DESIGNING A COHERENT PV STRATEGY FOR AUSTRALIA

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ABSTRACT

Australia has played an active role over the last 3 decades in the development of the international photovoltaics (PV) industry. Australia has been involved in pioneering research, manufacturing and application of PV, and more recently has led the world in PV education, training and standards development.

Over the last decade, the global PV market has boomed, largely as a result of proactive government policies in countries such as Japan, Germany and Spain, in support of grid-connected PV applications. PV research, manufacturing and deployment have advanced considerably and the sector is now driven by the goal of 'grid parity' within a decade. While Australia has remained active in many aspects of the PV chain, its relevance has declined and the industry has suffered several boom and bust cycles which have resulted in a lack of investment confidence. Now is an opportune time to examine Australia's strengths and weaknesses in the PV sector, with a view to strategic support.

The Australian PV Association (APVA) has been examining the status of Australia's PV research, manufacturing, grid and off-grid markets, exports, education, training and standards with the aim of developing a coherent PV Strategy for Australia over the next decade. Such a Strategy would aim to provide the background for confident investment in the sector as well as consistent policy support from governments. It is hoped that this paper will elicit comments and discussion which can be used in the development of a comprehensive and coherent strategy for PV in Australia.

BACKGROUND

The world PV market has been growing at rates of more than 35% per year for the past decade. 2007 installations exceeded 3 GW and the 2010 market is expected to be between 8 - 12 GW (Koot, 2008; Hirshman et al, 2008). The PV industry generated

US$17.2 billion in global revenues in 2007 (Marketbuzz, 2008:). With a large increase in manufacturing capacity and continued improvements in efficiency and production costs, grid parity is expected to begin to be reached in many markets from 2010 (Koon, 2008). This will transform the market from one dependent on government support policies to one driven by customers seeking long term electricity price certainty. The International Energy Agency's *Scenarios and Strategies to 2050* identifies PV as a significant player in the longer term, if strong greenhouse gas reduction targets are set, with the Blue Map scenario including 1400 GW of PV generating 3000 TWh of electricity by 2050 (~ 300 times the current production volume) (IEA, 2008). The European PV Industries Association is claiming that 12% of Europe's electricity demand in 2020 could be met by PV electricity, if grid parity is reached in all European countries over the period from 2010 to 2020 (EPIA, 2008).

The global industry is maturing fast, with strong competition and the likelihood of price reductions and industry consolidation over coming years, as supply from the many new manufacturing facilities begins to outstrip demand. At present there are more than 100 cell manufacturers, 300 module manufacturers and 80 thin film manufacturers around the world (Koot, 2008; Hirshman et al, 2008), with a growing number in the Asia-Pacific region, including China, India, Korea, Taiwan, Philippines, Malaysia and Singapore. Plant sizes are increasing from the present norm of around 50 MW/yr to plans for 0.5 – 1 GW/yr plants by 2010 (Koot, 2008). Thin film products are finally beginning to make market inroads and are expected to increase both market share and price pressure from now on.

In Australia, the PV industry remains relatively immature and dependent on short term, complex government support that only targets residential users or remote locations. There is now only one PV panel manufacturer. The off-grid market remains important for Australia, although many remote telecommunication links are already PV-powered and new projects provide lumpy rather than consistent markets. High diesel prices have increased interest in PV, but the up-front cost compared with diesel generators remains a difficulty. In the grid market, PV remains a relatively high upfront cost product that competes with the low ongoing cost of Australia's predominantly coal-derived electricity. PV products are generally only available through specialist operators, whereas fossil-fuel electricity is provided as the default. The renewable electricity target of 9,500 GWh by 2010 has not been a strong driver for PV, although the increased target of 20% by 2020 may prove more useful as PV prices fall and if localized resource constraints limit other renewable options. Despite approved standards and grid connection guidelines for PV, there remain complex local and State government installation requirements and varying electricity network connection costs which impose disproportionately large extra project costs for small PV systems.

Nevertheless, Australia has retained an active PV research presence, has developed some infrastructure to support both grid and off-grid markets, is facing increasing electricity costs in many jurisdictions for a variety of reasons and has an excellent solar resource base. Therefore, PV remains a potentially significant electricity technology for Australia in the long term. Yet there appears to be little coherence to the various PV development efforts, which capitalises on our strengths, ensures Australia continues to play a role on the world PV stage, and provides the necessary infrastructure locally to make best use of the technology.

AUSTRALIAN PV RESEARCH

Photovoltaics research and development is undertaken across a range of university, government and industry facilities. University research groups undertake both fundamental device research and applied industry-oriented R&D, while industry-based and collaborative research involves PV manufacturing processes and PV systems. Nevertheless, systems based research is notably neglected in Australia, and we have failed to capitalise on the international lead we had from our early PV deployment in both off-grid and grid applications.

The new Australian Solar Institute (ASI), to be established by the Australian Government, promises funding of $100 million over 4 years for solar PV and solar thermal electric research. This could represent a doubling of current PV research funding and is a welcome initiative, although it compares with annual budgets for PV alone in the US of ~ $200m, Germany ~$80m and Japan ~$50m (PVPS, 2008). The guidelines are now under development, and it appears that the Institute will continue to fund the current research programs described below and hopefully also more systems–based, market and policy research.

University Research

The *Photovoltaics Centre of Excellence, University of NSW* undertakes research in three interlinked strands aimed at near-term “first-generation” product based on silicon wafers, medium-term “second-generation” thin-film cell technology and long-term “third-generation” solar cells with both high-efficiency and thin-film.

The Centre for Sustainable Energy Systems, Australian National University undertakes both fundamental and industrially oriented research into solar thermal, PV and hybrid technologies including large-scale linear and paraboloidal dish concentrator systems, and smaller residential ‘microconcentrator’ systems. The Centre’s PV research is focused on Si technologies, physical properties and processing of Si cells, including ultrathin efficient slivers and other elongated cells.

Murdoch University has an amorphous silicon research group, investigating improved cell designs, using a combination of nanocrystalline and amorphous silicon alloys, and improved methods of producing solar grade silicon directly from metallurgical grade material. Murdoch University also hosts the *Research Institute for Sustainable Energy (RISE)*, which in turn runs *ResLab*, a renewable energy test and standards centre. RISE is involved in PV module testing, PV-based remote area power supply system modelling and development and PV standards development and verification.

The *University of Melbourne*, with partners Monash University, Securency, BP Solar, Merck, Blue Scope Steel, and NanoVic, is undertaking research into organic “plastic” PV cells with the possibility of producing flexible solar cells, or coatings that function as sunlight harvesting paints on roofs or as an integral part of fabrics. The *Universities of Wollongong*, *Sydney* and the *Queensland University of Technology* (partnered with Dyesol) all host research into aspects of organic and dye solar cells.

The *Commonwealth Scientific and Industrial Research Organisation* has a growing research programme in organic photovoltaics, with expertise in synthesis of light-harvesting molecular materials, organic device fabrication and characterisation of photovoltaic performance. It is working in collaboration with the Melbourne University-based team described above, as well as with international partners as part of the International Consortium for Organic Solar Cells.

Curtin University and the *University of Tasmania* undertake PV systems research, focussing on central and diesel grid integration.

Industry Research

Origin Energy is developing the SLIVER technology, based on research at ANU. A 75W Sliver panel produced on the pilot manufacturing line in South Australia has been IEC certified by TUV in Germany. In-house testing has demonstrated the robustness of the unique module architecture to various tests, including thermal cycling and damp heat.

BP Solar is refining its existing cell manufacturing processes to achieve significant yield increases from available silicon, which will reduce manufacturing costs, increase competitiveness for the Australian BP Solar business and make more efficient use of resources.

Solar Systems continues development of its PV concentrator technology, focussing on higher efficiencies, better mirror technology, reduced losses, improved manufacturing processes, operational reliability and control, and data acquisition during operation. Silicon-based cells have been replaced by multi-junction III-V photovoltaic cells, increasing output by more than 50%. The company is now developing technology for a 142 MW heliostat PV system to be installed in 2009.

CSG Solar continues research at its Botany laboratories in Sydney on Crystalline Silicon on Glass, a thin film PV technology based on initial research from the University of NSW, which is now manufactured in Germany.

Dyesol is the industrial research hub for the world's network of researchers into Dye Solar Cell (DSC) technology. Dyesol researches, develops and manufactures DSC materials and components, including nanoparticulate pastes and dyes, as well as equipment specifically designed to research and manufacture DSC.

Three cell manufacturing start-ups - Solarcell Technologies, Spark Solar Australia and Regency Media – continue this approach to innovation. *Spark Solar Australia* aims to develop a new cell design (the Angled Buried Contact (ABC) cell invented in Australia) and in parallel manufacture and export world-class screen printed cells, with an initial capacity of 30MW per year. They are also involved in research with the ANU and GP

Solar to achieve improved surface passivation of high efficiency cells.

PV MANUFACTURING

PV production worldwide grew an average of 44% per year between 1999 and 2007, from 202 MW to 4.28 GW (Hirshman et al, 2008). Australian production in 1999 was 7 MW (3.5% of global production) and in 2007 it was 36 MW (0.8%) (derived from Watt, 2000; Watt, 2008 and Hirshman et al, 2008). Manufacturing is now dominated by Q-Cells, Germany, Sharp, Japan and Suntech, China, with others also growing rapidly (ibid).

BP Solar is currently the only module manufacturer in Australia (with a module capacity of 10MW/yr). They also produce their own cells from imported wafers (with a maximum capacity of 50MW/yr). Solar Systems manufactures its own concentrator PV systems using imported cells, and is in the process of setting up cell manufacture in Victoria. Origin Energy currently manufactures SLIVER cell technology on a pilot scale, and there are currently three potential cell manufacturing start-ups: Solarcell Technologies, Spark Solar Australia and Regency Media. Queanbeyan based research and manufacturing company, Dyesol, already supplies materials to the international dye solar cell market.

There are a number of Australian manufacturers of inverters, battery charge controllers and inverter/chargers, particularly catering for the off-grid system market, including Selectronics, Plasmatronics and Latronics. Some of these manufacturers also supply inverters suitable for grid connection. Although some battery components are made in Australia, only a few companies manufacture complete solar batteries.

There has been no strategic plan in Australia for PV manufacturing, although there has been intermittent support over the past decade or so for commercialization. This contrasts with significant international efforts to encourage local manufacture, often at the State level. The market support for PV via the *Solar Homes and Communities* grants (previously the PV Rebate Program), the *Remote Renewable Power Generation Program* (RRPGP) and more recently the *Solar Cities* and *Solar Schools* programs have seen PV market growth in Australia, but of mainly imported products. This leaves us vulnerable to exchange rate fluctuations and international pricing pressures.

THE AUSTRALIAN PV MARKET

In 2007 the PV business in Australia was worth an estimated $210m, with another $81.6m in exports, while the value of imports was about $100m. Direct employment attributed to PV in the different sectors of policy, R&D, manufacturing, distribution and installation is estimated to be around 1660 people (Watt, 2008).

By the end of 2007, over 82,400 kW of PV had been installed in Australia, with just over 12,000 kW of this in 2007, as shown in Figure 1. Grid-connected systems accounted for 52% of 2007 installations but just under 22% of cumulative installed capacity – reflecting the relatively recent increased focus of government policy on residential grid-connected PV (ibid).

Over their lifetime (assumed to be 20 years), these systems would produce about 2,400 GWh of electricity, avoiding the release of over 2,000 Mt of greenhouse gases (or about 3.75 years of Australia's total current greenhouse emissions). The off-grid systems would avoid the use of about 645 ML of diesel over their lifetimes – which has balance of trade, as well as greenhouse benefits, as Australia is a net importer of both crude oil and diesel.

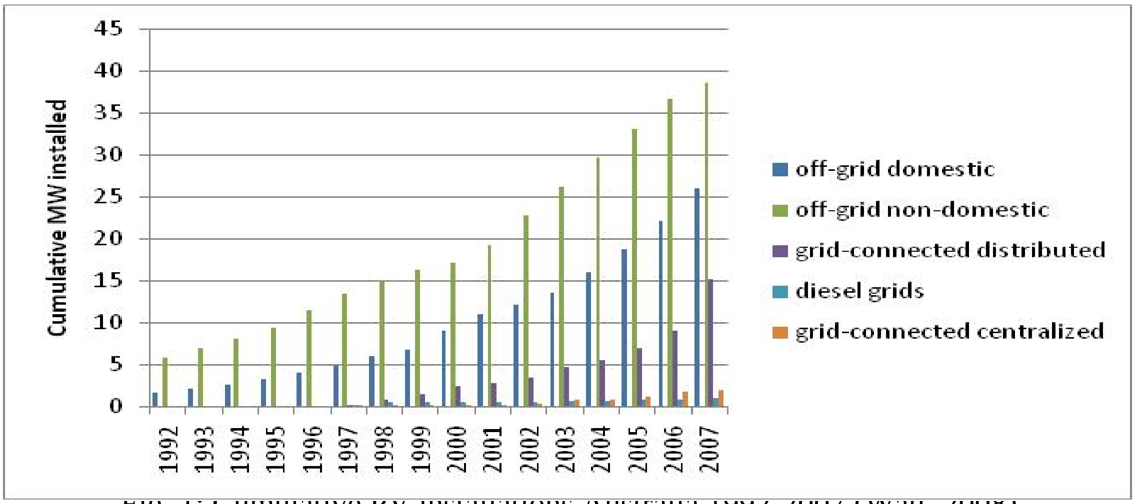

Fig. 1: Cumulative PV installations Australia 1992-2007 (Watt, 2008)

The Grid-Connected PV Market

The grid market is largely driven by government support programs. The most significant ones at present are the *Solar Homes and Communities Plan,* which has seen 19 MW of PV installed up to June (DEWHA, 2008) but is due to exhaust its funds this year due to the scheme's popularity, the *Solar Cities* program, which will create a useful driver for PV installations for the next year or two, and the *Solar Schools* program, which may see the installation of 20 MW of PV over the next 8 years. The majority of small PV systems installed create *Renewable Energy Certificates* (RECs) under the (*Mandatory) Renewable Energy Target* (MRET) scheme and some are registered under *GreenPower* programs, although many of these may have benefitted from the grant programs as well. No government programs have targeted the commercial sector, despite its high correlation of load to PV generation. Internationally, this sector has provided the system sizes, economies of scale and peak load benefits necessary to reduce prices and create significantly sized local PV businesses.

Further grant schemes are unlikely to be introduced, with the government indicating that they will work through the forum of the Council of Australian Governments to develop a consistent national approach to feed-in tariffs and, for renewable energy more generally, they intend to drive deployment through the expanded *Renewable Energy Target (RET),* the details of which are currently being developed, and the *Carbon Pollution Reduction Scheme (CPRS)*, which is to be introduced from 2010, but also with details not yet decided. If the RET and the CPRS operate as anticipated, they will not provide a significant driver for PV in the short term. For these reasons, there has been increased interest in the so called *Feed-in Tariffs* (FiTs), to do in Australia what they have done internationally, which is to largely take over from grant based PV support.

Since FiTs are typically funded via electricity sales levies and are not linked to government budget and election cycles, they can provide longer-term, more consistent support, albeit via government regulation. The German Feed-in Law transformed the world's renewable energy markets, with high, long term, FiTs, which reduce over time, for total generation from a range of different technologies. The FiT was accompanied by valuable manufacturing support programs and Germany now leads the world in both production and deployment of PV, with an installed capacity of over 4 GW, more than 1,500 businesses and more than 42,000 people employed in the field (Koot, 2008; PVPS, 2008). The PV FiT costs German households an average of €6.3 per year (Frondel et al, 2008). Feed-in tariffs have now been introduced in 37 countries. Not all FiTs have had the same impact as the German one. Some have set MW capacity limits, which have very quickly been met, others have suffered from inadequate connection and approval processes, while in others the tariff, the time over which it is available or the system size limits, have not been sufficient to grow demand.

In Australia, MRET has provided a premium tariff for renewables but, since it has no portfolios, has largely assisted lower cost technologies, such as wind, hydro and solar water heating. The Commonwealth Government has indicated that it wishes the States to develop consistent PV feed-in tariffs across Australia. To date South Australia, Queensland and Victoria have implemented tariffs of 44, 44 and 60 c/kWh respectively for 20 years. However, these tariffs are on net exported electricity only. The ACT Government has announced a feed-in tariff on total generation with an initial rate of 3.88X the retail tariff, while the Alice Springs Solar City is offering total generation tariffs of 45c/kWh. All Australian FiTs are restricted to small systems, typically less than 2kW, thus eliminating larger commercial or community scale systems which might benefit from economies of scale or multiple investors. With projected REC prices of $23-46/MWh (MMA, 2007), PV cost reductions of 6-10% per year (Rogol, 2008) and Australian electricity price increases of 5-10% per year (Hodge, 2008; QCA, 2008; IPART, 2007), grid connected PV systems are likely to start reaching grid parity within a decade. Thus, support for PV will only be required for a limited time – with it reducing the cost of electricity once it goes below parity.

The challenge facing us is to maintain and increase current production levels and deployment infrastructure over the next decade, so that Australia is in a position to benefit from the rapid uptake which is likely to follow grid parity. Without such a strategic approach, Australia will be largely reliant on imported product and would need to re-establish infrastructure and skills developed over the past decade, which will be lost in the interim if the grid market is not maintained. Ongoing deployment will also allow development of appropriate grid management strategies to maximise PV's impact on the electricity network as its level of penetration increases.

The Off-Grid PV Market

The largest installed capacity of PV in Australia is for off-grid industrial and agricultural applications. These include power systems for telecommunications, signalling, cathodic protection, water pumping and lighting. Significant markets also exist for off-grid residential and commercial power supplies and increasingly for fuel saving and peak load reduction on community diesel grid systems. Some of this market is supported by government grants through the RRPGP, which provides 50% of system costs with the aim of reducing diesel fuel use. There is also a market for recreational PV applications, for caravans, boats and off-road vehicles.

The Australian PV industry has historically shown strength in industrial innovation, providing solutions for different market requirements. This innovation was initially focused on the telecommunications network as well as on the power requirements of remote households, cattle stations and communities. The ongoing need for reliable power in remote locations has more recently seen innovations in large-scale concentrator PV systems as well as in water pumping applications.

To service the Australian off-grid market, the PV industry has developed very reliable systems, as well as distribution and installation networks. In addition to meeting customers' expectations, reliability is also driven by the high cost of travelling to remote systems for maintenance and repair. This 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 off-grid market will remain important for PV in Australia, since little additional grid extension is likely and we have many extremely remote locations in need of reliable power. With an increased reliance on imported diesel, likely continued diesel price increases over the long term, as well as the constant problems of fuel delivery to remote locations, PV remains a sensible option. The cost-effectiveness of PV in the off-grid market is dependent not only on PV module prices, but also on balance of system prices, availability and reliability. This includes inverters, load management, batteries, and control systems which allow for automatic operation and interconnection of different energy technologies.

The robust nature of both systems and installation methodologies also gives Australian systems competitive advantage when installed in developing countries in particular, where climates can be harsh and application sites difficult to access. Australia has developed a small but important export industry for products, systems and expertise in the Asia-Pacific region, which is heavily reliant on diesel fuel. There is a large potential for this market to grow. However, competition for these markets is strong and Australia's relatively small companies cannot always compete for projects, whilst many are reliant on aid funding, which is often tied to the donor country. Nevertheless, Australia's expertise is well regarded and we are in a good position to provide the much needed on-going project support, including training services.

RRPGP, including its subprograms of Bushlight, ResLab, water pumping and industry development, has provided an important stimulus for non-telecommunications PV applications in remote areas. The 50% subsidy it provides has still required remote area residents to find the other 50%, which has not always been easy. Nevertheless there will be a serious gap when this program finishes next year, particularly as Australia's reliance on imported diesel fuel increases.

PV EDUCATION AND TRAINING IN AUSTRALIA

An appropriately skilled workforce is critical to the successful development of the PV market. Australia commenced the world's first PV Engineering degree at the University of NSW (UNSW) in 2000, followed by a Renewable Energy Engineering degree in 2003. Other institutions now also offer Renewable Energy Engineering degrees, as well as a range of undergraduate and postgraduate photovoltaics, renewable energy and climate change courses. Enrolments in these courses is increasing in line with community interest in renewable energy and climate change. Numbers have been further boosted from 2008 with students from China, India and Korea studying in Australia under the Asia-Pacific Partnership on Clean Development and Climate.

The electro-technology training package, which is followed by all technical colleges within Australia and relates to the curriculums and qualifications for the electrical trades, includes qualifications for renewable energy and units which can be taught within the electrical trades courses prior to obtaining their BCSE accreditation for designing and installing PV systems. By the end of 2007, 15 institutions, mostly technical and further education (TAFE) colleges, were offering courses, in response to the overwhelming demand. The number of accredited PV installers is now over 500, with 95% of these grid-connect accreditations, mostly licensed electricians. There is also considerable interest in the Grid-connect Design and Supervise accreditation pathway. One private company Global Sustainable Energy Solutions (GSES) has developed an on-line training course and a new training centre in Pambula NSW for conducting practical training sessions. GSES has also been helping to develop training centres and deliver a range of PV training courses in many developing countries for the last 8 years.

PV education and training is one of Australia's key strengths. In such a rapidly developing field, it requires consistent support to grow and to ensure services are up to date and available where they are needed.

PV STANDARDS AND TESTING IN AUSTRALIA

Australia is actively involved in the local and international development of standards for PV modules and systems. This is a critically important factor in ensuring the public remains confident in the technology, its performance and its safety.

As the grid market develops and installers try to streamline procedures and installations to reduce costs, the varying local government, utility and State government requirements are becoming an increasing problem. Differences include the need for Development Applications in some local government areas, but not in others, different building codes, OH&S and insurance requirements in each State on top of PV system warranties, different metering arrangements, and different levels of inspection for commissioning. These can add several hundred to over a thousand dollars to an installation, as well as complicating and lengthening the application process.

Solar access is also becoming an issue, with PV system owners not guaranteed that future developments will not block their sunlight. This is an issue for all solar technologies, including passive solar design. If Australia is to move towards zero emission or zero energy homes, solar access rights must be well defined and defended.

THE WAY FORWARD – ISSUES TO CONSIDER FOR AN AUSTRALIAN PV STRATEGY

The discussion above has highlighted aspects which must be considered in any Australian PV Strategy. The APVA held a workshop in August 2008, aimed at identifying strategies which could be followed over the coming decade, during which time it is expected that PV costs will approach grid parity. These are summarised below. Some reflect the issues mentioned earlier in this paper, others deal with wider aspects. While some focus on government support, others either require action by the PV industry or require coordinated efforts by both the PV industry and government.

Consistent broad-based policy support

Photovoltaics can be a strategic energy industry for Australia, and we can capitalise on our R&D status, our history of PV applications, our education and training services and the large potential markets locally and in the region. A coherent PV strategy agreed between governments, industry, researchers and the community is needed to drive effective and efficient development, production and deployment of PV in Australia over the next decade. Driving continued and consistent strong growth in the deployment of PV systems in the residential, commercial and off-grid markets will enable Australia to once again punch above its weight on the international PV stage. This will require policies that are strategically directed, which provide a greater level of certainty than recent policies and which are focussed on maximising local production, learning and development. This will maximise opportunities for economies of scale and price reduction, whilst ensuring robust supply channels which are buffered from exchange rates and international market dynamics, via local manufacturing, standards, uniform regulations and provision of education and training. In this way we can maximise the value of PV policies for the Australian industry and community.

Public awareness and education

There is a need to educate the entire community about PV. This includes residential and commercial electricity customers, educators, community groups, the media, industry stakeholders, politicians, the finance sector and the building industry. Such education should be at an appropriate level and include: how PV systems can be installed, connected to the grid, used to replace diesel generators, operated on people's homes, in their communities, in local businesses and by electricity generating companies. There is also a need to educate the community regarding other advantages including: avoiding greenhouse emissions, achieving zero energy homes, assisting with peak electricity loads and reducing diesel use and imports.

Business models

There is a need for the PV industry to develop and promote business models that demonstrate the economic viability of the PV industry, providing the best outcomes per investment and which make best use of Australian Intellectual Property. Within Australia, these might include energy service providers (the ESCO model), power purchase agreements, and strategic partnerships. Globally, commercialisation models which provide returns to Australia can be drawn from other advanced technology sectors. A supportive legislative framework is a necessary precondition.

Research, Development and IP

There is a need to foster, recognise and capitalise on the value of Australian PV IP. This might include funding R&D programs, rather than specific projects, within a coordinated and well planned research – industry strategy. R&D should not only focus on developing devices and systems, but also on other aspects of the supply chain, including innovative financial models and systems of ownership, methods of system delivery and installation processes, as well as maintenance and repair. In addition to R&D funding, this requires consideration of issues such as tax incentives, local development incentives, mechanisms to facilitate industry – research interactions, including treatment of IP and recognition of commercial research needs, as well as higher education training and resourcing.

Training & education, Quality Assurance & Standards

In order to maintain public support, the PV industry must exhibit best practice. The relative roles of government and the PV industry in providing training, education, quality assurance and standards requires discussion.

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