IEA International Energy Agency

CO-OPERATIVE PROGRAMME ON PHOTOVOLTAIC POWER SYSTEMS

TASK 1

Exchange and dissemination of information on PV power systems

# AUSTRALIAN REPORT ON PV POWER APPLICATIONS 1996 - 1997

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# 1 EXECUTIVE SUMMARY

The manufacture and use of PV in Australia has continued to increase significantly over the period 1996-97. PV production is at full capacity of 7.5 MWp per year and the industry generates business worth around AUD91.5 M per year. PV also provides significant export earnings for Australia, with an average of 60% of PV produced being exported over the reporting period.

The local market continues to grow at around 20% per year, with the most significant trend being the increase in installation of on-grid PV systems, accompanied by a significant increase in utility involvement with PV. However, off-grid applications are still the major Australian market, with continued growth in water pumping, telecommunications and lighting applications. Although decommissioning is not significant, routine refurbishment of old PV based telecommunication systems is beginning, with PV replacements being undertaken at the same time. However, there is a market in second hand PV system components, so that decommissioned modules are most likely to be re-used for rural residential or agricultural purposes.

Commonwealth government funding for PV R, D&D and market activities has been around AUD 2.5 M per year and state government funding, including state owned utilities, between AUD 9 and 12.5 M per year. The trend is away from device research towards development of commercial product and market programs. Industry funded R,D&D focuses on improvements in components and system design. Joint industry and research institution activities continue in standards development and associated component testing.

With increasing emphasis on greenhouse gas reduction, combined with moves towards restructuring of the electricity industry, the emphasis in utility market development has moved from off-grid to on-grid applications, although many utilities routinely offer off-grid PV based power systems. Only one State government offered remote area power supply (RAPS) assistance grants during this period. On the East coast, there has been an emergence of greenpower programs, accompanied by a significant increase in utility PV activities. This is likely to continue, with a recent Federal government announcement of an increased 2% of new renewables on the grid by 2010.

Although several large PV systems have been installed on central and diesel grids, the main on-grid market is expected to be in smaller distributed systems. The number of distributed systems in the state of New South Wales particularly is expected to increase significantly under a new state government grant program, aimed at increasing the visibility of PV systems and improving the experience and product mix available for building integrated systems. Grants are available for building integrated PV installations on residences and on public buildings. The latter is expected to encourage schools and local governments to install PV systems for public demonstration and educational purposes, thereby increasing community knowledge and in turn further encouraging market development.

Existing and new manufacturers are planning large new production facilities which will result in installed capacity increasing from 7.5 MWp to over 40 MWp over the next 5 years. Employment in PV activities is around 840 people Australia wide at present, of which manufacturing accounts for about 50%. With the planned expansion of manufacturing capacity and continued increases in PV installations, employment is expected to increase significantly over the next 5 years. This will be accompanied by an increasing need for specialised PV training in all aspects of system design, installation and maintenance. As PV enters the urban market, there will also be increased interest in the visual appeal of installations, accompanied by the need for new PV products, and extending the need for PV knowledge to the building sector.

# 2 THE IMPLEMENTATION OF PV SYSTEMS

## *2.1 Total PV power installed*

**Table 1: Total cumulative installed PV power.**

| Year | Total cumulative installed PV power by the 31 December for systems (kWp) | Cumulative decommissioned PV power by the 31 December for systems larger than 5 kWp. (kWp) |
|---|---|---|
| 1997 | 18,700 | na |
| 1996 | 15,700 | na |
| 1995 | 12,700 | na |
| 1994 | 10,700 | na |
| 1993 | 8,900 | na |
| 1992 | 7,300 | na |

## *2.2 PV power system market sectors*

**Table 2: The cumulative installed PV power in 4 sub-markets.**

| Sub-market/ application | 31/12/92 kWp | 31/12/93 kWp | 31/12/94 kWp | 31/12/95 kWp | 31/12/96 kWp | 31/12/97 kWp |
|---|---|---|---|---|---|---|
| off-grid domestic | 1,560 | 2,030 | 2,600 | 3,270 | 4,080 | 4,860 |
| off-grid non-domestic | 5,740 | 6,865 | 8,080 | 9,380 | 11,520 | 13,320 |
| on-grid distributed | 0 | 5 | 20 | 30 | 80 | 200* |
| on-grid centralised | 0 | 0 | 0 | 20 | 20 | 320* |
| **TOTAL** | **7,300** | **8,900** | **10,700** | **12,700** | **15,700** | **18,700** |

* Includes PV systems on diesel mini grids.

**a) additional information on the overall trends and the trends in each market sector and highlight any changes or developments in each sector since the last report.**

The most significant trend over the period 1996-97 has been the increase in installations of on-grid systems, accompanied by a significant increase in utility involvement with PV. However, off-grid applications are still the major Australian market, with continued growth in water pumping, telecommunications and lighting applications.

**b) a summary of the highlights and trends in market development in your country.**

With increased awareness of greenhouse warming, combined with moves towards restructuring of the electricity industry, the emphasis in market development has moved from off-grid to on-grid PV market development. Hence, although many utilities now offer off-grid PV based power systems, only one State government offered remote area power supply (RAPS) assistance grants during this period. On the East coast, there has been an emergence of greenpower programs, accompanied by a significant increase in utility PV activities. This is likely to continue, with a recent Federal government announcement of an increased 2% of new renewables on the grid by 2010.

**c) the key market investors investing in PV.**

The investors vary according to the market: for off-grid domestic, the investors are largely private individuals and isolated communities; for off-grid industrial, the investors are largely telecommunications, mining and transport industries, including government owned transport authorities; for the on-grid distributed market, investors are largely utilities, with some private investors utilising new utility greenpower programs; on-grid centralised systems are utility owned.

### 2.2.1 On-grid systems

**Table 3: Indicative performance data for on-grid PV systems.**

| System latitude | Installed power (kWp) | Final annual yield[1] kWh/kWp/yr | Performance ratio[2] (%) | Comments |
|---|---|---|---|---|
| 27°S | 2.7 | 1825 | | Country guest house |
| 34ºS | 7.2 | 11-1400 | | Commercial office block |
| 37.5°S | 2 | 1060 | | Utility urban system |

1 Final annual yield is defined as the energy delivered to the load per day per kWp installed.

2 Performance ratio is defined as the ratio of the final yield to the reference yield, where the reference yield is the theoretically available energy per day per kWp installed.

## *2.3 Main demonstration and field test programmes*

### 2.3.1 Main demonstration programmes and projects

Although many systems serve a demonstration function, there are few systems in Australia which have been installed specifically for demonstration purposes. Most installations are commercial, either as cost effective options in remote areas, or as part of greenpower programs in the competitive electricity market. The following incorporate some demonstration aspects:

**a) reasons for, and goals of, embarking on the programme or project;**

1) Wilpena Pound, South Australia. To demonstrate the feasibilty and long term cost effectiveness of PV/diesel/battery hybrid systems for a tourist resort power supply, as an alternative to long distance grid extension.

2) Lord Howe Island, New South Wales. To reduce fossil fuel use in an environmentally sensitive, World Heritage area and to showcase renewable energy technology to visitors. Use of PV will also reduce the requirements for fuel delivery and diesel maintenance, which are costly to this island location.

**b) size (installed capacity to date and target installed capacity for the whole programme, kWp) and main technical and economic data;**

1) 100 kWp ground mounted, fixed array system, connected into a diesel grid, with battery storage.

2) 8 kWp roof mounted system, connected via a single inverter into a diesel grid, with no storage. Total installed cost, including transport to the island, $AUD 85,000.

**c) funding sources and cost sharing;**

1) 90% State Government funded
10% ETSA - State electricity distributor and retailer – to act as owner and operator.
The leasee of the tourist resort will pay standard ETSA rates for power used.

2) 2) 100% SEDA - State government authority. Power to be sold to the Lord Howe Island Board, which operates the island's power station.

**d) main accomplishments by end of 1997 or end of operating period (system efficiency, operating cost, etc.);**

Not yet available.

**e) problems encountered and lessons learned;**

Not yet available

**f) planned continuation of the programme and plans for new activities.**

Both these plants are expected to operate as standard power stations from now on. Other utilities and local governments are examining options for increased use of PV in their areas, with a degree of demonstration included in many projects.

**Table 4a: Total demonstration and field test effort in 1996.**

| Programme title | Total power installed under each demonstration and field test programme (kWp) | Total costs (NC) | Government funding (%) | Utility funding (%) | Is the utility state or privately owned? | Is the utility a generator, a distributor, a retailer or a combination of these? | Other funding (%) |
|---|---|---|---|---|---|---|---|
| | | | | | | | |
| | | | | | | | |

**Table 4b: Total demonstration and field test effort in 1997.**

| Programme title | Total power installed under each demonstration and field test programme (kWp) | Total costs (NC) | Government funding (%) | Utility funding (%) | Is the utility state or privately owned? | Is the utility a generator, a distributor, a retailer or a combination of these? | Other funding (%) |
|---|---|---|---|---|---|---|---|
| Wilpena Pound | 100 | AUD2.3M | 90 | 10 | Semi government | Retailer and distributor | |
| SEDA Building | 7.2 | AUD65,000 | 100 | | State | Retailer | |
| Lord Howe Island | 8 | AUD85,000 | 100 | | State | Combination | |

**Table 5: Summary of main demonstration and field test programmes**

| Project<br>Date plant start up | Technical data/Economic data | Objectives | Main accomplishments until the end of 1997/problems and lessons learned | Funding | Project management | Remarks |
|---|---|---|---|---|---|---|
| Wilpena Pound<br>1997 | 100 kWp ground mounted, fixed array system connected into a diesel grid, with battery storage. Total installed cost AUD2.3M. | To demonstrate the feasibilty and long term cost effectiveness of PV/diesel/battery hybrid systems for a tourist resort power supply, as an alternative to long distance grid extension. | Installation commenced 1997. Completion 1998. | 90% State (South Australia) government, 10% utility. | ETSA (State utility) | |
| SEDA Building<br>1996 | 7.2 kWp, roof mounted system, connected to main grid. Total installed cost AUD65,000. | To demonstate the use of PV in a grid connected urban environment. First Australian CBD building with PV. | 1996 | 100% State (New South Wales) Govt funded | SEDA | |
| Lord Howe Island<br>1997 | 8 kWp roof mounted system, connected via a single inverter into a diesel grid, with no storage. Total installed cost, including transport to the island, AUD 85,000. | To reduce fossil fuel use in an environmentally sensitive, World Heritage area and to showcase renewable energy technology to visitors. Use of PV will also reduce the requirements for fuel delivery and diesel maintenance, which are costly to this island location. | 1997 | Sustainable Energy Development Authority (SEDA) | SEDA | |
| | | | | | | |
| | | | | | | |

### 2.3.2 Summary of programmes and projects under construction

***Remote Area Power Supply programmes***

The Western Australian State Government's Renewable Energy Based RAPS program will continue to provide subsidies for renewable components in power systems where grid connection would exceed $50,000. 62 kWp of PV has been installed in the first 18 months of the programme's operation., with the government subsidy capped at $8,000 per installation and typically covering 50% of the total system cost.

The Queensland State Government plans to offer grants of $4,400 per year for rural properties operating their own power supplies and where grid extension would cost more than $50,000.

***Green Power programmes***

In April 1997, eight NSW utilities launched Green Power schemes, with marketing assistance and an 'accreditation' programme provided by the NSW Sustainable Energy Development Authority (SEDA). Other retailers in NSW, Queensland and Victoria have since launched Green Power products. These schemes offer consumers the opportunity to fund the development of a range of renewable energy projects which create less environmental impact than more traditional alternatives using combustion or large scale water impoundments. The range of schemes on offer include specific products designed for franchise and contestable customers in the domestic and business sectors.

The development of these Green Power schemes appears to be primarily a response to the regulatory framework for NSW electricity retailers, which requires them to meet greenhouse gas emission targets and implement renewable energy strategies. However, there may a number of additional reasons. These include:

- the realisation that distributed generation can yield significant savings in network costs;
- the need to gain experience in designing and marketing products for competitive markets;
- the support of SEDA.

By end 1997, there were around 15 000 green power customers, representing sales estimated at 60 000 MWh/a. Green Power schemes have funded the construction of an additional 1MWp of photovoltaic capacity and commitments to around AUD50 million for other new renewable energy projects.

The largest distributed project is the 665 kWp to be installed on individual rooftops at the Newington Solar Suburb, near the Sydney Olympic site, by Pacific Power. A number of school systems are also planned by Integral Energy.

Centralised systems planned include a 50 kWp plant at Dubbo Zoo, by Advance Energy, to be gradually expanded up to 500 kWp, and an additional 200 kWp at Singleton, by energyAustralia.

***Building Integration programmes***

The number of distributed systems in NSW is expected to increase significantly under a new SEDA grant program, aimed at increasing visibility of PV systems and improving the experience and product mix available for building integrated systems. Grants up to 20% of system costs are available for residential installations and 40% for installations on public buildings. The programme is accompanied by a requirement for testing of inverters against the Australian guidelines for grid connection.

# 3 INDUSTRY STATUS AND PV SYSTEMS COMPONENTS

## *3.1 Industry status*

**Table 6: PV industry revenue - including exports. Current AUDM**

| Year | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 |
|---|---|---|---|---|---|---|
| PV industry revenue* | na | 52.8 | 54.0 | 60 | 91.5 | 91.5 |

*Based on:
- 50% PV exported 92-95 @ AUD 9/Wp 93, AUD 8/Wp 94-95, 60% exported 96-97 @ AUD 7/Wp
– Av. AUD 24/Wp for complete systems installed in Australia 93, AUD22/Wp 94-95 and AUD 20/Wp 96-97.

**Table 7: Budgets for R & D, demonstration programmes and market incentives. AUD M***

| | R & D 1996 | Demo 1996 | Market 1996 | R & D 1997 | Demo 1997 | Market 1997 |
|---|---|---|---|---|---|---|
| National/federal NC | 2.25 | 0.2 | 0.13 | 2.11 | 0.2 | 0.11 |
| State/regional NC | 7.87 | 0.87 | 0.56 | 10.98 | 0.9 | 0.6 |

*Does not include tax benefits or private company funding.

**Table 8: Full time labour place equivalents in PV activities.**

| Field of activity | Number of full time labour place equivalents |
|---|---|
| R&D[1] | 210 |
| Manufacturers[2] | 430 |
| All other[3] | 200 |
| **Total** | **840** |

1. research institutes, universities, consultancies, government (agencies) etc.; not R&D at manufacturers
2. all manufacturers of components exclusively made for PV systems including R&D
3. e.g. in utilities, distribution companies and installation labour

### *3.2 PV modules*

**Table 9a: Price, production and production capacity information for each module manufacturer in 1996.**

| Module manufacturer | Technology (sc-Si, mc-Si, a-Si, CdTe) | Total Production in 1996 (MWp) | | Maximum production capacity in 1996 (MWp) | Average selling price in 1996 (small shipment) (NC/Wp) | Average selling price in 1996 (large shipment) (NC/Wp) |
|---|---|---|---|---|---|---|
| | | Cell | Module | | | |
| 1 BP Solar Australia | sc-Si | | 4.5 | 4.5 | AUD 8 | AUD 5 |
| 2 Solarex | mc-Si | | 3.0 | 3.0 | AUD 8 | AUD 5 |
| 3 | | | | | | |
| 4 | | | | | | |
| **TOTALS (where applicable)** | | | **7.5** | **7.5** | **AUD 8** | **AUD 5** |

**Table 9b: Price, production and production capacity information for each module manufacturer in 1997.**

| Module manufacturer | Technology (sc-Si, mc-Si, a-Si, CdTe) | Total Production in 1997 (MWp) | | Maximum production capacity in 1997 (MWp) | Average selling price in 1997 (small shipment) (NC/Wp) | Average selling price in 1997 (large shipment) (NC/Wp) |
|---|---|---|---|---|---|---|
| | | Cell | Module | | | |
| 1 BP Solar Australia | sc-Si | | 4.5 | 4.5 | AUD 8 | AUD 5 |
| 2 Solarex | mc-Si | | 3.0 | 3.0 | AUD 8 | AUD 5 |
| 3 | | | | | | |
| 4 | | | | | | |
| **TOTALS** | | | **7.5** | **7.5** | **AUD 8** | **AUD 5** |

**a) General description of the main steps of the production process employed for each manufacturer (feedstock, ingot crystallization, wafer cutting, cell fabrication, module fabrication and other appropriate steps).**

For both manufacturers: Cell fabrication through to module fabrication as well as total system production.

**b) Whether the manufacturer produces their own cells in-house or whether they are purchased on the international market, or both.**

For both manufacturers: majority in-house from imported wafers.

**c) The quantity of PV cell production sold as cells on the international market to other module manufacturers.**

Some cell sales to overseas subsidiaries.

**d) Technical characteristics of standard commercial modules, cell material, typical module output power range, type of encapsulation, length of typical warranty, certification).**

Modules range in size from 2 - 90 Wp, the most common being around 70 Wp. Almost all have front glass and EVA rear encapsulation. Warranties range from 10-20 year, depending on the application, as well as on the level of manufacturer involvement in system design.

**e) Certification of modules to IEC 1215 or IEC 1646 or equivalent. Certification to ISO 9000, ISO 14000.**

Australian standards, plus international standards via ISPRA testing.

**f) Availability of modules specially designed for utility applications (large size modules, high insulation modules, facade and roof top modules, etc.) and their characteristics.**

No.

**g) New developments and new products.**

Continual development, especially of BOS components.

**h) Details of module production capacity under construction at end of 1997 but not yet in production.**

Nil.

**i) Plans for future expansion in module production capacity.**

Significant expansion of manufacturing capability planned by existing manufacturers (BP Solar - 20MWp new c-Si capacity by end 1999), as well as by new companies entering the thin film market (Pacific Solar - 20MWp thin film c-Si by 2000 and Sustainable Technologies Australia - 2.5MWp titania nanocrystalline by 1999).

### *3.3 Other components*

**Table 10a: Number of inverter manufacturers.**

| | |
|---|---|
| NUMBER OF PV INVERTER MANUFACTURERS<br>(both off-grid and on-grid) | 8 |

**Table 10b: Number of inverter sold for on-grid PV applications.**

| SIZE OF INVERTER IN kVA | NUMBER OF INVERTERS SOLD IN 1996 | NUMBER OF INVERTERS SOLD IN 1997 | AVERAGE PRICE PER kVA (NC) |
|---|---|---|---|
| 0-1 | 5 | 15 | |
| 1-10 | 15 | 50 | |
| 10-100 | | 5 | |
| >100 | | | |
| TOTALS | 20 | 70 | |

**Please provide a summary of the business activities, trends and strategies concerning PV inverters and information on the main manufacturers, and on new developments/products such as the development of a.c. modules.**

The majority of inverters are imported.

R&D continues on high frequency inverters, smaller inverters (<1.5 kW), including ac module inverters, and general improvements for grid interconnection.

**Please provide a summary of other PV related industrial activities on other components for PV systems in your country, such as on:**

**a) inverters for stand-alone PV systems;**

Continual development & improvement.

**b) storage batteries;**

Specific solar batteries are available, including a new gel battery, developed by CSIRO.

**c) other components, such as battery charge controllers, DC switchgear, supporting structures and new products.**

Continual development and customising of BOS components, including system controllers, remote diagnostics and support structures for building integration.

### *3.4 PV installation companies*

**Table 11: Number of companies carrying out installation of PV systems.**

| | |
|---|---|
| PV SYSTEM INSTALLATION COMPANIES | 80 |

**Table 12: Prices of typical applications**

| CATEGORY/ RANGE | TYPICAL APPLICATION | PRICE PER Wp IN AUD |
|---|---|---|
| OFF-GRID[1]<br><br>40-1000 Wp | Lights, telemetery, dc supply for remote houses. | $20-40 for complete systems |
| OFF-GRID[1]<br><br>1-4 kWp | Remote households (RAPS), telecommunications, cathodic protection, water pumping. | $25-40 for complete systems, including container, batteries, diesel and PV. |
| ON-GRID<br>1-4 kWp | Rooftop systems | $10-12 |
| ON-GRID<br>10-50 kWp | Ground mounted | $12-15 |
| ON-GRID<br>10-50 kWp | Building integrated | $10-15 |
| ON-GRID<br>>50 kWp | Ground mounted, central power systems | $10-12 |

1. Prices should not include recurring charges after installation such as battery replacement or operation and maintenance

# 4 FRAMEWORK FOR DEPLOYMENT (NON-TECHNICAL FACTORS)

## *4.1 Indirect policy issues*

**a) international policies affecting the use of PV Power Systems;**

In response to international pressure for greenhouse gas reduction policies, the federal government has announced a target of 2% new renewables on the grid by 2010. The programmes to achieve this will be State based.

**b) the introduction of any favourable environmental regulations;**

In NSW, the distribution wires businesses and retail suppliers are subject to licence conditions which include the following:

- Before expanding the extent or capacity of its distribution system, a distributor must ascertain whether it would be cost-effective to avoid or postpone network investment by implementing distributed resource strategies.

Licence conditions imposed on retail supply businesses include the following:

- The licensee must develop greenhouse reduction strategies to meet targets negotiated with the Minister and audited by the Environmental Protection Agency,
- The licensee must develop, and publish in annual reports, 1, 3 and 5 year plans for:

  - energy efficiency and demand management,

  - purchases from sustainable energy sources.

Retail suppliers are intermediate commercial agents and have no direct responsibility for greenhouse gas emissions. They might adopt one or more of the following strategies to meet their greenhouse targets:

- Buy electricity from 'greenhouse friendly sources': All electricity from the pool will be assigned the same annual greenhouse gas coefficient, so this strategy would rely on buying from generators of less than 30 MW rating, which are deemed to be on the retail side of the pool.
- Work with customers to implement demand side measures such as energy efficiency or fuel switching, which reduce greenhouse gas emissions.
- Develop load-shifting mechanisms to reduce network losses and increase the fraction of electrical energy supplied from local sources.

The NSW government has also established SEDA, the Sustainable Energy Development Authority, to promote the commercialisation and greater use of sustainable energy technologies. Its primary purpose is to assist in overcoming barriers and market imperfections which impede the use of sustainable energy technologies. It can act as an ally to distributors and retailers in meeting their licence conditions. Other States are considering similar moves.

The above initiatives have led to an increased interest and use of PV by NSW electricity utilities, which is likely to continue in the short term. Plans for industry privatisation may impact in the longer term.

**c) studies relating to externalities and hidden costs of conventional energy generation when compared to renewable energy;**

Some studies have been undertaken, but no specific policies have so far been implemented.

**d) taxes on pollution (e.g. carbon tax).**

A number of options have been proposed, however, there is no indication at present that such policies will be implemented in the short term.

### *4.2 Promotion initiatives*

**Table 13: Promotion initiatives**

| | | Additional information / examples |
|---|---|---|
| Preferential Tariff | YES | Some utilities offer net metering, others have special PV buy-back rates (although none exceed standard tariffs). |
| Sales Tax exemption/reduction or other | YES | Solar cells are sales tax exempt. PV systems for industrial or commercial applications would be eligible for the standard capital investment depreciation rates. |
| RAPS grants | | Subsidies up to 75% of PV cost, to a maximum grant of $8,000 for remote area power supply systems in Western Australia. |
| Greenpower schemes | | PV installations using voluntary customer contributions towards sustainable energy supplies. |

### *4.3 Market deployment initiatives*

The NSW Sustainable Energy Development Authority (SEDA) has established an accreditation scheme for green power programs offered by utilities, with individual utilities offering different packages to their customers. Takeup rates after the first year have been up to 1% of domestic customers. Different packages are available for commercial and industrial customers. The schemes are voluntary, typically requiring customers to sign up for a minimum of one year, paying either a fixed amount or a premium on their electricity bill. The proceeds are used to fund renewable energy generating facilities. Utilities are keen for the early installations to be highly visible and close to the customer base, so that customers can see where their money is being spent.

Utilities offering RAPS systems also offer financing packages. The Federal government's Energycard, typically used to finance the purchase of solar water heaters, may be made available for PV systems.

### *4.4 Utility perceptions of PV*

**a) utility ownership of, and liability for, PV systems;**

Many utilities now offer PV based off-grid systems for residential customers, although few offer to operate them and sell power to customers. A number of utilities operate larger community sized off-grid PV systems. Some have installed grid connected systems to meet green power generation targets, others have allowed customer owned systems to be connected into their networks.

**b) national and/or regional programmes, plans, instruments and laws to promote the diffusion of photovoltaic generation;**

The Electricity Supply Association of Australia is working with the Federal government, State governments and utilities to develop strategies for implementation of the Federal government target of 2% new renewables by 2010.

The development of Australian guidelines for grid connection has facilitated PV installations.

As described in Section 4.1 (b), the NSW Electricity Act promotes consideration of renewable options by requiring least cost planning for grid extensions, as well as greenhouse gas reduction programs. These requirements have encouraged utilities to develop RAPS businesses and to install PV in green power programmes.

**c) environmental policies and treaties;**

As above.

**d) national and/or regional laws regulating non-utility production of electric energy;**

Restructuring of the electricity industry has potentially opened up the market for private generators, although to date the only non-utility PV generation has been from relatively small rooftop arrays.

**e) research and development activities carried out by utilities and other market parties;**

Although the major portion of PV R&D funding in Australia in 1996/97 was still directed to device research, utility R&D funding tends to be directed at the development of components or products aimed at the grid connected market. This includes development of specific PV products, testing and further development of inverters, protection devices, metering and monitoring systems, market surveys and analysis tools, and modelling of PV in grid systems.

**f) planned use of PV for demand or supply side applications (isolated/remote users, grid support, peak load production on customer premises, etc.).**

Many utilities already offer PV systems for off-grid applications. There is interest in the use of PV for grid support and peak load reduction, however, no systems have so far been expressly installed for this purpose.

### *4.5 Public perceptions of PV*

PV has a very positive public image in Australia. It is widely recognised as suitable for remote area applications and is expected to contribute significantly to Australia's electricity needs in the next century. There is caution about the cost effectiveness of grid connected PV, given the relatively low cost of central power supply in most parts of Australia. However most consumer surveys show a high level of support for increased use of renewable energy technologies, especially PV.

The success of Martin Green's PV Special Research Centre in maintaining a world leading position in PV R&D has increased public awareness of the technology, as have the widely publicised solar car races.

### *4.6 Standards and codes*

**a) main technical regulations for PV plant construction and operating (d.c. working voltage, safety and control devices, harmonic distortion, power factor, supporting structures, etc.);**

Standard building and electrical codes apply. Specific standards exist for RAPS systems and RAPS batteries.

**b) availability of standards and grid interconnection rules for PV systems;**

Australian guidelines for grid connection using inverters have been developed.

**c) specific rule problems to be solved in order to facilitate PV system diffusion;**

Protection measures for high DC voltages, particularly in building integrated PV systems.

Familiarity as well as professional (engineering, architecture) and trade training needed.

**d) building codes.**

Normal building codes and requirements apply. Some of these vary by local government area and by State.

### *4.7 Future opportunities*

Both major manufacturers are considering expansion over the next 5 years. In addition, Sustainable Technologies Australia and Pacific Solar, currently in the R,D&D phase, will begin pilot production in 1998 and expect to be in commercial production by 1999 and 2000 respectively.

### *4.8 Exchange Rate*

| | | |
|---|---|---|
| $AUD/$US | 0.58 | August, 1998 |

# ANNEX A: METHOD AND ACCURACY OF DATA.

**a) Give a summary of the method of the gathering and the processing and analysis of the data.**

The survey form was sent out to all Australian PVPS Consortium members for completion wrt their own undertakings. Separate forms were sent to manufacturers and major users, such as telecommunications utilities. Information was also sought from Commonwealth and State government departments.

**b) It is necessary to know the accuracy of the data. In the report this can be done in two ways. Firstly if the accuracy is worse than 10 % a range should be given around the estimated number, e.g. 14 kWp ± 4 kWp or 10 kWp to18 kWp. The alternative is to give the accuracy in a statistically well defined percentage. Please give in this appendix an analysis of the accuracy of the different data.**

The accuracy of production data and R,D&D funding is within 10%. End-use data is less certain as detailed records are not kept. Accuracy may be within 20%.

**c) In the case that a country cannot provide the necessary data please explain here the reason.**

Much of the cost information sought is considered confidential by manufacturers and utilities and was not made available for this report. The trend in Australia is towards privatisation of telecommunications, water and energy utilities, which are the main PV users. Hence the availablility of data required for this type of report will continue to decrease.