6.7 Appendix: Grid Connected Inverters - Control Types & Harmonic Performance

6.7.1 CONTROL TYPES

There are two types of waveform generation control schemes used for grid-connected inverters - Voltage control and Current control. Voltage and current controlled inverters look quite different on a sub 20ms time scale. On a longer time scale (ie seconds) however, inverters used for injection of energy from a PV array directly into the grid are controlled as power sources ie. they inject “constant” power into the grid at close to unity power factor. The control systems constantly monitor incoming power from the PV array and adjust the magnitude and phase of the ac voltage (voltage controlled) or current (current controlled) to export the power extracted from the PV array.

Voltage Control

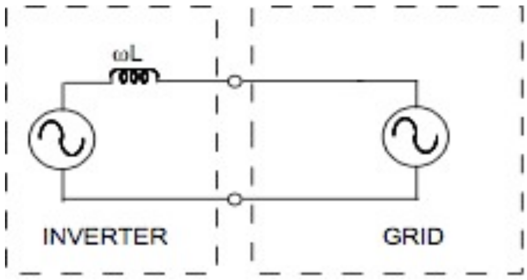

Figure 1a: Voltage control inverter ideal equivalent circuit.

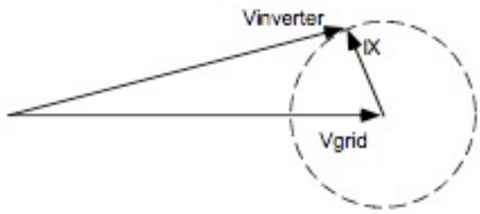

Figure 1b: Voltage control inverter vector diagram

A voltage control inverter produces a sinusoidal voltage output. It is capable of stand-alone operation supplying a local load. If non linear loads are connected within the rating of the inverter, the inverter’s output voltage remains sinusoidal and the inverter supplies non sinusoidal current as demanded by the load.

Because it is a voltage controlled source it cannot be directly connected to the grid. If the voltage or phase of the inverter is not identical to the grid, a theoretically infinite current would flow.

This type of inverter is therefore connected to the grid via an inductance.

The inverter voltage may be controlled in magnitude and phase with respect to the grid voltage - see Figures 1a and 1b. The inverter can be thought of as very similar to a conventional synchronous generator with a very low inertia. A phasor diagram for the system is shown in Figure 1b. The inverter voltage may be controlled by controlling the modulation index and this controls the VARs. The phase angle of the inverter may be controlled with respect to the grid and this controls the power.

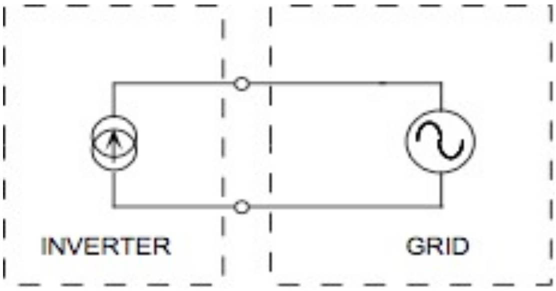

Figure 2a: Current control inverter ideal equivalent circuit.

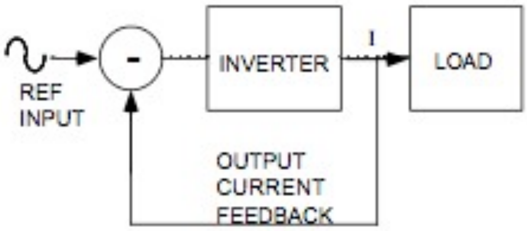

Figure 2b: Current control inverter control system diagram

Current Control

This type of inverter produces a sinusoidal current output. It is only used for injection into the grid, not for stand alone applications. The output is generated by producing a sinusoidal reference which is phase locked to the grid. The output stage is switched so that the output current follows the reference waveform - see Figure 2b. The reference waveform may be varied in amplitude and phase with respect to the grid and the output current of the inverter follows the reference.

The output current waveform is ideally not influenced by the grid voltage waveform quality. It always produces a sinusoidal output current. The current control inverter is inherently current-limited because the output current is tightly controlled even if the output is short circuited.

6.7.2 HARMONICS

It is important that any inverter system connected to the grid does not in any significant way degrade the quality of supply at the point of connection. It is also important to consider the effects of a poor quality of supply on an inverter added to the system.

The harmonic content of most modern pulse with modulated sine wave inverters is typically less than 3% THD. This is better than the grid supply in many areas because of the many electronic loads connected to the grid which have simple rectifier front ends (see waveform Figure 4).

These inverter systems should not seriously degrade the quality of supply with regard to harmonics. There is a large difference, however, between voltage control and current control inverters with respect to their harmonic affects on the grid.

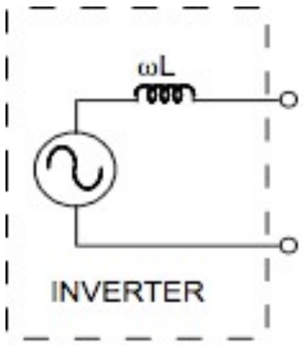

Figure 3a: Voltage controlled inverter 50Hz ideal equivalent circuit.

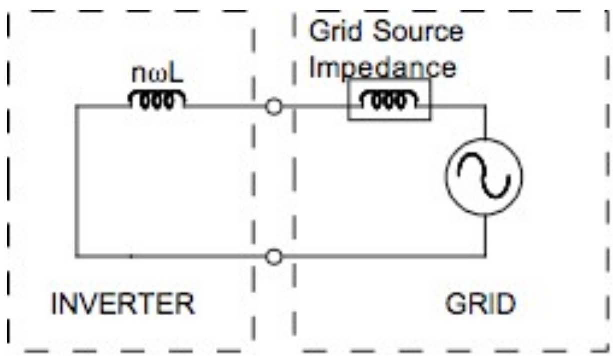

Figure 3b: Voltage controlled inverter harmonic ideal equivalent circuit.

Voltage Controlled Inverters

Voltage controlled inverters produce a sinusoidal voltage waveform and are connected to the grid via an inductive impedance - see Figure 3a. Looking from the grid into the inverter at other frequencies the inverter (provided it has very good waveform quality) will look like an inductive impedance only - as shown in Figure 3b.

If at the point of connection the grid impedance is inductive, the inverter will effectively attenuate the grid harmonic voltage at the point of connection. So the inverter will tend to improve the waveform quality at the point of connection. The other effect that becomes evident is that the inverter will absorb some harmonic current.

The amplitude of the harmonic current that flows will depend on the impedances in the system and the amplitude of the harmonic voltage on the grid.

If the loads local to the inverter are non linear and hence draw harmonic currents, (see Figure 4) the voltage controlled inverter will supply those harmonic currents or at least a portion of them. This reduces the harmonics seen by the grid.

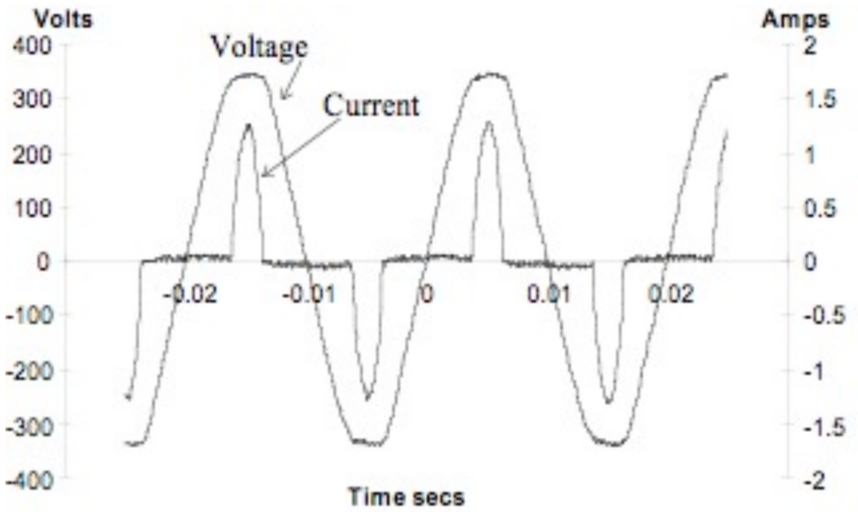

Figure 4: Computer input current (rectifier front end)

Care has to be taken in connecting a voltage controlled inverter to a severely distorted grid. In an extreme case the inverter could use all its output rating on harmonics absorbed from the grid. This is not necessarily a bad thing as it improves the grid voltage but the inverter may not then be capable of exporting power or VARS.

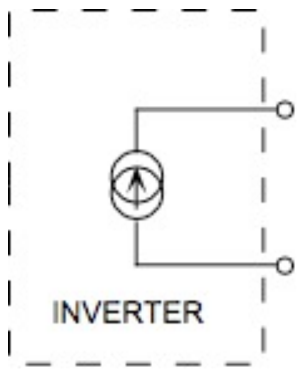

Figure 5a: Current controlled inverter 50Hz ideal equivalent circuit.

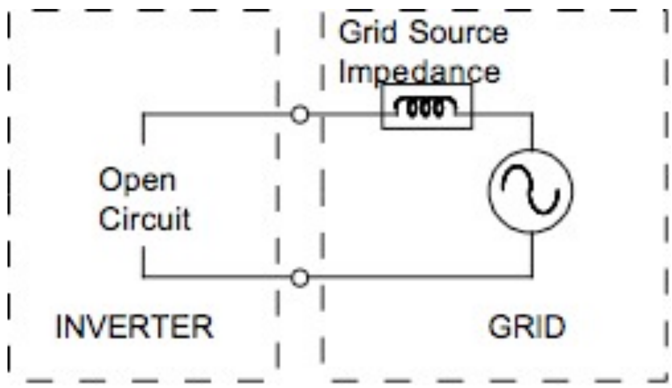

Figure 5b: Current controlled inverter harmonic ideal equivalent circuit.

Current controlled inverters

Current control inverters produce sinusoidal currents at 50 Hz - Figure 5a. At other harmonic frequencies the inverter appears as an open circuit – Figure 5b. This means that the inverter does not degrade the quality of supply at the point of connection but it also does not provide any improvement.

The Grid System is a voltage source - or many voltage sources in parallel. The loads are designed for voltage source inputs.

If a significant percentage of current controlled inverters are added to the grid it will be necessary to carefully analyse the grid with respect to its harmonic performance. The problem from an electric utilities perspective may be illustrated by a small example:

Consider a house with a grid connected current-controlled inverter which is supplying sinusoidal unity power factor current to the grid. The local loads are non-linear and so draw harmonic currents. If we assume that the inverter supplies all the unity power factor fundamental component of the local load then the utility is left to supply all the non unity power factor fundamental current and all the harmonic currents requirements of the local load. This is a worst case example but not totally unreasonable.

Conclusions

The two types of inverter control schemes are both capable of energy injection into the grid but are quite different in their harmonic performance. The voltage controlled inverter should be able to be used in much larger numbers (ie at a higher penetration rate) because it is capable of supplying the harmonic current needs of loads on the grid.

6.8 Appendix: Relevance of various market mechanisms and processes to PV

6.8.1 RESERVE CAPACITY MECHANISM

The Reserve Capacity Mechanism (RCM), which operates in the WA SWIS, is used to ensure there should be sufficient generation capacity for operation of the WA electricity market. The overall SWIS Reserve Capacity Requirement (RCR) is based on the expected maximum demand and includes a contribution to the system-wide reserve margin. Generators and providers of demand side management can commit to providing a certain amount of capacity when required (which is then their Reserve Capacity Obligation, RCO) and so earn Reserve Capacity Credits (RCCs). Market customers (eg. retailers) have an Individual Reserve Capacity Requirement (IRCR) meaning they have to purchase sufficient RCCs to cover their customer's expected demand and reserve margin.

The contribution to the SWIS RCR by loads that are temperature dependent (and so most relevant to PV) is based on the median[1] value of the three highest demand half hour intervals of the four highest demand days. Historically, temperature-dependent loads have been assigned reserve capacity obligations about 30% above their maximum demand, although they have been higher recently.[2] The actual figure will change depending on the amount of reserve capacity in the system and the actual temperature (and hence demand) compared with the forecast weather/demand. The Reserve Capacity Price is the price paid by the IMO for Capacity Credits not traded bilaterally and sets the price ceiling – see Table 1.

Table 1 Reserve Capacity Prices for the WA SWIS

Period	Price ($/MW/yr)
21/09/06 to 01/10/06	$127,500
01/10/06 to 01/10/07	$127,500
01/10/07 to 01/10/08	$127,500
01/10/08 to 01/10/09	$97,834.92
01/10/09 to 01/10/10	$142,200

To the extent that PV reduces a retailer's customer's demand during the highest demand intervals, it will reduce the retailer's IRCR. Larger PV systems may find it worthwhile to apply to the IMO to have their Reserve Capacity certified, after which they will be issued with a number of RCCs which can then be sold on the market through a bilateral trade or through an IMO auction, if one is required. No PV system has been issued with

1 Median: the middle number in a given sequence of numbers, taken as the average of the two middle numbers when the sequence has an even number of numbers.

2 See http://www.imowa.com.au/10_5_1_f_ix_individual_rc_requirement_ratios.htm for the IRCR ratios.

RCCs to date. Note that RCCs are valid for only a particular Reserve Capacity Year, which is for a 12-month period starting from 1 October of the year two years hence.

Dispatchable generators are fined if they fail to provide the capacity they have been credited for. Intermittent generators such as wind and PV are not fined but will subsequently earn less RCCs because their entitlement is based on their average generation over the last three years, up to and including the last hot season. They would also need to be able to meter total output, not just net export and so will need separate meters, or interval meters with a separate channel.

6.8.2 ***PV AND THE STEM***

The short term energy market (STEM) is a daily forward market for energy that allows Market Participants to refine their long term bilateral contract positions before submitting their net contract positions (combined bilateral and STEM) to the Independent Market Operator (IMO). The net contract positions then become the basis on which balancing market outcomes are assessed, with differences between net contract and actual average power levels being traded on the balancing market for each half-hour Trading Interval (TI). Market Participants submit STEM supply offer curves and/or demand bid curves to the IMO once per week for the following week. Different curves can be submitted for each TI in the following week. Market Participants are required to base their offers on SRMC principles.

For the time being and foreseeable future, PV systems do not participate in the STEM in their own right and only very large PV systems could conceivably do so. Retailers who sell electricity to end-users with PV systems installed have to forecast the production pattern of the PV system one day ahead as part of their process of determining their preferred net contract position. This is straightforward if the following day can be predicted with a high probability to be completely sunny (where PV systems are located) and if the temperature profile for the following day can also be predicted with high accuracy. Otherwise the retailers' forecasts of the net quantity of energy consumed by their end-users with PV systems installed are subject to uncertainty in PV system energy production during each (daytime) Trading Interval. This detracts from the commercial value to the retailer of the PV output because the retailer typically faces additional costs in the balancing market due to the added quantity uncertainty. This effect would be small for low levels of PV penetration and would be less of a problem for large retailers than small retailers.

Generators that use non-storable primary energy resources (whether renewable or not) have less value to a power system than generators that are fully dispatchable. The difference in value depends on the characteristics of the power system, including factors such as the overall portfolio of supply and demand-side resources and network robustness. In addition, non-storable primary energy resources may have value in their own right, such as low environmental impact.

The market design used in the SWIS is not efficient for generators that use non-storable renewable energy resources. This is because the bilateral trading design requires participants to forecast their individual future generation or consumption and then penalises mismatches between those forecasts and their actual production or consumption. However only the aggregate supply-demand balance matters in an electricity industry and thus only mismatches that are strongly correlated should be penalised.

6.8.3 *PV AND NETWORK ACCESS*

An electricity industry operates by maintaining a continuous flow of electrical energy from generators through its transmission and distribution network to end-use equipment. Electrical energy cannot be stored or transmitted in any other way, thus network access is essential for any generator or end-user that wishes to participate in an electricity industry.

In designing network access arrangements, engineers are concerned with maintaining availability and quality of supply and avoiding operating conditions that threaten security of supply or human safety. This is a specialised field and there can be strong asymmetries in knowledge and understanding between the engineering staff of a network service provider on the one hand and end-user and small generator staff on the other. From the perspective of end-users, network access can cause concerns with respect to cost of connection, and the imposition of operating constraints or what may appear to be onerous connection requirements.

Technical concerns can be alleviated by the development of peer-reviewed technical standards and connection rules. Commercial concerns may be harder to resolve and, for small generators, an argument can be made for a right of access to an industry ombudsman.

Specific concerns for small PV systems can include the following:

- From the network service provider’s perspective – islanding, impacts on quality of supply and the potential for cross-subsidy
- From the PV system owner’s perspective – cost of metering and protection requirements, and a low buy-back price compared to the retail price for electricity.

Grid-connected PV is an expensive way of generating electricity compared to other generation options. However, it has the advantages of being modular, light and silent in operation and having low maintenance requirements, which make it suitable for use in residential premises. PV is particularly useful in off-grid applications where there may be few alternative options.

Because of the high cost of PV, tensions about cash flow are inevitable and PV owners may have unrealistic expectations about the commercial value of energy produced by PV systems. Such expectations can be accommodated for political reasons at low levels of PV penetration but are more difficult to accommodate at high levels of penetration when other stakeholders may become concerned about cross-subsidy. This tension is easier to resolve in diesel grids where the avoidable cost is higher than in large power systems such as the SWIS.

6.8.4 *PV AND THE REGULATORY TEST*

The regulatory test is part of the regulatory regime for network service providers under the access regime implemented by the National Electricity Rules. The regulatory test is designed as a gatekeeper process that allows socially beneficial network investment to proceed, while rejecting inefficient investment. There are two arms to the regulatory test – a cost-benefit test and a reliability test.

In the cost-benefit test, the network service provider must demonstrate to the satisfaction of the regulator that the proposed network investment results in positive net-benefit to consumers of electricity. In doing so, the network service provider is required to demonstrate that there were not cheaper demand-side or embedded generation options.

In the reliability test, the network service provider must demonstrate to the satisfaction of the regulator that the proposed network investment is justified in terms of meeting an externally determined standard for reliability of supply.

As discussed elsewhere in this report, PV systems are not particularly effective at deferring network investment compared to other options such as reliable stand-by generation or demand that is flexible at times of local or system peak demand. Moreover, even generation and demand side options that are more competitive than PV face challenges in competing with network options. There are both physical and institutional reasons for this.

The physical reason is that network elements excel at allowing resources at another location to substitute for local resource. Thus a strong network allows all operating generators to contribute to maintaining high standards of availability and quality of supply. It is difficult for any local generation or demand side option to deliver comparable service.

The institutional reason is that, by default, the local network service provider holds legal responsibility for maintaining availability and quality of supply for each end-user. It is difficult for that local network service provider to contract away that accountability, for example to an embedded generator.

PV systems are not particularly effective at deferring network investment compared to other options such as reliable stand-by generation or demand that is flexible at times of local or system peak demand. In fact all generators that use non-storable primary energy resources benefit from a strong network.

6.8.5 PV AND THE BALANCING PROCESS

The balancing process for the SWIS is designed to manage the differences between the net contract positions of Market Participants after the STEM has run, and the actual production of generators for each Trading Interval during the ensuing day. Verve Energy is required to provide balancing services, and its generators are dispatched to do this, allowing the generators owned by other companies to track their net contract positions.

PV systems do not participate in providing balancing services. However, variability in the output of PV systems may increase the size of the balancing task. It is unlikely that any such additional cost would be recovered from the PV system owners.

6.9 Appendix: Current programs and policies that drive PV

The following section summarises current support strategies for PV and discusses their aims, which reflect the key drivers, and their effectiveness in capturing expected benefits.

Photovoltaic Rebate Program (PVRP)

Description and Objectives

The PVRP was announced in 1999 as part of the package of "Measures for a Better Environment" and commenced operation in 2000. It is Australian Government funded, with administration by the State Governments and agencies. An initial budget of $31 million was allocated over 4 years. Further allocations of $3.6 million, $5.8 million, $11.4 million and $150 million were made in 2003, 2005 and 2007. The program now runs to 2012. Grants are provided towards the capital cost of photovoltaics (PV) on residential and community buildings, including schools. The aims of the program are to:

- Support the installation of photovoltaic systems on, or adjacent to, and used by residential or community buildings.
- Reduce greenhouse gas emissions
- Develop the Australian PV industry
- Encourage the longer term use of renewable electricity generation from PVs.
- Increase the use of renewable energy in Australia
- Increase public awareness of renewable energy.

Cash rebates are available for grid-connected or stand-alone photovoltaic systems. Rebate levels have been changed over time. The current rebate levels are as follows:

- New residential systems: $8.00 per Watt peak, capped at $8,000
- Community buildings and schools (competitive tender): 50% of capital cost, capped at 2 kWp.
- Extensions to existing residential systems: $5.00 per peak watt, capped at $5,000.

Outcomes

Since the start of the programme in 2000 to December 2006, more than 8,000 systems, using 10.08 MWp of PV, were installed. Of this, 171 systems (246 kW) had been installed in WA, 108 (165 kW) grid and 63 (81 kW) off-grid.

Australia-wide approvals for grid-connected systems overtook those for off-grid systems by mid 2002 and now account for the majority of installations – see Figure 2. System sizes have remained steady, with grid systems averaging around 1.6 kWp. Installed PV system prices have reduced slightly in current dollars, and more appreciably in real terms, and now average $12 per Wp for grid systems. In WA, off-grid installations through PVRP dropped off after funding became available through the Renewable Remote Power Generation Program (see below), as shown in Figure 3.

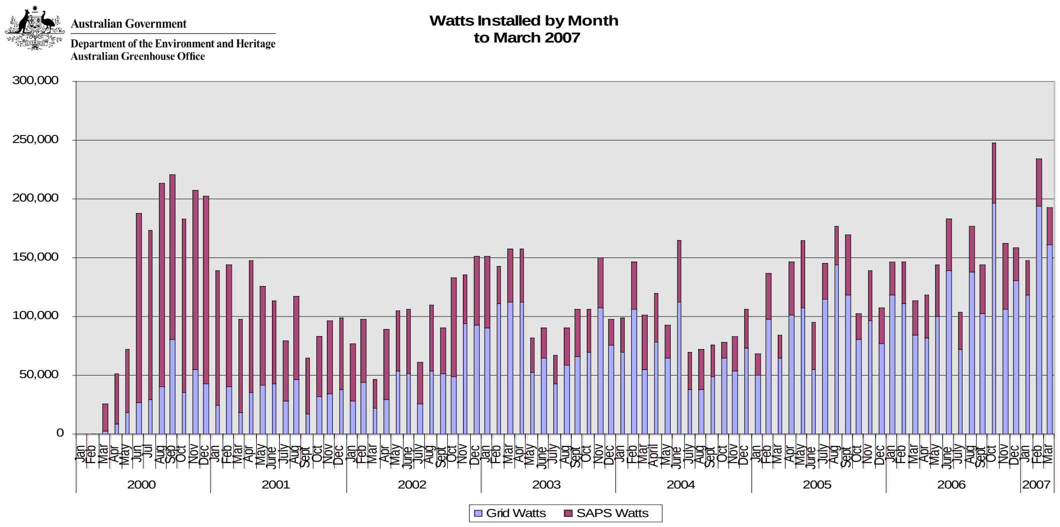

Figure 2 On-grid and off-grid PV installations by month funded through the PVRP. Source: AGO Website

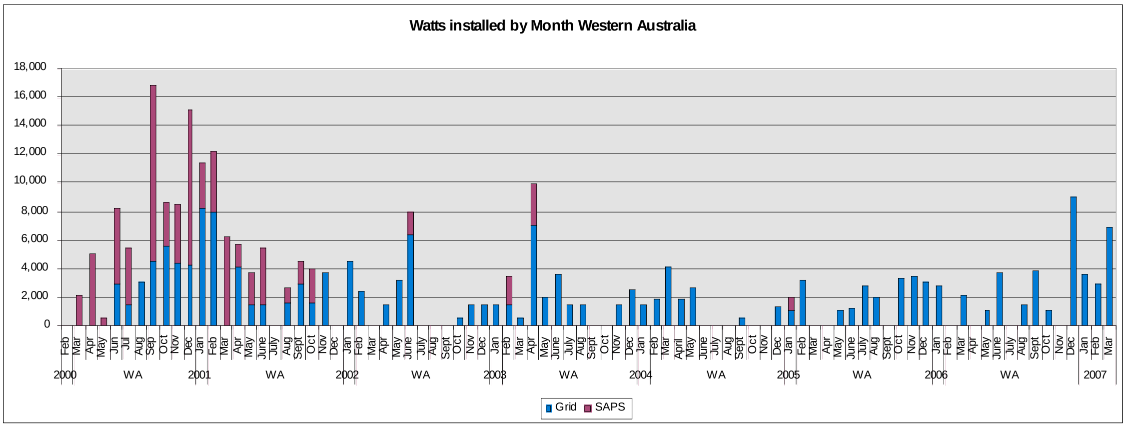

Figure 3 On-grid and off-grid PV installed by month in WA under PVRP . Source: AGO website.

Although information is not available for all grant recipients, surveys of PV customers undertaken by SEDA in NSW and by Sinclair Knight Merz in 2003 indicate that grid-connected recipients have incomes averaging $44,700 per year (SKM, 2003). The main reasons given for installation of PV systems were for necessity (off-grid) and environmental (grid). The highest proportion of grant recipients has been professionals, followed by retirees, trades and managers (SKM, 2003; SEDA, 2004).

Solar Schools programs have been established in all States, mostly using PVRP funds. However, in WA, the Government has made a separate State allocation of $1 million prior to 2007 and $4.1 million from 2007 to 2011 for Government Schools. Each school can apply for funding up to $10,000. Commonwealth Government funds via RRPGP (see below) can be used to supplement State funding in off-grid areas. Forty seven schools have participated in the WA program to date and an additional 254 are expected to participate by 2011. The WA Solar Schools program provides educational material and community promotion with each PV installation and hence provides an excellent long term investment in community PV understanding and acceptance.Renewable Remote Power Generation Program (RRPGP)

Description and Objectives

The RRPGP is a Federal Government program which is administered by the States. It supports PV and other renewables which displace fossil fuel-powered generation in off-grid and fringe of grid applications. The objectives of the program are to:

- Help provide an effective electricity supply to remote users
- Assist the development of the Australian renewable energy industry
- Help meet the energy infrastructure needs of indigenous communities
- Lead to long term greenhouse gas reductions.

The overall program initially had funds of around $205 million allocated to it. From this $7.5 million has been allocated to industry support activities, including test facilities, standards development, training, feasibility studies and demonstration projects and $8 million to the Bushlight programme, which services indigenous communities. In August 2006, a further $123.5 million was committed to RRPGP, including an additional $11 million to extend the Bushlight Program to more indigenous communities.

Outcomes

In WA the program is administered by SEDO and separated into different sub-programs (http://www1.sedo.energy.wa.gov.au/pages/rrpgp.asp). Only those sub-programs relevant to grid applications (diesel/gas grids and fringe of grid) are discussed below.

Remote Area Power Supply Program

Since the program's introduction in July 2001, up to February 2007, rebates totalling $16.8m have been paid for 513 renewable energy power systems. The program has enabled many pastoral stations, tourism facilities, individual households and small Aboriginal communities to obtain 24-hour power supplies and to substantially reduce fossil fuel consumption.

Rural Renewable Energy Program - small projects

The Rural Renewable Energy Program for small projects provides rebates for grid-connected renewable energy systems up to 30kW that are installed in specific 'fringe-of-grid' areas of the South West electricity grid. Since the program's introduction in June 2006, to February 2007, rebates totalling $12,300 have been paid for two grid-connected renewable energy power systems. Rebates have been committed for fourteen additional projects.

Rural Renewable Energy Program - medium projects

The Rural Renewable Energy Program for medium projects provides rebates for grid-connected renewable energy systems rated between 30kW and 2MW that are installed in specific 'fringe-of-grid' areas of the South West electricity grid. The first funding round closed in September 2006 and funding support has been requested for eight projects. Details of projects that are successful in securing funding are expected to be announced within the next few months.

Industry support projects

- Research Institute for Sustainable Energy
- BCSE Accreditation Development and Standards Seminar
- Training in Hybrid Power Systems for Aboriginal Communities
- DVD training for installation of solar-diesel power systems
- Training in Renewable Energy Systems for Remote Areas of WA

WA Renewable Energy Buyback Schemes (REBS)

Description and Objectives

Both Horizon Power and Synergy operate buyback schemes for excess electricity generated by small grid connected renewable energy systems, as required under their regulations. These are available to residential customers, non-profit organisations and educational institutions. They are essentially net metering schemes and apply to systems from 500W to 5kW (Synergy) and 500W to 10kW (single phase) or 30kW (3 phase) (Horizon Power). For systems installed by business customers, Horizon Power will negotiate an individual purchase contract.

Residential customers are offered renewable energy buyback rates equal to their electricity purchase rate, less the GST component. Synergy customers can be on A1 (standard residential) or SmartPower (time of use) tariffs, but not GreenPower tariffs. Horizon Power customers are on the A2 (standard residential) Tariff. Customers who join the Scheme are billed for their net import and credited for their net export of electricity over a billing period.

Both organisations install bidirectional meters and charge the cost to the customer. Customers are also charged $107 as an Assessment Fee to cover the design, acceptance and administration expenses of setting up a new account.

Outcomes

It may be expected that most of the grid-connected PV systems in WA (120 via PVRP) operate on the above buy-back rate basis. There has been considerable interest from the WA PV industry in higher buy-back rates as a means of stimulating the grid market. However, the recent doubling of the PVRP rebate may provide sufficient stimulus.

Mandatory Renewable Energy Target

Description and Objectives

The Federal Government's Mandatory Renewable Energy Target (MRET) scheme is a renewable obligation[3] that aims to promote renewable energy industry development. It does this by providing a revenue stream with some level of long-term certainty for investors wishing to deploy near-commercial renewable technologies. Established by the Renewable Energy (Electricity) Act 2000 which came into force on 1st April 2001, MRET requires electricity suppliers to source 9,500GWh of additional renewable energy by 2010 compared to 1997 levels. At the end of each year the scheme operates, liable parties, which are electricity retailers and wholesale electricity purchasers, must surrender a prescribed number of tradeable Renewable Energy Certificates (where 1 REC = 1MWh of so-called additional renewable energy) to the Office of the Renewable Energy Regulator (ORER) which oversees the scheme. The total number required to be surrendered rises progressively each year to 9.5 million in 2010, and, under the current operation of the scheme, will stay constant at that level for a further ten years. The

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3 Renewable obligations specify that a given amount of renewable energy must be produced by a given date. Renewable Portfolio Standards are similar except they also stipulate a proportion of the target must be met using one or more particular technologies. Both types of policy generally involve the use of tradeable certificates and so are sometimes referred to as Tradeable Green Certificate schemes (TGCs). They may also be referred to as Quota Schemes.

scheme will terminate in 2020. The total is allocated between retailers in proportion (with some fine detail adjustments) to their share of total Australian sales of electricity. PV systems can deem up to 15 years worth of RECs calculated according to the ORER deeming formula. Their sale can be incorporated into the system purchase or the owner can register with ORER ($20) and sell the RECs themselves.

Outcomes

MRET has operated very successfully to increase renewable energy generation around Australia. Despite initial fears that the industry was too immature to deliver the target, the learning experience from MRET has shown that the Australian renewable energy industry is more than capable of delivering at costs lower than most of the early projections and that the fundamentals of the mechanism are sound. It was developed after extensive consultation with all sectors, has an established operational structure and has been the basis for many subsequent international schemes.

Figure 4 shows that the price of RECs has varied significantly since the scheme began. The Energy White Paper and 2004 election result had clear impacts, as they were seen as confirming that the scheme would not be expanded or extended, at a time when generation projects being built or planned were seen as being sufficient to meet the projected requirement for RECs until the end of the scheme.

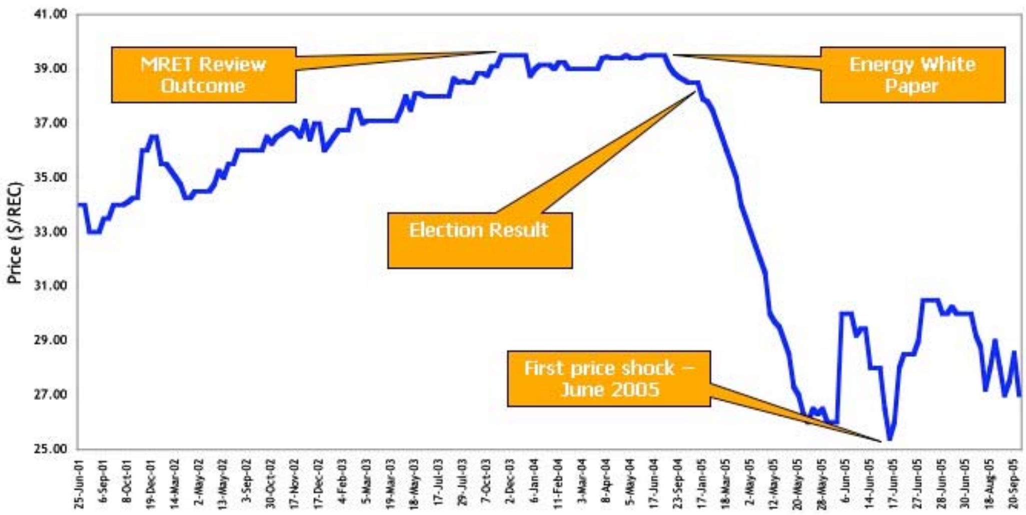

Figure 4 Historical REC spot prices

From BCSE (2006)

By end 2006, the cost of RECs was around $16 to $18, but had increased to around $29 during Feb and March 2007. Forward prices currently track fairly linearly up to around $40 by 2013.

GreenPower

Description and Objectives

GreenPower enables electricity customers to voluntarily pay a premium for a certain percentage of their electricity to be generated from accredited renewable sources. Accreditation is used to ensure that GreenPower products offered by energy suppliers comply with the guidelines of the GreenPower scheme, and thereby increase consumer confidence in GreenPower. A number of non-accredited green energy products are now available from some retailers, although not Synergy or Horizon. Typically these use renewable energy sources which were in place prior to 1997, when the accredited scheme was introduced and therefore do not serve to increase renewable energy installations.

The State-based National GreenPower Accreditation Steering Group (NGPASG), coordinated by the NSW Department of Water and Energy, oversees the scheme. The scheme was established prior to MRET, but its auditing requirements have now been integrated into MRET's accounting framework. Retailers must either be granted a Concession Arrangement by the NGPASG, or annually deposit into a dedicated account held by the ORER enough RECs created by GreenPower-accredited generators to cover their GreenPower sales. These requirements aim to ensure the same renewable generation cannot be used to meet both MRET and GreenPower liabilities.

Outcomes

For 2006, GreenPower sales in Australia amounted to 859,746 MWh and for the quarter Oct to Dec 2006 were 226,445 MWh. For the same quarter there were 2,811 residential GreenPower customers in WA and 178 commercial customers. GreenPower sales for WA for the quarter were 1,834 MWh for residential customers and 3,442 MWh for commercial customers, making a total of 5,276 MWh, or 2.3% of the Australian total.

Solar Cities Program

Description and Objectives

Under the Federal Government's Solar Cities initiative, which was announced as part of the 2004 Energy White Paper, $75 million has been allocated over 5 years to demonstrate high penetration uptake of solar technologies, energy efficiency, smart metering and other options aimed at improving the market for distributed generation and demand side energy solutions. Tenders were called in 2005 for consortia to install PV and other distributed generation options in four or more urban sites, with detailed monitoring and associated tariffs, marketing and financing also being supported. Eleven consortia from around Australia were short-listed from 23 applicants. Four cities, Adelaide, Townsville, Blacktown and Alice Springs, and the Central Victorian consortium involving 13 municipalities, have been awarded Solar City status, and it appears that no more shall be awarded. Two bids were made from WA – Perth and Kalgoorlie.

Outcomes

The Solar Cities initiative has stimulated interest in PV, and sustainable energy options more generally, from sectors which have not previously been especially active in the area, such as financial services and local government, and utilities which have been active in the past but not been able to pursue useful deployment recently. Although the immediate impact of Solar Cities will be in the cities chosen, the Federal Government hopes that the interest generated and the knowledge of PV which has been developed within the Consortia will remain even with the unsuccessful bids, thus facilitating community awareness, new PV deployment strategies and associated institutional change in the longer term. However, the long delay in announcing the winning bids has eroded some of this interest.

The SA Government in particular is using the Solar Cities program as the basis for promoting itself as a “Solar State” and in its promotion of Adelaide to tourists and business. Despite no WA bid being successful, a PV program in Perth or Kalgoorlie could nevertheless be pursued as a showcase for design and technology, for a PV-based GreenPower product, or as part of the State’s Renewable Energy Target. WA Government 20% Renewable Energy Target

Description and Objectives

The Western Australian Premier’s Climate Change Action Statement of May 2007 set a Renewable Energy Target for the SWIS of 15% by 2020 and 20% by 2025. This is part of the Government’s longer term strategy to cut greenhouse gas emissions by 60% of 2000 levels by 2050. This increases the previous 6% by 2010 target which was expected to be achieved largely through MRET.

Outcomes

Such an extended target is likely to be met by increased wind power, and also perhaps by integrated biomass and geothermal programs. A proposal is currently before the government concerning a large PV plant at Perenjori and perhaps such a plant may now go ahead. Similarly, concentrated PV systems, such as those being used in diesel grids in the NT and SA may be considered. Small-scale PV systems would assist the target and the increased Commonwealth Government PV rebates, along with other strategies suggested in this report, will assist their uptake.

The mechanism for encouraging increased renewables uptake to meet these targets has not been decided. However, if an extension to MRET is used, all liable parties would seek renewable energy at lowest cost from wherever possible. The current freeze on electricity prices is already hampering electricity industry development and such a target would need to include associated cost pass-through to customers. Unfortunately this may create a negative impression about renewables, which need not have occurred if appropriate price increases had already been allowed.

Synergy’s 50MW Capacity Credit Tender

Description and Objectives

Synergy is currently seeking the provision of up to 50MW of Capacity Credits from renewable energy generators connected to the SWIS as of 1st Oct 2009. They will also enter into an electricity supply contract (ESC), which would include all GreenPower Rights and an unspecified proportion of the RECs.

This does not seem to be suitable for smaller installations since:

“The ESC will require the Electricity Supplier to make Bilateral Submissions in favour of Synergy, in accordance with day-ahead nominations by Synergy, as follows:

- up to the rated sent-out capacity in each 30 minute trading interval, subject to the specified arrangements for day-ahead nominations consistent with operation of the Wholesale Electricity Market; and
- at a minimum take level, taken over each Capacity Year, dependent upon the technology to be used in the Project but not greater than the Average Vesting Level.”

This tender has now closed and it is understood that no PV projects have been proposed. If further tenders are called in future, such mechanisms could drive larger installations where they could generate significant Reserve Capacity Credits, for example in the Perth CBD or other regions with a predominantly commercial profile. However, as discussed above, the value of such Capacity Credits on their own is unlikely to make PV competitive with other renewable technologies.

Horizon Power’s 5% GHG Intensity KPI

Description and Objectives

One of Horizon Power’s Key Performance Indicators (KPI) is to reduce their greenhouse gas intensity by 5% over 5 years. It is now 0.86 kg/kWh, and their target is 0.81 kg/kWh.

This KPI should drive the deployment of renewable energy systems, and since Horizon Power’s operations are predominantly in the north, PV is a logical technology choice. It is worth noting that this KPI does not drive energy efficiency, which could result in major cost savings for Horizon Power, not only in reduced fuel use but also in reduced need for peaking capacity.

Low Emission Energy Development Fund

In his May 2007 Climate Action Statement, the WA Premier committed to creating a $36.5 million Low Emissions Energy Development (LEED) Fund to promote emission reduction and support technological advances that cut greenhouse gas emissions.

The Fund will focus investment towards technologies where Western Australia has clear natural and competitive advantages, including geothermal, bioenergy and clean coal technologies and renewable energy technologies such as wind, wave, tidal and solar. Matching contributions will be sought from industry and the Commonwealth Government.

LEED will provide an opportunity for Western Australia to become a world leader in low emission technologies, creating new technical and manufacturing jobs. Hence it could provide an opportunity for new PV based industries to establish themselves in WA, perhaps developing PV solutions unique to WA, but with potential for export. For instance:

- Large scale PV systems for use in regional grids
- Building integrated PV solutions for hot climates
- Stand-alone power systems for residential, industrial, agricultural applications and export, to build on existing WA PV industry expertise. This expertise could be developed further to provide PV solutions across the Asia Pacific region.
- Silicon production. WA already hosts the country’s only silicon production facility. Silicon has been in short supply around the world, as the use of PV increases. Although new production facilities are now being built in various places, the opportunity remains for WA to be a long term silicon supplier to the PV market.

6.10Appendix: Existing Barriers to PV Deployment

WA Electricity Market Barriers

Reserve Capacity Mechanism

Even though special provisions are in place to cater for renewable and intermittent generators, the administrative costs of registering as a Market Participant to use the RCM ($630) is prohibitive for small generators. Individual small PV system owners are unlikely to register as Market Participants in order to access such small amounts, especially as the process must be repeated every year, after 3 year's of output has been recorded (although presumably the registration fees would not have to be paid every year).

PV and the STEM

The market design used in the SWIS is not efficient for generators that use non-storable renewable energy resources. This is because the bilateral trading design requires participants to forecast their individual future generation or consumption and then penalises mismatches between those forecasts and their actual production or consumption.

Since only the aggregate supply-demand balance matters in an electricity industry the option of penalising only mismatches that are strongly correlated could be considered.

Regulatory Test

There are two arms to the regulatory test – a cost-benefit test and a reliability test.

PV systems are not particularly effective at deferring network investment compared to other options such as reliable stand-by generation or demand that is flexible at times of local or system peak demand. There are both physical and institutional reasons for this.

The physical reason is that network elements excel at allowing resources at another location to substitute for local resource. Thus a strong network allows all operating generators to contribute to maintaining high standards of availability and quality of supply. It is difficult for any local generation or demand side option to deliver comparable service.

The institutional reason is that, by default, the local network service provider holds legal responsibility for maintaining availability and quality of supply for each end-user. It is difficult for that local network service provider to contract away that accountability, for example to an embedded generator.

Grid Interconnect Technical Rules

The technical rules call up PV Standards AS4777 (Grid Connection on Energy Systems via Inverters) and AS5033 (Installation of Photovoltaic Arrays) and so pose no barriers in themselves. However, they do duplicate some clauses in these standards which could lead to misalignment of requirements later on, if the standards are revised.

The other area where there is potentially a barrier is in clause 3.7.8.3 (b):

> *Inverter protection systems must also be tested for correct functioning at regular intervals not exceeding 5 years. The Customer must arrange for a suitably*

qualified person to conduct the tests. Results of tests must be certified by a Chartered Professional Engineer with NPER standing and supplied to the Network

To our knowledge, this clause is not required by any other utility and is a potentially high cost each 5 years. The issue of faults arising with time could be handled by simple safe work practices in the utility, such as testing if live and earthing.

Grid Interconnection Costs

In addition to the above, Western Power requires a chartered professional engineer with NPER standing to certify connection drawings on system installation (Passey et al, 2004), which can add around $400 to installation costs, and purchase on a single phase meter costs $205 and of a three phase meter costs $655. Both Synergy and Horizon Power charge an Assessment Fee of $107 for the net metering account establishment. Horizon Power also charges import metering costs for single phase of $199 (new home) and $329 (existing home) and for three phase of $664 (new connection) and $794 (existing connection). They also charge $199 for an export meter. Hence up-front connection costs can end up being quite high and could certainly erode any potential electricity cost savings for a number of years.

For installations complying with the relevant Australian Standards and installed by a certified installer, engineering inspections should not be required. At the time of the Interconnection report cited above, no other utility had such a requirement, nor establishment fees. A new survey of interconnection procedures and costs is currently being undertaken by the BCSE.

Meter costs vary amongst Australian utilities and not all utilities require a new meter or change for them. Where a roll-out of interval meters is occurring in any case, installation of a new meter is sometimes undertaken when a PV system is installed, at no cost to the householder. It is noted that, in WA, interval meters required for uptake of time of use tariffs are charged for. It should be noted that, if higher buy-back rates are to be paid, rather than net-metering, a second meter or one with two channels would in any case be required.

Complexity of Market Rules

Although the market rules are not excessively complex, they have been developed for large supply side generators or demand management options and not for small scale options. Hence their emphasis, and the processes involved, are not suited to individual householder participation.

Therefore there is an additional role for collective Market Participants, as discussed above, to provide the information required in a streamlined way, so that PV owners have a quick and easy checklist of procedures to follow should they wish to take advantage of the various market mechanisms available.

PV uptake in regional areas

Although PV is significantly more cost effective on regional grids than it is on the SWIS, uptake has not been strong to date, although there are a number of significantly sized PV systems connected to regional grids. At present the net metering arrangements available through Horizon Power offer buy-back rates equivalent to residential tariffs, not to the actual cost of generation. For larger systems which do not qualify for net metering, buy-back rates are individually negotiated but are even lower. Hence PV generators must effectively compete with the subsidized electricity rates offered across the regional grids.

Consideration should be given to new definitions for net metering buy-back rates, with small, renewable energy generators offered rates equivalent to at least the displaced cost of fuel, if not the total generation cost.

General Barriers

In its 2004 PV Industry Roadmap, the PV industry examined the general barriers to the PV Industry in Australia and to PV uptake (BCSE, 2004). They concluded that the key barriers for industry were:

- The small market, with associated increases in unit costs, low awareness, difficulty in maintaining a presence in Australia and associated difficulty in building viable businesses
- Market instability, due to the stop-start nature of support programs and lack of a long-term view of PV's role in Australia's energy mix
- Finance difficulties due to unfamiliarity with PV businesses
- Low exposure to and high competition in export markets
- Customer reluctance to adopt new energy technologies, low energy prices and low exposure to the true costs of electricity supply

From the customer perspective, barriers to PV were considered to include:

- High up-front cost due in part to low sales volumes, associated high service overheads and subsidies to incumbent fossil fuel-based electricity supplies
- Difficulties with after-sales and service due to the small market, limited experience and dominance of other energy sources
- Complex purchase, installation, grid interconnection and grant access procedures
- Apprehension in the mainstream electricity industry and associated trades which manifests in difficult procedures and negative feedback
- Little exposure to PV by the building industry with associated obstacles in installation
- Limited R&D support for PV systems and products.

Although the PV industry has worked hard in the intervening years to overcome many of these barriers, including trade training, engagement with the building and finance sectors, and streamlining of procedures, the high cost, limited market and associated barriers remain. In addition, externalities, particularly greenhouse gas emissions, are not yet reflected in energy prices, while the electricity infrastructure and operating systems in Australia have been established to optimise central, fossil fuel based supply and do not cater well for distributed resources or demand side options.

Discussion

Many of these barriers are in areas that are being examined by SEDO's PV Working Group. The most useful role governments can play is to provide long-term market certainty so that businesses can invest in products, services and marketing. This should include appropriate information and regulation aimed at PV acceptance and streamlined access arrangements for grid interconnection.