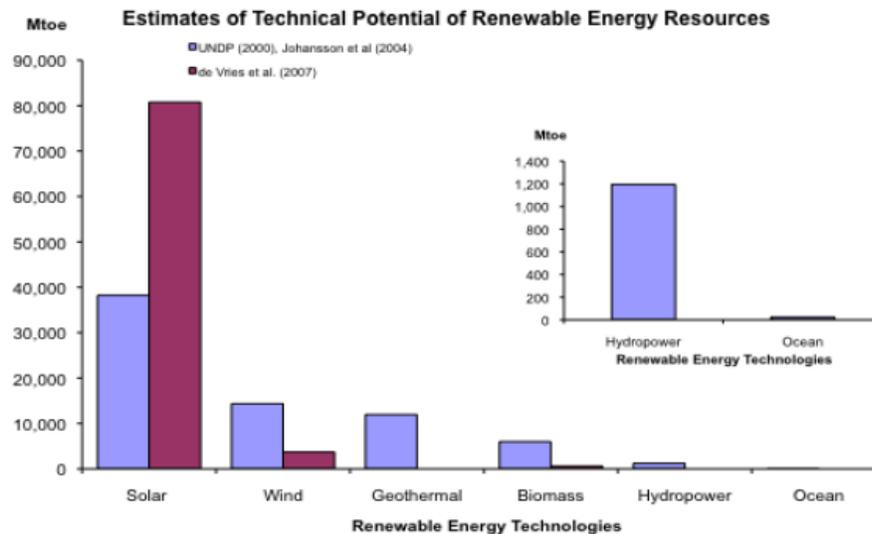


3.3 Solar PV

Theoretically, the entire global energy demand is much smaller than the resource potential of solar energy (European Photovoltaic Industry Association, 2007). In fact, solar energy has the greatest technical potential amongst all the renewable energy technologies (see Figure 3.3.1).

Figure 3.3.1 *Technical potential of renewable energy technologies*



Source: Goldemberg (2000), Johansson et al. (2004) and de Vries et al. (2007)

Active solar energy technologies¹⁹⁰ harness solar energy such that it can be converted for other applications such as electrical energy. Active solar energy can be broadly classified into two groups: (1) photovoltaic (PV) and (2) solar thermal.¹⁹¹ This paper will focus on the use of solar PV for the purpose of electricity production as it is currently the dominant solar technology.

Solar PV technology converts radiant energy into electrical energy when light falls upon semiconductor materials that exhibit the photovoltaic effect¹⁹² (Sorensen, 2000). Two types of PV technology are currently available in the market: (a) crystalline silicon-based PV cells and (b) thin film technologies made out of a range of different semi-conductor materials, including amorphous silicon,

¹⁹⁰ Solar energy technologies can broadly be classified into passive and active. As the name suggests, passive solar energy technologies use radiant solar energy but do not convert this into other forms of energy such as electricity. Examples of passive technologies include maximizing the use of day light or heat through building design (Bradford, 2006).

¹⁹¹ The estimated technical potential ranges from 1,338 EJ/year to 14,778 EJ/year for photovoltaic and 248 EJ/year to 10,791 EJ/year for concentrating solar power technology (Arvizu et al., 2011). Since the amount of solar energy that can be utilized depends significantly on local factors such as land availability, metrological conditions and demands for energy services, technical potential varies between different regions and locations.

¹⁹² The photovoltaic effect is the creation of voltage or electric current in a material upon exposure to light. The photovoltaic effect was first observed by Alexandre-Edmond Becquerel in 1839.

cadmium-telluride and copper indium gallium diselenide. Crystalline silicon has been the dominant PV technology till date and is expected to be the mainstay up until 2020 (IEA, 2008).

PV systems have two main applications, off-grid and grid-connected. Off-grid PV systems are used to provide electricity to rural areas without connection to a local electricity grid while grid-connected systems are able to supply electricity generated to existing electricity grids. Grid-connected PV systems are further classified by distributed and centralized systems. Distributed systems are small scale systems, usually installed on buildings or sites in an urban area. Centralized systems are large-scale utility systems of more than 1 MW that are usually ground mounted.

Global solar energy use

Over the past couple of decades, the solar industry has experienced rapid growth buoyed by government legislated subsidies or other forms of policy support like feed-in tariffs (FITs) in industrialized economies such as Germany and Spain (Doshi et al., 2011) and declining module prices.

From 1990 to 2009, the cumulative installed capacity of solar electricity grew at a compounded annual growth rate (CAGR) of 33.2%. Over the same period, the average module price fell from around US\$ 10/Wp to US\$ 2.8/Wp,¹⁹³ which is a decline of 72% in real terms. Of course, this price decline has not been monotonic. Factors such as a bottleneck in polysilicon production capacity caused an increase in module prices from 2003 to 2007 (Doshi et al., 2011). Nevertheless, the broad trend seems to point to declining costs of solar modules with several industry watchers indicating that this is likely to continue in the near future.

By December 2010, global installed capacity for PV had reached around 40 GW of which 85% is grid connected and 15% is off-grid (REN21, 2010). This market is currently dominated by crystalline silicon-based PV cells, which accounted for more than 80% of the market in 2010. The remainder of the market consists almost entirely of thin film technologies that use cells made by directly depositing a photovoltaic layer on a supporting substrate. The recent trend is strong growth in grid-connected PV development with installations that are over 200 kW, operating as centralized power plants (Timilsina et al., 2011). The leading markets for these applications include Germany, Italy, Spain and the United States.

¹⁹³ In PV, the maximum possible output of a solar module operating under standard conditions is defined as its peak output, which is measured as Wp (watt peak) or kWp (kilowatt peak).

3.3.1 Solar PV in Australia

Key findings

- Solar PV provided 0.3% of Australia's total electricity production in 2010 and is expected to provide 3% of Australia's large scale electricity generation by 2050.
- Key policies relating to solar PV in Australia include the Renewable Energy Target, feed-in-tariffs, rebates and the national carbon pricing scheme that will come into effect in July 2012.
- Australia's regulatory policies have contributed to significant growth in the solar PV industry, largely in on-grid residential scale systems. The evidence suggests that the benefits of small scale solar PV subsidies and feed-in tariffs (FiTs) have come at a high cost and government objectives in terms of greenhouse gas emission reductions and the development of the renewable energy sector could have been achieved at lower cost through broad market based instruments such as an economy wide carbon pricing scheme.

Costs, benefits and promotion

- The costs of solar PV are high relative to alternative forms of energy, especially for large scale solar. Technology-neutral policies such as the Renewable Energy Target have not incentivized solar PV as emissions reductions can be achieved more cheaply from other technologies such as wind.
- Australian government subsidies (including feed-in-tariffs) for small scale solar PV systems have led to a significant growth in the solar PV industry, but have proved a very expensive means of reducing CO₂ emissions. The estimated cost of abatement across all subsidy schemes is between approximately USD 431 and USD 1043/tCO₂e, compared to the abatement cost under the Renewable Energy Target which is in the USD 30 – \$70/CO₂e range.
- Australian government grants to large scale solar PV demonstration projects appear to be aimed at addressing early mover risks. However, governments have faced significant challenges in trying to co-manage the development of new technologies, leading to significant implementation delays.

Scientific integrity

- The technical potential for solar PV in Australia is large, with the total solar radiation every year amounting to 10,000 times Australia's annual energy consumption.

Flexibility

- Policies such as the Renewable Energy Target and the carbon pricing scheme (that is to be adopted starting from July 2012) are not technology-specific and thus allow the level of support provided to solar PV to be automatically adjusted in response to changing market conditions.

- By contrast, government grant programs, rebates and feed-in-tariff schemes are not flexible enough to respond automatically to changes in market conditions, which has led to larger than expected costs in the case of subsidies and project delays in the case of grants. However, the government has shown a willingness to periodically revise the rules for grant programs and the level of assistance for rebates and feed-in-tariffs.

Transparency

- Australian governments have introduced and generally implemented measures to promote transparency and stakeholder engagement across a range of solar PV policies. Most Australian solar PV policies appear to have been developed with stakeholder input.

Alignment

- Australian governments have introduced measures to promote alignment across policies, with policies between the Australian government and the State and Territory governments coordinated through the Council of Australian Governments (COAG). Despite the existence of COAG and best practice processes, there has been some overlap between Australian Government and State and Territory government solar policies.
- The duplication of support measures for small scale solar PV systems across jurisdictions led to large program demand and a surge in scheme costs. The co-existence of the Renewable Energy Target and the national carbon pricing is likely to drive up the cost of achieving emission reductions in Australia, without adding measurably to the total level of abatement achieved due to the duplication of efforts.

A. Size and Significance

Australia has the highest average solar radiation per square meter of any continent and it is estimated that total radiation could provide approximately 10,000 times Australia's annual energy consumption (Geoscience Australia (GA) and Australian Bureau of Agricultural and Resource Economics (ABARE), 2010).

The solar PV industry has been growing at very high rates in recent years. For instance it expanded almost five fold between 2009 and 2010 (Australian PV Association, 2011). While these growth numbers are impressive, they happened from a low base. Indeed, by August 2011 installed solar PV capacity had only reached 1031 MW (Clean Energy Council, 2011a).

Australian Government modeling suggests that the solar industry will grow at a more modest but still very fast 17% per year over the period to 2029-30. By this time it is projected that solar PV may provide around 1% of Australia's total electricity production (Syed et al., 2010) up from around 0.3% in 2010 (Morris and Johnston, 2011).

The Australian Government has singled out large scale solar as a strategically important technology due to its potentially significant role in Australia's future energy mix as well as generating additional spill

over benefits in the form of intellectual property or export earnings (Australian Government, 2011a). The government is expecting that large scale solar could provide around 3% of Australia's large scale electricity generation by 2050 (Australian Government, 2011a).

B. Policy Formulation

(i) History and Background

Australia led the world in the development and application of solar PV systems for telecommunications and remote area power supply in the 1970s and 1980s (Australian Business Council for Sustainable Energy (ABCSE), 2004). In the 1980s, the first government support scheme, the NSW Remote Area Power Assistance Scheme, was established and was followed by support schemes in other States. In 1989 the University of NSW established the Centre for PV Devices and Systems and in 1993, the Aurora Project in Melbourne, Victoria was established as one of Australia's first on-grid facilities (Australian Business Council for Sustainable Energy (ABCSE), 2004).

Interest in Australia's solar PV industry increased in the 2000s and Australian governments (at the national and State and Territory level) introduced a range of incentives including, for example:

- the Photovoltaic Rebate Program (2000) to provide rebates for the installation of solar PV on homes and in community buildings;
- the national Mandatory Renewable Energy Target (2001) to increase the share of renewable energy in national electricity generation; and
- State and Territory government solar feed-in-tariff (FiT) schemes (2008-10) to provide a premium for electricity generated by solar PV systems.

These policies have contributed to significant growth in the solar PV industry, largely in on-grid residential scale systems.¹⁹⁴ The most dramatic change in the industry began in 2009 when FiT schemes were introduced and favorable changes to Australia's Renewable Energy Target were made. At the same time, the price of PV systems fell dramatically due to factors such as excess system supply (AECOM, 2010), increasing market scale, favorable foreign exchange rates and increasing system size (Morris and Johnston, 2011). These factors helped account for the extraordinary growth in the industry from 2009 to 2010 (480% according to the Australian PV Association, 2011).

The Australian Government does not have a specific target for solar PV in general, nor for large scale solar PV more specifically. Instead, solar PV can generate renewable energy certificates under the renewable energy target and therefore has to compete with other renewable technologies. As such the role it will play in the future will be determined by factors such as relative system costs and broader climate change policies.

¹⁹⁴ Systems of more than 100 kW provide less than 1% of total capacity (Morris and Johnston 2011) and the largest PV system has a capacity of only 1.2 MW (Clean Energy Council 2011a).

(ii) Policy Description

MANDATES

Feed-in-tariffs

In 2008 Australian State and Territory governments started introducing mandatory Feed in Tariff (FiT) schemes to promote the deployment of largely small scale, on-grid solar PV systems in residential settings. These schemes provided a premium payment (above the residential cost of electricity) for solar energy that was sold back into the grid. The cost of the scheme was typically shared between all electricity consumers but rules varied between jurisdictions. During 2010 and 2011 most jurisdictions either stopped or rolled back their FiT schemes due to larger than expected demand and costs.

Renewable Energy Target

The Australian Government introduced the renewable energy target (RET) in 2001 to promote the development of a range of renewable energy sources including geothermal. The RET is designed to achieve approximately 20% of Australia's electricity production by 2020 from a broad range of renewable energy sources including hydro, wind, solar, biomass, wave, tidal and geothermal. The scheme requires liable entities to obtain and surrender renewable energy certificates up to the target for that year. The scheme includes two components: the Large-scale Renewable Energy Target Scheme (LRET) which is applicable to renewable energy power stations (e.g. wind and solar farms, hydro-electric power stations), and the Small-scale Renewable Energy Scheme (SRES) which is applicable to small-scale renewable energy installations (e.g. solar water heaters, heat pumps) and which includes the Solar Credits rebate scheme (described later).

The RET provides generators of renewable energy sources with a premium over the price of other electricity sources such as coal. In this way the RET is similar to a FiT scheme. However, it is not technology specific (one premium price is offered to all renewable energy technology types) and the price is not determined in advance but responds to changes in the cost of achieving the set target. For example, if the price of renewable energy falls then the cost of meeting a set target and the price of the premium paid to renewable energy sources will also fall.

FINANCIAL INCENTIVES

Research and development grants

Australian and State governments have allocated significant amounts of funding to public research organizations, centers of excellence and universities for the development of solar PV technologies and improved information about Australia's solar resources. A key example is the Australian Government's Australian Solar Institute (ASI) that has been provided with AU\$ 150 million to select and fund other organizations to conduct solar research.

Demonstration and deployment grants

Australian and State and Territory governments (with the exception of NSW and Tasmania) have provided a large range of competitive grants to support the demonstration of larger scale solar projects. The biggest example is the Australian Government's AU\$ 1.5 billion Solar Flagships Program which aimed to support the development of 1000 MW of large scale grid connected solar facilities. It has so far committed to support two projects valued at AU\$ 770.5 million, including AU\$ 306.5 million for a 150 MW solar PV project.

Rebates

The Australian Government has supported three solar PV rebate programs to provide upfront cash refunds to buyers of solar systems: the Solar Homes and Communities Program or SHCP; the Remote Renewable Power Generation Rebate or RRPGR; and the Solar Credits program which was introduced to replace the SHCP. Rather than being awarded on a competitive process, rebates were provided to all applicants that met a set of eligibility criteria. Rebates have typically been of lower value than a grant (and therefore supported smaller systems) but provided funding to more recipients. The SHCP and RRPGR were terminated early and the incentives under the Solar Credits scheme were reduced due to larger than expected demand and costs.

Future programs

In July 2011, the Australian Government introduced a range of new climate change policies. These included a national carbon pricing scheme that will initially impose a fixed price of AU\$ 23 (rising at 2.5% in real terms) per ton of CO₂-e emissions on around 500 of Australia's largest polluters (liable entities) including stationary energy from 1 July 2012 and then transition to an emissions trading scheme on 1 July 2015 (Australian Government, 2011b).¹⁹⁵ They also included the AU\$ 3.2 billion Australian Renewable Energy Agency (ARENA) to promote the research and development, demonstration, commercialization and deployment of renewable energy projects to improve the sector's competitiveness; and the AU\$ 10 billion Clean Energy Finance Corporation (CEFC) to provide commercial or concessional loans or equity investments to clean energy companies.

C. Regulatory Review

ECONOMIC EFFICIENCY AND EFFECTIVENESS

The stated benefits of using solar PV in Australia are that it can leverage Australia's world leading research and development facilities and may support innovations that generate export revenues. It can also generate electricity that produces no greenhouse gas emissions (and therefore contributes to emission reduction targets). Additional benefits cited include that solar PV output tends to correlate with daytime demand, is scalable from household to utility scales, can be combined with storage and dispatched with a high degree of predictability, and is supported by the community (Australian Government, 2011c).

¹⁹⁵ The stationary energy sector includes the generation of electricity and the combustion of fuels for purposes other than transport.

The major cost of using this resource is its cost relative to alternative forms of energy, including from fossil fuels and other renewable energy sources. High costs are particularly acute for the large scale solar PV industry. This is because these systems have not yet been demonstrated under Australian conditions and therefore face a range of implementation risks that are likely to increase the cost of finance. Large scale solar PV systems also face the challenge of grid connection, land acquisition, acquiring relevant solar data and negotiating long term pricing agreements (Clean Energy Council, 2011b).

The costs for small scale solar are lower than for large scale solar. This is due to the fact that the technology has been widely used under Australian conditions and therefore the risks are lower and also because small scale systems do not need to compete against wholesale electricity prices but instead compete against the final cost of electricity facing consumers (which includes transmission and distribution charges). There is evidence that the cost of solar from these small scale systems is approaching 'grid parity' under some conditions.

(i) Costs, Benefits and Promotion

Small scale solar subsidies and feed-in-tariffs

Australian governments have introduced a number of subsidies for small scale solar systems including Australian Government rebate programs and State and Territory government FiT schemes. These schemes are aimed at a commercially mature technology.

Australian government subsidy schemes have helped support a significant growth in the solar PV industry from around 29 MW in 2008 to more than 1000 MW in 2011 (Clean Energy Council, 2011a). They have provided significant benefits to some consumers, by lowering the price of electricity paid by them. They have also contributed to industry employment, which was estimated at around 14,000 in 2010 (Morris and Johnston, 2011). But their contribution to emission reductions is small: it is estimated that the Solar Homes and Communities Program will reduce emissions by around 0.09Mt CO₂e/yr over the life of the rebated PV systems or 0.015% of Australia's 2008 emissions (Macintosh and Wilkinson, 2010) at a cost to government of around USD 1.05 billion (Australian National Audit Office (ANAO), 2010).

While FiT schemes do not cost governments money (other than in terms of scheme administration), they impose a high cost on electricity consumers. For example, it is estimated that the NSW FiT scheme alone will cost around USD 1.44 billion (Independent Pricing and Regulatory Tribunal (IPART), 2011). Overall, the Productivity Commission (2011) estimated that the cost of reducing greenhouse gas emissions across all solar PV subsidy schemes (including FiTs given the classification used in the Productivity Commission study) is between USD 431 and USD 1043/tCO₂e (Productivity Commission, 2011). This is significantly higher than other renewable energy support schemes such as the RET (see below). The FiT and solar PV rebate schemes have also been criticized for being regressive and benefiting the relatively wealthy at the expense of poorer households.¹⁹⁶

The analysis above suggests that the benefits of small scale solar PV subsidies and FiT have come at a high cost and government objectives in terms of greenhouse gas emission reductions and the

¹⁹⁶ Macintosh and Wilkinson (2010) found that 66% of all successful applicants for the SHCP were in the medium-high and high income postal codes.

development of the RE sector could have been achieved at lower cost through broad market based instruments such as an economy wide carbon pricing scheme. Some may argue that the cost of solar PV subsidies could be reduced through more rigorous policy design. However, FiTs have also proven to be very expensive in other parts of the world (e.g. Germany).¹⁹⁷ This suggests that Australia should reconsider whether small scale solar PV subsidies and FiTs are appropriate. The industry is mature so additional market failures (other than those that can be targeted by broad market based instruments) are unlikely to play a significant role. In addition, Australia already has a mechanism to internalize the cost of greenhouse gas emission which makes additional support difficult to justify.

Renewable Energy Target

The costs and benefits of the RET have been assessed through a number of studies. For example, in 2009 it was projected that the cost of achieving Australia's target of 20% renewable energy by 2020 would be USD 4/MWh or a 3% increase in electricity prices (McLennan Magasanik Associates, 2009). There is also evidence on the actual performance of the RET. In 2010 it was estimated to have achieved abatement of 8.8 Mt CO₂e, more than any other on-going Australia climate change program and has done so at a cost of between USD 30 – \$70/tCO₂e (Daley et al., 2011) and impact of around 1 to 2% on electricity prices (Productivity Commission, 2011).

The abatement costs of the RET compares relatively well to other policies. For example, abatement under solar subsidies has cost up to USD 1000/tCO₂e. However, the RET is more expensive than energy efficiency standards (which are estimated to provide net benefits) and some grant programs (although the abatement achieved through grant programs is low) (Daley et al., 2011). The RET by itself is not sufficient to incentivize solar PV at current prices as emission reductions can be achieved more cheaply from other technologies such as wind.

While the RET compares well to other renewable energy policies in terms of the cost of achieving emissions reductions, Australia will introduce an economy-wide carbon pricing scheme in July 2012. This should, from an efficiency perspective, greatly weaken the rationale for supporting the RET scheme because a broad based carbon price incentivizes emissions reductions that are cheapest, including those from renewable energy deployment. Indeed, the co-existence of carbon pricing and the RET is likely to increase the cost of achieving Australia's emissions reduction target and suggests that once the national carbon price is fully operational the RET should be wound down.

Basic research and development

Australian governments have provided significant support to basic solar PV research and development (R&D) through programs such as the Australian Solar Institute, solar centers of excellence, universities, Geoscience Australia and an R&D tax incentive. This funding has supported technological innovations, the adaptation of technology to Australian circumstances and an improved understanding of Australia's solar resources.

¹⁹⁷ The Australian Productivity Commission estimates that the cost of abatement from Germany's solar FiT is (2010) USD 864/tCO₂e (Productivity Commission 2011, Appendix F).

The major benefit of solar R&D is that it may reduce long term industry costs and contribute to emission reductions both in Australia and overseas (by way of technology diffusion). Other benefits may include the generation of export revenue from solar innovations and the potential to leverage Australia's high quality solar resources and world leading R&D facilities and researchers.

Without specific data on the benefits and costs of government supported solar R&D programs it is only possible to make some general observations. While benefits of R&D support indeed exist, the question is whether net benefits are realized after taking into account the costs associated with raising the funds for R&D support and the potentially distortive effects of assistance for specific projects over others.

A recent statement by a group of prominent economists and scientists issued after a meeting in Stanford University in 2008 to discuss the role of R&D in developing effective policies for addressing the adverse potential consequences of climate change captures this well (Arrow et al, 2009).¹⁹⁸ The statement pointed to the downside of R&D subsidies that tend to support favored firms, industries and organized interests, and advocated agency independence to overcome such distortions.¹⁹⁹ Australia's R&D grants for solar PV technologies are mostly directed at public research organizations, centers of excellence and universities, as opposed to private firms and industry. As such, R&D grants are unlikely to be allocated so as to support favored firms or organized interests.

Demonstration grants

Australian governments have provided significant support for the demonstration of large scale solar PV projects under Australian conditions. For example, the Australian Government committed AU\$ 1.5 billion to the Solar Flagships program to support the development of 1000 MW of large scale grid connected solar power. The Australian Government has also agreed to provide USD 75 million to support a 100 MW solar power plant under the Low Emissions Technology Demonstration Fund (LETDF) (this project has also received AU\$ 50 million in funding from the Victorian Government).

The major potential benefit of government support for demonstration projects is that it can demonstrate how key industry risks can be overcome, thus reducing long term financing costs, encouraging industry development and providing the opportunity for large scale emission reductions. Demonstration schemes may also support regional employment. For example, one estimate suggests that the development of a 100 MW plant under the Solar Flagships program will create around 300 jobs during construction.

The problem with Australian government grant programs is that they require governments to be involved in project decision making (e.g. in project selection and in ensuring that projects adhere to the terms of the grant program). This is a difficult role for governments because the projects are likely to involve cutting edge technologies and processes which may be poorly understood. This may lead to lengthy contract negotiation and poor project selection. Governments are also likely to include inflexible

¹⁹⁸ Arrow, K. et al, "A statement on the appropriate role for R&D in climate policy", *Economists Voice*, February 2009 (www.bepress.com/ev)

¹⁹⁹ The problem of agency dependency is well recognized in the public choice literature on the widely observed phenomenon of regulatory capture (for instance, Stigler, G. 1971. The theory of economic regulation. *Bell J. Econ. Man. Sci.* 2:3-21.)

terms and conditions to safeguard the use of government funds. This may mean that original contracts cannot be fulfilled, particularly if there is a change in the assumptions under which they were originally made. These issues have led to significant project delays and in some cases project termination.

The issue of grant program delays was initially reported by the Australian National Audit Office (2004) in relation to Australian government climate change programs more broadly. It was repeated in Australian National Audit Office (2010) who found that Solar Cities had spent only 26% of its original budget over a 5 year period and the Low Emissions Technology Demonstration Fund (LETDF) spent less than 5% of its budget over a 5 year period. Moreover, this problem seems set to continue. For example, in December 2011 it was reported that the two large scale solar projects to be funded under the Australian Government's Solar Flagship program had missed a deadline for financial close (Climate Spectator, 2011).

There is a cost associated with grant program delays in terms of under-utilized funding which could have been allocated to more productive areas of the economy. The delays also mean that none of the potential benefits have been realized. This suggests that many Australian government grant programs to the large scale solar PV industry are unlikely to have minimized costs and maximized benefits.

One potential argument for continued support of the industry is that it will help bring long term industry costs down (the infant industry argument). However, Australian governments have been supporting large scale solar PV projects for a number of years and commercial production is yet to commence.²⁰⁰ Another argument for continued (but temporary) support of demonstration projects is that it will help address early mover market failures including barriers in financial markets and the cost of interaction with governments to establish an appropriate regulatory regime. A problem with this approach is that it will be difficult to quantify the level of funding that is justified by the market failures. If governments are able to overcome this barrier they still face the challenge of targeting the funding to the most prospective projects. This can be assisted by bringing market pressures to bear on project selection decisions (rather than relying on the judgment of bureaucrats).

On this basis, it is recommended that Australian governments reconsider if funding for solar PV demonstration projects is appropriate. The final decision on appropriate policy mechanism and funding allocation (if any) should include analysis of a range of policy options and consideration of their full range of costs and benefits as recommended in guides to best practice regulation.

(ii) Scientific Integrity

Australia has the highest average solar radiation per square meter of any continent. Geoscience Australia and the Australian Bureau of Agricultural and Resource Economics (2010) have estimated that total solar radiation is 58 million petajoules (PJ) annually, which is approximately 10,000 times Australia's annual energy consumption. This implies that the technical potential for electricity generation from solar PV is large and unlikely to act as a capacity constraint, providing a scientific basis for supporting solar PV in Australia.

²⁰⁰ This funding could produce results in the near future but there is also a risk that government support may be continue to be needed over the long term – which is unlikely to provide value for tax payer money.

Australian R&D funding for solar PV has supported technological innovations, the adaptation of technology to Australian circumstances and an improved understanding of Australia's solar resources. However, it remains unclear whether the design of solar PV policies took into account the findings of such R&D efforts.

(iii) Flexibility

The flexibility of Australian government solar programs is different for different programs. The overall level of support for the industry is flexible because governments have not committed to any specific development targets. This allows governments to respond to changes in relative market prices, for instance by increasing efforts in the solar PV sector if relative prices fall, or vice-versa. However, it reduces certainty for investors potentially delaying investment in the sector and other supporting sectors (e.g. supply channels).

In particular, policies such as the Renewable Energy Target and the carbon pricing scheme (that is to be adopted starting from July 2012) are not technology-specific and thus allow automatic adjustments to the level of support to be made in response to changing market conditions. For instance, the RET covers a large range of renewable technologies and therefore provide businesses with greater freedom to choose how they will contribute to the renewable target (e.g. a business may choose to contribute to the RET through the development of solar, wind, geothermal or any other eligible technology). This flexibility allows business to respond to market conditions, for example, to reduce the use of a particular technology in response to price rises or vice versa. This helps to minimize costs for business and the broader economy while still ensuring the environmental objectives are achieved.

In the case of demonstration grants, governments have typically provided one-off funding rounds which provide the government with flexibility to change the rules for subsequent programs. However, once announced, grant programs lack flexibility. For example, grants are likely to be provided according to a set of criteria designed to ensure that government funds are not misused. These criteria may limit the firm's or government's ability to respond to unexpected market conditions (which are quite likely during the early stages of technology development). As a result many grant programs have not allocated their full funding commitment²⁰¹ or have taken many years to negotiate a final funding agreement.²⁰²

Government rebates and FiT schemes have provided pre-determined levels of assistance to recipients. The level of assistance can be changed (and has been changed) through government policy intervention or regulatory amendment, but the policies are not flexible enough to automatically adapt when market conditions change. For example after 2008 the price of solar PV systems fell but the level of government assistance provided to recipients did not respond. This provided a larger benefit to solar investors than originally anticipated and led to a large increase in scheme demand and scheme costs, and finally to the early termination of some of the policies such as the SHCP as well as various FiT schemes. Due to these

²⁰¹ Funding for the Australian Solar Flagships program was reduced by AU \$150 million in the May 2011 budget and in July 2011 it was agreed that allocated programs funds would be absorbed by ARENA with future funding decisions to be made by the ARENA Board.

²⁰² A solar PV project agreed under the LETDF (which closed for applications in March 2006) did not finalise a funding agreement with the Australian Government until June 2011.

changes, the PV industry in Australia has been subject to very pronounced and highly undesirable boom and bust cycles.

ADMINISTRATIVE AND POLITICAL VIABILITY

(iv) Transparency

Australian governments have developed a number of mechanisms to facilitate stakeholder input to the policy development process, including best practice approaches to regulation and grants (see the Australian Geothermal Case Study for details).

Most Australian government solar PV policies appear to have been developed with stakeholder input. For example:

- *Demonstration grants.* The Australian National Audit Office (ANAO) reports that two support mechanisms - the Low Emissions Technology Demonstration Fund (LETDF) and Solar Cities program - both issued draft guidelines and a Statement of Challenges and Opportunities prior to finalizing program rules (Australian National Audit Office, 2010). These were widely disseminated to stakeholders and the programs were further communicated through workshops. The Australian National Audit Office (2010) suggests that the consultation process initially delayed the roll-out of the programs but led to more targeted and higher quality applications.
- *Feed-in tariff schemes.* Many FiT schemes were introduced through legislation and developed with stakeholder input. For example, in 2008, the NSW Government established the NSW Feed-in Tariff Taskforce to advise on the design of a feed-in tariff for New South Wales (NSW Government 2012). The Taskforce was required to investigate the likely cost of a FiT scheme and ensure it was complementary to the proposed national carbon pricing scheme. Stakeholders were invited to comment on the proposals of the task force. The Australian Capital Territory (ACT) Government also released a FiT scheme discussion paper and held community consultation sessions to seek input to the design and amendments of a FiT scheme.
- *Renewable energy target.* Stakeholders (from business, different levels of government and the non-for-profit sector) have had an opportunity to provide input to the development of the RET. For example, a 2003 independent review of the RET (previously known as the Mandatory Renewable Energy Target or MRET) received 264 substantive submissions, met with 115 different stakeholders and travelled to 16 different communities (Mandatory Renewable Energy Target Review Panel, 2003). More recently stakeholders have been asked to provide feedback on the 2009 and 2010 RET legislative amendments including feedback on scheme design options, exposure drafts of legislation and regulation, and input to parliamentary inquiries.
- *National carbon pricing scheme.* To help develop the national carbon pricing scheme the Australian Government organized a series of roundtables with business groups, environmental/non-government organizations, community sector groups and primary industry

representatives over a 6 month period (Australian Government, 2011c). The government also received over 1300 submissions from individuals, business groups, non-government organizations, community groups, state and local government bodies and industry associations.

There is also evidence that some policies did not follow best practice approaches. For example, the Australian National Audit Office (2010) reports that Australian Government rebate schemes (SHCP and the RRP GP) were introduced with minimal stakeholder consultation and were not assessed through formal policy processes by government agencies. As noted above, cases wherein there are minimal stakeholder consultations seem to be the exception rather than the norm.

More recently, the Australian Government has sought feedback from stakeholders on the broad challenges and opportunities facing the solar industry. This was achieved, for example, through the 2010 release by the Australian Centre for Renewable Energy (ACRE)²⁰³ of a draft of its Strategic Directions paper. The paper sought stakeholder views on ACRE's future funding strategy to support the development, commercialization and deployment of renewable energy and enabling technologies, including solar PV. In 2011, the Australian Government convened a large scale solar roundtable to seek the input of the solar industry, solar researchers and State governments on the opportunities and challenges facing the large scale solar industry. The results of the workshop were released in a large scale solar discussion paper and it was indicated that they would contribute to future consideration by Governments and institutions on policy settings for large scale solar.

The legislation to support Australian Government market mechanisms (the national carbon pricing scheme and the RET) is available at the Australian Government's ComLaw website and through the website of the Department of Climate Change and Energy Efficiency. The interpretation of regulations and legislation is assisted by explanatory memoranda and overview documents developed by Australian Government agencies. For example, the Office of the Renewable Energy Regulator has developed a range of guidance material on the operation of the RET.

(v) Alignment

Australian governments have taken a number of steps to achieve policy alignment. At a broad level, policies between the Australian and State and Territory governments are coordinated through the Council of Australian Governments (COAG). COAG includes the Australian Prime Minister as its Chair, State Premiers, Territory Chief Ministers and the President of the Australian Local Government Association. It has been operating since 1992.

Australia has also established a system of Australian and State and Territory government Ministerial Councils under COAG to facilitate consultation and cooperation between jurisdictions in specific policy areas. An OECD review found that Australia stands out among OECD member economies for establishing mechanisms for systematic coordination and cooperation across levels of government (OECD, 2010).

²⁰³ ACRE is an Australian Government funded body established in 2009 through legislation to manage more than AU \$690 million of renewable energy investment. It has an independent Board of Directors and Chief Executive Officer.

Australian governments have taken specific actions to achieve alignment on climate change policies. For example, in 2007, the Australian Government commissioned the *Strategic Review of Australian Government Climate Change Programs* (Wilkins, 2008) to review all existing climate change programs to ensure complementarity with its proposed national emissions trading scheme (the Carbon Pollution Reduction Scheme or CPRS²⁰⁴) and rationalize duplicative programs. The Wilkins Review found that “the programs that governments (throughout Australia) collectively have for supporting solar energy are confused and duplicative” (Wilkins, 2008, p.141) and more generally that there were too many climate change programs, many were ad hoc or badly targeted, there was no framework or logic to organize the policies and there was significant overlap between Australian and State and Territory government programs.

To help address this issue, in 2008 COAG agreed to a set of principles to ensure complementarity between mitigation measures and the CPRS and that each jurisdiction would review existing policies. The review identified 488 State and Territory government climate change programs running concurrently (Australian National Audit Office, 2010). As a result of the review State and Territory governments agreed to redesign or terminate some of their programs. For example, NSW reported on 26 programs and agreed to terminate three and redesign or partially terminate another 16 programs.

Australian governments have also worked collaboratively through COAG on the design of the expanded RET: this included the replacement of existing national and state based schemes with a single national approach. Outside of the COAG process, alignment of policies at the Australian and State and Territory government level is encouraged through best practice regulatory and grants processes (for details on these processes see the Australian Geothermal Case Study).

Despite the existence of COAG and best practice processes, there has been significant overlap between Australian Government and State and Territory government solar policies. In 2008, the Australian Government doubled the rebate available to households for small scale solar PV systems through the Solar Home and Communities Program (SHCP). At the same time State and Territory governments introduced FiT schemes that in the case of NSW offered to buy energy from solar PV systems at a rate that was up to three times the price paid by consumers.²⁰⁵ The combined impact of the two incentive schemes plus increasing electricity prices and falling solar PV systems prices led to large program demand. This caused a surge in scheme costs and subsequently led to the premature cancellation of the SHCP and many FiT schemes. This parallels the experience in Germany and Spain where the solar boom was followed by a crash due to overwhelming demand due to overly generous FiT schemes.

There is also overlap between Australian Government schemes. The Australian Government has legislated to introduce a national carbon pricing scheme in July 2012 which will operate in tandem with the Renewable Energy Target (RET). The operation of the two schemes together is unlikely to achieve significant additional abatement because emission reductions achieved by the RET will also contribute to the national mitigation target. Moreover, abatement costs are likely to increase. This is because the RET requires some of the abatement to be achieved from a specific source (renewable energy) when cheaper

²⁰⁴ The CPRS was rejected by the Australian Parliament and has been superseded by the national carbon pricing scheme.

²⁰⁵ The NSW FiT provided a gross feed-in tariff of AU \$0.60 per kWh compared to retail electricity prices of between AU \$0.20 and \$0.25 per kWh (Independent Pricing and Regulatory Tribunal, 2011).

abatement may be available through other means such as energy efficiency or in other sectors such as forestry, industrial processes or transport. The overlap will also increase administrative costs. To help address this issue the government plans that the RET will be a transitional mechanism only and will not provide support beyond 2020. In the meantime, however, it will increase the cost to Australia of achieving its emission reduction objectives.

3.3.2 Solar PV in Thailand

Key findings

- Thailand has allocated a substantial amount of funds to promote the renewables sector in general and to the solar PV industry in particular. This stems from Thailand's solar resource potential and the imperative of energy diversification.
- The subsidies provided by the Thai government have encouraged rapid growth in Thai solar installations. However, the promotion of the industry has come at a large cost in terms of the tariff burden on consumers. Because of the high costs and concerns about the impact on electricity consumers, the Thai government has often changed the regulations and tariffs governing the industry. This has adversely impacted investor confidence. Furthermore, if the aim of promoting the industry was the reduction of emissions, the high cost of solar PV relative to other alternatives makes it a very expensive option in Thailand.

Costs, benefits and promotion

- The costs of abating a ton of CO₂ by replacing conventional fossil-fuel electricity with solar PV are very high at around US\$ 417 per ton of CO₂.
- Adder tariffs for solar PV on consumers impose a significant price burden on consumers that amounts to around US\$ 600 million annually.

Scientific integrity

- There is some indication that scientific evidence and analyses are taken into account in the design of Thailand's policies relating to solar PV, though lack of technical expertise is a challenge to the development of rural or off-grid PV applications.

Flexibility

- The government of Thailand has periodically revised its solar PV targets, tariffs and conditions. While this has provided important flexibility to government to react to changing market conditions (e.g. fuel prices, technological change), this sort of flexibility may increase the risks and therefore the costs faced by investors.

Transparency

- The process for the formulation of Thailand's building energy efficiency policies allows stakeholders' views to be reflected.
- Information on renewable energy programs and their environmental impact is not readily available, or out-of-date.

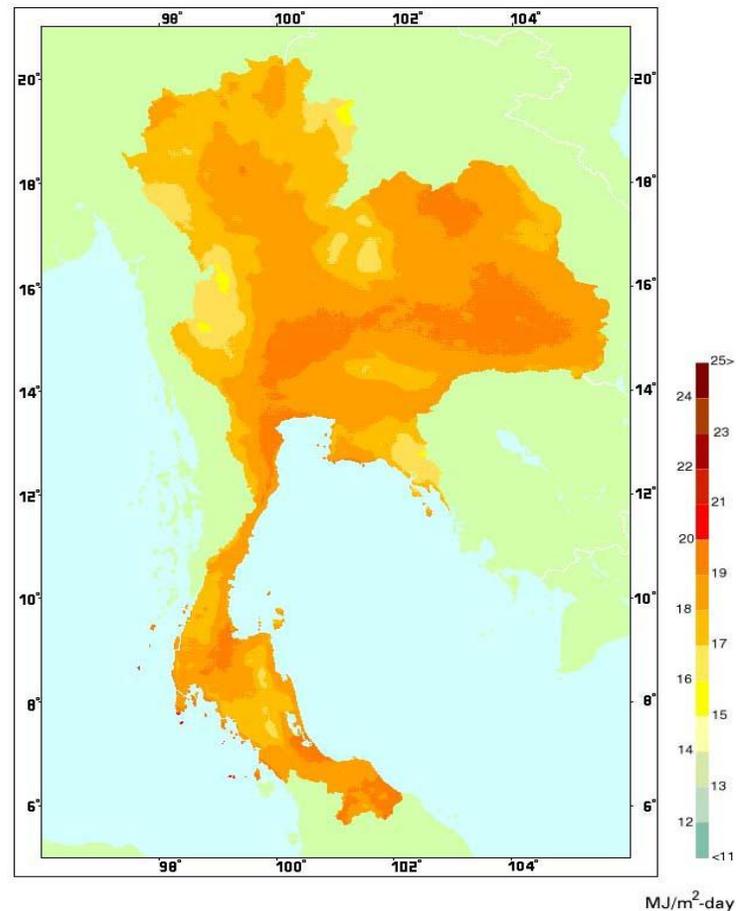
Alignment

- Many different agencies are in charge of renewable energy policy in general and solar PV policy in particular. However, it is not clear that agencies are able to coordinate effectively amongst each other.

A. Size and Significance

Roughly half of Thailand's total land cover enjoys high levels of solar radiation of over 5 kWh/m² (see Figure 3.3.2). The highest radiation level is observed in the northern region and part of the central region, which occupies 14% of Thailand's total land cover. The potential installed capacity has been estimated to be as high as 50,000 MW (Asian Development Bank, 2008).

Figure 3.3.2 *Solar energy map of Thailand*



Source: Department of Alternative Energy Development and Efficiency (DEDE) and Faculty of Science at Silpakorn University (2009).

It is estimated that Thailand’s potential installed capacity from solar PV exceeds that of all other renewables combined (see Table 3.3.1). Biomass, with the next biggest potential, stands at 4,400 MW. However, care must be taken when using the potential installed capacity to make judgments about the generation potential of different renewables. A renewable such as solar is intermittent in nature. When the sun does not shine, there is no electricity produced. Hence the key in comparing the electricity generation potential across different technologies is to take into account capacity factors (the fraction of the number of hours in a year that a power plant operates). With a capacity factor of 20% for solar, the 50,000 MW solar installed capacity gives an output of 87,600,000 MWh a year. A capacity factor of 80% for a biomass plant puts the electricity generated from the 4,400 MW installations at 30,835,200 MWh a year. Thus, while solar remains the renewable with the highest potential output, its relative potential is closer to other renewables than the straightforward comparison of the potential installed capacities would suggest.

Table 3.3.1 Potential capacity additions

Energy Type	Potential (MW)
Solar	50,000
Wind	1,600
Hydropower	700
Biomass	4,400
Biogas	190
Municipal Solid Waste	5

Source: Asian Development Bank, 2008.

B. Policy Formulation

(i) History and Background

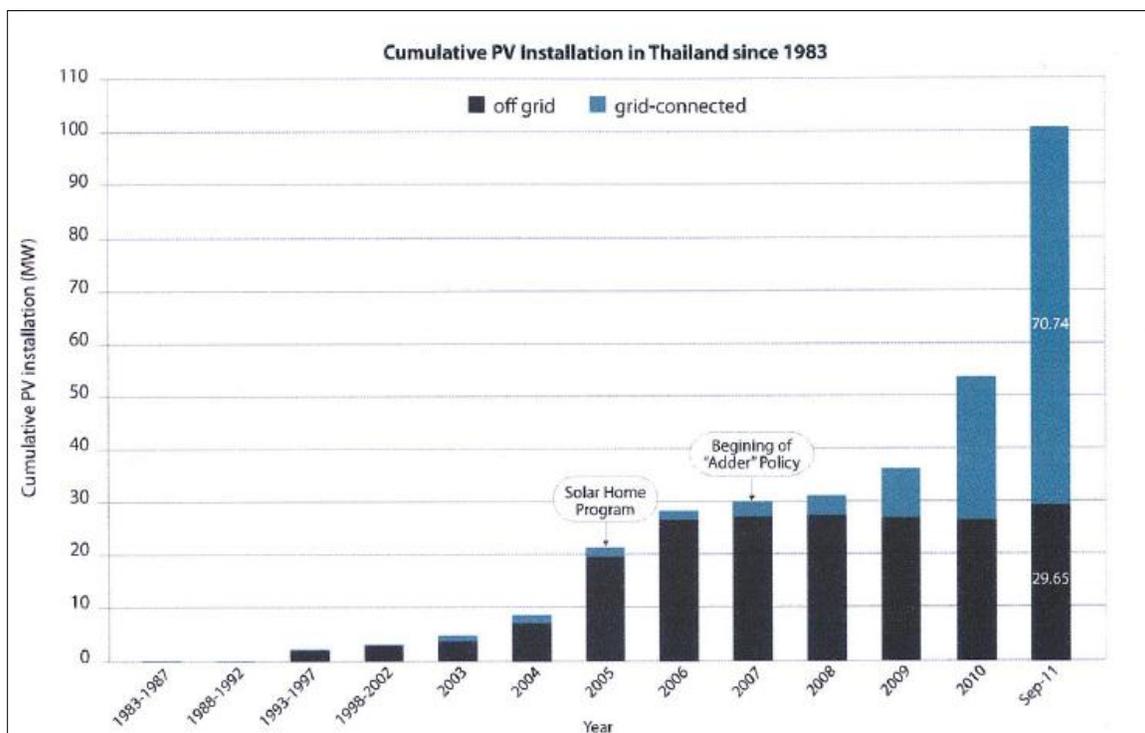
Solar PV installations in Thailand have a long history. The first phase of nation-wide PV installations occurred around 1976 (Kirtikara, 1997). Nearly 300 panels were installed at rural health stations for communication equipment by the Ministry of Public Health and the Medical Volunteers. PV technology was first incorporated into the national energy development plan as part of the 5th National Plan (1982–1986) following the oil crises during the 1970s. Major early PV applications in Thailand include powering telecommunication links, PV water pumping systems and PV centralized battery charging systems for rural villages.

The installed capacity of solar PV rose from 0.5 MW in 1990 to 2.5 MW in 1996 (Kirtikara, 1997). Over the next decade and a half, solar capacity grew at an average rate of approximately 24% per annum. By September 2011, Thailand had a cumulative installed PV capacity of about 100 MW, with about 30

MW being off-grid systems (See Figure 3.3.3). By the end of 2010, grid connected PV systems accounted for 0.01% of electricity demand (Department of Alternative Energy Development and Efficiency, 2011). The annual market during 2010 was about 10 MW, mostly grid-connected systems.

A number of PV farms are under construction, totaling about 160 MW – with expansion plans up to almost 400 MW. In December 2011, one of the world’s largest solar PV projects, the Lopburi solar power plant began operation. It has a capacity of 73 MW that will increase to 84 MW upon completion (Pattaya Mail, 2011). The Lopburi plant is the first alternative energy project in the region that has received support, through a long-term loan, from the Asian Development Bank (ADB) under the recent Asian Solar Energy Initiative (ASEI).

Figure 3.3.3 Cumulative PV installation in Thailand since 1983 (updated September 2011)



Source: Department of Alternative Energy Development and Efficiency, 2011

(ii) Policy Description

Thailand’s solar power policies are laid out in the Renewable Energy Development Plan (REDP) (2008-2022). The broad objectives of the 15-year REDP are:

- to increase the share of alternative energy to 20% of Thailand’s final energy demand in 2022,
- to utilize alternative energy as a major energy source, replacing oil imports,
- to increase energy security,
- to promote integrated green energy utilization in communities,
- to enhance the development of the domestic alternative energy technology industry, and

- to research, develop and encourage high-efficiency alternative energy technologies.

The REDP aims to increase the installed capacity of solar from 55 MW in 2011 to 500 MW by 2022, which is ultimately targeted at bringing renewable energy to around 20.3% of the energy mix (Sutabutr, Choosuk and Siriput, 2010). This will contribute to the target of reducing Thailand's GHG emissions by at least 42 million tons (CO₂ equivalent) by 2020, relative to 1990. Achievement of the REDP will be assisted by the policies described below.

Before we launch into specific policies, it is important to note that elements of Thailand's efforts to restructure the electricity sector have a strong influence on small renewable power installations. In this respect, one important move was the liberalization of the Thai electricity sector, encouraging private participation via the Small Power Producers (SPPs) program and the Very Small Power Producers (VSPPs) program.²⁰⁶ The Small and Very Small Power Purchase Agreements policy was implemented by the Electricity Generating Authority of Thailand (EGAT) in 1994 and updated in 2002, following the amendment of the EGAT Act (Amatayakul & Greacen, 2002), and gave small power producers certainty regarding the conditions under which they can sell power into the grid.

MANDATES

Feed-in tariffs (or adder feed-in premiums)

In May 2001, the government initiated a "pricing subsidy" in the form of energy payment adder for electricity generated by renewable energy for a period of five years at a maximum rate of 0.36 THB/kWh,²⁰⁷ under competitive bidding. A budget of 3,060 million baht²⁰⁸ was allocated from the ENCON (Energy Conservation Promotion) Fund for this purpose. This pilot scheme was expected to generate about 300 MW of electricity from renewable energy.

In mid-2002, the Thai authorities announced that the two power distribution utilities, the Provincial Electricity Authority (PEA) and the Metropolitan Electricity Authority (MEA), would purchase power from installations with a capacity of 1 MW or less. This program was initiated because meeting the existing SPP regulations of Electricity Generating Authority of Thailand would be too costly for power producers with installations of 1 MW or less. In recognition of the fact that the compliance burden associated with the SPP regulations affected the viability of installations with a capacity greater than 1 MW, in September 2006, the government, via the National Energy Policy Council (NEPC), re-defined the capacity limit for VSPPs, increasing it from 1 MW to 10 MW. Furthermore, technical interconnection requirements were revised to better cater for VSPPs.

In December 2006, the NEPC approved an increase in the power purchased from SPPs (i.e. power producers with capacity ranging from 10MW to 100MW), from 3,200 MW to 4,000 MW. At the same time, the "Adder Provision" was initiated, providing an additional increment over and above the prices that power producers were already receiving for electricity they were selling to utilities.

²⁰⁶ The capacity range for VSPPs is less than 10 MW and that for SPPs is between 10 MW and 100 MW.

²⁰⁷ This is approximately 1 US cent (assuming that 1 USD = 30 Thai Baht).

²⁰⁸ This is approximately US\$ 102 million.

These Feed-in Premiums were very effective at encouraging the deployment of renewables, leading to an oversubscription (Sutabutr, Choosuk and Siriput, 2010). However, despite the fact that solar enjoyed a higher adder than other renewable sources of 8 Baht/kWh²⁰⁹ (plus an additional special adder of 1.5 Baht/kWh²¹⁰ in the three southernmost provinces), no solar projects were being initiated as of 2008, due to the high relative cost of solar PV generation. As a result, the government increased the timeframe over which the adder would be provided from 7 to 10 years (Ruangrong, 2008).

The extension of the period over which the feed in premium would operate, coupled with declining technology costs for solar PV, led to a much higher level of interest in solar PV than the government was anticipating. There were over 1,600 MW of solar PV applications under the VSPP program, compared to the Thai solar targets of 55 MW by 2011, 95 MW by 2016, and 500 MW by 2022 (Rangsan, 2009).

Fears of a blowout in costs for electricity consumers from this large volume of solar PV, given the high adder rates, led the Thai Cabinet to reduce the solar adder from 8 to 6.5 Baht/kWh²¹¹ in June 2010 for all projects that had not yet been approved, including those already submitted. In addition, it was stipulated that no new applications would be accepted until the finalization of a revision of the adder to a new Feed-in-Tariff (FiT) arrangement (Tongsopit, 2011). As of December 2011, the Energy Policy and Planning Office (EPPO)²¹² has suspended the adder tariffs for all renewable energy projects except for solar projects to allow implementation of the FiT.²¹³

In addition, Thailand was for a time looking at implementing a renewable portfolio standard, which is essentially a quota on the amount of electricity that a producer has to generate from renewables. In 2003, a Renewable Portfolio Standard (RPS) was proposed for new power plants whereby 5% of their generation capacity must be generated by renewable energy (Lidula et al., 2007). In 2003, the RPS was imposed only on the Electricity Generating Authority of Thailand (EGAT). In 2008, DEDE planned to impose a RPS on Independent Power Producers (IPPs), but the legislation was not approved. In the 2012, a RPS has once again been proposed for IPPs.²¹⁴

FISCAL INCENTIVES

There are several fiscal incentive schemes that are currently in operation in Thailand. A short overview of the most prominent of these, namely the Energy Conservation Promotion Fund (ENCON Fund), the Power Development Fund, and tax incentives through the Board of Investment (BoI) is provided in the following discussion.

²⁰⁹ This is approximately 27 US cents (assuming that 1 USD = 30 Thai Baht).

²¹⁰ This is approximately 5 US cents.

²¹¹ This is a reduction from approximately 27 US cents to 22 US cents.

²¹² The Energy Policy and Planning Office is the executive body of the National Energy Policy Council (NEPC) and recommends economy-wide energy policies and planning.

²¹³ This information was gleaned from the interviews that we conducted with members of the Department of Alternative Energy Development and Efficiency, Thailand (19 Jan 2012).

²¹⁴ This information was gleaned from the interviews that we conducted with members of the Department of Alternative Energy Development and Efficiency, Thailand (19 Jan 2012).

Energy Conservation Promotion Fund (ENCON Fund)

The ENCON Fund was established in 1995, following the launch of the ENCON Act in the same year. Its revenues are derived from levies from petroleum producers and importers, power surcharges, and remittance rates from consumer petrol prices (Ministry of Natural Resources and Environment, 2002).

Through the ENCON Fund, 1,000 million Baht (US\$ 33 million) is made available for a co-investment scheme to encourage renewable energy projects. The scheme utilizes several facets of project-financing schemes to share risks with private developers, such as equity investment, venture capital, equipment leasing, creation of carbon credit market, and credit guarantee facility (IEA, 2010)²¹⁵. By March 2011, the fund had stimulated investments in renewable energy and energy efficiency projects with a total value of over 4,500 million baht/year (US\$ 150 million/year).

The ENCON Act has various programs targeting different groups and sectors. Under the Voluntary Program, the ENCON Fund financially supports the development and use of renewable energy sources. This is undertaken through three sub-programs: renewable energy and rural industry, industry liaison, and research and development. The two types of financial support for the implementation of the Voluntary Program are non-binding grants and investment subsidies (IEA, 2010).²¹⁶ For government agencies and non-profit organizations, non-binding grants cover the operational costs of managing, administration, marketing, maintenance and after-sales services of the funded renewable energy project. Investment subsidies, which are available to private sector investors, encourage investment in renewable energy projects. Subsidies can cover up to 60% of the project cost, depending on the investment amount, and in practice generally cover between 35 to 45% of the cost.

Power Development Fund

Following the Energy Industry Act of 2007, the Power Development Fund was set up in the Office of the Energy Regulatory Commission. In addition to being used to promote renewable and environmentally friendly energy generation technology, the Fund is also used to implement the subsidy arrangements for underprivileged power consumers, rehabilitate localities, and compensate people affected by power plant operations. Revenue for the Fund is provided by a levy on power generators through the electricity tariffs. All power plants have to pay a levy to the Fund during the plant commissioning at the following rates (Energy Regulatory Commission, 2009).²¹⁷ As Table 3.3.2 below illustrates, the levy for renewable energy sources such as wind, solar and biomass is lower than the levy for fossil fuel sources such as coal and diesel.

²¹⁵ IEA Global Renewable Energy Policies and Measures Database, Energy Conservation Program, Thailand

²¹⁶ IEA Global Renewable Energy Policies and Measures Database, Energy Conservation Program, Thailand

²¹⁷ The Energy Business Act (December, 2007) created a single regulatory body, the Energy Regulatory Commission (ERC), the first in Thailand's history, with the responsibility to regulate the activities of operators in the electricity sector, in addition to ensuring their compliance with the Act.

Table 3.3.2 Levy on power generators for different fuel types²¹⁸

Fuel Type	Satang/unit
Natural Gas	1.0
Fuel Oil/Diesel	1.5
Lignite/coal	2.0
Wind/Solar	0
Biomass/msw	1.0
Hydro	2.0

Source: Energy Regulatory Commission, 2009

Tax Incentives through the Board of Investment (BoI)

There are a series of tax incentives to lower investment costs in energy efficiency and renewable energy projects. These include exemptions of duties for imported machinery and a corporate income tax holiday of eight years combined with a 50% reduction of corporate income tax on net profits from the 9th to 13th years (Sutabutr, Choosuk and Siriput, 2010). In addition, the facility installation and construction cost of projects, not exceeding 25% of investment capital, is discounted from net profits for taxable purposes. Specific to the solar industry, the Board of Investment (BOI) gives producers of solar cells its maximum incentive of 8 years of an income tax holiday.²¹⁹

Research and development (R&D) Funds

Solar R&D on topics ranging from solar cell materials to PV applications is being conducted by universities, government research institutes and the private sector (Department of Alternative Energy Development and Efficiency, 2011). The Research and Development sub-program of the ENCON Fund aims to develop new technologies and improve on existing ones, provide support to small-scale demonstration projects and facilitate information dissemination. The Fund has supported more than 50 R&D projects for energy technology development and conservation undertaken by various government agencies and academic institutions. R&D projects eligible for funding include policy studies, adaptation of technologies used in other economies and dissemination of research through small-scale demonstration projects, workshops and conferences (IEA, 2010). Grants have been given to encourage R&D on solar energy (Ministry of Natural Resources and Environment, 2002). Examples of funded projects are:

- the development of solar radiation measuring station network for Thailand;

²¹⁸ 100 Satang = 1 Baht

²¹⁹ See for instance http://ns.boi.go.th/english/download/publication_investment/60/april06.pdf

- the demonstration project of electricity generation and distribution system using solar cells in Mae Hong Sorn Province in northern Thailand;
- the establishment of a “Solar Energy Park” to serve as a demonstration center and to disseminate information on solar energy.

In addition, the Thailand Research Fund, an independent organization under the Office of the Prime Minister, is another institute supporting R&D and facilitating information on solar cells (Ministry of Natural Resources and Environment, 2002).

FINANCIAL INCENTIVES

Asian Solar Energy Initiative (ASEI)²²⁰

The ASEI is a three year project launched by the ADB in order to implement 3,000MW of solar electricity generation capacity in Asia and the Pacific (Asian Development Bank, 2011). The target will be achieved by facilitating solar technology transfer to Asia and the Pacific, providing assistance in project development and implementing innovative financing schemes. In the first year of the ASEI, the first projects supported were two private sector–led solar PV electricity generation projects with capacities of 73.0 MW and 44.5 MW in central Thailand.

The ADB plans to finance up to US\$2.25 billion directly under the ASEI and leverage an additional \$6.75 billion in solar investments over the same period, using instruments such as London interbank offered rate (LIBOR)–based loans, donor contributions, grant funds, innovative risk mitigation mechanisms, carbon market support measures and direct support. In addition, a separate Asia Accelerated Solar Energy Development Fund of up to \$500 million is used to mitigate risks associated with solar energy projects and push down the initial cost of solar energy development. This will encourage commercial banks and the private sector to invest in solar technologies and projects.

Energy Efficiency Revolving Fund

The Thai Ministry of Energy (MoE) has established a “Revolving Fund” to assist the investors in RE and EE projects by allocating budget from the ENCON Fund for 2-stepped loans via commercial banks. This scheme is currently in the fourth period (2009- 2011) and has a loan ceiling of 400 million baht.²²¹ The interest rate has been set at maximum 4% for a loan period of 7 years. The past three periods of the project were fully subscribed and initiated a total investment of 6,724 million baht (US\$ 225 million), which is expected to reduce energy consumption by 2,200 million baht or US\$ 73 million annually (Sutabutr, Choosuk and Siriput, 2010).

²²⁰ Although this fund is instituted by a multilateral agency, it has been included given that this financing avenue has been tapped by the Thai solar energy sector.

²²¹ This is approximately US\$ 13 million (assuming that 1 US\$ = 30 Thai Baht)

Clean Development Mechanism

The Clean Development Mechanism (CDM) allows developed economies to fulfill their commitments under the Kyoto Protocol (an international climate change agreement under the United Nations Framework Convention on Climate Change) by incentivizing emissions reductions in developing economies and is another avenue through which solar PV projects in Thailand can receive additional funding. However, the uptake of CDM through solar PV projects has been slow. Of the 154 projects that have been approved by Thailand's Designated National Authority (the body that manages CDM credits in Thailand), only 4 are solar energy projects (Department of Alternative Energy Development and Efficiency, 2011). A lack of technical specialists for many renewables and the inability of the authorities to focus on the development of many renewables as a priority issue are some of the reasons that have been suggested to explain this (Dabbaransi, 2010).

C. Regulatory Review

ECONOMIC EFFICIENCY AND EFFECTIVENESS

(i) Costs, Benefits and Promotion

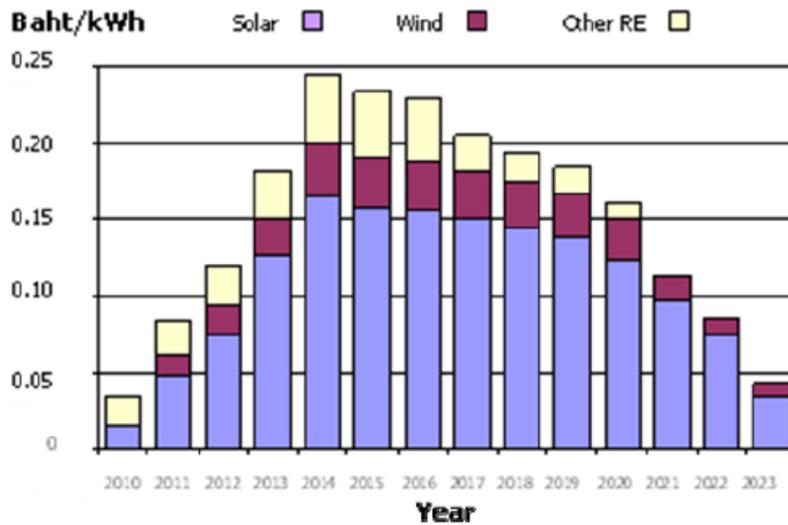
The VSPP programme combined with the adder tariff has increased the incentives for the establishment of small scale renewable energy projects. In recent years, solar PV applications to the SPP and VSPP programs have greatly exceeded government expectations (Wongdeethai, 2011). As of October 2011, about 3,500MW of solar PV and concentrating solar thermal projects were in the pipeline. This is significantly higher than the revised target of 2,000MW of solar generation capacity by 2022.

However, the achievement of this expansion is likely to come at considerable cost (Figure 3.3.4). An analysis on the Return of Investment of solar PV projects and the impact of the tariff burden on consumers was conducted by the Energy Policy & Planning Office (EPPO). The findings led the National Energy Policy Committee (NEPC) to reduce the adder rate and to stop accepting new applications (Tongsopit, 2011). Based on the initial adder of 8 baht/kWh,²²² 3 GW of solar at 15% capacity factor could add a net burden to consumers of 31 billion baht/year or US\$ 930 million/year (Greacen, 2011). Even with the revision of the solar adder rate to 6.5 baht/kWh²²³ in 2009, the annual cost remains high at approximately 25 billion baht/year (US\$ 833 million/year).

²²² This is approximately 26 US cents (assuming that 1 US\$ = 30 Thai Baht).

²²³ This is approximately 22 US cents.

Figure 3.3.4 Price impact of adder tariffs to consumers



Source: Sutabutr, Choosuk and Siriput (2010)

If the aim of the scheme was to contribute to emissions reductions, the high cost of solar PV relative to other alternatives makes this a very expensive option. The estimated abatement costs are as high as 417 US\$ per tCO₂, which is over ten times higher, for instance, than the peak price of emission certificates under the EU ETS (these have never exceeded €32 per tonne of CO₂e and have been below €10 per tonne for a considerable amount of time).

Because the costs have been so high and the government has been concerned about the impact on electricity consumers, the government has been changing the rules and tariffs regularly. The resulting uncertainty makes project selection and development risky and has negatively impacted on investor confidence. A drawback of the way in which the adder was managed was that many of the project applications were speculative in nature, and were clogging the pipeline by occupying locations denied to legitimate projects (Greacen, 2011).

Fundamentally, a more efficient approach to promoting renewable technologies would be to make policies more technology neutral, such as through a Renewable Energy Standard as was proposed and is still being considered. That way, emissions reductions and energy security objectives could be met at a lower cost than by applying different rates to different technologies, since the least choice mix of technologies is more likely to be achieved through the market mechanism. Energy security objectives²²⁴ could also be met more efficiently by imposing taxes on imported energy sources – the revenues from this could then be recycled into the Thai energy sector, benefitting local production and production technologies that do not rely on imported energy inputs.

In summary, the main challenge faced by the Thai PV sector has been the high cost of solar PV systems. This has made solar uncompetitive in comparison with other electricity generation methods and

²²⁴ The Thai government is concerned about Thailand's high dependence on energy imports, particularly oil. In 2007, net energy imports accounted for 56% of energy supply in the economy (REEEP, 2010).

calls into question programs designed to overcome barriers to the implementation of solar PV on cost benefit grounds. That said, the pace of technological change in the solar PV sector has been very high and grid parity for distributed systems may be reached very soon. Removing non-cost barriers may ensure the technology can develop freely if and when relative prices (including environmental costs) become favorable.

Technical barriers associated with renewables in Thailand have resulted from lack of standards and know-how associated with solar PV systems and equipment. While standards for PV modules are being developed in Thailand, enforcement will only be on a voluntary basis. The service sector for solar PV O&M would also have to grow to support rooftop PV installations (Buranasajjaraporn, 2012).

The Factory Act (BE2535) prohibits residential units from containing more than 5 horsepower (equivalent to 3.7kW). Buildings with more than 5 horsepower are considered factories and cannot be located in housing developments and within 100m of schools, hospitals, temples, and government agencies (Tongsopit, 2011). This is a legal barrier towards promoting rooftop PV in residential buildings. At the moment, such PV systems are allowed as energy efficiency improvements in buildings, but not as power plants, meaning they are not eligible for the solar adder. Partly as a result of this, at present, 99.9% of solar proposals approved are ground mounted PV. The DEDE is trying to change the laws to allow exceptions for renewable energy. In addition, rules pertaining to solar PV such as warranty, rooftop rental, and building ownership will also have to be reviewed to promote solar PV in Thailand.²²⁵

Lack of community support is another barrier to renewables in general and solar PV in particular. There has been opposition to some renewable generation projects among the Thai people. Although solar PV is generally recognized as an environmentally friendly way to generate electricity, one negative environmental impact recognized in Thailand is the disposal of lead acid batteries used in solar PV systems (Uddin, Taplin, and Yu, 2010).

(ii) Scientific Integrity

As discussed earlier, the technical potential for solar energy in Thailand is high, with a potential installed capacity of 50,000 MW that exceeds the potential installed capacity of all the other renewables combined. Even after taking into account the fact that the capacity factor (the fraction of the number of hours in a year that a power plant operates) is relatively low for solar, solar remains the renewable with the highest potential electricity output. This provides a scientific basis for policies supporting the uptake of solar PV in Thailand.

There is some indication that scientific evidence and analyses are taken into account in the design of Thailand's policies relating to solar energy. For instance, scientific analysis carried out by the Department of Alternative Energy Development and Efficiency (DEDE) and the Faculty of Science at Silpakorn University (2009) suggests that the highest solar radiation levels in Thailand are observed in the northern region and part of the central region. Consistent with that, many of Thailand's solar PV installations (both existing and planned) are located in the northern and central region. The Lopburi solar plant, one of the world's largest, has been constructed in Lopburi province in central Thailand, supported by policies such

²²⁵ This information was gleaned from the interviews that we conducted with members of the Department of Alternative Energy Development and Efficiency, Thailand (19 Jan 2012).

as the Asian Solar Energy Initiative. In the northeastern Isaan region, the Solar Power Company (SPC) has plans for 34 solar plants that will total 204 MW by 2012 (Wilcox, 2012). To put that into context, Thailand's cumulative installed PV capacity in September 2011 was 100 MW.

However, one issue faced by rural/off-grid PV applications is the lack of maintenance of PV systems partially arising from the lack of technical expertise in those areas. As a result, output from PV systems is reduced and benefits gained by villagers are not maximized (Green, 2004). Such issues are especially pertinent for Thailand given that off-grid applications accounted for around 30% of Thailand's installed capacity in 2011 (see Figure 3.3.3).

(iii) Flexibility

The Renewable Energy Development Plan (REDP) has enumerated the renewables targets for Thailand up until 2022, and will, in a sense, provide the blueprint for the development of the Thai renewables sector. However, the plan by itself does not imply an inflexible approach as the targets do not constitute upper limits and are subject to revision. For example, as mentioned earlier, the REDP solar capacity in 2022 was revised upwards to 2,000 MW from the previous target of 500 MW.

The same appears to be true for the adder tariffs. The Energy Policy and Planning Office (EPPO) revised the tariffs in 2006, due to the lack of uptake, and again in 2009 and 2011 in response to oversubscription. The EPPO recently terminated adder tariffs, a special rate given to private renewable energy producers to promote the sector, and a new feed-in tariff is in preparation. Apart from reducing the tariff rate, stricter approval criteria were implemented in 2009 as well as a provision for the termination of projects which are unable to meet the timelines specified in their contracts (Tongsopit, 2011).

Whilst the ability to revise targets, tariffs and conditions provides the government with some flexibility to react to changing conditions, this sort of flexibility also imposes costs on investors, especially when such changes are not based on criteria that can be predicted. Renewable energy projects across the board require high upfront capital expenditure and are therefore very sensitive to changes in risk (because risk affects the cost of capital). While providing important flexibility to government to balance costs and benefits as new information emerges, the flexibility of Thailand's incentives and renewables targets might be at cross purposes with the recognized fact that the renewables targets will only be met if there is sufficient private sector investment.

A Renewable Energy Standard, as is being considered in Thailand, would provide added flexibility, leaving predictions about which renewable technologies may best achieve emissions reduction objectives to the market rather than requiring that the government regularly change tariffs, conditions and targets for specific RE technologies as technologies and relative prices change.

ADMINISTRATIVE AND POLITICAL VIABILITY

(iv) Transparency

In planning new policies, Thai government agencies follow standard procedures for conducting public hearings with relevant stakeholders.²²⁶ Stakeholders include specialists, academics, suppliers and users (public) and about 3 to 4 public hearings are held. Before the policies/laws are imposed, they are announced 1 year in advance. Following the implementation of policies, the agency responsible (which in the case of renewables policy is the DEDE) monitors and evaluates the policies. Agencies obtain feedback by conducting focus group discussions and fine-tune policies every 3 to 5 years if needed.

The Thai authorities provide information to the public on renewable energy potential. Examples of databases include biomass, wind, solar energy potential, micro-sitting information and information on equipment suppliers (Sutabutr, Choosuk and Siriput, 2010). However, information on renewable energy programs and their environmental impacts is not readily available (Uddin, Taplin, and Yu, 2010).

A visit to the websites of key institutions such as the DEDE revealed that relevant information was not available or out of date. It must be noted, however, that this observation was true for the websites in English and this may not be true for information in Thai. Nevertheless, given the international nature of the renewable industry, the lack of a well-structured English-language interface might pose an impediment to the development of the Thai renewables sector.

(v) Alignment

There are several agencies that have a say with respect to renewable energy policy. The Ministry of Energy is in charge of energy activities in general but shares responsibility with other bodies as follows:

- the National Energy Policy Council (NEPC), a cabinet-level agency prepares guidelines for the implementation of the energy program, while its executing body, the Energy Policy and Planning Office (EPPO), recommends economy-wide energy policies and planning.
- the Department of Alternative Energy Development and Efficiency (DEDE) promotes the efficient use of energy, monitors energy conservation activities, explores alternative energy sources, and disseminates energy-related technologies.
- the Department of Energy Business (DEB) regulates energy quality and safety standards, the environment and energy security, and improves standards to protect consumers' interests.
- the Department of Mineral Fuels (DMF) facilitates energy resource exploration and development.
- the Energy Regulatory Commission (ERC) is responsible for regulating the energy sector.

At present it is not clear whether there is effective coordination across these agencies as well as more broadly across government, NGOs, and multilateral agencies.²²⁷ Since energy planning is decentralized in Thailand, obtaining the necessary information from different agencies can be an issue. Furthermore, there

²²⁶ This information was gleaned from the interviews that we conducted with members of the Department of Alternative Energy Development and Efficiency, Thailand (19 Jan 2012) and with academics from the Joint Graduate School of Energy and Environment (20 Jan 2012).

²²⁷ See, for instance, REEEP (2010).

is often resistance to planning and implementing policies. This happens due to the different perspectives of each of the concerned organizations; even if they have the same end goal, they might not always agree on the processes to reach the target.²²⁸ For instance, while the DEDE was created in 2002 for the sole purpose of promoting renewable energy and energy efficiency, it is unclear how conflicts with other agencies may be resolved when they arise. Furthermore, the extent of overlapping work done by the organizations is unclear.²²⁹ Researchers such as Uddin et al. (2006) have noted that more concerted coordination would be required amongst concerned ministries and departments in monitoring and evaluating the progress of Thailand's renewables program.

²²⁸ This information was gleaned from interviews conducted with officials from the Department of Alternative Energy Development and Efficiency (DEDE), Ministry of Energy, Thailand (19 Jan 2012).

²²⁹ Personal Communication (19 Jan 2012), Prof Surapong Chirarattananon, Asian Institute of Technology, Thailand.

3.3.3 Concluding Remarks

The technical potential for solar energy is high in both Australia and Thailand. Australia has the highest average solar radiation per square meter of any continent, while half of Thailand's land area enjoys high levels of solar radiation. There is thus a scientific basis for policies supporting the development of solar PV in both economies.

Solar PV is, however, expensive relative to alternative sources of energy. The estimated cost of abatement of greenhouse gases from solar PV in Australia is approximately in the range of US \$430–1040 per tonne of CO₂e, while the abatement cost from solar PV in Thailand is US\$ 417 per tonne of CO₂e.

Given the high costs of solar PV, solar subsidies and feed-in-tariffs impose a significant price burden on consumers and are unlikely to be justified from a financial cost-benefit perspective in either economy, especially since there are cheaper alternative abatement options: in Australia, for instance, the average cost of abatement from renewable energy sources is in the range of US \$30–\$70 per tonne of CO₂e. Moreover, such schemes do not respond automatically to changing market conditions, meaning that they are modified and revised on a regular basis by the government in both economies. This has created an uncertain environment for investors in the industry.

Technology-neutral policies, which do not discriminate between different technologies, perform better from a cost-benefit perspective. For instance, the Renewable Energy Target adopted in Australia sets an overall target for electricity generation from renewables and allows the market to choose the cheapest mix of renewables to meet the target. Australia's carbon pricing regime goes still further, allowing the market to choose the measures (whether renewable energy or energy efficiency) that allow greenhouse gas abatement to be carried out at the lowest cost. The adoption of such technology-neutral policies is recommended for Thailand, though care should be taken to ensure that the policies adopted are not overlapping or duplicative. In Australia, for instance, the fact that the Renewable Energy Target and the carbon pricing regime duplicate each other is likely to raise the cost of abatement without adding measurably to the total level of abatement. The Renewable Energy Target should therefore be phased out once the carbon pricing regime is operational in Australia.

Australia's regulatory policies have contributed to significant growth in the solar PV industry, largely in on-grid residential scale systems. The evidence suggests that the benefits of small scale solar PV subsidies and feed-in tariffs (FiTs) have come at a high cost and government objectives in terms of greenhouse gas emission reductions and the development of the renewable energy sector could have been achieved at lower cost through broad market based instruments such as an economy wide carbon pricing scheme.

The subsidies provided by Thailand have encouraged rapid growth in Thai solar installations. However, the promotion of the industry has come at a large cost in terms of the tariff burden on consumers. Because of the high costs and concerns about the impact on electricity consumers, the Thai government has often changed the regulations and tariffs governing the industry. This has adversely impacted investor confidence. Furthermore, if the aim of promoting the industry was the reduction of emissions, the high cost of solar PV relative to other alternatives makes it a very expensive option in Thailand.

3.3.4 References

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