generic Mandatory Renewable Energy Target.

6.1. The German Experience

In Germany, PV uptake has been supported for the past 15 years, from 1990-1999 via the 1000 rooftop program, from 1999-2003 via the 100,000 rooftop program and, since 2000, via an enhanced feed-in tariff. Annual installations over this period are shown in Figure 3. The rooftop programs offered low interest loans; for the 100,000 rooftop program an interest rate of 1.91% was available until installed capacity reached 300MWp. The feed-in tariff started at around €0.50 and was increased in 2004, after the soft loans ceased. Current rates are available for a period of 20 years and vary with system size and type, as shown in Table 3. Facades qualify for a higher tariff, on the basis that output will be lower.

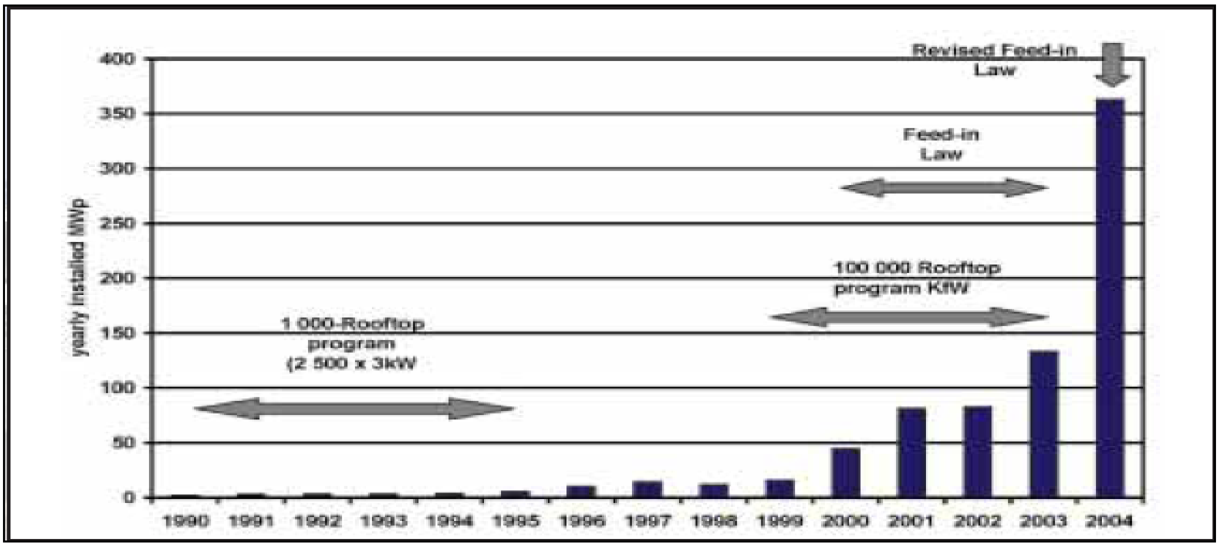

Figure 3: PV installations in Germany under the Roof-top Programs and Feed-in Law (EPIA, 2005).

In 2004 Germany overtook Japan with the highest level of PV installations – 363 MWp. The installed capacity in Germany to end 2004 was 794 MWp. Industry turnover was €1.7 billion and 20,000 people were employed in the sector (EurObserv'ER, 2005).

Feed-in tariffs have also been used to support other renewable energy technologies. Wind installations in Germany were boosted significantly during the period 1990-95 and installation targets were met earlier than anticipated (EPIA, 2005).

Table 3: German Feed-in Tariffs under the Renewable Energy Law, 2004 (EurObserv'ER, 2005)

Free surfaces (not roofs):	45.7 c€/kWh
Roofs between 30 and 100 kWp	54.6 c€/kWh
Facades < 30 kWp:	62.4 c€/kW
Facades > 100 kWp	59 c€/kWh
Roofs < 30 kWp:	57.4 c€/kWh
Roofs > 100 kWp:	54 c€/kWh
Facades between 30 and 100 kWp:	59.6 c€/kWh

6.2. The Spanish experience

Spain has a very important energy dependence problem: around 80% of its primary energy is imported. Spain has also signed the Kyoto protocol, and agreed to have 12% of its energy supplied by renewable sources by 2010. This target includes producing 29% of all its electricity generation from renewable sources by 2010, including big hydro, which currently meets around 15% of the electrical load (IDAE, 2005). In 2004, only 22% of electrical energy was generated from a renewable source (CNE, 2004), whilst electricity use is growing rapidly, at an average rate of 5% over the past 5 years. Therefore, the Spanish government developed a strong set of supporting regulations for renewable energy sources, and for combined heat and power (CHP) as a high efficiency solution, in its Spanish Royal Decree 2818/1998.

This regulation created a "Special Regime" of generators, with specific rights and duties. The regulation listed several technologies that were supported, and enforced specific technical and economic operating conditions for each technology. Once an installation succeeded in joining the "Special Regime" through an administrative process, it had practically no technical obligations, except security-related ones, and also had the right to sell all its energy output at a fixed feed-in tariff, that was different for each technology. CHP systems qualified only for net metering. These feed-in tariffs were to be revised every 4 years, depending on how the initial objectives were fulfilled.

The success of this type of regulation depends largely on the feed-in tariff. While comparatively little biomass, CHP and other technologies have been installed, considerable numbers of wind farms have been developed, because the tariff available for wind better matched its state of technology development. From the time of the regulation's introduction in 1998 to the end of 2004, around 9,000 MW of wind were installed at a rate of more than 1,500 MW per year in the last few years. The government expects to have more than 20,000 MW of wind capacity by 2010.

Initially, relatively little PV was installed, however numbers are now increasing. The regulation established a feed-in tariff of 0.40 €/kWh (0.64 A$/kWh) for PV installations under 5 kWp, revised every 4 years, and 0.22 €/kWh (0.35 A$/kWh) for larger installations. However, only when a specific connection standard was developed in 2000 did PV begin to be installed in significant quantities. Since then, 21 MW have been installed, with 7 MW in 2004 alone. However, this rate is far from that required to reach the objective of 400 MW of photovoltaic installed capacity by 2010, and most of the installed capacity has had some sort of additional support from local government.

Due to the large differences in uptake of each technology, the original regulation was revised and a new regulation has been in place since March 2004 through the Spanish Royal Decree 436/2004. This new regulation tries both to better integrate all the new installed capacity, and to rearrange supporting mechanisms for the technologies which were not successful previously. The aim is to develop as many technologies as possible, on the basis that all will be needed if Spain is to increase its energy self sufficiency and to meet its Kyoto obligations.

The main changes in the new regulations are new technical obligations, such as mandatory output prediction, with associated deviation costs, for installations larger than 10 MW, economic support for active participation in the energy market as an ordinary generator, and long term stability of the feed-in tariff.

The changes applicable to PV are expected to provide a significant boost to installations. First, the feed-in tariff has been secured for the whole life of each installation – at a full rate for 25 years and then at 80%. Although this tariff is to be revised every 4 years, any changes will only apply to new installations, and so the financial risk is minimised. Secondly, the installed capacity limit to access the 0.40 €/kWh feed-in tariff has been increased from 5kWp to 100kWp. This way, the government hopes not only to attract residential customers, but also small investors who would be interested in low risk investments.

6.3. An Australian Example

While feed-in tariffs could be set at a State level, the benefits of a national feed-in tariff policy are clear since the costs would be spread over a large base of electricity consumers. The appropriate tariff for Australia would need to start at around 85c/kWh, if installed system prices of $11,500 can be achieved and the tariff is available for 20 years. The guaranteed tariff is then decreased by 7% per annum (to ensure the benefits of scaling are passed to the consumer) such that systems installed in the 15th and final year receive 31c/kWh; and market price thereafter. For the household studied earlier in this paper, their annual income from the PV system would be $1,190, resulting in a net income of $415 per year when off-set against their current electricity bill of $775 under a Continuous tariff.

If the feed-in tariff cost is spread across all residential and commercial users - avoiding the more sensitive industrial sector - the policy would never add more than 2% to electricity costs and yet would result in the Australian PV Industry Roadmap target of 350MW installed capacity by 2010; and 1.9GW installed by 2020. Figure 4 shows the percentage increases in costs, which are net of the value of the electricity they acquire, assuming a flat retail tariff beginning at 12c/kWh and inflating at 3%. The chart shows that in the early years the net cost to residential and commercial retail customers is far below 2% of annual electricity costs, and also that the value of the electricity produced quickly ‘catches up’ to the cost of the tariff after 2020. Including a price on CO_2 emissions would significantly decrease relative costs.

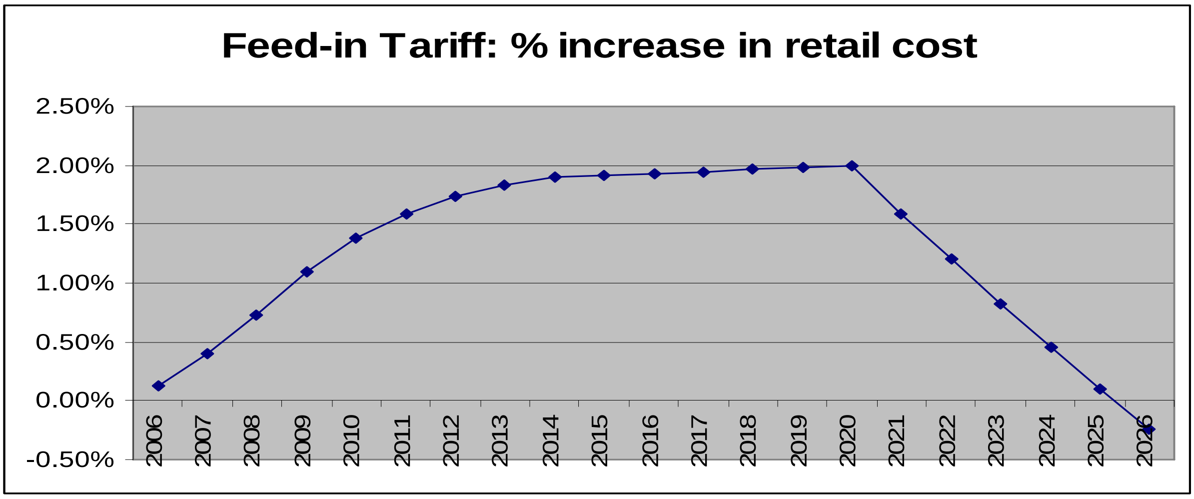

Figure 4: Possible costs of an Australian Feed-in Tariff as a percentage increase in retail electricity costs for residential and commercial customers.

Critically, if an Australian feed-in tariff provides the sort of industry boost as has been achieved elsewhere, the industry could build up the infrastructure required to compete at scale without support by the end of the 15 year period – installing over 300MW PV per annum by year 15 – just as the incumbent fossil fuel generators and distributors were themselves built up with public support to achieve their current mature and low costs. The economic cost of such a policy is estimated to have a present value far below that of the macroeconomic benefits of reduced greenhouse gas emissions, improved network performance from distributed and peaking generation, improved energy security, thousands of new high tech jobs, and hundreds of millions of dollars in annual tax receipts, with no related government expense.

The feed-in tariff option therefore warrants near-term assessment at both a state and federal government level, to assess the viability of a tariff mechanism that could create value to new PV customers, overcoming the financial barrier that has limited growth of the domestic industry to date, despite Australia's world class PV expertise and solar resources.

7. ACKNOWLEDGMENTS

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