the australian **photovoltaic** industry roadmap ///

/// July 2004

AUSTRALIAN **BUSINESS COUNCIL FOR SUSTAINABLE ENERGY**

BCSE

// FOREWORD

This Roadmap has been developed by the Australian Business Council for Sustainable Energy (BCSE), with financial support from the Australian Government through AusIndustry. The BCSE has developed this Roadmap to identify the potential of Australia's PV industry and the economic, social and environmental benefits it could deliver over the next twenty-five years. It also sets out how this potential could be achieved through 'joined-up' actions between government and industry.

The BCSE acknowledges the assistance of a number of its members and other stakeholders in providing input for this Roadmap. It also acknowledges the assistance and support of the consultants Dr David Crossley and Greg Watt (Energy Futures Australia), Paul Cowley (IT Power Australia), Geoff Stapleton (Global Sustainable Energy Solutions) and Richard Collins (Punchline Energy). In addition, this Roadmap would not have been possible without significant inputs from industry, and it acknowledges these inputs especially from Muriel Watt, Andrew Blakers, Georgine Duncan, Philip Mackey, Mark Twidell, Tony Stocken, Alison Reeves, Fiona O'Hehir, Sylvia Tulloch and Peter Lawley.

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// ABOUT THE AUSTRALIAN BUSINESS COUNCIL FOR SUSTAINABLE ENERGY

The BCSE is the leading advocate for sustainable energy in Australia. It has more than 250 organisations as members ranging from installers and designers of renewable energy systems to large project developers and equipment manufacturers. Members also include both retailer and generator companies.

The BCSE undertakes activities and programs which support the development of the PV industry in Australia. These activities are aimed at building industry capacity and capability, addressing impediments, and promoting the benefits to potential customers. Industry development activities include:

- → Providing the Chair and Secretariat for the Renewable Energy Action Agenda Implementation Group. This is the Implementation Group for the Renewable Energy Industry Action Agenda. This is a joint industry-government strategy to grow the renewable energy industry to annual sales of $4 billion by 2010.
- → Maintaining an accreditation scheme for industry practitioners who design and install stand-alone and grid-connected PV systems and stand-alone hybrid energy systems.
- → Working with state agencies on programs and projects to facilitate development of the renewable and sustainable energy industries.
- → Developing guides and other resources, often with financial support from government, to assist the implementation of sustainable energy projects.
- → Working with industry sectors to increase training and skills.

This report was funded by AusIndustry and the BCSE.

Please note that all dollar figures expressed in this document are in Australian dollars (AUD) unless otherwise specified. Reference to 'government' refers to the Australian Government, not to the state governments, which are described as such or delineated by state.

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// EXECUTIVE SUMMARY

The vision for Australia's PV industry

Solar photovoltaic (PV) technology generates electricity from sunlight. There are no greenhouse gas emissions in its operation and no noise, and it can provide both off-grid and grid-connected benefits. PV is an unobtrusive, decentralised technology that can be deployed in innovative ways in a myriad of applications. The fuel for PV – the sun – is a source of boundless energy.

This Roadmap sets out the industry development strategy to deliver a cost competitive, vibrant Australian PV industry by 2020. Funded by AusIndustry and the Australian PV industry, the Roadmap is the culmination of an extensive 10 month consultation process involving input from all areas of the industry and taking into account international developments impacting upon the PV industry.

The PV industry is growing internationally to be multi-billion dollar industry. Awareness of the benefits is increasing as innovative international government programs take effect. This in turn results in industry development and a significant increase in installed capacity. Accordingly, the cost of PV technology is continuing to fall.

Australia has vast solar resources, we have leading technologies and world class researchers, we have a number of promising start-up companies – so why have we failed to deliver on the potential? And why have other countries overtaken us? What can we do to redress the problem? These are the issues that this Roadmap seeks to address – it seeks to reposition Australia as a world leader in a field in which we have historically excelled.

Australia is currently at a crossroads in terms of its participation in this global scene.

The issue for the Australian PV industry today is that there is enormous market potential, built up through a natural competitiveness in Australian research and development, industry investment and government policy support. However, despite this growth, the industry is not yet self-sustaining and advantages gained to date could be lost. The PV industry cannot continue to actively invest in strategic industry development unless the Australian government is also committed to the journey.

The industry has identified its strengths and necessary developments in technology and markets, but requires policy and program support to assist it in bridging the gap to mainstream commercial competitiveness.

A strategic industry – government development framework is now required for Australia to leverage historical expertise and develop a growing domestic market with associated benefits into the future. Global growth in the PV industry and resulting cost reductions will continue with or without Australian participation. However, the absence of a strategic industry development framework will see Australia develop as a net importer of PV systems and components, thus losing local jobs and investment in manufacture and system development.

During the consultation process for this Roadmap, Australian industry has outlined 'Sunrise' targets for PV market expansion for 2010 and 2020 that it has the capability to deliver in cooperation with government. The main industry objectives are to meet an installed capacity of 6,740 MW by 2020, PV sector jobs of 31,600, revenue of $5,160 million annually and nearly 10 million tonnes of CO_2 of avoided in 2020.

Sunrise targets

Australian PV industry	2003 actual	2010	2020
Installed Capacity (MW)	46	350	6,740
Employment	1,100	5,290	31,600
Total sales revenue ($ million)	204	1,180	5,160
CO_2 abated in year ('000 tonnes)	65	490	9,320

The Roadmap identifies two critical components:

→ Belief from industry and the financial sector that a significant PV opportunity exists in Australia and for export markets, in which it is worth investing considerable financial and infrastructure resources, to build a strong, sustainable industry sector; and

→ Recognition by the government that PV has an important place in the Australian energy fuel mix, through the implementation of a sustainable industry development strategy that will assist in bridging the gap for consumers between now and commercial viability.

For the 'Sunrise' targets to be achieved, the PV industry requires that current electricity market impediments constraining the uptake of PV be addressed by government. Until such time as these are rectified, compensatory measures that reward the benefits provided by the large-scale deployment of PV need to be implemented.

The Roadmap thus requires that government and industry work together to develop the market for PV in Australia, and to leverage the resultant expertise to build a vibrant export industry. Key actions coming from the Roadmap are:

Government to provide an industry development framework that supports new investment and includes:

→ Market stimulation – this addresses specific market impediments that prevent the benefits that PV provides being adequately recognised and rewarded. Market stimulation underpins increased demand by bridging the current cost competitive gap in the key PV markets for off-grid and grid-connect. This includes feed-in tariffs, enhancing the Mandatory Renewable Energy Target, implementing effective building codes and standards, supporting diesel replacement, and providing financial support for strategic market development.

→ Removal of regulatory barriers – this addresses electricity market impediments that result in increased installation costs, and delays arising from metering, connection and pricing arrangements.

→ Building industry capacity and capability – this includes supporting industry development activities that build local industry capacity, and includes support for exports, innovation, training and education.

For its part Australia's PV industry will continue to build on and leverage its investments to date with specific actions as follows:

→ Drive installed system costs downwards.

→ Improve quality, reliability and performance.

→ Expand and develop markets and applications.

→ Support for industry capacity building.

Australia has the makings of a world class PV industry. The industry is poised to make the required investment, the economic value of which will flow across the Australian economy, if it is provided with a stable and transparent long-term policy framework that enables PV to compete on its merits and be rewarded for its benefits.

A growing global industry

The global PV industry has been growing at over 30 per cent per annum over the last ten years and this growth is expected to continue well into the future. Expectations are that it will grow to $15 billion per annum by 2010 and in the order of $1.5 to $2 trillion by 2030. This growth has been underpinned by market-based programs that have been supporting the deployment of PV in order to reduce its cost and make it mainstream.

In addition, higher values are increasingly being placed on ancillary services, such as power system reliability and voltage stability, so that a simple comparison of energy cost is no longer appropriate as a measure of competitiveness.

PV industry support programs in a number of developed countries will sustain a high global growth rate. These programs have ambitious targets for installed PV capacity in their respective countries, for instance: Japan – 4820 MW by 2010; Germany – 2000 MW by 2010; and the US – 3000 MW by 2010.

This support for PV is principally driven by the desire to reduce greenhouse gas emissions, to create new sustainable employment and investment, meet future energy demands, and to maintain or achieve energy supply security. In addition, there are additional region-specific drivers that facilitate growth of the global PV industry.

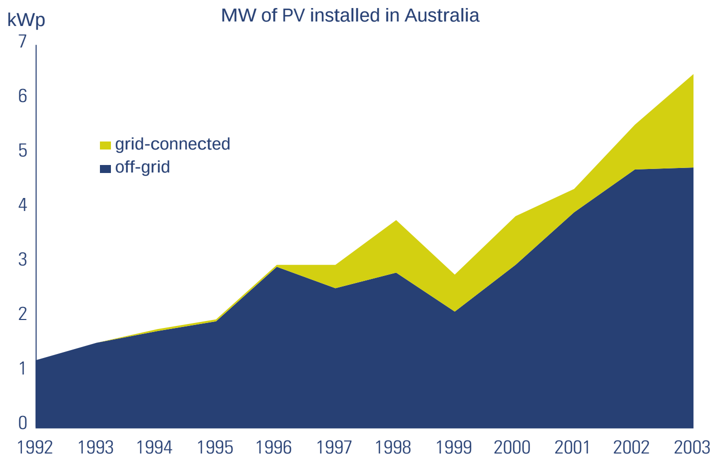
The market for grid-connected PV has grown at 65 per cent and the market for off-grid PV has grown at 18 per cent over the last five years. Whilst it is difficult to predict how the PV industry will grow into the future, industry experts believe that annual growth rates in the range of 15 per cent to 30 per cent are likely to be achieved over the period to 2010.

The PV industry in Australia

To meet the agreed government-industry target under the Renewable Energy Industry Action Agenda of sales of $4 billion by 2010 (including exports of $1.8 billion) will require a significant contribution from the PV industry. The PV industry currently accounts for more than one-third of Australian renewable energy export income.

Industry dimensions	Total renewable energy industry[1]	PV industry
Annual revenue	$1,052 million	$ 204 million
Export sales	$241 million	$100 million
Employment	6,189	1,100

Australia has undertaken PV module manufacturing since 1976. Today, Australia is only one of four countries exporting PV modules. As of December 2003, Australia had an installed capacity of 46 MW of PV and over 1100 people employed in the industry. The annual revenue generated by the industry was more than $200 million.



PV has enormous potential in Australia across a range of applications and activities. The 350 MW installed capacity target under the industry's 'Sunrise vision' comprises the following sector projections:

Sunrise 2010 projections by market sector

Installed capacity (MW) By application sector	**2003 actual**	**Sunrise 2010**
Off-grid domestic		
Remote households, holiday homes, pastoral stations, isolated communities (indigenous), fringe-grid	13.5 MW	40 MW
Off-grid non-domestic		
Telecoms, water pumping, signalling, cathodic protection, electric fences, street lights, tourist facilities	20 MW	94 MW
Off-grid mini-grids		
Isolated communities (mines), public generation	6.0 MW	12 MW
Grid-connected distributed		
Residential rooftops, commercial BIPV	6.5 MW	163 MW
Grid-connected centralised		
Network strengthening, bulk power	1.5 MW	38 MW
Consumer devices		
Small portable electronic devices	0.2 MW	1 MW
TOTAL	46 MW	350 MW

The Australian PV Industry has invested significant funds and dedication to build the PV market to its present internationally recognised level of achievement. Over the last six years alone, the Australian industry has invested the following efforts:

- → Investment of more than $150 million in R&D, mostly in the past three years.
- → Investment in additional manufacturing facilities for modules and system components.
- → Creation of new jobs across the industry to over 1,100.
- → Development of export markets in technology and services by meeting the needs of targeted aid budgets and international development activity.
- → Continued improvement and development of installer training and accreditation.
- → Developing Australian Standards.
- → Development and expansion of distribution and marketing channels.
- → Development and expansion of education and training facilities.
- → Informing markets and governments of the technologies benefits.
- → Promotion and demonstration of the benefits of PV through programs and activities such as Solar House Day.
- → Participation in international collaborative programs such as the International Energy Agency PV Power Systems (PVPS) program.
- → Dedicating effort to international trade missions.
- → Supporting the BCSE as an industry association to build industry capacity and capability.
- → Dedicating considerable time and effort to the development of an industry development vision and strategy.

International opportunities for Australia

The developing world is expected to dominate future growth in demand for energy services. PV is already cost-competitive in some applications, particularly off-grid, and frequently offers the lowest cost energy service on a life-cycle basis compared to other supply options, such as conventional power networks. PV offers developing countries an appropriate means of delivering reliable energy services to rural populations in an environmentally sustainable way. For this type of application, energy services can meet requirements for potable water, health care and lighting. The potential demand for PV in Africa, Asia and Latin America is estimated at 19 GW[2]; this is seven times more than the current worldwide installed capacity.

International market development activities impacting on renewable energy include the following:[3]

- → Internationally-coordinated greenhouse gas reduction polices and clean air policies. The Kyoto Protocol and associated programs, for example the Clean Development Mechanism, provide financial incentives for the implementation of renewable energy projects, particularly in developing countries.
- → Bilateral arrangements, such as the renewable energy component under Australia-US Climate Action Partnership, provide opportunities for driving renewable energy markets and exports.
- → Specific programs for the implementation of renewables in developing countries. These may be classified as financial incentives, however their implementation requires policy initiatives by developing and developed country governments, plus multilateral and bilateral donors. The World Bank recently committed to increase its investment in renewables within its energy portfolio by 20 per cent annually (the current level is four per cent).
- → The introduction of competitive energy markets that allow consumers to choose more environmentally sustainable power supply.

Technology trends

Currently between 50 and 65 per cent of the PV market value, which includes much research and development and intellectual property value, is 'locked' within the PV modules. The remainder of the market value comes from the enabling technology (or 'balance of system') components, such as power conditioning equipment, batteries (mainly for off-grid systems), cables and fittings, and from non-component services, such as design, installation, maintenance and provision of consultancy services.

Over the past decade, global PV module prices have consistently decreased at the rate of approximately 18 per cent with each doubling of cumulative production experience (82 per cent cost to progress ratio). At current market growth rates this equates to annual cost reductions of around 6 per cent. The rate of progress is expected to continue for at least the next 10 years. Current international targets for PV foresee a fourfold increase from the current worldwide installed power of almost 3 GW to at least 11 GW by 2010. PV module prices will therefore fall by at least a third over the next seven to eight years, which will be reflected by similar reductions in the cost of PV electricity.

The case for continued support for Australia's PV industry

As PV is coming from a very low level of installed capacity, its full life cycle cost is still considerably more expensive that conventionally-supplied coal-based electricity.

PV can be competitive in a greater number of markets, but is prevented from being so as pricing structures in Australia's energy markets do not currently capture the economic and environmental benefits that PV systems provide, thus disadvantaging PV in economic decisions made by energy consumers. In addition, the higher up-front installed cost makes it difficult for customers to finance.

Current coal-based grid electricity prices do not reflect a range of environmental, technical and social externalities which are borne by the community and which would be reduced for each kWh substituted by PV generation. There are a number of unpriced benefits that PV provides, which are not currently recognised and rewarded. The policy framework that has been advanced by the industry in this Roadmap requires that these benefits be recognised, or if not, then other measures be introduced to compensate:

- → Offsetting escalating peak power demand.
- → Low environmental impact.
- → Use of a building integrated material.
- → Security of supply.

Importantly, adopting the 'Sunrise' policy framework that is outlined in the Roadmap will additionally enable:

- → The development of a local industry where Australia can build a substantial global position in the growing global PV industry, well beyond its GDP share of the world economy.
- → Local manufacturers and suppliers to be able to plan and invest to update and expand their facilities. The stop-start approach to PV support taken to date has created significant uncertainty at a time when Australia could have been further leveraging off its competitive advantage.
- → PV to become accessible to all Australians, thereby enabling the community to directly embrace sustainable development and the reduction of greenhouse gas emissions.
- → The community to understand that the government is serious about reducing greenhouse gas emissions as PV is a most highly visible sustainable energy technology and one in which households, community groups & businesses can directly participate.

- The continuation of support for capacity building that will enable PV to become cost effective in the medium to longer term, enabling Australia to achieve the deep cuts in greenhouse emissions that are required to stabilise the impacts of climate change.
- The development of a transition path where the benefits of PV are valued by customers and the electricity industry.

This will deliver a vibrant local industry that will make a significant contribution to the Australian economy and to the task of reducing greenhouse gas emissions. The PV industry can grow to an installed capacity of 6,740 MW by 2020, provide nearly 32,000 jobs, have annual sales of $5,160 million and avoid nearly 10 million tonnes of CO_2 in 2020.

PV industry activity framework

To deliver the 'Sunrise vision' for installed capacity of 350 MW by 2010 requires specific actions and activities by both industry and government. The policy framework required of government is in relation to specific PV market sectors, and the Roadmap sets out a comprehensive approach that considers market stimulation, addresses impediments and builds industry capacity and capability.

For its part Australia's PV industry will continue to build on and leverage its investment to date. Specific actions for industry include:

1. Continue to drive installed system costs downwards through:
   - Investing in the expansion of manufacturing facilities, including modules and balance of systems components.
   - Investing in improved manufacturing, logistics and resourcing processes.
   - Improving component and product standardisation to reduce unit costs.
   - Continued investment in research and development to improve system performance and lower cost per kWh of system output.
   - Developing new products and installation methods for both existing and new markets.
   - Increasing the efficiency of the supply chain to bring services to customers in more timely and cost-effective manner.
   - Developing innovative financing approaches that reduce the effective cost to customers.
   - Developing synergies with other industry sectors such as building and construction (particular new buildings), electricity distribution business (with regard to network strengthening and connection) as well as infrastructure owners and operators.
   - Developing innovative and flexible supply channels to access new and expanding market segments.
   - Improved system packaging and integration to deliver lower installed costs.
2. Continue to improve quality, reliability and performance of PV systems through:
   - Continued development of standards, training and accreditation of designers and installers of PV and hybrid systems.
   - Continued investment in expanding and extending system and component testing.
   - Continued investment in development of process and control equipment to optimise system performance.
   - Continued improvement in after sales service availability and cost.
3. Continue to expand and develop markets and applications for PV by:
   - Continuing to differentiate service provided by PV from alternative fossil fuel generation.
   - Continuing work on promotion of the benefits that PV delivers and seeking to get these recognised and rewarded in the market.
   - Increasing marketing, consumer awareness and education.
   - Undertaking extensive promotion and training within the building industry and trades.
   - Seeking out higher value markets that provide a premium by recognising, aesthetics, reliability and security of supply.
   - Developing product solutions that are valued by different market sectors, e.g. BIPV, telecoms, and transport market solutions.
   - Partnering with existing industries and supply chains so as to streamline marketing and supply and to expand into new markets.
   - Supporting trade initiatives and the further development of channels and markets overseas.
   - Continuing to develop export markets for Australian components, systems and services.
4. Support industry capacity building by:
   - Continuing support for development of training and education infrastructure.
   - Supporting international collaboration on research and development, market development and standards.
   - Undertaking regular market surveys to ascertain customer requirements for products and services.

Proposed Government PV policy framework

To support industry's actions, the following policy roadmap provides government with a portfolio of sustainable industry development policy mechanisms that deliver multiple benefits to both the PV industry and the Australian economy more broadly. This will consolidate Australia's international competitiveness, promote innovation and investment and increase the range of economic and social benefits which PV can deliver.

The policy framework is set out in two steps. The first step includes the broad-based industry development and energy market initiatives that are required to establish an overall energy market framework that facilitates the development of the PV industry. The second step has a suite of measures that focus on the three specific PV markets: grid-connect, off-grid and export.

Step 1 – Broad-based and industry development initiatives

- → Building industry capacity and capability, through:
  - – Targeted funding programs to underpin industry development, including developing industry standards, developing a skilled and accredited workforce, as well as participation in international taskforces on industry development.
  - – Support for innovation and commercialisation in the areas of technology, financing, applications and marketing to ensure that Australian industry can maintain a competitive advantage over time.
- → The introduction of a greenhouse price signal into the electricity sector would ensure that investment, purchasing and operating decisions include the cost of greenhouse gas emissions. This also recognises the greenhouse benefits of installing PV rather than being supplied by emission intensive coal-fired power generation.
- → Changes to make MRET more effective as an industry development initiative for PV. This includes changes to the 'deeming' provisions for PV so as to reduce transactions costs and better reflect the performance of PV systems.

Step 2 – Sector-specific programs

In addition to the broader energy market and the general industry capacity building initiatives, specific programs have been developed that focus on the three specific PV markets; grid-connect, off-grid and export. These programs provide a suite of measures that will stimulate each sector and address the impediments that are preventing the full potential of PV being realised.

i. 150,000 Roofs by 2010 program – grid-connect market

This program consists of five measures that are geared to the development of the grid-connect market so that by 2010, this market has grown to 200 MW installed capacity and the total installed PV capacity in Australia has grown to 350 MW. Like other developed countries the grid-connect market will drive future growth of Australia's PV industry. To achieve large-scale deployment of PV in this sector, systems must be available at $5000 per installed kW to consumers. At this level PV becomes economically viable for customers.

It is important that growth in the grid-connect market be maintained by extending the existing PV Rebate Program (PVRP), or an equivalent strategy, until such time as the following proposed industry development measures are implemented. Failure to do so will create a hiatus that will cause the industry to stall.

Reward network benefits of grid-connect systems through a 'feed in tariff'

A 'feed in tariff' is proposed as the optimum industry development method for the grid-connect market to follow on from the completion of PVRP. Feed-in tariffs work by arranging for all PV customers to be paid a higher price for electricity produced from their PV system. This approach has been demonstrated to be very effective in a number of countries.

The higher value for the power produced reflects the considerable benefits that distributed PV systems provide to the electricity distribution system that are not currently recognised, nor rewarded. These include contribution to meeting peak power requirements and network integrity and security.

Ensure that PV is incorporated in new building Codes and Standards

A number of state governments are implementing mandatory minimum energy performance standards for new residential buildings. This provides an important opportunity for PV to be incorporated into new residential buildings and provides building developers with a number of options to meet the greenhouse reduction requirements.

This model should be developed and rolled out into other states and also roll out into new non-residential buildings. States such as Victoria and South Australia have introduced minimum five star energy efficiency requirements for new residential buildings. At present these schemes do not give credit to customers who install PV, but there is potential for this to occur in the future. All energy performance schemes should appropriately recognise and reward the contribution of PV systems to electricity supply for the building envelope.

Support for market development

Targeted funding programs are important to underpin community acceptance and understanding and to support industry development. In the case of the grid-connect market these activities include:

- Improving the visibility of PV in the built environment through an expansion of the successful schools programs and extending schemes to other government and community facilities.
- New government and public buildings to be required to consider PV integrated with energy efficiency measures in the design phase.
- Support outreach education programs to highlight the benefits of PV, including the further development of curriculum materials for schools.
- Support the development of iconic high profile PV projects. Each state should develop at least four such facilities by 2010, perhaps through design competitions, which would create even greater awareness.
- Training and promotion to building designers, engineers, planners and consultants to increase their expertise and awareness about PV technology.
- Marketing and promotion of the benefits and opportunities that PV can deliver.

Creating a level economic playing field

PV technology will compete more effectively in Australia's energy markets when current market distortions are addressed to create a level playing field with more efficient economic outcomes.

This requires that power prices to consumers be more cost reflective in terms of location and time of use. In this way consumers are provided with price signals in proportion to the impact that their electricity use has on the investment required in the network and in new generation.

Processes and requirements for the connection and deployment of PV systems currently act as a significant hurdle to investing in a PV system. Cconnection should be streamlined by standardising connection agreements to best practice and enabling customers to choose a metering system with a minimum requirement of digital net metering. Guidelines need to be established by state-based electricity regulators relating to metering and connection of PV systems so as to minimise costs to customers, as well as reduce delays in connection.

ii Diesel replacement program – Off-grid market development

PV in off-grid applications is currently disadvantaged through the operation of subsidised pricing for customers supplied through remote grids, particularly in Queensland, NT and WA. In addition, changes to the fuel excise arrangements proposed in the Prime Minister's 2004 Energy Statement, will mean that all power generation outside metropolitan areas will be able to use diesel and other petroleum products excise-free. This undermines the competitive position of PV, and increases Australia's dependence on imported fossil fuels.

To deliver on the PV targets for off-grid applications the following measures are required:

- Diesel used for public generation should continue to accrue excise. This brings it into line with diesel used in metropolitan areas and recognises the adverse environmental, security of supply and balance of payments impacts that come from reliance on imported petroleum products.
- Customers in remote areas that are not connected to public grids who choose to install renewable energy rather than rely on diesel should be able to internalise the value of the excise that would have been paid had the system been in metropolitan areas.
- Governments should progressively introduce more cost-reflective and transparent pricing practices for remote consumers. Retailers should charge regionally appropriate prices and offer rebates to consumers who install renewable energy systems equivalent to the difference between the full cost of supplying that customer and the uniform price actually paid by the customer.

iii. Facilitate the export of PV equipment and services, particularly to developing countries

There are significant opportunities for Australia to export products and services, particularly in line with its off-grid PV expenses:

- Increase access to international aid programs by providing funding assistance to support the employment of industry experts to promote Australian industries capabilities overseas and also to identify and disseminate overseas opportunities locally.
- PV to be included in Australian Aid projects to recognise that health care, education, local development and other development objectives are facilitated by the provision of cost-effective local energy supply options. Renewable energy systems can play a key role in delivering development objectives.
- Assistance to utilise bilateral agreements that Australia has to leverage opportunities for market development and industry collaboration.

- → Facilitate greater participation in international collaborative programs – this includes more comprehensive participation in the International Energy Agency PV Power Systems (IEA PVPS) program activities, as well as accessing the collaborative programs of the European Commission.
- → Assistance to build Australian industry capacity to export. Existing networks such as the Australian Renewable Energy Exporter Network (AREEN) need to be strengthened to allow for a full-time secondee from industry to support capacity building and market development.

Australia has the makings of a world class industry. The industry is poised to make the required investment if it is provided with a long-term policy framework that enables PV to compete on its merits, with benefits recognised and rewarded.

// TABLE OF CONTENTS

1// INTRODUCTION

Solar photovoltaic (PV) technology generates electricity from sunlight. There are no greenhouse gas emissions in its operation and no noise, and it can provide both off-grid and grid-connected benefits.

This Roadmap sets out the industry development strategy to deliver a cost-competitive, vibrant Australian PV industry by 2020.

Under this strategy, PV will provide 3 per cent of Australia's power needs by 2020, and will have become accessible to the wider community at prices competitive to projected grid electricity prices. The technology will be applied according to innovative Australian market developments. This means integration into Australia's urban as well as rural environment – into the façades and atriums of commercial buildings, on structures alongside roads and highways, as individual applications such as street lighting, and most importantly, on homes connected to the grid.

Over the past twenty years, the Australian PV industry has proven itself to be both innovative and commercially practical. Australia has a place among the world leaders in PV technology, particularly in providing reliable power to remote applications, in its world-class research, and in development of PV technologies and their applicability to markets.

This document sets out the PV industry in both a global and Australian context, and details national and export markets. Scenario modelling for the Australian PV industry's capabilities is explained and targets are set out for installed domestic capacity for 2010, 2020 and 2030. This modelling underpins the way forward for the PV industry with an appropriate industry activity framework delivering industry benefits stimulated by a portfolio of government industry development policies.

Developing the Roadmap

This Roadmap is the culmination of a 10 month extensive consultation process that has involved input from all aspects of Australia's PV industry and has been informed by developments in the international PV industry.

A brief summary of the consultation process is set out below:

→ An initial scoping meeting was held in August 2003 between the consultancy team, BCSE and the initial consortium of key interested parties, including industry and universities.

→ The first workshop was held in Sydney in September 2004. Prior to the workshop, stakeholders were invited to submit three points or ideas in relation to each of the following questions:

   i. Where do we want the PV industry to be in the short term (say 2010), the medium term (say 2020) and the long term (say 2030)?

   ii. What's stopping the PV industry from realising these short, medium and long term goals?

   iii. What strategies should the PV industry and its various stakeholders adopt to achieve the short, medium and long term goals?

   The responses were collated prior to the workshop and used to guide the discussion at the workshop. During the workshop, break-out sessions were held to discuss the three questions.

→ To capture input from other interested stakeholders, a series of workshops were held during August, September and October 2003 in all mainland capital cities. These meetings comprised:

   i. PV industry consultation forums – during which experts involved in the PV industry were able to express their views and visions for the future of the industry in the short, medium and long terms. It also involved those currently not active in the industry, but who could be, such as architects.

   ii. Focus groups – small group meetings during which those involved in the PV industry and other potential stakeholders (such as representatives of the building industry, local councils and government policy makers) were also able to express their views.

   These events were attended by a total of 106 people from a range of areas, including PV manufacture, PV supply chain, PV research and development (R&D), PV policy and support, PV users, energy suppliers, government representatives, architects and designers, and the building sector.

→ Workshops were also held in Sydney and Melbourne with BCSE industry stakeholders and the project team, to develop and synthesise results of the consultations, develop and refine the industry modelling and develop industry and government actions under the Roadmap.

→ In addition, the project team took advantage of a number of industry conferences and seminars to discuss the Roadmap process and obtain input from delegates. These included:

   – Alternative Technology Retailers Association Annual Conference, Hobart, 8–10 August 2003.

   – Urban Development Institute of Australia Conference, Brisbane, 25 September 2003.

   – BCSE National Conference, Sydney, 30 March–1 April 2004.

2// THE AUSTRALIAN AND INTERNATIONAL CONTEXT FOR PHOTOVOLTAICS

Globally, the PV industry has been growing at over 30 per cent per annum over the last ten years, and this level of growth is expected to continue well into the future. Recent growth rates have been due to substantial uptake of PV in grid-connected markets in Europe, Japan and the US. This growth has been underpinned by market-based programs that have been supporting the deployment of PV in order to reduce costs and make it mainstream.

The global rationale underlying this concerted drive for growth in the PV industry are varied and often complex. Four fundamental factors, however, underpin the attractiveness of PV and explain the fervent response internationally:

i. The use of PV for electricity is an effective response to the globally recognised imperative to reduce greenhouse gas emissions in order to stabilise human-induced climate change.

ii. PV is seen as an important technology in addressing energy security, in terms of:
   - → Being a foil to rising international energy prices.
   - → Requirements to import large amounts of fossil fuels.
   - → Improved security and reliability of supply.

iii. PV is an effective way in which to meet the growing energy demands of developing countries and, in particular, to provide power to the 2 billion people in the developing world who do not presently have access to electricity.

iv. PV is a globally emerging industry that will revolutionise the way that energy is generated and consumed, and will provide significant growth in employment globally.

In addition to the above, the structure, ownership and operation of electricity systems around the world are changing in response to industry restructuring, the availability of new technologies and increasing environmental awareness. Large-scale, central power generation and distribution, which has characterised the electricity industry for much of the 20th century, is being challenged by new technologies, which are cleaner, faster to deploy and better matched to local requirements. These have the advantage of being decentralised, which means that they are generating electricity closer to point of use, they are less vulnerable to terrorist attacks, and they increase security of supply.

Higher values are increasingly being placed on ancillary services, such as power system reliability and voltage stability, so that a simple comparison of energy cost is no longer appropriate as a measure of competitiveness. PV electricity is unique amongst the new energy sources for the wide range of energy and non-energy benefits which can be provided, while the use of PV power systems as an integral part of a building provides the greatest opportunity for exploiting non-energy benefits and for adding value to the PV power system. PV is also unique in its ability to deliver energy from microwatts to megawatts.

PV is proving that it can deliver the above requirements. It is an unobtrusive technology that can be deployed in innovative ways in decentralised locations. The fuel for PV – the sun – is a source of boundless energy.

The USA,[1] the European Union[2] and Japan[3] all have recently published Roadmaps for the development of their PV industries, which show the level of international commitment. These all reflect PV as a major industry growth opportunity.

Meeting global energy needs

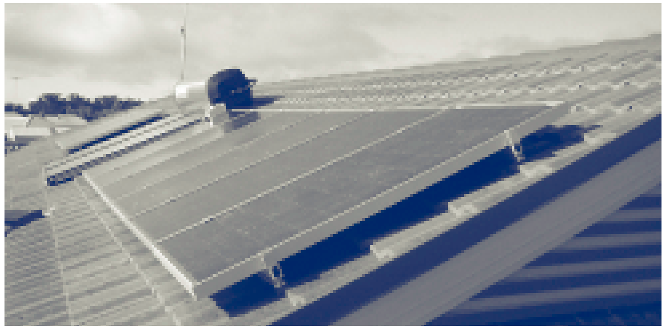
According to the International Energy Agency (IEA), global electricity consumption is expected to increase by over 130 per cent from 2001 levels by 2040 to 36,346 TWh[4]. This presents the global community with an awesome challenge in being able to supply this electricity in a manner that not only addresses important energy security considerations but also results in a net reduction in greenhouse gas emissions.

BP's Statistical Review of World Energy 2004[5] was published on June 15th, and shows that, at current rates of production, the world's proved reserves of oil are sufficient to last for 40 years, with nearly 77 per cent of those reserves are located in OPEC countries. The proved reserves of natural gas are sufficient to last for 67 years at current rates of production, with the largest reserves in the countries of the former Soviet Union. Proved reserves of coal are sufficient to last 192 years at current production rates, with most reserves in North America, the Asia Pacific region, and Europe and Eurasia.

World energy use increased three percent in 2003, with the strongest growth (six percent) in the Asia Pacific region. Among fossil fuels, coal grew fastest in 2003, with an increase of 7 percent, largely due to a reported increase of more than 15 per cent in China. Chinese oil demand has also doubled over the past ten years, leading BPs Chief Executive, Lord Browne of Madingley, to conclude in his foreword that China 'will be a major influence on the world energy scene from now on'.

In contrast to its fossil fuel statistics, BPs statistics on renewable energy sources are relatively limited. The report does note that PV capacity has increased more than ten-fold over the last decade.

Shell International Petroleum has also recognised the capability and potential of renewable energy. In a report released in 2003,[6] it predicted that more than half of the world's energy supply will come from renewable resources by 2050. Shell is acting on this view by increasing its investment in renewables, including PV, having provided PV



systems to 28,000 more rural homes with no access to power from the grid in 2003, bringing the total to 50,000 since off-grid rural operations began in 2000.[7] Other major global companies such as General Electric are moving into the renewables sphere through the acquisition and development of wind and PV businesses over the last few years.

Renewable energy therefore has a critical role to play in meeting our global demand for energy as recognised by two of the world's largest energy companies. The European Renewable Energy Council (EREC)[8] in its report 'Renewable Energy Scenarios to 2040,'[9] concluded that renewables could provide 50 per cent of global energy needs by 2040, compared to the 2001 renewables contribution of 14 per cent. The report showed that, in terms of share of power consumption, renewables have the potential to increase its market share from 19 per cent in 2001 to over 80 per cent in 2040. They also concluded that, to achieve this vision, effective European policy frameworks are required to assist in the deployment of these technologies. The report showed that growing developing country markets, where distributed PV can replace the need to build expensive and intrusive electricity supply infrastructure, will ensure that PV will be the energy source of choice for many years to come.

The greenhouse imperative: an important PV driver in Australia

The way in which we use and produce energy has significant environmental and economic impacts. Meeting Australia's growing energy needs currently results in the emission of millions of tonnes of greenhouse gases, which is having an increasingly harmful impact on climate. This will continue to be a particularly sensitive issue in Australia. As shown in Figure 2.1, Australia is now the highest greenhouse emitter per capita in the world at 27 tonnes per person and the USA is second highest at 21 tonnes per capita.[10] This arises as a result of the significant amounts of energy used by industry, in particular the aluminium industry, and our reliance on coal fired generation (the worst greenhouse gas emitter) to meet 80 per cent of our electricity needs.

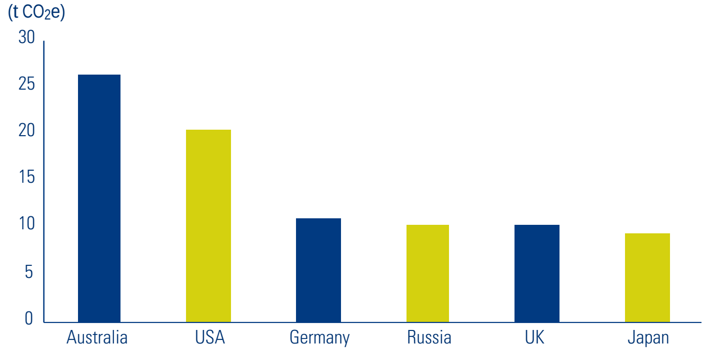


Figure 2.1 Greenhouse gas emissions per capita for selected Annex I countries, 2001 (t CO_2e)
Source: The Australia Institute, 2004

Climate change is an immediate problem requiring urgent action. As the world is getting hotter on average, Australia is also warming and getting drier. Australian scientists, including the Chief Scientist of CSIRO Atmospheric Research Graham Pearman[11], agree that this is due to the enormous amounts of fossil fuels that we burn – coal to generate electricity and oil to drive cars. The effects of global warming include making extreme weather events more common, droughts worse and bushfires more severe.

Significantly reducing greenhouse emission is an important challenge facing the global community. The need for deep cuts has been formally acknowledged by the Australian Government. The Foreign Minister, Alexander Downer, has stated:

"If we are going to achieve stability in global temperatures in the years ahead then CO_2 emissions will have to be reduced by between one half and two thirds."[12]

In 2000, the UK Royal Commission on Environmental Pollution brought down a report examining the feasibility of achieving a 60 per cent reduction in Britain's emissions by 2050. The report observed:

Human use of energy has grown enormously, based overwhelmingly on burning fossil fuels. This is causing a significant change in the composition of the atmosphere which, unless halted, is likely to have very serious consequences… In addition to previously recognised risks from obtaining and using energy, the world is now faced with a radical challenge of a totally new kind, which requires an urgent response. The longer the response is deferred, the more painful the consequences will be.[13]

The Blair Government has responded with a detailed study and discussion of how such a reduction might be achieved.[14] Noting that the UK 'is likely to face increasingly demanding carbon reduction targets', the UK Government concludes:

Credible scenarios for 2050 can deliver a 60 per cent cut in CO_2 emissions, but large changes would be needed both in the energy system and in society… Given the strong chance that future, legally binding, international targets will become more stringent beyond 2012, a precautionary approach suggests that the UK should be setting about creating a range of future options by which low carbon futures could be delivered, as, and when, the time comes.[15]

The European Union (EU) is in the process of implementing an emissions trading scheme that will place a value on carbon dioxide. The scheme is scheduled to commence on 1 January 2005. Current carbon dioxide prices quoted in the EU are around € 10 per tonne (approximately $18 per tonne).

Energy supply in Australia

Australia's electricity supply is dominated by coal, whith over 80 per cent of electricity produced supplied through the use of brown and black coal. Gas currently provides around 11 per cent of electricity needs and renewables make up less than 9 per cent.

Australia's overall energy consumption is expected to increase by nearly 60 per cent to 2040. Electricity demand is expected to increase by nearly 65 per cent to over 355 TWh[16]. Australia therefore has a critical challenge in reducing the carbon intensity of its power supply. In the report 'Securing Australia's Energy Future' launched by the Prime Minister in June 2004, it is estimated that over $37 billion of new energy infrastructure will be required to meet Australia's growing energy needs to 2020.[17]

It is critical that an effective framework is adopted to guide future investment and ensure that we are not just compounding our current greenhouse problems and creating a greater burden for the future. Using energy more efficiently and switching from coal to renewable power generation are effective, long-term and globally accepted ways in which to mitigate climate change.

Australia has the renewable energy resource base to be able to significantly reduce emissions. Greenhouse gas emissions from the stationary energy sector (which accounts for nearly half of Australia's total greenhouse gas emissions) can be halved by 2040 using existing technology and without affecting economic growth, according to the 'Clean Energy Future for Australia' study.

The 'Clean Energy Future' study found that Australia has sufficient natural gas and renewable energy resources, like solar, wind and bioenergy, to make up the bulk of electricity supply in 2040.[18]

To underpin this vision it is imperative for Government to implement policies that incorporate the following:

- → Support fuel switching away from coal to zero or low emission fuels.
- → Provide a greenhouse price signal into the energy market to guide new investment decisions in energy infrastructure.
- → Remove energy market impediments to distributed energy sources and create a level playing field with centralised fossil fuel generators.

The Clean Energy Future study has conservatively estimated that PV could contribute five per cent of Australia's electricity needs in 2040, equivalent to an installed capacity of 9,000 MW. This did not include sector specific support mechanisms as outlined in this Roadmap. The Australian PV industry has proposed a targeted vision for its capabilities under the Sunrise targets, as outlined in Chapter 5. A sector-specific industry development program is proposed meet these targets and to deliver a thriving domestic and competitive PV industry in Australia.

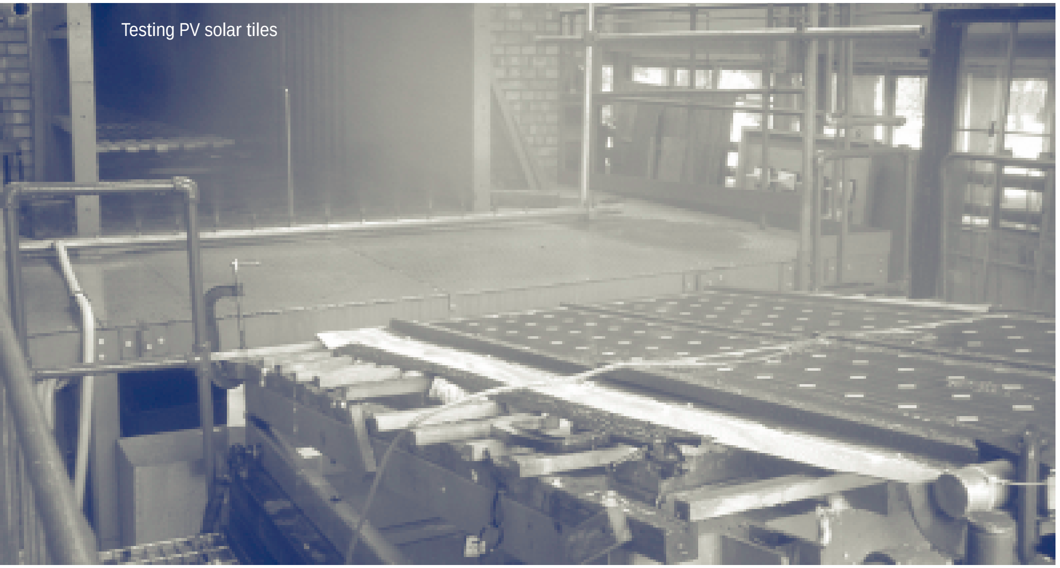
Australian industry at the crossroads

The global PV industry includes new manufacturing capacity that is located in countries that actively support PV and have growing local markets. In addition, the emphasis for the application of PV in recent years has shifted internationally from off-grid to grid-connected markets and applications.

Australia is currently at a crossroads in terms of its participation in the global PV market. Whilst building up considerable expertise in PV over several decades and currently holding a position of some leadership internationally, particularly in the field of off-grid systems, Australian industry is in danger of losing this leadership. Significant government policies are needed to assist the Australian industry to have confidence in expanding, investing, innovating and becoming a profitable and cost-effective energy sector industry.

A strategic industry development framework is now required to be implemented for Australia to leverage historical expertise and develop sustainable domestic market growth, with associated economic, environmental and social benefits into the future. Global growth in the PV industry and resulting cost reductions will continue with or without Australian participation. The absence of a strategic industry development framework will see Australia as a net importer of PV systems and components, thus losing local jobs and investment in R&D, manufacture, and system development and installation.

The Department of Education Science and Training has published a Report entitled Commercialisation of Photovoltaics Research in Australia.[19] This highlights the history of Australian leadership in PV technology, and the 'difficulty of gaining investors in PV' in Australia to commercialise the IP developed, especially compared to the commitment of governments overseas.



Testing PV solar tiles

CASE STUDY: **PACIFIC SOLAR – AUSTRALIAN INNOVATION AND MANUFACTURING LOST OFFSHORE**

Pacific Solar was an Australian-formed company that commercialised Australian research and development at a site in Sydney and looked set to provide innovative low-cost technology packaged product solutions to Australian customers.

Founded in February 1995, Pacific Solar was a high-tech spin-off company from the University of New South Wales, which provided the company's initial intellectual property.

Pacific Solar's Crystalline Silicon on Glass (CSG) technology is a unique thin-film PV technology that was readied for commercialisation and set up a pilot line plant in Sydney. Pacific Solar invested over $90 million in developing CSG and related technologies, including intellectual property valued at over $19 million.

Unexpected changes to government funding support programs in early 2003 put the new company in jeopardy. Market immaturity and uncertainty made securing the necessary financial capital impossible and forced Pacific Solar to look for investment in manufacturing and markets elsewhere.

In June 2004, the 20 former employees of Pacific Solar announced the formation of a new company, CSG Solar, to be based in Germany, that will construct a plant for the manufacture of Australian developed technology and innovation.

The case of Pacific Solar highlights the imperative for sustainable market and industry development policies to keep the benefits of Australian innovation onshore.

3// THE AUSTRALIAN PV INDUSTRY

The Australian PV industry has participated in technology development and delivery for over three decades. This chapter explains the current commercial technology, the development of the PV industry in Australia and the industry's value, commercial strengths, activities and commitments to date. At present, Australia manufactures the majority of PV components for the domestic market and undertakes significant research and development into technology and product development for the market.

The Australian PV industry is composed of the following sectors:

- → Research and development.
- → PV cell and module manufacturing.
- → Balance of System (BOS) manufacturing.
- → Distribution, wholesaling and retail sales.
- → System integration, including design and installation.
- → Electricity supply.
- → Education and training.
- → Standards and Accreditation.

PV cells and modules

PV cells are semiconductor devices that convert sunlight into direct current (DC) electricity. They do this silently and with no moving parts or emissions. There are a variety of technologies available, at various stages of development and commercialisation. Today, the dominant, widely used cell technologies are mono-crystalline, multi-crystalline (first generation) and amorphous silicon (second generation) products.

Mono-crystalline and multi-crystalline cells are manufactured as individual elements. As a single PV cell, they are fragile and deteriorate if exposed to the environment. PV modules, the useful structural electricity generation product, are manufactured by electrically connecting PV cells together and encapsulating them in weatherproof packages.

Each technology type has different manufacturing techniques, cost and performance, and are usually compared on a dollar per Watt basis. Each is more suited to various applications. For example, where surface area available is limited, mono-crystalline modules provide maximum power output. Conversely, where low cost per square metre is important, amorphous modules may provide an advantage.

Each PV module provides a building block for a complete PV system consisting of a number of modules and other electrical components. PV modules are electrically connected in series (to build up voltage) and in parallel (to build up current) to suit the demand and voltage requirements of a specific electrical load.

In Australia, there are no silicon wafers produced, but BP Solar produces both mono and multicrystralline silicon cells from imported wafers, and Origin plans to use imported monosilcion wafers to produce its Sliver® cells. There is no thin film (second generation) production, of amorphous silicon, cadmium telluride (CdTe) or copper indium deselinide (CIS). Pilot production of Dye Solar Cells (DSC), a third generation technology based on artificial photosynthesis, is undertaken at Sustainable Technologies International (STI).

Further Australian PV technology types include concentrator 'dishes', which work by concentrating light onto PV cells and tracking the sun's path.

For more information on all the technologies outlined above, see Appendix 1.

Applications

There are two common applications, being Stand-alone Power Systems (SPS) and grid-connected systems. These are explained below.

Stand-alone Power Systems (SPS): also referred to as 'off-grid systems', include a system controller, batteries for energy storage for night or periods of poor sunshine and an inverter, if the load requires it, to convert the DC of the batteries into conventional AC power. Figure 3.1 shows the typical composition of a SPS, where the quantity of PV modules and battery capacity are determined by the application.

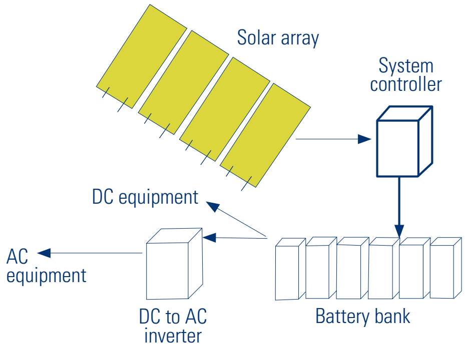


Figure 3.1 Stand-alone PV power system

Such off-grid applications include electricity for houses not on the grid, remote lighting and security systems, telecommunications, cathodic protection, battery charging, navigation aids, traffic and railway signalling, and monitoring systems.

The exception to the configuration in Figure 3.1 are PV pumping systems, which typically only have a PV array, a pump and control equipment. They typically do not have batteries, as the water is usually pumped to storage during daylight hours, for use when required. Irrigation systems typically are used during daylight hours, so they also usually do not require battery storage. Water pumps run on DC electricity, and thus do not require conversion to AC.

Grid-connected power systems: include a DC to AC inverter, plus safety devices. Figure 3.2 shows the typical composition of a grid connect system.

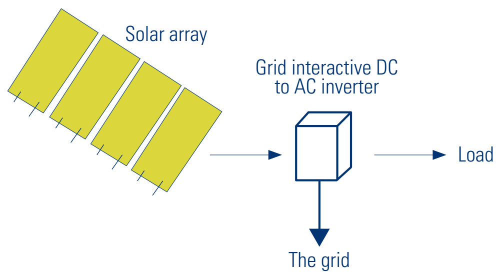


Figure 3.2 Grid-connected PV power system layout

Figure 3.3 depicts global trends in the improvement of efficiencies of PV cell, module and inverter technologies. As can be seen, there have been significant efficiency improvements in all of these aspects of a PV system.

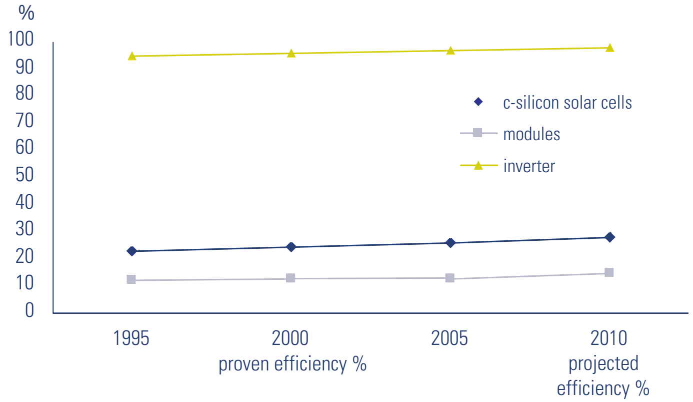


Figure 3.3 Improving efficiencies of PV technologies

Source: ESTIR, 2002, Energy technology indicators

Solar radiation

Solar radiation from the sun is the 'fuel' for the PV system. Where there is more available solar radiation, the output of the system will be greater

Solar radiation is affected by a number of factors:

- → Latitude – position on the globe affects the relative position of the sun in the sky and hence its intensity.
- → Proximity to the coast or mountains – generally the closer to the coast or mountains, the greater the frequency of cloud coverage that obscures the sun.
- → Time of day – the further away from noon then the lower the sun is in the sky and therefore the intensity of solar radiation is lower.
- → Time of year – seasonal changes bring varying cloud effects, position of the sun in the sky and day length.

Compared to most other countries, Australia is rich in solar resources. The high average solar radiation available in Australia is shown in Figure 3.4, compared to other regions. For the grid-connect market, the majority of Australia's population enjoys high annual solar radiation. In addition, the availability of the solar radiation correlates closely with peak loads (80 per cent of PV system output is during times of summer peak demand). The majority of the off-grid power system market is also located in areas with high radiation and where the cost of delivering diesel is expensive or in some cases, such as in tropical areas, impossible to access in the wet season.

Figure 3.4 Average irradiation by region
Source: IEA Greenhouse Gas R&D Program, 2003 [1]

Additionally, Australia also has the highest potential effective surface area per inhabitant in the world outside the USA for use by decentralised PV electricity generation (19.9 m^2 roof and 5.0 m^2 façade).[2] This means that Australia has an enormous potential for roof-mounted and façade-integrated PV systems.

History of the PV industry in Australia

Australia has been at the forefront of PV applications over several decades. Australia led the world in the development and application of PV systems for telecommunications and remote area power supply in the 1970s and 1980s.

In 1978, Telecom Australia installed one of the world's first and largest PV-powered microwave repeater stations in central Australia, and established an important PV research, development and testing program at its Telecom Research Laboratories, with close links to the CSIRO battery research and testing facility in Melbourne. In 1979, Tideland Energy was established as the first PV manufacturing plant in the Southern Hemisphere with financial assistance from the NSW government. In 1980 Telecom Research Laboratories commenced field tests in Australia on crystalline silicon modules. In 1981, Australian National Railways installed a PV-powered signal relay and communications system, also one of the world's largest at the time. Other signalling and telecommunications installations followed.

These developments sparked interest in PV for a range of SPS applications, and Australia led the world in the development and use of PV in off-grid household, agricultural and industrial applications. Australia was also at the forefront of Solar Car Racing, which aided public awareness of PV technology and stimulated international research efforts in both PV technology and balance of system components, such as motors and batteries. The Solar Car Race from Darwin to Adelaide continues with international competitors.

During the 1980s, the Solarex Corporation established manufacturing in Sydney, and BP Solar purchased Tideland Energy (which included their manufacturing plant) in 1985. Both companies serviced the telecommunications, export and other off-grid markets. Hybrid power systems, using a combination of diesel or petrol generators and PV and/or wind, emerged. The development of sine-wave inverters saw rapid development of this market, especially for off-grid residential power supplies. The first government PV support scheme, the NSW Remote Area Power Assistance Scheme (RAPAS) was developed to allow remote residents to gain 24 hour power supply where grid power was not available. This was followed by schemes in other States and by larger installations in diesel grids around Australia.

In 1985, BP Solar licensed the 'Laser Grooved Buried Grid' technology from the University of New South Wales (UNSW). 1989 saw the establishment of the Centre for Photovoltaic Devices and Systems at the UNSW.

In the mid 90s the Australian government Energy Research and Development Corporation (ERDC) formed a consortium to bring DSC (artificial photosynthesis) technology to Australia. Sustainable Technologies International (STI) lead that consortium and has since established the world leading DSC development and commercialisation operation in Queanbeyan. STI continues to cooperate with the Swiss Federal Institute EPFL. Investment to date in the Australian operation has been ~$20 million, of which 25 per cent has been government support. That investment included the establishment of a pilot manufacturing facility, which produced 'maoduels' with 95 per cent Australian content.

Grid-connected applications followed the development of sine-wave grid interactive inverters. Project Aurora, one of Australia's first grid interactive PV systems, was installed at CERES in Melbourne and connected to the Brunswick Electricity Supply Department. The system included 48 PV modules and a 14 kW 3-phase grid interactive inverter. Energy Australia installed what is still the largest grid connected system in Australia – the Singleton PV power station at 400 kW. In 2003, Melbourne City Council commissioned Origin Energy and BP Solar to install Australia's largest roof-top PV array (199 kW) on the roof of the Queen Victoria Market.

In line with the ecologically sustainable development goals of the Sydney 2000 Olympics, Pacific Power, with financial assistance from SEDA, commissioned BP Solar to install 640 x 1 kW PV systems on houses in the Newington Solar Village (Mirvac Lend Lease Village Consortium). Several other landmark PV systems were installed on sites around the Olympic facilities, including water pumping systems and the iconic Olympic Boulevard lights.


Solar lighting at Olympic Stadium, Sydney

In 2001, BP Solar opened a new manufacturing plant at Sydney Olympic Park, NSW, which replaced its existing two manufacturing plants in NSW. The new plant reached 25 MW in capacity by the end of year and was subsequently expanded to 35 MW in 2003.

The Australian National University (ANU) Combined Heat and Power Solar system (CHAPS) was launched in 2002, and a demonstration system installed on Bruce Hall, Canberra, in 2003.

In 2003, Origin Energy announced plans to establish a new plant in South Australia to manufacture Sliver® Cell technology, which was developed by ANU. This technology utilises mono-crystalline type PV cells that are developed with an innovative manufacturing process. Sliver® technology uses 90 per cent less expensive silicon than current conventional PV modules yet aims to deliver commercially competitive cell and module efficiencies.

In March 2004, Australia Post released a set of four renewable energy stamps. Its Philatelic Department reported unprecedented interest with demand outstripping predictions by 75 per cent.

See Appendix 2 for details of milestones in the development of PV in Australia and internationally.

CASE STUDY: **BP SOLAR SYDNEY OLYMPIC PARK PV MANUFACTURING PLANT**

In 1998, BP Solar Australia unveiled an initiative to build a new PV manufacturing plant in Sydney. The new facility, which opened in 2001 and is located in Sydney Olympic Park, was the result of the merger between BP Solar and Amoco Solarex and doubled the combined production capacity of the two companies' former facilities. It is one of the largest facilities of its type in the world. It cost $57 million to construct, provides almost 300 jobs for Australians, and will ultimately be capable of supplying 40 MW of PV cells each year for domestic and international markets.

The creation of the facility involved the upgrading of plant and equipment, innovative architectural design (including building-integrated PV modules) and the incorporation of energy efficient and waste reduction features in the production process. The facility caters for the production of both mono-crystalline and multi-crystalline PV technologies, using an advanced screen printed processing system that yields cells with a performance equal to the best in the world. The plant expects to export up to $100 million worth of PV products a year by the end of 2004.

Value of the Australian PV industry

In 2003, total production of PV cells in Australia rose to 27 MW, and total conventional module production output increased to 10 MW. Full PV cell production capacity was 34 MW, with a further 5 MW capacity in concentrator systems. Of the PV cells produced in Australia, 17 MW (64 per cent) were exported. See Figure 3.5 for Australia's contribution to world cell and module production. Of the 10 MW of conventional PV modules produced in Australia, 5 MW (49 per cent) was exported.

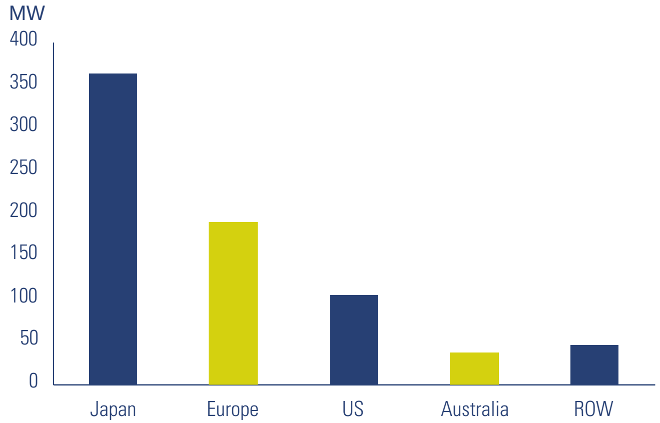


Figure 3.5 World PV cell and module production 2003
Source: PV News, March 2004

Exports of both cells and modules are expected to increase considerably from 2004 onwards as production at BP Solar's Sydney Olympic Park facility reaches full capacity and again in 2005 when Origin Energy's new factory is expected to come on line. Imported cells and modules also feature quite significantly in installations in Australia – around 2 MW, accounting for 30 per cent of installed capacity in 2003.

Of the 7 MW of PV product supplied into the Australian market in 2003, approximately 5 MW went into off-grid applications, valued at an average system cost of $20 per Watt. The balance of around 2 MW went into grid-connected systems, valued at a system average cost of $10 per Watt. The local market is therefore worth approximately $95 million, not including exceptional installation costs.

The exported 17 MW of cells and 15 MW of modules added an export value of approximately $106 million. The export figure should be treated with caution as to Australia's export success. Whilst BP Solar and others enjoy export success, a significant proportion is inter-company/market transfer by BP Solar, which could just as easily be sourced by alternative or new plants located in countries with more vibrant domestic markets and or export support.

The overall net value of PV manufacture and sales in Australia in 2003 was therefore estimated to be around $201 million. However, all silicon wafers (the raw material for silicon PV cells) were imported, which reduces the net value of the product to Australia by approximately $14 million. The $187 million net value does not include:

- → Extraordinary installation costs in remote areas or for special Building Integrated PV (BIPV) systems.
- → On-going operation and maintenance (O&M) costs. Based on the installed PV capacity in Australia of 46 MW at the end of 2003, these costs could add a further $16 million to industry value, if off-grid system O&M costs are 2 per cent and grid-connected system costs are 1 per cent per annum of PV system value at current costs.
- → Exports of enabling technology ('balance of system') components, including inverters, batteries and controllers. Inverter prices range from about $1.00 to $2.20/kVA. Manufacturers of batteries and other enabling technology components also export their products, although on a relatively small scale.
- → Exports of intellectual property/license fees.

In addition, costs for R&D undertaken by universities and industry amounted to more than $33 million in 2002.

Table 3.1 provides a breakdown of non-export PV sales in Australia in 2003, which totalled approximately $95 million for over 3,200 installations.

Table 3.1 Non-export Sales of PV in Australia in 2003
Source: Watt, Muriel [3]

	Annual sales ($ million)	**Capacity of installations (kW)**
Off-grid domestic applications	29.0	1,450
Off-grid non-domestic applications	49.8	3,320
Grid-connected distributed applications	12.3	1,230
Grid-connected centralised electricity generation	4.0	500
Total	95.1	6,500

The total installed capacity of PV in Australia as at the end of 2003 was 46 MW. Figure 3.6 shows annual capacity installed in Australia over the past ten years. Cumulative growth of non-export PV sales has been around 15 per cent per annum over the last few years and growth in 2003 was 17 per cent.

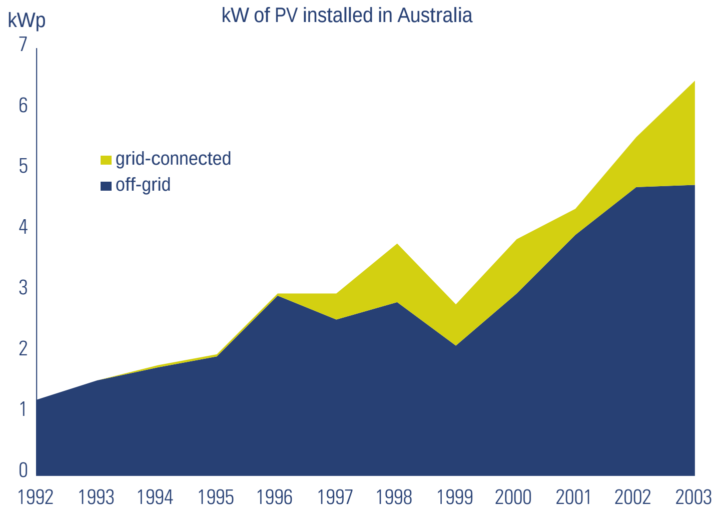


Figure 3.6 Annual capacity installed in Australia
Source: IEA PVPS, 2003[4]

Employment

In the PV industry, more jobs are created in the installation and servicing of PV systems than in their manufacture. Based on industry information, it is estimated that 20 jobs are created per MW of capacity during manufacture and about 30 jobs per MW during the process of installation, retailing and providing other local services.[5] Table 3.2 shows the level of direct employment in the Australian PV industry in 2004. In addition, there are hundreds of jobs created indirectly, through the materials supply chain in particular.

Table 3.2 PV industry employment in Australia, 2004

Sector	Companies/organisations	Direct employees
Research and development	University of NSW (PV Centre) Australian National University RISE (Murdoch University) Individual companies	85+
PV cell and module manufacturing	BP Solar – Sydney Olympic Park (34 MW capacity) Origin Energy – Adelaide PV cell and module manufacturing plant under construction Sustainable Technologies International – Queanbeyan pilot plant	340
Enabling technology manufacturing	Inverters, batteries and components	100+
Distribution, wholesaling and retail sales	90+ organisations	200+
Design and installation	370 accredited installers	400+
Energy supply	Including AGL, Origin, Energex, Ergon, AIEW	30+
Total		1,155+

Australia's competitive advantages

Research and development

Researchers at the University of New South Wales (UNSW) and the Australian National University are among world leaders in innovation in PV cell technology development.

The Centre for PV Engineering at UNSW is undertaking research into improved crystalline and thin film silicon cell efficiencies. In conjunction with industry licensees, the Centre is working on improved manufacturing processes for its 'Saturn' laser grooved cell technology. The Centre is also undertaking theoretical research into so-called 'third generation photovoltaics', which is expected to provide the basis for significant increases in PV device conversion efficiency over the next decade.

Origin Energy has provided funding to the Centre for Sustainable Energy Systems at the Australian National University (ANU) to develop a new thin film PV technology, which uses just one tenth of the costly silicon used in conventional PV panels. ANU is also developing parabolic trough and paraboloidal dish PV concentrator systems and a combined heat and power solar system (CHAPS) that integrates PV electricity generation and solar hot water production using 25 times concentrating troughs.

STI has over 30 patents for DSC technology and products and also operates a pilot line and is continuing to develop its titania dye solar cell (DSC) technology.

Murdoch University is developing methods of producing low cost silicon from a number of new sources for both wafer-based and thin film silicon PV cells. The process will provide options for the PV industry if the price of conventional silicon wafers increases.

Solar Systems is manufacturing and continuing development of its CS500 PV tracking concentrator dishes. System efficiencies of 20 per cent have been achieved. The systems are currently based on silicon cells, but work is continuing on development of non-silicon devices, which are expected to achieve 40 per cent efficiency. Solar Systems is also investing in research to develop new storage technologies for mini-grid systems.

Manufacturing

Cell and module manufacture

Over the past four years, BP Solar's PV cell and module manufacturing facilities have grown over three-fold. In 1999, the facilities were capable of producing about 10 MW of PV product per annum, whereas in 2003 the combined cell and module production capacity was 34 MW per annum. The current BP Solar plant at Sydney Olympic Park, Sydney utilises high volume world class manufacturing methodology including high performance screen-printed processing to produce both mono- and multi-crystalline cells and modules. BP Solar is currently evaluating a further expansion of production capacity to 40 MW per annum which will be dependent on local market conditions.

In late 2003, Origin Energy announced the investment of $35 million in a PV cell and module manufacturing facility in Adelaide using Sliver® cell technology developed at ANU. The plant is expected to being production in early 2005 at the 5 MW/year capacity plant.

STI has been manufacturing and selling DSC cells and modules components in small quantities since 2002. The company has plans to establish volume manufacturing and to increase the range of DSC products from BIPV façade panels to include micropower modules and standard panels, but is having difficulties in raising the necessary venture capital and state government support.

Balance of System technology manufacturing

(BOS) components support the generation of a PV system. They include inverters, batteries, regulators, control equipment and mounting systems.

Australian companies originally developed inverters for the off-grid market, manufacturing quality products suitable for both the Australian and most international markets. In 2004, products cover both grid-connected and off-grid markets and range in size from less than 1 KVA to over 100 KVA. Advanced Energy Systems, Selectronics, Power Solutions Australia, Latronics and Solar Energy Australia are all involved in the manufacture and development of inverters in Australia. Advanced Energy Systems and Power Solutions Australia also manufacture very advanced generator interactive inverters. With the exception of Selectronics (which partly owns Power Systems Australia), all manufacture grid-interactive inverters.

Melbourne-based company, Plasmatronics, designs, develops and manufactures innovative electronic regulating and metering devices for off-grid PV power systems that are utilised in Australia and exported globally. Australian Energy Research Laboratories (AERL) in Queensland and Advanced Energy Systems design, develop and manufacture maximum power point trackers (MPPT) controllers that act to optimise the PV power system.

BP Solar also produces system controllers which range from small power systems to sophisticated PV diesel hybrid controllers with remote control and data-logging and alarm facilities for the high-end telecommunications sector.

Innovations for markets

The Australian PV industry has historically shown strength in industrial innovation, providing solutions for different market requirements. This includes early innovations to suit the power requirements for Australia's vast telecommunications network. This led on to providing reliable solutions for remote households and communities, transport systems such as rail, navigation aids for waterways, and remote monitoring systems for water, air and traffic.

More recently, innovation has been increasing for grid-connected markets, in particular with the use of PV as a building material. For example, PV has been included in a façade on a building at Melbourne University, as transparent eaves on a Brisbane high rise, and dye-sensitised PV has formed part of an atrium roof for the CSIRO's new building in Newcastle.

Further developments have been made on the use of PV integrated into roof-tiles. Products have also been developed to optimise airflows and temperature differentials under the tiles, and to use this heat within the building.

Innovation for remote power continues. In particular, Solar Systems provide solutions for reliable and efficient remote community power use with large PV parabolic dishes. Power and Water Corporation, Advanced Energy Systems and Telstra NDC provide optimised solar and diesel hybrid systems on small grids as power stations for remote communities.

System development

To service the Australian off-grid market, the PV industry has developed very reliable distribution and installation networks. In addition to meeting customers' expectations, reliability is also driven by the high-cost travelling to remote systems for maintenance and repair.

Investments in manufacturing facilities, including investments via government support programs, has lead to the development of more reliable components and products that can be monitored remotely and are easy to repair on-site. These products must be suitable for hot deserts, colder regions of southern Australia and extremely humid conditions of the tropical north. The robust nature of both systems and installation methodologies gives Australian systems competitive advantage when installed in developing countries in particular, where climates can be harsh and application sites difficult to access.

PV designers and installers have developed into competent suppliers of systems, from small systems or weekenders to larger hybrid systems that are used in household systems and for remote communities. Grid-connect system design (including system packages and system configuration options) are becoming increasingly cost competitive and high quality, as well as meeting customers' various requirements. Grid-connect system design includes homes as well has community and commercial buildings.

There are over 350 small to medium sized businesses that typically employ 1–15 people in the design and/or installation of PV systems. These operate primarily in the off-grid market at present, but an increasing number are entering the grid-connect market. The majority of these are located outside the larger urban areas.

Delivery to customers

Australian has a unique and efficient supply chain that has developed since the 1970s. PV modules and BOS equipment are generally sold by distributors and wholesalers to smaller retail outlets and individual system designers and installers (this includes system integrators who are typically project-focussed), though some PV BOS manufacturers sell directly to retail outlets and installers.

BP Solar has approximately 12 major distributors with at least one located in each state. These tend to be relatively larger companies for the industry (5–20 employees) who then on-sell modules to smaller retail installer businesses. With the exception of one company, RF Industries, all distributors retail direct to end-use customers in addition to supplying to the smaller retailers and installers on a wholesale basis. Kyocera has established its own Australian sales operation for PV modules which sells to retailers and installers, while Sharp and Sanyo sell to retailers/installers from their parent companies' Australian operations. Shell, Unisolar, Helios, Kaneka, and some Indian module manufacturers have distributors of their equipment within Australia.

Retail sales of PV systems to end-users are undertaken by wholesalers, retail shops (which typically include design and installation staff) and directly by designers and installers. It is estimated that there are over 90 wholesale and retail outlets for PV systems throughout Australia. While there are over 370 accredited PV system designers and installers within Australia, not all have formal retail outlets. Some operate from their own homes, conducting retail sales directly with the end-user in their homes. Designers and installers have developed businesses that can design, supply, install and maintain systems throughout Australia.

Many PV system wholesalers and retailers commenced operation as suppliers of off-grid systems and have branched into grid-connected systems since 2000. Those in the capital and larger cities are more active in grid-connected systems than those in the rural areas, some of which continue as wholly off-grid power or water pumping specialists.

In the 1990s a number of electricity distributors, for example Integral Energy, Energy Australia, Energex and Ergon, were actively involved in retailing and installing PV systems in the off-grid market. Today Ergon is still actively involved in this market, and Western Power and Power and Water Corporation are installing and planning the additional installation of PV systems to supplement diesel mini-grids in remote areas. Origin Energy is also retailing and installing in the grid-connect market; this includes turn-key projects.

Figure 3.7 shows a diagram of the supply chain in Australia.

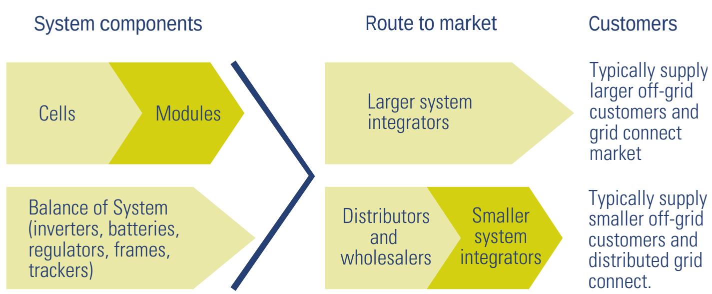


Figure 3.7 Australian supply chain

CASE STUDY: **AUSTRALIAN PV CONTRACTOR, IVAN DENOSOVITCH, EXPLAINS SYSTEM DELIVERY**

Australian PV contractor, Ivan Denosovitch, explains system delivery in rural areas.

The average turnaround time to deliver a PV stand-alone power system (SPS) system is 6 months from the initial quotation to the final placing of an order and installation.

Once a client has decided to go ahead, we the contractors complete all the necessary paperwork for the various rebate schemes that are available. This can take 1-2 months to progress through the system.

Once the rebates have been approved, the commercial part is taken care of with a 35 per cent deposit. 35 per cent progress payment and delivery of equipment to site, with a final 30 per cent payment on completion.

A hybrid system installation comprising of a 5 kW array, 10 kW inverter, battery bank and a diesel generator would typically require:

- 3 days preparation of equipment and packing of the truck
- 1–2 days driving to site
- on site > 1 week
- return to base 1–2 days
- _ day to clean and restore truck & equipment

Fifty per cent of installations require a second visit in the first 6 months, with 100 per cent requiring a subsequent visit in 2 years, to undertake routine maintenance and check system optimisation.

Generally there is a 12 month warranty on the installation, with any call outs within this period being free of charge. A proportion of these call outs are generally done by plane in remote areas, as there is generally no equipment transfer required.

Off-grid solar home

Education and training

It is important that adequate and appropriate training, from trade to professional levels is readily available, to ensure that appropriate skills are available to develop a sustainable PV industry. Over the last 10 years, appropriate renewable energy training modules have been developed and implemented to education institutions. Table 3.3 provides details on PV education at universities and TAFEs around Australia. Resource materials have also been developed by a number of organisations, such as the ACRE-produced suite of Resource Books and Learning Guides to support training and lift the standard and consistency. This was a very significant project and achieved a world class resource for the renewable energy industry.

Installing a PV tiled roof

Table 3.3 PV Education in Australia, 2004

Sector	Institutes
TAFE	TAFE (Trade level) qualifications: → Advanced Diploma of Renewable Energy or → Certificate IV & Diploma in Electrotechnology – Renewable Energy
	QLD Brisbane North Institute of TAFE Cooloola – Sunshine TAFE Cairns TAFE
	VICTORIA Swinburne Institute of TAFE Chisholm TAFE Northern Metropolitan Institute of TAFE Gordon TAFE
	NT Centralian TAFE Swan TAFE
	NSW Ultimo TAFE Muswellbrook TAFE Granville College of TAFE
	WA Central TAFE
	SA Regency TAFE Spencer TAFE
University	University of NSW, Sydney: Bachelor of Engineering in Photovoltaics and Solar Energy
	Murdoch University, Perth: A range of graduate and post graduate energy studies programs, both on campus and via distance education
	Charles Darwin University, Darwin: offers a Bachelor of Electrical and Electronic Engineering Degree which contains some renewable energy units
	Australian National University, Canberra: Home to the Centre for Sustainable Energy Systems. Offers two degree courses – Bachelor of Engineering (Sustainable Energy) and Bachelor of Sustainable Engineering (Environmental Systems).
	University of Melbourne: Masters in Environment which includes modules on renewable energy
	RMIT University, Melbourne: Masters in Sustainable Energy (to begin semester 1, 2005)

Standards and accreditation

A number of relevant Australian Standards and industry guidelines are in place and more are under development. Standards are necessary for system performance, quality and installation, a high level of safety, market acceptance, and confidence.

Renewable energy standards (AS4086 and AS4509) have been developed and implemented. A PV array standard and an inverter standard for SPS are under development and are expected to be finalised by 2005. A standard contract form between the installer and the system owner for off-grid systems has been developed with the industry by the BCSE.

Similarly, installer Accreditation provides a means of ensuring that designers/installer practitioners have a minimum level of competence in the design and installation of renewable energy systems. The Accreditation scheme works to improve customer confidence, safety standards, system performance and also establishes a network of designers/installers of systems across the country.

Since the Accreditation scheme's commencement in 1993, 439 individuals have obtained accreditation in total and over 370 individuals are currently accredited. The Accreditation program is administered by the BCSE, and is overseen by an independent committee of PV experts. All training is currently undertaken in the TAFE courses outlined above.

The Accreditation system also gives support to the various government grant and subsidy programs for PV available over the last ten years. The majority of these schemes require PV systems to be designed and installed by a BCSE-accredited person.

The Accreditation scheme continues to be developed by the BCSE. A particular focus is further development of a dispute resolution process between installers and customers, and OH&S issues.

A number of PV organisations work with the Australian Standards Organisation (ASO) to develop Standards for equipment and installation. For instance, the Research Institute for Sustainable Energy (RISE) works closely with Australian and International bodies in the development of standards for stand-alone PV systems and components. They also are able to test equipment to those Standards, and input into the development of new Australian.

Investment by the Australian PV industry

The Australian PV Industry has invested significant financial resources and dedication to build the PV market to its present internationally-recognised level of achievement. Over the last six years alone, the Australian industry has invested the following efforts:

- → More than $150 million in R&D, much of it in the past three years – the majority of which is for market innovation, followed by technology and social research.
- → Investment in additional manufacturing facilities for PV modules and system components.
- → Creation of new jobs across the industry, particularly in regional areas and in manufacturing.
- → Development of export markets in technology and services by meeting the needs of international development activities.
- → Continued improvement and development of training and Accreditation.
- → Developing Australian Standards.
- → Development and expansion of distribution and marketing channels.
- → Development and expansion of education facilities.
- → Educating customers and governments about the benefits of PV.
- → Promotion and demonstration of the benefits of PV through programs and activities such as Solar House Day.
- → Participation in international collaborative programs such as the International Energy Agency PV Power Systems program.
- → Participating in international trade missions.
- → Supporting the BCSE as the PV industry association to build industry capacity and capability.
- → Dedicating considerable time and effort to the development of an industry development vision and strategy, through activities such as the development of this Roadmap, consultations with government officials at federal, state and local levels, and ongoing consultations through various BCSE fora.

4// THE PV MARKET

Global PV market

Globally, PV is a rapidly expanding, high-tech, future-focused industry presently worth in the order of $4 to $5 billion per annum in terms of final annual sales revenue. Expectations are that it will grow to $15 billion per annum by 2010 and in the order of $1.5 to $2 trillion by 2030.

Currently between 50 and 65 per cent of the PV market value, which includes much research and development and intellectual property value, is 'locked' within the PV modules. The remainder of the market value comes from the BOS components, such as power conditioning equipment, batteries (mainly for off-grid systems), cables and fittings, and from non-component services, such as design, installation, maintenance and provision of consultancy services.

PV is one of the fastest growing industries in the world, growing on an annual basis at an average of 33 per cent globally over the last five years (see Figure 4.1). The market for grid-connected PV has grown at 65 per cent per annum, and the market for off-grid PV has grown at 18 per cent over the last five years. Whilst it is difficult to predict how the PV industry will grow into the future, industry experts believe that annual growth rates in the range of 15 per cent to 30 per cent are likely to be achieved over the period to 2010.[1]

Annual market growth rates used by the PV industry usually refer to the growth in terms of the cumulative market to date (total systems installed or produced) as this tends to be a less erratic indicator than variation in sales from one year to the next. This is particularly the case when markets are analysed by application sector as for an emerging industry one or two large projects can have a significant impact on growth from one year to the next.

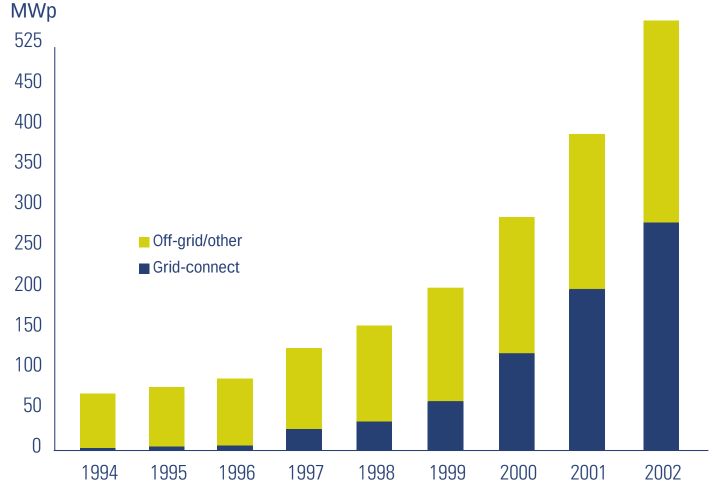
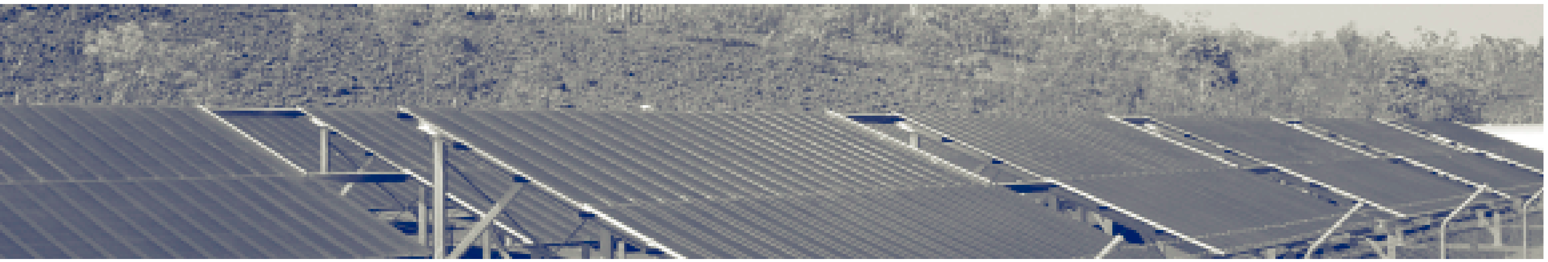


Figure 4.1 Growth in the global PV market
Source: Renewable Energy World, 2003

PV industry support programs in several developed countries are likely to sustain a high global growth rate. These programs have ambitious targets for installed PV capacity in their respective countries, for instance: Japan – 4820 MW by 2010; Germany – 2000 MW by 2010; and the USA – 3000 MW by 2010. This is also reflected in the location of manufacturing facilities around the world, the majority of which are in Germany and Japan. Figure 4.2 shows the leading manufacturers as of March 2004, the majority of whom are located in either Japan or Germany.



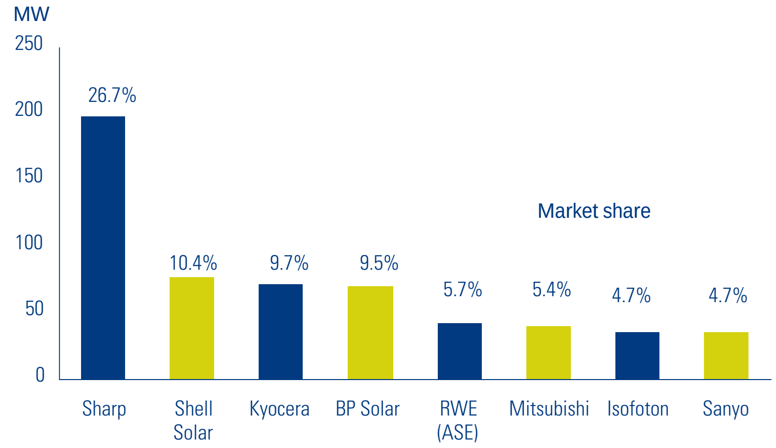


Figure 4.2 Leading PV cell/module producers in 2003
Source PV News, March 2004

By the end of 2002, a cumulative total of about 1,330 MW of PV electricity capacity had been installed in the 20 IEA PVPS member countries.[2] IEA PVPS countries have accounted for more than 90 per cent of global PV production. However, it is interesting to note that Japan installed more capacity in 2002 than the remaining countries combined and that three countries accounted for 85 per cent of the total installed capacity and more than 92 per cent of new capacity.

The annual rate of growth of PV installed in the IEA PVPS countries has varied between 20 per cent in 1994 and 40 per cent in 2000. However, the rate of growth between 2001 and 2002 (34 per cent) was similar to the rate of growth between 2000 and 2001 (36 per cent). As in previous years, the majority of the growth in 2002 was in Japan and Germany, with these two countries alone accounting for 79 per cent of reported capacity installed during the year and driving the doubling of market size that has occurred a little more than every two years in the IEA PVPS countries in recent years. While the proportion of grid-connected PV capacity now makes up about three-quarters of the total (mainly due to large scale, government or utility supported programs) in Japan, Germany and the USA off-grid applications still account for more total installed capacity and new capacity installed in the majority of the 20 reporting countries.

Annual module production in IEA PVPS countries rose by over 50 per cent in 2002, to 482 MW. Module production capacity increased by almost 49 per cent in 2002 to a capacity of 792 MW. Currently 47 per cent of cell production and 54 per cent of module production in the reporting countries occur in Japan. The vast majority of modules produced continue to be based on crystalline silicon material. A number of other technology types are in production but at a much smaller scale.

Regional drivers for international growth

As outlined in Chapter 2, many countries recognise the benefits of PV and are investing in supporting the technology to ensure that they will play an active role in future developments. Support internationally for PV is principally driven by the requirement to reduce greenhouse gas emissions, to create new sustainable employment and investment and to maintain or achieve energy supply security. In addition, there are additional region-specific drivers that facilitate growth of the global PV industry.

In several key developed economies – notably Japan and in parts of the United States, including California – electricity from PV is moving towards being competitive with retail electricity prices after the inclusion of modest subsidies to internalise environmental benefits.

Japan's retail electricity price for residential customers is some three times that of the Australian average (38.5c/kWh), while Germany's retail price is typically double. In parts of California the electricity tariffs are up to three times higher than our own. With the current level of target industry development work, PV electricity is likely to become cost-competitive with grid-supplied electricity in Japan and California within the next five years.[3]

The developing world is expected to dominate future growth in demand for energy services. PV is already cost-competitive in some applications, particularly off-grid, and frequently offers the lowest energy service cost on a life-cycle basis than other supply options, such as conventional power networks. PV offers developing countries an appropriate means of delivering reliable energy services to rural populations. For this type of application, energy services can meet requirements for portable water, health care and a range of lighting and house-hold power. The potential demand for PV in Africa, Asia and Latin America is estimated at 19 GW[4]; this is some seven times more than the current worldwide installed capacity.

Over the past decade, global PV module prices, which account for about half of the price of a PV system, have consistently decreased at the rate of approximately 18 per cent with each doubling of cumulative production experience (82 per cent cost to progress ratio). At current market growth rates this equates to annual cost reductions of around 6 per cent. The rate of progress is expected to continue for at least the next 10 years.

Current international targets for PV foresee a fourfold increase from the current worldwide installed power of almost 3 GW to at least 11 GW by 2010. PV module prices will therefore fall by at least a third over the next seven to eight years, which will be reflected by similar reductions in the cost of PV electricity.

Market development activities for renewables

Current international market development activities impacting on renewable energy include the following[5]:

- Internationally coordinated greenhouse gas reduction polices and clean air policies. The Kyoto Protocol and associated measures, for example, the Clean Development Mechanism give financial incentives for the implementation of renewable energy projects, particularly in developing countries.
- Bilateral arrangements, such as the renewable agreement under the Australia-USA Climate Action Partnership, provide opportunities for driving renewable markets and exports.
- Specific programs for the implementation of renewables in developing countries, particularly through development aid initiatives. Their implementation requires policy initiatives by developing and developed country governments plus multi-lateral and bi-lateral donors. The World Bank recently committed to increase its investment in renewables within its energy portfolio by 20 per cent annually (the current level is four per cent).
- The introduction of competitive energy markets that allow consumers to choose 'green power'.

In line with these drivers for renewables, governments in both developed and developing countries are initiating policies and programs that directly stimulate the installation of PV and therefore the growth in the PV industry.

Figure 4.3 spans the period of 1992 to 2008. Data for the period of 2002 and earlier are 'historical', whereas data for years beyond 2002 are 'best projections'. The graph shows continued progress toward meeting the Project goals of decreasing direct manufacturing costs and increasing production capacity.

CASE STUDY: **PV MANUFACTURING R&D PROGRAM IN THE USA**

The PV Manufacturing R&D Program in the USA (formerly known as PVMaT) is a R&D partnership between the US Department of Energy (DOE) and the US PV industry. These partnerships date back to 1990, when the project was started. The program is designed to help US industry improve PV manufacturing processes and equipment; accelerate manufacturing cost reductions for PV modules, balance-of-systems components, and integrated systems; increase commercial product performance and reliability; and enhance the investment opportunities for substantially scaling up US manufacturing capacity and increasing US market share.

Industry participants are selected through competitive procurements. This project has helped the USA's PV industry accomplish several goals since its inception:

- Improve module manufacturing processes and equipment.
- Accelerate manufacturing cost reductions for PV modules, balance-of-systems components, and integrated systems.
- Increase commercial product performance and reliability.
- Enhance the investment opportunities for the substantial scale-up of US-based PV manufacturing plant capacities.

Figure 4.3 shows the 2002 data of 15 PV Manufacturing R&D module manufacturing partners who had active manufacturing lines in 2002. (A 'partner,' in this context, refers to a subcontractor with a specific technology. The 15 partners represent 11 companies.) The graph shows continued progress toward meeting the Project goals of decreasing direct manufacturing costs and increasing production capacity.

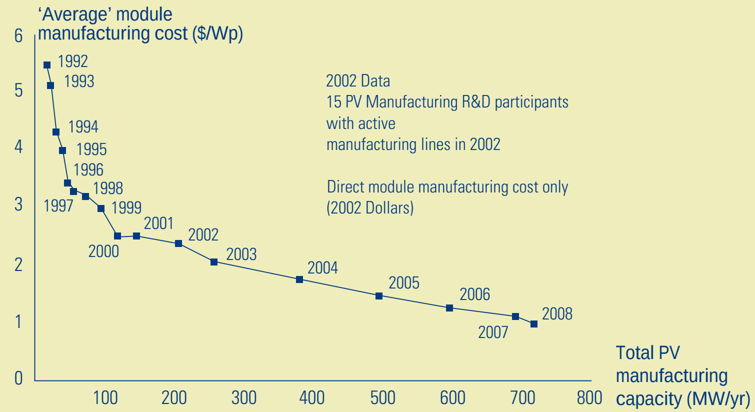


Figure 4.3 PV manufacturing R&D cost/capacity *Source: NREL, 2004* [6]

Financing support schemes

Market growth is currently facilitated globally by financial arrangements that enable affordable access to PV.

Particularly successful schemes in developed countries to provide financial assistance for the purchase of PV systems have been as follows:

- → Subsidies or rebates that reduce up-front price of the system.
- → Guarantees for high purchase price for the energy that recognise network benefits.
- → Low interest loans when buying the system.
- → Personal and corporate income tax credits.
- → Property tax credits.
- → Sales tax exemptions.
- → Competitive grants, often targeted to specific markets.

Some countries also offer incentives to encourage the establishment of new manufacturing plants. These are generally been in the form of tax credits.

Appendix 6 summarises the financial incentives currently in operation in the USA, whilst Chapter 7 includes case studies on the drivers in the Japanese and German markets.

Appropriate financing mechanisms are being recognised as one of the key drivers for the deployment of renewable energy systems in developing countries as well. These are utilised by multilateral organisations, for example the World Bank, the United Nations Development Program (UNDP), the United Nations Environment Program (UNEP), bilateral organisations, national governments and non-government organisations. The financial programs that encourage the installation of PV systems include:

- → Soft loans – often in the form of micro-credit which allow the owner to pay for the system over a number of years.
- → Revolving funds.
- → Direct subsidies to reduce the upfront capital costs.

Multilateral and bilateral agencies are financing and implementing programs in many countries. These focus on the implementation of solar home systems. Other financial initiatives are implemented to more broadly encourage the development of PV. This includes initiatives for market transformation, to support the development and expansion of local renewable businesses.

The Australian PV market

The market for PV in Australia has been increasing at an average rate of 15 per cent over the past three years across all sectors. Growth in 2003 was 17 per cent. In comparison, global growth rates are currently 33 per cent per annum (as discussed previously) and long-term OECD trends show an average growth of 28 per cent. While the marked growth in Japanese (45 per cent) and German (59 per cent) markets over the

CASE STUDY: **THE EUROPEAN UNION**

The EU has a strategy to double renewable energy market share from the present 6 per cent to 12 per cent by 2010. Within its 6th Research Framework Programme the EU will devote € 810 million to renewable energy sources. During 2004 new targets to increase market share to 20 per cent by 2020 have been accepted in principal[7]. The effect of this will be to increase PV supply from 0.02 to 0.2 per cent of energy supply.

Meeting the new 20 per cent by 2020 targets have equally important benefits, such as avoided fuel costs of more than € 100 billion, CO_2 reductions of over 700Mt/year (some 17 per cent of 1990 emissions), saved external costs of up to € 300 billion and extra employment of 2 million people.

However, the EU is aware that certain issues still need to be tackled in order to achieve a substantial increase in the share of renewables. These include:

- → Setting targets for growth.
- → Stable policy framework for security of investment.
- → Creating a level energy playing field.
- → Tackling administrative and grid barriers through the strict enforcement of regulatory frameworks.
- → Creating frameworks for accelerating the growth of market for renewable heating and cooling.
- → Expanding the financial support for research and development (R&D).[8]

The growth in PV module sales in Europe is principally as a result of the 100,000 Roofs Program and the Renewable Energy Law, both of which created a large demand in Germany. Over 80 per cent of the PV module sales in Europe in 2002 were into Germany. Figure 4.4 shows the total annual MW of PV installed in the 13 European countries.

CASE STUDY: **THE EUROPEAN UNION** CONTINUED

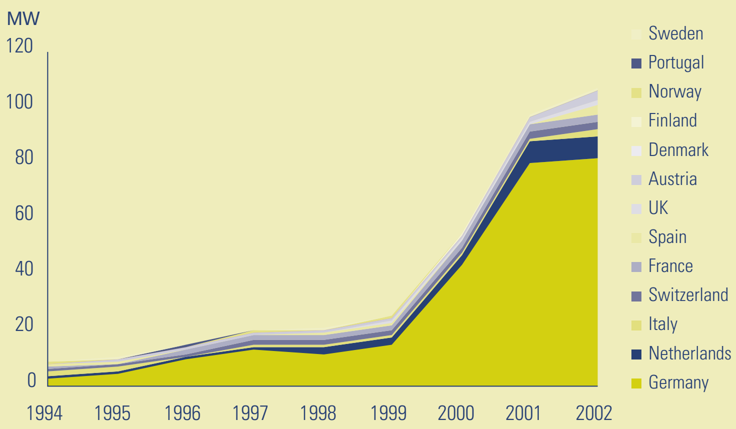


Figure 4.4 Annual PV installed (MW) in 13 European countries

Sources: IEA PVPS, 2003 and EurObserv'ER, Photovoltaic Energy. Barometer April, 2003

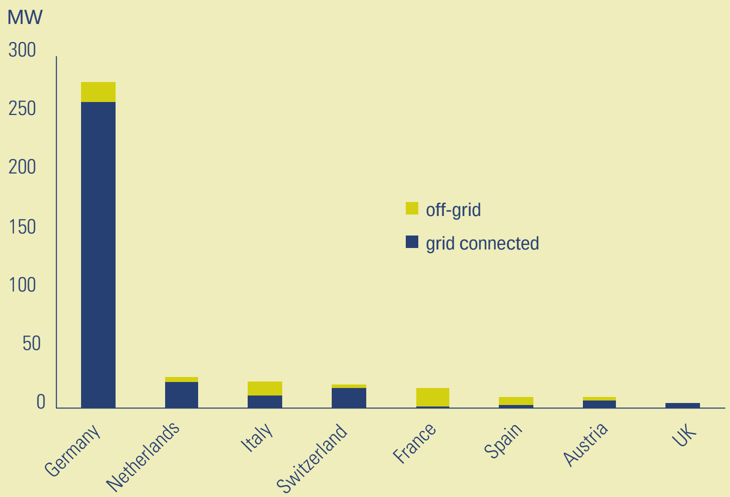


Figure 4.5 Breakdown of cumulative PV installed in 4 different markets for 13 European countries, 2002

Source: IEA PVPS, 2003

last three years have an impact on the global data, Australian growth in PV lags behind that of Austria (35 per cent), Canada (20 per cent), France (24 per cent), Korea (16 per cent), the Netherlands (46 per cent), Portugal (26 per cent), UK (55 per cent) and the USA (22 per cent)[9].

With strengths in PV technology innovation, and robust product design and construction, Australia has the potential to capture between 7 per cent and 15 per cent of the global PV market.

Market segments

Over the past ten years, the total PV capacity installed in Australia has grown over five-fold from 9 MW to 46 MW in 2003 (see Figure 4.6). Currently, there are six main market sectors for photovoltaic technology in Australia as listed below. Table 4.3 shows the breakdown of data for the total installed PV capacity in Australia for the first four market sectors.

i. Off-grid domestic applications.
ii. Off-grid non-domestic applications.
iii. Grid-connected distributed applications.
iv. Grid-connected centralised electricity generation.
v. Mini-grid systems.
vi. PV cells in small portable electronic devices.

In addition, there is a market for intellectual property across the range of sectors.

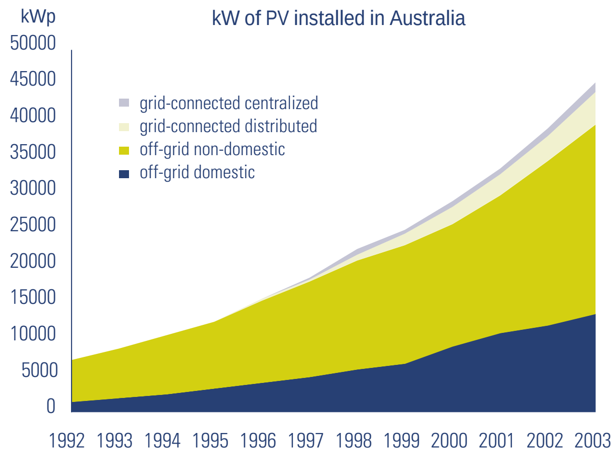


Figure 4.6 Installed capacity 1993 – 2003 in Australia
Source: Watt, Muriel, 2004

Table 4.3 Total installed PV capacity in Australia, December 2003

Market Sector	**Capacity (MW)**
Off-grid domestic applications	13.6
Off-grid non-domestic applications	26.1
Grid-connected distributed applications	4.6
Grid-connected centralised electricity generation	1.4
Total	45.6

Source: Watt, Muriel, 2004

Off-grid systems

Australia has developed world-leading expertise in PV for off-grid power supply. Australia manufactures some of the most robust and reliable components for off-grid applications, particularly inverters and batteries for harsh conditions. These products and services that are highly appropriate to export, particularly to our regional neighbours who have large populations remote from electricity networks.

Off-grid power requirements still represent an essential market for the PV industry in Australia and PV can compete economically with conventional off-grid SPV power supply solutions. However, domestic market volume, which is estimated to be between 15 and 20 MW per annum, is not sufficient to sustain local manufacture of PV components and systems.

Table 4.4 shows an analysis of diesel generation by application. The table quantifies the current potential market for off-grid PV. It is estimated that currently in the order of 600 to 700 million litres of diesel is used for power generation in remote communities (this accounts for an increase from the 1999 figures below).[10]

Table 4.4 Analysis of diesel generation by application

Sector	**Generation capacity (MW)**	**Diesel consumed (ML/a)**
Indigenous	19	13.6
Pastoral	44	20.0
Households	62	12.0
Tourist	15	13.1
Public generation	195	123.4
Mining	330	384.4
Total	665	566.5

Domestic applications

Approximately 13,000 homes throughout Australia have off-grid PV installations. The remaining off-grid domestic market for PV in Australia is small, estimated at between 20,000 and 30,000 homes and other buildings not connected to the main electricity grids. The installed capacity for off-grid domestic applications was about 13.6 MW as at December 2003.

A typical new off-grid PV system has a capacity of 1.5 kWp, compared with systems installed in the 1980s and early 1990s which were typically less than 1 kW. Typical costs for a 1 kWp system are about $20,000, including the cost of battery storage, inverter, back-up generator and other control equipment. The per kW cost of larger systems is lower, but depends on the mix of PV, generator and battery storage chosen. Such hybrid energy systems may also include a kW-sized wind generator.

Prior to the commencement of the Government's Photovoltaic Rebate Program in 2000, the majority of sales were off-grid PV systems installed in regional areas and supported by state-based incentive schemes.

A potentially large market for PV electricity as an alternative or supplement to grid-supplied electricity is for residential dwellings in fringe-of-grid locations. This opportunity is dependent upon electricity industry responses to rising network costs. If the electricity industry accepts PV as a cost-effective solution to network augmentation in fringe-of-grid areas, a market of 5 to 10 MW per annum could exist between 2015 and 2030. Additionally, a stable demand of 1 to 2 MW per annum for repowering or extending existing off-grid domestic properties (mostly isolated farms) is predicted.

Non-domestic applications

Off-grid non-domestic applications include telecommunications, pipeline cathodic protection, water pumping, remote PV power stations (sometimes with local mini-grids), road signage, monitoring systems, electric fences, and navigational aids. About 26 MW of off-grid non-domestic PV applications was installed at December 2003. These applications currently comprise 57 per cent of total installed PV capacity in Australia. The long-term stable demand for off-grid non-domestic applications is estimated to be in the order of 5 to 10 MW per annum for water pumping and 2 to 3 MW per annum for other off-grid non-domestic applications.

The off-grid non-domestic sector has been dominated by telecommunications applications. During the 1980s and early 1990s, Telstra (then Telecom Australia) was the biggest customer for PV modules with massive infrastructure development across Australia using PV. With the introduction of other telecommunication companies in recent years, further infrastructure development has occurred that has required the application of PV modules. In the past Telstra (Telecom) purchased PV equipment on period contract, today the purchase of PV generally is related to particular projects or outsourced as part of maintenance contracts. However, there is still considerable potential for PV-powered mobile phone relay systems in regional areas.

Cathodic protection for pipelines was another major application in the 1980s and 1990s with a number of companies specialising in this market at the time. This market is not as large as it was 10 years ago and is dependent on new pipeline projects (eg in the oil and gas industry). An associated market is PV-powered protection equipment on oil rigs.

PV water pumping is a market which will continue to grow in the coming years. Local companies, Mono Pumps and Solar Energy Systems, specialise in manufacturing PV water pumping systems, and there are a number of other firms specialising in system installation.

Australia also has a considerable history in the deployment of PV systems to power navigational aids. These range from small port lighting systems, to channel lighting and light-houses (e.g. Cape Otway, Victoria). Recreational activities, such as yachting and river craft, use PV to power on-board equipment, such as security and navigation systems.

Under a different policy, the electricity industry might consider that a decentralised approach based on distributed generators with no loss of amenity for customers is more sensible economically than extending or maintaining electricity networks to fringe locations. If 2.5 per cent of customers in the most isolated fringe-of-grid locations were instead powered by PV SPS, this would imply an additional market for PV of 20 to 30 MW per annum[11].

Mini-grid systems

The Renewable Remote Power Generation Program (RRPGP) is stimulating the installation of PV power stations to parallel with diesel generators in remote communities and towns. In 2003, Power and Water Corporation in the Northern Territory installed a 56 kW system at Bulman and a 225 kW system at King's Canyon. Depending on the cost effectiveness of these systems, Power and Water Authority is planning to install many megawatts of additional capacity in the coming five years. A 220 kW concentrator system has been completed for the Pitjantjatjara community in South Australia by Victorian company Solar Systems. The system operates in a mini-grid with a diesel power station to supply six communities, with costs lower than for flat plate PV systems. Between now and mid-2005 a total of thirty 25 kW PV concentrating dishes (manufactured by Solar Systems) will be installed at three sites in the Northern Territory (Hermannsburg, Yuendumu and Lajamanu) to supply 750 kW.

CASE STUDY: **ANANGU PITJANTJATJARA SOLAR STATION**

The Anangu Pitjantjatjara lands cover an area in excess of 100 000 square kilometres in north-west South Australia. They are home to approximately 2,500 people living in communities and outstations.

A PV power station of 10 concentrating dishes was installed for the communities as a cost-saving measure and to reduce diesel consumption by more than 160,000 litres each year. The 'Sun Farm', as it is referred to by the locals, will interconnect the larger Umuwa and Ernabella communities to a mini-grid and complement a 3 MW diesel station. The PV plant is expected to produce approximately 5 MWh of electricity per annum.

Solar Systems' high-concentration solar PV dish technology uses mirrored parabolic collectors to concentrate the sun approximately 500 times onto the highly efficient PV receivers. Each of the 10 dishes tracks on a dual axes and are optimised by dynamic auto-educating software. Built-in telemetry allows remote monitoring and control, guaranteeing maximum power generation during the life of the plant. The 220 kW station cost $2.5 million to build, install and commission.

The Pitjantjatjara Council received a $1 million Renewable Energy Commercialisation Program grant from the Australian Greenhouse Office, complemented by funds for the project from the South Australian Department of Aboriginal Affairs and the Aboriginal and Torres Strait Islander Commission.

Grid-connected systems

Distributed applications

Grid-connected distributed applications comprise PV systems installed on residential dwellings, and community buildings such as schools and kindergartens. About 2,000 homes throughout Australia have grid-connected PV installations. The installed capacity for grid-connected distributed applications was about 4.6 MW as at December 2003.

The projected grid-connected market is relatively large, comprising more than seven million homes and community buildings. Even if only a quarter of this market has a north-facing roof or other building surfaces suitable for PV, this amounts to a potential market of some 2,600 MW at system sizes of 1.5 kW each, 500 times current total annual PV installation rates. It is this market that has the most potential to deliver significant PV industry investment in Australia (as identified in the Sunrise targets in Chapter 5), and provide a sufficiently large domestic base for increasing export growth and reducing greenhouse gas emissions.

In January 2000, apart from the Sydney Olympics Athletes Village, there was little demand for grid-connected PV and virtually no widespread infrastructure to deliver it. By 2001, the Photovoltaic Rebate Program had stimulated rising demand and the development of infrastructure to support grid-connected PV.

In Australia, the market for Building Integrated PV (BIPV) on commercial and public buildings is in its infancy, but the International Energy Agency has calculated[12] that there are about 14,700,000 m^2 of available good solar capture area for BIPV façades on commercial and industrial building in Australia.

Centralised electricity generation

Although the distinction between distributed and centralised PV systems can sometimes be vague, for the purposes of the PV Roadmap we have classified systems which have their own dedicated electrical substation as centralised systems.

The Energy Australia 400 kW PV array, installed at Singleton in 1997/98, is the largest centralised grid-connected plant in Australia. The impetus for this installation was the initiation of the Green Power program in Australia. Under a Green Power program, electricity retailers provide a 'green' tariff option to customers which is at a premium to regular tariffs. The retailer commits to ensuring that an equivalent amount of electricity to the amount of Green Power energy purchased by a customer is produced from renewable energy sources by approved electricity generators.

The Green Power program also led to Country Energy installing SEDA-supported 50 kW PV arrays in Queanbeyan and Dubbo. Though these are 'centralised' plants installed by an electricity distributor and having their own substation, they could also be considered as 'distributed' systems since they are embedded within the electricity distribution network.

It is expected that, in the future, larger PV systems will also be installed in the built environment, either on existing buildings or new buildings. Some of these will require the installation of their own substations and will be connected to medium voltage grids and therefore could be considered as centralised systems. The distinction between centralised systems and large distributed systems will be difficult at times.

Research is being undertaken overseas to investigate the installation of large centralised PV plants in desert and regional locations and transmitting the electricity to urban locations. This work is being led by Japan, and there is activity under Task 8 of the IEA PVPS program. However, commercial installation of very large systems is not anticipated in Australia in the next 10 years unless undertaken via a carbon credit program with foreign companies/governments.

Solar Systems is developing new concentrating systems suitable for centralised electricity generation. Currently they are focusing on applying the technology in small community and village power systems such as mini-grids that currently use diesel generators. It is expected that this technology will be cost competitive with standard fossil fuel generators for centralised grid connected generation in 15 to 20 years. It also has significant export potential, particularly to countries with high radiation levels, large available spaces and a high electricity demand, such as the USA.

Small portable electronic devices

The use of PV in small portable devices is growing. PV cells and small modules are currently used in a variety of applications, such as watches, calculators, torches, garden lights and measuring and recording equipment. It is estimated that approximately 10 MW of PV cells per annum are installed in electronic components used in Australia. These appliances use imported cells, and are not included under the Australian PV power system market described above. The release of the next generation PV modules, which perform better in low light conditions than silicon cells, coincides with the growth in the development of small electronic devices. These include mobile phones, portable radio equipment, miniature transmitters and sensor equipment.

Next generation PV will have features which will very significantly expand the potential for PV in the electronics sector. PV with the ability to deliver good efficiency indoors and in other low light situations can be used for:

- → Emergency power for battery switching.
- → Storage life extension for batteries through trickle charging and smart electronics.
- → Better utilization of batteries through capacitive properties of nano-technology PV.
- → Next generation power enhancement for mobile devices.

The ability to perform in low light conditions can give a new feature to existing products. Applications where the PV module trickle charges a battery can prolong the autonomy of an existing product. Applications where a battery or grid supply is replaced by PV will be possible where the product is always used in a lighted position eg in retail premises and hotel corridors. This will provide a cost savings in battery replacement or wiring installation.

By 2010, the international market for PV components could be 10 per cent of the relative battery market, which is currently over $25 billion, and likely to be double that by 2010.

At present, Australia has virtually none of this market, but if we maintain our position in the development of 3rd generation PV, then it is not unrealistic to say we could capture 5 to 10 per cent of the market, that is around $2.5 billion to $5 billion, although a significant proportion of this could be manufactured by licensees in countries with cheaper manufacturing costs.

PV system pricing

System price data for Australia is difficult to obtain and represent accurately. As Australia currently has a relatively small market, large systems can dominate market price curves. In addition, module prices make up a significant proportion of system prices and these are set by global trends that are affected by foreign exchange rates and economies of scale achieved in other countries.

The current price for a single grid connected 1 kW system installed is approximately $12,200 excluding GST (Origin, 2004). Industry experts put the price for the same system five years ago at approximately $18,000 excluding GST. Note that the price per system can be reduced by up to 15–20 per cent for bulk installations. Figure 4.7 shows the recent downward trend in average off-grid and grid-connected PV systems prices in Australia since 2000.

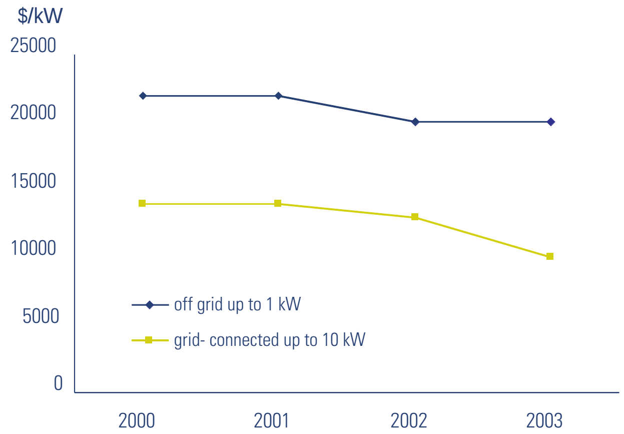


Figure 4.7 Average system prices for PV systems installed in Australia
Source: Watt, Muriel, 2004

A similar downward trend for BP Solar's wholesale selling prices per Watt in Australia since 1995 is shown in Figure 4.8. BP Solar currently has a 65 to 70 per cent market share module sales in Australia.

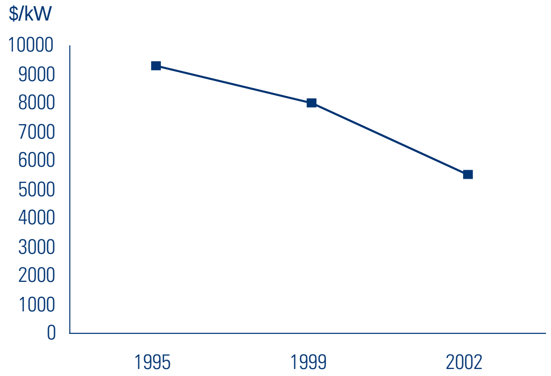


Figure 4.8 Trend in wholesale selling price of PV modules
Source: BP Solar, 2003

Figure 4.9 shows the breakdown of current upfront grid-connected installed systems cost. Modules make up the majority of system cost (52 per cent), followed by inverter (25 per cent) and installation/other (23 per cent).

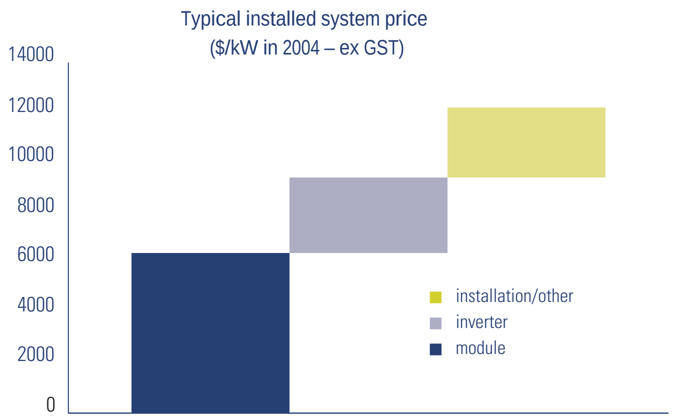


Figure 4.9 Grid-connected installed systems price

Unpriced benefits of PV

Pricing structures in Australia's energy markets do not currently capture the economic and environmental benefits that PV systems provide, thus disadvantaging PV in market decisions made by energy customers.

Current coal-based grid electricity prices do not reflect a range of environmental, technical and social externalities which are borne by the community and which would be reduced for each kWh substituted by PV generation. This is relevant to the case of grid-connected PV, whereby the value of systems is currently based only on the value of the total kWh generated over each operational year at retail electricity prices. Typically, any net export from the PV system to the grid is credited to the electricity customer's retail bill.

Offsetting the escalating peak power problem

The increasing demand for electricity at peak times during summer is well recognised. According to the National Electricity Market Management Company, all states participating in the national electricity market require additional generation by 2005/06 to meet growing summer power demands.[13]

Electricity demand patterns are becoming increasingly more 'peaky' – the ratio of average load to peak load is decreasing. In some new residential subdivisions in Adelaide, for example, 50 per cent of local network capacity is now used for only five per cent of the time.[14]

NEMMCO has projected that peak summer demands will increase significantly; in NSW summer demand will increase by 1500 MW in 2007/08. This growth is driving significant expenditure on infrastructure. In NSW alone, distribution and transmission companies are to spend $5 billio on network upgrades in the next five years. Some two thirds of this network expenditure is attributed to peak demand.[15] The $5 billion in new investment equates to a staggering $3,300 per kW of peak power incurred. The requirement for further investment in peak generation (for example, gas turbines) to meet this demand, equates to as much as an additional $1 billion in investment.

The daily maximum generation output of PV systems is closely correlated with peak demand times. PV generation has around 80–90 per cent availability during peak times. PV output offsets importing electricity from the grid at peak times and therefore provides a network benefit.

Some two thirds of the additional network investment could be avoided by offsetting growth in peak demand – such as by investing in a grid connected PV system. This investment equates to an avoided $2,200 per kW. This benefit of installing a PV system is not currently rewarded.

Figure 4.10 shows a NSW-specific example of the value of a 1 kW grid-connected PV system in relation to retail electricity prices. This value includes the wholesale NEM spot price equivalent for typical hours of PV operation; retail margin on the wholesale price including network losses, ancillary services and pool fees and charges; and the annual value of offsetting peak demand in network investment assuming 10 years of operation. The PV system provides a value to the electricity system of $240/MWh.

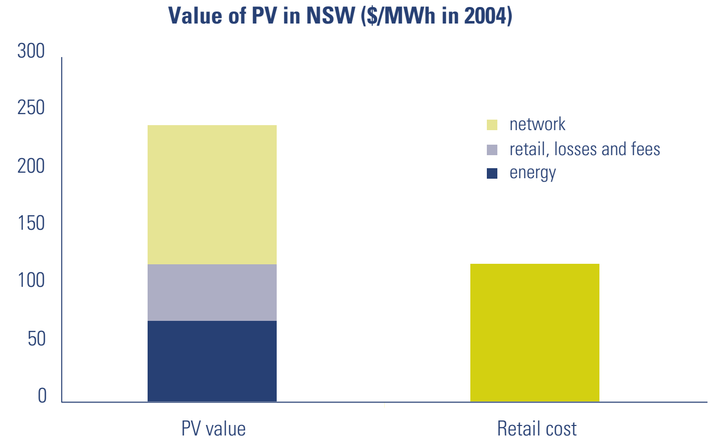


Figure 4.10 PV Value to the electricity system in relation to retail cost

Low environmental impact

The value of electricity generated by PV systems currently competes with fossil fuel retail energy prices that do not yet internalise all environmental impacts. Environmental externalities include local impacts such as air pollution, land use and water use. When PV displaces coal fired generation, NOx emissions are typically reduced by 50 per cent per MWh and SOx emissions by 90 per cent, making PV photovoltaic electricity a valuable addition to clean air policies.

The major global environmental impact of fossil fuel energy generation is greenhouse gas emissions. PV systems generate electricity with zero emissions. Lifetime CO_2 equivalent emissions (including the impact of PV production) with current PV power system technologies are 85 to 94 per cent less than those from coal fired power stations and will be 95 to 97 per cent less with the new PV technologies now being introduced into the market.[16] Increasingly the cost of carbon is being internalised into international economies (Europe in particular), which results in PV systems becoming more economically viable. The European emissions trading scheme will be introduced in 2005 and carbon permits are currently trading at an equivalent of $17 per MWh.

Use as a building integrated material

PV integrated into the surfaces of buildings (such as façades, atria and roofs), allow the possibilities of combining energy production with other functions of the building envelope, such as appearance, weatherproofing, shading and/or solar thermal collection. Cost savings through these combined functions can be substantial. Additionally, no high-value land is required and electricity is generated at the point of use, generally matching peak generation with peak demand, such as summer electricity loads. The electricity generated contributes directly to the building occupant's electricity requirements, whilst also avoiding transmission and distribution losses, and reducing capital and maintenance costs for utilities.

The integration of the PV power system into the architectural design offers more than cost benefits. It allows the designer to create environmentally benign and energy efficient buildings, without sacrificing comfort, aesthetics or economy, and offers a new and versatile building material.[17] Commercial buildings often use expensive external façade material that may be comparable in cost to PV modules. However, no price signal currently exists to building developers or architects that reflect the benefit of energy production to future building owners and tenants once the building is operational.

Security of supply

PV systems are a distributed form of generation. This modularity provides benefits to electricity utilities by allowing for generation to be expanded, or reduced (by relocation), to match demand more easily than with large central generation plant. Lead-times are also shorter, exposure to fuel price volatility is reduced and grid augmentation can be avoided.[18] Hence financial costs and risks are reduced. The use of PV systems adds to electricity network integrity by reducing stress on networks (particularly during times of high demand). In additional PV systems are smaller targets and therefore reduce the risk of terrorist attack.

PV can be used in conjunction with a small battery supply to provide an UPS capability at the domestic level greatly improving the availability of supply to essential appliances eg lighting, refrigeration, communications et. It can also can be used by emergency services to provide backup energy independent of fossil fuels or distributed electricity.

Government support programs

The development of the Australian PV market has been underpinned by a number of Australian and State Government support programs that are described below. See Appendix 3 for further details on these programs.

National programs

Photovoltaic Rebate Program (PVRP)

PVRP commenced in 2000 to support market development of PV. The program is funded by the Australian Government and administered by the states and are available to householders and owners of community-use buildings. The initial funding was $31 million over 4 years and due to finish at the end of 2003. In February 2003, the program had been oversubscribed for the 2002/2003 financial year and was capped to $100,000 per month. In the 2003/04 Budget, announced in May 2003, PVRP received an additional $3.6 million for 2003/04 (total funding $5.8 million for the year) and $5.8 million for the 2004/05 financial year. The program is now due for completion in June 2005. Of the funding for 2004/05, $1 million has been assigned PV projects by property developers, which are to be selected via a competitive bidding process.

Grants of $5.50 per Watt (up to 1.5 kW) were initially available. Since there was a rapid uptake of the grants in the first 6 months the rules were changed to $4 per Watt for new systems and $2.50 per Watt for system upgrades. Some states have developed programs for 'solar schools' under PVRP. Since the start of the program, over 5000 PV systems have been installed, representing over 5.7 MW of PV installed (see Figure 4.11).

Renewable Remote Power Generation Program (RRPGP)

The objectives of RRPGP are to increase the use of renewable energy for power generation in off-grid areas, reduce diesel use, support market development of PV, assist in meeting the infrastructure needs of indigenous communities and to reduce greenhouse gas emissions. RRRPGP funding is available for industry support programs that relate directly to the use of renewable energy generation in off-grid areas, including training, information provision, equipment testing and development of standards, renewable resource and system applicability studies and demonstration projects.

Funding for RRPGP is provided to the States by the Australian government, collected from diesel fuel excise from 2001/02 to 2003/04 for diesel fuel used by public generators not connected to main electricity grids. Grants of up to 50 per cent of the capital cost of renewable energy systems are available for diesel replacement. Up to $200 million is expected to be available over the life of the program up to 2010. As at the end of April 2004, $130m of RRPGP funds has been committed.

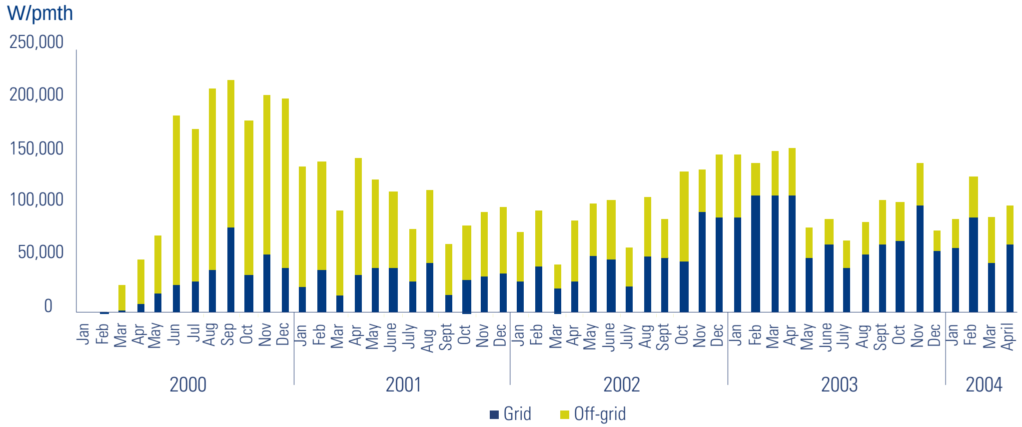


Figure 4.11 Watts installed per month under PVRP
Source: Australian Greenhouse Office, 2004

The States have developed different approaches for targeting the funding. A specific allocation of $8 million has been made to the Aboriginal and Torres Strait Islander Commission (ATSIC) to assist with the development of industry capability and local understanding of renewable energy systems in indigenous communities. This program is entitled 'Bushlight'.

Mandatory Renewable Energy Target

The Mandatory Renewable Energy Target (MRET) was introduced by the Australian Government in 2001. MRET requires electricity retailers to meet annually renewable energy targets that increase 9500 GWh of additional renewable energy by 2010 and continue at this level to 2020. Renewable Energy Certificates (RECs; 1 REC = 1 MWh) are created from eligible generation to meet the targets. For PV systems up to 10 kW, five years of RECs can be created upfront, or deemed, on installation. For PV systems greater than 10 kW RECs are only eligible to be created from the actual generation.

Renewable Energy Equity Fund (REEF)

The Renewable Energy Equity Fund is a $26.5 million venture capital fund established to increase investment in renewable energy technologies through the provision of equity finance. It is funded to $18 million under the Australian Government's REEF program and $8.5 million (approx) from private sources.

State government programs

States are involved in administering the PVRP, and RRPGP (all states except Victoria), and some states have additional programs and/or contribute funds to existing Australian programs. State Government programs that apply to PV and are additional to the Australian Government schemes include the following.

Victoria

The Renewable Energy Support Fund (RESF) is designed to support innovative applications of medium-scale, renewable energy technologies – such as energy generated from PV or mini-hydro projects. RESF is a key initiative of the Victorian Greenhouse Strategy.

New South Wales

The Renewables Investment Program (RIP) provides funding assistance for renewable energy projects in NSW through regular six monthly funding rounds. Appropriate projects are funded on a competitive basis based on greenhouse gas savings, the level of innovation displayed, the degree of market transformation and commercial returns. NSW provides a top-up to PVRP funding available to support applications not eligible for PVRP support. The Department of Utilities Energy and Sustainability (DEUS) also supports broad PV industry development through activities such as 'Who Buys Solar Power' market surveys and facilitating cooperation between the PV and the Electricity Supply industries in NSW.

Queensland

The Working Property Rebate Program (WPRS) is a joint Queensland Government and Australian Government initiative, this scheme applies to family owned working properties located in selected remote shires in Western and Northern Queensland not connected to the main or Mount Isa electricity grids. The WPRS is designed to encourage the use of renewable energy, reduce the use of diesel, and service the power needs of working properties in remote Queensland. The scheme is funded under RRPGP ($8 million) and by the Queensland Government ($4 million). The scheme is currently expected to continue until the earliest of mid 2006.

Western Australia

The Remote Area Power Supply Program provides rebates for renewable energy power systems used instead of diesel generation in off-grid areas of WA. Rebates are available for systems serving Aboriginal communities, businesses and households. The Program is jointly funded by the Australian and WA Governments. The Renewable Energy Water Pumping Program provides rebates for medium and large sized renewable energy based pumps, such as PV pumps and windmills, used instead of diesel based pumps in off-grid areas of WA. Total funding of up to $4.8 million is expected to be available under the Renewable Energy Water Pumping Program from February 2002 to June 2006. The program provides rebates on the capital cost of the renewable energy component of eligible pumping systems.

Energy statement – 'Securing Australia's energy future'

Australia's Prime Minister delivered the Energy Statement for Australia in June 2004.[19] This Statement has delivered the Australian Government's visions for the future direction of the energy sector and therefore has implications for the role of the PV industry.

The key features of the statement that impact on the PV industry are as follows:

i. *Establishment of a Research and Development fund* with a total of $500 million which will be available to projects that result in a reduction in greenhouse gas emissions. Funds will be available for qualifying projects and will receive $1 for every $2 contributed by the project proponents. Eligible projects will include geosequestration, efficient coal-fired technology, energy efficiency, renewable energy, gas-fired generation and cogeneration as well as transport and agricultural emission reductions.

ii. *$200 million* specifically available for renewable energy and energy efficiency, which includes the following:

    a. $20 million to improve energy storage for intermittent generation.

    b. $75 million for Solar Cities trials to demonstrate solar energy and energy efficiency. This funding is to develop an operational model of solar energy, energy efficiency and energy market to assist in providing appropriate pricing signals. The program funding is to be committed over a 5 year period to fund trials. Trials will include time of day pricing, interval metering, cost reflective buy back arrangements.

    c. $100 million for commercialisation of renewable energy technologies with commercial potential.

iii. *MRET* – the Australian Government has committed to continue the scheme but not to increase the current target. A scheduled review of the scheme prior to the Energy Statement by an independent panel recommended an extension of the scheme and an increasing target following 2010. While the Government has not adopted this recommendation, it has committed to a number of other recommendations, including:

    a. Establish time limits for the creation of RECs.

    b. Publish additional data on baselines of generators commissioned prior to 1997 and additional data on generation.

c. Extending deeming provisions for PV and increase threshold to 100 kW – this would become an important driver for PV as it would allow a customer access to upfront funding more in line with module guarantee periods.

d. Provisional accreditation for renewable energy generators.

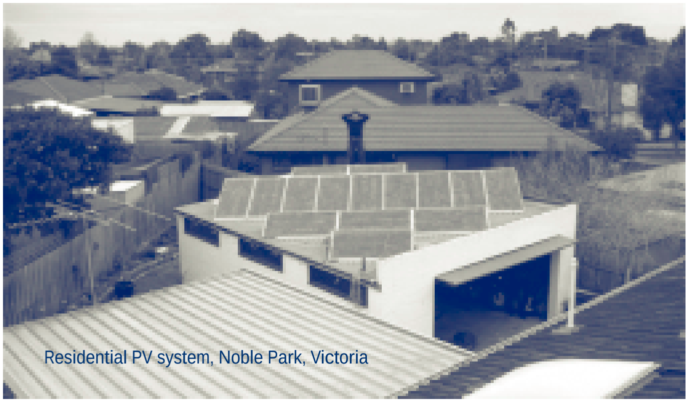
iv. *Energy efficiency* –The key measures announced are:

a. Providing information to consumers and business on the energy performance of buildings, requiring landlords and building owners to disclose energy performance information to prospective tenants and purchasers.

b. Large energy users (using more than 0.5 PJ/a, about 250 companies) will be required to undertake energy audits and report on their emissions and mitigation plans.

c. Continue with existing programs to further develop minimum performance standards for appliances and buildings (nothing new in this initiative).

v. *Changes to diesel excise* – Excise is currently levied on the use of fuels in Australia including the use of petrol and diesel. The level of excise on diesel currently amounts to around 40 per cent of the total fuel cost (excluding transport). Excise relief is currently available for a number of users in remote and regional Australia. The fuel excise changes substantially expand the availability of excise relief effectively making excise free the use of fuels used for stationary energy applications such as power generation, heating and industrial applications. This will have a significant adverse impact on the competitiveness of off-grid renewable power generation projects. The changes are expected to be effective from 1 July 2006. The biggest impact will be felt by the PV distributor, designer/installer component of the market and system integrators



Residential PV system, Noble Park, Victoria

Impediments to further uptake of PV

During the consultation undertaken for the PV Roadmap, a number of barriers were identified by the various stakeholders. These were then identified by cause and effect, the urgency to resolve the barrier and what possible solutions could be, and who would be involved in assisting with their dissolution. Appendix 7 contains full details on the barriers and their possible solutions. Table 4.5 summarises the key barriers identified by industry.

CASE STUDY: **CONNECTION PROCESS**

Complications with system connection and metering led to a Melbourne resident being unable to generate electricity from her installed 2.1 kW PV system for four months. The system owner's distribution network service provider (DNSP) required the existing net meter at the domestic residence be replaced with an interval meter (at a cost of $81 plus $70 annual rental) as well as a separate cable to be taken from the switchboard to the meter in order to separately measure the solar system output. The contract sent by the retailer for this work had a clause requiring the resident to sign over RECs worth more than $2000 (over the life of the system) to the retailer.

The resident then decided to switch to another retailer not requiring her to sign over her RECs and with a better buy-back fee. Unfortunately the new retailer is yet to provide a contract, so the DNSP has refused to install the meter and the PV system remains unconnected. Owners of systems are also not eligible for PVRP rebate funds until the system is connected. The connection process for systems is commonly protracted and complex such as in this case.

Table 4.5 Summary of key barriers to the large-scale deployment of PV in Australia

Barrier	Causes	Effects
Barriers from PV Industry Perspective		
Instability of the market for PV in Australia	Immature market compounded by short-term, start-stop support policies	Consumer uncertainty; difficulty planning and building viable businesses
Small PV market volume in Australia	High up-front costs for PV systems, long 'payback' period, low awareness, low recognition of added-values of PV, disjointed support measures	Falling share of global PV market; critical pressures to relocate PV cell and PV manufacturing out of Australia
Business development finance hard to access for the PV industry	Finance sector unfamiliar with PV/over-cautious	PV industry businesses cannot easily grow
Weak export orientation by the PV industry	Low awareness among aid and trade sectors	Failure to capture viable export opportunities; danger of crowding-out by overseas competitors
Ambivalence among consumers towards non-conventional energy sources	Very low electricity prices and inadequate price signals; consumers unaware of the costs they impose on the electricity industry; low awareness of personal impact on greenhouse gas emissions; limited PV awareness by consumers	PV viewed as uneconomic, impractical or only of distant future benefit
Barriers from Other Stakeholders Perspectives		
High up-front cost/long payback period for PV systems	Small market volumes (little mass-production effect); limited (service) industry experience; technologies still being optimised (especially grid-connect)	Demand and experience remain low; competitors with large subsidised markets pull ahead;
Complex 'purchase' procedures (subsidies, RECs interconnection, buy-back)	Subsidy and RECs programs are new and unfamiliar to the consumer; electricity industry is unfamiliar with PV and applies inappropriate procedures for interconnection and buyback	Reluctance by consumers to deal with the complexities involved in purchasing PV systems
Apprehension about PV amongst the electricity industry	Risk-averse electricity industry with little experience of PV, uncertainty about added value claims because little quantification of unpriced benefits has been carried out	PV overlooked or discounted as a viable demand management or distributed generation option (only for distant future)
Building developers are largely unfamiliar with PV and unaware of its potential value to them	Little PV exposure and experience in the building industry; little awareness of their ability to influence the energy sources used in buildings and therefore reduce operating costs	Very few BIPV buildings in Australia The main opportunity for PV is inaccessible
Lack of strategic R&D support	Closure of government funding programs	Collapse of research groups. Reduction in educational opportunities

5// WHAT IS THE POTENTIAL OF THE AUSTRALIAN PV INDUSTRY?

For Australia to build a strong PV industry, two critical components are required:

- Belief from industry and the financing sector that a significant opportunity exists in Australia that is worth investing considerable financial and infrastructure resources in to build a strong, sustainable industry sector. This investment includes additional private investment in capability and capacity as well as corporate investment in streamlining industry representation, accreditation and standards; and
- Recognition by the government that PV has a place in the Australian energy fuel mix, through the implementation of a sustainable industry development that will assist in bridging the gap for consumers between now and commercial viability.

In order to make a clear case for industry and government, this Roadmap presents a vision for the PV industry called 'Sunrise' with target installed capacity to 2030.

This Chapter considers two principal scenarios for the purpose of establishing the 'Sunrise vision'. The two scenarios are 'Business as Usual' (BAU), and an alternative enhanced scenario 'Sunrise 350'. The BAU scenario is representative of a 'sit and wait' approach, with no further additional government support, while Sunrise 350 presents an ambitious vision for the Australian PV sector, but one that is achievable through the industry development programs presented in Chapter 7. Both scenarios have been informed through the industry and stakeholder consultations undertaken during the development of the PV Roadmap, and has been influenced by broader international perspectives and developments.

Figures 5.1 and 5.2 show these two very different outcomes for the PV industry in Australia. The BAU case shows an industry fragmented by stop/start government support policies that manages to sustain itself until commerciality. In this case, the industry will ultimately build itself around imported modules but will not support a solid manufacturing base.

In contrast, the Sunrise 350 scenario shows an industry with considerable depth in module and balance of system manufacturing, distribution and installation. Not only does government support bridge the gap for consumers, but the certainty allows industry to invest in its capability and build capacity. Sunrise 350 shows an industry contributing significantly to the Australian economy in terms of jobs, revenue (national and exports), electricity supply and carbon abatement.

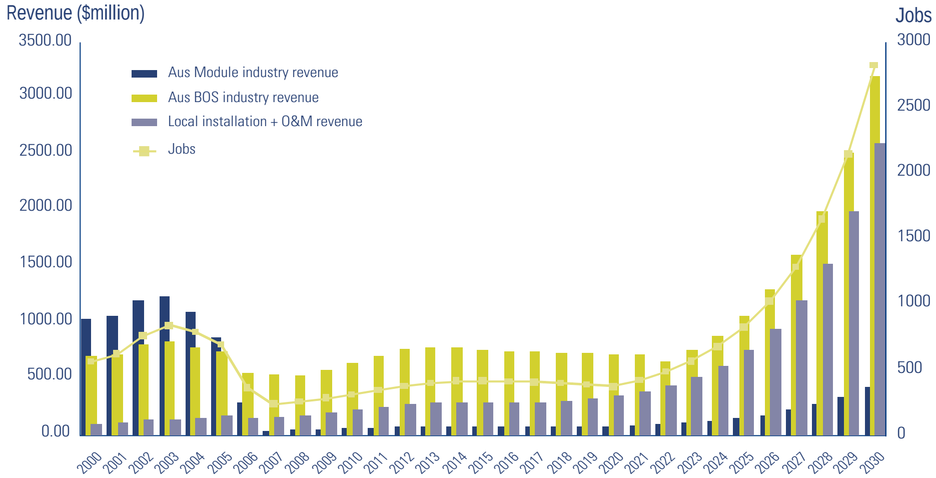


Figure 5.1 BAU scenario of revenue and jobs projections to 2030

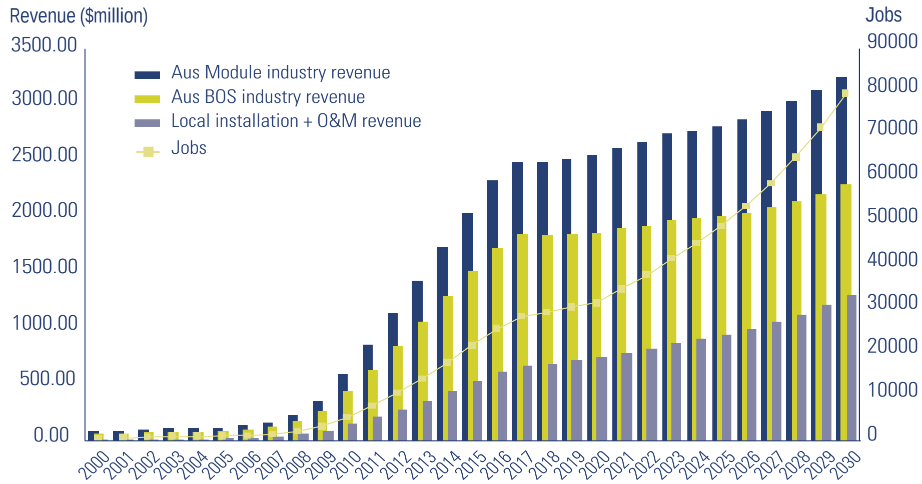


Figure 5.2 'Sunrise 350' revenue and jobs projections to 2030

The results shown in Figures 5.1 and 5.2 are summarised in the following table. As previously stated, the scenarios were built in consultation with industry and use a range of assumptions taken from global market growth scenarios. The comprehensive detail sitting behind the modelling is available at Appendix 4. The scenarios themselves are summarised in Table 5.1.

Table 5.1 Results of the PV Roadmap Scenario Modelling

	2010		2020		2030	
	BAU	**Sunrise 350**	**BAU**	**Sunrise 350**	**BAU**	**Sunrise 350**
Total PV Installed (cumulative MW)	120	350	420	6,740	2,090	23,910
PV Sector Jobs	310	5,290	370	31,600	2,820	79,570
PV Sector Revenue (annual $ million)	80	1,180	100	5,160	530	6,830
Electricity Generated (annual MWh)	160	490	580	9,320	2,890	33,050
CO_2e abated in year ('000 tonnes)	160	490	580	9,320	2,890	33,050
Exports ($m)	19	445	22	1916	93	2438

Key common assumptions

Both scenarios share some common assumptions, notably:

- → Global market growth rate for the foreseeable future is 25 per cent per annum.
- → Price versus production has a Progress Ratio of 82 per cent for modules, BOS and installation. This is equivalent to an 18 per cent reduction with every doubling of installed capacity.
- → Cost (and price) reductions of internationally-traded components such as modules and BOS are based on global market volumes, while installation cost (price) reductions are based on local market volumes.
- → Starting electricity prices used are Australian averages as determined by the Energy Supply Association of Australia. Electricity prices in states such as SA and WA in particular are likely to be higher than the national average, while NSW and Victoria may be lower than the average.
- → Average yield figures (typical output of a 1 kW unit of PV, which is mainly a measure of the average annual solar resource at the installed location) are based on MRET Zone 3 deeming values for (small) PV generators and is equivalent to 1.4 MWh per annum for a 1 kW system. Zone 3 covers most major Australian centres. Notable exceptions which will experience higher yields are Darwin, Alice Springs and Moree. Melbourne and all of Tasmania will have lower yields.
- → RRPGP continues to 2010 with gradual phase-out (i.e. no 'step' withdrawal at the end of program term).

What is 'Business as Usual'?

An analysis of the historical development of Australia's PV market over the last decade for the four main PV application sectors is summarised as follows:

1. Demand in the off-grid, non-domestic sector was declining until the introduction of the RRPGP in 2000. This is believed to indicate that the traditional market for telecoms and other industrial applications was approaching saturation. RRPGP has stimulated new demand for PV SPS for diesel replacement and water pumping, and for new industrial and semi-commercial applications. The two-year average growth rate (16 per cent) is therefore believed to be appropriate for market projections in the Business as Usual scenario, at least while RRPGP remains in operation, that is, until around 2010.
2. Grid-connected centralised power is dominated by a small, infrequent number of very large projects which tend to distort the growth rate. Nevertheless, the three year average growth rate (10 per cent) is seen to be generally indicative of BAU demand trends in this sector.
3. The grid-connected distributed power market in 1998 and 1999 was similarly influenced by large 'atypical' demand for modules for the Newington Olympic Village and other applications for the 2000 Olympics in Sydney.
4. The introduction of GST in 2000 stimulated a further spike in demand, notably for both grid-connected and off-grid domestic systems. The years 2001 and 2002 are felt to demonstrate a more typical demand pattern, and the two-year average growth rates (19 per cent and 16 per cent respectively) are believed to be more appropriate for BAU market projections for the off-grid domestic and grid-connected distributed sectors whilst PVRP remains in place.

Table 5.2 'Business as Usual' scenario summary

Scenario overview	Arguably BAU is more reflective of market forces. However, the slow local growth relative to strong overseas industry development has impacts on local industry development; ultimately this leads to a marginalised role for local component manufacturers. Consequentially, there is weak export potential.
Key assumptions	PVRP concludes mid-2005 with no successor. RRPGP continues to 2010 with gradual phase-out (i.e. no 'step' withdrawal at the end of program term). MRET deeming period remains as per current regulations (maximum 5 year blocks). No new incentives or other industry development measures. Continuing cross-subsidy to fringe-of-grid customers.
Market shape	*Near-term* PVRP conclusion leads to immediate 50 per cent drop in residential PV sectors (both on and off-grid). Demand subsequently begins to rebuild in line with BAU growth rate, but from this lower level, such that 2010 market volume is no larger than volume at the end of PVRP. Commercial off-grid exhibits 'traditional' growth rate. Water pumping and 'community power' (isolated rural mini-grids) continue to be driven by RRPGP to 2010. *Mid-term* Off-grid markets reach sustainable demand levels between 2012 and 2015. Revived interest from DNSPs. Trials for weak-grid support and as network capacity management tool. Distributed residential demand re-emerges towards the end of this term as PV electricity approaches competitiveness with grid-tariffs. SA and WA will see this before QLD, VIC, NSW/ACT and TAS due to higher electricity prices. *Long-term* Increasing residential and remote community uptake. Emerging opportunities including PV for Hydrogen production and possibly Multi-MW Desert PV (Centralised generation) systems.
Industry profile	*Near-term* Existing cell/module manufacturers dramatically scale-down production. Consequent job losses. This has some knock-on impact on BOS manufacturers and R&D centres (much reduced grid-connect R&D focus) as well as installers, with a contraction of the installer pool. Potentially this could result in a reduced maintenance focus with consequential implications for broad industry reputation. Possible impact on economic growth in regional areas due to job losses. *Medium-term* Modules largely imported. No module export. Influx of overseas BOS (notably inverters) towards end of term as grid-connect re-emerges. *Long-term* Possible module manufacture re-entry (Overseas IP). Strong overseas module dominance. BOS retained, but significant imports from more developed competitors.

Table 5.3 Sunrise 350 Scenario Summary

Scenario overview	Strong market intervention and support for local industry development. Requires continuing intervention coupled to industry development, building for the next 5–6 years, and then gradually diminishing over a period of a further 6–7 years. Focused on strong local industry, with local manufacturing meeting 75 per cent of local demand into the long-term future. This provides a strong base for product R&D. Consequentially Australian PV industry is more visible internationally with robust, innovative products and a stronger export focus.
Key assumptions	PVRP concludes mid-2005, superseded by an alternative incentive scheme for residential customers, particularly focused at stimulating demand for grid-connect systems. Similar focus on commercial building sector (incentives or mandatory targets). Network strategy refocused towards distributed generation as a capacity and demand management tool. RRPGP continues to 2010 with gradual phase-out (i.e. no 'step' withdrawal at the end of program term). Gradual adoption of PV as a viable supply for fringe-of-grid customers
Market shape	*Near-term* Intervention program to succeed PVRP, stimulating high levels of demand for residential grid-connect. Likewise new initiatives to stimulate demand for commercial building sector. Annual growth rates for distributed grid-connect of 100 per cent from 2005 to 2010 for an (annual) market of approximately 80 MW in 2010. Similarly intervention to stimulate utility sector demand for centralised grid-connect PV under DSM/Capacity Management Strategies. Also doubling sector market volume year on year from 2006 to achieve 20 MW per annum in 2010. Commercial off-grid exhibits 'traditional' growth rate. Water pumping and 'community power' (isolated rural mini-grids) continue to be driven by RRPGP to 2010, but with stronger marketing e.g. for water pumping to address inland salinity issues and additional inclusion of fringe-of-grid applications. Export drive focused on delivering 50 per cent of production (modules and BOS) overseas, particularly to regional neighbours. *Medium-term* Gradual phase-out of intervention as PV electricity price approaches retail electricity prices. Residential/commercial grid-connect demand growth rates gradually slow. Distributed grid-connect sector approaches long-term sustainable annual demand (600 MW pa) by the end of the term. Off-grid non-domestic (including mini-grids) achieves sustainable annual limits early in the term, with demand remaining stable thereafter. Off-grid residential developing more of the fringe-of-grid opportunity continues to expand, though slowing towards the mid-term and achieving the sustainable limit by the end of this term. *Long-term* All major markets with the exception of grid-connect centralised are stabilised, commencing 'replacement' cycle towards the end of the term. Centralised continues to grow, responding to emerging opportunities including PV for hydrogen production and possibly Multi-MW Desert PV (Centralised generation).
Industry profile	*Near-term* Module manufacturing is retained, including some cell manufacture. Revitalised R&D focus both fundamental and applied, particularly with industry focus on developing/expanding appropriate building integrated (BIPV) solutions. Beginnings of regional export expansion. Deep and broad installer service pool with strong technical and customer-service focus. *Medium to long-term* Seventy-five per cent of all locally-used components manufactured in Australia. 50 per cent of Australian product exported. Continuing investment and innovation to develop both third generation cell technology and solutions for emerging opportunities such as large-scale desalination (potable water production) and sustainable, particularly distributed, hydrogen production.

Further assumptions pertinent to the modelling include those already made in the previous chapters about the projections of future PV sales in each market sector.

Projections of future PV sales

Market growth projections of future PV sales are clearly open to some speculation, particularly as there is very little 'real' market experience on which to base growth expectations. Even internationally, in industrialised countries there is no market performance history of PV as a fully economic alternative to traditional electricity sources, other than in specific remote industrial applications. Furthermore, it has not been possible so far to assess customer uptake where marketing and appropriate financial devices are fully functional.

The model in some way attempts to reconcile PV market growth expectations with the 'S-shaped' product demand profile common to other consumer products: relatively slow demand (early adopters) governs the early stages of a product's life-cycle; subsequently growth rates accelerate as the product gains mainstream interest, before eventually slowing as the market becomes saturated and demand is driven by replacement and upgrades.

A critical consideration therefore is the saturation limit (for each application sector). The scenario modelling is therefore also informed by assumptions about the likely maximum sustainable annual sales for each individual PV application. Table 5.4 shows the 'limits to growth' for each sector. These are presented in more detail below.

Finally, particularly under Business as Usual, a measure of price elasticity is introduced, such that annual sales growth is linked to the difference between the PV electricity price[1] and that of grid-supply. Thus as the price differentials decrease, the annual PV sales growth rates increase. This presupposes that the customer is able to finance the upfront capital cost of purchasing the PV system – a very important assumption.

Table 5.4 Estimates of maximum sustainable annual sales for PV applications

Application sector	Maximum sustainable annual sales estimate
Off-grid domestic	
Remote households, holiday homes, pastoral stations, isolated communities (Indigenous)	3.0 MW pa
Fringe-grid (potential market – needs different electrification approach)	20–30 MW pa
Off-grid non-domestic	
Telecoms, water pumping, signalling, cathodic protection, electric fences, street lights, tourist facilities	14–16 MW pa
Mini-grids	
Isolated communities (mines), public generation	7 MW pa
Grid-connected distributed	
Residential rooftops, commercial BIPV	600 MW pa
Grid-connected centralised	
Network strengthening, bulk power	200–2000 MW pa
Consumer devices	
Small portable electronic devices	10 MW pa

Following are the assumptions made in the scenario modelling regarding the limiting factors to growth in the use of PV in each of the application sectors.

For the off-grid sectors in general, sustainable annual sales are based on 25 year (replacement) cycles and 50 per cent penetration of the identified potential market, the remainder being accounted for by competing technologies. Where PV is directly replacing diesel, it is further assumed that PV offsets two-thirds of the diesel capacity, the remainder being retained as backup generation plant.

Off-grid domestic

The total potential market, based on saturating existing off-grid residences, is estimated at 150 MW.[2] However, competing technologies, and existing penetration in this sector support the view that the accessible market in the short to medium term based on current system trends is perhaps only 25 per cent to 50 per cent of this capacity. A 1999 assessment of diesel SPS market indicated a short to medium-term annual market of 1000 to 2000 systems (or 1–4 MW per annum)[3].

However, as costs decrease and experience grows, off-grid PV is expected to gain wider acceptance by the electricity industry as a viable alternative to grid-supplied electricity in fringe-grid locations. The theoretical long-term potential for fringe-grid replacement or augmentation is estimated to be in the order of 1000–1750 MW.[4] Nevertheless, this may be a difficult market to penetrate given that it involves either installing individual PV systems for each customer on a thin rural electricity line or disconnecting customers from the existing electricity network and providing them with individual PV RAPS systems. Additionally, unless the electricity industry introduces differential price tariffs for rural customers, the economic incentive for these customers to invest in PV is far less persuasive than for existing off-grid users who may be paying three times more per kilowatt-hour for diesel-generated electricity compared to the average domestic tariff. Hence, the PV investment may need to be made by the electricity network supplier rather than the customer.

In the long-term (beyond 2030), the sustainable annual market for off-grid domestic PV is tentatively estimated at 25–45 MW, however under current utility policies to continue extending the main electricity grid, this market sector is not expected to greatly exceed 10 MW per annum.

For modelling purposes, the Sunrise 350 scenario assumes that, with successful demonstrations of the benefits of PV for electricity networks, inroads are made into fringe grid applications building towards and sustaining a market of around 30 MW per annum from 2017. This application is assumed not to be accessible under the BAU scenario.

Off-grid non-domestic

The economic industrial applications that have driven demand for PV RAPS system in the past will continue to present demand for PV, though this market sector is believed to be largely saturated with growth dependent on major new infrastructure projects, such as gas pipelines. The size of this sector is estimated at 2–4 MW per annum into the future, irrespective of PV industry development actions.

Estimates for the PV water pumping sub-sector are based on rebuilding demand for decentralised pumping solutions (which traditionally used mechanical windpumps) to the level experienced in 1960s and 1970s. At that time the total market was estimated to consist of 500,000 units with annual sales in the order of 10,000 units. This implies a potential sustainable PV water pumping market of 10 MW per annum. This is seen as an alternative to piped water supply and also to address the growing salinity problems associated with rising water tables.

The long-term sustainable annual market for off-grid non-domestic PV is therefore estimated to be in the order of 20 MW per annum. It is further assumed that, as per the off-grid domestic sector, industry development initiatives under Sunrise 350 assist earlier penetration into emerging sectors, such as the mining regions.

Mini-grid systems

In the longer term, penetration into the mining sector (where diesel-based generation costs are much lower than other off-grid sectors due to the lower excise payable on the diesel fuel) is expected to increase, such that the ultimate potential market across this sub-sector is estimated to be at least 300 to 350 MW, or 10–15 MW per annum.

Grid-connected distributed

The potential market for grid-connected PV on residential and commercial buildings and other applications in the built-environment is extremely large. Incorporating 1.5kW of PV for every existing residence in Australia implies a total market in the order of 10,500 MW[5], or in the long-term a sustainable market of at least 350 MW per annum. New-build residential sector construction rates also support a theoretical annual market in excess of 600 MW, based on current progress of 150,000 new residences each year.

A large proportion of this opportunity (building to 50 per cent to 70 per cent) is expected to be captured beyond 2015 as the costs of PV electricity approach residential retail tariffs. In the interim, however, demand is likely to be largely dictated by the availability or not of financial incentives to bridge the gap between the levelised cost of PV electricity and the residential electricity price. Beyond 2005, without interim support to build on PVRP, the grid-connected distributed sector is expected to contract sharply and growth will not revive until the life-cycle economics favour PV over alternative electricity supply options and adequate packages are available for financing purchases of PV systems. This implies a BAU demand to 2010 in the order of only 2 MW per annum in the absence of market stimulation incentives, compared to a dramatic ramping-up of demand to approximately 80 MW per annum in 2010 under the Sunrise 350 scenario.

The opportunity in the commercial sector is slightly harder to assess, given the lack of available data about building stock. On the basis of energy demand comparisons between the commercial and residential sectors, and assuming similar penetration levels and replacement cycles, the sustainable annual sales volume is estimated to be approximately 200 MW. While some demand for PV product is expected to be generated among commercial building owners, a stronger driver initially will be the architectural and building communities. A key factor in engaging these stakeholders will be promotion and education and demonstration via a series of appropriate, accessible exemplar projects.

Grid-connected centralised

In an increasingly carbon-conscious environment, there is clearly an enormous potential for a variety of emerging technologies to contribute to future centralised power applications. For photovoltaics, the near-term opportunities are envisaged to be predominately capacity and demand management related, particularly support for weak grids. The potential sustainable volume of this subsector is extremely difficult to assess. However, there are clear opportunities for PV in areas such as sustainable hydrogen production as well as other vital future services such as large-scale desalination.

Based on the Australian National Hydrogen Study, 35.5 TWh/yr of electricity might be required to achieve the 2030 'medium' scenario[6]. Assuming PV is capable of capturing 20 per cent of this potential, this equates to some 5GW of PV for this application alone by 2030 (assuming approximately 1400 GWh/GWp). Note that by 2025 prices for PV electricity from centralised generation are projected to be less than the prices paid by industrial customers for grid-supplied electricity, so co-location could be entirely feasible and PV's penetration into the hydrogen economy might be greater than 20 per cent. This depends amongst other issues on how the proposed carbon sequestration solution progresses, which might mean more reforming from coal rather than electrolysis from PV.

Conclusions of modelling

As with any forecasting, conclusions from the modelling ought to be handled with some caution; the outputs are strongly dependent upon the validity of the assumptions used and the accuracy of the input parameters. In developing the model, the Roadmap consortium has sought to be robust in assessing the key inputs and cautious where doubt exists. While the 'end of term' indicators cannot be guaranteed, the general implications in terms of the relative scale of jobs and revenue created, and emissions abated under the two alternative scenarios, are unmistakable:

- → The off-grid application sectors are a vital near-term opportunity for PV industry development, including the basis for developing our regional exports. However, these sectors are not of sufficient volume to enable Australia to command anything other than a marginal role on the global industry level in the medium to long-term.
- → Significant off-grid market opportunity – perhaps as much as 50 per cent of the total – will not be available to the PV industry (or other distributed generation sources) while current rural electrification strategies remain.
- → The grid-connected applications sectors present a much greater market opportunity (perhaps 20–75 times greater) than the identified off-grid potential. This has proportionately similar implications for greenhouse gas abatement, jobs and revenue creation.
- → Until PV electricity generation costs approach comparable electricity prices there is unlikely to be significant uptake of PV technology without some additional incentive or mandatory requirement upon would-be users.
- → PVRP will expire in mid-2005. MRET even with the proposed 15 year deeming is currently insufficient to bridge-the-gap between PV electricity cost and electricity prices.
- → PV has considerable potential for a variety of indirect electricity applications: desalination and hydrogen production in particular are key innovation areas to which PV could be appropriately coupled.
- → The commercial building sector represents a considerable, and so far virtually entirely untapped, opportunity both for reducing peak electricity demands and network peak capacity. There is currently no significant Australian focus on this application sector.
- → Commercial building integration products are only slowly emerging on the global market and these may not be appropriate for Australia or other relatively low-latitude countries. There is therefore a window of opportunity for the Australian industry to address this opportunity.
- → When existing incentives are removed, the capital cost of PV systems will remain high in comparison to the alternatives – notably diesel generators or grid-supplied electricity. Appropriate financing mechanisms or energy service approaches, and supportive government policies and programs will therefore remain essential for future PV market development.

The PV industry worldwide is developing rapidly. Unless Australia implements a variety of measures to stimulate and support interim domestic demand for PV our entire industry will become increasingly marginalised on the world scene. A strong, long-term grid-connect focused program would create an 'innovation environment' for local manufacturers and systems integrators, to develop new integration products appropriate for the domestic market and for export.

6// **EXPORT** MARKETS

Export markets provide an important opportunity for Australian renewable energy business to leverage off proven skills and experience gained in Australia's traditional stand-alone power systems (SPS) markets.

Australian PV industry strengths in SPS are particularly relevant to developing country markets. These have growing needs for reliable power generation technology – particularly in mini-grid and remote power applications.

Export markets have been important to date for a number of renewable energy businesses, and have provided an important buffer against the stop-start approach to PV industry support in Australia to date. With uncertainties in the traditional Australian off-grid market created by the removal of excise on petroleum products for off-grid power generation, the development of export markets becomes critical for existing renewable energy businesses.

The Australian Government has developed bilateral agreements with the USA, China, Japan, the European Union, and New Zealand. The Australian Renewable Energy Export Network (AREEN), in consultation with industry, has identified China, Thailand, Malaysia, the Philippines, Vietnam, Laos and the US as priority countries for Australian renewable energy exports. These countries present significant opportunities for Australian PV exports, alongside nations in the Pacific region.

Opportunities to export Australian R&D services and intellectual property

Innovations developed in Australia are already included in many PV products manufactured internationally. However, to date, the returns to Australia have not been optimised, although returns have repaid some government R&D funds. The key is to ensure that our national returns from the development of Intellectual Property are adequate. This can be achieved through appropriate commercial arrangements, in the understanding that manufacture in Australia is sometimes not the best commercial outcome for Australia, or is perhaps not possible due for instance to market barriers in the venture capital sector. Other technology sectors in Australia have been developing these skills in the export of Intellectual Property, and the PV industry needs to access these skills, with government assistance where necessary.


PV pumping system, Solomon Islands

CASE STUDY: **SPECIALISED SERVICE EXPORTING – GLOBAL SUSTAINABLE ENERGY SOLUTIONS (GSES)**

GSES began in 1998 as a consortium of renewable energy system designers and installers. The initial aim was to partner with businesses in developing companies, and to become involved in projects within these countries. A need was quickly identified for technical training in the design, installation and maintenance of systems, and GSES began to export a training course suitable for small Solar Home Systems (SHS).

The first training course was conducted for Shell Solar in Sri Lanka in 1999. The importance of developing local capacity in training was immediately recognised in order that a local trainer could continue to conduct training in their own language.

Over the next few years GSES conducted advanced courses in Sri Lanka, funded by the World Bank in stand-alone power systems, grid-connected systems and PV water pumping for senior technicians, all with the local trainer acting as translator. The local trainer has continued to develop his skills, and since 2001, has trained over 400 technicians who are now installing SHS.

GSES have since expanded, and is now exporting similar training services to West Africa, APEC and ASEAN regions and work with a number of international funding organisations.

Market opportunities in developing countries

It is estimated that 2 billion people in developing countries do not have access to electricity. To supply the minimum off-grid electrification using PV will require at least 19,000 MWp[1]. PV systems can supply power to meet the needs of:

- → Water pumping systems (potable water, irrigation and stock watering).
- → Rural education (e.g. schools).
- → Health care (e.g. health centres, vaccine refrigeration).
- → Telecommunications (mobile phone networks, radiophones, satellite links).
- → Solar Home Systems (SHS – lighting, TV, radio, refrigeration, ventilation).
- → Local enterprise development (power for small factories, shops and light industry).
- → Community Centres (village meeting halls, religious centres, municipal halls, clubs, cinemas).
- → Sports facilities (lighting, audio visual, ventilation).
- → Outdoor lighting & signage.

There are also traditional industrial opportunities for PV, such as large-scale telecommunications, marine-based navigation systems, traffic and other exterior signage, street lighting, monitoring systems, signalling systems, parking meters, cathodic protection, end-of-grid strengthening, and UPS systems.

Australia has developed world-leading expertise in PV products and systems for off-grid power supply, and manufactures some of the world's most robust and reliable components for these applications, which are suitable for all the markets described above. Indeed, there are a number of Australian firms which are already accessing a variety of export markets, such as Solar Sales, Solar Energy Systems, Alternative Energy Systems, BP Solar Australia, Power Solutions Australia, Selectronics, Latronics, Global Sustainable Energy Solutions, and SMEC.

Asia represents by far the largest potential market for PV applications, and the demand for SHS represents a major market development opportunity PV. Figure 6.1 shows the market potential for PV SPS applications in developing countries, by region. The enormous rural populations in Asia (particularly China and India) represent significant markets for stand-alone PV, and the expansion of this market is being assisted by major programs being undertaken in a number of countries by multilateral and bilateral organisations. Figure 6.2 illustrates the market potential for PV systems in developing countries, by application.

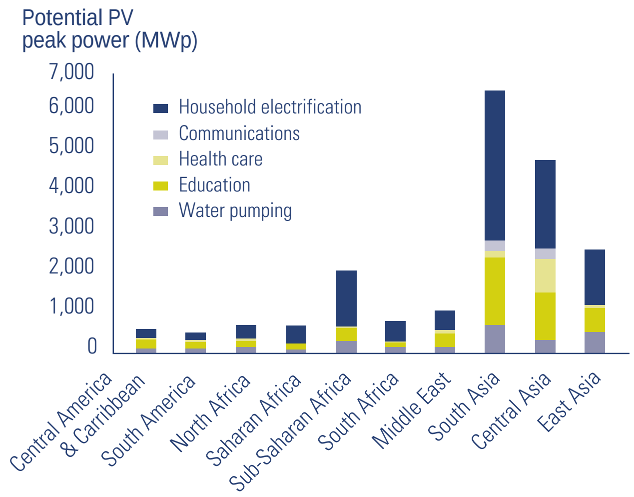


Figure 6.1 Market potential for stand-alone PV systems in the developing world, by region

Source: EPIA, 2003

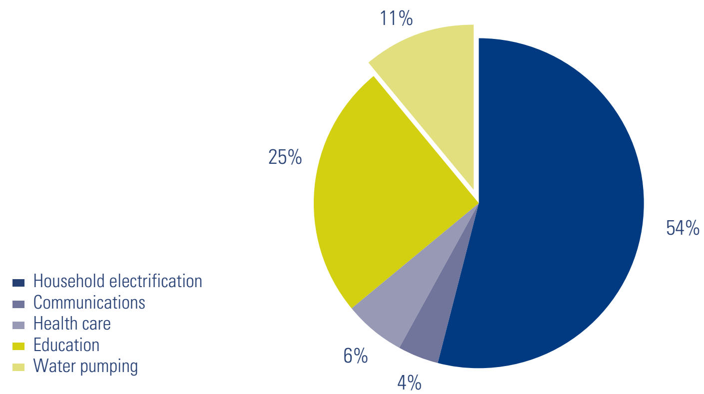


Figure 6.2 Market potential for stand-alone PV systems in the developing world, by application

Source: EPIA, 2003

Significant market opportunities also exist for grid-connected PV systems. There are three main applications for grid connected systems:

→ Large central systems that will add capacity to the existing supply system.

→ Grid distributed on residential and commercial buildings.

→ Grid distributed with battery storage.

The third application is suitable for areas where the existing grid is 'weak' and blackouts or 'brownouts' are common. For instance, PV grid-connected systems with battery storage are increasingly common in certain regions of India, and there are increasing numbers of commercial, industrial and domestic premises connected to PV-powered UPS systems.

Specific market opportunities for Australia

China has 900 million people living in rural China, of which 10 per cent are without access to modern energy services. To meet this need a number of initiatives have been introduced. These include: the Brightness Program, which plans to provide electricity for 23 million people in rural and remote regions by 2010 (2000 villages, 2 million homes); the Township project – 'Song Dian Dao Xiang', which will electrify 1061 townships – 378 with small hydro, 666 with PV, 17 with PV-Wind hybrids. The total PV capacity from these programs alone is anticipated to be 20 MW. In early 2004 the Government announced that they will spend US1.2 billion on PV over the next 5 years[2]. There are already relationships being built between Australian and Chinese organisations, such as the DSC co-development programme between the Chinese Academy of Science and STI.

As in most developing countries, the ASEAN market has historically been dominated by aid projects. In the 1990's this region was led by Indonesia with many multilateral and bilateral programs. Sukatani was the first village to be 'electrified' with PV-powered Solar Home Systems in Indonesia, and this provided the example and impetus for PV development in other developing countries in the region[3]. After some years of little investment, PV electrification projects are again being developed by agencies such as the World Bank.

The Philippines has a long history of aid-sponsored PV systems, beginning with German programs to electrify islands and remote communities with PV in the 1980s. A large $36 million partly Australian-funded project (MSIP) was undertaken in 1998/2000 to provide institutional power (schools, health clinics, hospitals, village meeting halls, water pumping, street lighting) for some 400 villages mainly in the Central Visayas.

Today, there are a number of bilateral programs underway, as well as a large PV electrification project funded by the World Bank[4].

Thailand: BP Solar recently announced a US$20 million contract to supply PV power products and services to Thailand-based Solartron Co Ltd.[5] The products and services will be used by Solartron in the construction of PV power systems for the government-funded Mega Rural Electrification Project, which will provide light to 120,000 homes.

The Government of Thailand has announced that it will increase their share of renewable energy from the present 0.5 per cent to 8 per cent by 2008. This will include PV with a PV grid-connect bill being passed in 2003.

In India, a country-wide PV program has been implemented by the Ministry of Non-Conventional Energy Sources (MNES) for about last two decades. The Program is aimed at developing the cost effective PV technology and its applications for large-scale diffusion in different sectors, especially in rural and remote areas. Major components of PV program include R&D, Demonstration and Utilisation, Testing & Standardisation, Industrial and Promotional activities[6].

There are about 80,000 unelectrified villages in India. Of these, about 18,000 villages cannot be electrified through extension of the conventional grid. The objective of the MNES village electrification program is to electrify all these villages through renewable energy sources by the year 2012. A target for electrifying 5,000 such villages has been fixed for the Tenth Plan period. Figure 6.3 shows the use of modules by market sector in India.

In addition, MNES is implementing two major schemes for deployment of stand-alone PV systems in the country. One scheme deals with demonstration and utilisation of lighting systems, off-grid power plants and other specialised systems; the other scheme deals with deployment.

Approximately 75 per cent of the 15 million rural households in Bangladesh are not connected to the grid[7]. There is currently a World Bank program to electrify 700,000 systems by the grid and 64,000 rural households with solar home systems.

The Asian Development Bank (ADB) has a new renewable energy development project in Pakistan[8]. In Pakistan only 50 per cent of the population has access to electricity, and the remaining 50 per cent of the population without electricity live in rural and mountainous areas. Because of the remoteness and rough terrain, the extension of the national grid to these areas is uneconomical. The ADB reports that development of renewable energy sources is environmentally friendly and will provide electricity to the remote areas and less-developed regions of the country. This will create job opportunities and will be an instrument in providing input for poverty alleviation.

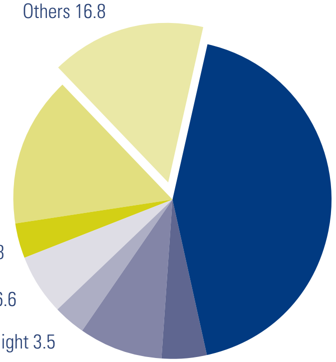


Figure 6.3 Use of modules by market sector in India
Source: MNES, 2004

The Pacific region includes many of the world's communities that are most at risk from catastrophic events caused by climate change. Australia is already heavily involved with assisting Pacific Island nations with solving security issues offering strategic 'policing', administrative and accounting assistance (for instance, in East Timor, Solomon Islands, PNG, Nauru). Many of these nations are extremely oil dependent, and this, together with rising oil prices and falling export earnings is further threatening their economic and political stability. This presents an opportunity for energy efficiency and renewables to help 'wean' these countries off their oil dependence.

CASE STUDY: **PLASMATRONICS – MANUFACTURERS AND EXPORTERS**

Melbourne based company, Plasmatronics, designs and manufactures robust electronic regulating and metering devices for PV power systems. Currently, direct exports comprise 40 per cent of their sales. Components are exported to Europe and Singapore, and installed in Middle Eastern countries, China, South-East Asia, South America and through UN projects in Northern Africa.

In other regions of the world, there are other PV programs that Australian companies can access:

- The government in South Africa is to provide 40,000 PV systems to rural areas as part of its electrification program, with funding from the German development bank KfW. International interested bidders were invited to submit applications to provide the solar home systems in Eastern Cape and North West.
- Morocco's energy minister, Mohamed Boutaleb, has stated that solar energy in rural electrification will be increased by up to 10 per cent by 2007–08, compared with the current contribution of 3 per cent.

Market opportunities in industrialised countries

Japan, Germany and the USA have all had PV rebate programs for many years and more countries are developing or planning new programs. These markets will continue to grow in coming years and provide opportunities for the Australian Industry.

The USA is covered by an Australian bilateral agreement, and additionally by the Climate Action Partnership and the proposed Free Trade Agreement. These mechanisms facilitate the importation of Australian skills, services and products into the US market. There are enormous potential market opportunities for PV in the US today, facilitated primarily by:

- State-based renewable energy targets, backed by substantial support programs and financial incentives (Appendix 6 lists each of these programs by State).
- High awareness of renewable energy products and services across sectors.
- Long history of using PV systems in particularly off-grid application, but also ten years' experience with grid-tied PV systems.
- Substantial R&D funding for PV, provided to the National Renewable Energy Laboratory (NREL) as well as to other national research institutes.

Leveraging Australia's aid programs

Australia, through AusAID, delivers our aid priorities. AusAID advises the Government on development policy and manages Australian development cooperation programs focussed on achieving broad-based growth, stability and effective governance, particularly in our region[9]. The aid program's objective is to advance Australia's national interest by assisting developing countries to reduce poverty and achieve sustainable development. Just as Germany's development agency GTZ, the UK-Overseas Development Agency, the European Union and other major donor countries incorporate renewable energy technologies in the delivery of these objectives, so can Australia. Indeed, AidAID has already done so previously in programs in the Philippines, Indonesia and Papua New Guinea. It has aid programs with all the countries in the Asia Pacific region, and many of these lend themselves to utilising PV systems, in applications as described above.

An opportunity needs to be created to develop the role of PV in the delivery of Australia's strategic aid programs. In Indonesia, for example, Australia is working with the Indonesian Ministry of Health and the World Bank to provide water and sanitation to low-income communities, in West and East Java, West Nusa Tenggara, West and South Sumatra, and Bangka Belitung and South Sulawesi.[10] This will be achieved through improving the health behaviour and health services related to water borne diseases of the communities; providing safe, adequate, cost-effective, and easily accessible water supply and sanitation services; and developing sustainability and effectiveness through community participation. PV could play a role in the delivery of health services, potable water supplies in particular – but it needs to be allowed to compete in the project by being recognised as an appropriate delivery mechanism from the project information document through to the tender specifications.

There are other programs under development within Australia's aid program which could offer similar opportunities for PV.

Opportunities to access international programs

REEEP

Australia is investigating joining the Renewable Energy and Energy Efficiency Partnership (REEEP).[11] REEEP is a coalition of governments, businesses and organisations committed to accelerating the development of renewable and energy efficiency systems. On April 28th, the United States joined REEEP, which is led by the United Kingdom.

Initiated at the Johannesburg World Summit on Sustainable Development (WSSD) in August 2002 by the UK Government, REEEP provides a framework within which governments work together to meet their own sustainable energy objectives according to their own timetables. REEEP seeks to accelerate and expand the development of renewable energy and energy efficiency systems in economies and in energy portfolios. REEEP recognises that these sustainable energy systems can address the key challenges of sustainable development, notably improving energy security, fostering economic development, and greater social equity whilst reducing the environmental impact of energy consumption and production.

If Australia does join REEEP, it will facilitate:

- → Australian companies further access to projects under tender.
- → Australia to have government and/or industry representatives on the main Boards.
- → Potentially host the Secretariat for Oceania (in itself bringing more export opportunities).

International Energy Agency Implementing Agreements

Australia is signatory to over 20 collaborative R&D Agreements, eight of which are on renewable energy technologies. These include the Photovoltaic Power Systems Programme (PVPS), established in 1992.[12]

The objectives of PVPS are to:

- → Contribute to the cost reduction of the PV power systems applications.
- → Increase the awareness of the potential and value of PV power systems.
- → Foster their market deployment by removing technical and non-technical barriers.
- → Enhance technology cooperation with non-IEA countries.

Railway signalling, regional Victoria

These objectives fit well with Australia's PV industry goals, as well as contributing to an understanding of the R&D and commercial barriers to the greater deployment of PV for both stand-alone and grid-connect applications.

Australia has been active in Task I: Information Dissemination; Task III: Stand-alone and Island Systems; Task 7: PV in the Built Environment (completed 2003); Task 9: PV in Developing Countries; and now Task 10: PV for the Urban Environment.

Australia's participation is through the Australian PVPS Consortium, and is open to any organisation upon payment of fees. These fees pay for participation at the international level, as well as partially funding local expertise. Funding to participate in this international collaboration in other countries is typically provided to national experts by national government support programs, which puts Australia at a disadvantage as it cannot participate at a level which would truly leverage the expertise and international collaboration opportunities provided by the other 20 countries participating in PVPS. In Task 9, there are significant international trade opportunities which could be more fully leveraged as well.[13]

Other international opportunities

In addition to the above opportunities, a number of other initiatives have commenced in recent years to help in the delivery of energy to developing countries. These include Global Village Energy Partnership (GVEP), African Renewable Energy Enterprise Development (AREED) which was followed by BREED for Brazil, and CREED for China.

How do we increase our PV exports?

Although the Australian PV industry has significant export potential, it faces a number of local and overseas challenges that need to be addressed.[14]

1. *Increase access to international aid programs.* The majority of industrialised countries receive significant assistance from their governments to access developing country markets. For instance, in the UK two trade promoters are dedicated to the renewable energy market, financed through the UK Department for Trade and Industry's export assistance scheme.[15] The German government has just increased its budget allocation the German aid agency, GTZ, by US$500 million.[16] This is primarily to develop renewable energy projects in developing countries. The USA has traditionally supported its PV industry through developing international markets via national organisations such as NREL and others.
2. *PV to be included in Australian Aid projects, as appropriate.* Most other countries recognise that health care, education, local development and other development objectives are facilitated by the provision of cost-effective local energy supply options. In many cases, this energy can be supplied by PV systems, with applications identified under technical assistance contracts, and services/systems put out to tender (including local training and system support services). Some countries have tied-aid, but most have open tendering systems. The difference to Australia is that they allow renewable energy systems to play a key role as appropriate in delivering their development objectives.
3. *Assistance to utilise bilateral agreements.* There are a number of opportunities which the Australian government is providing already through the development of bilateral Agreements. These need to be explored for the ways in which these can assist the Australian PV industry.

One of the mechanisms already being developed is under the 'Climate Action Partnership' (CAP) in the USA. As a result of an industry mission to the USA in May 2004, agreement has been reached between the Australian Business Council for Sustainable Energy (BCSE) and the US Department of Energy (DOE) to develop the following:

- → An Australian RE trade mission in August 2004 to NREL and the World Renewable Energy Congress.
- → This mission will be followed by a senior delegation of USA RE delegates to the World Energy Congress in Sydney (September 2004), which will facilitate further discussions between USA and Australian officials and organisations involved in the CAP.

- There is support for a trade mission of USA industry, led by the US-BCSE, to come to Melbourne to participate in the Australian BCSE's Annual Conference in April 2005.
- There is agreement to work to increase Australia's expertise in Building Integrated PV through collaboration between experts in the USA and Australia over and above participation in the IEA PVPS Task 10: PV for the Urban Environment.
- Undertaking collaborative analysis on the role of renewable energy for peak power deployment on the grid and the value of avoiding costs associated with building other forms of peaking plant.

There are also significant opportunities to be explored within the **European Union**, to access their collaborative energy Research, Development and Demonstration programs under the Sixth Framework. Through this Agreement Australian companies are already able to participate in these programs, but are unable to receive any EU funding for their participation (unlike EU-based organisations). The funding for participation at present has to come from the Australian organisations themselves (indeed CSIRO is participating in just such a project, with their own funding). Funding for Australian R, D & D projects could be linked to the Calls for Proposals and topics under Framework 6, in order to leverage the millions which are allocated each round to renewable energy and energy efficiency projects.


PV water pumping, Western Australia

4. ***Facilitate greater participation in international collaborative programs*** – this includes more comprehensive participation in the IEA PVPS activities, as well as accessing the collaborative R, D & D programs of the European Commission. This includes additional resources to compliment existing industry self-funding.
5. ***Assistance to become more 'export savvy'*** – AREEN undertook a series of Exporter Seminars around Australia in June 2004. These were primarily for renewable energy companies who wish to increase their export expertise. AREEN needs to be strengthened to allow for a full-time person seconded from industry to:

- Develop, coordinate and run export training for PV companies.
- Provide international market information to the Australian renewable energy industry.
- Raise the profile of the Australian renewable energy industry internationally,
- Liaise with industry in Australia and promote their products, services and expertise overseas (on an Australian not company-specific basis).
- Represent the Australian PV and/or renewable energy industry at trade shows. conferences and exhibitions overseas, and particularly in the main identified target region of Asia.
- Keep the industry informed on all the initiatives being developed globally that will benefit the deployment of PV systems.
- Undertake market research on target markets, as well as on AREEN member needs.

7// THE WAY FORWARD FOR THE AUSTRALIAN PV INDUSTRY

This Chapter provides an industry development framework for the PV industry and sets out how industry and government can work together to achieve the 'Sunrise vision' outlined in Chapter 5. This development framework is supported by a detailed analysis of barriers that currently exist to industry growth which have been identified by industry together with proposed solutions, and are outlined in more detail in Appendix 7.

Key points

- → The global PV industry is expanding rapidly and Australia has well established, and globally recognised strengths and capabilities in this growing market, developed over the last thirty years.
- → The PV industry has responded convincingly to government initiatives to date, with over 1100 people currently employed in the industry, and annual sales of over $200 million, more than half of which result from exports.
- → The Australian industry is at the crossroads: whilst making great strides over the last 10 years in reducing installed costs, the PV industry is still relatively immature and will continue to rely on government support to further reduce costs and improve market penetration.
- → Countries like Japan, Germany and the USA have implemented aggressive policies to underpin the continued growth and development of PV in their countries. This will mean that costs will continue to fall internationally and in Australia.
- → The real challenge for Australia is to determine whether this is an industry that is worthy of continued support and whether the benefits to the Australian economy are worth the continued investment by government and the community.
- → A significant component of this investment is a commitment to address or make-good the impediments in energy markets that prevent the benefits of PV being recognised and rewarded.
- → The 'Sunrise vision' for the industry, of 350 MW installed capacity by 2010 and 6,740 MW by 2020, requires a long-term policy framework from government that will underpin continued investment by industry.
- → This will deliver considerable benefits to the Australian community by 2020, such as installed capacity of 6,740 MW, PV sector jobs of 31,600, revenues of $5,160 million annually and nearly 10 million tonnes of CO_2 avoided per annum.
- → A broad policy framework is required from government that involves measures that cover market stimulation, removing regulatory barriers and building industry capacity and capability. In relation to specific PV market sectors the following programs have been developed to support the above targets:
  - – 150,000 roof-top program for the grid-connected market, the key feature being the introduction of feed-in tariffs that recognise the benefits that are provided by PV which go unrecognised in the market.
  - – diesel replacement program, the key feature being the ability of PV to internalise a competitive cost advantage with diesel that includes excise.
  - – export market program that aims to build the export capability of Australian businesses and develop market opportunities for these businesses.
- → Industry for its part is prepared to continue to invest in the manufacturing, distribution, marketing, training and other infrastructure, as well as continued research, development and commercialisation to support the realisation of the vision.

The PV industry is growing internationally to be a significant global industry. Awareness of the technology benefits is increasing, as innovative international government programs take effect. This in turn results in industry development and a significant increase in installed capacity. Accordingly, the cost of PV technology is continuing to fall. The global market has been doubling in size every two and a half years; PV module costs are currently falling by 18 per cent with every doubling of capacity.

The global PV industry includes new manufacturing capacity located in countries that actively support PV and have growing local markets. In addition, the emphasis for application of PV in recent years has shifted internationally from off-grid to grid-connected markets.

Australia is currently at a crossroads in terms of its participation in this global market. It has built up considerable expertise in PV over several decades and currently holds a position of some leadership internationally, particularly in the field of off-grid systems.

The issue for the Australian PV industry today is that there is enormous potential as identified throughout this document. This potential has been built through a natural competitiveness in Australian research and development, industry investment and government policy support. Despite growth to date, the industry is not yet self-sustaining and advantages gained to date could be lost. The PV industry cannot continue to actively invest in industry development if the Australian government is not fully committed to the journey.

The industry has identified its strengths and necessary developments in technology and markets, but requires support and assistance to bridge the current commercial gap and increase its positioning in the international market.

A strategic industry development framework is now required for Australia to leverage historical expertise and develop a growing domestic market, with associated benefits into the future. Global growth in the PV industry and resulting cost reductions will continue with or without Australian participation. The absence of a strategic industry development framework will see Australia as a net importer of PV systems and components, thus losing local jobs and investment in manufacture and systems development.

During the consultation process outlined in Chapter 1, Australian industry identified 'Sunrise' targets for PV market expansion for 2010 and 2020 that is has the capability to deliver in cooperation with government. Investment of the Australian public's funds in the PV industry will provide significant returns. The main industry objective is to meet an installed capacity of 6,740 MW by 2020, which will result in PV sector jobs of 31,600, revenue of $5,160 million annually and nearly 10 million tonnes of CO_2 of avoided in 2020. This is illustrated in Table 7.1.

Table 7.1 Sunrise targets

Australian PV industry	2003 actual	2010	2020
Installed Capacity (MW)	46	350	6,740
Employment	1000	5,290	31,600
Local sales revenue ($ million)	185	786	4,178
PV sector exports revenue ($ million)	19	444	2,438
CO_2 abated in year ('000 tonnes)	65	490	9,320

In 2003, there was 46 MW of PV capacity installed in Australia, with over 1,100 people are employed in the industry, and annual revenues of more than $200 million are generated.

Strategic domestic industry development activity by both Australian industry and government to deliver industry's full capability, as outlined in the 'Sunrise targets' can deliver a vibrant, billion-dollar PV industry in Australia by 2010. This industry would deliver a broad range of benefits to the Australian community, including:

- → Continued growth in exports.
- → Significant increase in local jobs and investments.
- → Considerable long-term reductions in Australia's greenhouse emissions.
- → Offsetting large investments in electricity networks, particularly as a result of peak demand constraints.
- → Reduction in transmission and distribution.
- → Improved security of supply as a result of a more distributed electricity system.

The Sunrise modelling identified the grid-connect market as the way for the PV industry to exponentially expand and become cost competitive. Off-grid applications, many of which can be already cost competitive, will continue to grow but at a lower rate.

Figure 7.1 presents the results of the scenario modelling, and shows that the price of PV electricity for residential dwellings will become competitive with grid-supplied electricity by 2020, as detailed in Chapter 5 and Appendix 4. The underlying power prices against which PV competes are expected to grow at a faster rate than the Consumer Price Index, due to rising peak power demands, which will mean that peak prices will rise at a much faster rate average prices.

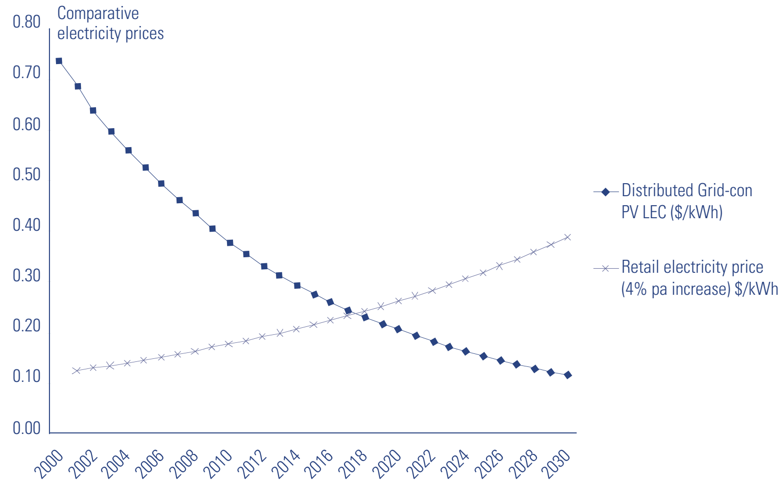


Figure 7.1 Prices of PV-generated & grid-supplied electricity for residential dwellings in Australia
Source: Historical data and scenario modelling for the PV Roadmap

Between 2004 and 2020, industry development policy approaches are required to support Australia's emerging PV industry, in order to deliver competitive prices and the benefits listed above well into the future. This is represented pictorially in Figure 7.2 below, whereby a strategic government industry development policy framework would support investments by industry and sustain industry growth. In other words, 'keep the ball rolling'. This would also result in increased installed capacity, and ensure that Australian industry can deliver competitive prices and therefore associated benefits well into the future. Such long-term price reductions for PV would allow greater community access to these benefits.

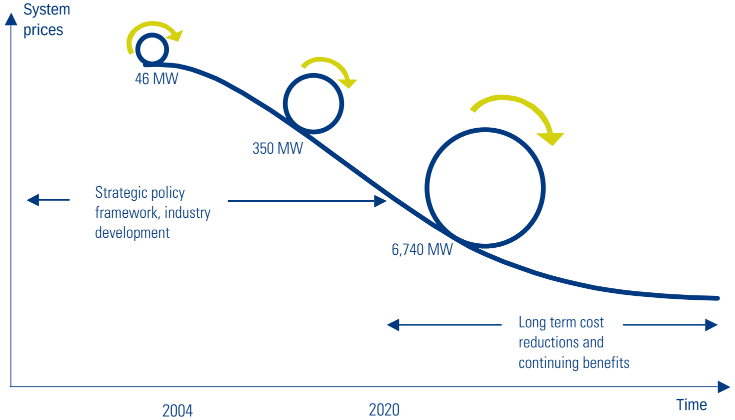


Figure 7.2 Outcomes of strategic industry development policy

Source: Adapted from Kurokawa and Aratani, 2004 [1]

To be effective, industry development must be based on sound policy principles that deliver sustainable growth. For the Australian PV industry these principles include the following:

- Clear and transparent policy development processes.
- Building a significant market demand for PV in Australia.
- Long-term certainty to underpin new investment and cost reductions.
- Stimulus to drive continuous innovation in technology, financing, applications and marketing.
- Providing a level playing field for competing technologies.
- Appropriate market decision making by informed stakeholders in the economy.

A successful strategy could be based upon an industry-government 'covenant', with long-term commitments to key industry development outcomes. This more formalised type of relationship has been developed for the solar industry in the Netherlands, and can be seen to be akin to previous Australian Government industry strategies such as the Steel Industry Plan, Motor Vehicle Plan or the Clothing and Textile Plan. Such an approach would create the mutually-supportive framework necessary to deliver sustainable industry growth and a competitive industry.

CASE STUDY: **JAPAN**

Japan has invested heavily in PV to build a strong, sustainable industry with Japanese companies producing 46 per cent of the global PV cell production.[2] The government established the Sunshine Project in 1974. This required considerable government and industry investments to stimulate market uptake and to drive prices down. Figure 7.3 clearly shows how installed costs have fallen dramatically over the 10 years from 1993 as the installed capacity has grown. Once the market was on its way subsidies have been slowly reduced as the industry starts to stand on its own with solid growth. Figure 7.4 shows the progressive reduction in government support to 1999 as increases in installed capacity have driven down installed costs.

The Japanese strategy was to invest heavily in supporting cell and module technological development and manufacturing. In 1994, government subsidies were at $15,000/kW, when the average system price was $33,000 – meeting around 50 per cent of the cost of a system. Over time system prices have halved and the government subsidy is closer to $3000/kW.

Japan has the strongest government support for PV worldwide. It therefore is not surprising that by the end of 2003 Japan accounted for nearly half of global PV cell manufacturing. The Japanese government spent US$223 million in 2003 to support PV, and a further US$412 million was allocated to new energy entrepreneur support programs for regional introduction of new energy. Most of this funding provides incentives and support for residential customer installations. Specifically, the New Energy Foundation under the Ministry of Economy, Trade, and Industry (METI) now provides ¥90,000 per kW ($820 per kW) as a subsidy for residential installations smaller than 10 kW. Subsidies have been reduced as prices have fallen since the

CASE STUDY: **JAPAN** CONTINUED

program started in 1993, and will eventually be phased out as PV becomes cost competitive with other electricity generation technologies.[3] In addition to national-level support, local governments also provide a wide range of incentives ($80 to $1,800 per kW plus low-interest loans). The result is average incentives of more than $1,100 per kW installed and interest rates below 3 per cent. These incentives and support lower the average cost of PV power generation from $0.36 to $0.32 per kWh.[4]

Japanese targets for PV are 4820 MW by 2010, and 100 GW cumulative installed capacity by 2030.[5] Japan is aiming to halve installation costs by 2010.

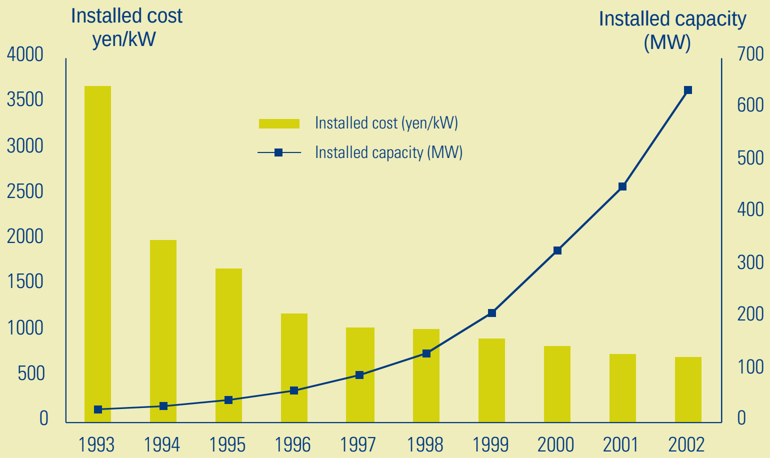


Figure 7.3 Growing the Japanese PV industry
Source: METI, 2004

Japan's policy for New and Renewable Energy Promotion has five major components:

- R, D&D (cost reduction, output stability).
- Support for introduction (by the business sector, for residential PV systems, and support for NGO promotional activities).
- Support for promotion of RE in Regional Governments (support for developing new energy vision, and promotion of RE by regional governments).
- Voluntary action by private sector to purchase Renewable Energy Electricity (RECs, voluntary actions by power companies to purchase RE electricity).
- Renewable Portfolio Standard System (obligation rests with the electricity suppliers).[6]

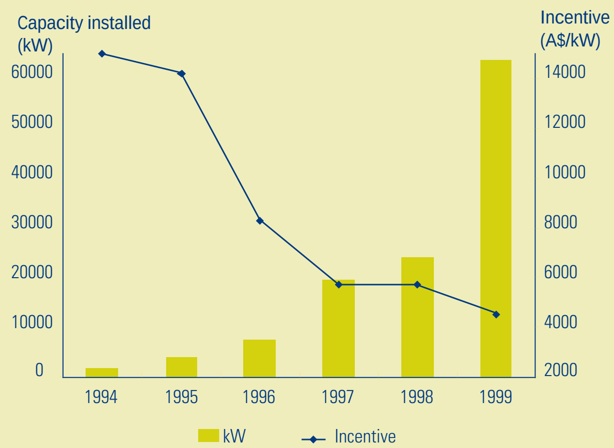


Figure 7.4 Japanese government support for PV
Source: Mitsuru Takeshita, 2003

Industry development policy framework

To date, investment in the PV industry by the Australian Government has driven the following investment in the PV industry by the private sector:

- → Investment of more that $150 million in research and development, much of it in the past three years.
- → Investment in additional manufacturing facilities and creation of new jobs.
- → Development of export markets, in the face of strong competition from countries that have access to flexibility mechanisms such as the Clean Development Mechanism (CDM) and supported by aid budgets.
- → Continued improvement and development of Standards, training and accreditation.
- → Development and expansion of distribution and marketing channels.
- → Development and expansion of education and training facilities.
- → Promotion and demonstration of the benefits of PV through programs and activities such as Solar House Day.
- → Funding studies and research into the unquantified and unrewarded network and electricity system benefits of PV.
- → Participation in international collaborative programs such as the International Energy Agency PVPS program.
- → Supporting the BCSE as an industry association to build industry capacity and capability.

Further delivery of innovation and investment by the industry is detailed in Chapter 8.

Government rebate programs have provided much of the continued local market stimulation. The Photovoltaic Rebate Program (PVRP) in particular has created growth in grid-connected PV capacity in Australia in recent years. This program is currently due to be complete in the financial year 2004/05. But where do we go from here?

A stable, long-term and transparent policy framework is needed for industry to have the confidence to make significant investments across the PV sector supply chain. This will require a policy framework that involves the following strategic elements:

Market stimulation – this addresses specific market failures that prevent the benefits that PV provide being adequately recognised or rewarded. Market stimulation underpins increased demand by bridging the current cost gap in the key PV markets both on and off-grid. Strategies include feed-in tariffs, enhancing MRET or other mechanisms to reward low emission generation, effective building codes and standards, credits for network benefits, supporting diesel replacement, grants and rebates and strategic market development.

Removal of regulatory barriers – this addresses electricity market failures that result in increased installation costs and delays arising from metering, connection and pricing arrangements.

Building industry capacity and capability – this includes supporting industry development activities that build local industry capacity and includes support for local manufacture, exports, innovation, training and education.

The Australian PV industry has identified that, to reach its initial Sunrise target of 350 MW of installed capacity by 2010, it requires policy support to bridge the cost-competitive gap so that the cost paid by grid-connected consumers effectively reduces from $12,000 at present ($8,000 after PVRP) to $5,000 per kW by 2010. Stimulation of the grid-connect market will have flow-on benefits to the off-grid market.

The cost at $5,000 per installed kilowatt has been identified by the industry as an important benchmark that brings PV within the range of competitiveness. While still at the high end of competitiveness $5,000/kW should be sufficient to enable the large-scale uptake of PV, particularly in the grid-connect market. It will still require significant investment in marketing and promotion by the industry. However, the industry is prepared to undertake this investment, if supported by a long-term industry development framework.

PV has enormous potential in Australia across a range of applications and activities. The 350 MW installed capacity target under the industry's 'Sunrise vision' comprises the sector projections in Table 7.2.

PV street lighting, Mornington

Table 7.2 – 'Sunrise 350' projections by market sector

Installed capacity (MW) By application sector	2003 actual	Sunrise 2010
Off-grid domestic		
Remote households, holiday homes, pastoral stations, isolated communities (indigenous), fringe-grid	13.5 MW	44 MW
Off-grid non-domestic		
Telecoms, water pumping, signalling, cathodic protection, electric fences, street lights, tourist facilities	20 MW	94 MW
Off-grid mini-grids		
Isolated communities (mines), public generation	6.0 MW	12 MW
Grid-connected distributed		
Residential rooftops, commercial BIPV	4.5 MW	163 MW
Grid-connected centralised		
Network strengthening, bulk power	1.4 MW	38 MW
Consumer devices		
Small portable electronic devices	0.2 MW	1 MW
TOTAL	46 MW	350 MW

PV industry activity framework

To deliver the 'Sunrise vision' for 2010 requires specific 'joined-up' actions and activities by both industry and government. The policy framework required by government is set out below in relation to specific PV market sectors. This identifies a comprehensive approach that considers market stimulation, addresses impediments and builds industry capacity and capability.

For its part, Australia's PV industry will continue to build on and leverage its investment to date. Specific actions for industry are listed below and a more comprehensive coverage of the research, development and innovation activities and opportunities are set out in Chapter 8.

1. Continue to drive installed system costs downwards through:
   - → Investing in the expansion of manufacturing facilities, including modules and balance of systems components.
   - → Investing in improved manufacturing, logistics and resourcing processes.
   - → Improve component standardisation (and product standardisation where appropriate) so as to reduce unit costs.
   - → Continued investment in research and development to improve system performance and lower cost per kWh of system output.
   - → Developing new products and installation methods for both existing and new markets.
   - → Increasing the efficiency of the supply chain to bring services to customers in more timely and cost-effective manner.
   - → Develop innovative financing approaches that reduce the effective cost to customers.
   - → Develop synergies with other industry sectors such as building and construction (particularly new buildings), electricity distribution businesses with regard to network strengthening and connection, as well as infrastructure owners and operators.
   - → Develop innovative and flexible supply channels, including through established industries, to access new and expanding market segments.
   - → Improved system packaging and integration to deliver lower installed costs.
2. Continue to improve quality, reliability and performance of PV systems
   - → Continue the development of Standards, training and accreditation of designers and installers of PV systems.
   - → Continue investment in expanding and extending system and component testing.
   - → Continue to invest in development of process and control equipment to optimise system performance.
   - → Continue to improve after sales-service availability and costs.
3. Continue to expand and develop markets and applications for PV
   - → Continue to differentiate service provided by PV from alternative fossil fuel generation.
   - → Continue work on promotion of the benefits that PV delivers and seeking to get these recognised and rewarded in the market.
   - → Increase marketing, consumer awareness-building and education.
   - → Undertake extensive promotion and training within the building industry and trades.
   - → Seek out higher value markets that provide a premium by recognising aesthetics, reliability and security of supply.
   - → Develop product solutions that are valued by different market sectors, e.g. building integrated PV systems, new and improved industrial applications, transport market solutions, etc.
   - → Partner with existing industries and supply chains, to streamline marketing and

supply and to develop products and energy solutions for new markets.

- → Support trade initiatives and the further development of channels and markets overseas.
- → Continue to develop export markets for Australian-made components, systems and services.

4. Support industry capacity building
   - → Continue support for development of training and education infrastructures.
   - → Increase international collaboration on research and development, market development and Standards.
   - → Undertake regular market surveys to ascertain customer requirements for products and services.

Proposed Government PV policy framework

To support industry's actions, the following policy roadmap provides government with a portfolio approach for sustainable industry development policy mechanisms that deliver multiple benefits to both the PV industry and the Australian community more broadly. This will consolidate Australia's international competitiveness, promote innovation and investment and increase the range of economic and social benefits which PV can deliver.

The policy framework is set out in two steps: the first step is the broad-based industry development and energy market initiatives that are required to establish an overall energy market framework that facilitates the development of the PV industry. Step 2 involves a suite of measures that focus on the three specific PV markets: grid-connect, off-grid and exports. With the input and support of the PV industry, these will stimulate the particular market segment and address the impediments that are preventing the full potential of PV being realised.

Step 1 — Broad-based industry development initiatives

This step considers the broader energy market initiatives that are required to build industry capacity and capability. The initiatives in this first step are set out below.

Greenhouse price signal

The introduction of a greenhouse price signal into the electricity sector would ensure that investment, purchasing and operating decisions would internalise the cost of greenhouse gas emissions. This would also recognise the greenhouse benefits of installing PV rather than being achieved by emission-intensive coal-fired power generation.

Carbon dioxide has been projected by the Australian Greenhouse Office[7] to be priced at between $8 and $13 per MWh of generation. The NSW Benchmark Scheme currently prices carbon at $10.50. In addition, carbon products currently trading in the European emissions trading market have been priced at 9.75 Euro (or roughly $17.00) per tonne of CO_2.

The reduction of greenhouse emission is an important priority for governments. But until the cost is incorporated into the energy market, the benefit that PV provides in this regard fails to get recognised.

Changes to make MRET more effective as an industry development initiative

One particular hurdle to the uptake of PV is high up-front cost of capital. As an industry development scheme, the Mandatory Renewable Energy Target (MRET) addresses this issue for PV with provisions for 'deeming' Renewable Energy Certificates (RECs) to the amount of electricity offset over a given period, and making these available upfront at the time of purchase. However, the current five year deeming provisions within MRET have not effectively increased uptake of PV and can be improved by making the following changes:

- → RECs equivalent to a minimum of 20 years of deemed production to be available 'up front' compared with five years at present. This lines up with the current 20 year plus guarantees from PV module suppliers; to the extent that module suppliers are prepared to offer longer guarantees, then this should also be recognised.
- → Maximum system size under which deeming provisions to apply to be increased from 10 kW at present to 100 kW.
- → Where the deemed REC approach is used, the PV system should be installed by an accredited system installer. This builds confidence in the ability of the system to perform and deliver on expectations over its lifetime.
- → There has also been some consideration of PV being provided with more than one REC per MWh of generation to recognise the other distributed generation benefits provided by PV to the electricity system.

Building industry capacity and capability

Industry development support

Targeted funding programs are important to underpin industry development activities in delivering sustainable industry growth. These activities include developing industry standards, developing a skilled and accredited workforce, as well as participation in international taskforces on industry development. The following programs identify the issue specific programs required:

- → Continued development of industry Standards and associated testing programs.
- → Continued support for training and accreditation initiatives for systems designers and installers.
- → Participation in the International Energy Agency PVPS.
- → Industry, community and education outreach programs.

Support for innovation and commercialisation

Continued innovation and commercialisation in the areas of technology, financing, applications and marketing is critical for Australian industry to maintain a competitive advantage over time.

Technology areas for innovation include module materials, battery capability for remote power systems and system optimisation. Application innovation may include uses of PV as a building material and other methods of integration within the urban environment. Innovative financing approaches may become a vital part of market development and provide greater access opportunities for the community. Innovative marketing strategies by both government and industry have the potential to enhance and develop greater community understanding of the technology and its related benefits.

Government has a crucial role to play in leveraging strategic research and development funding, including the provision of funding to cover these areas. This should best be administered by an appropriate organisation that is informed by industry as to its requirements.

Step 2 — Sector-specific programs

In addition to the broader energy market and the general industry capacity-building initiatives, specific programs have been identified that focus on the three specific PV markets: grid-connect, off-grid and exports. These programs provide a suite of measures that will stimulate the particular market segments and address the impediments that are preventing the full potential of PV being realised.

1. 150,000 Roofs by 2010 program – grid-connect market

This program consists of five measures geared to the development of the grid-connect market so that by 2010 this market has grown to 200 MW installed capacity and the total installed PV capacity in Australia has grown to 350 MW. Like other developed countries, the grid-connect market will drive future growth of Australia's PV industry. To achieve large-scale deployment, PV systems must be available at $5000 per installed kW to consumers. At this level PV becomes economically viable for customers. At $5000 per kW,[8] a PV system can be amortised economically over a 25 year mortgage. The economic viability would be achieved by the policy framework delineated below.

The 150,000 rooftop figure is symbolic of capacity and will include systems that are grid-connected, but not on domestic roofs.

Figure 7.5 outlines the industry development framework by installed cost and system volume required to deliver grid-connected PV systems at a competitive cost to customers. Note that in the period until 2010, targeted industry development funding is required. This could be delivered as targeting strategic markets in order to increase installed volume or via an extended PVRP rebate program.

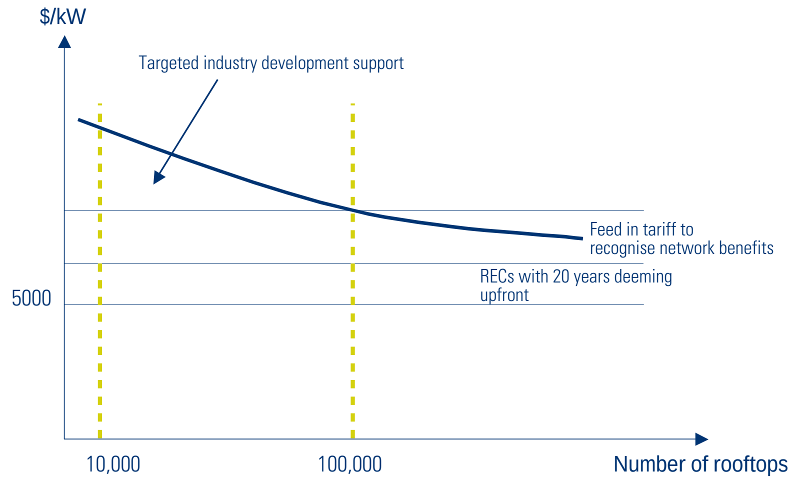


Figure 7.5 Installed cost reduction curve

It is important that the work done to provide growth in the grid-connect market be maintained by extending the existing PV Rebate Program, or an equivalent strategy, until such time as the proposed industry development measures are implemented. Failure to do so will create a hiatus that will cause the industry to stall.

It is also important that all areas of Australia have access to initiatives under this proposed program. This nationwide approach will enable the market to choose its best locations, and will support accredited installer in regional, as well as metropolitan areas.

Reward network benefits of grid-connect systems through a 'feed in tariff'

A 'feed in tariff' is proposed as the optimum industry development method for the grid-connect market to follow on from PVRP. Feed-in tariffs work by arranging for all PV customers to be paid a higher value for electricity that is produced from their PV system. This approach has been demonstrated to be very effective in a number of countries, such as Germany.

The higher value for the electricity fed into the grid reflects the considerable benefits that distributed PV systems provide to the electricity distribution system that are not currently recognised or rewarded. These include contribution to meeting peak power requirements and network integrity and security (for more detailed information on benefits see Chapter 4).

The additional network value that is provided by PV is priced at $130 to $200 per MWh. This price is higher in regional and end-of-grid areas, and the additional value should be reflected in the final delivered price to the consumer.

The feed-in tariff has the potential to provide long-term market certainty for investment in the PV industry, and is a transparent market-based mechanism. In addition, it is not subject to any potential variability or uncertainty in program budgets. Local manufacturers and suppliers would thus have more certainty to drive investment in their facilities.

CASE STUDY: **GERMANY – FEED IN LAW AND TARIFFS**

The 'Feed-in Law' in Germany, which came into effect April, 2000, permits customers to receive preferential tariffs for PV-generated electricity depending on the nature and size of the installation. For ground-mounted systems, the new tariffs permit up to 45.7 € cents/kWh. PV installations on buildings receive higher rates of up to 57.4 € cents/kWh. However, the Feed-in Law also requires that the tariff paid for PV electricity is reduced by 5 per cent per year, and by 6.5 per cent per annum for ground-mounted systems. The tariffs for approved renewable energy projects are fixed for a 20 year period from the plant commissioning.

Some 20,000 PV systems, yielding an output of about 145 MW, were installed in 2003, almost twice the volume installed in the previous year. With these additions, the total solar electricity capacity in Germany is now estimated at over 400 MW.[9] According to current estimates, the German PV market generated total revenues of over € 800 million in 2003.

The German Government provided, through the KfW Bank, loans totalling 1.7 billion euros for the procurement of PV systems under the 100,000 Roofs Program, which terminated at the end of 2003. Loans are still available, but under slightly less advantageous conditions. Some German states have subsidy programs for PV installations that can be used in combination with the national Feed-in Law.

The German Solar Industry Association (Bsi) expects a growth rate in excess of 50 per cent for the German PV sector during 2004, with sales of over € 1 billion, equal to 200 MWp of new installation. The great public interest in photovoltaics is the result of the new feed-in tariffs introduced at the start of the year. The Bsi has forecast that as a result of the current boom, the costs of solar power will drop by 5 per cent per year. Over the past five years, German companies have invested over € 1 billion in solar manufacturing plant. During 2003, over 10,000 people were employed in production, distribution and installation.[10]

Table 7.3 PV Installations by year in Germany (in Megawatts)

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
Total	0.60	1.00	3.10	3.5	4.0	5.9	10.6	14.5	12.6	16.5	44.0	80.0	83.0	145.0

Source: Solarbuzz, Fast Energy Facts, 2004

Incorporation into Building Codes and Standards

A number of state governments are implementing mandatory minimum energy performance standards for new residential buildings. The Building Sustainability Index (BASIX) which was introduced into NSW on 1 July 2004 will require new residential homes to progressively reduce greenhouse emissions so that by 2006 new homes will produce 40 per cent less emissions that the current NSW average. This provides an important opportunity for PV to be incorporated into new residential buildings and provides building developers with a number of options to meet the greenhouse reduction requirements.

This model should be developed and rolled out into other states and also rolled out into new non-residential buildings. States such as Victoria and South Australia have introduced minimum five star energy efficiency requirements for new residential buildings. At present these schemes do not give credit to customers who install PV, but there is potential for this to occur in the future.

All energy performance schemes should appropriately recognise and reward the contribution of PV systems to electricity supply for the building envelope.

Support for market development

Targeted programs are important to underpin community acceptance and understanding of PV and to support industry development. In the case of the grid-connect market these activities could include:

- → Improving the visibility of PV in the built environment through an expansion of solar schools programs, and this extending to other government and community facilities.
- → New government and public buildings to be required to consider PV integrated with energy efficiency measures in the design phase.
- → Support outreach education programs to highlight the benefits of PV including the further development of curriculum materials for schools.
- → Support the development of iconic high profile PV projects, such as the 200 kW Queen Victoria market site in Victoria. Each state should develop at least four such facilities by 2010, perhaps through design competitions, which would create even greater awareness.
- → Training and promotion to increase the expertise and awareness on PV technology of building designers, engineers, planners and consultants.
- → Marketing and promotion of the benefits and opportunities that PV can deliver.

Creating a level economic playing field

PV technology will compete more effectively in Australia's energy markets when current market distortions are addressed, creating a level playing field with economically efficient outcomes.

This requires that power prices to consumers are more cost reflective in terms of location and time of use. In this way, consumers are provided with price signals in proportion to the impact that their electricity use has on investment required in the network and in new generation.

Processes and requirements for the connection and deployment of PV systems currently act as a significant hurdle to investing in a PV system. The connection should be streamlined by standardising connection agreements to best practice and enabling customers to choose a metering system with a minimum requirement of digital net metering. Guidelines need to be established by state-based electricity regulators relating to metering and connection of PV systems, to minimise costs to customers as well as reduce delays in connecting systems to the electricity grid.

It is critical that all new homes install appropriate digital 'time of use' meters that are capable of measuring imports and exports, in a transition to introducing appropriate pricing practices.

Non-regional specific (or postage stamp) pricing practices make if difficult for PV to compete in many markets, such as off-grid and end-of-grid applications, where the cost of supplying electricity is higher. These practices should be made transparent by requiring retailers to publish the real costs of supply per region, and to work towards charging regionally appropriate prices and offering rebates for the quantity of any reductions in price made by uniform pricing practices.

2. Diesel replacement program – off-grid market development

Off-grid power systems have become increasingly competitive with diesel power generation units. They offer many benefits, including significant fuel savings, 24 hour reliable power supply and quiet, non-polluting operation.

A funding support program that continues to provide a financial incentive in off-grid markets is essential for further market development at this stage of development. This financial incentive needs to capture the additional values of utilising off-grid and small-grid PV systems over diesel technology.

PV in off-grid applications is currently disadvantaged through the operation of subsidised pricing for customers supplied through remote grids, particularly in Queensland, NT and WA. In addition, changes to the fuel excise arrangements, proposed in the Prime Minister's 2004 Energy Statement,[11] will mean that all power generation outside metropolitan areas will be able to use diesel and other petroleum products excise free. This undermines the competitive position of PV, is counter to the government's own RRPGP program, and serves to increase Australia's dependence on imported fossil fuels.

To deliver the 'Sunrise vision' for off-grid applications the following measures are required:

- → Diesel used for public generation should continue to accrue excise. This brings it into line with diesel used in metropolitan areas and recognises the adverse environmental, security of supply and balance of payments impacts that comes from reliance on imported petroleum products.
- → Customers in remote areas, not connected to public grids, who chose to install renewable energy rather than rely on diesel, should be able to internalise the value of the excise that would have been paid had the system been in metropolitan areas.
- → Governments should progressively introduce more cost-reflective and transparent pricing practices for remote consumers. There also needs to be a requirement for retailers to charge regionally appropriate prices, and offer rebates to consumers who install renewable energy systems equivalent to the difference between the full cost of supplying that customer and the uniform price actually paid by the customer.

3. Facilitating exports

There are significant opportunities for Australia to increase the export of products, systems and services in line with expertise in off-grid PV. There will be additional opportunities in the future, as the industry increases its expertise in the on-grid PV market. These opportunities are outlined in more detail in Chapter 6.

Initiatives which would assist in the development of export markets include the following:

- → Increase access to international aid programs by proving funding assistance to support the employment of industry experts to promote Australian capabilities overseas, and to identify and disseminate overseas opportunities locally.
- → PV to be included in Australian Aid projects in recognition that health care, education, capacity building and other development objectives are facilitated by the provision of cost-effective local energy supply options. PV systems in particular can play a key role in delivering these.
- → Assistance to utilise Australian bilateral agreements to leverage opportunities for market development and industry collaboration.
- → Facilitate greater participation in international collaborative programs, including more comprehensive participation in the IEA PVPS activities, as well as accessing the collaborative R,D&D programs of the European Commission. This includes additional resources to compliment existing industry self-funding.
- → Assistance to build Australian industry capacity to export. Existing networks, such as AREEN, need to be strengthened to allow for a full-time person seconded from industry to support capacity building and market development.

The above measures provide a comprehensive framework to deliver on the potential of PV and ensure that the 'Sunrise vision' is achieved by 2010.

The Prime Minister's Energy Statement included a number of measures that will have implications for achieving the Sunrise vision. The key initiatives to impact on the PV industry are:

- → The $75 million Solar Cities initiative will provide a limited opportunity for deployment of PV in some locations. However, it is only a short-term measure and limited in its application.
- → The $100 million Renewable Energy Development Initiative has the potential to assist in building industry capability and capacity and could also provide assistance in the development of domestic and export market opportunities.
- → The removal of excise from fuels used for power generation in non-metropolitan areas will reduce the competitive position of PV in the stand-alone power market, which had been the traditional market for PV in Australia and in export markets.

These measures, while providing some limited assistance towards achieving the Sunrise targets, do not obviate the need for a strategic industry development policy framework that can underpin long-term investment.

8// **CREATING THE DRIVERS** FOR INNOVATION

The PV Roadmap is a means of defining where in the innovation cycle the Australian PV industry currently sits and of identifying what now needs to be done, who should do it and who should fund it. The history of PV R&D in Australia has been discussed in Passey et al[1] and in previous chapters, and the issues facing commercialisation of PV technologies have been covered separately by Watt[2]. However, the new and expanded markets which the PV industry wishes to pursue over the coming decades will need a combination of technical, market and policy innovation in order to achieve successful diffusion.

This Roadmap takes into account the discussions about the respective roles of government and the private sector in stimulating investment in science, R&D, skills and the commercialisation of good ideas, as outlined in *Backing Australia's Ability*[3]. In particular, it looked at the initiatives already in place to stimulate innovation in the business sector (as well as the new programs outlines in the June 2004 Prime Minister's Energy Statement), stimulating interaction and transferring ideas, and the commercialisation of these ideas.

The Renewable Energy Technology Roadmap[4] identified Innovation Priorities for Australia's renewable energy technologies. The priority view was that there is a need to consolidate and refine Australia's strengths in renewable energy. This is also the conclusion from this PV Roadmap consultation process, with similar views being expressed for R&D, commercialisation, and a market focus on solutions (rather than technology for technology's sake), The one area of major differentiation is in identifying long-term, transparent policy support from government as a turn-key mechanism in delivering the 'Sunrise vision'. This joined-upon thinking between government and industry is necessary in order to create the right investment environment, which will in turn stimulate innovation in R&D, product design and delivery, and streamlining services. Other area of differentiation between the two Roadmaps is in identifying the need for demonstration, in order to mitigate some of the real and perceived risks associated with supporting new technologies, applications, and start-up companies.

Policy support

PV research has been supported over the past two decades by various government research, development and commercialisation programs. However, there has been no overall or coordinated PV research strategy for Australia. The PV research group at the University of NSW has gained a significant advantage over other groups by being awarded successive Australian Research Council (ARC) grants. This has been key to the establishment and maintenance of their infrastructure and research teams necessary for successful outcomes. However, it has often meant that funding agencies have had to choose between continued funding of this Centre and funding for worthy proposals by other research groups.

At the industry level, international developments in manufacturing and applications are now moving very rapidly. PV is an international commodity and the market is very competitive. Countries such as Japan and the Netherlands have had twenty year strategic plans for PV, and Japan now dominates the world market. It is within this context that Australian companies are now making decisions about manufacturing and commercialising Australian PV developments. Government development programs in the past have operated within a policy framework which has given no clear indication of Australia's long term commitment to PV at a government level. Hence they have tended to result in boom – bust cycles, with little longer term industry development.

Photon science and technology, including photovoltaics, has recently been added to the ARC's priority research list and clean energy generally is now one of the key focus areas of the government's innovation strategy. The PV sector must use these listings as the basis for seeking specific commitments for action on a number of fronts:

Strategic industry status

If Australia is to maintain its presence in the burgeoning PV sector, it should now be looking to establishing PV as a strategic industry sector. Such status would be a clear indication of Australia's long term commitment to both the development and the application of PV, which in turn would provide confidence and reduce uncertainty amongst research groups, potential industry partners, investors and end-users. This status should be:

→ Reflected in Australia's long-term energy strategy.

→ Used as the background for specific market expansion targets, via MRET or other mechanisms.

→ Recognised in energy regulations at Local, State and Commonwealth levels.

→ Used to encourage an increased interest in PV by the financial sector and hence ease the difficulties of raising capital currently experienced by new PV entrants.

→ Used to argue for preferential R&D tax incentives for industry.

PV R,D&D Fund

Strategic industry status should be accompanied by the establishment of a research, development, demonstration (R,D&D) and commercialisation framework for PV, with funding and joint administration shared between the Commonwealth Government (both ARC and the recently announced renewable energy R&D fund), State governments and industry. This would facilitate:

- → Technology transfer from researchers to industry, which has been identified internationally as one of the most difficult stages in the innovation cycle. Joint industry/research efforts, such as the US PVMaT program have been successful in allowing both competitive research funding and successful industry take-up of research outcomes.
- → Development of several research groups with the ability to focus long-term on a range of strategic technologies and markets.
- → A more co-ordinated approach to the establishment of research facilities, instead of competing with each other for scarce funds.
- → An increased emphasis on research into applications, balance of system components and consumer requirements. These areas have been highlighted as critical to the successful deployment of PV, but have received relatively little funding support in the past, because ARC funding tends to be focussed at the research rather than the application end of the innovation chain.
- → Establishment of a Cooperative Research Centre for solar energy, to further facilitate the long-term collaboration between industry, universities and government agencies.

Technical innovation

The PV industry has seen important Australian technical innovations over the past three decades, in research, off-grid applications, industry development and export markets. Australian researchers have led the world in crystalline silicon cell efficiencies for over a decade, with an Australian invention, the 'Saturn' cell, being the most successful new crystalline silicon cell technology to be commercialised world-wide over the past decade. Australia is also at the forefront of DSC technology developments. Australia pioneered the large-scale use of photovoltaics for telecommunications, remote signalling and remote area power supply, while its expertise in manufacturing, system design and technical training are world-recognised. This wide ranging expert base has taken decades to establish and represents valuable intellectual capital for Australia.

Despite its 20 year history, PV is still an emerging industry, and developments are now rapid. If Australia is to maintain and capitalise on its PV investments, it must ensure that its own market allows for continued innovation and accelerated application of PV, and that it is able keep its place in the international arena. Continued innovation is necessary to:

- → Better service growing markets.
- → Capture new markets.
- → Improve products and delivery.
- → Reduce costs.
- → Meet new implementation challenges.
- → Develop new products.

For society more generally, the platform needs to be developed now to enable a choice of energy futures.

Technology innovation in itself is not, however, sufficient for successful PV diffusion. Haas[5] has found that it requires a combination of technology development, social acceptance, market development and customer awareness, as illustrated in Figure 8.1.

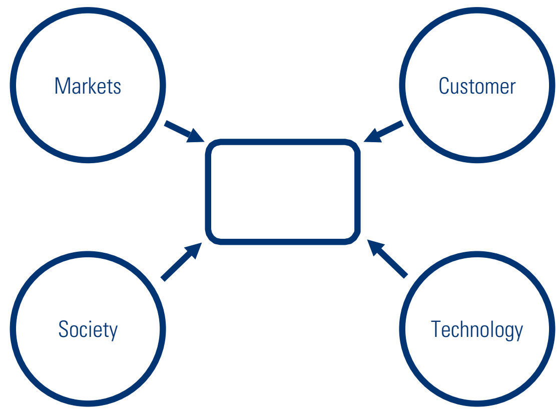


Figure 8.1 Components essential to successful PV diffusion
Source, Haas, IR, 2002[6]

For PV technology specifically, innovation can be broadly defined as part of a cycle comprising:

- → Invention – demonstrating the feasibility of an idea.
- → Innovation, developing applications for the invention, new or improved products or processes.
- → Commercialisation.
- → Diffusion, adoption of the innovation by the wider community.

Adoption leads to new requirements and solutions, which then need invention and innovation, thus continuing the cycle.

Hence, it is important to ensure that all stages of the cycle are acknowledged and supported. Most importantly for the current development phase for Australian PV technology, it is essential that a feedback cycle be established between end-users of PV (existing and potential) and the inventors and innovators. To date, researchers and industry have followed a more linear, or 'technology push' approach. The Industry Commission refers to this as the 'First Generation Innovation Model'. More recent analysis has stressed that innovation involves much more than R&D – such as the integration between R&D, manufacturing and marketing inputs, the importance of strong linkages with suppliers and leading edge customers, and the use of collaborative research and marketing arrangements.[7]

In Australia, some PV markets have been developed more than others, notably off-grid applications. However, the needs of each market sector are different, and the following section contains more detailed discussion of innovation requirements.

Financial innovation

One of the initiatives of the Renewable Energy Action Agenda[8] is to improve access to investment capital and consumer finance to support the growth of the renewable energy industry. There are already some instances in Queensland of financial organisations providing mortgages and low-rate loans to fund the purchase of solar hot water systems. This could be extended to PV systems, and other innovative financing packages developed to better serve both the off-grid and grid-connect domestic markets in particular. KfW in Germany and a number of financial institutions in the USA support the deployment of PV systems through the provision of preferential loans to PV costumers applying for subsidies.

Elsewhere, such as in the UK and other countries in Europe, project financing is provided for renewable energy projects primarily by private sector organisations. These projects have usually been recipient to subsidies or other schemes supported by the national government, which helps mitigate the risk of investment for private investors, such as the Renewables Obligation in the UK.[9]

If there were a strong, transparent and long-term renewable energy government policy and industry development support scheme for renewable energy, then there would be a natural flow-on of innovation in financing arrangements for PV projects, at both a consumer and project level.

Innovation requirements by market sector

Off-grid residential

While this sector is reasonably well-established across Australia, there is still a need for cost reduction and improved system design, operation and after-sales servicing. This is especially necessary if the market is to grow to its full potential in Australia and have a competitive advantage in overseas markets. Continued standardisation of products and systems is required, including pre-delivery factory testing. To gain consumer confidence, attractive, well-designed systems which are easy to order and install are essential. While a PV module is rarely the cause of problems, continued product development is required to improve reliability, efficiency and robustness of complete systems, including components such as inverters, batteries, regulators, maximum power point trackers, interconnects and switches. Building-integrated products, described under grid-connected systems, will also be relevant for off-grid users, but should be well-proven in urban areas before deployment in remote locations.

Specific innovation and activity requirements for this sector include:

- → Improve component and system standardisation, in order to reduce unit cost and improve reliability and ease of installation.
- → Develop financing options with lending institutions to overcome the barrier of high upfront capital costs (versus lower upfront costs for diesel generators but higher running costs and higher overall costs during the life-time of the system).
- → Monitor real time system performance for feedback to designers and developers via collaboration with academic institutions.
- → Production of 'easy to understand' information packs, covering technical and financial matters, and added value benefits of PV systems.
- → Continue investment in expanding and extending system and component testing.
- → Continue participation in of the development Australian Standards.

On-grid residential, including building-integrated PV

This has been the fastest growing PV market sector internationally, but has only recently gained momentum in Australia, supported by a government grant program which is due to end in the first quarter of 2005 (PVRP). In Australia's competitive electricity market, many of the strategies used internationally to support growth in this market are difficult to implement. Hence both new products and new marketing strategies need to be deployed. New systems have been developed to target this market over the past few years, but they have typically involved packaging of conventional modules, rather than development of new products.

Specific innovation and activity requirements for this sector include:

- → Development of new building products, suitable for standard integration into the building envelope of commercial, industrial, community and residential buildings.
- → Continued investment in research and development to improve system performance, and component and product standardisation, in order to lower cost per kWh of system output.
- → Work with housing developers to achieve economies of scale and increase public awareness of PV systems. Such initiative would include ensuring that houses are built with north facing aspects, and that PV roof systems are one of the standard options for project homes.
- → Development of financing options with lending institutions to overcome the barrier of initial capital costs.
- → Improved system packaging and integration to deliver standardised lower installed costs.
- → Continue the development of Standards, training and accreditation of designers and installers of PV systems.
- → Continue to invest in development of process and control equipment to optimise system performance.
- → Continue work to promote the benefits that PV delivers, and seek to get these recognised and rewarded in the electricity market.
- → Establish networks and partnerships with architects and engineers to inform them about building integrated PV (BIPV), recognising the benefits, such as displacing some costs of the building envelope as well as contributing to the overall functionality of the building.
- → Develop linkages with energy efficiency practitioners to provide a more financially attractive outcome by reducing the energy consumption within a building in the first instance, thus influencing the capital impact of PV and the overall energy consumption of the building.
- → Provide information on building integration, solar access requirements and PV solutions to building information centres, local government centres and community groups.
- → Develop new market sectors and associated products, such as PV carports, conservatories and window shades, which provide dual values and hence spread the capital cost amongst different functions.
- → Support the widespread use of 'smart meters', and make data available to education institutions for system performance analysis and information dissemination.
- → Develop innovating hardware and software packages for use by schools and community centres to increase public awareness and information.
- → Improve BOS specifications for various Australian conditions. This will affect the total energy output of the system, and its global competitiveness.
- → Continue investment in system and component testing.
- → Establish linkages with electricity distributors to develop solutions that realise the benefit of distributed PV generation.

Off-grid industrial, including diesel grids

This is the best established market in Australia, and future installations in the telecommunication sector in particular will be reliant mainly on the replacement market or major new infrastructure developments. The water pumping market has been increasing strongly via the RRPGP and there is still a large potential market for diesel replacement in roadhouses and remote communities, including islands, and the mining sector. Both flat plate and concentrator PV systems are now being deployed in such applications. Assisted by the potentially significant RRPGP funding available over the coming decade, this will be a key PV market, albeit tempered by recent announcements to remove diesel fuel excise from power generation facilities. Developments in this market also have potentially large applications into export markets.

Specific innovation and activity requirements for this sector include:

- → Develop packages that improve particularly remote monitoring of system performance and maintenance requirements.
- → Disseminate information gained from monitoring systems to educate potential new owner/operators of operating parameters and real savings provided by PV systems over system life-time.
- → Work with the financial sector to develop suitable financing packages.
- → Develop information packs on the benefits of interactive inverters and batteries for diesel grids as an alternative to diesel upgrades or multiple-sized generating sets.
- → Improve system packaging, integration and installation to deliver lower overall costs.

- Continue the development of Standards and training of designers and installers of such PV systems.
- Continue investment in expanding and extending system and component testing.
- Continue to invest in development of process and control equipment to optimise system performance.

Centralised grid-connected systems

Australia has only four central grid-connected PV systems of 'reasonable' size, these being 400 kW at Singleton, 50 kW at Queanbeyan and Dubbo, plus the circa 200 kW roof top system on the Queen Victoria Market in Melbourne. The centralised grid-connected market is gaining interest internationally, and Australia may be well-placed to develop key aspects of new technical approaches. Australia may also serve as a site for internationally funded installations, if emission trading schemes are established.

There is also considerable experience from the 20 kWp tracking system at Kalbarri site, in Western Australia, which was installed to provide grid support to the 'end' of a long power line.

Specific innovation and requirements for this sector include:

- Develop linkages with electricity distributors on the deployment of PV, with or without storage, for line support and peak load shaving.
- Support academic institutions in the monitoring and analysis of installed systems.
- Develop rapid deployment products for large-scale systems.
- Continued investment in research and development to improve system performance and lower cost per kWh of system output.
- Work with local authorities to obtain feedback on regional grid conditions and opportunities for PV.
- Continue to invest in development of process and control equipment to optimise system performance.
- Continue investment in system and component testing.
- Develop new market sectors where there are existing structures, such as PV car parks, sports facility roofs, industrial rooftops, etc., to spread the capital cost across multi-functional applications.

PV-powered garden light

Small portable devices

This market has been one of steady growth, with current international sales of 10 MW er annum. This is a market with the potential for very high growth as wireless devices become universal, because PV offers the possibility of wireless power to match the wireless communication. For Australia to stake a claim in this market sector, it will be necessary to proceed with:

- Development of suitable cell technologies, which work well in low light conditions (e.g. indoors), such as DSC.
- Undertaking R&D into duel function devices, such as the CEGS (combined energy generation and storage) devices underdevelopment at STI.
- Develop strategic alliances with the overseas major manufactures of wireless devices.
- Develop business models which ensure fair returns to Australia when overseas manufacture is necessary.
- Continue investment in product testing.
- New products and new market applications.

9// CONCLUSIONS

The PV industry is developing into a multi-billion dollar industry globally, as concerns for the environment and energy security continue to increase, and installed PV costs continue to fall.

In order for Australia to continue to attract a share of the considerable investment being made worldwide in PV, a vibrant national market is required. This can be achieved by a long-term policy framework that gives industry confidence to invest, leverages the growing public concerns for the environment and support for renewable energy, and makes good economic sense.

Such an approach can create a billion dollar PV industry in Australia with significant exports, delivering local jobs and investment, while contributing to significant long-term reductions in Australia's greenhouse emissions.

The Australian PV industry is at the crossroads. Australia was recognised as a world leader in PV a number of years ago, largely driven by the extensive roll-out of PV in off-grid applications – our traditional market.

PV module manufacturing has taken place in Australia since 1976, and we are currently only one of four countries exporting PV modules. We have vast solar resources that are the envy of many Northern Hemisphere countries. Australia has leading PV technologies, world-class researchers, a number of promising start-up companies, and breadth (but not depth) to the existing industry in terms of BOS manufacture, distribution and wholesaling, systems packaging, integration and installation, and export capability.

Our position in the international rankings has however slipped, due to reduced competitive advantages, and we now risk losing our place in this growing and dynamic industry.

Australia's PV industry, like those of other developed countries, has been supported by government support programs. These programs, while they have been ad hoc, have delivered an industry that employs over 1,100 people and has annual sales of over $200 million, of which exports account for over $100 million. Importantly, government support has leveraged increasing domestic sales and as a result installed costs have continued to fall.

Unfortunately the PV industry globally has not yet reached the stage where it can be self-sustaining. Continuing government support is required to build a market that can underpin continued reductions in cost. This Roadmap, therefore, sets out the nature of the government support required and in turn what the industry will do to deliver on the industry potential.

The dividend for Australia in supporting the 'Sunrise vision' is that a sustainable dynamic and vibrant industry will result by 2010, with the following dimensions:

Installed capacity (MW)	350
Employment	5,290
Local sales revenue ($ million)	786
PV sector exports ($ million)	444
CO_2 abated in year ('000 tonnes)	490

Government has in the past made decisions about which industries it will support and develop and those that it will not. Technologies not supported have gone offshore, and other countries have benefited from the IP developed in Australia. We are already starting to see this with the PV industry, and the transfer of the UNSW / Pacific Solar PV cell technology to Germany in 2004.

The 'Sunrise vision' requires government assists industry to remove many of the impediments and barriers to large-scale, economic deployment in Australia. These include the current electricity market impediments, such as lack of efficient time and locational pricing that currently constrain the uptake of PV. Or, until such time that these are rectified needs to implement compensatory measures that reward the benefits provided by the large scale deployment of PV.

This Roadmap for the PV industry thus requires government and industry to work together to implement a strategy which will stimulate long-term growth of the market in Australia, and to leverage the resultant expertise and capacity to build a vibrant export industry. The actions in the Roadmap can be summarised as follows:

Government to provide an industry development framework that supports new investment and includes:

Market stimulation – this addresses specific market impediments that prevent the benefits that PV provide being adequately recognised or rewarded. Market stimulation underpins increased demand by bridging the current cost competitive gap in the key PV markets of off-grid and grid-connect. This includes feed-in tariffs, enhancing the Mandatory Renewable Energy Target, implementing effective building codes and standards, supporting diesel replacement, and providing financial support for strategic market development.

Removal of regulatory barriers – this addresses electricity market impediments that result in increased installation costs and delays arising from metering, connection and pricing arrangements.

Building industry capacity and capability – this includes supporting industry development activities that build local industry capacity and includes support for exports, innovation, training and education.

Australia's PV industry would continue to build on and leverage its investment to date, with specific actions as follows:

Continue to drive installed system costs downwards – undertake investment in manufacturing and research and development to reduce manufacturing costs and improve system performance. Develop new products and installation methods, continue to improve the efficiency of supply channels and improve system packaging and integration.

Continue to improve quality, reliability and performance – continue the development of standards, training and accreditation and investment in expanding and extending system and component testing. Investment in development of process and control equipment to optimise system performance.

Continue to expand and develop products, markets and applications – continue to differentiate service provided by PV and promote the benefits that PV delivers and seeking to get these recognised and rewarded in the market. Continue building consumer awareness and development of product solutions that are valued by different market sectors. Support trade initiatives and the further development of channels and markets overseas.

Support capacity building – continue support for development of training and education infrastructure and international collaboration on research and development, market development and standards.

Australia has the makings of a world class industry. The industry is poised to make the required investment if it is provided with a long term-policy framework that enables PV to compete on its merit and the benefits that it provides are recognised and rewarded.

// NOTES

// Executive summary

1 *Renewable Energy Industry in Australia, BCSE, September 2003 and includes bulk power sales for all renewable power plants including pre-existing hydro projects*

2 *European Photovoltaic Industry Association for the European Commission (1995). Photovoltaics in 2010 (PV2010).*

3 *Watt, M. & Outhred, H. 1999 Electricity Industry Sustainability: Policy Options, ACRE, p. 30*

2// The Australian and international context for photovoltaics

1 *http://www.nrel.gov/ncpv/pdfs/25847X.pdf*

2 *http://paris.fe.uni-lj.si/pvnet/files/Roadmap_Final_1.pdf*

3 *http://www.oja-services.nl/iea-pvps/conference/downloads/s52_kobayashi.pdf*

4 *International Energy Agency, International Energy Agency, Energy Statistics of OECD Countries, 2001–2002 – 2004 Edition, Paris, 2004*

5 *BP Ltd, The BP Statistical Review of World Energy, 2004 , June 2004*

6 *Shell International, Van der Veer, J, Dutch/Shell Group and Dawson: Shell International Renewables, Press Release from Shell International, London, October 1997*

7 *The Shell Report 2003, Meeting the energy challenge, Seventh report of the Royal Dutch/Shell Group of Companies, The Hague, May 2003*

8 *EREC is comprised of the 6 European RE associations, namely EPIA – European Photovoltaic Industry Association, ESHA – European Small Hydropower Association, ESIF – European Solar Industry Federation, EUBIA – European Biomass Industry Association, EWEA – European Wind Energy Association, EUREC Agency – European Renewable Energy Research Centres Agency*

9 *European Renewable Energy Council, Renewable Energy Target for Europe 20% by 2020*

10 *Turton, 2004, for the Institute for Applied Systems Analysis, Laxenburg, Austria*

11 *Graham, Greenhouse Science, what it means for energy, Conference of the Australian Business Council for Sustainable Energy, Sydney, 2004*

12 *Answers to questions by the Minister for Foreign Affairs, the Minister for Trade and their representatives in the Senate, Question without Notice, http://www.dfat.gov.au/qwon/2002/qwn_020627d.html*

13 *Royal Commission on Environmental Pollution, 22nd REPORT: Energy – The Changing Climate, London, June 2000*

14 *Department of Trade and Industry, New & Renewable Energy. Prospects for the 21st Century, London, March 1999*

15 *The Energy Review, A Performance and Innovation Unit Report, Cabinet Office, London, February 2002*

16 *Business Council for Sustainable Energy et al, A Clean Energy Future for Australia, March 2004*

17 *Howard, John, Securing Australia's Energy Future, Commonwealth of Australia, Canberra, 2004*

18 *A Clean Energy Future for Australia, March 2004, ibid*

19 *http://www.detya.gov.au/mapping/pubs/case_studies/photovoltaics.pdf*

3// The Australian PV industry

1 *International Energy Agency, Greenhouse Gas R&D Programme, 'The potential of Solar Electricity to Reduce CO_2 Emissions, Report Number PH4/14', 2003*

2 *Ibid*

3 *Watt, Muriel for the International Energy Agency, Co-operative Programme on Photovoltaic Power Systems, Task 1, National Survey Report of PV Power Applications in Australia 2003, Sydney, June 2004*

4 *International Energy Agency, Trends in Photovoltaic Applications Survey report of selected IEA countries between 1992 & 2002, Report IEA-PVPS t1-12:2003*

5 *Greenpeace and the European Photovoltaic Industry Association, Solar Generation, 2002*

4// The PV market

1 *Watt, Muriel for the International Energy Agency, Co-operative Programme on Photovoltaic Power Systems, Task 1, June 2004*

2 *International Energy Agency Photovoltaic Power Systems Programme (2003). Trends in Photovoltaic Applications: Survey Report of Selected IEA Countries between 1992 and 2002. IEA-PVPS*

3 *Okumoto, Nami, Outline of New and Renewable Energy Policy in Japan, Ministry of Economy, Trade and Industry, Tokyo, May 2004; http://www.eere.energy.gov/ US DOE Energy Efficiency and Renewable Energy (EERE) home page*

4 *European Photovoltaic Industry Association for the European Commission (1995). Photovoltaics in 2010 (PV2010)*

5 *Watt, M. & Outhred, H. 1999 Electricity Industry Sustainability: Policy Options, ACRE, p.30*

6 *National Renewable Energy Laboratory, PV Manufacturing R&D Program (PVMaT), hppt://www.nrel.gov/pvmat/ downloaded June 2004*

7 *The Berlin European Conference for Renewable Energy 'Intelligent Policy Options', June 2004*

8 *www.erec-renewables.org, June 2004*

9 *Jager-Waldau, A., PV Status Report 2003. Research, Solar Cell Production and Market Implementation in Japan, US and the European Union', European Commission JRC, 2003*

10 *Energy Strategies, ACRE, CAT, GSES, Assessment of Diesel Use in Remote Area Power Supply, Australian Greenhouse Office, 1999*

11 *Assumes 2.5% of 7 million households and average 3–5 kW PV–SPS system*

12 *Potential for Building Integrated Photovoltaics Report IEA T7-4: 2001*

13 *National Electricity Market Management Company, 2003 Statement of Opportunity for the National Electricity Market, 2003*

14 *Watt, M., Oliphant, M. et al, Using PV to Meet Peak Summer Electricity Loads, 2003*

15 *EcoGeneration, October/November 2003*

16 *Watt, M. (2001), Added Values of Photovoltaic Power Systems, Report IEA-PVPS, March 2001*

17 *Gutschner, M., Potential for Building Integrated Photovoltaics, IEA-PVPS Task 7, July 2002*

18 *Watt, ibid*

19 *Howard, John, Securing Australia's Energy Future, Commonwealth of Australia, Canberra, 2004*

5// What is the potential of the Australian PV Industry?

1 *In most cases this will be the retail price since PV electricity mostly competes at the retail level rather than the wholesale level*

2 *Assumes 30,000 to 40,000 off-grid residences (holiday homes, pastoral stations and small indigenous communities) and average 5 kW PV SPS system. Note that under current support mechanisms, off-grid residences are eligible for PVRP support to a maximum of 1.0 kW and the average off-grid domestic system size is 1 kWp. Watt, M. National Survey Report of PV Applications in Australia, 2002*

3 *Energy Strategies et al, 'Assessment of Diesel Use in Remote Area Power Supply', 1999*

4 *Assumes 2.5% of 7 million households located in viable fringe-grid locations and average 3–5 kW PV SPS system. This acknowledges that competing technologies (particularly small wind and micro-hydro generators) would probably be a more cost-effective solution for some 30% of this theoretical potential*

5 *Assumes 7 million households each with 1.5kW grid-connected PV. Note that as PV prices fall, particularly beyond 2015/2020 when PV electricity is competitive with grid-supplied electricity, the incentive will be to install larger systems, in the order of 3–5kW to offset more of the contribution from the grid – i.e. the potential market in this market sector could be 2–3 times greater than indicated*

6 *The medium hydrogen scenario assumes hydrogen penetration to support 10% of transport energy requirements and 3% of distributed generation. National Hydrogen Study, A report prepared by ACIL Tasman and Parsons Brinckerhoff for the Department of Industry, Tourism and Resources, Canberra, 2003*

6// Export markets

1 *European Renewable Energy Exports Council, Export Strategy, Brussels, 2004*
2 *PV News, Feb 2004*
3 *Gregory, J A et al, Financing Renewable Energy Systems, A Guide for Development Workers, London, 1996*
4 *Philippines Rural Power Project, World Bank Project ID P066397*
5 *Solaraccess, May 24 2004*
6 *Ministry of Non-Conventional Energy Sources website, http://www.mnes.nic.in/ downloaded May 2004*
7 *World Bank Report 23887-BD May 2002: Project Appraisal Document – Bangladesh*
8 *Asian Development Bank, PPTA: PAK34339-0*
9 *http://www.ausaid.gov.au/about/objective.cfm*
10 *WSLIC II is a six-year, US$ 106 million project funded through grant assistance from Australia, the IDA, the Indonesian Government and the beneficiaries themselves. This project aims to improve the health status, productivity and quality of life of poor communities in under-served rural villages in the project provinces. http://www.indo.ausaid.gov.au/projects/wslic.html*
11 *http://www.reeep.org/*
12 *http://www.iea-pvps.org/*
13 *http://www.oja-services.nl/iea-pvps/tasks/index.htm*
14 *Please note: whilst the opportunities identified in this section relate to expanding PV exports, many of the initiatives would also relate to increasing exports for other renewable energy technologies*
15 *http://www.dti.gov.uk/energy/renewables/renewables_uk/trade_promoters.shtml*
16 *GTZ is an enterprise for international cooperation with worldwide operations. On behalf of the German government, GTZ also offers its know-how and services in international markets on a commercial basis. http://www.gtz.de/*

7// The way forward for the Australian PV industry

1 *Okumoto, Nami, Outline of New and Renewable Energy Policy in Japan, Ministry of Economy, Trade and Industry, Tokyo, May 2004*
2 *Photon International, March 2004*
3 *International Energy Agency/OECD, Experience Curves for Energy Technology Policy, Paris,*
4 *Okumoto, ibid; Agency for Natural Resources and Energy, 'Energy in Japan', www.enecho.meti.gov.jp*
5 *Kurokawa, Kossuke and Aratani, Fukuo, Perceived Technical Issues Accompanying Large PV Development and Japanese 'PV2030', 19th EU-PVSEC, Paris June 2004*
6 *Okumoto, ibid*
7 *National Emission Trading, Crediting the Carbon, Discussion paper 3, Australian Greenhouse Office, October 1999*
8 *Current consumer price for a 1 kW PV system is $12,200*
9 *Solabuzz, FAST SOLAR ENERGY FACTS, http://www.solarbuzz.com/FastFactsGermany.htm, downloaded July 2004*
10 *Renewable Energy World, May–June 2004*
11 *Howard, ibid*

8// Creating the drivers for innovation

1 *Passey, Robert, Watt, Muriel & Collins, Richard, Review of Government Support for Photovoltaics in Australia, ACRE Policy Group, March 2003*
2 *Watt, M., The Commercialisation of Photovoltaics Research in Australia, University of NSW, Sydney, 2003*
3 *Backing Australia's Ability, Real Results, Real Jobs, The Government's Innovation Report 2001–2002, Canberra, 2003*
4 *Australian Business Council for Sustainable Energy, ACRE, Australian Greenhouse Office, Industry, Tourism, Resources, Renewable Energy Technology Roadmap, Commonwealth of Australia, October 2002*
5 *Haas, R., Building PV Markets – Customers and Prices, Renewable Energy World. May–June 2002*
6 *Ibid*
7 *Australian Chamber of Commerce and Industry, Innovation: Leading Australian Business, Kingston, 2003*
8 *www.industry.gov.au/agendas*
9 *The Renewables Obligation, introduced by the UK in 2002, is similar to Australia's Mandatory Renewable Energy Target, in that it places an obligation on electricity suppliers to source an increasing proportion of generation from renewable energy sources. It was one of the major recommendations from the RCEP provides a stable and long-term market for renewable energy, remaining in place until 2027. Yearly targets have been set up to the 2010/2011 period. http://www.dti.gov.uk/energy/renewables/policy/renewables_obligation.shtml*

// REFERENCES

'Addressing peak demand', EcoGeneration, Issue 20, October/November 2003

Agency for Natural Resources and Energy, Energy in Japan, hppt://www.enecho.meti.gov.jp

Aitken, D, W., Transitioning to a renewable energy future, The International Solar Energy Society, Freiburg, 2003

Australian Business Council for Sustainable Energy, ACRE, Australian Greenhouse Office, Industry, Tourism, Resources, Renewable energy technology roadmap, Commonwealth of Australia, October 2002

Australian Business Council for Sustainable Energy et al, A clean energy future for Australia, March 2004

Australian Business Council for Sustainable Energy, Background paper on the PV industry in Australia, Carlton, February 2003

Australian Chamber of Commerce and Industry, Innovation: leading Australian business, Kingston, 2003, downloaded June 2004 from http://www.acci.asn.au/text_files/policies/Innovation_2003.pdf

Australian Greenhouse Office, National Emissions Trading, Creating the Carbon, Canberra, 1999

'Backing Australia's ability, real results, real jobs', The Government's innovation report 2001–2002, Canberra, 2003

Bell J, J., A survey of Canadian policies to compensate small power producers for electricity fed to the grid: net metering and net billing, 2003.

BP Solar, BP Solar Australia's MRET submission, 2003

BP, The BP Statistical review of World Energy 2004, June 2004. http://www.bp.com/statisticalreview2004

'Bringing solar within everyone's reach', EcoGeneration, Issue 16, February/March 2003

Charles River Associates for Integral Energy, Impact of air conditioning on integral energy's network, Melbourne, May 2003

Department for Trade and Industry, Renewables obligation, http://www.dti.gov.uk/energy/renewables/policy/renewables_obligation.shtml, downloaded May 2004

Department of Trade and Industry, New & renewable energy – prospects for the 21st century, London, March 1999. Available from www.dti.gov.uk/renew/condoc

Downer, Alexander, Answers to questions by the Minister for Foreign Affairs, the Minister for Trade and their representatives in the Senate, Question without Notice, http://www.dfat.gov.au/qwon/2002/qwn_020627d.html

Dunn, S. ,'Micropower – changing the landscape of power production' Renewable Energy World, November–December, 2000.

Ellis, Mark & Associates, Economic oerformance and contribution of the sustainable energy industry 2002, Australia and Victoria, Lilyfield, Sept 2002

Endo, Eiichi and Tamura, Yoshihiko, Cost-effectiveness analysis of R&D on solar cells in Japan, Summary for the International PVSEC-12, Japan, 2004

Energetics, US Photovoltaic Industry, PV industry roadmap workshop, Illinois, September 1999.

Energy Strategies, ACRE, CAT, GSES, Assessment of diesel use in remote area power Ssupply, Australian Greenhouse Office, 1999

Environmental finance news, June 2003, http://www.environmental-finance.com/2003/0306jun/news.htm#jn7

ESTIR, Scientific and technological references energy technology indicators, September, 2002.

EurObserv'ER / European Renewable Energy Centres Agency (EUREC Agency), Photovoltaic energy barometer 2003, Brussels, 2003, http://www.eurec.be/projects/RE_barometer.htm

European Photovoltaics Industry Association, Solarelectricity in 2010. Building on a decade of industrial and political commitment, Brussels, 2004.

European Renewable Energy Council, Export strategy, Brussels, 2004

European Renewable Energy Council, Renewable energy scenario to 2040. Half of the global energy supply from renewables in 2040, Brussels, 2004.

European Renewable Energy Council, Renewable energy target for Europe, 20 per cent by 2020, Brussels 2004

G8 Renewable Energy Task Force, Chairman's report, July 2001

Greenpeace and the European photovoltaic Industry Association, Solar Generation, 2002

Gregory, Jenniy et al., Financing renewable energy projects, A guide for development workers, IT Publications, London, 1996

Gutschner, M., Potential for building integrated photovoltaics, IEA-PVPS Task 7, July 2002

Haas, R, Market deployment strategies for PV systems in the built environment, An evaluation of incentives, support programmes and marketing activities, IEA-PVPS Task 7, September 2002

Haas, R., 'Building PV markets – customers and prices', Renewable Energy World, May–June 2002

Howard, John, Securing Australia's energy future, Department of the Prime Minister and Cabinet, Commonwealth of Australia, Canberra, 2004.

Ingrouille, Stephen, Introduction to photovoltaic technology and applications and a brief history of photovoltaics in Australia, Carlton, May 2004.

International Energy Agency, Greenhouse gas R&D programme, The potential of solar eectricity to reduce CO_2 emissions, Report number PH4/14, March 2003

International Energy Agency, Energy statistics of OECD countries, 2001–2002, 2004 Edition, Paris, 2004

International Energy Agency, Environmental benefits of renewables in the power sector, http://www.iea.org/pubs/studies/files/benign/full/06-bene.htm

International Energy Agency, Renewable energy – market and policy trends in IEA countries, Paris, 2004.

International Energy Agency, Renewables information – 2003 edition, Paris, 2003

International Energy Agency, Trends in photovoltaic applications, survey report of selected IEA countries between 1992 & 2002, Report IEA-PVPS t1-12:2003.

International Energy Agency/OECD, Experience curves for energy technology policy, Paris, 2000 http://www.iea.org/public/studies/curves.htm

International Energy Agency/OECD, Experience curves for energy technology policy, Paris, 2000

Jager-Waldau, A., PV status report 2003. Research, solar cell production and market implementation in Japan, US and the European Union', European Commission JRC, 2003

Jawetz, Pincas et al for the e7, Renewable energy technology diffusion, Final Report, USA 2003

Kurokawa, Kossuke and Aratani, Fukuo, Perceived technical issues accompanying large PV development and Japanese 'PV2030', 19th EU-PVSEC, Paris June 2004

Little, Arthur D., Potential cost reduction in PV systems, ETSU for the Department of Trade and Industry, London 2001.

Lorentzen, J., The role of certificate systems in supporting the development of renewable energy in the EU, European Commission, Brussels, 2003 .

MacGill, I. Passey R. Watt, M., Australian renewable energy case studies – Draft October. The Australian CRC for Renewable Energy Policy Group, 2001.

MacGill, Iain, Passey, Rob & Watt, Muriel, The economic development and job creation potential of renewable energy, Australian Case Studies, ACRE Policy Group, October 2001

Mandatory Renewable Energy Target Review – Renewable opportunities, a review of the operation of the Renewable Energy Electricity Act (2000), http://www.mretreview.gov.au/report/index.html

Maycock, P. (ed), Photovoltaic news. Volume 23 No.3 March, PV Energy Systems Inc, Virginia, 2004.

Mott Macdonald for the UK Department of Trade and Industry, Renewable supply chain gap analysis, Summary report, London, January 2004

Muriel Watt and Iain MacGill, PV research and development in Australia – where to from here? Proceedings of the National Conference and Exhibition of the Australian Business Council for Sustainable Energy, Brisbane, April 2003..

National Energy Market Management Company, 2003 Statement of Opportunities for the National Electricity Market, Mansfield, 2003

National Hydrogen Study, A report prepared by ACIL Tasman and Parsons Brinckerhoff for the Department of Industry, Tourism and Resources, Canberra, 2003

National Institute of Advanced Industrial Science and Technology, Cost-effectiveness analysis of R&D on solar cells in Japan, retrieved March 2004, http://www.aist.go.jp/ETL/etl/divisions/~6436/index-e.html

National Renewable Energy Laboratory, PV manufacturing R&D program (PVMaT), http://www.nrel.gov/pvmat/pvmat_frame.shtml?pvmatoverview.html, downloaded June 2004

Niermeijer, P., Demand for RECS certificates, Salzburg, 2003.

Okumoto, Nami, Outline of new and renewable energy policy in Japan, Ministry of Economy, Trade and Industry, Tokyo, May 2004

Passey, Robert, Watt, Muriel & Collins, Richard, Review of government support for photovoltaics in Australia, ACRE Policy Group, March 2003

Peak lopping for diesel mini-grids, PV power, IEA PVPS newsletter, Issue 19, December 2003

Pearman, Graham, Greenhouse science, what it means for energy, Conference of the Australian Business Council for Sustainable Energy, Sydney, 2004

Prasad, Deo and Snow, Mark, Designing with solar power, A source book for building integrated photovoltaics (BIPV), IEA-PVPS Task 7, May 2004

REEP – IEA and REEEP, Putting efficiency at the heart of sustainable energy, http://www.reeep.org/index.cfm?articleid=765

Refocus, Jan/Feb 2003, International Solar Energy Society.

Renewable energy action agenda, third implementation report, Australian Business Council for Sustainable Energy and the Department for Industry, Tourism and Resources, Carlton, 2003

Renewable Energy World, May–June 2004

Rogel, M., Tipping Point. Will Japan become the first mass market for solar power. Cambridge Energy Research Associates, Massachusetts, 2004.

Royal Commission on Environmental Pollution, 22nd REPORT: Energy – the changing climate, presented to Parliament by Command of Her Majesty, London, June 2000, http://www.rcep.org.uk/

Solar Catalyst Group, Solar opportunity assessment report, Washington DC, 2003

Solarbuzz, Fast solar energy facts, http://www.solarbuzz.com/FastFactsGermany.htm, downloaded July 2004

Solarbuzz, Solar module price highlights – March 2004, http://www.solarbuzz.com/ModulePrices

'Solar power – the next silicon rising star', EcoGeneration, Issue 16, February/March 2003

Soros, P., Summary of AusIndustry products, version 7.2, 2004

Takeshita, Mitura, Sustainable Energy and the Global Environment – Japan's response, presentation, NEDO, Sydney, 2003

The energy review, A performance and innovation unit report, Cabinet Office, London, February 2002

The Shell report 2003, Meeting the energy challenge – our progress in contributing to sustainable development, Seventh report of the Royal Dutch/Shell Group of Companies on their progress in contributing to sustainable development, The Hague, May 2003.

Turton, H., Greenhouse gas emissions in industrialised countries. Where does Australia stand? Discussion paper number 66, The Australia Institute, 2004

United Nations Development Program, World energy assessment – energy and the challenges of sustainability, New York, 2000

United Nations Development Program, World energy assessment, energy and the challenge of sustainability, New York, 2000

Van der Veer, J, Dutch/Shell Group and Dawson: Shell international renewables, Press release from Shell International, London, October 1997

Watt, M, Added values of photovoltaic power systems, Report IEA-PVPS T1-09:2001, International Energy Agency, March 2001

Watt, M., The commercialisation of photovoltaics research in Australia, a report for science and innovation mapping for DEST, University of NSW, Sydney, September 2003

Watt, M. Oliphant, H. Outhred and R. Collins, Using PV to meet peak summer electricity loads, ANZSES conference, Melbourne, 2003.

Watt, M., Co-operative programme on photovoltaic power systems, University of NSW, Sydney, 2003.

Watt, M., The value of PV in summer peaks, University of NSW, Sydney, 2004.

Watt, Muriel for the International Energy Agency, Co-operative programme on photovoltaic power systems, Task 1, National survey report of PV power applications in Australia 2003, Sydney, June 2004

// WEBSITES

http://energy.sourceguides.com/businesses/index.shtml Renewable Energy Businesses in the World.

http://www.aseanenergy.org/pressea/thailand/countryprofile/renewable_energy_sources.htm PRESSEA Thailand – Country Profile Renewable Energy Sources

http://www.ausaid.gov.au/country/default.cfm AusAID Country Programs

http://www.cordis.lu/eesd/src/indicators.htm CORDIS EESD Library Scientific and Technological References – Energy Technology Indicators

http://www.cordis.lu/eesd/src/proj_eng.htm CORDIS EESD Funded Projects Part B Energy

http://www.creia.net/ Chinese Renewable Energy Industry Association

http://www.daws.com.au/Projects/Denham.html Diesel and Wind Systems, Denham, WA

http://www.dti.gov.uk/ Department of Trade and Industry Homepage

http://www.dti.gov.uk/energy/inform/energy_stats/renewables/index.shtml DTI Energy Statistics Renewables

http://www.eere.energy.gov/ US DOE Energy Efficiency and Renewable Energy (EERE) Home Page

http://www.eere.energy.gov/state_energy/policy_options.cfm State – Policy Issues What are the Policy Options for Renewable Energy

http://www.eia.doe.gov/cneaf/solar.renewables/page/renewelec.html#rea2001 Renewables in Electricity

http://www.eia.doe.gov/fuelrenewable.html Renewable Energy Data, Tables and Charts

http://www.epia.org European Photovoltaic Industry Association

http://www.eppo.go.th/index-E.html EPPO Energy Policy and Planning Office, Thailand

http://www.erec-renewables.org/berlin2004.htm EREC Events

http://www.eurec.be/ European Renewable Energy Centres Agency

http://www.euromoneyenergy.com/energy.asp Euromoney Energy Events

http://europa.eu.int/comm/dgs/energy_transport/index_en.html EURPOA – Directorate-General Energy and Transport – Home Page

http://europa.eu.int/comm/research/energy/nn/nn_rt_pv1_en.html EUROPA – Research – Energy – Non-Nuclear Energy – Research Topics – Photovoltaics

http://www.fco.gov.uk/ Foreign and Commonwealth Office Home

http://www.fse-directory.net/search United National Environment Program, Financing Sustainable Energy Directory

http://www.globalclimate.org/ Global Climate

http://www.greenhouse.gov.au/ Australian Greenhouse Office

http://www.greenhouse.gov.au/international/kyoto/mechanisms.html Australian firms and the market based mechanism of the Kyoto Protocol

http://www.greenpeace.org/international_en/ Greenpeace International

http://www.iea-pvps.org/ IEA PV Power Systems Program

http://www.industry.gov.au/ Australian Department for Industry, Tourism and Resources

http://www.jxj.com/ James and James Science Publishers

htp://www.mnes.nic.in/ Ministry of Non-Conventional Energy Sources, Government of India

http://www.meti.go.jp/english/aboutmeti/data/a234004e.html Japan Agency of Industrial Science and Technology

http://www.novem.org 'Tailor-made Sustainability', Novem, Dutch Agency for Energy Efficiency and Renewable Energy.

http://www.nrel.gov/ US National Renewable Energy Laboratory (NREL)

http://www.originenergy.com.au/home/home_subnav.php?pageid=174 Origin Energy Australia – For My Home – Solar Energy.

http://www.platts.com/ Platts Energy Bulletin

http://www.platts.com/features/emissions/emissionsindex.shtml Platts Guide to the Emissions Marketplace

http://www.reeep.org/index.cfm?articleid=4 Renewable Energy and Energy Efficiency Program, Innovative Financing

http://www.re-focus.net/index.html REFOCUS The International Renewable Energy Magazine

http://www.solaraccess.com/news/story?storyid=6793 Renewable Energy News- BP Solar Lands Major Thailand Contract

http://www.solarbuzz.com/Links/OffGrid.htm Solar Energy Markets Off Grid.

http://www.uneptie.org/energy/ United nations Environment program (UNEP) Energy Unit

http://www.unf.org United Nations Foundation

http://www.worldbank.org/ The World Bank Group

// **GLOSSARY** AND ABBREVIATIONS

ABARE	Australian Bureau of Agricultural and Resource Economics
AC	Alternating Current
ACRE	Australian Cooperative Research Centre for Renewable Energy
ACT	Australian Capital Territory
ADB	Asian Development Bank
AERL	Australian Energy Research Laboratories
AGO	Australian Greenhouse Office
ANU	Australian National University
ANZSES	Australia and New Zealand Solar Energy Society
APEC	Asia Pacific Economic Cooperation
ARC	Australian Research Council
AREEN	Australian Renewable Energy Export Network
ASEAN	Association of South East Asian Nations
a-Si	Amorphous Silicon
BAU	Business as Usual
BASIX	Building Sustainability Index
BCA	Building Code of Australia
BCSE	[Australian] Business Council for Sustainable Energy
BIPV	Building Integrated Photovoltaics
BOS	Balance of System
Bsi	German Solar Industry Association
CAP	Climate Action Partnership
CdTe	Cadmium Telluride
CDM	Clean Development Mechanism
CEGS	Combined Energy Generation and Storage
CERES	Centre for Education and Research into Environmental Strategies
CHAPS	Combined Heat and Power Solar system
CIS	Copper Indium Diselinide
COP	Conference of the Parties
CREIA	Chinese Renewable Energy Industry Association
c-Si	Crystalline silicon
CSIRO	Commonwealth Scientific and Industrial Research Organisation
DC	Direct Current
DEUS	[NSW] Department of Energy, Utilities and Sustainability
DOE	Department of Energy (US)
DSC	Dye Sensitised Cells
DSM	Demand System Management
DSNP	Distributed Service Network Provider
DTI	Department of Trade and Industry (UK)
EPIA	European Photovoltaic Industry Association
ERDC	Energy Research and Development Corporation
EREC	European Renewable Energy Council
ESAA	Electricity Supply Association of Australia
EU	European Union
GEF	Global Environment Facility
GSES	Global Sustainable Energy Solutions Pty Ltd
GST	Goods and Services Tax
GTZDeutsche	Gesellschaft für Technische Zusammenarbeit GmbH, German Technical Cooperation, is an enterprise for international cooperation with worldwide operations, on behalf of the German government
GVEP	Global Village Energy Partnership
GW	Gigawatt
GWh	Gigawatt hours
GWp	Gigawatt peak
IEA	International Energy Agency
IP	Intellectual Property
ITR	Department of Industry Tourism and Resources
KfW	KfW Bankgruppe (owner by the German government (80%) and the Länder (20%)); development bank
kVA	Kilovolt ampere
kW/m2	Kilowatts per square metre
kWh/m2	Kilowatt hours per square metre

kWp	Kilowatt peak
MJ	Megajoule
MJ/m2	Megajoules per square metre
MNES	Ministry of Non-conventional Energy Sources (India)
MOU	Memorandum of Understanding
MPPT	Maximum Power Point Tracker
MRET	Mandatory Renewable Energy Target
MW	Megawatt
MWh	Megawatt hours
MWp	Megawatt peak
Mt	Million tonnes
NEM	National electricity markets
NEMMCO	National Electricity Market Management Company
NGOs	Non-Government Organisations
Ni-cd	Nickel Cadmium
NREL	National Renewable Energy Laboratory
NSW	New South Wales
O&M	Operation and maintenance
OECD	Organisation for Economic Co-Operation and Development
ORER	Office of the Renewable Energy Regulator
Pa	Per annum
PAWA	Power and Water Authority
PV	Photovoltaic [solar electricity]
PVMaT	PV Manufacturing Program (USA)
PVPS	Photovoltaic Power Systems Program [of the IEA]
PVRP	Photovoltaic Rebate Program
R&D	Research and Development
R,D&D	Research, Development & Demonstration
RAPAS	Remote Area Power Assistance Scheme
RCEP	The Royal Commission on Environmental Pollution (UK)
RECP	Renewable Energy Commercialisation Program
RECs	Renewable Energy Certificates
REEEP	Renewable Energy and Energy Efficiency Partnership
REID	Renewable Energy Industry Development [program, of the AGO]
RISE	Research Institute for Sustainable Energy
RRPGP	Renewable Remote Power Generation Program
RTOs	Registered Training Organisations
SEAV	Sustainable Energy Authority Victoria
SECV	State Electricity Commission of Victoria
SEDA	[NSW] Sustainable Energy Development Authority
SEDO	[WA] Sustainable Energy Development Office
SHS	Solar Home System
SMUD	Sacramento Municipal Utility District
SPS	Stand-alone Power Systems (previously referred to as RAPs)
STI	Sustainable Technology International
TAFE	Technical And Further Education
TWh	Terawatt hours
TWh/yr	Terawatt hours per year
UK	United Kingdom of Great Britain and Northern Ireland
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
UNSW	University of New South Wales
UPS	Uninterruptible Power Supply
USA	United States of America
USD	United States Dollars
W	Watts
Wh	Watt hours
WWF	World-Wide Fund for Nature
W/m2	Watts per square metre
€	Euro dollar
¥	Japanese yen

// APPENDICES

Appendix 1: The science of photovoltaics
Appendix 2: Chronology of the development of the PV industry
Appendix 3: Australian Government support programs
Appendix 4: Summary of US state policies
Appendix 5: Summary of USA state-based financial incentives
Appendix 6: PV modelling scenarios
Appendix 7: Key barriers to development of PV market in Australia
Appendix 8: Domestic market estimates by application sector

APPENDIX 1// THE SCIENCE OF SOLAR PHOTOVOLTAICS

The solar resource

Solar energy as a resource is available where ever the sun shines. The quantity of the available resource is dependent on the latitude of the location, the local climatic conditions, and in most locations, the time of year.

A location close to the equator and in the middle of a continent, where there is little cloud cover, will generally have the greatest available resource. Moving away from the equator, the available resource is reduced and this reduction is increased when the site is near a coast where cloud from the ocean is typical

The instantaneous radiant solar power (called irradiance) is measured in Watts per square metre (W/m^2) and the energy from the sun arrives at the earth's surface with a peak value of about 1kW/ m^2. The instantaneous radiant solar power varies throughout the day as a result of the sun moving across the sky. The available solar power increases during the morning and peaks at about solar noon and then decreases in the afternoon as the sun 'sinks' down to the western horizon.

The total quantity of solar energy received over a day (called irradiation) is measured in megajoules (MJ) per square metre. Manufacturers rate their PV modules at a peak power value, that is, when the power from the sun is 1kW/ m^2. To determine the daily output of the PV module requires the daily solar energy to be converted to a kWh/m^2 figure. This is obtained by dividing the MJ per square metre by 3.6.

Solar energy expressed in kWh/m^2 is also called peak sun hours. The number of peak sun hours for the day is the representative (or equivalent) number of hours for which energy at the rate of $1kW/m^2$ is hitting the earth's surface. Multiplying the peak sun hours by the peak power rating of a solar module determines the maximum amount of energy supplied by that module during the day.

At any given location, the available solar radiation is a maximum on the plane that points directly at the sun. In reality with grid connected systems, the PV modules could face either north east or north west, subject to the direction the roof of the building is facing. When a PV module is not facing true north, the available solar resource is reduced. The angle between true north and that which the module faces is known as the azimuth.

The available solar radiation data has been used to develop world maps showing average irradiation contours. An example of one of these maps is shown in Figure XX. This map shows the average value of irradiation received each day on an optimal tilted surface during the month with lowest solar radiation received on that surface.

Most of Europe, where there is a large demand for grid connected systems, generally has an average figure below 3 kWh/m^2 per day. In the developing countries, particularly the African Continent and through South East Asia, figures are above 4 kWh/m^2 per day, which is ideal for stand alone power systems.

Australia, being a largely dry continent, has an excellent solar resource. Most of the country (generally north of latitude 35 degrees south) is above 4 kWh/m^2 per day in the worst month of the year, which is ideal for stand-alone and grid connected systems. It is only in the south western section of Victoria, south-eastern corner of South Australia and in Tasmania where the average solar irradiation in the worst month is between 2 and 3 kWh/m^2 per day.

Photovoltaic science and technologies

Photovoltaics, as the word implies (photo = light, voltaic = electricity), convert sunlight directly into electricity. Photovoltaic (PV) or solar cells are made of special materials called semiconductors, such as silicon, which is currently the most commonly used material. Basically, when light strikes the cell, a certain portion of it is absorbed within the semiconductor material. This means that the energy of the absorbed light is transferred to the semiconductor. The energy knocks electrons loose, allowing them to flow freely. PV cells also all have one or more electric fields that act to force electrons freed by light absorption to flow in a certain direction. This flow of electrons is a current, and by placing metal contacts on the top and bottom of the PV cell, we can draw that current off to use externally. This current, together with the cell's voltage (which is a result of its built-in electric field or fields), defines the power (measured in watts) that the PV cell can produce.

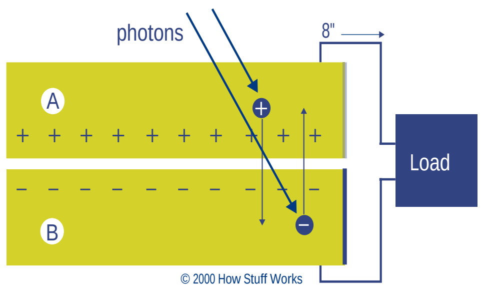
Silicon has some special chemical properties, especially in its crystalline form. Silicon has excess electrons which can be freed by photons (light energy) and therefore captured as electricity. The silicon in a PV cell is modified slightly so that it will work as a PV cell. In particular, it contains impurities – other atoms mixed in with the silicon atoms, changing the way it reacts. We usually think of impurities as something undesirable, but in this case, PV cells wouldn't work without them. Consider silicon with an atom of phosphorous here and there, maybe one for every million silicon atoms. Phosphorous has five electrons in its outer shell, silicon has four. It still bonds with the silicon atoms, but phosphorous has one spare electron which doesn't form part of a bond.

When energy is added to pure silicon, it can cause a few electrons to break free of their bonds and leave their atoms. A hole is left behind in each case. These electrons then wander randomly around the crystalline lattice looking for another hole to fall into. These electrons are called free carriers, and can carry electrical current. There are so few of them in pure silicon, however, that they aren't very useful. Impure silicon with phosphorous atoms mixed in is a different story. It takes a lot less energy to knock loose one of the extra phosphorous electrons because they aren't tied up in a bond. The process of adding impurities on purpose is called doping, and when doped with phosphorous, the resulting silicon is called N-type ('n' for negative) because of the prevalence of free electrons. N-type doped silicon is a much better conductor than pure silicon.

However, only part of the PV cell is N-type. The other part is doped with boron, which has only three electrons in its outer shell instead of four, to become P-type silicon. Instead of having free electrons, P-type silicon ('p' for positive) has free holes. Holes really are just the absence of electrons, so they carry the opposite (positive) charge. They move around just like electrons.

Every PV cell has at least one electric field. Without an electric field, the cell wouldn't work, and this field forms when the N-type and P-type silicon are in contact. Suddenly, the free electrons in the N side, which have been searching for holes to fall into, move to fill all the free holes on the P side. The electron flow provides the current, and the cell's electric field causes a voltage. With both current and voltage, we have power, which is the product of the two.

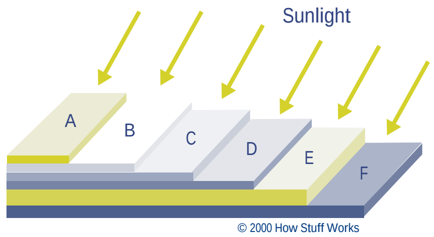
The maximum energy that most cells can absorb from sunlight to produce electricity is about 25 per cent. However, in practice the efficiency is closer to 17 per cent or less.



Ⓐ n-type silicon
Ⓑ p-type silicon

Figure A1.1 Operation of a PV cell

The band gap also determines the strength (voltage) of the electric field, and if it's too low, then what is made up in extra current (by absorbing more photons), is lost by having a small voltage. Power is voltage times current, and the optimal band gap, balancing these two effects, is around 1.4 eV for a cell made from a single material.



A Cover glass
B Anti-reflective coating
C Contact grid
D N-type SI
E P-type SI
F Back contact

Figure A1.2 Composition of a PV module

There are a few more steps left before we can really use the cell. Silicon is a very shiny material, which means that it is very reflective. Photons that are reflected can't be used by the cell. For that reason, an antireflective coating is applied to the top of the cell to reduce reflection losses to less than 5 per cent. The final step is the glass cover plate that protects the cell from the elements. PV modules are made by connecting several cells (usually 36) in series and parallel to achieve useful levels of voltage and current, and putting them in a sturdy frame complete with a glass cover and positive and negative terminals on the back.

Single crystal silicon isn't the only material used in PV cells. Polycrystalline silicon is also used to cut manufacturing costs, although resulting cells aren't as efficient as single crystal silicon. Amorphous silicon, which has no crystalline structure and is formed by deposition onto a substrate, is also used, again in an attempt to reduce production costs. Other materials used include gallium arsenide, copper indium diselenide and cadmium telluride. These technologies are discussed in the following section. Since different materials have different band gaps, they are 'tuned' to different wavelengths, or photons of different energies. One way efficiency has been improved is to use two or more layers of different materials with different band gaps. The higher band gap material is on the surface, absorbing high-energy photons while allowing lower-energy photons to be absorbed by the lower band gap material beneath. This technique can result in much higher efficiencies. Such cells, called multi-junction cells, can have more than one electric field.

PV cell and module technologies[1]

An individual PV cell is small in size and produces a small DC voltage, regardless of cell type. Thus they are typically connected in series and parallel to produce more substantial voltages and currents, and packaged in PV modules for ease of installation and environmental protection. PV modules are configured either as flat panels or in concentrating systems where lenses or mirrors are used to focus sunlight on the cells.

Several different types of PV cell are manufactured, using a range of materials and production methods. Thin film cells are made by depositing thin layers of semi-conductor on low cost backing, such as glass, steel or plastic. Silicon is used to produce monocrystalline, polycrystalline and amorphous cells. Other materials are also used, including gallium arsenide, copper indium diselenide, cadmium telluride, and dye sensitised titania. Cells made from thicker silicon still dominate the market.

Crystalline silicon (c-Si)

Crystalline silicon is the leading commercial material for PV cells. Its advantages include stable performance, low module manufacturing costs and mostly non-toxic materials used in final production. It exists in several forms:

Monocrystalline or single crystalline silicon

Monocrystalline silicon is the most common and efficient commercial technology available. Monocrystalline silicon cells are, however, approaching their limit of efficiency (about 25 per cent) this limit is determined by the band gap energy of silicon, meaning they can only absorb about one quarter of the light that strikes the cell.

Crystalline silicon cells work as described in the general solar overview above, and are manufactured by cutting silicon wavers from one homogenous crystal in which all silicon atoms are arranged in the same direction. The monocrystal is manufactured using either the Czochralski method or the floating-zone (FZ) technique.

Efficiency	
→ Lab	24%
→ Commercial	13–18%
Embodied Energy	5600–24200 MJ/m^2

Multicrystalline or polycrystalline silicon

Efficiency: The operation of multicystalline PV cells is essentially the same as monocrystalline cells. The differences exist in the way the PV cells are manufactured. In multicrystalline cell production a cast block of silicon is sawed first into bars and then into wafers. These wafers are then joined in series to form PV modules.

Efficiency	
→ Lab	20%
→ Commercial	12–17%
Embodied energy	2700–8300 MJ/m^2

A new method of using c-Si cells has been developed by the Australian National University and is being commercialised by Origin Energy. The Sliver, cell technology involves slicing cells into thin strips and then positioning the strips into modules with varying separations, depending on transparency and module output requirements. The quantity of silicon required for a given power output can be significantly reduced. Micromachined using innovative manufacturing techniques to less than 70 microns thick (thinner than a human hair) from monocrystalline silicon, Sliver® cells demonstrate efficiencies of 19.5 per cent. While Sliver® cell efficiencies are competitive with other conventional solar cells, they perform much better than most other thin film technologies. Sliver® cell trial modules tested by Sandia National Laboratories in the United States show efficiencies comparable with other solar power module products now on the market.

Sliver® cells also differ radically from conventional solar cells in size and shape. They are long, ultra thin, quite flexible and perfectly bifacial. This is unlike conventional solar cells which are typically square or round, up to 4 to 5 times thicker, quite rigid and usually single sided. Pilot production is expected in Adelaide in late 2004.

Ribbon and sheet technology

Ribbon and sheet silicon, as the name suggests, is formed as a ribbon or sheet of silicon. This can be formed by extracting either a hollow tube or two parallel dendrites from molten silicon. These processes result in either a ribbon or sheet of silicon which can then be cut into the desired length for module production.

This process is viewed as having possibilities for cost reduction compared to the mono- and multi-crystalline manufacture described above, however current production is limited, and the efficiency of these types of panels is relatively low.

Efficiency	
→ Lab	16%
→ Commercial	10% (Evergreen solar)
Embodied energy	Not available

Thin layer silicon

Thin-layer crystalline silicon PV cells are believed to offer low cost high efficiency production. Thin-layer silicon is considered to be <50 nanometers thick and is deposited on a foreign substrate. Potential advantages of thin-layer approaches include less silicon usage, lower deposition temperatures relative to melt growth and monolithic module construction possibilities.

Disadvantages include incomplete light absorption and therefore the probable need for light-trapping. The challenge for successful thin-layer silicon is to produce a 10 to 50-nanometre silicon layer of sufficient electronic quality with a diffusion length greater than the layer thickness and a grain size comparable to the thickness. A fast deposition rate of >10m/min on a low-cost substrate such as glass is also needed. There is not yet any significant quantity of thin-layer crystalline silicon in commercial production for PV because only partial successes have been achieved in meeting the challenge. Improvements in substrate quality are necessary for high quality consistency and efficient PV cells.

One such technology is being developed by Pacific Solar Australia, in a joint venture with Unisearch, the commercial arm of the University of NSW, and a number of public and private investors. The technology consists of multiple very thin layers of polycrystalline silicon on glass of approximately 3mm thickness. Pilot production has commenced and full production is planned in Germany for 2005.

Efficiency	
→ Lab	8.2%
→ Commercial	No commercial production
Embodied Energy	Not available

Thin film technologies

Thin film photovoltaic cells use layers of semiconductor materials only a few micrometers thick, attached to an inexpensive backing such as glass, flexible plastic, or stainless steel.

Amorphous silicon (A-Si)

Amorphous silicon is one semiconductor material used for thin film modules; it differs from the panels previously described because it does not have a crystalline structure.

The advantage of these modules is that they can be produced cheaply. They do however carry some disadvantages, such as lower efficiency, and so are much larger (surface area per watt) than the other technologies and they also deteriorate, at least initially, with exposure to the sun. This is due to the Staebler-Wronski effect.

After a brief period of commercial production of larger scale modules by a number of manufacturers, amorphous silicon is now less than 10 per cent of the PV market and essentially used for purpose made roofing products and for very small applications, such as calculators and watches.

Efficiency	
→ Lab	13%
→ Commercial	6–9%
Embodied energy	1010–2750 MJ/m^2

Copper indium diselenide (CIS)

This type of thin layer PV cell has shown the highest efficiency of the thin film modules, in fact it has proven to be as efficient as polycrystalline silicon cells. These efficient modules have been developed by including gallium and graded layers (differing levels of Gallium) in the cells to increase efficiency.

Before CIS modules can become commercially viable, some issues need to be resolved regarding manufacturing. CIS is efficient because it is complex, and this complexity makes manufacturing difficult and expensive. This technology is fairly new and there is no commercial production, however National Renewable Energy Laboratory in USA has patented some technologies for commercial production.

Efficiency	
→ Lab	18%
→ Commercial	No commercial modules
Embodied energy	Not available

Cadmium Telluride (CdTe)

This technology is only very new to commercial production, apart from small applications such as calculators. These modules are viewed as the easiest of the thin film modules to manufacture. A thin layer of Cadmium Telluride is bonded to light weight backing plates, but the manufacturing process is far from optimized. Another concern regarding this technology is that cadmium is toxic and hence the technology is being closely monitored by health officials. Double glass modules are being used, to ensure the cadmium is kept confined and a large number of tests have been carried out to determine the potential for cadmium to leach from the modules during fires or breakage. To date, the modules have been shown to be safe. Nevertheless, negative public perceptions of the technology have already seen BP Solar cease manufacture.

Efficiency	
→ Lab	16%
→ Commercial	7–10%
Embodied energy	1500MJ/m2

Group III–V technologies

Group III and Group V refers to the group of elements on the periodic table from which the elements used in the production of these PV modules come. This type of module design is able to produce the highest efficiency of any module type, currently 34 per cent, with it being seen as possible to reach 50 per cent efficiency in the future. They are however complex and expensive to manufacture at this point in time.

Group III–V technologies involve layering different semiconductor materials, with differing band gaps, onto backing materials, with the highest band gap material at the top and the lowest at the bottom. This enables the PV module to capture a much larger range of light rays than single junction cells. In this arrangement the top layer absorbs light rays with band gap energies equal or greater than that semiconductor's band gap and those light rays with band gaps lower than the semiconductor material pass through to the next layer, where the same process occurs. Gallium arsenide is often used in these modules, as it can be alloyed with elements such as indium, phosphorus, and aluminium to create semiconductors that respond to different energies of sunlight.

Currently these modules are manufactured by two methods, monolithically (each layer of the cell is grown in situ) or by physically stacking each independently grown layer. The latter, however, is seen as being more problematic as it is bulky, and involves additional expenses and heat sinking challenges.

It is with Group III–V technologies that there are the greatest advantages to be gained from the use of Concentration systems. They can increase the power produced by 100 to 1200-fold, thus justifying the increased cost of manufacturing these cells. Concentrator system are varied and, in the most part, scalable. However, it is likely they will only be used for centralized power production due to their complexity. Australian company Solar Systems has built its first commercial system (220 kWp) for the Anangu Pitjantjatjara Lands. The system comprises 10 x 22 kWp PV concentrator dishes feeding power into a diesel grid. The systems currently use silicon cells, but Solar Systems has III–V cells under development.

Efficiency (III–V cells)	
→ Lab	34%
→ Commercial (space)	21%
Embodied energy	Not available

Dye sensitised cells (DSC)

This technology is produced by an Australian company, STI (Sustainable Technology International) and several international companies. It involves bonding a layer of artificially photosynthetic pigment onto a backing of titanium dioxide. Artificial photosynthesis is based on the concept of a dye analogous to chlorophyll absorbing light and thus generating electrons which enter the conduction band of a semiconductor film which has a large surface area.

DSC technology is able to use both direct and diffuse radiation and its products are aimed at the buildings market, especially in semi-transparent applications such as windows. It may therefore be best suited for use in 'smart windows' and for locations in high latitudes where the sun is lower in the sky.

Efficiency	
→ Lab	7%
→ Commercial	5%
Embodied energy: 150MJ/m2	

Heterojunction with Intrinsic Thin-Layer (HIT)

In 1997, Sanyo Solar Industries Corporation presented it's HIT cell for the first time. It consists of two extremely thin a-Si layers with a monocrystalline layer in between. The HIT is 200 microns (0.2mm) thick compared to the typical monocrystalline cell which is 300 microns (0.3mm).

While the performance of most crystalline cells drops by 0.4 to 0.5 per cent with each degree Centigrade increase in temperature, HIT only decreases by 0.33.

Sanyo released the technology in commercial modules in April 2003 as one of the highest efficiency PV technologies on the market.

Efficiency	
→ Lab	21%
→ Commercial	19.55%
Embodied energy	Not available

Balance of system components

A PV system produces electrical energy and, depending on the design of the power-conditioning unit, a grid-connected PV system can also contribute to local voltage control and waveform improvement. With the addition of energy storage (usually in the form of batteries), a grid-connected PV system can also improve reliability of supply to high-value end-uses by providing an uninterruptible power supply (UPS) function. By adding more storage, an autonomous power supply system can be created that can supply local load without grid connection, providing that the PV system is sized appropriately to the requirements of the load.

Though the PV array is the central part of any PV power system, other equipment is required to either allow the output of the array to connect to loads (off-grid systems) or to interconnect to the grid (grid connect systems). This equipment is typically referred to as Balance of System (BOS) components.

Figure 3 shows the typical system schematic for a PV off-grid system. The system includes a solar regulator (or controller), battery bank and it may or may not include an inverter. Simple systems, for example solar lighting or telecommunication systems, typically operate directly from the controller/battery system. Multi-function systems, for example power systems for rural Australian households, would use an inverter so that standard 240 volt ac appliances can be used.

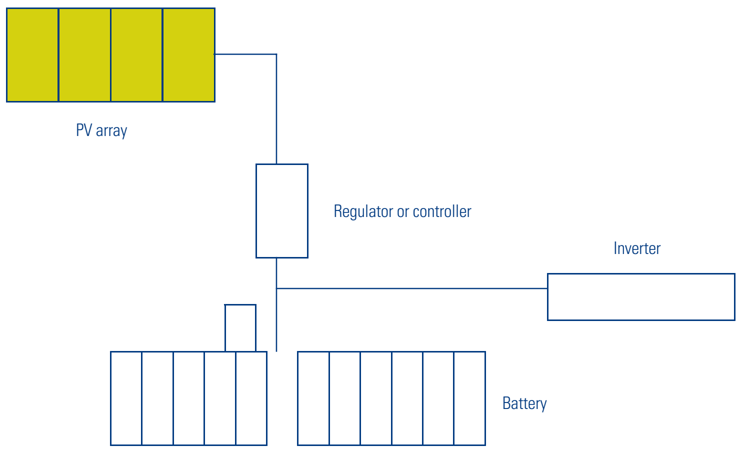


Figure A1.3Schematic of typical off-grid system

Figure 4 shows the schematic of a grid-connected system. Other than wiring and metering, the only additional equipment required is a grid interactive inverter.

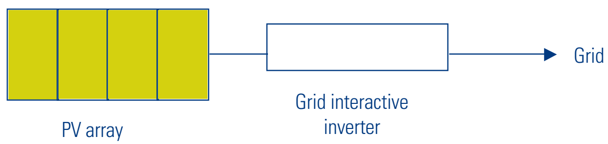


Figure A1.4 Schematic of typicalgrid interactivesystem

Batteries

Power can be supplied by a PV module only when there is sufficient solar radiation, and only during the day. Therefore, there are only a few applications, like water pumping, where a PV module can be directly connected to the load. However, in many stand-alone system applications, the demand for electricity may be at night or in cloudy weather, so there needs to be a way to store the energy generated from the PV modules during the day for later use.

Many systems for energy storage have been tried but at present battery storage is the most convenient and cost effective for stand alone power supply systems. Batteries store potential energy in the chemical bonds of the materials within the battery. At present, the most cost effective batteries for PV power systems are vented lead acid batteries which are made up of battery cells, each of which produce 2 volts nominal.

Not all batteries are the same. Batteries are designed to meet specific requirements. A car battery is designed to provide large currents for a short period of time to start a motor. Although the operating principles are the same, the design of a car battery, particularly the plates and the acid level within the electrolyte, is completely different to a battery required in a stand alone PV system. The latter need smaller currents for longer periods and are known as deep cycle batteries. They must be suitable for deep discharging but also be able to be recharged effectively by the typical charging currents available from the PV array.

Though wet lead acid batteries are the most common batteries used in stand alone power systems, other types of batteries can be used. These include:

- → Valve regulated lead acid (VRLA).
- → Gel batteries.
- → Nickel Cadmium (Ni-cd)

Batteries under development but not fully commercialized include:

- → Vanadium redox battery.
- → Zinc-bromine battery.

Solar regulator

Batteries are the 'heart' of off-grid power systems. They must be protected from overcharging (which causes plate corrosion, gassing and loss of water) and from discharging below their cut-off voltage, which can cause permanent damage to the battery and loss of capacity. Regulators (sometimes called controllers) are an essential part of any battery based electrical system to prevent overcharging of the battery and subsequent damage.

When a battery is being charged the battery's voltage will rise. At a certain voltage (typically between 14V and 15V for a 12V battery), nominated by the battery manufacturer, the battery will be assumed to be charged. The voltage should not rise above this level. At this voltage level the solar regulator must then control the charging current from the PV array to ensure the battery is not overcharged.

Some regulators will include an LCD screen that can show:

- → Charge current.
- → Battery voltage.
- → Load current.
- → Battery state of charge.

Some of these regulators can also perform a system control function by incorporating switches that can be programmed to be opened and closed at certain times or voltages. These switches could be used to connect the PV array to certain loads (eg. pumps) when the batteries are fully charged or to start a genset if the battery voltage is low.

Another type of regulator is known as the Maximum Power Point Tracker (MPPT). These track the maximum power point of the PV array and since this voltage point is higher than that required to charge the battery , the extra voltage (actually power) is electronically transferred by a DC-DC power converter into extra charging current at the lower battery charging voltage. The MPPT's then perform as a regulator and prevent the battery from being overcharged by reducing the charge current when the 'boost' voltage is reached and then maintaining a 'float' voltage for the rest of the day.

Inverters

Off-grid systems

PV modules produce power as DC, that is direct current, and batteries store energy as DC. Many appliances can be manufactured to operate from DC power. In Solar Home Systems in developing countries the system is only DC and the householders use DC lights and some have DC TVs, radios and other appliances.

The power grid supplies power as AC, alternating current. In Australia the typical voltage is 240V, in Europe 220 to 230V and in USA 110V.

To convert the DC power from the batteries to 240V AC an electronic device called an inverter is used. In principle this unit uses electronic switching to convert the DC voltage from the battery bank to an AC voltage of similar value. A transformer is then used to convert from the smaller AC voltage to 240V, the same voltage as the battery bank.

Sine wave inverters are the standard inverter installed in the Australian market. They are available in different configurations, including:

- → Inverter only: These convert DC battery power to AC power as previously described.
- → Inverter/charger: These act as a standard inverter but when connected to another AC generator source, they work backwards by converting the AC power to DC power and charging the batteries (similar to a standard battery charger).
- → Interactiveinverter: These act as a standard inverter but when the genset starts, the inverters will synchronise with the genset, then parallel with the genset and then connect the loads to the genset before reverting to a battery charger.

Grid interactive

A grid interactive inverter converts the DC power from the PV array to AC power which is then supplied to the local load or exported or fed into the local AC power grid. In most countries the inverter must meet many safety and protection requirements before being approved for grid connection.

In general the inverter must be able to:

- → Synchronise with the grid before connecting the PV array power to the grid.
- → Immediately disconnect from the grid when the grid has failed (blackout).
- → Continuously monitor the grid for variation of certain technical parameters (e.g. voltage, frequency) and disconnect immediately from the grid under certain specified variations.
- → Not supply the loads directly while still connected to the grid, but when the grid has failed (No Islanding).

The standard grid interactive inverter is designed only to supply power to the grid and therefore not to operate with a battery. To achieve maximum output from the PV array the inverter will incorporate a maximum power point tracker (MPPT). This is part of the inbuilt electronics of the inverter and not a separate device.

APPENDIX 2// **CHRONOLOGY** OF THE DEVELOPMENT OF THE PV INDUSTRY[1]

This chronology has been prepared to give indicative time frames fort he development of the PV industry in Australia, and to place it in a global timeframe as well. It is not exhaustive, and a more in-depth analysis of the development of the PV industry is available in the publication, *From Space to Earth, The Story of Solar Electricity*, by John Perlin.

1839	'Edmond Becquerel discovers the photovoltaic effect, the first of several effects discovered in the 19th century; he observes a voltage between two electrodes in an electrolyte produced by exposing one electrode to light'.
1876	'William G. Adams and R. E. Day conduct an experimental study on the photovoltaic properties of selenium and discover the effect in selenium barrier-cells'.
1930	The photovoltaic effect of light on selenium is rediscovered by B. Lange.
1931	'The photovoltaic effect of light on selenium is rediscovered for the second time in two years, this time by L. Bergmann'.
1954	'Bell Telephone scientists D. M. Chaplin, Calvin Souther Fuller and G. L. Pearson, following an idea put forward… by Paul Rappaport, develop the silicon photovoltaic cell, which can produce electric power from sunlight'.
1979	Tideland Energy establish first solar manufacturing plant in the Southern Hemisphere with help from the government
1980	Field tests in Australia on crystalline silicon modules by Telecom Research Laboratories start.
1981	'Adam Heller, Barry Miller and Ferdinand A. Theil announce a liquid junction cell that converts 11.5 per cent of solar energy into electricity'.
1983	'A team of German scientists develops a 'wet' solar cell that has an energy conversion efficiency of 9.5 per cent'.
1988 ~	Field tests in Australia on amorphous silicon modules by Telecom Research Laboratories start.
1984 ~	PV cell efficiency – under one-sun illumination – reaches 17 per cent.
1984	Texas Instruments begin exploring a PV manufacturing process called Spheral Solar™ – 'spheres of silicon embedded into aluminium that creat a highly flexible durable cell'. {Graf, 1993}
1985 ~	'The first non-concentrating silicon solar cell to exceed 20 per cent efficiency was made at the University of New South Wales (UNSW)'. {Thorpe et al 1993}
1985	BP purchases American owned PV manufacturing plant in Sydney from Tideland Energy and establishes BP Solar.
1985	BP license Laser Grooved Buried Grid technology from UNSW.
1989	Establishment of Centre for Photovoltaic Devices and Systems at UNSW
1989	'Scientists at the High Technology Centre of Boeing develop a stacked photovoltaic cell that converts 37 per cent of solar radiation into electricity; the cell consists of two types of photovoltaic materials mounted on top of each other; the upper cell consists of gallium arsenide and captures the energy of blue light, while the second cell is made of gallium antimonide, converting red light into electricity'.
1989	'Scientists at Scandia National Laboratories develop a single photovoltaic cell containing silicon that converts 20.3 per cent of radiation into electricity'.
1989	BP Solar awarded turnkey project for 1,000 Lighting Kits in Sri Lanka.
1990	BP Solar establish 'Pilot' Production of 'Saturn' (UNSW)high efficiency cell technology.
1991	'Michael Gratzel and co-workers at the Swiss Federal Institute of Technology in Lausanne patent a type of transparent solar panel that supplies electricity and can be fitted on buildings as ordinary windows'.
1992	Centre for Sustainable Energy Systems at Australian National University (ANU) begins solar cell fabrication and significant R & D
	BP Solar awarded US$2m Contract for Rural Infrastructure Project in Sri Lanka
1993	PV cell efficiency of 23.1 per cent – under one-sun illumination – achieved by UNSW.
1993	Project Aurora, one of Australia's first grid interactive PV systems was installed at CERES in Melbourne and connected to the (then) Brunswick

1 *A Brief History of Photovoltaics in Australia, prepared by Stephen Ingourille, Going Solar, on behalf of Business Council for Sustainable Energy for the Australian PV Roadmap, June 2004*

Electricity Supply Department. The system (designed by Butler Solar) included 48 PV modules (supplied by Going Solar in Victoria) and a 14 kW 3 phase grid interactive inverter (from Butler/Siemens).

1993 24kW of 'buried contact' solar cells installed 'to power a funicular railway near the parliament house in Bern, Switzerland'. {Thorpe et al 1993} The cells were manufactured in Spain under licence to UNSW.

1993 Nine of the top ten cars in the long distance 'Sunrayce 93' from Arlington, Texas to Minneapolis near the Canadian border, use 'buried contact' solar cells developed by the UNSW.

1994 ANU research into Combined Heat and Power Solar (CHAPS) systems beings.

1995 ANU multicrystalline cell research begins – resulting in world record efficiencies.

1995 BP Solar awarded US$5m contract for East-West Pipeline Telecommunications Project in Saudi Arabia.

1996 BP Solar awarded US$4m contract for rural infrastructure project (MORD1) in Malaysia.

1996 BP Solar supply A$44M worth of systems to 36,400 homes in Indonesia.

1997 Epilift technique invented at ANU – and lead to research into current Sliver® technology

1997 200kW 'solar farm' established near Singleton in NSW by energyAustralia using BP Solar modules.

1997 600kW aid project to supply PV on houses in the Philippines by BP Solar

1998 Boral (now Origin Energy) invests $3.6 million over 3.5 years to commercialise ANU Epilift tewchnology.

1998 BP Solar supply 100kW of PV for the Wilpena Pound solar diesel hybrid power plant in South Australia

1998 629 homes (initially) in the Sydney Olympic Village supplied with grid interactive PV systems by BP Solar.

1998 BP Solar awarded contract for provision of innovative PV systems for the grid connected lighting towers in the Olympic Boulevard

1998 Solarex awarded Exporter of the Year in the category of medium size business.

1999 BP merges with Amoco worldwide and as a consequence the Sydney-based Solarex and BP companies merge with the eventual establishment of a new factory at Sydney Olympic Park in Sydney.

1999 BP Solar receives RECP grant for improvements to performance and manufacture of polycrystalline cells.

1999 Melbourne utility, CitiPower, initiates '100 PV Roofs Program'. (Most systems installed by Allied Solar in the two months before the GST was introduced.)

2000 BP Solar relocates all manufacturing, sales and engineering to Sydney Olympic Park, Sydney, expanding capacity by 400 per cent.

2001 BP Solar opens Sydney Olympic Park manufacturing Facility (25 MW capacity by end of year)

2002 Australia's largest PV array – 199.2 kWp – installed on the roof of the Queen Victoria Market sheds.

2002 ANU CHAPS system launched.

2003 Demonstration ANU CHAPS system installed on Bruce Hall.

2003 BP Solar increased capacity of Sydney Olympic Park manufacturing facility to 35MW.

2003 ~ Origin Energy establishes plant in South Australia to manufacture Sliver cell technology developed by Andrew Blakers of ANU.

2004 Australia Post releases set of four renewable energy stamps. Philatelic Department reports unprecedented interest with demand outstripping prediction by 75 per cent.

~ Dates are indicative

APPENDIX 3// AUSTRALIAN SUPPORT PROGRAMS FOR PV

Directly supported national programs

PVRP – Photovoltaics Rebate Program

The PVRP program commenced in January 2000 to encourage the development and use of building mounted PV, in particular in the grid connected market. Since the RRPGP (see below) was not planned to operate in Victoria and only has limited funding in New South Wales, the PVRP was also available to be used for stand alone systems.

The program is funded by the Australian Government and administered by the States. The initial funding was $31 million over 4 years and was due to finish at the end of 2003. In February 2003, the program had been oversubscribed for the 2002/2003 financial year and was capped to $100,000 per month. In the 2003/04 Budget, announced in May 2003, the program received an extra $3.6 million for 2003/04 (total funding $5.8 million available for the year, making a total of $40.4million) and also $5.8 million for the 2004/05 financial year. The program is now due for completion around June 2005. Of this funding, $1 million has been assigned for demonstrative PV projects by property developer companies. These projects are to be selected via a competitive bidding process.

Initially, grants of $5.50 per Watt were available for both new systems and extensions to existing systems, up to 1500 Watts. Therefore the maximum grant was $8250. Since there was a rapid uptake of the grants in the first 6 months (see figure 4.4) the rules were changed to $5 per Watt for new systems ($7500 the maximum grant) and $2.50 per Watt for system upgrades.

At the time of the May 2003 budget, new rules were announced:

→ All new residential systems – $4 per watt grant up to a 1000 watt system. (Maximum grant $4000).
→ For system upgrades – $2.50 per watt grant up to a 1000 watts (maximum grant $2500).
→ For Community buildings – $4 per watt up to a 2000 watt system (maximum grant $8000).

Since the start of the program, over 5000 systems have been installed, representing over 5.7MWp of PV installed.

RRPGP – Remote Renewable Power Generation Program

The purpose of this program is to:

→ Increase the use of renewable energy for power generation in off-grid areas.
→ To reduce diesel use.
→ To assist the Australian renewable energy industry.
→ To assist in meeting the infrastructure needs of indigenous communities.
→ To reduce greenhouse gas emissions.

Core funding for this program is provided to the States by the Australian government, on the basis of diesel fuel excise collected in the years 2001/02 to 2003/04 from diesel fuel used by public generators not connected to main electricity grids. Grants of up to 50 per cent of the capital cost of renewable energy systems are available for diesel replacement. The program is administered by State governments, with additional funding provided by some States. Up to $200 million is expected to be available over the life of the program, which can extend to 2010. As at the end of April 2004, $130m of RRPGP funds has been committed.

A specific allocation of $8 million has been made to the Aboriginal and Torres Strait Islander Commission (ATSIC) to assist with the development of industry capability and local understanding of renewable energy systems in indigenous communities.

Each State has established a slightly different program, to meet the specific needs of local off-grid applications. However, in general, the target groups are indigenous and other small communities, commercial operations, including pastoral properties, tourist facilities and

2.1 MWp of PV has so far been installed under generic State programs, and 1MWp has been installed or approved in large PV projects, including solar arrays and dish concentrators. Although RRPGP is not PV specific, most systems installed to date include some PV and PV makes up a significant proportion of installed capacity. $128 million has been allocated to date under the program.

OVERVIEW: **BUSHLIGHT**

The Bushlight program will operate over 4yrs, from 2002 to 2006. Its funding of $8 million comes from the Australian Greenhouse Office (RRPGP program) and ATSIS

$4 million has been expended to date on project deployment, with approximately 200 remote Communities visited, and 15 systems installed (35 kWp total).
Typical household systems are designed to deliver 6–8 kWh per day, and cost around $75,000.

Bushlight has a number of expected outcomes

Improve design of RE systems. This is happening on three levels

- Small household systems – approximately 30 installed or currently being installed, with design review underway. Systems typically designed to meet energy needs of single house or house plus shelters.
- Community systems – Design loads in range of 10–32 kWh per day. Typically supply a small group of houses.
- Larger hybrid systems – Design loads 30–150 kWh per day. Typically supply large group of houses.

Improve community capacity to manage energy services

- Education (see below)
- Access to information (see below)
- Community Energy Planning (CEP) process. Regional teams carry out this process with about 30 communities involved so far. Energy decisions are owned and documented by the community with very positive results so far. Based on a participative planning process including significant community based education in the areas of energy sources and uses, energy efficiency, demand side management, RE system operation and troubleshooting. Key element of CEP is agreement on how systems will be serviced, maintained and financed. CEP is appropriately documented to record decisions and to ensure ongoing community access to information.

Improve access to service provision

- Self support Community based support
- Training as many people in the community as possible to operate, troubleshoot and carry out very basic maintenance of RE systems
- Resource Agencies
- Developed a short course to train office and field staff of resource agencies to usefully answer questions about RE systems and to provide first level support in the field.
- Will be rolling this out comprehensively over the next year
- Technical Service Providers
- Identifying people who will support remote area communities
- Ensuring the right resources are available
- Drawings and parts list available on disk before visit to community
- Spare parts kit available in each region
- Increasing the number of BCSE accredited people who can respond to technical service calls.

Mandatory Renewable Energy Target

The Mandatory Renewable Energy Target (MRET) was introduced by the Australian Government in 2001. MRET requires electricity retailers to meet annually increasing renewable energy targets. The scheme aims to deliver 9500GWh of additional renewable energy from 1997 levels (15,970GWh) by 2010 and continues to 2020 (see graph below). Under MRET, Renewable Energy Certificates (RECs) are created; 1 REC = 1 MWh. Once RECs are created from generation or 'deeming', they can then be traded. Retailers must surrender RECs to meet their renewable energy target. The scheme is currently undergoing a scheduled review. For solar photovoltaic (PV) systems, five years of RECs can be created upfront, or deemed, on installation of the system for expected generation (and every five years thereafter). BCSE believes that PV systems should be eligible for 20 years deeming upfront, in line with product guarantees, for more effective industry development. 'Deeming' is an innovative feature which we believe is unique to MRET, but which has significant potential application to schemes in many other countries.

Indirect government PV support programs

In addition to the two grant programs above, the Australian Government over the last 5 years has initiated a number of other programs which can provide indirect support for PV. Note that the RECP funding has been fully committed, but some of the funded projects are still being completed. The indirect programs include:

Renewable Energy Commercialisation Program (RECP)

The RECP operated from 1998 to 2002 and had an initial budget of $56 million, of which $6 million was allocated to industry development (see below).

The RECP (Commercialisation) had a total of six rounds and provided funding between $100,000 and $1 million to support competitively selected projects which demonstrated:

- → Strong commercialisation potential (or, for feasibility studies and/or prototype development, a clear pathway to commercialisation).
- → Contribution to the wider development and diversification of Australia's renewable energy industry, domestically and/or internationally.
- → Reduction of greenhouse gas emissions.

Approximately $11.3 million was allocated to PV related projects.

Renewable Energy Industry Development (REID)

This $6 million program continued until 2003 with three rounds of funding being completed. The programs funded were for renewable energy not just for PV, but $1.3 million has been allocated to contribute to the development of the PV industry. The types of projects supported helped the PV industry through such activities as promotion, support and development of training, accreditation programs, standards development and product testing.

Renewable Energy Equity Fund (REEF)

The Renewable Energy Equity Fund is a $26.5 million (approx) venture capital fund established to increase investment in renewable energy technologies through the provision of equity finance. It is funded to $18 million (approx) under the Australian Government's REEF program and $8.5 million (approx) from private sources. The Fund invests in high growth emerging Australian companies with domestic and global market potential in the renewable energy industry.

State Government Programs

All states are involved in administering the PVRP and RRPGP (all states except Victoria and Tasmania) and some states have additional programs and/or contribute funds to existing federal programs. Some programs are dedicated to PV while other programs are designed for all Renewable Energy technologies. State government programs for PV include the following.

Victoria

Over the last 4 years, Victoria has allocated $6,772,456, under PVRP. This equates to 1,419,109 kWp installed, with system sizes ranging from 4.5 kW to 19.2 kW, and costing between $10,000 to $28,000.

The Victorian Renewable Energy Assistance Program (REAP) ran for a two year period over 1995 and 1996. This followed the earlier Remote Area Power Supply Incentive Scheme (RAPSIS) run by the SECV. The initial budget was $100,000 of state government funding and $40,00 of funding from Eastern Energy and Powecor. REAP provided a maximum of $300o for RAPS systems

The objectives were to encourage the use of RE components in the supply of electricity in off grid residential situations and to improve the quality of installations of these systems.

New South Wales

SEDA/DEUS's Renewables Investment Program (RIP) provides funding assistance for renewable energy projects in NSW through regular six monthly funding rounds. Appropriate projects are funded on a competitive basis based on greenhouse gas savings, the level of innovation displayed, the degree of market transformation and commercial returns. The RIP provides loans of up to 40 per cent and grants (if available) of up to 20 per cent of the total capital cost of projects. RIP grants were made available for two innovative solar projects in 2002/03.

The SEDA-administered Building Integrated PV Rebates end as of end June 2004. Since July 2003 SEDA has been providing grants purely for investment properties (up to $2400/1kWp) and businesses (up to $4800/2kWp), which are not eligible for PVRP support.

SEDA also supports broad PV industry development under its solar program through activities such as the 'Who Buys Solar Power' market surveys and facilitating cooperation between the PV and the Electricity Supply industries in NSW.

SEDA initiated a program called 'Solar in Schools' (SIS) in 1999 and is currently engaged with Phase 3 of the program. SIS provides participating schools across NSW with a PV system. The participating schools receive:

→ Installation of a 1.5kW (nominal) grid-connected solar power system

→ A 'Solar Explorer' educational resource kit for use within the school.

→ Teachers' training to use the kits and the related SIS website.

Other schools not directly participating in the program can also learn about solar energy, access historical performance data from participating schools and benefit from the results of the program through the national solar schools education website: www.solarschools.net

The Solar in Schools program commenced in November 1999 with a pilot program of 18 schools. This was a partnership between the Sustainable Energy Development Authority (SEDA), the NSW Department of Education and Training (DET) and Integral Energy. SEDA developed educational resources, provided financial support and managed the program. DET supplied financial support. Integral Energy supplied equipment and carried out installations.

In 2002, SEDA and DET extended Solar in Schools to a further 25 schools (Phase 2), so that today, more than 20,000 school children in 43 NSW Solar Schools are learning about renewable energy, energy efficiency and global warming through the Solar in Schools program. with 70.56kWp of PV in total. Total program expenditure to date is $950,000. SEDA created between 25 and 50 new Solar Schools in 2003.

Northern Territory

Under RRPGP implementation there have been 120 SPV installations and 70 water pumping systems approved for rebates. The Total approved rebate to date amounts to $10.3 million. The expected annual diesel fuel savings will be 1.53 million litres, and there will be expected annual GHG savings of 4100 tonnes. Total RE installed capacity approved in the Territory under the RRPGP is 1.44 MW. The break-up of this is as follows:

→ Concentrators	720 kW
→ PV fuel saver	280 kW
→ PV Hybrid	325 kW
→ PV stand alone	63 kW
→ PV/Wind	9 kW
→ PV Water pumping	47 kW

Queensland

Working Property Rebate Program (WPRS)

A joint Queensland Government and Commonwealth initiative, this scheme applies to family owned working properties located in selected remote shires in Western and Northern Queensland not connected to the main or Mount Isa electricity grids. Applications from properties outside these basic criteria will be considered on a case by case basis.

The WPRS is designed to encourage the use of renewable energy, reduce the use of diesel, and service the power needs of working properties in remote Queensland. The purpose of the scheme is to make appropriate and reliable electricity supplies available to remote working properties, thereby improving the quality of life.

It assists with the installation of large Stand-alone Power Systems (SPS). It is funded under the RRPGP ($8M) and by the Queensland Government ($4M). The scheme is currently expected to continue until the earliest of mid 2006 or funds are exhausted.

Applicants who satisfy the conditions of the scheme may be eligible for a rebate of up to $175,000. The maximum rebate is funded as follows:

→ Commonwealth funding 50 percent up to $150,000.

→ State funding 15 percent up to $25,000.

The rebate is payable on new renewable energy generating equipment, essential enabling equipment and essential non-equipment expenditure.

Applicants may also be eligible for an additional funding of five percent of the cost of the rebateable items or $10,000 (whichever is the lesser) to be used to assist with the cost of replacing batteries at the end of their useful life.

Renewable Energy Diesel Replacement Scheme (REDRS)

The aim of the REDRS is to encourage the use of renewable energy and reduce the use of diesel, in meeting electricity generation requirements in off-grid areas of Queensland (areas not connected to the main or Mount Isa electricity grids). The program provides financial support for the installation of new renewable energy stand-alone power generation systems, or incorporation of renewable energy generating equipment within existing generation for off-grid users of diesel for electricity supply (including domestic, commercial and industrial properties, and remote communities).

Applicants who satisfy the conditions of the scheme may be eligible for a rebate of 50 percent. The maximum rebate applicable for installations servicing domestic premises is $150,000. The rebate is payable on new renewable energy generating equipment, essential enabling equipment and essential non-equipment expenditure.

It is funded under the RRPGP (approx. $17M). The scheme is currently expected to continue until the earliest of mid 2006 or funds are exhausted.

Western Australia

RRPGP

Funding applications for large projects have to be individually assessed and approved by both the State and Commonwealth Governments. Funding may also be available for scoping studies that assess the viability of potential renewable energy projects.

Remote Area Power Supply Program

The Remote Area Power Supply Program provides rebates for renewable energy power systems used instead of diesel generation in off-grid areas of WA. Rebates are available for systems serving Aboriginal communities, businesses and households.

The Remote Area Power Supply Program is proposed to run from July 2001 to June 2008 with total funding of up to $20 million available for eligible projects. The program provides rebates of 55 per cent of the capital cost of renewable energy systems, up to a maximum of $550,000. The Program is jointly funded by the Commonwealth and WA Governments. Funding applications made under the Program are assessed and approved by the Sustainable Energy Development Office.

Renewable Energy Water Pumping Program

The Renewable Energy Water Pumping Program provides rebates for medium and large sized renewable energy based pumps, such as solar pumps and windmills, used instead of diesel based pumps in off-grid areas of WA. Total funding of up to $4.8m is expected to be available under the Renewable Energy Water Pumping Program from February 2002 to June 2006. The program provides rebates on the capital cost of the renewable energy component of eligible pumping systems. The maximum rebate available is:

→ $20,000 per site, for pastoral stations, communities and towns only.

→ $10,000 per site, for farms and other sites.

Eligibility for the program is limited to businesses, government agencies and incorporated organisations that are registered for the GST.

Industry support programs

Industry support programs that help improve the capabilities of the local renewable energy industry and increase understanding amongst end-users are recognised as being important in meeting the Renewable Remote Power Generation Program objectives.

Renewable Remote Power Generation Program funding may be available for industry support programs that relate directly to the use of renewable energy generation in off-grid areas, including training, information provision, equipment testing and development of standards, renewable resource and system applicability studies and demonstration projects.

South Australia

The RRPGP in SA will finish on the 30 June 2004. SA's total funding allocation under the program is dependant on the certified DFE in SA. Energy SA estimates SA's total DFE over the four years of the program to be $8.65m as the figure for the 03/04 financial year is yet to be certified.

Under the RRPGP, 276 stand-alone power systems (SAPS) have been installed with $6.4m being paid out in rebates. The systems collectively have 537 kW of photovoltaic capacity and 60 kW of wind generating capacity.

Thirty-two systems are yet to be installed, with approximately $1.4m approved in rebates. The 32 systems have a combined photovoltaic capacity of 108 kW and 60 kW of wind generating capacity.

Some of the remaining $.85m of SA's RRPGP funding has been spent on Administration and Industry Support, whilst the remaining funds have been pre-committed to the RAES subsidised Public Generators budget line to make up for the shortfall of funds allocated to this scheme during the four-years of the RRPGP in SA.

The 'Solar School's Program' is being subsidised through the Australian Government's Photovoltaic Rebate Program (PVRP). The first successful sites in the three-year SA Solar Schools Program were announced in May 2004 by the Premier of South Australia, Mike Rann.

These sites will now become the first schools and preschools to receive funding to facilitate the installation of a 2 kW array of photovoltaics. Sites will harness energy from the sun and will produce electricity for their own use. The photovoltaics will be grid-connected, enabling schools to become net providers of electricity when power is not required in buildings, for example, during school holidays and weekends.

The SA Solar Schools Program will continue until December 2005 by which time it will have taken solar power to over one hundred schools and preschools. In doing so the program complements the recently released South Australia Strategic Plan which emphasises the importance of sustainability in our State's future. A key objective of the State Government's plan is to make South Australia world-renowned for being 'clean, green and sustainable,' with a target to lead Australia in the production of wind and solar power within ten years. The significance of the SA Solar Schools Program is highlighted with the Premier announcing his aim to extend the SA Solar Schools Program to 300 schools by 2014.

APPENDIX 4// SCENARIO MODELLING

Model structure and assumptions

The PV Roadmap model consists of four main inter-related modules:

- → Module price-progress engine, which determines likely module price corresponding to cumulative global market volume.
- → A global market growth engine, which simply projects future cumulative market volume year by year on the basis of consistent annual growth rates.
- → An Australian market growth engine which is used to determine future local market volume year by year on the basis of annual market growth expectations in five main market segments (off-grid domestic, off-grid non-domestic, mini-grids, grid-connected distributed and grid-connected centralised).
- → A PV electricity price calculator which equates module prices to life-cycle system costs, establishes the amount of electricity generated by a typical system over its lifetime and accordingly determines the levelised cost of PV electricity on a year by year basis for comparison to retail tariffs.

The price-progress engine establishes a module price for any cumulative market volume according to historical price-experience growth rates, which demonstrate that module prices have reduced by approximately 18 per cent for every doubling of cumulative production experience (i.e. 82 per cent Progress Ratio). This effect has also translated into cost reductions in other 'balance of system' components. For the purposes of the model, balance of system prices are projected to fall at the same rate as module prices.

The model operates on the principle that price-reductions are not in themselves time-dependent. Instead, the timing of when a particular module price point will be achieved is driven by the global market growth rate: a very small growth rate equates to slow production experience and so delays price reductions, whereas large growth in the global PV market requires rapid production increases and correspondingly tends to accelerate price reductions. This is a strong premise behind the market stimulation programs of many major PV manufacturing countries; creating or sustaining a high-level of demand for PV through various market incentives is expected to bring forward the point at which PV energy services are competitive with alternative service options, and in particular the point when PV is competitive with tariffs for grid-supplied electricity.

The Australian market growth engine is largely independent of the global growth module, and is used to determine the impact of alternative Australian industry and market development scenarios, in terms of jobs, local and export sales, production capacity and emissions abatement. However the two are inextricably inter-related in respect of certain key outputs – notably the Australian industry share of the global market, and indirectly in terms of the sales revenue generated as the global scenario selected (global market growth rate) establishes the module price and hence value of system sales. This engine is strongly reliant upon industry experience to determine likely future growth patterns, and in assessing future market growth it is also essential that we have a good appreciation of the 'limits to growth' in each of the market segments. These were discussed in more detail in Chapter 3. Likewise, industry best estimates have been adopted to establish expectations for the likely proportion of component exports and imports under different Australian scenarios.

The PV electricity price calculator's purpose is largely to determine the point at which PV electricity is likely to be competitive with grid-supplied electricity. It also serves to assess the 'price gap' (i.e. the difference between PV and grid-supplied electricity) year by year, which to some extent is used to colour expectations about likely local market growth. The expectation is that as PV electricity prices approach and then improve on grid-supplied electricity prices, natural demand for PV will increase. In reality, this is an oversimplification of PV decision making processes as comparative price is by no means the only driver for end-user investment in PV. It is, nonetheless, likely to exert reasonable influence on market growth rates. This elasticity of demand with respect to energy prices is acknowledged in the Australian market growth module.

The key assumptions in the scenario modelling are summarised in Table A4.1.

Table A4.1 Key assumptions in the PV Roadmap model

International PV module price development	Continues to decline at 18 per cent per doubling of cumulative production (For global market growth of 25 per cent this equates to 6.2 per cent annual price decrease; Global market growth of 30 per cent equates to 7.2 per cent annual decrease). Note that 18 per cent reduction is the average market price-experience rate recorded over the past fifteen years.
Global market growth expectations	Targets in the three main industrialised PV market regions (Europe, Japan, USA) require over 11 GW of PV generation capacity to be installed by 2010. This equates to an average annual market growth rate of approximately 23 per cent per annum. This takes no account of additional demand in the rest of the world – i.e. it excludes amongst many others the requirements of Australia, China and India. A 25 per cent average global growth rate is therefore not unrealistic – certainly in the 2010 timeframe – and indeed 30 per cent is believed to be more representative of future demand. Note that for IEA-PVPS countries, which currently account for 65 per cent to 75 per cent of the global demand for PV modules, market growth rates have averaged over 33 per cent for the past five years and over 36 per cent in the last three years.
Australian module prices	Reflect average international prices. As such, it is international market development that largely drives Australian hardware cost reductions.
System cost components	Modules represent 50 per cent of the system hardware cost: inverter(s) represents 25 per cent; other 'BOS', balance of system components (support structure, protection, cabling etc.), account for the remaining 25 per cent.
BOS price reduction	Same rate as module price reduction. (This is supported by Japanese experience under the 70,000 Rooftops Program.)
Installation cost component	Installation as a component of the total system price also decreases at 18 per cent, though on the basis of local installed experience, rather than international experience. This means that while an Australian program which builds the local market faster than the global average might have only a small effect on system hardware cost reduction rate, it is expected to have a more pronounced impact on the installation component. Additionally it is assumed that a minimum cost 'floor' of $300/kW exists (i.e. irrespective of future hardware cost reductions, it will not be possible to install a system for less than $300/kW).
Operation and maintenance costs	Estimated at slightly under 1 per cent of the total system (hardware) cost.
System lifetime (modules)	25 years.
Replacement costs	Assumes that the inverter needs replacing after 25 years. This is not necessarily reflective of current systems, where inverters may typically need replacing after 15–20 years. However, 25–30 year inverter lifetimes are expected within the 2010 timeframe (indeed Pacific Solar's module-integrated inverters are already designed to exceed 1 million hours MTBF) and as such for purposes of determining price convergence point the use of the longer lifetime is valid.
Application sector energy costs	In order to estimate the generation cost from systems other than residential PV systems, simple scale factors have been applied. The scale factors used are: → Centralised grid-connect systems = x 0.9 (result of lower capital cost/kW). → Domestic RAPS = x 1.3 (result of higher capital cost, higher life-cycle replacement costs and lower system yield) → Non-domestic RAPS = x 1.2 (result of higher capital cost, higher life-cycle replacement costs and lower system yield).
Retail electricity prices	Main estimates for 'price convergence' refer to residential tariffs. The retail electricity price adopted is based on an Australia-wide average as reported by ESAA (12.4c/kWh, 2001 figures). It is felt to be largely representative of tariffs in NSW and Victoria. However it is likely to be conservative in respect of South Australia, implying that the price convergence point in SA may occur rather earlier than predicted by the model (all other assumptions remaining valid).
Average retail electricity price increases	3 per cent per annum (real).
Renewable energy certificates	RECs are estimated to have a value of 35 $/MWh. It is assumed that there will be no substantial change to the deeming provisions for PV under MRET, i.e. RECS may be deemed in 5 year blocks.
System yield	For estimating lifetime energy generation, a PV system annual yield of 1382 kWh/kW is adopted, in line with MRET Deeming Zone 3, which is valid for main population centres in ACT, NSW, QLD, SA and WA. It underestimates expected yield for centres in NT, and overestimates for VIC and TAS.. (It is assumed that the deeming rate accounts for slight performance deterioration due to module degradation expected over the life of the system.)
Electricity demand growth	For the purposes of estimating PV contribution to future national electricity production, an average electricity demand growth of 2.6 per cent is adopted.
Discount rate	5 per cent is applied.
CO_2 abatement potential	Calculated on the basis of current national average emission intensity of 1.12 Tonnes CO_2-e / MWh estimated from AGO's greenhouse challenge workbook.

Scenario descriptions

'Business as Usual' scenario

Under the 'Business as Usual' scenario, demand for PV over the next ten years will continue to be largely driven by off-grid, rural/remote applications where PV is already competitive, for example telecommunications and other industrial applications, as well as for individual remote houses, pastoral stations and isolated mini-grids for rural or remote communities. Beyond 2010, the diesel replacement market for mining regions is expected to become more accessible.

Industrial applications aside, growth within the off-grid sector to 2010 is expected to remain largely reliant on capital subsidies available under the Renewable Remote Power Generation Program . Industry consensus, as determined during the Roadmap consultation process, estimates the sustainable annual market for off-grid PV applications, while current practices of widespread cross-subsidy of rural networks remain, to be approximately 25 MW. Over 80 per cent of this is in the non-domestic sector (i.e. industrial applications and mini-grids). Even under BAU, all off-grid sectors are anticipated to rise to their respective sustainable limits by 2012–2015 and maintain these levels thereafter. The BAU scenario also acknowledges some demand elasticity effects as system prices decline.

With the termination of the Photovoltaic Rebate Program (PVRP) in 2005, and in the absence of other measures, demand for grid-connected systems (which is highly price sensitive, and currently a market strongly influenced by incentives) is expected to falter. According to PV users' surveys by SEDA in New South Wales , the availability and size of the PVRP subsidy does have an influence on purchasing decisions. A survey of residential PV system purchases between 2002 and 2003 indicated that in the order of 60 per cent of users would not have invested in PV in the absence of the rebate. Accordingly, under the BAU scenario, residential PV demand is anticipated to halve immediately post PVRP, and it will take most of the rest of the decade before demand returns to the levels experienced under PVRP.

The remaining drivers for on-grid systems, such as state government initiatives for PV in schools, together with investments from committed 'green' householders will return demand for grid-connected distributed PV to around the level of 1 MW per year in 2010. Thereafter we anticipate strong growth in demand for grid-connected PV initially driven by adoption of PV by electricity network service providers to support weak grids and to offset investment in distribution network augmentation. Subsequently, demand will be taken-up by residential customers as PV electricity prices become increasingly competitive with household tariffs (expected to occur between 2015 and 2020 driven largely by international module price reductions).

Demand growth rates for centralised systems are expected to peak towards the middle 2020s, reflecting PV's increasing competitiveness with industrial electricity tariffs. Strong growth rates are expected to remain in both the distributed and centralised grid-connect markets to 2030.

Under the BAU scenario it is likely that existing PV manufacturers will effectively be forced to end their production in Australia in the near term. Without a home market of at least 50 per cent of production, there is little justification for global industries to retain their production capacity here and manufacturing is likely to be switched closer to the final market overseas. This will result in significant job losses which are not expected to be regained for over a decade.

'Sunrise 350' scenario

The initial target of the Sunrise 350 scenario is that Australia will seek to have installed approximately 350 MW of PV by the end of 2010. Establishing this goal is itself a significant measure, which is expected to galvanise the industry and provide the framework for action over the coming few years. The target for 2010 is acknowledged to be ambitious, requiring over 125 MW to be installed during 2010 alone. However, it is an achievable goal if underpinned by the coordinated and focused industry and market development plan outlined in the Roadmap, and one which delivers substantial benefits to Australia over the BAU approach.

Under the Sunrise 350 scenario, the PV industry picture to 2010 is governed largely by stimulated demand for distributed grid-connected systems through government support programs for residential rooftop PV and building integration in the commercial sector. Sunrise 350 envisions annual growth rates in the distributed grid-connected sector increasing to 100 per cent within three years (i.e. twice as much new capacity will be installed in 2007 as was installed in 2006), and maintaining this to 2010. Post 2010, the distributed grid-connect support program is expected to begin to be phased out and demand will stabilise at the sustainable annual level (approximately 600 MW pa) by 2017. This coincides with PV electricity prices converging with the price of grid-supplied electricity. Beyond 2017, government support measures are expected to be phased out for new PV systems (though enabling measures such as access to finance, streamlined connection procedures, installer competency training etc. must remain).

Over a similar time period, mandated requirements on electricity network service providers to assess PV in grid-support configurations will kick-start demand for centralised PV. This is expected to confirm the unpriced benefits provided by PV to electricity networks and to build electricity industry confidence in PV that can sustain annual growth rates of 25 per cent to 35 per cent to 2020 (annual growth rates gradually diminishing towards the end of the term). Beyond 2020, new applications for centralised PV emerge, for instance as part of a clean hydrogen economy to create an energy carrier for the transport sector, which can sustain long-term growth rates in the order of 15 per cent. This is expected to see centralised PV demand approach the estimated sustainable limit for this application sector of 2000 MW per annum by 2030.

Demand patterns for PV in the off-grid market sectors are expected to be quite similar to those predicted for the BAU scenario, with the exception that the disruption to the off-grid domestic sector resulting from the cessation of PVRP is avoided, while additional enabling measures (e.g. better access to finance, expansion of support policies, and stronger local industry capability resulting from the program) will support additional demand for off-grid non-domestic applications.

A further important consideration is that the Sunrise 350 scenario anticipates much heavier reliance on domestically manufactured PV modules and inverters than BAU, on the expectation that the stronger industry development measures serve to build a more globally competitive local industry that can better stave-off overseas competition. The assumption is that in the long-term 75 per cent of demand under the Sunrise 350 scenario is met by local production, compared to 50 per cent under BAU.

APPENDIX 5// SUMMARY OF USA STATE POLICIES AND INITIATIVES[1]

Note – virtually all states have similar solar access and easement legislation.

Program	Policy / initiative	Summary
Arizona		
Environment Portfolio Standards (EPS)	State utilities to source electricity from renewables. then 60% PV	0.2% in 2001 increasing to 1.1% in 2007, then 1.1% to 2012 50% must be PV in 2001 to 2004,
Salt River Project	Net metering	For PV systems up 10 kWac net exported power purchased at average market price.
Tuscon Electric Power	Net metering for up to 500 kW of PV in the region.	For PV systems up 10 kW net exported power credited against following months bill..
Arizona Corporation Commission	Cost benefit analysis	For remote locations, utilities must conduct a cost/benefit analysis to compare the cost of line extension with the cost of installation of a stand alone photovoltaic system
California		
Renewable Energy Portfolio	Renewable Portfolio Standards 2002 Bill	Electricity retailers to increase their use of renewable resources by at least 1% per year. Retailers must produce at least 20% of their retail electricity sales from renewables by 2017.
Net metering	Net metering law	California's investor-owned electric utilities and rural cooperatives, must allow net metering for all customer for systems up to 1 MW. Los Angeles Department of Water and Power, the largest municipal utility in the nation, and the Sacramento Municipal Utility District (SMUD) already offered net metering.
Colorado		
Renewable Portfolio Standards	Electric Energy Supply Policy – Fort Collins → Develop and implement policies and programs that support renewable energy, sustainable practices, reduction or global warming, and the design and construction of energy efficient buildings → Develop and implement policies that require the use of energy efficient design principles in the renovation and construction of all City facilities	Policy objectives include the following: → Reduce consumption 10% by 2012 (from 2002 baseline) → Reduce peak day electric demand 15% by 2012 (from 2002 baseline) → Develop and implement effective DSMt programs → Develop a plan to evaluate a systems benefit charge, efficiency programs, incentive programs, educational programs, revolving loan programs and innovative rate structures → Whenever possible, integrate efforts related to energy efficiency, renewable resources, green buildings (energy code), sustainable practices and education.
Connecticut		
Renewable Portfolio Standards		10% of all retail electricity to come from RE sources by 2010
Net metering	1998 Act companies only have to offer to residential customers.	Utilities and distribution companies to offer net metering for systems up to 100 kW. Distribution
Delaware		
Net metering	Act 1999	Net metering of RE systems up to 25 kW
Georgia		
Net metering	Act 1999	Net metering of RE systems up to 25 kW

1 *Summarised from http://www.dsireusa.org, downloaded June 2004*

Program	Policy / initiative	Summary
Hawaii		
Renewable Portfolio Standards	2004 enforceable standard	Each electric utility is required to establish the following RPS percentages: (1) 7% of its net electricity sales by December 31, 2003. (2) 8% of its net electricity sales by December 31, 2005. (3) 10% of its net electricity sales by December 31, 2010. (4) 15% of its net electricity sales by December 31, 2015. (5) 20 % of its net electricity sales by December 31, 2020.
Net metering	Act 2001, amended 2004	Net metering to capacity limit 50 kW. Utilities have to offer net metering until total net metering capacity equals 0.5% of each utility's peak demand, which corresponds to a total 'cap' of approximately 10 MW for the state. No payment for a net excess.
Idaho		
Net metering		All utilities voluntarily offer net metering.
Illinois		
Renewable Portfolio Standards	Resource Development and Energy Security Act	The legislation adopted a state-wide renewable energy goal of at least 5% of total energy by 2010, and at least 15% by 2020.
Net metering	April 2000 voluntary decision by Commonwealth Edison	Net metering of photovoltaic and wind energy systems up to 40 kW. Customer paid utility's avoided cost on a monthly basis. Also an additional annual payment for the customer's total excess power during the year (up to the amount of power taken by the customer). Customers are paid the difference between the average avoided cost and the average retail rate paid by the customer during the year.
Green Power purchasing	2002 executive order City of Chicago	Commitment by the state to purchase 5% green power by 2010. The amount of renewable energy purchased will grow to at least 15% by 2020. The City of Chicago signed an agreement to purchase 20% of their electricity used by 2005.
Indiana		
Net metering	Renewable Energy Systems	System capacity limit of 10 kW to a total capacity limit of 13.2 MW.
Iowa		
Net metering	Iowa Utilities Board	Net metering allowed and net excess purchased at utilities' avoided cost.
Green power	Iowa Utilities Board	Investor owned utilities to purchase 105 MW of renewable energy. All utilities to offer green power.
Maine		
Renewable Portfolio Standards	1999 Ruling	Requirement for utilities to supply at least 30% of energy from eligible 'small' renewable resources of up to 80 MW capacity. Annual reports on compliance with penalties being paid to a renewable energy resource R & D fund.
Net metering	1987	Net metering with net excess rolling over to the next month. Annual net excess is granted to the utility at no cost.

Program	Policy / initiative	Summary
Maryland		
Renewable Portfolio Standards	Renewable Energy Portfolio Standard and Credit Trading Act, 2004	In 2006 utilities must supply 1% of retail sales from eligible RE sources which then increases at 1% per annum until 2018. A US$0.002/kWh penalty for shortfalls to be paid to Maryland's RE Fund.
Net metering	1997 law	Net metering for residential and school PV systems up to 80 kW. Utilities to supply meters and offer the programme at no extra charge.
Green power	Executive order 2001	6% of electricity consumed at State facilities to come from approved RE sources, with a 50% cap on landfill sources. The order also calls for a reduction in energy use in state buildings of 10% by 2005 and 15% by 2010 and the use of energy efficient products.
Massachusetts		
Renewable Portfolio Standards	Regulations 2002	All retail electricity to utilise new RE sources for at least 1% of their power supply in 2003, increasing to 4% by 2009, then at 1% pa. Non compliance payments of US 5c per kWh is paid to the state's renewable energy trust.
Net metering	1997 amendment	Net metering for facilities up to 60 kW capacity, with net excess rolling to the following month.
Minnesota		
Renewable Portfolio Standards	2003 amendment	In 2005, at least 1% of the retail electric to be from eligible RE sources. To be increased by 1% pa until 2015.
Net metering	1983	Utilities must purchase net excess generation at the average retail rate.
Green Power		Utilities in Minnesota must offer customers the option to purchase green power. Rates charged for green power must be based on the difference between the cost of the renewable energy and the same amount of non-renewable energy.
Montana		
Net metering	1999	Up to 10 kW. Utilities are not obliged to buy excess.
Green Power	2003	Default electricity suppliers must provide green power option.
Nevada		
Renewable Portfolio Standard	1997	% Renewables — Date 5% — 01/01/2003 7% — 01/01/2005 9% — 01/01/2007 11% — 01/01/2009 13% — 01/01/2011 15% — 01/01/2013 Not less than 5% of the renewable energy must be generated from solar renewable energy systems.
RECs	2002	Energy providers can buy and sell RECs. PV allowed 2.4 RECs /kWh
Net metering	1997 amended 2003	30 kW cap. Customer generators are billed monthly except in situations in which the customer and the utility agree on annual billing. Net excess generation is credited to the utility
New Hampshire		
Net metering	1998 amended 2001	Up to 25 kW capacity. Total capped at 0.05% of annual peak demand.

Program	**Policy / initiative**	**Summary**
New Jersey		
Renewable Portfolio Standards	2004	Utility requirement for 4% of retail generation from RE and an additional 2.5% from RE by May 31, 2008. Percentages beyond 2008 will be adopted in a future rule making.
RECs	2004	Establishment of REC and a solar REC that can be traded.
Net metering	1999	100 kW cap on the system. Net monthly excess kWhs rolled over up to one year.
Green Power		NJ agencies are purchasing Green-E certified electricity in order to meet the 10% environmentally friendly green power goal.
New Mexico		
Renewable Portfolio Standards	2002	Investor owned utilities to produce 5% of all energy from RE by 2006. RE must increase by at least 1% per year until the portfolio standard (RPS) of 10% is attained in the year 2011.
RECs		One kilowatt-hour of solar power is worth three kilowatt-hours, i.e. 3 RECs.
Net metering		Up to 10 kW capacity, net excess generation rolls to next month with any unused credited granted to the utility at the end of the year.
Cost benefit analysis		Utilities are required to provide information on RE systems to remote customers with less than a 25 kW load who request line extensions. Requirement applies when the cost of the line extension is greater than 15 times the estimated annual revenue from the line extension.
Green Power		Utilities must offer green power and develop education and training programmes.
New York		
Net metering	1997	Up to 10 kW capacity. Net excess rolls to next month. Annual net excess can be sold at avoided cost.
Tax		Income tax credit of 25% of the cost of qualifying PV system.
Green Power	2001 Order	Commits State government to purchase at least 10% from RE by 2005, and 20% by 2010.
North Dakota		
Net metering	1991	Up to 100 kW capacity. Net excess can be sold at avoided cost.
Ohio		
Net metering	1999	No limit on capacity. Net excess can be sold.
Oklahoma		
Net metering	1988	Up to 100 kW capacity. Net excess can be sold at avoided cost.
Pennyslvania		
Utility restructuring	1996	To qualify as a default supplier, during a utility restructuring, some 2% a renewable energy portfolio requirement was established.
Net metering		Maximum capacity varies by utility. Up to 10, 40 and 50kW
Green Power		Commonwealth of Pennsylvania signed a contract with Community Energy Inc. to purchase 100 million kWh of green power over two years starting January 1, 2002. The green power is 5 percent of the state government's needs.
Tennessee		
Green Power	2002	All state buildings in Nashville, will obtain a portion of their electricity from renewable energy sources. Green power accounts for 720 MWh pa.

Program	Policy / initiative	Summary	
Texas			
Net metering	2002	MW New Renewables by	Date
		400 MW	01/01/2002
		400 MW	01/01/2003
		850 MW	01/01/2004
		850 MW	01/01/2005
		1,400 MW	01/01/2006
		1,400 MW – MW	01/01/2007
		2,000 MW	01/01/2008
		2,000 MW	01/01/2009–2019
REC trading		Utilities allocated targets based upon retail sales. The penalty is the lesser of $50 per MWh or 200% of the average cost of credits traded during the year	
Net metering		Net consumption is billed at the applicable tariff and excess generation by the customers during a billing cycle is purchased by utilities at rates not to exceed the avoided cost (fuel cost only, no capacity component)	
Cost benefit analysis		Where the utility requires a customer to pay a contribution toward the construction of extending utility power lines to a remote location, the utility must provide information about on-site renewable energy technology options	
Utah			
Net metering	2002	To 25 kW. Net excess bought at avoided cost.	
Vermont			
Net metering	1998 on	To 10 kW. Farmers to 150 kW.	
Monthly net excess rolls to next month.			
Virginia			
Net metering	2004	Residential to 10 kW	
Commercial to 500 kW			
Monthly net excess rolls to next month.			
Washington			
Net metering		Net metering up to 25 kW. Net excess rolls to next month. Any net excess at year end is credited to utility.	
Green Power	2001	Mandated that utilities must offer green power.	
Wisconsin			
Renewable Portfolio	Bill 1999. Percentage of renewables	0.5% by 12/31/2001 0.85% by 12/31/2003 1.2% by 12/31/2005 1.55% by 12/31/2007 1.9% by 12/31/2009 2.2% by 12/31/2011	
Net metering	Order 1992	Utilities pay retail rate for excess net generation	
Wyoming			
Net Metering	Bill 2001	Net metering for systems up to 25 kW	

APPENDIX 6// SUMMARY OF THE STATE-BASED FINANCIAL INCENTIVES IN THE USA[1]

There are a variety of schemes administered by the various states in the USA which support renewable energy systems including. Some of these are common over a number of states, others are individually-administered and funded schemes. This appendix lists the schemes which include PV and which could have relevance for Australian conditions.

Mainstay Energy Rewards Program – Green Tag Purchase Program: Mainstay Energy is a private company offering customers who install, or have installed, renewable energy systems the opportunity to sell the green tags (also known as renewable energy credits, or RECs) associated with the energy generated by these systems. These green tags will be brought to market as Green-e* certified products. Through the Mainstay Energy Rewards Program, participating customers receive regular, recurring payments. The amount of the payments depends on the type of renewable energy technology, the production of electricity by that system, and the length of the contract period. Mainstay offers 3, 5, and 10-year purchase contracts. The longer the contract period, the greater the incentive payment on a $/kWh basis. Typical payments, which are made quarterly, are as follows: Solar PV: 2¢/kWh – 5¢/kWh (estimated $50–$250/year for residential systems, $300–$3000/year for commercial). Mainstay Energy is the first company in the US to purchase green tags from small-scale renewable producers on a national scale. The Mainstay Rewards Program currently has about 200 participants – both commercial and residential, located across 18 states.

BEF – Renewable Energy Grant: Using revenues generated from the sales of Green Tags, Bonneville Environmental Foundation (BEF), a not-for-profit organization, accepts proposals for funding for renewable energy projects located in the Pacific Northwest. Any private person, organization, local or tribal government located in the Pacific Northwest may participate. Projects that generate electricity are preferred. Acceptable projects include solar photovoltaics, solar thermal electric, solar hot water, wind, hydro, biomass, and animal waste-to-energy.

BEF may deliver funding through various means, including grants, loans, convertible loans, guarantees, and direct investments in renewable energy projects. BEF renewable energy grants and investments may range from a few thousand dollars for small installations, to significant investments in central station grid-connected renewable energy projects. If a BEF grant is requested for a generating project, the BEF share will not exceed 33 per cent of total capital costs, and zero per cent of operating costs. BEF generally does not fund residential and small business renewable energy projects with grants or investments. States participating in this scheme include Idaho, Montana, Oregon and Washington State.

1 *http://www.dsireusa.org*

State	Type of scheme	Details relating to PV
Arizona	Personal tax credit	Solar and Wind Energy Systems Credit: this isma credit against the personal income tax in the amount of 25 per cent of the cost of a solar or wind energy device.
	Sales tax exemption	Solar and Wind Equipment Sales Tax Exemption: sales tax exemption for solar and wind energy equipment purchased from a retailer.
	Utility rebate program	APS – EPS Credit Purchase Program: Through the EPS Credit Purchase Program, Arizona Public Service offers customers who install photovoltaic systems the opportunity to sell the credits associated with the energy generated by these systems to APS
	EP-SunShare PV buydown	Tucson Electric Power created the SunShare hardware buydown program to encourage residential and business customers to install new photovoltaic equipment.
California	Corporate tax credit	Solar or Wind Energy System Credit – Corporate: provides personal and corporate income tax credits for the purchase and installation of solar energy systems.
	Local rebate program	San Diego – Residential Solar Electric Incentive for Homes Destroyed in Wildfires: $6.57 million[2] in funding, and offering incentives of $4 per watt for installing solar electric (photovoltaic) systems of 0.5 to 5 kW on a new home that replaces a home destroyed by Cedar, Paradise or Otay 2003 wildfires.
	Personal tax credit	Solar or Wind Energy System Credit – Personal: The law provides personal and corporate income tax credits for the purchase and installation of solar energy systems.
	Production incentive	Supplemental Energy Payments (SEPs): Retail sellers are California's three largest investor-owned utilities: PG&E, SDG&E, and SCE. Payments cover the above costs of renewable energy and should be made for contracts of 3 to 10 years.
	State rebate program	Emerging Renewables (Rebate) Program: This provides rebates for the purchase of four types of renewable energy generating 50 kW or less. Total funding under the program is $118 million. SELFGEN – Self-Generation Program: this provides incentives to encourage customers to produce energy using renewables including PV. Solar Schools Program: On May 19, 2004, the Energy Commission adopted specific funding and eligibility requirements for the Solar Schools element of the Emerging Renewables Program (ERP).
	Utility rebate program	Anaheim Public Utilities – PV Buydown Program: Rebate through the Anaheim Advantage Residential PV Buydown Program for customers with qualifying PV systems that are 3–20 kW and which do not exceed the historical or current electric needs of the electricity consumer at the site of installation. Burbank Water & Power – Residential & Commercial Solar Support: Burbank Water & Power offers residential customers a rebate of $3 per Watt for PV systems of up to 2 kW, for a maximum incentive of $6,000. The utility offers business customers a rebate of $3 per Watt for PV systems of up to 3 kW, for a maximum incentive of $9,000. City of Palo Alto Utilities– PV Partners: Initiated a PV rebate program which offers up to $4/Watt to Palo Alto Utility customers who install qualifying PV systems. CPAU offers information to help customers plan and buy their systems. LADWP – Solar Incentive Program: Solar buydown program designed to encourage the use of renewable energy through the installation of PV systems by residents and businesses in Los Angeles. LADWP has budgeted $20 million for this fiscal year and $16 million for the following year to help meet the rise in demand. Redding Electric – Vantage Renewable Energy Rebate Program: Residential and business customers of Redding Electric Utility are eligible to apply for rebates of up to 50% of project costs for PV and solar thermal systems. The rebate program encourages the development and demonstrates the benefits of solar technology in REU's service territory.
Delaware	State rebate program	Green Energy Program Rebates: The purpose of the program is to introduce renewable energy technologies into the Delaware market by reducing the net system costs through the use of rebates.

2 All dollar ($) amounts in this Appendix are in US dollars

State	Type of scheme	Details relating to PV
Hawaii	Corporate tax credit	Corporate Solar and Wind Energy Credit: the Hawaii Energy Tax Credits: Allow individuals or corporations an income tax credit of 35 per cent of the cost of equipment and installation of a PV system
	Industry recruitment	High Technology Business Investment Tax Credit: Offers a 100 per cent tax credit on an equity investment in a qualified high tech business. The purpose of this credit is to encourage investment in Hawaii's high tech companies.
	Personal tax credit	Residential Solar and Wind Energy Credit: The Hawaii energy tax credits allow individuals or corporations an income tax credit of 35 per cent of the cost of equipment and installation of a PV system.
Idaho	Personal deduction	Solar, Wind, and Geothermal Deduction: This statute allows taxpayers an income tax deduction of 40 per cent of the cost of a solar, wind or geothermal device used for heating or electricity generation.
	State loan program	Low-interest Loans for Renewable Energy Resource Program: This makes funds available at a 4 per cent interest rate for PV projects. Residential loans are available from $1,000 to $10,000. In commercial and industrial sectors there is a minimum loan amount of $1,000 and a maximum cap of $100,000. Loans are repaid in five years or less.
Illinois	Grant program	Illinois Clean Energy Community Foundation Grants: The ICECF supports programs and projects that will improve energy efficiency, develop renewable energy resources, and preserve and enhance natural areas throughout Illinois. The ICECF provides financial support in three principal ways: grantmaking; partnerships with public agencies; and direct initiatives. The ICECF identifies strategic opportunities to undertake large-scale, high-impact projects and special initiatives that further its program objectives in energy efficiency, renewable energy and natural areas conservation.
	Property tax exemption	Special Assessment for Renewable Energy Systems: This statute allows for a special assessment of PV systems for property tax purposes. Solar equipment is valued at no more than a conventional energy system.
	State grant program	Renewable Energy Resources Program (RERP) Grants This promotes the development and adoption of renewable energy within the state.
	Utility rebate program	Chicago Photovoltaic Incentive Program (PIP): ComEd, in partnership with Spire Solar Chicago, offers Chicago property owners a rebate to help support locally-based PV manufacturing and the installation of photovoltaic systems. Under the PV Incentive Program (PIP), individuals and organizations are eligible for ComEd rebates on grid-tied PV systems purchased from Spire Solar Chicago.
Maryland	Corporate tax credit & Personal tax credit	Clean Energy Incentive Act (Corporate Credit): Sales tax exemptions or income tax credits when purchasing certain qualifying high efficiency appliances, electric and hybrid-electric vehicles, and certain renewable resource energy systems. An individual or a corporation may claim a state income tax credit of 15 per cent of the total installed cost of a PV system. Personal Income Tax Credit for Green Buildings: This income tax credit applies to nonresidential and residential multifamily buildings of at least 20,000 square feet that are constructed or rehabilitated to meet criteria set forth by the US Green Building Council or other similar criteria.
	State grant program	Solar Energy Grant Program the solar energy grant program provides financial incentives to homeowners and businesses that install solar energy devices.
Massachusetts	Corporate deduction	Alternative Energy and Energy Conservation Patent Exemption (Corporate): Corporate and personal income tax deductions for any income received from the sale of or royalty income from a patent that is deemed beneficial for energy conservation or alternative energy development. This deduction is unique among incentives in that it targets patents and not simply real property. Solar and Wind Energy System Deduction: Businesses may deduct from net income, for state tax purposes, costs incurred from the installation of any PV systems. The installation must be located in Massachusetts and used exclusively in the trade or business of the corporation.
	Corporate exemption	Solar and Wind Power Systems Excise Tax Exemption: This exempts solar and wind energy systems from the corporate excise tax for the length of the system's depreciation period.

State	Type of scheme	Details relating to PV
	Personal deduction	Alternative Energy and Energy Conservation Patent Exemption (Personal): Offers both corporate and personal income tax deductions for any income received from the sale of or royalty income from a patent that is deemed beneficial for energy conservation or alternative energy development.
	Personal tax credit	Renewable Energy State Income Tax Credit: This provides a 15 per cent credit against the state income tax for the cost of a renewable energy system (including installation) installed on an individual's primary residence.
	Production incentive	Mass Energy and People's Power & Light (a sister organization serving Rhode Island), are buying green attributes from PV systems in Massachusetts and Rhode Island. The renewable energy attributes from PV systems will be packaged together with wind, small hydro and biomass renewable energy certificates and sold as New England GreenStartSM, a new renewable energy-based electricity product sold through 'GreenUp', a new green pricing program being offered by National Grid, the utility serving most of Massachusetts and Rhode Island. Mass Energy and PP&L are offering to purchase renewable energy certificates at a rate of $60 per Megawatt-hour (or $.06 per kWh) for a period of three years from PV systems installed after 1998.
	Property tax exemption	Local Property Tax Exemption: PV and wind powered devices utilized as a primary or auxiliary power system for the purpose of heating or otherwise supplying the energy needs of taxable property qualify for property tax exemptions for a period of 20 years from the date of installation.
	Sales tax exemption	Renewable Energy Equipment Sales Tax Exemption: This exempts PV systems from the state sales tax. This exemption is limited to systems which will be used in an individual's principal residence and is not available to commercial users.
	State grant program	Commercial, Industrial, & Institutional Initiative Grants: offers a total of $6,000,000 in grant funding to expand the use of distributed renewable energy generation at commercial, industrial and institutional facilities in Massachusetts. The building or facility utilizing the power generated by the project must be grid-connected and greater than 50 per cent of the renewable energy produced must be consumed on-site.
	State rebate program	Clustered PV Installation Program: Six Massachusetts organizations are facilitating the installation of approximately 250 PV systems on homes and businesses in clustered regions throughout the state. These organizations will provide outreach activities in their communities and offer installation rebates to lower the PV system purchase cost for consumers. Open PV Installation Program: MTC has awarded more than $1.4 million to 9 organizations in the first round of its Open PV Installation Grant program. These organizations will facilitate the installation of and provide financial incentives for approximately 300 kW of PV throughout the state. Eligible PV projects must be pre-approved and installed by PV experts with licensed installers and electricians.
Minnesota	Property tax exemption	Wind and Solar-Electric (PV) Systems Exemption: This excludes from property taxation the value added by PV systems.
	Sales tax exemption	Solar-Electric (PV) Sales Tax Exemption: Certain energy-efficient products (including PV systems) are exempt from the state sales tax.
	State rebate program	Solar-Electric (PV) Rebate Program: The Minnesota Department of Commerce administers a PV rebate program, funded by Xcel Energy, to buy down the up-front costs of grid-connected solar-electric (PV) systems by $2,000 per kW, with a maximum award of $8,000 per system.
	Utility grant program	Renewable Development Fund Grants: To provide direct grants totalling up to $25 million to support new development projects (totalling approximately $15 million) that result in the production of renewable energy, and research and development projects (totalling approximately $10 million) to lead these technologies toward full commercialization.
Montana	Corporate exemption	Corporate Property Tax Reduction for New/Expanded Generating Facilities: Montana generating plants producing 1 MW or more by means of an alternative renewable energy source are eligible for the new or expanded industry property tax reduction on the local mill levy during the first nine years of operation, subject to approval by the local government. If so approved, the facility is taxed at 50 percent of its taxable value in the first five years after the construction permit is issued. Generation Facility Corporate Tax Exemption: New generating facilities built in Montana with a nameplate capacity of less than 1 MW and using an alternative renewable energy source are exempt from property taxes for 5 years after start of operation.
	Corporate tax credit	Alternative Energy Investment Corporate Tax Credit: Commercial and net metering alternative energy investments of $5,000 or more are eligible for a tax credit of up to 35 per cent against individual or corporate tax on income generated by the investment.

State	Type of scheme	Details relating to PV
	Personal tax credit	Residential Alternative Energy System Tax Credit: Residential taxpayers who install an energy system using a recognized non-fossil form of energy on their home after 12/31/01 are eligible for a tax credit equal to the amount of the cost of the system and installation of the system, not to exceed $500. The tax credit may be carried over for the next four taxable years.
	Property tax exemption	Renewable Energy Systems Exemption: Montana's property tax exemption for buildings using a recognized non-fossil form of energy generation, including PV may be claimed for 10 years after installation of the property.
	State loan program	Alternative Energy Revolving Loan Program: provides loans to individuals and small businesses to install alternative energy systems that generate energy for their own use. Net metering is allowed. The program is funded by air quality penalties collected by the Department of Environmental Quality. NorthWestern Energy – USB Renewable Energy Fund: provides funding to its customers for renewable energy projects. The Universal System Benefits Program requires all electric and gas utilities to establish USB funds for low-income energy assistance, weatherization, nergy efficiency activities, and development of renewable energy resources.
	Utility rebate program	NorthWestern Energy – PV Rebate Program: Electricity distribution customers may qualify for a rebate of $4 per Watt (peak DC) for the installation of a PV system up to a maximum of $8,000.00 per customer. Under this PV rebate program, rebates are available for grid-tied PV systems only. NorthWestern Energy – PV Systems for Fire Stations: In 2003, six fire stations served by the NorthWestern Energy electric distribution system qualified for free solar electric systems of up to a maximum of 2 kW in size. Under the project, roof-mounted, grid-tied photovoltaic systems will be installed on the roofs of the fire stations. The systems have a battery bank to provide un-interruptible power supply (UPS), and include a performance-monitoring component. NorthWestern Energy – Sun4Communities: NorthWestern Energy is recruiting ten Montana communities to participate in its new Sun4Communities project. The Sun4Communities project enables secondary schools and city and county government buildings to qualify for free solar energy systems. Sun4Communities is an expansion of the popular Sun4Schools project, which installed photovoltaic systems on 27 middle and high schools in Montana between 1999 and 2003. Each system will be capable of generating two kW and will provide a portion of the building's electricity needs. Any excess electricity produced by the system will be fed into the utility grid through a net metering agreement.
New Jersey	State grant program	Renewable Energy Advanced Power Program: The New Jersey Board of Public Utilities has issued a request for proposals for a competitive incentive and financing program to encourage development of distributed renewable electricity generation projects. Projects will be expected to supply electricity to the PJM Power Pool, or to large power users, by installing a minimum of 1 MW power generation at their facility or by aggregating a minimum of 1 MW of renewable electricity generation systems into one proposal. This solicitation is designed to provide seed grants and access to capital in order to make renewably-powered electricity cost competitive with conventional power plants.
		Renewable Energy Economic Development Program (REED): Provides funding in the form of a recoverable grant for the development of renewable energy businesses, renewable technologies and market infrastructure through the Renewable Energy Economic Development (REED) program. The concept is to provide seed capital for new businesses or business ventures and then to transition the business into traditional capital markets. Total program funding at this time is $5.0 million. The REED program is open to applicants who seek funding for research, business development, commercialization and technology demonstrations of innovative products or services that advance the delivery of renewable energy systems to the marketplace. Innovations in the renewable energy industry in terms of technology, services, system integration, financing, and supporting systems and fuels are sought. The REED program is not intended to provide financing for construction and installation of renewable energy systems. The minimum award amount is $50,000 and the maximum is $500,000.

State	Type of scheme	Details relating to PV
	State loan program	Reduced Energy Demand Options for Local Governments and Schools (REDO): Offering local governments and schools a low-interest, long-term financing program – the Reduced Energy Demand Options for Local Governments and Schools (REDO). Financing under this program will cover the entire incremental cost of energy efficiency and renewable energy projects, enabling the governmental entities to finance the projects completely, with no up front capital necessary.
	State rebate program	New Jersey Clean Energy Rebate Program: Provides for investments in energy efficiency and renewable energy through the 'Societal Benefits Charge' collected from all electric public utility customers. Renewable energy programs include a customer-sited renewables rebate program administered by the state's utilities.
New York	Personal tax credit	Solar and Fuel Cell Electric Generating Equipment Tax Credit: This personal income tax credit applies to expenditures on PV equipment used on residential property, and includes provisions for the net metering of the same equipment. There is a 10 kW limit on the size of equipment eligible for net metering. There is also a state-wide limit on the amount of total capacity that may be net metered.
	Property tax exemption	Solar and Wind Energy Systems Exemption: This provides a 15-year real property tax exemption for solar and wind energy systems constructed in New York State. The intent of the law is to encourage the installation of solar, wind and farm waste energy equipment systems and ensure property owners that their real property taxes will not increase as a result of the installation of these systems.
	State grant program	Renewables R&D Grant Program: This competitive research program is run by the New York State Energy Research and Development Authority (NYSERDA). The program is to assist companies in development, testing and commercialization of renewable energy technologies that will be manufactured in New York. NYSERDA provides funding support along the product development-to-commercialization continuum and provides the due diligence necessary to acquire private sector funding.
	State loan program	Energy $mart Loan Fund: The New York Energy $mart(SM) Loan program, administered by the NYSERDA, provides reduced-interest loans through participating lenders to finance renovation or construction projects that improve a facility's energy efficiency or incorporate renewable energy systems. There are currently over 80 participating lenders. Any commercial, industrial, retail, agricultural, non-profit, residential, or multifamily facility is eligible for this program, which cuts interest rates by 4 per cent for up to a 10-year term (previously a 4.5 per cent reduction and 5-year term). To qualify for the loan program, the facility must be an electricity distribution customer of one of the state's six investor-owned utilities.
	State rebate program	Energy $mart New Construction Program: Designed to accelerate the incorporation of energy efficiency and renewable energy sources in the design, construction, and operation of commercial, industrial, institutional, and multifamily buildings. The New Construction Program provides opportunities to implement permanent energy efficiency and load management improvements in building envelopes and major systems at the time of new construction or substantial renovation. Incentives to install building-integrated photovoltaics (BIPV), etc. are also available. PV Incentive Program (up to 15 kW): Provides incentives of $4 to $5 per Watt (DC) to eligible installers for the installation of approved, grid-connected, PV systems up to 15 kW. Incentives are only available to eligible installers and incentives must be passed on to customers. Once eligible, installers reserve incentives for approved systems, for specific customers, on a first-come, first-served basis, for as long as funds (~$2.5 million) are available. The program continuously accepts applications from installers who would like to participate in the program. The goal is to increase the network of eligible installers across the State, offering customers a choice of qualified or certified installers in their area.
	Utility rebate program	LIPA – Solar Pioneer Program: The Solar Pioneer Program (1999–2008) encourages the use of solar energy among Long Island homeowners and businesses and to help make the installation of a PV system more affordable. The Solar Pioneer Program is a five-year Clean Energy Initiative that is part of LIPA's $32 million commitment to developing clean energy alternatives.

State	Type of scheme	Details relating to PV
North Carolina	Corporate tax credit	Renewable Energy Tax Credit – Corporate: Provide an expanded tax credit of 35 per cent of the cost of renewable energy property constructed, purchased or leased by a taxpayer and placed into service in North Carolina during the taxable year. There is a maximum limit of $10,500 for residential PV systems; and a maximum of $250,000 for all solar, wind, hydro and biomass applications on commercial and industrial facilities.
	Industry recruitment	Renewable Energy Equipment Manufacturer Incentive: In addition to North Carolina's 35 per cent corporate tax credit for renewable energy installations, the state offers a corporate income tax credit to manufacturers of renewable energy products and equipment. The credit is equal to 25 per cent of the installation and equipment costs of construction, with no maximum limit.
	Personal tax credit	Renewable Energy Tax Credit – Personal: Provides for an expanded tax credit of 35 per cent of the cost of renewable energy property constructed, purchased or leased by a taxpayer and placed into service in North Carolina during the taxable year. The credit is subject to various ceilings depending on sector and the type of renewable energy system. The credit can be taken against franchise tax, income tax or, if the taxpayer is an insurance company, against the gross premiums tax.
	Production incentive	TVA – Green Power Switch® Generation Partners Program: TVA and participating power distributors currently offer a dual metering option to residential and small commercial consumers (non-demand metered) through the Green Power Switch® Generation Partners program. Through this program, TVA will purchase the entire output of a qualifying system ($0.15 per kWh) through a participating power distributor and the consumer will receive a credit for the power generated. Participation in this program is entirely up to the discretion of the power distributor.
	State loan program	Energy Improvement Loan Program: Available to businesses, local governments and non-profit organizations (including public schools) that demonstrate energy efficiency, use of renewable energy resources, energy cost savings or reduced energy demand. Loans with an interest rate of 1 per cent are available for certain renewable energy and energy recycling projects.
North Dakota	Corporate tax credit & Personal tax credit	Geothermal, Solar, and Wind Corporate Credit: Allows any taxpayer to claim an income tax credit of 3 per cent per year for five years for the cost of equipment and installation of a PV system.
	Property tax exemption	Geothermal, Solar, and Wind Property Exemption: Exempts PV systems from local property taxes. Qualifying systems can be stand-alone or part of a conventional system, but only the renewable energy portion of the total system is eligible.
Oregon	Corporate tax credit	Business Energy Tax Credit: For investments in energy conservation, recycling, renewable energy resources, or less-polluting transportation fuels. The 35 percent tax credit is taken over five years. To date, more than 6,500 energy tax credits have been awarded to Oregon businesses. Altogether, those investments save or generate energy worth about $100 million a year.
	Personal tax credit	Residential Energy Tax Credit: Homeowners and renters who pay Oregon income taxes are eligible for the Residential Energy Tax Credit if they purchase a range of energy efficient and/or renewable energy systems.
	Property tax exemption	Renewable Energy Systems Exemption: The added value to any property from the installation of a qualifying renewable energy system not be included in the assessment of the property's value for property tax purposes. This exemption is intended for end users and does not apply to property owned by anyone directly or indirectly involved in the energy industry.
	State grant program	New Renewable Energy Resources Grants: The Open Solicitations program is designed to support renewable energy projects that do not already have an established incentive program developed and launched by the Energy Trust of Oregon. The program does not fund R&D or pre-commercial activities.
	State loan program	Small Scale Energy Loan Program (SELP): The sale of bonds is made on a periodic basis and, occasionally, to accommodate a particularly large loan request. Loans are available to individuals, businesses, schools, cities, counties, special districts, state and federal agencies, public corporations, cooperatives, tribes, and non-profits. Though there is no legal maximum loan, the largest single loan has been $16.8 million.
	State rebate program	Solar Electric Buy-down Program: Available to customers of Pacific Power and PGE who install new PV systems on their new or existing homes, commercial and community buildings, farms, and municipal facilities.

State	Type of scheme	Details relating to PV
	Utility rebate program	Ashland – Solar Electric Program: The City of Ashland encourages electricity customers to install PV systems and interconnect them with the electrical supply grid by offering a one time cash rebate. In order to qualify, the system must be a net metered system interconnected with the City's electrical grid and must comply with all of the City's net metering requirements. The system must have unobstructed solar access between the hours of 10 am to 2 pm on December 21. OTEC – Photovoltaic Rebate Program: Customers of Oregon Trail Electric Cooperative (OTEC) who install grid-connected PV systems are eligible for a rebate of $600/kW of installed capacity. Systems must meet OTEC's net metering and interconnection agreement to be eligible. Customers who choose to net meter will receive a bi-directional meter from OTEC.
Rhode Island	Personal tax credit	Renewable Energy Personal Tax Credit: Eligible technologies for Rhode Island's personal renewable energy tax credit include photovoltaics (on and off-grid minimum system sizes apply).
	Production Incentive	People's Power & Light – Renewable Energy Certificate Incentive: See entry under Massachusetts for GreenStartSM, and 'GreenUp'.
		Renewable Generation Supply Incentive: The Renewable Energy Fund has funding available to support eligible new renewables projects located in New England which serve Rhode Island customers. Facilities may either be customer-sited or bulk power supply projects. Applicants may be either (a) generators, (b) wholesale intermediaries, or current or potential suppliers of retail electricity to Rhode Island customers with agreements with specific eligible generators or (c) end-users proposing supply installations in excess of 25 kW nameplate capacity. The method of distributing available funds will be in the form of a production incentive for a specified amount per kWh produced and delivered to Rhode Island consumers over a specified term, up to a total cap on the award.
	Property tax exemption	Renewable Energy Property Tax Exemption: For purposes of local municipal property tax assessment, renewable energy systems cannot be assessed at more than the value of a conventional heating, hot water, or other energy production system. Qualifying technologies include photovoltaics, etc.
	State grant program	PV Grant for Commercial, Industrial and Institutional Buildings: The Rhode Island Renewable Energy Fund has issued a Request for Proposals (RFP) for funding to support the installation of PV applications on commercial, industrial and institutional buildings in Rhode Island. Eligible projects include new PV installations which will demonstrate the use of PV systems as viable distributed generation resources, raise awareness in the public and business community of the new and opportunities for renewables in Rhode Island, and advance the infrastructure necessary to install and support future Rhode Island PV applications. RFP for Purchase/Sale of Renewable Electricity to Large Customers: This is designed to encourage the purchase of renewable energy-based electricity supply by large electricity customers in Rhode Island, including business, government, and institutional customers. Supports proposals by large electric customers and/or registered retail electricity suppliers for the purchase or sales of green power to large electricity customers in Rhode Island. The intent is to buy-down but not eliminate entirely the cost premium associated with purchasing green power. Possible funding structures include, but are not limited to: *Customer Rebates:* A fixed grant to either the supplier or the customer, distributed upon green power delivery, intended to buy-down a portion of the cost of the purchase; and a *Purchase Incentive:* A cents/kWh incentive offered to the customer or the marketer based on kWh of green power purchased/sold.
	State rebate program	PV & Wind Rebate Program: a $5 per watt buy-down up to 50 per cent of the system cost is available to the state's residents, businesses and non-profits for the installation of PV systems. Installations on schools, non-profits, and local government buildings enjoy higher levels of incentives provided they are high visibility locations, or in the case of non-profits, include education and outreach about renewable energy as part of their mission. Incentives are available for up to 90 per cent of the first $50,000, 80 per cent of the next $50,000, and 70 per cent of installation costs over $100,000. Small Customer Incentive Program for Green Power Marketers: Financial incentives to retail electricity suppliers registered in Rhode Island who offer eligible green power products to residential and small business consumers in the state. Products eligible for this incentive are either 'bundled' electricity supply offerings from competitive energy suppliers or tradable renewable certificate (TRC) offerings (either sold through the Narragansett Electric Company GreenUp Program, or independently) that meet the product eligibility requirements. The incentive structure specified can support the enrollment of approximately 15,000 customers.

State	Type of scheme	Details relating to PV
Utah	Corporate tax credit	Renewable Energy Systems Tax Credit – Corporate: Applies to 10 per cent of the cost of installation of a system up to $50,000. For residential buildings owned by the business, the credit is 25 per cent of the cost of installation of a system up to a maximum credit of $2,000 per system.
	Personal tax credit	Renewable Energy Systems Tax Credit – Personal: Utah's individual income tax credit for renewable energy systems on residential buildings applies to 25 per cent of the cost of installation of a system up to a maximum credit of $2,000 per system.
	Sales tax exemption	Renewable Energy Sales Tax Exemption: Sales of equipment and machinery used to generate electricity from renewable resources are exempt from the state sales tax.
Washington	Industry recruitment	High Technology Product Manufacturers Excise Tax Exemption: Washington's High Technology Sales/Use Tax Deferral exempts qualifying high technology manufacturers from the sales and use tax. The definition of high technology includes the development of alternative energy sources. Chelan County PUD –- Sustainable Natural Alternative Power (SNAP) Producers Program: Encourages customers to install alternative power generators such as PV and connect them to the District's electrical distribution system by offering an incentive payment based on the system's production. The amount paid on a $/kWh basis by Chelan County PUD to SNAP Producers will depend on the total amount contributed by SNAP Purchasers through the utility's green pricing program and the total amount generated by all SNAP Producers. Orcas Power & Light – Production Incentive: Orcas Power and Light (OPALCO), an electric cooperative serving Washington's San Juan Islands, provides an interconnection incentive for residential and commercial members who generate energy from PV etc. To receive an incentive, members must sign an Agreement for Interconnection granting OPALCO rights to the system's Green Tags. Solar generators can choose either a net metering or buy/sell option.
	Sales tax exemption	Sales and Use Tax Exemption: Sales and use tax exemption for solar, wind, and landfill gas electric generating facilities to include fuel cells. In addition, the exemption now applies to smaller systems, with a generating capacity of at least 2 kW.
		Puget Sound Energy – Solar PV System Rebate: Rebate to residential electricity customers who install a PV system on their home. The rebate incentive amount depends on the level of capacity and in which county the PV system is installed.
Wisconsin	Property tax exemption	Solar and Wind Energy Equipment Exemption: Any value added by a solar or wind energy system is exempted from general property taxes.
	State grant program	Focus on Energy – Grant Programs: Focus on Energy offers several grant programs to support the development of renewable energy. Financial support is provided thorugh: Business & Marketing Grants for developing business skills and marketing materials for organizations and businesses that provide renewable energy services; and Feasibility Study Grants for assessing the feasibility of using complex, customer-sited renewable energy systems. Feasibility Study Grants are intended to increase the ability of businesses or organizations to make informed decisions about using renewable energy systems by understanding and solving technical uncertainties. Implementation grants provide financial support for large renewable energy projects (greater than 20 kW or 5,000 therms per year).
	State loan program	Focus on Energy – Loan Program: Offers low-interest loans to finance renewable energy projects on existing owner-occupied single-family and duplex homes. Homeowners can borrow $2,500 – $20,000 at an interest rate of 1.99%. Loan terms vary from three to 10 years. Systems must be installed by a participating contractor.
	State rebate program	Focus on Energy – Cash-Back Reward: Offers Cash-Back Rewards for installing or expanding renewable energy systems on businesses and homes. Payments are based on an estimate of the amount of electricity or therms produced annually.
	Utility rebate program	Wisconsin Municipal Utility Solar Energy Cash Allowance: Many of Wisconsin's municipal utilities support customer use of solar energy by providing cash incentives for qualifying projects.

APPENDIX 7// KEY BARRIERS

Key barriers identified during the PV Roadmap consultation process and proposed solutions

Barrier	Causes	Effects	Urgency of resolution	Proposed solution	Solution providers
Barriers from PV industry perspective					
Instability of the market for PV in Australia	Immature market compounded by short-term, start-stop support policy	Consumer uncertainty; difficulty planning and building viable businesses	Extremely urgent	Establish clear target for PV market growth. Define clearly budgeted industry development measures and stick to these for at least 7 years	Government (Commonwealth in cooperation with States)
Small PV market volume in Australia	High up-front costs for PV systems, long 'payback' period, low awareness, low recognition of added-values of PV, disjointed support measures	Falling share of global PV market; critical pressures to relocate PV cell and PV manufacturing out of Australia	Address policy immediately others over next 2–10 years	Stimulate installation of on-grid distributed PV through phased incentives; Introduce low-cost finance solutions to address high up-front costs of PV systems; Implement PV experience program	Government (Commonwealth in cooperation with States)
Political indifference/ lack of political will	Weak messages from PV industry (economic timescale and value, jobs); Strong energy intensive users and fossil fuel counter-lobbies	Falling share of global PV market; risk of missing new high-value industry opportunities; long-term negative climate change implications	Immediate	Initiate stronger PV industry coordination; Establish high-level 'steering committee' with key stakeholders	Initiated by PV industry to improve communication with all levels of Government
Business development finance hard to access for the PV industry	Finance sector unfamiliar with PV/ over-cautious	PV industry businesses cannot easily grow	Extremely urgent	Short-term: establish industry development 'bank' Medium-term: work with commercial finance sector to resolve concerns	Commonwealth Government in association with the finance industry
Weak export orientation by the PV industry	Mainly small enterprises involved in PV export; low awareness among aid and trade sectors	Failure to capture viable export opportunities; danger of crowding-out by overseas competitors	Short and medium term	Implement 'PV Ambassador' capacity building within AusAID; Establish industry development bank to finance project development	Commonwealth Government in association with the finance industry
Ambivalence among consumers towards non-conventional energy sources	Very low electricity prices and inadequate price signals; consumers unaware of the costs they impose on the electricity industry; low awareness of personal impact on greenhouse gas emissions; limited PV awareness by consumers	PV viewed as uneconomic, impractical or only of distant future benefit	Start today, but with medium to long term view	Strengthen price signals for electricity consumer: Implement PV public facilities experience program (schools, libraries, government offices, public housing); Initiate well-publicised PV demonstration projects	Commonwealth and State Governments

Barrier	Causes	Effects	Urgency of resolution	Proposed solution	Solution providers
Apparently small off-grid market for PV	Widespread rural grid availability/ uniform tariffs	Reduced opportunity for PV in potentially economic applications	Medium to long term	Initiate projects to demonstrate viability of PV for fringe-grid locations; Work with electricity industry to define more appropriate policies for distributed generation as an alternative to network expansion in remote areas; Implement specialised off-grid promotion and finance programs for water pumping and desalination	Initiated by the PV industry in cooperation with all levels of Government and the electricity industry
Barriers from other stakeholders perspectives					
High up-front cost/long payback period for PV systems	Small market volumes (little mass-production effect); limited (service) industry experience; technologies still being optimised (especially grid-connect)	Demand and experience remain low; competitors with large subsidised markets pull ahead;	Short and medium term	Continue to reduce prices of PV system components Develop consumer finance packages for installation of PV systems; Include costs of BIPV systems in building construction costs; Provide incentives for early adopters of BIPV systems; Reward non-energy benefits of PV (eg use of PV as an alternative to network expansion in remote areas)	Initiated by the PV industry in cooperation with all levels of Government and the electricity, finance and building industries
Complex 'purchase' procedures (subsidies, RECs interconnection, buy-back)	Subsidy and RECs programs are new and unfamiliar to the consumer; electricity industry is unfamiliar with PV and applies inappropriate procedures for interconnection and buyback	Reluctance by consumers to deal with the complexities involved in purchasing PV systems	Immediate	Streamline application procedures for subsidies and creation of RECs; Establish a common interconnection and buyback agreement for PV systems throughout Australia; Train installers to deal with all the procedures on behalf of the consumer	Initiated by the PV industry in cooperation with all levels of Government and the electricity industry
Apprehension about PV amongst electricity industry	Risk-averse electricity industry with little experience of PV, uncertainty about added value claims because little quantification of unpriced benefits has been carried out	PV overlooked or discounted as a viable demand management or distributed generation option (only for distant future)	Next 2–5 years	Quantify, demonstrate and publicise added-values of PV through monitored demonstration projects; Establish high-level 'steering committee' with key stakeholders in the electricity industry	Initiated by the PV industry in cooperation with the electricity industry

Barrier	Causes	Effects	Urgency of resolution	Proposed solution	Solution providers
PV electricity is not dispatchable/ cannot fully displace firm convention generation	PV is an intermittent resource; no ideal storage solution as yet	Electricity industry see PV as a niche generation technology of uncertain value	Medium term	Focus on development of storage technology; Work on interfacing PV with future-focussed technologies (e.g. hydrogen & fuel cells)	R&D by the PV industry (including universities and research institutes)
Building developers are largely unfamiliar with PV and unaware of its potential value to them	Little PV exposure and experience in the building industry; little awareness of their ability to influence the energy sources used in buildings and therefore reduce operating costs	The main opportunity for PV is inaccessible	Short and medium term	Demonstrate appropriate BIPV applications; Quantify and report costs and benefits of BIPV; Introduce more stringent building minimum energy performance standards	Initiated by the PV industry in cooperation with all levels of Government and the building industry
Lack of strategic R&D support	Closure of Government funding programs	Collapse of research groups Reduction in educational opportunities	High	Establishment of a Strategic PV R&D Fund	Commonwealth and State Governments in cooperation with the PV industry

APPENDIX 8// DOMESTIC MARKET ESTIMATES BY APPLICATION

Application	Description/comments	Typical PV unit size (average)	Market potential	Current penetration	Maximum sustainable annual sales estimate	Assumptions
Off-grid domestic						
Remote households	Traditional market, increasing penetration	1–3 kW (1.5)	30,000–45,000 households (150 MW)	8,000–13,000 systems (12 MW)	3.0 MW pa N.B typical diesel capacity 7.5kW	25 year cycle, 50% penetration. Offsetting 2/3 of diesel capacity.
Holiday homes	Usually good correlatation to typical time and profile of occupancy	0.5–1 kW (1.5)	Included in above	Included in above	Included in above	Offsetting diesel and petrol generators, or grid extension
Pastoral stations	Traditional market, increasing penetration	2.5 kW+	44MW (Included in above)	Included in above	Included in above	Offsetting diesel generators
Isolated communities (Indigenous)	Increasing market, especially for mini-grids	Need to add	19.3 MW (Included in above)	Included in above	Included in above	Offsetting diesel generators
Fringe-grid	Hard to access with current electrification policy	3–5 kW (assumes as per remote household)	5% of 7 million households 1000–1750 MW	Nil	20–30 MW pa	25 year cycle, 50% penetration.
				Sector total	3.0 MW (25+ MW with different electrification approach)	
Off-grid non-domestic						
Telecoms	Standard application	0.2–1.0 kW		Very High	2–3 MW pa	Stable
Water pumping	Potential for addressing salinity issues	0.1–2.0 kW	Windpump market was 500k units and 10k units pa	Small	10 MW pa (?)	25 year cycle, 50% penetration of 'old' windpump market
Signalling	Road, rail, airport	10W–2 kW			0.5 MW	Best estimate
Cathodic protection	Standard application	50W–0.2 kW			0.2 MW	Stable
Electric fences	Standard product	10–20 W			0.1 MW	Best estimate
Lighting	Street lighting, remote lighting	50W – 0.1kW			1–2 MW pa	Best estimate
Isolated communities (Mines)	Reports suggest not easily accessible before 2010		330 MW	Negligible	4.4 MW pa	25 year cycle, 50% penetration. Offsetting 2/3 of diesel capacity
Tourist facilities	Driven by ecotourism		15 MW	Negligible	0.3 MW pa	25 year cycle, 50% penetration.
Public generation		200–19000 kW	195 MW	Negligible	2.6 MW pa	25 year cycle, 50% penetration. Offsetting 2/3 of diesel capacity
				Sector total	20 MW	

Application	Description/comments (average)	Typical PV unit size	Market potential	Current penetration	Maximum sustainable annual sales estimate	Assumptions
Grid-connected distributed						
Residential rooftops	New market, significant potential	1–3 kW (1.5)	95% of 7,000,000 households (6–20 GW)	3,000 systems (3.5MW) future system size 3kW	400 MW pa	25 year cycle, 50% penetration,
Commercial BIPV	Emerging market, significant potential	10–100kW	(3.8–11.5 GW)	Small (<0.5MW)	200 MW pa	25 year cycle, 50% penetration
				Sector total	600 MW	
Grid-connected centralised						
Network strengthening	Support for weak grids (some overlap with fringe-grid and distributed generation), but mainly utility driven	100–1000kW		Small (0.5 MW)	Included in below	
Bulk power	Future desert PV and/or Hydrogen production	>1 MW	2003 Elec Demand of 2 230 TWh (i.e. >160 GW PV at full penetration). 030 demand est. 400 TWh 2030 electricity demand for H_2 = 35.5 TWh	Nil	At least 200 MW, possibly up to 2000 MW pa	Lower figure is 20% penetration of power for H_2 production by 2030. Higher is 20% penetration of total power sector (less distributed capacity which generates potentially 42TWhpa)
				Sector total	200–2000 MW	
Small portable electronic devices						
Small portable electronic devices	Particularly next generation PV modules which perform in low light conditions	1–10 W	Could be very large		10 MW	Best estimate
				Sector total	10 MW	

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