

國立政治大學亞太研究英語碩士學位學程  
International Master's Program in Asia-Pacific Studies  
College of Social Sciences  
National Chengchi University

碩士論文  
Master's Thesis

Taiwan's Residential Solar Photovoltaic (PV) Market:  
Barriers, Solutions and Developmental Prospects

Student: Karl Wendell Haby  
Advisor: Lin, Tze-luen

中華民國 100 年 6 月  
6/2011

台灣的住戶太陽能市場: 障礙, 解決辦法與發展遠景  
Taiwan's Residential Solar Photovoltaic (PV) Market:  
Barriers, Solutions and Developmental Prospects

研究: Karl Haby  
指導教授: 林子倫

國立政治大學

亞太研究英語碩士學位學程

碩士論文

A Thesis

Submitted to the International Master's Program in Asia-Pacific  
Studies

National Chengchi University

In partial fulfillment of the Requirement

For the degree of Master in Asia-Pacific Studies

中華民國 100 年 6 月  
6/2011

## Abstract

The motivation for this research stems from an obvious contradiction in Taiwan's approach to renewable energy – that while Taiwan remains a leading manufacturer of solar photovoltaics (PV) technology, and has adopted a feed-in-tariff (FIT) to promote solar PV and other renewable energies, market uptake (and completion of new projects) has so far been slow.

In order to understand why, this thesis adopts two broad-based perspectives first identified by the International Energy Agency (IEA): (i) the Market Barriers Perspective provides a concise summary of the economics of domestic solar PV installation in Taiwan, specifically for the small scale (residential) investor contemplating grid connection under the FIT scheme; (ii) the Market Transformation Perspective identifies those factors (or actors) contributing to inertia in the renewable energy market in Taiwan. A final section in this thesis is given over to describing practical steps and policy approaches which may help boost solar PV (and other renewable) capacity in Taiwan.

The results of this research point to a complicated and time-consuming applications process, repeated changes to relevant legislation, and a FIT which is set too low, as the primary reasons for the limited success to date in developing Taiwan's small-scale (distributed) solar PV market. These difficulties are compounded by low electricity prices and a mutual dependency that has developed between the government, Taiwan Power, and large energy-intensive industries to avoid any upset to the status quo.

In order to address these problem areas this thesis recommends immediately revising the FIT upwards (to at least NT\$12.6 per kWh) in conjunction with the reinstatement of capital subsidies for small to medium investors. Removing administrative and procedural barriers is likewise deemed essential to fostering growth in the local solar PV market and establishing confidence in overall program. A Developmental Framework in the final section of this thesis describes some potential solutions to the more intractable problems slowing the diversification of Taiwan's energy supply.

## 摘要

雖然台灣在太陽能 PV 科技製造業上位居於領先位置，也採取了 FIT 來推廣太陽能 PV 及其他再生能源，但是市場的吸收（以及新計畫的完成）至今仍是進展緩慢；因此再生能源在台灣明顯且矛盾的狀況成了本論文的研究動機

爲了解理解爲什麼有這種狀況，本論文採用了兩個廣泛的觀點：

（一）市場障礙觀點：這個觀點提供了一個簡明的總結；在經濟學上國內太陽能 PV 的安裝，特別是家用投資者在 FIT 計劃下考慮電網連接。

（二）市場轉型觀點：這個觀點確定了影響並降低台灣再生能源市場的因素或是參與者（政府機關或其他相關團體的人員）。

本論文最後一個章節中提出了可能有助於提高台灣太陽能 PV 或是其他再生能源的接受度的實用步驟及政策措施。

本研究結果指向複雜且費時的申請手續，反覆修改的相關法令，及設定太低的 FIT 爲至今台灣太陽能 PV 市場開發成功有限的主要原因。低電價、政府與台電間所發展出的相互依賴狀況以及極力避免破壞現況的密集產業爲造成這些狀況的難題。

爲了解解決這些缺陷，本論文建議立即將 FIT 上修（至少每千瓦新台幣 12.6 元）並恢復補貼中小型投資者的資本。消除行政與程序上的障礙是促進在地太陽能 PV 市場和建立信心的整體方案上非常重要的一環。論文中的最後一章節提到一個發展框架，並且描述了一些針對於更棘手並減緩台灣的多元化能源供應問題的可能解決方案。

## Acknowledgements

The author first wishes to acknowledge the support and assistance of his close friends and family in the compilation of this thesis. Special thanks to Joy Lin, without whose help and patience this project would have been so much harder to complete. Whenever there was an issue finding or making sense of Chinese-language material, Joy was more than willing and able to assist. Nothing was too much trouble. Thank-you.

Other mentions go to my friend and confidant Daniel Bowman, who could always be relied on for his upbeat support, a cup of coffee, and as a reliable sounding board whenever I ran into difficulties. Also to Frank Lamacchia, who helped stimulate my interest in environmental issues and renewable energy, and who was there with me for some amazing and fun times in Taiwan.

I also wish to acknowledge the help and guidance provided by my thesis adviser – Lin Tze-luen – whose energy and enthusiasm for environmental and social issues is a real inspiration. Finally, this thesis and my participation in the Asia-Pacific Studies program at NCCU would not have been possible without the kind support of Taiwan’s Ministry of Education and the Taiwanese taxpayer. For that support and the many memorable experiences I have had in Taiwan, I am, and will always be truly grateful.

# Contents

<b>1. Introductory Remarks &amp; General Aims</b>	<b>7</b>
<b>1.1. Market Barriers Perspective</b>	<b>9</b>
<b>1.2. Market Transformation Perspective</b>	<b>10</b>
<b>2. Renewable Energy Policy around the World</b>	<b>11</b>
<b>2.1. Feed-in-tariffs (FITs)</b>	<b>12</b>
<b>2.2. Renewable Portfolio Standards</b>	<b>15</b>
<b>2.3. Other incentives</b>	<b>17</b>
<b>3. Research Design</b>	<b>19</b>
<b>3.1. Research Structure &amp; Research Questions</b>	<b>20</b>
<b>3.2. Research Methodology</b>	<b>21</b>
<b>3.3. Research Design Limitations</b>	<b>22</b>
<b>4. Part I: Background &amp; Policy Frameworks</b>	<b>24</b>
<b>4.1. Energy Situation in Taiwan</b>	<b>24</b>
<b>4.2. Energy Policy &amp; Projects</b>	<b>28</b>
<b>4.2.1. Framework of Taiwan's Sustainable Energy Policy</b>	<b>28</b>
<b>4.2.2. Act Governing the Development of Renewable Energy</b>	<b>29</b>
<b>4.2.3. Future Directions</b>	<b>36</b>
<b>5. Part II: Market Barriers Perspective</b>	<b>39</b>
<b>5.1. The FIT</b>	<b>39</b>
<b>5.2. Features of Taiwan's Solar PV Market</b>	<b>41</b>
<b>5.3. Economics of Solar PV (Residential Applications) in Taiwan</b>	<b>42</b>
<b>5.4. Taiwan Compared</b>	<b>44</b>
<b>5.4.1. Countries Used for Comparison</b>	<b>44</b>
<b>5.4.2. Financial Support Measures</b>	<b>46</b>

<b>5.5. Lessons from Abroad</b>	<b>51</b>
<b>5.5.1. South Korea</b>	<b>51</b>
<b>5.5.2. Japan</b>	<b>53</b>
<b>5.5.3. Germany &amp; Italy</b>	<b>55</b>
<b>5.5.4. Additional Financial Strategies</b>	<b>55</b>
<b>6. Part III: Market Transformation Perspective</b>	<b>60</b>
<b>6.1 Systemic Barriers</b>	<b>60</b>
<b>6.1.1. Developmental Features &amp; Systemic Inertia</b>	<b>61</b>
<b>6.1.2. Challenges to the Status Quo</b>	<b>65</b>
<b>6.1.3. Zero Sum Game?</b>	<b>67</b>
<b>6.2 Transforming the Market</b>	<b>69</b>
<b>6.2.1. Developmental Framework</b>	<b>69</b>
<b>6.2.2. Implementing Change</b>	<b>75</b>
<b>7. Part IV: Interim Conclusions</b>	<b>78</b>
<b>7.1. Current Barriers &amp; Prospects</b>	<b>78</b>
<b>7.2. Key Recommendations</b>	<b>78</b>
<b>8. References</b>	<b>81</b>
<b>9. Appendices</b>	<b>85</b>
<b>9.1. Appendix A</b>	<b>85</b>
<b>9.2. Appendix B</b>	<b>86</b>
<b>9.3. Appendix C</b>	<b>87</b>

# 1. Introductory Remarks & General Aims

Taiwan remains a leading manufacturer of solar PV (photovoltaic) technology, having produced approximately 1,400 megawatts (MW) of PV cell capacity, or around 12% of the total global output in 2009 (International Energy Agency, 2010a). Paradoxically, however, Taiwan has very little in the way of installed solar PV capacity (approximately 9.5 MW) especially when compared to other leading manufacturers of solar PV cells and componentry - Germany, for example, as the second largest (behind China) producer of PV cells, had an installed capacity of 9,845MW at the end of 2009 (IEA, 2010a); Japan, in third place (and just ahead of Taiwan in terms of total PV cell production), had 2,627MW of installed capacity; South Korea, whose production figures were far less impressive (231MW) nevertheless eclipses Taiwan in terms of total installed PV (442MW).

So while it's disappointing that Taiwan has so far not been able to capitalize on its production capabilities and technical expertise to boost solar PV demand at home, this picture hopefully *should* begin to change soon, especially in light of the more recently promulgated energy policy framework mandating that 8% of total output comes from renewable sources by 2025<sup>1</sup>, a Renewable Energy Act signed into law in July 2009 designed to promote expansion of renewable energy applications in Taiwan, and a new Feed-in Tariff (FIT) regime which sees energy supply and utility companies (like the state-owned Taiwan Power Corporation) purchase the electricity generated by individual producers of renewable energy (householders and other privately-owned operators) at a premium and over a fixed term (20 years)<sup>2</sup>.

---

<sup>1</sup> Readers should refer to the Framework of Taiwan's Sustainable Energy Policy (2008) released by the Ministry of Economic Affairs (MOEA) and published in English. Additionally, the Science and Technology Advisory Group of the Executive Yuan met in 2007 and set a target of 8.45GW (14.9%) of total generating capacity to come from renewable sources by 2020 (Liou, 2010).

<sup>2</sup> Readers should refer to the Act Governing Development of Renewable Energy (再生能源發展條例) ratified in July 2009 (and amended once since then). The FIT is administered via this Act. Archival information and the latest updates can be obtained via the BOEs special information portal - <http://www.moeaboe.gov.tw/Policy/Renewable/news/SENewsList.aspx>

Without doubt these are positive first steps from the government, but developing a self-sustaining renewable energies sector where solar PV is at the forefront requires more than just ‘nice sounding’ policies and some additional funding. It requires genuine commitment and timely action from all government agencies charged with implementing renewable energy policy,<sup>3</sup> consultation and cooperation between those agencies and the private sector (including industry and environmental groups), and of course, a well informed and empowered public willing to invest in new energy technologies because it makes financial and environmental sense to do so.

As just mentioned, real growth in the solar PV market has been slow despite a renewable energy roadmap<sup>4</sup> which set 75MW as the target amount to have been installed by 2010 – indeed, since the promulgation of the Act in 2009, the total amount of grid-connected solar PV capacity installed and potentially eligible to sell electricity under the FIT scheme stands at just 4MW.<sup>5</sup> What factors might help explain this slower than expected progress? Are the FIT and subsidy measures generous enough to stimulate private sector investment? Are there systemic issues that slow or prevent the roll-out of new energy technologies in Taiwan, and especially solar PV? Is it perhaps still too early for us to judge whether the FIT and other subsidies offered by the government have been successful or not?

We are thus lead to the purpose of this thesis, which is to explore those factors impacting on the development of a sustainable residential solar PV market in Taiwan over the short

---

<sup>3</sup> Major players in this area include the Ministry of Economic Affairs (MOEA) and its Bureau of Energy (BOE) primarily responsible for designing, implementing and reporting on energy policy, a special Pricing Committee (躉購費率審定會), established in accordance with the Act and convening annually to review the FIT and subsidy arrangements, and the state-owned Taiwan Power Corporation who approves and oversees grid-connections.

<sup>4</sup> These targets were agreed upon and published by Taiwan’s Executive Yuan, subsequent to a meeting on Promoting the Development of New Energy (行政院新能源發展推動會) in August last year. The ‘roadmap’ aims at bringing Taiwan’s total installed solar capacity up to 2,500MW by 2030. Based on the latest planned revisions to supporting legislation, however, the actual target can be revised at any time by the MOEA.

<sup>5</sup> As of 23 December 2010 when the MOEA released its (unpublished) report into the state of renewable energy developments in Taiwan – Renewable Energy Policy Directions, Decision Making and Implementation (再生能源之政策方向, 決策流程及執行情形).

to medium term – the residential (small scale) solar PV market is of particular interest to us in this study because this is (perhaps) where the greatest potential resides for the expansion of distributed grid-connected solar PV capacity,<sup>6</sup> as seen in the countries used for comparison in this thesis, namely Germany, Italy, and Japan.<sup>7</sup> In focusing on the residential PV market we adopt two unique but complementary developmental perspectives, both of which are necessary to our understanding of the potential barriers and also opportunities for growing Taiwan’s renewable energy sector, and solar PV in particular; these are the Market Barriers Perspective and the Market Transformation Perspective. It’s worth noting that in its (2003) report, the IEA identified an additional perspective – the Research, Development, and Deployment Perspective – which has been deliberately omitted in order to narrow the focus of our investigation.

### **1.1. Market Barriers Perspective**

The Market Barriers Perspective, which ‘characterizes the adoption of a new technology as a market process (and) focuses on decisions made by investors and consumers’ (IEA, 2003, pg. 18), is useful in identifying the scope and magnitude of the financial hurdles impeding capital outlays. Using this perspective we aim to;

1. Provide a concise summary of the economics of domestic solar PV installation in Taiwan, specifically for the small scale (household) investor contemplating a grid-connection under the government’s FIT scheme.
2. Compare the kinds of subsidy and support measures offered in Taiwan with countries (including close regional neighbors) where residential solar PV has been deployed successfully.

---

<sup>6</sup> Small scale (distributed) grid-connected solar PV capacity is the focus of this thesis and refers to solar installations typically found on the rooves of residential, commercial, industrial and other public facilities. These installations collect solar energy, converting it into electricity which is subsequently fed into the local power grid or network.

<sup>7</sup> At the end of 2009 cumulative installed PV power (MWp) grew to 2,627MW in Japan, 1,181MW in Italy, and 9,845MW in Germany (IEA, 2010a). The majority of this cumulative installed capacity was to be found in the distributed (rather than centralized) sector of the solar PV market.

3. Comment on the appropriateness of current policy and financial incentives aimed at expanding domestic solar PV capacity.

## 1.2. Market Transformation Perspective

The Market Transformation Perspective seeks to identify those factors (or actors) contributing to inertia in the renewable energy market in Taiwan; using this approach we try to explain some of the underlying reasons limiting the penetration and overall competitiveness of solar PV in the energy market place. In particular, we aim to;

1. Examine the linkages between various stakeholders – government, industry, electricity producers and consumers – in shaping energy policy and pricing.
2. Describe systemic barriers to the implementation of a successful renewable energy development strategy.
3. Make suggestions as to how best to stimulate demand for domestic solar PV in Taiwan.

At this point we must stress that these two perspectives are not in anyway formalized theories and therefore lack any predictive power. Where these two perspectives are able to help us, however, is in providing a general framework around which we can make observations, draw comparisons, and contextualize features of Taiwan's renewable energy developments. We should also note that these two perspectives are *not mutually exclusive* and often share points of overlap as well as points of difference – as such, readers will find elements of the other in the separate analyses conducted here. Before conducting any analysis, however, we must first take a look at features of renewable energy policy developments around the world with a brief review of the literature.

## 2. Renewable Energy Policy around the World

We begin this section – and brief appraisal of the literature – by making an observation that may at once seem obvious, but is nevertheless essential to understanding how renewable policy is formed and implemented in various countries around the world, including Taiwan.

That is, that the features of any one particular national energy policy framework tend to be shaped by a whole range of factors, including (but not limited to) prevailing economic, political, environmental and social conditions; a country that might seem particularly well suited to deploying wind energy, for example, might not ever realize this potential due to local political factors and (well founded or not) opposition from residents concerned about the negative impacts of the placement of wind turbines in their neighborhood. The opposite can also be true of course; a country that is not particularly well endowed in terms of solar irradiation potential, but still manages to achieve spectacular growth in its solar PV market (and renewable energy production figures) due to the right combination of economic incentives, effective administration and regulation, and a well informed and educated public.

A second related observation is that there are as many approaches to (renewable) energy policy as there are national governments implementing programs to encourage renewable energy deployment; according to the Renewable Energy Policy Networks' (REN 21, p.37, 2010) most recent report, by the end of 2009 there were at least 83 countries – 41 developed/transition countries and 42 developing countries – employing some type of policy (or combination of policies) to promote renewable power generation; these included such measures as feed-in-tariffs (FITs), renewable portfolio standards, capital subsidies or grants, investment tax credits, sales tax or value added tax (VAT) exemptions, green certificate trading, direct energy production payments or tax credits, net metering, direct public investment or financing, and public competitive bidding.

Given the sheer number and diversity of policy measures that exist for promoting renewable energy around the world, this section merely attempts to identify and describe *two* of the most influential and commonly adopted policy measures – in doing so we shall highlight their relative advantages, disadvantages, general efficiency and effectiveness.

## **2.1. Feed-in-tariffs (FITs)**

Beginning with the FIT which – according to the same REN 21 report cited above – is the most commonly deployed policy with at least 50 countries and 25 states/provinces adopting the FIT in some form or another; readers will appreciate that the widespread adoption (particularly in recent years) of FITs around the world is no accident, with a number of studies and reports identifying it as the most effective (and cheapest) policy tool for promoting a broad basket of renewable energy technologies within a relatively short period of time.

In the largest study of its kind, the International Energy Agency (IEA) in 2008 examined the effectiveness (market growth) and cost efficiency of renewable energy policies across 35 countries including members of the EU, the US, and the so-called BRICS nations (Brazil, Russia, India, China, and South Africa). One of the report's key findings was that between 2000 and 2005, the most successful countries in deploying wind power (relative to their realizable potential) were the EU-15 countries in Germany, Spain, Ireland and Denmark; of these four countries, all but one (Ireland) relied exclusively on the FIT to achieve growth in their local renewables sector.

Similarly, and with regard to the development of solar PV markets, strongest growth between 2002 and 2005 was observed in Luxembourg and Germany, followed by Japan, Switzerland, the Netherlands, Australia, Austria and the United States. In all of these countries – with the notable exceptions of Japan, Australia, and the US – this development was achieved through the implementation of fixed FITs which serve both to

guarantee a return on investment for new market entrants, whilst improving predictability in pricing for utilities and consumers (Mendonca, Jaconbs & Sovacool, 2010).<sup>8</sup>

Further support for use of FITs to boost renewable deployment is to be found in a research project funded by the German Federal Ministry for the Environment, Nature Conservation, and Nuclear Safety, which gave an appraisal of various support schemes and their relative expense in promoting wind energy in individual member states of the EU. The authors found that those countries relying on quota systems (to be discussed subsequently) as the main support system – Italy, the UK, and Belgium – had a high expected annuity of support (due to high certificate prices at the time) contributing to both increased costs for end-use electricity consumers and limited growth in wind energy capacity in their respective local markets (Ragwitz et al., 2006). Conversely, the report noted, those countries supporting wind energy (and other renewable options) via a FIT – Germany, Austria, Spain – were more effective at generally moderate levels of financial support, notwithstanding additional administrative barriers which can also impede market expansion.

A second report also released on behalf of the German Federal Ministry for the Environment, Nature Conservation, and Nuclear Safety (Durr Schmidt & van Mark, 2007), and which looked at the relative costs, benefits, and general developments associated with the Renewable Energy Sources Act (EEG), gives us some insight into why Germany has been so successful at expanding renewable capacity using a FIT. As the report explains, while total and differential costs of electricity procurement have been on the rise in Germany due to the FIT (€2.5 billion in 2004 to €3.3 billion in 2006), these additional costs are more than offset by a number of secondary effects that expanding renewable capacity has had on the system and economy as a whole. These additional benefits include a reduction in the total quantity of energy imports in 2006 totaling approximately €0.9 billion, a saving for the economy in the order of €3.4 billion due to the massive reduction in CO<sub>2</sub> emissions (45 millions tones) which would have otherwise

---

<sup>8</sup> We should point out that Japan, Australia, and the US have all since begun employing an FIT in combination with other measures to boost renewable capacity.

had to be accounted for, and an overall lowering in prices on the electricity market of between €3 and €5 billion due to the ‘merit order effect’, which acts to reduce spot prices for electricity during times of peak demand.

If we then compare the costs of the system attributable to FIT-related payments under the EEG (as well as incidental regulatory and transaction costs) with the savings just described, we find that the German economy in 2006 came out ahead by approximately €6 billion dollars. This remarkable figure doesn’t even take into account the additional value to the economy associated with a large (and continually growing) renewable energy sector – with an estimated 280,000 people in employment until 2008 – and an annual turnover of €30 billion dollars (Mendonca et al., 2010).

And while the German scheme is to be applauded for its effectiveness and relative (cost) efficiency, we should perhaps point out that a FIT scheme is not a one-size-fits-all policy. Simply instituting FITs without careful consideration of the type and technological maturity of the renewable resource to be developed, is likely to be ineffective in creating new generating capacity and investment. Mendonca et al. (2010), for example, describe a number of potential pitfalls or obstacles associated with the implementation of FIT schemes around the world; these include such issues as faulty tariff calculation methodologies leading to tariffs which are too high or too low and triggering over and under investment, poor financing and regulatory mechanisms which result in higher costs to the government and taxpayer and renewable capacity caps which artificially limit investment and drive market instability. Readers should keep these deficiencies in mind when we come to analyze in more detail Taiwan’s newly implemented (since 2009) FIT system.

At this point it must also be said that all of these policy failings and their flow-on effects are either completely or largely avoidable; that is to say, that there is nothing *inherently* problematic about the idea of using a FIT to develop national markets for renewables, only in the way FITs are designed and implemented by policy-makers. Indeed, when employed correctly FITs have a number of distinct advantages over other policies which

we may summarize as follows (Ragwitz et al., 2006): FITs act to drive down capital costs through rapid uptake of emerging energy technologies (economies of scale) and learning effects; FITs are able to promote a diversified portfolio of technologies and industrial sectors rather than just least cost options; FITs provide a predictable and secure investment environment which helps to minimize electricity costs and reduce large windfall profits for producers.

## **2.2. Renewable Portfolio Standards (RPS) and Tradable Certificates**

RPS, also called renewable obligations or quotas, like those employed by government's in the US, Europe, and elsewhere mandate that utilities source a specific amount of their electricity sales or generating capacity (within a certain time frame), from qualified renewable energy sources like wind, solar, biomass, hydro and geothermal power plants (Mendonca et al., 2010, p.150). In places like the UK, utilities are required to produce evidence of their compliance via Renewable Obligation Certificates,<sup>9</sup> which show that a specified amount of electricity has been produced (or sourced) from an eligible renewable source. Certificates (or credits) may be traded between participants in the scheme, introducing an additional degree of flexibility, while non-compliance is enforced via financial penalties equal to around £30 per MWh in the UK (in 2002 and subject to inflation) which can be used by government's to further incentivize investment in renewable energy projects (Carbon Trust, 2006).

But while quota systems – and the ‘tradable certificate’ systems used to support these schemes – appear to have some attractive features at first glance, there are a number of *inherent* drawbacks to their use which have been borne out by evidence in the literature.

As was described in the previous section, those countries in Europe employing FITs were able to achieve a far more rapid expansion of their renewable markets much more cheaply than was the case for countries using quota systems (Ragwitz et al., 2006)(CEC, 2008). One of the key reasons for this being that in contrast to a price-based instruments

---

<sup>9</sup> Each ROC is equivalent to 1MWh of electricity generated.

like the FIT, quota systems tend to result in price instability and higher costs for both developers and consumers. This is because quota systems relying on tradable certificates or credits are *always* going to be subject to market fluctuations – prices for tradable certificates and other manufacturing articles (like the steel needed to produce wind turbines) vary on the open market as a natural consequence of supply and demand, and the constraints imposed by capacity caps within a quota system framework (Mendonca et al., 2010). As a result of this uncertainty and added risk, developers and utilities requiring capital for new projects are inevitably charged more (via higher lending rates) for the money they borrow from banks or other credit sources. This premium on risk means that increased costs are not only transferred on to the consumer in the form of higher electricity bills, but that funds which might have been spent on additional renewable projects instead go to the servicing of loans.

Another inherent flaw in quota based schemes connected to the argument presented above, is that whereas FITs have the flexibility to promote a whole range of renewable energy technologies at different stages of their development concurrently, quota-based systems will tend to revert to the least-cost option; this is brought about as a direct result of producers and suppliers of renewable energy attempting to keep costs low through the use of more mature (cheaper) technologies – typically onshore wind capacity.

As Jacobsson et al. (2009) describe in their study, those EU countries employing quota or tradable certificate-based systems to meet national renewable energy targets, rely exclusively on one or two (least cost) options. Besides government's of Sweden, the UK, and Flanders all struggling to meet mandated renewable targets, overreliance on one or two renewable energy technologies in each of these countries has had other serious consequences, not the least of which include higher costs for end-use consumers (for reasons outlined before), and huge profit-taking by the largest the energy utilities, precluding participation of small-scale wind and solar operators in development plans and stifling innovation and diversification in energy portfolios. Such a strategy is in direct contrast to the experience of Germany, Spain and elsewhere, where the rapid expansion of renewable generating capacity (particularly solar PV) has been characterized by

ensuring easy and equitable grid-access for thousands of distributed applications through a FIT.

In summing up then, RPS and tradable certificate schemes have enjoyed some success at promoting renewable energy capacity around the world, but the positive features associated with their adoption – like clearly specified targets and flexibility for producers and electricity utilities in meeting their renewable quotas – tend to be outweighed by some fairly serious shortcomings. These include the instability inherent in the tradable certificates market, increased private sector risk and higher lending costs, an added burden on electricity consumers and taxpayers, over reliance on only the cheapest technologies, and administrative and compliance challenges.

Given these considerations, and based on current evidence, it appears that an appropriately designed and implemented FIT scheme remains the most effective and cost-efficient option for promoting large scale deployment of renewable energy options, regardless of the level of market maturity of those technologies. Taiwan is fortunate in that the national government, in addition to legislating (relatively ambitious) national renewable energy targets, has also adopted the use of FIT to boost renewable generating capacity. The results of these efforts shall be appraised in the following sections of this thesis, specifically with regard to how the FIT has impacted on (distributed) solar PV capacity.

### **2.3. Other Incentivization Methods**

Having now covered the two most influential and commonly deployed policies used to encourage large-scale investment in the renewables sector, let us now just quickly review some complementary incentivization measures, which will be referred to again later on in this thesis;

- Capital grants, subsidies, rebates: as of 2009, some type of direct capital investment subsidy, grant, or rebate was offered in approximately 45 countries

(REN 21, 2010). This type of targeted financial assistance offered by state and federal governments around the world, and in addition to larger incentivization schemes like a FIT, is designed primarily to lower investment barriers for new market entrants. This is particularly important for small-scale private and household investors who might otherwise not be able to gain access to (more expensive) renewable technologies like solar PV.

- Tax credits – sometimes classified as investment tax credits (ITCs) and production tax credits (PTCs) – are another commonly used tool to encourage investment in renewable energy projects. However, whereas capital grants, subsidies, and rebate schemes tend to lower initial investment hurdles for new market entrants, tax credits tend to accrue benefits for those who can already afford the upfront expense – typically larger companies and producers looking to offset costs. As such, poorly designed tax credit systems will tend to discriminate against small scale private and household investors, while reducing government tax revenues (Mendonca et al, 2010).
- Net Metering (also called ‘net billing’) is a widely-deployed and important policy for rooftop solar PV and other renewables, allowing owners of grid-connected renewable generating capacity to be credited for the electricity provided to the grid (REN 21, 2010). Net metering (unlike a FIT) however, does not allow a producer to derive any additional financial benefit from their renewable installation, with the utility simply crediting (rather than reimbursing) the producer for excess amounts (over an above their level of consumption) of electricity produced. As such, net metering is mostly ineffective in providing financial assistance to large renewable energy power plants (Mendonca et al., 2010).

### 3. Research Design

In order to address the aims outlined in the introductory section, this thesis is divided into four main parts: Parts I, II and III comprise four research questions, with Part IV an additional section where we synthesize our findings.

#### 3.1. Research Structure & Research Questions

##### Part I: Background & Policy Frameworks

###### Research Question One (RQ1):

- (i) Which factors might help explain existing patterns of energy supply and consumption in Taiwan?
- (ii) What are the implications of relevant<sup>10</sup> energy policies and capacity building projects for the expansion of renewable energies like solar PV?

##### Part II: Market Barriers Perspective

###### Research Question Two (RQ2):

- (i) Do the current subsidy and FIT measures provide adequate<sup>11</sup> financial support for private sector (household) investors in Taiwan?<sup>12</sup>

---

<sup>10</sup> There are of course many policies (economic, environmental, security etc.) with the potential to impact on the development of Taiwan's energy framework. We are concerned primarily, however, with the two pieces of legislation described in the introduction: the Framework of Taiwan's Sustainable Energy Policy (MOEA, 2008) and the Act Governing Development of Renewable Energy (MOEA, 2009).

<sup>11</sup> In coming to define 'adequate support' we identify here with the potential investor and whether or not the current FIT and other subsidy measures are enough to cover the initial outlay and provide for a modest return – see the Research Methodology for an operationalized definition.

### **Research Question Three (RQ3):**

- (i) How does Taiwan compare with selected Photovoltaic Power Systems Programme (PVPS) countries in terms of financial support measures – specifically the FIT and capital subsidies – and overall performance in the grid-connected (distributed) PV sector?
- (ii) What are some possible lessons or insights from those selected PVPS countries that Taiwan could utilize in growing its own domestic solar PV market? And what additional (financial) strategies or incentives should be considered to facilitate dissemination of domestic solar PV applications?

### **Part III: Market Transformation Perspective**

#### **Research Question Four (RQ4):**

- (i) What systemic factors might explain the relatively slow penetration of renewable alternatives, particularly solar PV, in the local energy market?
- (ii) And what should/could be done from a Market Transformation Perspective to enhance demand for solar PV and improve its competitiveness?

### **Part IV: Interim Conclusions**

No Research Question.

---

<sup>12</sup> This point is critical because without favorable returns, even those (less risk averse) investors knowledgeable about renewable energy and environmental issues will be discouraged from entering the market.

## 3.2. Research Methodology

### A Note on Sources

This thesis draws primarily on statistics sourced from government and non-government organizations. When examining Taiwan's energy framework in Part I, for example, we use the most recent statistics supplied by the Ministry of Economic Affairs' (MOEA) Bureau of Energy (BOE), which are readily accessible online from the statistics section of the Bureau's website. We also rely on government sources (e.g., policy documents and interim reports) to help us discern the direction of future developments in the renewable energies market.

In Part II, where we conduct an economic analysis as to the attractiveness of investing in solar PV in Taiwan, we again use the BOE's website to collect the most recent FIT and subsidy information – for those that read Chinese, this information is attainable via the specialized Act Governing Development of Renewable Energy portal outlined in a previous footnote. We complete the analysis in Part II by drawing on the information comprised in individual country reports submitted to the International Energy Agency's (IEA) Photovoltaic Power Systems Programme (PVPS). All calculations which are used to underpin the analysis in Part II are the author's own, as are any mistakes or oversights.

In Part III, where we analyze some of the more institutional or systemic barriers to the dissemination of solar PV in Taiwan, we rely primarily on secondary sources such as government and newspaper reports, press releases, and peer-reviewed journal articles; these sources are consulted in addition to raw statistical data in order to contextualize our findings and give an up-to-date picture of developments in renewable energy in Taiwan. Part IV is simply a synthesis of our findings from the first three sections, and as such, we don't introduce any new sources.

## **Operationalized Definitions**

In order to answer *RQ2(i)* - Do the current subsidy and FIT measures provide adequate financial support for private sector (household) investors? – we must first arrive at an agreeable definition for ‘adequate financial support.’

*Adequate financial support is, defined at a minimum, the amount of financial support that the government provides through the FIT, a capital subsidy, or a combination of both, that would allow a small scale (household) investor to recoup the costs of their original outlay before the expiration of an electricity purchasing contract (typically 20 years), and factoring in the present value of a future sum.*

While this figure of 20 years may not seem particularly attractive to a potential investor aiming for at least a modest return on their (not insignificant) outlay, we adopt it here as a (minimum) baseline for comparison. Anything exceeding 20 years is obviously going to be of limited value in attracting renewable energy investors (and particularly small scale solar PV investors) into the market.

### **3.3. Research Design Limitations**

This thesis attempts to use the most current information available when reporting on the state of Taiwan’s domestic solar PV market. This has posed a challenge due to a number of changes to the Act, important supporting legislation (e.g., proposed Draft Amendments for Renewable Energy Installations Approvals Process - 再生能源發電設備認定辦法修正草案總說明 – MOEA, 2011a), and FIT/subsidy arrangements, that have occurred during the course of the writing process. As the changes pertaining to the development of renewable energy in Taiwan are almost exclusively reported on and published in Chinese, I have attempted to translate their implications faithfully into English. Any errors arising from translation of this material are the author’s own.

In Part II we conduct our economic analysis as to the costs and benefits of solar PV and wherever possible we use data from primary sources (annual reports from individual countries reports or reliable second-hand sources like the IEA's PVPS. Some additional points to be aware of:

- Although figures related to the cost of installation of a solar PV system are the most recent available (2009 figures), they are likely higher than current (2011) prices due to the trend for solar PV technology to become cheaper over time. As a result, there may be a slight distortion in the economic analysis undertaken in Part II with regard to total capital cost and payback times – with the technology becoming cheaper, the total capital cost to an investor in 2011 will actually be lower than in 2009 and the payback times comparatively shorter (supposing FIT rates don't change drastically). This means our results may show higher capital costs and longer payback times than may necessarily be the case.
- The FIT figures quoted in this thesis are the most recent 2010 figures, except for Taiwan where the 2011 figures have become available. In some cases the FIT figures are lower in 2010 than they were in 2009 due to maturing markets, and individual governments allowing for the cost buy down effect – this may distort the results again in the same direction so that when using the reduced 2010 FIT (or 2011 rate in the case of Taiwan) rates to calculate the payback times and financial returns on a more expensive 2009 solar installation, we might see higher payback times and lower net gains than would otherwise be the case for a (cheaper) 2010-2011 solar PV installation.
- Difficulty calculating costs and FIT rates across different countries and currencies: With international money rates varying on a constant and daily basis, we convert directly from the 'foreign' currency to the NT dollar, with the date and on-line location of the conversion also specified where relevant.

## 4. Part I: Background & Policy Frameworks

### 4.1. Energy Situation in Taiwan

Over the last twenty years or so, Taiwan's energy supply figures have grown by roughly two and a half times, from nearly 53 million kiloliters of oil equivalent in 1989, to around 138 million kiloliters of oil equivalent in 2009 (see Figure 1 over page). Of this energy supply, 99.36% was imported (up from 95.4% in 1989), with Coal and Coal Products (30.45%), Crude Oil and Petroleum Products (51.82%), and Natural Gas (8.62%) forming the largest overall contributions (BOE, 2010).

In terms of total electricity generating capacity the trend has also been upwards; total installed capacity rose from 17,253MW in 1989 to around 47,985MW in 2009, with most of the recent growth being driven by LNG-fired power stations (30.77% of total capacity), but with coal-fired power stations also contributing significantly (37.35%). As has already been alluded to, renewable energies like Wind (0.78% or 376MW) and Solar PV (0.02% or 9.5MW) have not yet been developed or sufficiently exploited for them to make a larger contribution.

Similar trends are observable for total power generation with Taiwan producing 84,057GWh in 1989 growing to 229,593GWh in 2009 – Coal (53.35%), LNG (20.35%) and Nuclear (18.10%) are the largest contributors. Electricity from Hydro sources generated 7,053GWh (or 3.07%) with Wind (0.34%) and Solar PV (0.00) generating negligible amounts of electricity. Interestingly, total power generation has levelled off over the last five years, possibly reflecting slowed Per Capita Real GDP growth (due to the associated impacts of the Global Financial Crisis) and/or declining figures for Energy Intensity<sup>13</sup> (BOE, 2010).

---

<sup>13</sup> Energy Intensity is a measure of the energy efficiency of a nation's economy and is calculated as units of energy per unit of GDP. More efficient use of energy (in the absence of fluctuations in other contributing factors) will lower Energy Intensity, while a less efficient conversion of energy into GDP will cause the opposite to be the case.

Figure 1: Structure of Taiwan's Energy Supply (1989-2009)

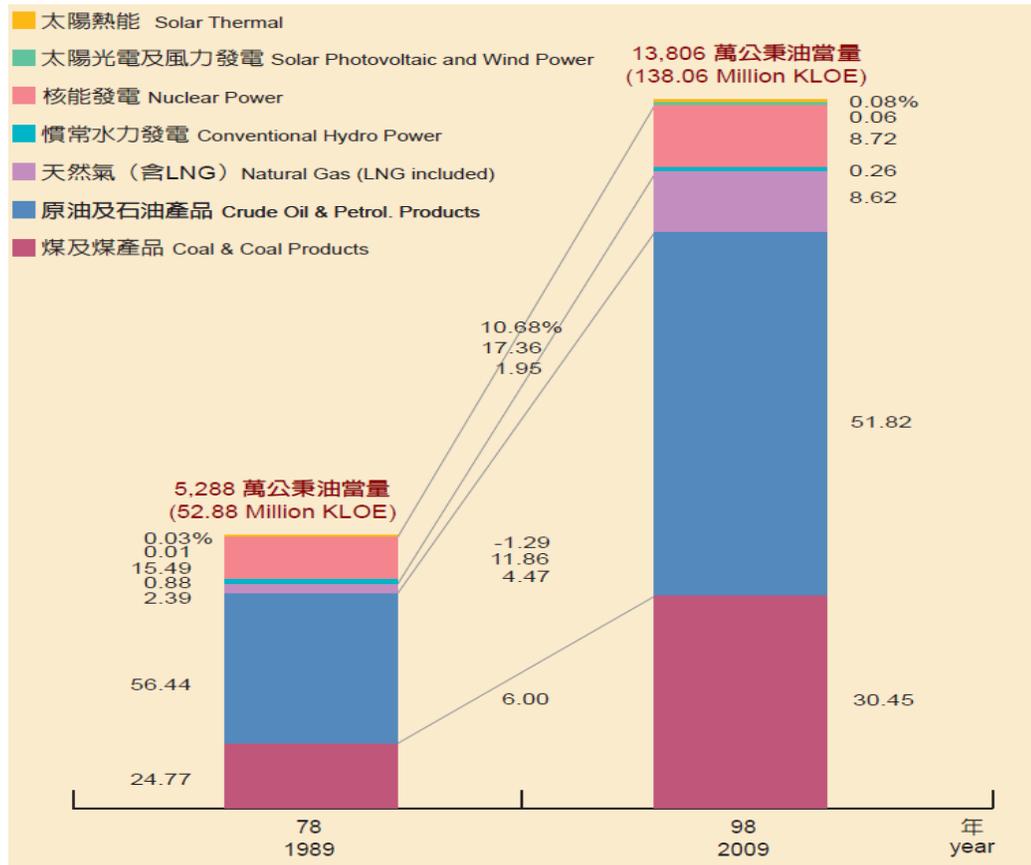


Figure from BOE's Energy Statistical Handbook (2010, p.25)

Unsurprisingly, rising energy demands (both in terms of installed capacity and total power generation) over the years have coincided with a fairly rapid rise in CO<sub>2</sub> emissions – Taiwan's emissions were estimated at about 116 million tonnes in 1990 but had grown to just over 268 million tonnes by 2008 (IEA, 2010).<sup>14</sup> This represents an increase of over 132% in CO<sub>2</sub> emissions over the last 18 years for which data is available, and counts among one of the highest growth rates in industrialised Asia.

Historically speaking, the continued upward trending of Taiwan's energy import and supply needs, concomitant rise in CO<sub>2</sub> emissions, and the relatively small contribution

<sup>14</sup> International Energy Agency (IEA) 2010b, CO<sub>2</sub> emissions from fuel combustion. CO<sub>2</sub> emissions data as per the Reference Approach. The Reference Approach is a theoretical value obtained from a country's energy supply data and represents an upper-bound to the amount of CO<sub>2</sub> produced during conversion.

from renewable energies like Solar PV and Wind, can be explained by several interconnected developmental factors;

1. Taiwan's geographical position, small size, and lack of exploitable natural resources make it heavily reliant on other nations and already proven low-cost energy technologies (e.g., coal, oil and natural gas) for energy supply and security (BOE, 2010).
2. Taiwan continues to utilize comparatively cheap (but carbon intensive) fossil fuel imports to depress operating costs for its large-scale industries<sup>15</sup> and transport sector, and to satisfy domestic consumers' demand for low-cost energy.<sup>1617</sup> And while electricity prices in Taiwan have risen slowly over the last five years, they are still some of the lowest in the world (equivalent to Mexico's) at NT\$2.9 per KWh for 'light' users, and NT\$2.46 per KWh for industrial purposes (BOE, 2010). Under these conditions, and without key externalities (like costs associated with the deleterious effects of greenhouse gas emissions) factored in to the price of energy in Taiwan, more expensive (renewable) alternatives will continue to find it hard to gain a foothold in the market. Reducing electricity consumption through behavioural change (at the individual and organizational level) will also prove similarly difficult to achieve.
3. The relatively slow implementation of comprehensive policy and financial support (when compared to countries like Japan or Germany, for example) mean that a larger, self-sustaining renewable energies market is yet to develop in

---

<sup>15</sup> Energy and Industrial sectors accounted for 59.7% of all energy consumption in 2009, with Transport (13.16%), Services (11.48%) and Residential (11.64%) sectors also consuming significant resources (BOE, 2010).

<sup>16</sup> BOE (2010) report: since 1989, the average cost of electricity has risen by only NT\$0.49 (US\$0.015) per KWh.

<sup>17</sup> Wang (2009) reports that the day after the Cabinet's Tax Reform Committee announced a plan to levy new energy and carbon taxes commencing in 2011, the Premier Wu Den-yi cited negative public sentiment and the struggling economy as reasons for delaying the plan indefinitely.

Taiwan. With the exception of electricity derived from Hydro sources, renewable alternatives like Solar and Wind are still seemingly a long way off occupying a significant place in the market. As previously reported, since the passage of the Act Governing Development of Renewable Energy in mid-2009, total installed grid-capable solar PV capacity eligible for the FIT was just 4MW. According to one source,<sup>18</sup> the real figure is probably closer to zero (0MW) due to delays in approval and certification on completed projects, and constant changes to the way the program is being administered.<sup>19</sup> We shall revisit this in more detail in a subsequent section.

In summing up this section, and on the positive side, we see that Total Energy Supply (134,839 – 138,057 million KLOE), Total Domestic Consumption (108,768 – 113,085 million KLOE), Total Power Generation (218,396 – 229,693Gwh), Per Capita Electricity Consumption (9,297 – 9,609KWh) and Total CO<sub>2</sub> Emissions (270 – 268 million tonnes of CO<sub>2</sub>) have all demonstrated slowed or negative growth over the latest five year reporting period (2004 – 2008/9). Less positive for the overall diversity and sustainability of Taiwan's energy supply, however, is that Taiwan still remains heavily dependent on carbon-intensive electricity generation and foreign energy imports, sells its electricity too cheaply to energy-intensive export industries, and has so far made very slow progress towards transforming its energy system.

---

<sup>18</sup> Lai Zeng Hua (賴增華) from the Solar Power Generation System Association (中華民國太陽光電發電系統商業同業公會) asserted in an interview with the author on 18 January 2011 that no solar PV projects have received final approval to begin selling electricity via government purchase arrangements. Although this claim has not been verified independently there have been a number of similar media reports.

<sup>19</sup> The MOEA on the 26 January 2011 proposed sweeping changes to the Renewable Energy Installations Approvals Process (再生能源發電設備認定辦法) – the most significant changes mean that the MOEA may at anytime refuse to process new applications or register new projects, that Taipower will become gate-keeper for all new applications, as well as stricter timelines with regard to the completion, connection and registration of new solar projects.

## 4.2. Energy Policy and Projects

### 4.2.1. The Framework of Taiwan's Sustainable Energy Policy (2008)

We begin our discussion in this section with a more in-depth look at the relevant legislation only briefly mentioned in the introduction. The Framework of Taiwan's Sustainable Energy Policy,<sup>20</sup> promulgated in 2008, identifies several priority areas to be pursued by the government; these include the development of Cleaner Energy Supply, the Rationalization of Energy Demand, and working towards a Comprehensive Regulatory Framework to support cleaner energy (low or no carbon) alternatives and reduced emissions.

With particular relevance to *RQI*, the Cleaner Energy Supply section of the Framework includes several concrete goals; chief among them, that 8% of Taiwan's total electricity output is to be derived from renewable sources by 2025 (this is in addition to a target advanced in 2007 which mandates 15% of total capacity to be derived from renewable sources by 2020); that nationwide CO<sub>2</sub> emissions are to return to 2008 levels between 2016 and 2020, and further reduced to 2000 levels by 2025; and finally, that energy efficiency is to improve across all sectors so that when compared with 2005 levels, overall energy intensity is reduced 20% by 2015, and 50% by 2025.

Whether or not these goals are sufficiently ambitious is certainly open to debate, and would require an additional level of analysis to explore fully, suffice it to say that the means by which the government intends to realize *these particular set of targets* are referenced in the Comprehensive Regulatory Framework portion of the document. The most important of these instruments (certainly from the perspective of developing a

---

<sup>20</sup> The strategies and goals outlined in the Framework can be viewed as an extension of the decision making undertaken at Taiwan's 2<sup>nd</sup> National Energy Conference in 2005 (which included conservative targets for renewable energy production and support for legislative efforts to hasten passage of the Act), and the 2007 meeting of the government's Strategic Review Board (under the auspices of the Science and Technology Advisory Group of the Executive Yuan) which discussed similar goals for Taiwan's total renewable energy capacity.

domestic solar PV market) is the Act Governing Development of Renewable Energy (再生能源發展條例) signed into law on 8 July 2009.

#### **4.2.2. The Act Governing Development of Renewable Energy (2009)**

This landmark piece of legislation finally establishes and formalizes the role of generators of renewable energy as (at least notionally) equal participants (and potential competitors) in Taiwan's electricity supply network. In addition to setting specific targets with regard to total renewable energy capacity to be installed and over what time period,<sup>21</sup> the Act and its supporting legislation provide specific guidelines, procedures, and incentives (like the FIT and capital subsidies) to allow producers of renewable energy (wind, solar, hydro, biomass etc.) to enter the market and supply and sell energy to Taiwan's grid.

Just as the importance of the Act for the development and growth of a renewable energy sector can't be overstated, however, neither can the consequences of getting it wrong. We now turn our attention to understanding the development, current health, and functioning of the Act, as it applies to the growth of a domestic solar PV market. As has already been mentioned, since the passage of the Act only 4MW<sup>22</sup> of solar PV capacity has been successfully installed.<sup>23</sup> What might explain this slow roll-out of solar PV? In the first instance, and somewhat benignly, is the slow formulation and release of key details which would actually allow the legislation to function; around six months elapsed between the passage of the Act in July 2009 and the publication of the FIT Formula and

---

<sup>21</sup> Article Six of the Act (第六條) sets a target of between 6,500MW-10,000MW of renewable energy capacity to be installed within 20 years of it first taking affect (8/7/09). The MOEA, in its Renewable Energy Policy Directions, Decision Making and Implementation (再生能源之政策方向, 決策流程及執行情形) report (unpublished), sets a specific target of 2,500MW of solar PV capacity to be available by 2030 with total renewable energy capacity expected to reach 10,858MW (slightly higher than the figure that appears in the Act).

<sup>22</sup> By the end of 2010 total cumulative installed solar PV capacity was supposed to have reached 75MW (64MW was anticipated to have been added in 2010).

<sup>23</sup> In order to reach full compliance, and begin selling electricity under the FIT scheme, a completed solar PV installation must first be tested, certified, and then registered by the BOE.

applicable rates on January 25, 2010; it took over nine months to complete and publish relevant sub-rules (再生能源發展條例子法) in support of the legislation on April 30. And while it's difficult to criticize the MOEA for exercising due diligence in this matter, these processes should (and probably could) have been expedited to capitalize on momentum generated by passage of the Act, and subsequent demand for renewable energy as evidenced by the number of new applications the BOE received<sup>24</sup>.

### **Recent Developments: Negotiating the (New) Applications Process**

An additional, and largely avoidable, reason for the slow progress is the complicated and time-inefficient nature of the administrative and applications process, a process that has been further complicated by the major changes proposed to key parts of relevant legislation (e.g., the Draft Amendments to the Renewable Energy Installations Approval Process - 再生能源發電設備認定辦法修正草案總說明) – MOEA, 2011a). Figure 2 (over page) attempts to illustrate the various steps involved with securing approval for a new solar PV project.

Prior to the proposed amendments, initial approval was to be sought from the BOE, with Taipower subsequently needing to verify the project before work could begin: should the changes become law, however, the responsibility for vetting new projects will reside with Taipower, with applicants first needing to satisfactorily meet the requirements set forth in the Application for Connection Check (申請併聯審查) process.<sup>25</sup> Applicants who under the old system had had their new projects approved by the BOE, or approved but not

---

<sup>24</sup> Between 8 July 2009 and 23 December 2010, the BOE had received applications for 1,565 solar PV projects (216MW) and approved 1,029 (151MW) of them. Of those 1,029 cases, however, only 406 (74MW) passed inspection by Taiwan Power.

<sup>25</sup> According to Article Six (第六條) of the Draft Amendments for Renewable Energy Installations Approval Process (再生能源發電設備認定辦法修正草案總說明), applicants must first obtain the Connection Check Recommendations (併聯審查意見書) from Taipower before being eligible to apply for similar approval from the BOE – Application to Approve Installation (申請同意備案).

signed a contract with Taipower, will be asked to begin the process again according to the new rules.<sup>26</sup>

Figure 2: New Administrative Procedures Based on the Draft Amendments to the Renewable Energy Installations Approval Process  
 再生能源發電設備認定辦法修正草案總說明



Notes: The above figure is a simplified representation of the actual application and approvals process for electricity procurement via the FIT, modified from the original – Taiwan Power Renewable Electricity Procurement Procedures (台電公司再生能源電能收購作業流程) – and available from the Taipower website (Taiwan Power Corporation, 2010).

<sup>26</sup> Readers should refer to the newly inserted Article Eighteen (第十八條) of the Draft changes.

Besides the confusion associated with these changes, an enhanced role for Taipower may also impede the approvals process and subsequent growth in the residential solar PV market; Taipower currently generates, supplies, and sells the majority of Taiwan's electricity. With the introduction of the Act and these new Draft measures, however, Taipower is now also charged with fostering the growth of a competing (and privately owned) renewable energies sector. It's conceivable that Taipower, finding it increasingly difficult to maintain its own bottom line,<sup>27</sup> will delay processing a higher proportion of new projects should they impact significantly on business operations.

In the last of the major changes, a newly inserted clause (Article Five – 第五條) in the Draft grants the BOE (and its overseeing body, the MOEA) the right to delay, or halt altogether any new renewable developments – no detail is provided as to what would happen to applications already in process – so that in addition to Taipower functioning as primary gatekeeper for all new applications, the BOE may (at anytime) also decide to apply the brakes.

### **Additional Obstacles: A Cap on Renewable Energy**

A final obstacle embedded in the Act itself, is the cap on renewable developments as described in Article Six (第六條). Article Six caps total renewable developments at between 6,500MW to 10,000MW of capacity within 20 years of operation of the Act,<sup>28</sup> with solar PV expected to account for approximately 2,500MW of that capacity. While these figures look impressive (10,000MW is around 20% of Taiwan's current total installed electricity generating capacity) on paper, they must be put into perspective.

---

<sup>27</sup> An expansion of solar PV (and other renewable energy applications) entails significantly more resources to be diverted to the processing of applications, carrying-out of inspections, and facilitation of grid-connections. Supposing renewables gain a significant foothold in Taiwan's energy market, Taipower's sales of electricity (generated from traditional sources) will also likely suffer.

<sup>28</sup> The final target is to be reviewed by the MOEA once renewable capacity reaches 5000MW.

In the last five years, Taiwan has added approximately 4,000MW of generating capacity mostly in the form of LNG-fired power stations (BOE, 2010). Were growth in generating capacity to continue at this rate, and supposing the government could actually reach its target of 10,000MW of renewable capacity, by 2030 Taiwan would see around 15% of its total electricity generating capacity supplied by renewable energy, but also a huge leap in the total amount of energy derived from non-renewable sources (from 42,321MW in 2009 to approximately 53,984MW by the end of the Act's operational period).

By enforcing a cap, the government is not only effectively limiting (prematurely and artificially) the extent to which a renewables market can grow in Taiwan, but also impacting (negatively) on the ability of Taiwan to reach its long-term emissions (a return to 2000 levels by 2025) and renewable energy targets (8% of total electricity output). This seems especially unfortunate, given that solar PV technology should become increasingly cost competitive after cost buy down and learning effects accumulate over time,<sup>29</sup> and the fact that Taiwan is also one of the world's largest manufacturers and exporters of solar PV technology.

As touched on in the literature review earlier, another potential consequence of enforcing a cap is the introduction of additional volatility into the local renewable energy market. Investors wishing to capitalize on government support for solar PV, for example, may rush to install new systems just prior to the cap being reached. As has been seen in other markets, most notably Spain, this disproportionate and rapid uptake may drive up costs for renewable support programs in the short term, and disrupt supply chains and sustainable growth in the longer term. This may, then, be one reason why the government has added Article Five to the Draft – as an emergency brake should renewable installations under the FIT scheme become too popular with investors.

---

<sup>29</sup> According to the IEA (2010a), the average price of grid-connected systems (although varying widely between PVPS member nations) was \$4.8 USD per Watt, more than 30% lower than the 2008 price.

## **Additional Obstacles: the FIT Schedule and Electricity Pricing**

Returning now to a key plank of the Act, and the mechanism by which renewable energy is theoretically able to compete with traditional forms of energy generation, the FIT. Part of the reason for delays in formalizing the FIT arrangements (and the slow pace of new installations) has been the difficulty in setting an appropriate (or attractive enough) FIT pricing schedule. This is evidenced by the number of hearings the BOE conducted in the lead up to the policy release - between the formation of the Pricing Committee on 1 September 2009 and the publication of the FIT formula and applicable rates on 25 January 2010, the Committee met five times and conducted two public hearings<sup>30</sup>. And despite what has seemed like extensive consultation and deliberation from the government, there has been no shortage of confusion and policy on the run.

As reported on earlier, the government on 17 December 2010 suddenly announced that solar PV applicants that had signed a contract with Taipower for electricity procurement, but not able to complete work on projects before 31 December would no longer be eligible for the (higher) 2010 FIT rate and subsidy program (equivalent to NT\$50,000 per KWp of installed capacity). Having signed a contract in good faith with Taipower for 2010 rates, new investors would it seemed be forced to accept 2011 rates.

That was the case until the Pricing Committee (perhaps responding to criticism from solar industry groups and members of the public) on 31 January of this year, released the new FIT guidelines and pricing schedule. As it stands now, applicants who had signed a contract before 17 December 2010 and completing construction before 28 February 2011 *are* eligible for the 2010 rates. Applicants who had signed a contract last year but completing construction between 28 February and 31 May of this year will instead receive the reduced 2011 FIT rate. Finally, applicants that had signed a contract last year

---

<sup>30</sup> The debate between government and renewable energy generators remains ongoing, however; the Taipei Times reported in February last year, for example, that German firm Infravest (英華威集團), Taiwan's only private wind generator would cease operations citing 'a lack of confidence' in the government's renewable energy strategy and uncompetitive FIT rates for wind energy (Tan, 2010).

but who complete construction after 31 May will have to ‘bid’ (details are unclear) on their respective FIT arrangements.

These problems are relatively superficial, however, compared with the difficulty that the government faces in balancing the interests of industry (and other large consumers of electricity) on the one hand, and the growth of a renewable energy sector (as mandated in the Framework and the Act) on the other. Put quite simply, the cost of electricity in Taiwan is much too low, putting downward pressure on the FIT (the cost of purchasing electricity from solar PV sources is already more than three times the current retail price of electricity and significantly higher again when compared with wholesale energy prices<sup>31</sup>) and attracting criticism from all sides; Taipower and industry would be concerned by what they see as changes to the status quo and a potential increase to their operating costs if forced to subsidize the FIT through higher electricity prices; renewable providers and private investors, meanwhile, will find it difficult to compete because the FIT offers only marginal returns whilst also carrying a substantial amount of risk should the government keep changing the goal posts on procurement policy.

And while this problem seems intractable – the result of Taiwan’s export oriented economy combined with a centralized (state dominated) approach to management of energy grid issues – we don’t *actually* know whether the current FIT rates are problematic or not, due to procedural problems associated with the application and approvals process as reported on earlier. That is, too few solar PV applicants have completed, registered, and finally sold electricity to the grid via the FIT for us to make an informed judgment about this. In the next stage of the analysis, however – The Market Barriers Perspective – we attempt to determine whether the current subsidy and FIT arrangements are sufficiently attractive (at least in theory) to attract new investment in solar PV.

---

<sup>31</sup> For a 1-10kW solar PV installation the government is offering a FIT rate of NT\$10.3185 per KWh (MOEA, 2011). The current retail price is approximately NT\$2.9 per KWh for residential users, and NT\$2.46 per KWh for industrial purposes (IEA, 2010c). Taiwan’s FIT rate, incidentally, is significantly lower than South Korea’s (NT\$15.7) who also has comparable retail rates for electricity.

### 4.2.3. Future Directions

Given the difficulty associated with negotiating revisions to the application and approvals process, and the new FIT arrangements, investors might reasonably ask ‘why bother’? Is the government actually serious about developing renewable energy in Taiwan, and solar PV in particular? Perhaps one explanation for the government’s slightly schizophrenic approach to things, besides the problems over electricity pricing, is that a much larger debate continues within government, industry, and academic circles as to what the make-up of Taiwan’s electricity network should look like in ten, twenty or thirty years from now.

This section does not attempt to provide any sure answers with regard to Taiwan’s future energy mix, suffice to say that some clues are provided in the state of ongoing capacity building projects in Taiwan. In 2009, nuclear energy accounted for 5,144MW (or 10.72%) of Taiwan’s generating capacity and 18.1% of total output (41,571Gwh) (BOE, 2010). And while the percentage of total electricity generated from nuclear sources has been shrinking (from 33% in 1989 to the current figure), this situation is likely to change again should construction on Taiwan’s controversial<sup>32</sup> Fourth Nuclear Power Plant finally reach completion, and plans to extend the lifespan of its current three nuclear power plants also be enacted (Huang et al., 2010).<sup>33</sup>

The importance of nuclear power to Taiwan’s overall energy framework has, similarly, been underlined in a number of major policy forums and documents where the direction of future energy supply was discussed; as reported on by Liou (2010), the conference summary of the 2<sup>nd</sup> National Energy Conference (2005) made *specific* mention of the importance of proceeding with Taiwan’s Fourth Nuclear Power Plant; the Framework (2007) urged a reconsideration of ‘nuclear power as *no-carbon* energy option’ in efforts

---

<sup>32</sup> Aside from the obvious environmental and security issues associated with long-term storage and management of nuclear waste, the Plant is reportedly situated in close proximity to several geographical fault lines (Loa, 2010). These safety concerns are in addition to cost blow-outs on the project in the order of NT\$100 billion – Taipei Times (2010).

<sup>33</sup> According to Huang et al. (2010), the government has plans to extend the operating life of these nuclear plants by 20 years, commencing in 2018.

to increase energy supply diversity; and at the 3<sup>rd</sup> National Energy Conference (2009), a degree of controversy surrounded the decision to allocate part of the renewable energies development budget to supporting nuclear power instead.

But while there has been no shortage of criticism aimed at the government over its commitment to the development of nuclear power, the enthusiasm with which Taiwan's successive administrations have proceeded is not particularly hard to understand.<sup>34</sup>

For Taiwan to meet the targets set out in policy documents and existing legislation like the Framework and the Act, it will need to not only enhance current energy conservation efforts but also expand quite significantly the percentage of 'low emissions' alternatives capable of producing base-load amounts of power in the system – in government parlance, 'low emissions' or 'low carbon energy' refers to nuclear, LNG, and other renewable energy alternatives. The nuclear 'solution', however, would appear to suit both the government who is looking for short to medium-term reductions in carbon emissions, and the state-owned Taipower which would retain control of a large portion of centralized generating capacity – a scenario unlikely to play out were distributed renewable energy applications expand to partially replace traditional (more carbon-intensive) forms of electricity generation.

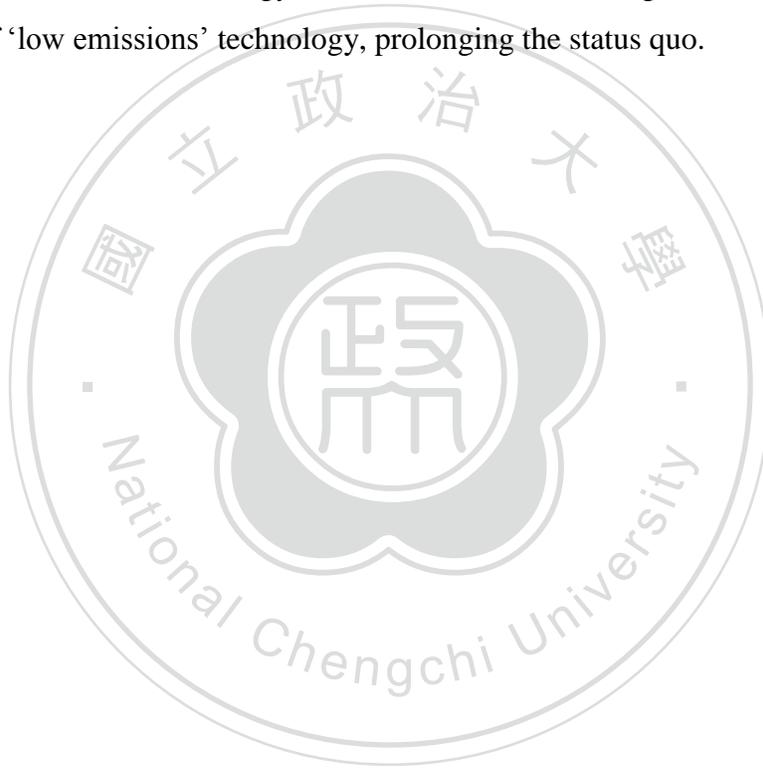
This preference of the Taiwanese government for developing the 'low emissions' suite of technologies and infrastructure is not restricted to nuclear generation: coal and oil-fired power stations, whilst still occupying a significant portion of the energy supply sector (approximately 47% of installed capacity and 57% of total output), have seen their relative importance diminish as LNG catches up – approximately 4,000MW of LNG-fired capacity was added in the last five years (2004-2009) with LNG now representing 31% of Taiwan's total generating capacity and 20% of its total output (BOE, 2010). This

---

<sup>34</sup> Just prior to the submission of this thesis, Japan experienced a potentially catastrophic situation at one of its nuclear plants, caused by a severe earthquake and tsunami in March of this year. This event has served to reinvigorate the debate about the future of nuclear power in Taiwan.

is a trend that will possibly continue given LNG's 'low emissions' credentials and the government's commitment to developing more capacity under the Framework<sup>35</sup>.

So, where do all these developments leave renewable energies like solar PV? On paper, recent legislative measures which facilitate the installation of renewable energy applications through a comprehensive applications process and FIT regime should help the solar PV market to expand. However, should the development of Taiwan's renewable energy sector and solar PV market become too (politically) painful or too expensive, commitment to renewable energy and the aforementioned targets will likely be deferred in favor of 'low emissions' technology, prolonging the status quo.



---

<sup>35</sup> The Framework sets as a goal, to 'increase the utilization of low carbon natural gas...so that it could account for more than 25% of power generated in 2025.' Its perhaps worth noting here, however, that this goal seems to sit at odds with the

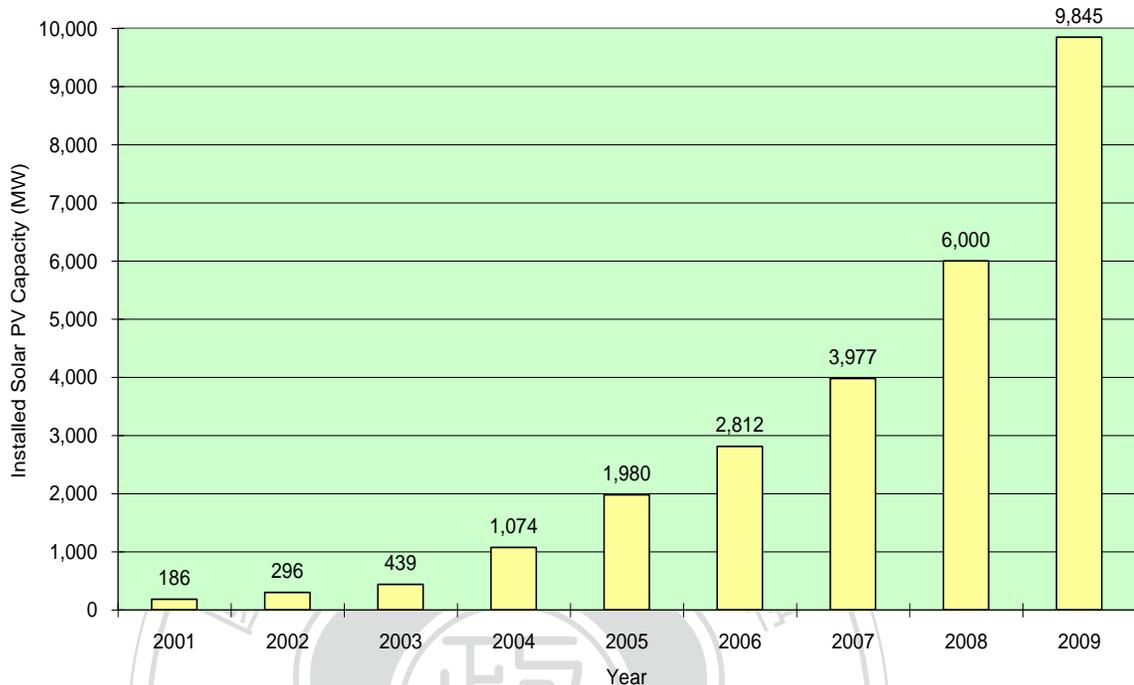
## 5. Part II: Market Barriers Perspective

### 5.1. The Feed-in-tariff (FIT)

We begin this section by quickly reviewing what the FIT actually is and how it operates to attract private investment in renewable energy alternatives like solar PV. Under a FIT regime, households with solar panels feeding electricity back into the grid are reimbursed by an energy utility (Taipower in this case) at a certain rate per KWh (kilowatt hour) of electricity produced. Via the FIT, a household investor may, over a certain period of time, recoup the costs of the initial installation and derive a modest return. It's only if the FIT (and any additional subsidies) are able to guarantee 'adequate support', that potential investors would likely consider entering the market and into an electricity procurement contract with an energy utility.

'Adequate' support, as defined in the Method section of this thesis, is '...the amount of financial support that the government provides through the FIT, a capital subsidy, or a combination of both, that would allow a small-scale (household) investor to recoup the costs of their original outlay before the expiration of an electricity purchasing contract (typically 20 years), and factoring in the present value of a future sum.' Because, while adequate financial support is by no means the only consideration in expanding renewable energy capacity, it is a *necessary pre-requisite*, as seen in countries demonstrating growth in their respective markets. Figure 3, for example, which maps recent developments in the Germany's domestic solar PV market, clearly demonstrates the responsiveness of this market to an *appropriately administered* FIT program.

Figure 3: The Affect of FITs on Solar PV Uptake in Germany (MWp)



The introduction of the Renewable Energy Sources Act and a new Feed-In-Tariff scheme in 2000, followed by subsequent amendments to the scheme in 2004 and 2009, contributed to a doubling in Germany's installed solar PV capacity between 2004 and 2005 (from 1,074MW to 1,980MW) with strong continuing despite (or perhaps because of) ongoing degression measures by the government<sup>36</sup>; in 2009 alone, for example, nearly 4,000MW of capacity was installed which represented a 39% increase on the previous year (IEA, 2010a). We should also note here that Germany's success is far from unique, with domestic PV markets in South Korea and Italy also growing rapidly in recent years following the introduction of competitive FIT rates.<sup>37</sup>

<sup>36</sup> As domestic markets mature and installation costs reduce, governments employing the FIT to stimulate demand will begin to revise the FIT downwards.

<sup>37</sup> Korea installed approximately 84MW of solar PV capacity in 2009 (19% growth) to bring total capacity to 442MW. Italy was even more impressive, adding 723MW in 2009 (161% growth) to bring total capacity to 1,181MW. In all cases, Germany, South Korea, and Italy, over 99% of their respective installed solar PV capacity is grid-connected and eligible for the FIT.

## 5.2. Features of Taiwan's Solar PV Market

As reported previously, and according to the latest figures, Taiwan currently has approximately 9.5MW of installed capacity, producing 8GWh of electricity annually (BOE, 2010) – the real figures should be higher given that (i) there is likely to have been additional (non grid-connected) capacity installed on the roofs of Taiwan's public buildings and private residences since the previous reporting period and (ii) since the Act began operating in mid-2009, we can verify that the BOE and Taipower together have overseen the installation of approximately 4MW of *grid-capable* solar PV capacity. Other features of Taiwan's solar PV market worth highlighting include:

- Installed capacity (1): While we know that Taiwan currently has approximately 4MW of *grid-capable* (installed and tested) capacity there is no information as to how much of that has met with final approval (refer to Figure 2 for complete approvals process). i.e., we don't know how much electricity has to date been sold via the FIT arrangements since the Act came into operation.
- Installed capacity (2): It's unclear at this stage what proportion of this grid-capable capacity is centralized (which means typically larger ground-based installations) and what proportion is distributed (rooftop-mounted systems) – again, without this information it's difficult to get a more complete picture about who is investing in Taiwan's solar PV market and why.
- The current FIT rate: The Pricing Committee earlier this year set the FIT rate at NT\$10.3185 per KWh of electricity produced from roof-mounted (1-10KWp) solar PV systems (BOE, 2011). This new rate is a substantial reduction on the NT\$11.1883 offered last year (2010), and is meant to reflect lower installation costs in Taiwan.
- Subsidies and other measures: Those household investors eligible to receive the 2010 rate are also able to receive an additional capital outlay subsidy (for set-up

costs) in the order of NT\$50,000 per KWp installed (available only for systems less than 10KWp). The Pricing Committee this year, however, has decided to stop providing this subsidy and has yet to nominate a replacement subsidy or loans scheme.

- **Contracts:** Contracts signed with Taipower are valid for 20 years as per most countries employing the FIT to develop domestic renewable markets. In practical terms, Taipower is obliged to buy power from the signatory at the FIT rate specified when the contract was signed.
- **Metering:** Net-metering options are excluded from the current FIT scheme.

### **5.3. Economics of Solar PV (Residential Applications) in Taiwan**

The figures in this section represent ballpark estimates as to the overall cost, payback times, and net benefits (where applicable) for household investors installing a solar PV system under current (2011) FIT and subsidy arrangements. We should note that these estimations are based on real-world<sup>38</sup> data and don't necessarily conform to the same set of assumptions regarding operating efficiencies of PV cells and market discount rates, the Pricing Committee uses when calculating FIT rates and expected payback times via the formula (see Appendix B). Readers should also be aware that we compare data for solar PV installations of varying sizes (1KWp, 3KWp and 5KWp), so as to understand how the performance of the FIT differs under these conditions.

With reference to *RQ2*, and based on the economic analysis undertaken here, it appears that the FIT rate (currently set at NT\$10.3185 per KWh) is *not* sufficient to guarantee 'adequate' support for a household investor who decides to install a roof-mounted solar PV system of any size in Taiwan. Let us now demonstrate why this is the case.

---

<sup>38</sup> This includes calculating the actual (not stated) operating efficiencies of solar PV cells in Taiwan based on figures for installed capacity and electricity output (see Appendix A).

According to the latest figures, it costs approximately NT\$151,000 to buy and install 1KWp of solar PV capacity.<sup>39</sup> In Taiwan, and over an entire year, 1KWp of solar PV capacity can be expected to produce approximately 840.96KWh<sup>40</sup> of electricity.

If we then apply the current FIT rate of \$NT10.3185 per KWh and factor in a discount rate of 3.59%<sup>41</sup> we get a total (gross) return in the order of NT\$123,695.87 at the end of 20 years. If we then subtract the initial capital cost of NT\$151,000 for 1KWp of installed capacity from this figure, we find that the total net return for an investor is -NT\$27,304.13. A negative return (i.e., no return inside the 20 year lifetime of the purchasing contract) is obviously of questionable value in attracting small-scale (household) investors into the market and falls outside our definition of ‘adequate’ support.

Table 1: Economics of Domestic Solar PV for Systems of Different Sizes

System size	Capital cost (\$NTD)	Subsidy (\$NTD)	FIT (\$NTD)	Discount rate	Total Net (\$NTD)	Years 'til payback
<b>1KWp</b>	151,000	N/A	10.3185	3.59%	-27,304.13	N/A
<b>3KWp</b>	453,000	N/A	10.3185	3.59%	-81,912.39	N/A
<b>5KWp</b>	755,000	N/A	10.3185	3.59%	-136,520.65	N/A

<sup>39</sup> Taiwan’s MOEA in a press release explaining changes to the Act on 20 December 2010 released figures detailing average set-up costs. Last year, the average price was NT\$151,000 per KWp representing a 23.35% decrease on the year previous. We should note that this figure is slightly above the average (2009) cost of PV systems installed in IEA PVPS member countries (approximately NT\$138,000 per KW or US\$4.8p/W).

<sup>40</sup> Solar PV capacity operates at 9.6% efficiency in Taiwan. Average output in a year = 0.096KW (or KJ/sec) × 3600 seconds in an hour × 24 hours in a day × 365 days in a year = 3,027,456 KJ per year. 3,027,456 KJ per year ÷ 3600 seconds in an hour = 840.96KWh per year.

<sup>41</sup> Discount rate based on an average of the last five years (2006–2010) of base lending rate data for commercial banks in Taiwan:

<http://www.cbc.gov.tw/public/data/Ebanking/EINTEREST-N.pdf>

But what about in the case of larger 3KWp and 5KWp systems mentioned at the start of this analysis? Unsurprisingly, we find that the total net (negative) return increases in direct proportion to the size of the system. Table 1 (above) illustrates, for instance, that installing a 3KWp system will result in a negative return three times as large as the 1KWp system. What's immediately clear from the data therefore is that under no condition (1KW, 3KW, or 5KW) does the government provide 'adequate' support for small scale solar PV investors.

## 5.4. Taiwan Compared

### 5.4.1 Countries Used For Comparison

As alluded to previously, we compare Taiwan with four other (PVPS member) countries<sup>42</sup> – namely Korea, Japan, Germany, and Italy – to give context to our findings in previous sections. We aim here to provide some simple information and a brief explanation here as to the reasons for their selection.

- South Korea, a close Asian neighbour with a rapidly growing solar PV sector, is included for comparison because of some interesting features Taiwan and South Korea both share – both are export oriented economies which rely heavily on low electricity costs<sup>43</sup> to enhance the competitiveness of manufacturing and service industries. Despite this, or perhaps because of this, South Korea offers fairly generous FIT rates and capital subsidy measures to assist with initial solar PV set-up costs.

---

<sup>42</sup> Although Taiwan is not an IEA PVPS member nation, the IEA still regularly reports on developments in Taiwan's solar PV market.

<sup>43</sup> Electricity prices for South Korea's industrial sector in 2009 were approximately NT\$1.8 per KWh. Electricity for households was approximately NT\$2.6 per KWh (IEA, 2010c). Both rates are significantly lower than Taiwan's current retail rates for electricity.

Another feature of South Korea's solar PV market is that while the majority of installed capacity is grid-connected (99%), only 21% of that is actually distributed. The remaining 78% is centralized generating capacity,<sup>44</sup> which suggests that larger private and public entities (rather than individual householders) are driving growth in South Korea's market.

- Japan, another close Asian neighbour, already has a relatively mature solar PV market with over 2,627MW of capacity installed (IEA, 2010). Unlike South Korea's fairly new and developing market, however, most (96%) of Japan's grid-connected capacity resides in the distributed (residential) sector, giving us an interesting juxtaposition between the two countries' approaches. Japan also remains a worthy case study due to its demonstrable commitment to ongoing investment a renewables program,<sup>45</sup> despite what has been seen domestically and abroad as fairly stagnant economic growth in recent years.
- Germany is included in this analysis largely because it is viewed by most as the 'gold standard' in terms of renewable energy developments. Germany currently has a total solar PV generating capacity in the order of 10,000MW, 99.54% of which is in grid-connected form. And while the market seems fairly mature in Germany, the government nevertheless continues to offer competitive FIT rates (via the Renewable Energy Sources Act or EEG), low interest loans, tax benefits, as well as new and loftier targets for renewable energy production.<sup>46</sup>

---

<sup>44</sup> Of the 84.4MW of solar PV capacity installed in South Korea in 2009, well over 50% was found in installations 100KW or larger (Yoon, 2010).

<sup>45</sup> The Act on the Promotion of the Use of Non-fossil Energy Sources and Effective Use of Fossil Energy Source Materials by Energy Suppliers obliges electric utilities to purchase surplus PV power at double the price of conventional electricity (Yamamoto, 2010). Japan's government also has increased the target of installed solar PV capacity from 14GW by 2020, to 28GW.

<sup>46</sup> As of 2009, renewable energies accounted for 16.1% of domestic electricity production, surpassing the initial target of 12.5% by 2010. The target of 20% share of electricity production by 2020 has now been revised upwards to 30% (Wissig, 2010).

- Italy, finally, is included due to its standout performance in 2009; while nowhere near as large as Germany’s overall growth figures, Italy still installed over 700MW of solar PV capacity (a 161% expansion of the market) with a relatively even split in total installed capacity between centralized (43%) and distributed (56%) sectors (Castello et al., 2010).

#### 5.4.2. Taiwan Compared: Financial Support Measures

Returning now to *RQ3(i)*, we find that Taiwan not only offers the lowest FIT rate (NT\$10.3185) of all the countries used for comparison, but as of this year has also eliminated capital subsidies for new solar PV projects (see Table 2 below). This is unfortunate given that the continuation of the NT\$50,000 per KWp installed capacity would have offset changes to the FIT and allowed for a payback period inside 20 years.

Table 2: Taiwan and Selected PVPS Countries Compared

	Taiwan	South Korea	Japan	Germany	Italy
<b>Capital Subsidy (2010)</b>	N/A (2011)	60% capital costs	NT\$25,400 p/KW	N/A	N/A
<b>FIT (2010) per kWh</b>	NT\$10.3185	NT\$15.7	NT\$16.8	NT\$13.03	NT\$18.62
<b>Installed unit prices (2009) per KWp</b>	NT\$151,000	NT\$151,430	NT\$214,460	NT\$171,000	NT\$197,980
<b>Total PV (end of 2009)</b>	9.5MW	441.9MW	2,627.2MW	9,845MW	1,181.3MW
<b>Off-grid</b>	X	1%	3.60%	0.46%	1%
<b>On-grid [c]</b>	X	78%	0.40%	X	43%
<b>On-grid [d]</b>	X	21%	96%	X	56%

Notes: South Korea - Installed price based on 3KW rooftop system. FIT contract = 15 years. Japan - Installed price based on 3-5KW residential system. Germany – FIT rate as of December 2010. The installed unit price is cheaper for larger (3-5KW) installations. Italy - FIT rate assumes 2% deggression over 2009 figure. An “X” in the Table indicates that data is not available. All conversions accurate on 10/2/2011 from <http://www.xe.com/ucc/>, XE Universal Currency Converter.

Of the other countries, we find that South Korea has the most generous capital subsidy arrangements in place, with the government covering 60% of the set-up costs of a residential installation, followed by Japan which offers the equivalent of NT\$25,400 per KWp of solar PV capacity installed (up to 10KWp). The other two, Germany and Italy, conversely, do not offer capital subsidies; this is due mainly to the fact that their respective FIT rates are still competitive relative to reported installation costs, and that installation costs have been declining steadily as evidenced by ongoing adjustments to the FIT in both Italy (a 2% reduction over 2009 rates) and Germany (9%) (IEA, 2010).

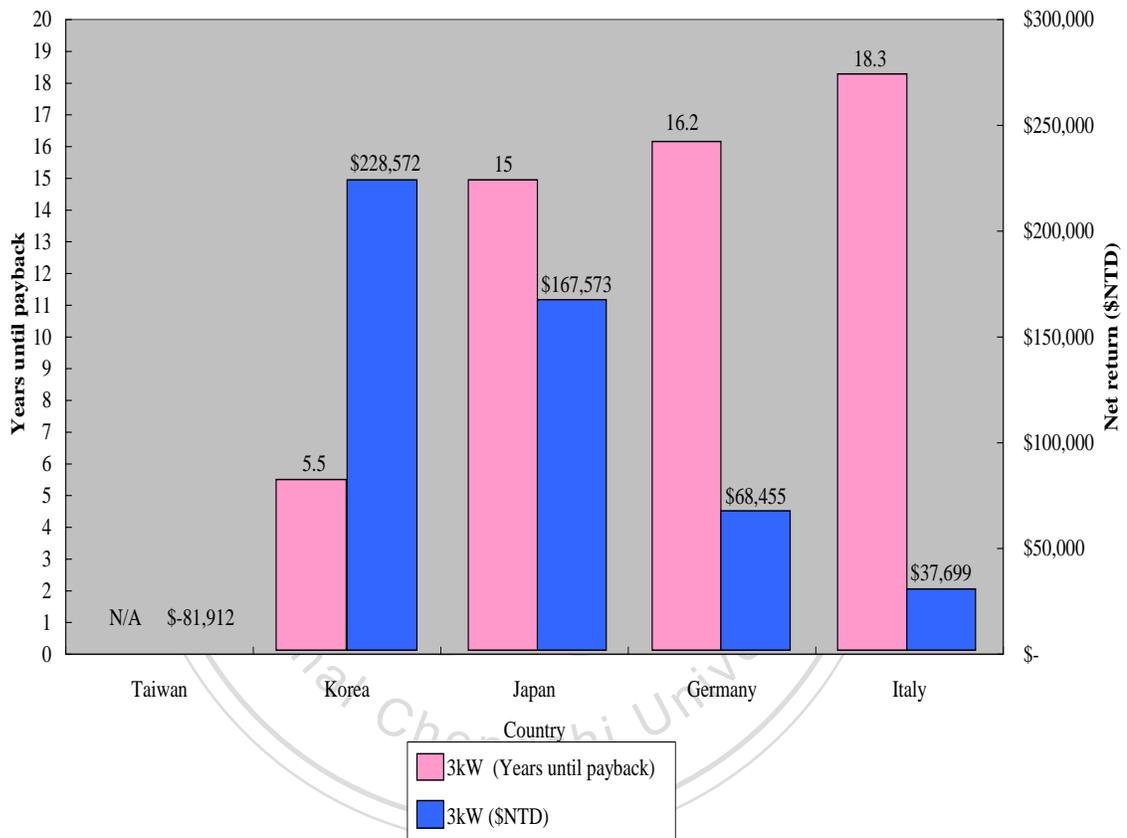
As for the FIT rates recorded in Table 2, we see that Italy has the most competitive at NT\$18.62 (perhaps giving us part of the reason why growth was so spectacular in 2009), followed by Japan (NT\$16.8), and South Korea (NT\$15.8). Germany (NT\$13.03) comes in at fourth, with another large drop to Taiwan in fifth. What readers must keep in mind when looking at these figures, however, is that the FIT does not exist separately from all the other elements; a much more complicated interaction between subsidy supports, prevailing installation (including labour) costs, overall maturity of the market and indigenous solar insolation potentials combine to affect the growth of solar PV as well as household investment decisions.

Before we turn our attention now to how Taiwan compares with South Korea, Japan, Germany, and Italy in terms of overall performance (payback times and net benefits) in the grid-connected (distributed) solar PV sector, a quick word is necessary on how we have arrived at the discount rates used in this analysis. As per the analysis for Taiwan, I have calculated an average of the last five years of base lending rate data for each individual country; these are 5.26% for South Korea, 3.58% for Germany, 4.26% for Italy and 1.46% for Japan. All data was supplied by individual countries as part of their reporting obligations to the Organization for Economic Cooperation and Development (OECD), and may be viewed by searching for the ‘interest rate: long term interest rates, per cent, per annum, forecast’ section of this website:

[http://www.oecd.org/document/0,3746,en\\_2649\\_201185\\_46462759\\_1\\_1\\_1\\_1,00.html](http://www.oecd.org/document/0,3746,en_2649_201185_46462759_1_1_1_1,00.html)

Figure 4 (see over page) charts overall performances for a 3KWp solar PV installation across the five countries used for comparison. Given the 3KWp condition is perhaps more in-line with ‘real world’ expectations about the size and cost of a typical rooftop-mounted solar PV installation, we use this as our starting point and exclude the 1KWp dealt with when looking at Taiwan.

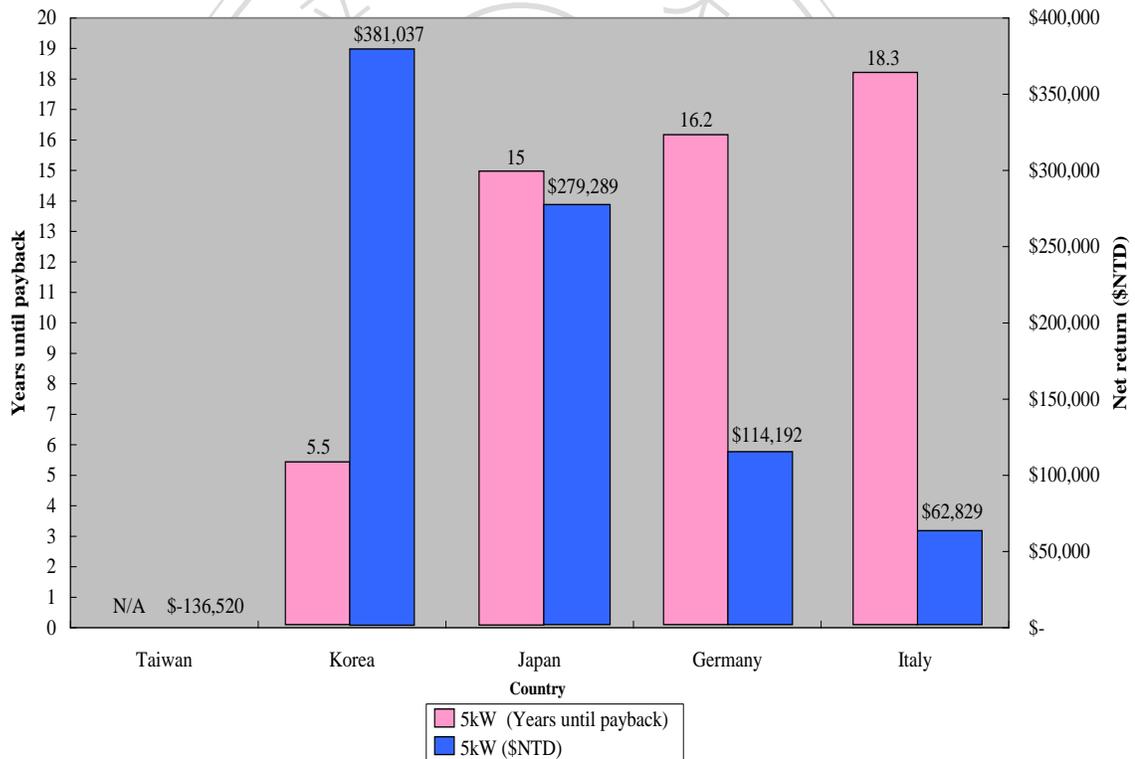
Figure 4: Taiwan & Selected PVPS Countries Compared (3KWp)



Disclaimer: for ease of comparison, we use Taiwan’s average solar PV operating efficiency of 9.6% (unchanged over the lifetime of the 20 year purchasing agreement) and apply it across all countries (except for South Korea where the contract length is 15 years). This is a conservative figure and the results in this section must therefore be treated with a degree of caution, particularly when the countries being compared differ significantly in their theoretical insolation values. E.g., sub-tropical Taiwan and a colder-climate European nation like Germany (see Appendix C) – depending on the specific location – may differ on average values for operating efficiency of PV cells. Also note that solar PV installation costs across the five countries used for comparison exclude local application, connection, and unit maintenance costs.

Figure 4 demonstrates quite clearly that in terms of years until payback South Korea is the clear leader at 5.5 years. Japan is the next best performer with a payback period of approximately 15 years, with Germany (16.2) just ahead of Italy (18.3). Taiwan, as was pointed out earlier doesn't figure in the results due to a net negative return to the investor after 20 years. In terms of total net returns, this analysis indicates that South Korea is again well ahead with NT\$228,572 at the end of the investment cycle (15 years). Japan is second with NT\$167,573, followed by Germany (NT\$68,455) and Italy (NT\$37,699) at the end of 20 years.<sup>47</sup>

Figure 5: Taiwan & Selected PVPS Countries Compared (5KWp)



The results for the 5KWp condition, unsurprisingly, are similar to those for the 3KWp condition – payback times are identical to the 3KWp condition across all four countries –

<sup>47</sup> A full-accounting of these results and the assumptions which underpin this analysis are available from the author at [karlhaby@hotmail.com](mailto:karlhaby@hotmail.com).

the only difference this time being that total net returns are slightly more exaggerated. A small-scale (household) investor in South Korea who installs a 5KWp roof-installed solar PV system can expect a return equivalent to NT\$381,037, while Japan (NT\$279,289), Germany (NT\$114,192) and Italy (NT\$62,829) all offer attractive incentives to invest. Taiwan is again last for reasons outlined previously.

If we were now to rank the countries for overall performance (factoring in years until payback and financial rewards) across the two conditions (3KWp and 5KWp) we would find that South Korea leads the way, followed by Japan, Germany, Italy, and then Taiwan. Taken in sum, the above results suggest that Taiwan does indeed lag behind (at least theoretically) other nations in terms of financial support for small-scale distributed solar PV, with payback times exceeding 20 years in all cases. These results are most simply explained by (i) an FIT rate that appears to be too low and (ii) the absence of a subsidy or loans scheme which might ease the initial set-up cost burden.

It is perhaps illustrative to point out here that were the Pricing Committee (with the cooperation of Taiwan's MOEA) to reinstate the subsidy scheme of NT\$50,000 per KWp of PV installed, Taiwan would actually compare quite favourably to the other countries used for analysis in this section; total net return to an investor under the 3KWp condition would amount to NT\$68,087 after twenty years, with a payback period of around 15 years (similar to Japan or Germany). Under the 5KWp condition the total net return would be NT\$113,479. It must also be said, finally, that a payback period of 15 years is more in-line with what one would expect to find in a relatively small and fledgling market (like Taiwan's) in critical need of new investment.

## 5.5. Lessons from Abroad

### 5.5.1. South Korea

As was highlighted in a previous section, where we discussed the functioning of the Act and its relationship with electricity prices in Taiwan, the low cost of energy is certainly one explanation for a FIT rate which doesn't provide for 'adequate' financial support for solar PV. This explanation, however, is not particularly compelling when we look at how South Korea has gone about implementing its solar PV development program. Despite electricity prices which are as comparably low as Taiwan's, South Korea still offers very competitive FIT rates (and a subsidy support scheme) which allows the average investor to see returns within six years. This would tend to indicate that South Korea is both prioritizing the development of solar PV, and making the necessary financial resources (at least provisionally) available.<sup>48</sup>

We should note here, however, that there is a potential downside to this picture (high rates of return and very short payback periods) which involves speculation in the renewable energy market, a blow-out in costs, and collapse of the overall scheme. Given that the costs of FIT scheme in South Korea are largely worn by the taxpayer,<sup>49</sup> and given that to date most of the solar PV capacity is centralized rather than distributed, we may have the unsustainable (and inequitable) situation emerging whereby the South Korean public underwrites the profitability of a few large renewable energy operators or utilities.

Nevertheless, in returning to why South Korea has experienced relative success in growing its solar PV market (besides the obvious financial incentives), we find that part

---

<sup>48</sup> We should perhaps note here, however, that the efficiency of South Korea's administrative and approvals process for new solar PV developments is a separate issue and one likely to be just as influential as financial considerations in attracting investment.

<sup>49</sup> Mendonca et al. (2010, p. 61) describe how the South Korean government have already announced plans to replace the FIT scheme in 2012 with a renewable portfolio standard mechanism. This has been attributed to the high costs of the program and the program's financing arrangements. As we know from the literature review component of this thesis, however, RPS schemes tend to be more expensive and less effective at promoting a broad-basket of renewable energy technologies when compared with FITs. It's therefore questionable as to whether this change of strategy will be successful.

of the reason may be to do with the composition of the market and overall development strategy adopted in that country. Table 2 reveals that approximately 78% of South Korea's 442MW of solar PV capacity is centralized grid-connected capacity; in its annual submission to the PVPS, South Korea noted that 'during 2008, the annual installed capacity exceeded 276 MW...mainly due to the (approval) and construction of a tremendous number of large size PV plants under the feed-in-tariff scheme' (Yoon, 2010).

Taiwan's government, and the MOEA in particular, could benefit from South Korea's example by beginning to explore options for opening up the market to larger-scale solar PV investments and building projects. This approach would seem to have several (theoretical) advantages, including: (1) An immediate easing of the pressure on Taipower to sift through the large number of individual applications currently (and projected) to be in the system. (2) Raising quite substantially (and quickly) the share of installed solar PV capacity giving confidence to other investors and reducing system prices. (3) Larger (commercial) operators entering the market means that the government (MOEA) could afford to apply a lower FIT rate thereby reducing the costs of the overall scheme.

Large-scale private operators are perhaps also better placed than the average household investor to take advantage of the current (but less than ideal) arrangements again for several reasons; (1) In relative terms, larger solar PV installations should result in reduced establishment costs (dollars per KWp) due to additional purchasing power along the supply chain – in practical terms this would mean shorter relative payback periods and higher overall net returns than would otherwise be the case for smaller distributed applications. (2) Obstacles facing individual household investors like those of high set-up costs and prolonged installation times should be less problematic for a larger private concern – providing the company has ready access to credit, construction could begin as soon as the project had met with approval from the relevant authorities. (3)

Administrative and logistical support – renewable energy operators are likely to be better equipped to negotiate the complicated applications process.

This hypothetical scenario of private operators coming to occupy a larger space in the energy market is of course dependent on the willingness of the government (and by extension Taipower) to ‘outsource’ Taiwan’s electricity supply to renewable energy providers. It’s also highly dependent on private (solar PV) operators deeming the investment environment in Taiwan to be sufficiently stable and attractive enough. While to date we have seen little to encourage us in either view, it nevertheless remains one possibility for growing domestic solar PV capacity, and one which the government (if it’s not already) should be considering seriously. Such a strategy, incidentally, would also benefit the distributed sector of the market as the benefits associated with learning effects and lower PV unit prices filter down to all.

### **5.5.2. Japan**

Moving on now to potential lessons from the Japanese experience and we find that Japan is worthy of further examination for precisely the opposite reason as is the case in Korea. That is, how has Japan managed to integrate solar PV capacity so comprehensively into new and existing building designs so that distributed solar PV now accounts for 96% of its 2,627MW of installed capacity? Readers may be disappointed to learn that this author has no sure answers to this question, but that possibilities include, the:

- Diversity of solar PV applications planned or currently deployed; in general terms, solar PV installations at Japan’s public facilities account for approximately 2.8% of the entire PV market, while PV systems deployed at industrial and commercial locations account for 7.4% (Yamamoto, 2010). These results have been achieved on the back of a number of targeted initiatives including the ‘Field Test Project on New Photovoltaic Power Generation Technology’ (propagated since 2003) which has seen approximately 80MW of solar PV capacity installed at industrial facilities and public-use facilities across Japan; the Project for Promoting the Local Introduction of New Energy (in operation since 1997), similarly, supports PV developments initiated by local authorities – in 2009, 547 solar PV projects (73.5MW) were approved, including new installations at city halls, water

treatment facilities, schools, kindergartens, hospitals, social welfare facilities, temples and factories (Yamamoto, 2010).

- Cross-ministerial approach: Besides the Ministry of Economy Trade and Industry (METI) and the Ministry of Environment (MoE), at the time of writing at least two other ministries were closely involved with the roll-out and expansion of solar PV applications – notably, the Ministry of Land, Infrastructure, Transport and Tourism (MLIT), and the Ministry of Education, and the Culture, Sports, and Science and Technology (MEXT) (Yamamoto, 2010). Both ministries offer subsidy support for set-up costs, which is available in addition to financial assistance from the central governing authorities (METI). The MLIT and MEXT through a collaborative partnership, are also responsible for the Eco-School Pilot Model Project (initiated in 1997) which gives assistance to schools wanting to incorporate solar PV into new or existing building designs, as well as enhance overall sustainability.
- Involvement at the local level: Since the METI resumed the Subsidy for Installation of Residential Photovoltaic Systems program for residential PV systems, over 500 municipalities have implemented their own support programs for residential PV systems – In 2009, for example, the Tokyo Metropolitan Government began providing residents with a subsidy of \$100,000 JPY (NT\$35,000) per KWp of solar PV installed (resulting in approximately 8,000 applications) (Yamamoto, 2010).

So while we don't have firm answers with regard to why Japan has so successfully grown the distributed sector of the solar PV market, when taken in sum these three factors perhaps go some way to explaining progress to date. The types of initiatives and collaborative efforts across government departments seen in Japan, furthermore, may also have some value for Taiwan and its policy-makers. As an example of what could be done to enhance the diversity of solar PV applications in Taiwan, introducing minimum

standards for renewable energy production for new facilities of a certain size (and then partially subsidizing the cost of installation) would help lead to the spread of solar PV in industrial, commercial and residential contexts, and supplement electricity supplied to the grid in those built locations.

As another example, this time focusing on the local engagement aspect of development, local governments (empowered by the MOEA or BOE) could consider forming partnerships with public schools and universities interested in reducing electricity costs and enhancing their environmental credentials. Such activities would serve to broaden the appeal of solar PV (both amongst government and non-government entities) and allow the general public to learn about its advantages without necessarily having to invest a lot of time and money personally. Incorporating solar PV (where appropriate/suitable) may also come to be viewed as simply the next stage (after efficiency measures) in reducing the energy requirements of new and existing buildings.

### **5.5.3. Germany & Italy**

With regard to the other two countries included in this section for comparison – Germany and Italy – we deliberately omit them for further analysis due to insufficient data. Although we know that over 99% of Germany’s installed solar PV shares a connection to the grid, there are no specific figures outlining where this capacity is to be found. i.e., how much of it centralized generating capacity and how much is accounted for by the distributed residential market; in the case of Italy, while we have this sort of market data available to us, we don’t have enough information on the promotional measures and strategies that Italy is currently adopting to encourage growth in the solar PV market. As such, we make no further comments or comparisons.

### **5.5.4. Additional Financial Strategies & Incentives**

Most readers are perhaps by now starting to draw their own conclusions about the kinds of financial measures or strategies the government needs to adopt in order to reduce

market barriers and stimulate growth in both the residential and non-residential (distributed) sectors. These measures might include:

- Immediately revising the FIT to a level which would allow for a (small scale) private investor to see payback well inside 20 years – based on the assumptions that we used to carry out the previous analysis, an FIT rate of approximately NT\$12.6 per KWh would be sufficient (even without a capital subsidy) to allow a small scale (household) investor to recoup costs within that critical 20 year period. The actual likelihood of such a move by the government is unclear, however, given that the FIT rate for domestic installations of less than 10KWp last year (2010) was only NT\$11.18 and already too low.
- Re-introducing the capital subsidy measures – should the government's Pricing Committee be unwilling to take action on the FIT, additional financial resources could be directed towards assisting new investors with their set-up costs. As was demonstrated earlier, a capital subsidy of NT\$50,000 per KWp installed (and still available to some investors in 2011) would allow for costs to be recouped in approximately 15 years. Such a scheme could be administered in partnership with local agencies through a special budget allocated for the specific purpose of promoting the dissemination of solar PV applications in a broadest range of contexts possible.
- Combining work on both the FIT and subsidy measures – some combination of a slightly higher FIT rate and a revised capital subsidy could be explored by the government to stimulate investment in the residential and non-residential (distributed) PV markets. In order to guide thinking on this issue, however, the government must first determine what is more concerning to potential investors contemplating a solar PV installation – Is it that high set-up costs and lack of easy access to credit are prohibiting some investors from entering the market? Or is it that interim financial incentives (e.g., money returned on a monthly and yearly basis via the FIT) are insufficient? In short, the government urgently needs to

identify who is a potential solar PV investor and what *combination* of financial incentives should be made available to assist them.

- Establishing easier lines of credit for the domestic investor – we have seen previously that it costs approximately NT\$453,000 to buy and install a medium-sized (3KWp) PV unit in Taiwan. One can imagine that for a not insignificant percentage of potential small scale (household) investors, this \$453,000 is a considerable outlay requiring additional financial support; if this assistance is to come from a commercial lending institution, then the additional interest involved in making repayments may (understandably) give investors cause to think twice before taking out a loan. The government in Taiwan, borrowing from the German example this time, could play a role in alleviating this problem by making available a certain number of low or interest free loans (through central or state-owned banks) to investors with small-scale PV projects. This would represent a fairly non-interventionist approach (i.e., no change to the FIT or subsidy arrangements) from the government, yet go some way to addressing an obvious and significant market barrier.
- Additional incentives – this might include amending current laws to allow an extension of tax benefits to not just commercial or industrial operators investing in renewable energy technologies, but to individual investors deciding to join the market as well. In the simplest version of such a plan, a household or small scale investor could earn tax credits equal to some proportion of the initial set-up costs. Similar schemes could also be devised for small business owners in Taiwan wanting to both offset electricity costs (by installing PV) and derive preferential tax treatment from the government. Advocating the use of tax credits to promote the deployment of renewable energy comes with a couple of caveats, however; (1) For small-scale investors, removing financial barriers associated with initial set-up costs (by providing access to low or no interest loans) are likely to be more effective than a tax credit scheme, due to the fact that inadequate capital resources are the first stumbling block for any new project. (2) That for larger commercial

installations any issuing of tax credits is dependent on the actual operation and production of electricity from these installations. This is to avoid the previously reported problem of (wind energy) companies in the US establishing renewable capacity in order to gain preferential tax treatment, only to leave that capacity sit idle (Mendoza et al, 2010).

We should point out here, however, that whether or not the government actually chooses to adopt any of the measures or strategies described previously, is secondary somewhat to another issue already canvassed. That is the serious problem so far of ensuring a consistent approach to the administration of financial incentives and schemes; sudden changes to the Act, like the one which involved investors signing a contract in 2010 no longer being eligible for 2010 FIT rates unless work was completed before the end of December, does not help investor confidence or the growth of the market. Nor is the decision to completely phase out the capital subsidy without announcing a replacement scheme, or at least adopting a gradual winding down of the subsidy instead. Both of these developments, in addition to the difficult and time consuming applications process, have potentially harmed the chances of new investors entering the market.

In summing up the results from this section, then, we find that the Taiwanese government does not provide 'adequate' (financial) support for private sector (household) investors in Taiwan (payback times exceed 20 years), and that Taiwan seems to lag behind its close Asian neighbors in South Korea and Japan in terms of total installed capacity and financial incentives on offer. Unsurprisingly, the same is also true when comparing Taiwan to the two European nations (Germany and Italy) profiled here.

There are a number of interventions (from a Market Barriers Perspective) the government could potentially adopt to remedy this situation, some of which include welcoming more large scale (local and overseas) private investment, working closely with local (city and county level) governments in developing new solar PV projects, and revising some of the financial incentives currently available (like the FIT and capital subsidy) so that they're more attractive to household investors – providing adequate financial incentives would

seem especially critical given the infancy of Taiwan's domestic solar PV market. Finally, and in addition to things like the provision of low or no interest loans, relevant government agencies should adopt a more consistent approach to policy implementation if they seek to attract genuine interest from the public for solar PV.



## 6. Part III: Market Transformation Perspective

### 6.1. Systemic Barriers

We have already discussed in-depth a number of issues or obstacles that have likely slowed the dissemination of renewable alternatives (like solar PV) in Taiwan's energy market. These include changes to the Act concerning the applicability of FIT rates; proposed revisions to supporting legislation (Draft Amendments for Renewable Energy Installations Approval Process – 再生能源發電設備認定辦法修正草案總說明); and a decision by the Pricing Committee to both reduce the FIT and eliminate capital subsidies for PV projects commencing in 2011.

Such changes to existing legislation coupled with what is a fairly complicated and time consuming applications process, have no doubt contributed to the modest figures we have for the amount of solar PV capacity both installed *and* eligible for electricity procurement under the FIT scheme. And while these sorts of (systemic) issues are certainly critical in the short term to the dissemination of solar PV and the growth of a domestic market in Taiwan, they are merely symptomatic of a number of deeper (and more difficult to negotiate) issues which underpin them.

The purpose of this section is to use the Market Transformation Perspective described in the introduction to explain and link together some of the more intractable problems that renewable energy (and energy market liberalization and diversification more generally) faces in Taiwan. In doing so we might also explain why the government has to date adopted the slightly 'schizophrenic' approach to renewable developments that it has, where outwardly the MOEA and BOE seek to promote the dissemination of renewable alternatives via the Act and a number of supporting measures, but at the same time construct artificial barriers to slow this same process down.

### 6.1.1. Developmental Features & Systemic Inertia

With the above aims in mind we begin answering *RQ4(i)* by making an observation that is by now both quite familiar to us (see Part I), and also essential to understanding the background to certain institutionalized barriers affecting the growth of the renewable energies market. i.e., that Taiwan's lack of natural resources and somewhat unique developmental trajectory have shaped (and continue to shape) developments in the energy and industrial sectors of Taiwan's economy. These developments, which are really more like entrenched features, include:

- Existing patterns of supply and consumption (1): Taiwan as an island nation is heavily reliant on relatively cheap but carbon intensive foreign energy imports to meet what have been historically growing energy demands; demands which, beginning in the 50s, and then gathering speed in the late 70s and 80s as Taiwan began a period of rapid (state-led) industrialization and export growth, have only recently begun showing signs of leveling off. The net result of these trends, in addition to the competitiveness of modern day global markets for manufactured and processed goods, has encouraged what is now a fairly high level of *dependence* on cheap electricity (and oil and petroleum products) to power the nation's economic and industrial growth, and an *interdependence* between government and industry (including the energy industry) to see that there aren't any major disturbances to this business as usual approach.
- Existing patterns of supply and consumption (2): Coal-, Oil-, and LNG-fired power stations accounted for approximately 78% of Taiwan's total electricity generating capacity and around 44% of its total output in 2009 (BOE, 2010). The single largest consumer of this electricity was Taiwan's Industrial sector at 50% of the total, with the Services (20.46%), Residential (19.5%), and Energy Sector Own Use (8.7%) also figuring strongly (refer to Figure 7 over page). Focusing now on the industrial sector of Taiwan's economy, and we find that a number of sub-sectors feature more prominently than others in terms of overall energy

consumption and CO<sub>2</sub> emissions<sup>50</sup> – these include the manufacturing of nonmetal mineral products, basic metal products (including steel, metal, and metal products), chemical materials, and paper-making and paper products, with growing energy consumption in recent years reflecting continued growth in these industries' economic output (Huang et al, 2010). So, while the majority benefit from the low energy and electricity prices in Taiwan, clearly those with the highest levels of consumption (and biggest profits) benefit disproportionately.

- Centralized control of Taiwan's electricity generation, transmission, and distribution networks: Another legacy of Taiwan's earlier strong-State development approach is the size and scope of operations for which Taipower has primary responsibility. Indeed, while the situation has improved markedly since the introduction of legislation in 1994 allowing IPPs (Individual Power Producers) to supplement Taiwan's electricity supply and enter into long-term purchasing agreements with Taipower,<sup>51</sup> Taipower still retains control of approximately 70% (excluding cogeneration plants) of electricity generating capacity, guides thinking on fundamental grid policy issues, and as we have already reported on in this thesis,<sup>52</sup> major influence over the application and approvals process for new renewable energy projects. Such an arrangement has obvious ramifications for the ability of new energy technologies like solar PV to gain a substantial place in the market, and for the general competitiveness of these new market entrants.

---

<sup>50</sup> China Steel Corp (中鋼) at 15.1%, China Petrochemical Development Corp (中石化) at 9.9% and CPC Corp, Taiwan (CPC, 台灣中油) at 4.3%, are the three largest individual emitters of CO<sub>2</sub> after Taipower (51.1%), based on 2008 figures (Huang et al., 2010).

<sup>51</sup> Wang, K (2006). Readers should perhaps note that major private concerns, in addition to their core business interests have also become IPPs since deregulation began. The 1,800MW Mailiao coal-fired power station owned by Formosa Plastics, for example, sells about three-quarters of its output to Taipower. The Ho-ping plant (1,297MW), which is a joint venture between Taiwan Cement and China Light and Power Corporation, underlines again the interconnectedness of large (energy intensive) industries and the power generation sector in Taiwan.

<sup>52</sup> Taipower currently oversees most aspects of the applications, approvals, and grid-connections process for renewable developments.

Figure 7: Structure of Taiwan's Total Domestic Consumption (By Sector): 1989-2009

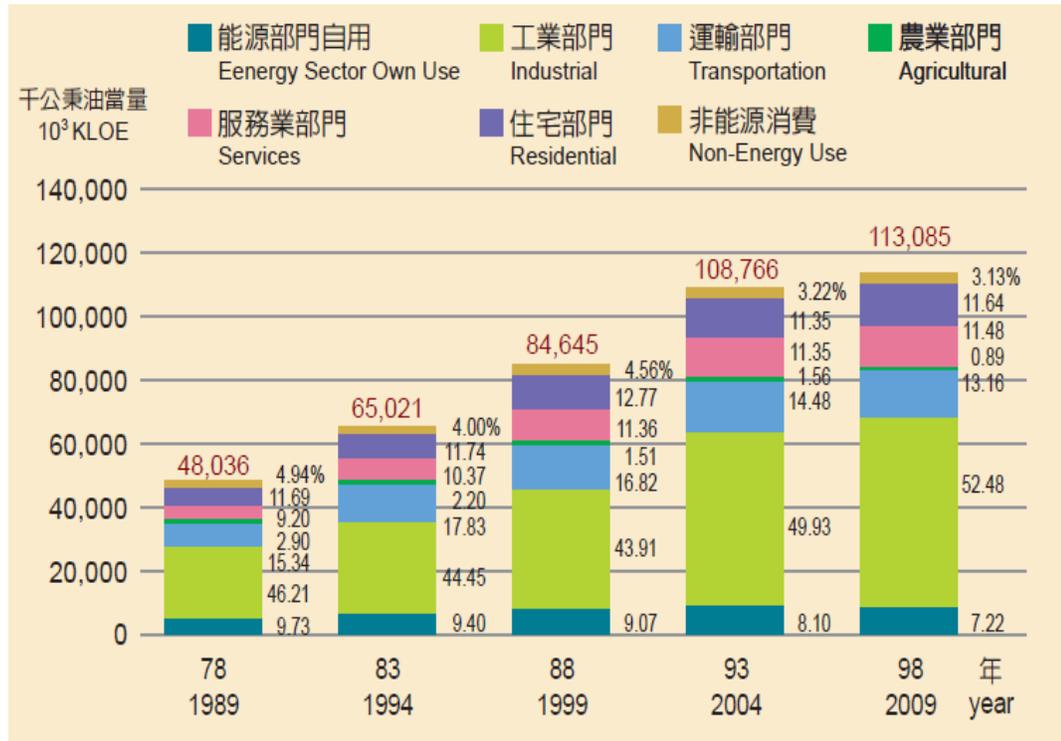


Figure from the BOE's Energy Statistical Handbook (2010, p.29)

- Electricity pricing and resistance to change: Readers are probably well aware by now that Taiwan's electricity prices are some of the lowest in the world, with the non-industrial sector subsidizing electricity for industrial purposes.<sup>53</sup> As has already been explained, these prices have been kept artificially low to benefit certain sectors of Taiwan's economy and to help bolster their economic viability. Despite rising global prices for coal, oil, and natural gas (main electricity generating sources), Taiwan's wholesale electricity prices have remained relatively static, with cumulative adjustments equal to around NT\$0.45 per KWh (or approximately US\$ 1.5 cents) over the last 20 years (BOE, 2010). Thus, with price signals largely absent from Taiwan's electricity and energy market, there are few incentives for those larger energy consuming sectors of Taiwan's economy to

<sup>53</sup> The retail price for electricity for 'light' users is almost NT\$0.5 per KWh more expensive than electricity for industrial purposes.

modify operating methods or step-up energy efficiency efforts. Finally, and in the face of what seems to be a critical weakness in government plans to reign in energy consumption, improve efficiency, and promote renewable energy use at home, there has been little progress to date in rationalizing energy prices to reflect the true cost of their production and consumption.

- The (lack of) competition (at least from a renewables' perspective) in Taiwan's energy market: We have already shown that Taiwan's energy market is dominated both by Taipower who retains centralized control, and by more carbon-intensive forms of electricity production which Taipower employs to minimize wholesale and retail electricity prices. And while the government has recently taken legislative steps in hopes of altering this situation (e.g., through the passage of the Act and other legislative measure slated for introduction soon), it remains to be seen whether current FIT and subsidy support levels are sufficiently good to attract new investors into the renewables market, thereby dragging down the cost of electricity production from solar and other sources. Indeed, without this initial investment from those less risk averse 'innovators' or 'early adopters', the domestic market for solar PV in Taiwan will struggle to reach that critical point where adoption 'takes off' and the market becomes more self-sustaining (IEA, 2010).<sup>54</sup>

The major explanation, therefore, as to why renewable energies like solar PV face such stiff resistance when entering the energy market, is that a significant expansion of renewable energy poses a challenge to each of these fairly well established features of Taiwan's energy supply and consumption network, as well as the stable and mutually beneficial relationships that have developed between government, Taipower, and local business interests.

---

<sup>54</sup> The ultimate goal is to get to a point where the market is sufficiently mature (through a culmination of learning improvements and reduced system prices) to allow government support for solar PV to be phased down. The IEA identify 'innovators' and 'early adopters' as playing a critical role in helping the market for a new energy technologies reach 'take off'.

### 6.1.2. Challenges to the Status Quo

In order to expand upon the previous point and demonstrate how a significant expansion of renewable capacity challenges in-built inertia in the system, we shall now highlight the (hypothetical) impacts on one or two of the aforementioned features, beginning with the issue of electricity pricing in Taiwan.

For the domestic solar PV market (and market for other renewables) to grow to a level commensurate with government plans outlined in the Act and the Framework,<sup>55</sup> Taipower and the MOEA (BOE), together, will be required to oversee the expansion and incorporation of thousands of megawatts of new renewable electricity generating capacity into Taiwan's current energy and electricity framework. An expansion of renewable capacity of this magnitude will likely entail significant added expense (in the short-term at least) to the operating budget of state-owned Taipower for two main reasons:

(1) The additional resources needed for the administration of the application, approvals, and grid-connections processes: this is already shaping up as a major issue given the significant lag we have seen so far between an initial submission of an application to the BOE/Taipower and final certification and approval of a project. (2) Rising costs (to Taipower and the government) of electricity procurement under the FIT scheme: As new installations increase and the market for solar PV and other renewable energies expand via the Act, Taipower (as the State's monopoly energy purchaser and distributor) will be obliged to buy more and more electricity from these (for the moment) more expensive sources – this will impact not only on Taipower's bottom-line, but will also have likely flow on effects for end-use consumers.

---

<sup>55</sup> These targets are for around 10,000MW of new renewable capacity to be installed by 2030. Solar PV is expected to account for around 2,500MW of this new generating capacity.

Putting aside for a moment the types of longer-term savings and environmental benefits that an expansion of renewable energy would eventually bring,<sup>56</sup> additional short-term costs like those described above *will* have to be passed on in one form or the other; in the absence of an additional source of revenue like an energy tariff or tax, the most likely and direct alternative means of addressing rising operating costs will be to increase electricity prices (and prices for other energy products) to reflect the changed scenario. The problem, as alluded to earlier, is that there are major public and private sector interests that will resist strenuously such a move.

Starting with the types of energy intensive manufacturing and processing industries – steel, metal, petrochemical, chemical, and paper – mentioned at the start of this section: Barring any additional government assistance or plans for a phased entry, an increase in electricity prices (or energy products like petroleum, oil, or gas which support these industries) will likely have an immediate impact on the profits and overall competitiveness of those businesses operating in that sub-sector of the market. In addition to shrinking profit margins, rising costs may also involve some painful and expensive restructuring as companies look for ways to enhance efficiency and reduce the costs of their operations.

A worst case scenario (certainly from the government’s perspective), would be if local commercial interests decide to scale down operations and/or begin laying-off workers. Politicians (local and national) would come under increasing pressure from business and members of the local community to do what they could to mitigate these and other economic effects. On a broader (national) level, lower company revenues due to higher operating costs would have the effect of reducing the government’s overall takings, with economic growth targets perhaps also requiring some revision – those in the political arena (and especially the ruling KMT party) are unlikely to welcome such developments

---

<sup>56</sup> Including reduced dependence on foreign energy imports, lower costs associated with a reduction in greenhouse gas emissions, lower electricity costs as a result of the ‘merit order’ effect, and lower installed unit prices for solar PV

at a time when the economy has only just started showing signs of recovery, and following a sustained period of small or negative real GDP growth.<sup>57</sup>

This unwillingness on behalf of the current KMT government to do anything that may signal a rise in energy prices was highlighted most clearly in 2009 when the Cabinet, one day after it was announced, suddenly scrapped plans to introduce an ‘incremental levy’ on CO<sub>2</sub> emissions, gasoline, diesel, gas, and other energy sources beginning in 2011 (Wang, 2009). Reasons given by the Premier, Wu Den-yi (吳敦義), for the sudden reversal included a sluggish economy, struggling local employment market, and concern for a general public ‘still having a hard time making a living’.

And despite a slightly rosier economic picture painted by last years’ GDP growth figures (reported to be in the range of 10% - MOEA 2010b), there is little to indicate that the government will revisit its earlier decision in the near term – this seems a shame given that the ‘revenue neutral’ tax would have generated an estimated NT\$151.3 billion<sup>58</sup> in additional tax revenues after the first ten years, and potentially have allowed the government to direct some short-term funding towards subsidy programs for renewable energy whilst offsetting rising energy costs for the most economically disadvantaged in Taiwan.

### **6.1.3. Zero Sum Game?**

We thus arrive at the situation renewable energy generators and the government both facing in trying to invigorate and diversify Taiwan’s energy market. That while boosting renewable and solar PV generating capacity remains a priority policy goal, doing so might entail some unwelcome (and difficult) changes to current energy and industrial policy. i.e., towards a less energy intensive and more efficient, higher value-added economy, brought about in part by the rationalization of electricity and energy prices and

---

<sup>57</sup> Real GDP growth in 2010 was estimated at 8.3%. In 2009 and 2008 the figures were -1.9% and 0.7% respectively (MOEA, 2011b)

<sup>58</sup> As reported by Hsu (2009) for the Taipei Times.

targeted assistance/subsidy packages. These are the sorts of structural changes, furthermore, that are likely to take considerable time and effort to first form consensus on and then implement.

This is not to say, however, that renewable developments won't be able to find a foothold and expand to some degree under current conditions, but that the government is more likely to work around the edges of the current system to promote them, so as to avoid major economic (or political) disruptions of the sort described previously. This conservative approach is evidenced by the stop-start nature of renewable energy developments seen so far. Where, for example, and with the passage of the Act in 2009 and the establishment of electricity procurement mechanism, generators of renewable energy are now able to sell their electricity to the grid at a premium. But where certain amendments to supporting legislation allow the government to cap or halt the processing of renewable projects at any time with little warning or recourse for those affected; and in addition to the Pricing Committee's decision to reduce the FIT and eliminate subsidies for solar PV projects in 2011.

While one can only speculate as to the logic underpinning such an approach, it seems that the priority of the government is to first emphasize growth of its solar PV export market (Taiwan is currently ranked number four in the world in terms of PV cell production) and then begin focusing on the domestic market once unit costs reach an acceptable level and the FIT can be scaled back accordingly. The author has doubts as to whether or not this strategy can work, given that part of the reduction in solar PV installation costs are attributable to learning effects that accumulate over time and under local conditions.

Nevertheless, in the following section, we shall explore a possible range of policies and tools the government might be able to employ to help with the (energy) market transformation process.

## **6.2. Transforming the Market**

### **6.2.1. Developmental Framework**

We begin this section by first giving some more background information on what the Market Transformation Perspective is, and how it might help us in overcoming some of the barriers described in previous sections.

As described by the IEA in its ‘Creating Markets for Energy Technologies’ (2003) report, the Market Transformation Perspective means focusing on the outcome to be achieved – in this case boosting domestic demand and competitiveness of solar PV in Taiwan – and then running the logic back through all the factors that would be necessary to attain that outcome. A necessary first step involves first identifying (systemic or market) barriers to the deployment of a given energy technology, and then modifying where practical and possible the underlying reasons for those barriers.

In Part I of this thesis, for example, we identified relevant pieces of legislation and interpreted their impacts on the growth of renewable energies in Taiwan. As part of this analysis, we also highlighted some inconsistencies and flaws in the government’s approach so far, like the implementation of a complicated and time-consuming applications process (for which Taipower has primary oversight), and the decision to put a cap on renewable developments also written into the Act.

In Part II, similarly, we undertook an in-depth analysis of the financial implications of investing in solar PV (as taken from the perspective of a household investor), and showed that while the government has the requisite policies and tools at its disposal, an uncompetitive FIT rate and lack of subsidy support is likely to dampen future interest from the private sector. Finally, and at the beginning of this Part III, we have shown how certain systemic (or institutional) factors, like the low cost of electricity in Taiwan and its varying implications, have hampered efforts to expand and diversify the domestic energy market.

In much of this analysis, readers may have noted that we highlight again and again the role of government in enhancing the competitiveness of new energy technologies like solar PV. This is certainly *not* to say that government should take primary responsibility for altering market dynamics, but that the government has a key role in influencing market and private energy-related decisions by helping to reduce market barriers, change incentive structures, provide public information and encourage competition (IEA, 2003). Market transformation then, requires the government to address instances of market failure so that competing technologies (in this case solar PV) are able to proliferate based on relative merit (reduced environmental and social costs) and become cheaper as their market share expands.

The following Table (see over page) describes a range of options or strategies<sup>59</sup> available to the government, some of which have been presented before in one way or another in previous sections of this thesis. Readers should be aware that whilst we have separated these measures into six different categories, this doesn't mean implementing one strategy or solution in isolation will produce the desired result. When taken in combination, however, and as part of an overall or more comprehensive development strategy, these are the sorts of measures that could have a profound impact on the market; implementation of an appropriate FIT scheme as we have canvassed previously in the literature review, is the single most important factor in spurring sustainable growth in this sector of the market.

---

<sup>59</sup> This list is by no means exhaustive and is only meant to be a summary of the information given so far; it does not, for example, make mention of potential research and development strategies which should also be pursued.

Table 3: Developmental Framework for the Domestic Solar PV Market

<b>Categories</b>	<b>Measures</b>	<b>Implementation</b>	<b>Expected Outcome(s)</b>
<b>Adjustments to Financial Incentives</b>	<ol style="list-style-type: none"> <li>1. Revise the FIT upwards.</li> <li>2. Re-introduce capital subsidies.</li> <li>3. Provision of low or no interest loans.</li> <li>4. Tax incentives.</li> </ol>	<ol style="list-style-type: none"> <li>1. Raise to approximately NT\$12.6 per KWh for solar PV applications under 10KWp. Once sufficient uptake has occurred, begin to introduce degression measures as per the German experience.</li> <li>2. Consider introduction of subsidies across a range of sizes of PV applications.</li> <li>3. Loans could be administered by state banks in partnership with the MOEA. As mentioned earlier, establishing easier lines of credit is likely to be more effective than tax credits in stimulating uptake.</li> <li>4. With certain provisos, preferential tax treatment for residential and commercial investors may be used as a way of off-setting establishment costs.</li> </ol>	<p>Guarantee adequate returns for investors whilst reducing payback times; Minimize and lower entry hurdles for new solar PV investors.</p>
<b>Adjustments to Administrative Processes</b>	<ol style="list-style-type: none"> <li>1. Simplify (and expedite) application and approval procedures.</li> <li>2. Increase accountability.</li> </ol>	<ol style="list-style-type: none"> <li>1. Identify and eliminate administrative overlap between the BOE &amp; Taipower.</li> <li>2. Regular (quarterly or half-yearly) progress reports from Taipower to the MOEA (BOE) as to the state of new applications, size and type of new</li> </ol>	<p>Changes should expedite the application and approvals process; Eliminating waste will free up additional resources; Better monitoring and</p>

		projects etc. These reports should also be made publicly available.	oversight of Taipower's operations to ensure targets are being met.
<b>Strategic Policy Review</b>	<p>1. MOEA (BOE), Taipower &amp; other relevant agencies should convene and develop a comprehensive solar PV action plan.</p> <p>2. Review the decision to cap renewable energy developments.</p> <p>3. Review changes which allow the MOEA to delay or halt processing without giving due notice to affected parties.</p>	<p>1. Identify which areas of the market are most cost-effective to exploit (e.g., distributed vs. centralized vs. some combination of both) and then develop a strategy to attract foreign and domestic investment.</p> <p>2. Remove references to the cap in the Act, and instead focus on the (minimum) percentage of renewable (solar PV) capacity to be installed within a specific timeframe. Process and approve applications in-line with these goals.</p> <p>3. Scrap the proposed amendments to the Draft; introduce consistency and better guarantees for potential investors.</p>	The developmental potential of all sectors of the market are appraised; A cost-benefit analysis which identifies Taiwan's solar PV market's inherent strengths and weaknesses should also be carried out; Legislative changes will highlight the government's commitment to carry these plans forward.
<b>4. Strategic Partnership Building &amp; Diversification</b>	<p>1. Private sector – Government</p> <p>2. Local – National</p> <p>3. Local – Community</p> <p>4. Government – Business</p>	1. Enhanced role for the public and renewable industry representatives to participate in Pricing Committee decisions, particularly with regard to the FIT. Government to channel additional resources to informing and educating the public regarding the importance of investing in renewable (solar PV) energy.	Rapid expansion of solar PV in a broad range of contexts for a variety of purposes; Should assist with increasing the appeal and acceptance of solar PV in the community; Small business

		<p>2. Increased financial resources for local government-sponsored solar PV projects via dollar for dollar funding and deployment schemes.</p> <p>3. Local (city and county) governments to support community projects (e.g., schools, universities, sporting facilities) in order to assist with the dissemination of solar PV in broad range of contexts.</p> <p>4. Government to work with local PV manufacturers, small business, as well as industrial and commercial operators to help develop and meet the costs of new projects.</p>	<p>and industries to become more energy efficient and less dependent on the grid.</p>
<p><b>5. Foreign Investment &amp; Niche Development</b></p>	<p>Identify niche areas of the domestic solar PV market and where necessary solicit interest from outside investors and renewable generators.</p>	<p>Centralized generating capacity is an under-developed area of Taiwan's domestic solar PV market. The government should consider ways to attract investment in this area through special incentive programs, as well as make available relevant information to potential investors through a dedicated portal/office/website within the BOE.</p>	<p>An additional source of capital; Should help alleviate some of the risk associated with opening up new areas of the renewable energy market; Could result in a rapid expansion of solar PV and trigger falling prices with positive flow on effects for domestic investors.</p>

<p><b>6.Institutional/ Structural Change</b></p>	<p>1. Review decision to halt implementation of tax on carbon and other polluting energy sources.</p> <p>2. Revise electricity prices to reflect the true cost of production</p> <p>3. Implement existing plans for industrial transformation.</p> <p>4. Legislation introducing mandatory minimum renewable energy generating standards for new buildings of a certain size, purpose, and predicted average electricity consumption.</p> <p>5. Continue with efforts to liberalize and diversify the electricity market.</p>	<p>1. Revenues from this tax could be invested in renewable energy developments, energy efficiency measures, and assistance for Taiwan's low income earners.</p> <p>2. Government could introduce a kind of modified float for electricity prices to better reflect global commodity prices for coal, oil, gas, and petroleum.</p> <p>3. Government should review immediately any existing plans for expansion of energy intensive manufacturing or processing plants. E.g., the proposed naphtha cracking facility in Changhua County.</p> <p>4. Applicable to new industrial premises, commercial and residential developments. May be pursued through incentivization schemes (subsidies, tax relief etc.)</p> <p>5. Review Taipower's position as monopoly generator and distributor so that the FIT (and related measures) are supported by the public and private sectors together; Consumers given the option to pay more to source 'green' energy should they wish to.</p>	<p>Changes will boost the cost competitiveness of renewable energies like solar PV and assist with their dissemination; Additional revenues from higher energy prices can be used for subsidy programs and those most heavily affected; Should assist in Taiwan's industrial transformation and transition to a more efficient higher value added economy.</p>
--	---	--	--

### 6.2.2. Implementing Change

Readers by this point will no doubt be aware that the success of the strategies comprised in this developmental framework, rely to a great extent on the commitment from government to explore ways of expanding renewable energy generating capacity. If the government(s) of the day is not sufficiently committed, or if the political or economic cost associated with implementing a given measure is considered too high, it's unlikely that these sorts of things will be adopted any time soon.

Similarly, and given that a great many of these problems stem from the government's approach to (renewable) energy and industrial policy, it may seem ironic (or even naive) to some readers to expect the government's help and full compliance in fixing them. The purpose of this section is not to demand (or expect) action on each and every one of these items, but simply to highlight a few important areas (and potential solutions) which could be brought to the attention of policy-makers, and starting with what might seem intuitively to be the most achievable and straightforward first.

We have previously described, for example, the importance of the FIT to stimulating growth in renewable markets and some reasons as to why the FIT has been set at the fairly uncompetitive level we have now. Such a situation leads us to an obvious question; how would additional program costs be worn (by the government, taxpayer, and electricity consumer) if the FIT were to be raised and the capital subsidy scheme reinstated as per the 'Adjustments to Financial Incentives' category of Table 3?

This thesis contends that the government has *at least* one of two options open to it: the government can either (1) pursue ways and means that allow it to draw down additional financial resources to fund these schemes, or (2) the government can make reducing (domestic) solar PV capital costs its top priority and instigate work on collaborative projects that will help in achieving that goal. A third option, which involves ameliorating the costs of the FIT (and additional support schemes) by liberalizing Taiwan's energy market is not considered further in this section due to the complexity and long-term

nature of the changes required. Suffice it to say, that were private utilities allowed to enter and compete in Taiwan's energy market, and were they also bound to purchase electricity generated from renewable sources, the burden on the government (and by extension the Taiwanese taxpayer) would be reduced substantially and distributed more evenly.

In relation to the first option, and as was alluded to in the above Table, the government should give serious consideration to introducing the kind of energy tax that was proposed by the Cabinet in 2009. That is, an incremental levy on CO<sub>2</sub> emissions, gasoline, diesel, gas, and other energy sources. If the introduction of a levy isn't considered targeted or sensitive enough by the government, then phasing in higher electricity prices for industry (and perhaps even certain sub-sectors of industry) may be an alternative means of raising the additional funds. While both options would seem to carry a substantial level of political and economic risk, both have been mooted publicly more than once previously, and moreover, would be consistent with current government policy on industrial transformation and prevailing public attitudes toward reducing greenhouse emissions.

With regard to the second option – reducing the costs of domestic solar PV unit prices – one strategy might be to begin work on attracting more local and foreign investment for large-scale (centralized) solar PV installations. As identified in the Table, this is a largely undeveloped area of Taiwan's solar PV market with significant growth potential: Associated benefits of this approach are also likely to include an immediate large-scale capital injection for Taiwan's domestic PV market, the prospect of sharing risk between government and the private sector as new areas of the market open up, and a productivity stimulus for local equipment manufacturers and installers. As solar PV gains greater market penetration and solar PV costs begin falling as a consequence, the FIT (and any additional subsidy measures) can be adjusted downwards accordingly thereby reducing the cost of the overall scheme.

In closing, and regardless of which direction the government proceeds to promote the development of a domestic renewables (and solar PV) market, it's reasonable to suggest

that part of this process will have to involve a degree of consensus building. i.e., forging agreement amongst government, academia, the public, and private sector interests about what the optimal make up of Taiwan's energy mix is/should look like in the short, medium, and long term. Industry, as the largest consumer of electricity in Taiwan must undoubtedly be part of these sorts of deliberations; but industry's concerns must be counterbalanced by Taiwan's future energy security needs, and stated commitments to reducing and off-setting the deleterious environmental and social effects of carbon intensive electricity generation and economic growth.

Renewable energy, as the government has rightfully identified, must play a major role. At the same time, and as we have shown throughout this thesis, however, existing measures the government has in place must be fortified, and the administrative, financial, and institutional obstacles that private sector (household) investors are facing reduced substantially before renewable energy (and solar PV) can become really competitive in Taiwan. Finally, and was only touched on briefly in this section, developing a coherent development strategy for renewable energy alternatives necessarily involves raising their profile amongst general populous in Taiwan; the case must be made as to why Taiwan should build more renewable capacity into the system, and why it's likely that everyone will need to contribute a little more (e.g., in the form of slightly higher electricity bills) to see that Taiwan's renewable energy goals are achieved. Appropriate information and assistance must also be made available to potential investors so that initial barriers or concerns can be overcome and informed investment decisions facilitated.

## 7. Part IV: Interim Conclusion(s) & Key Findings

### 7.1. Current Barriers & Prospects

In an effort to boost renewable generating capacity, Taiwan's government has introduced legislation allowing small scale (household) solar PV investors to sell electricity back to the grid via a FIT. To date, however, progress has been slow in developing this sector of Taiwan's renewable energy market, due in part to repeated changes to supporting legislation and the types of economic barriers and administrative issues which we may briefly summarize as follows;

- Administrative Barriers in the form of a complicated and time-consuming applications procedure have slowed progress to date. This is most obviously evidenced by the (large) number of applications received versus (very few) projects completed and selling electricity via the FIT. Indeed, the apparent (strong) demand from solar PV investors – and a potential expansion in the costs of the scheme – may have been one reason why the government decided to apply the (legislative) brakes
- Market-based (economic) Barriers: based on the findings in Part II of this thesis, it appears that administrative obstacles are not the only thing which could pose difficulties for Taiwan's fledgling solar PV market. The lack of adequate financial support (via the FIT) means that the average household investor won't break even on their investment inside 20 years. Indeed, when compared to other countries, and in particular its close Asian neighbours in South Korea and Japan, financial incentives (including subsidies for equipment costs) for renewable investors in Taiwan are significantly less generous.
- Market-based (systemic) Barriers: this thesis makes the case that the types of legislative, administrative, and financial barriers facing new market entrants are indicative of systemic and harder to negotiate issues. These include, for example,

established energy supply and consumption patterns and a dependence on low electricity prices to power the nation's most energy intensive industries. Part III outlines a number of additional reasons why the domestic solar PV market in Taiwan has been slow to take-off, but focuses mainly on the additional costs that Taipower and the government would incur following a significant expansion of renewable (or solar PV) capacity. These additional costs, which would have to be passed on in one form or another, could signal higher electricity and energy prices in the future. This thesis contends that the flow-on political and economic effects of such a scenario may also preclude the government from making these readjustments.

## 7.2. Key Recommendations

Part III also presents a range of strategies or solutions that *could* be adopted to help facilitate the dissemination of solar PV capacity and stimulate domestic investment. In order to facilitate this dissemination, the government should immediately take steps to both stabilize the market and make investment in solar PV a more attractive proposition for both local and overseas investors.

In an ideal world, these measures (see below) would be undertaken in conjunction with more broad-reaching economic, industrial, and environmental policies, so as to accelerate the transformation of Taiwan's energy market and remove some of the more systemic barriers to its diversification and 'decarbonisation'.

- Immediately revise the FIT upwards to approximately NT\$12.6 per KWh for small scale (household) investors and/or reinstate the capital subsidy; additional financial inducements might include providing access to low or no interest loans (thereby offsetting the impacts of variable discount rates) and tax credits – regardless of which policy (or combination of policies) is employed, the overall goal should be to guarantee a return for solar PV investors, regardless of the size

of the application, well within the 20 year timeframe of an electricity procurement contract with Taipower.

- Simplify the current administrative and approvals process in order to reduce lead times for new projects and improve market stability; the current figures indicate that very few (if any) small-scale solar projects have met with approval and begun selling electricity since the Act was first ratified in 2009. This scenario risks harming investor sentiment and confidence in the government's renewable energy development plans. In resolving this issue Taipower (as the gatekeeper for all new applications) and the BOE, together, must be more efficient and transparent in how they handle new applications and new grid-connections.
- Removing the cap on renewable developments from existing provisions found in the Act, while at the same time introducing minimum installed capacity targets (and completion dates) for a broad basket of renewable technologies. Article Five of the Draft, similarly, which grants the BOE (and its overseeing body, the MOEA) the power to delay, or halt altogether the progress of new renewable developments must be scrapped or modified; this should be done to avoid the highly undesirable scenario of a small scale (household) PV investor commencing or completing work on an installation and then finding themselves unable to sell electricity via the FIT scheme.
- Consider a high-level review of Taiwan's renewable and solar PV development strategy; this might include an appraisal of which area(s) of the market Taiwan is best positioned to exploit, strategies for reducing current administrative, planning, and regulatory barriers, and a realistic assessment of the level of economic support required to stimulate investment and uptake of renewable technology. In carrying out the recommendations of such a review, the government and its relevant agencies should aim to build collaborative relationships with a range of stakeholders, including city and county-level governments, industry, renewable energy and advocacy groups, and the Taiwanese public.

## 8. Reference Materials

- Bureau of Energy (BOE) 2011, *Renewable energy FIT rates for 2011 (100 年度各類別再生能源躉購費率)*, Ministry of Economic Affairs, Taiwan (ROC), viewed 2 February 2011:  
[http://www.moeaboe.gov.tw/Policy/Renewable/news/SENewsDetail.aspx?serno=01068&TYPE\\_KIND=News](http://www.moeaboe.gov.tw/Policy/Renewable/news/SENewsDetail.aspx?serno=01068&TYPE_KIND=News)
- Bureau of Energy (BOE) 2010a, *Energy statistics handbook 2009*, Ministry of Economic Affairs, Taiwan (ROC).
- Bureau of Energy (BOE) 2010b, *Adjustment to FIT contract arrangements for solar PV applications (太陽光電躉購費率修正為[完工日]之措施說明)*, Ministry of Economic Affairs, Taiwan (ROC), viewed 28 February 2011:  
<http://60.251.181.242/news.asp?date=20101220&idx=1>
- Castello, S, De Lillo, A, Guastella, S, & Paletta, F 2010, *National Survey Report of PV Power Applications in Italy 2009*, International Energy Agency Co-operative Program on Photovoltaic Power Systems.
- Carbon Trust 2006, *Policy frameworks for renewables: analysis on policy frameworks to drive future investment in near and long-term renewable power in the UK*, The Carbon Trust and L.E.K. Consulting, London.
- CEC 2008, *Proposal for a directive of the European Parliament and of the Council on the promotion of use of energy from renewable sources*, Commission of the European Communities, viewed 4 May 2011:  
[http://ec.europa.eu/energy/climate\\_actions/doc/2008\\_res\\_directive\\_en.pdf](http://ec.europa.eu/energy/climate_actions/doc/2008_res_directive_en.pdf)
- Durrtschmidt, W, van Mark, M 2007, *Background Information on the EEG Progress Report 2007*, Federal Ministry for the Environment, Nature Conservation, and Nuclear Safety, viewed 30 April 2011:  
[http://www.erneuerbare-energien.de/files/english/pdf/application/pdf/eeg\\_kosten\\_nutzen\\_hintergrund\\_en.pdf](http://www.erneuerbare-energien.de/files/english/pdf/application/pdf/eeg_kosten_nutzen_hintergrund_en.pdf)
- Hsu, C 2009, 'Commission proposes new energy, emissions taxes', *Taipei Times*, October 20, p.1.

- Huang, Y, Bor, J, Peng, C 2010, 'The long-term forecast of Taiwan's energy supply and demand: LEAP model application', *Energy Policy*, doi:10.1016/j.enpol.2010.10.023
- International Energy Agency (IEA) 2010a, *Trends in Photovoltaic Applications: Survey Report of Selected IEA Countries Between 1992 and 2009*, Photovoltaic Power Systems Programme (PVPS), viewed 10 November 2010:  
[http://www.iea-pvps.org/fileadmin/dam/public/report/statistics/tr\\_2009\\_neu.pdf](http://www.iea-pvps.org/fileadmin/dam/public/report/statistics/tr_2009_neu.pdf)
- International Energy Agency (IEA) 2010b, *Statistics: CO<sub>2</sub> emissions from fuel combustion highlights 2009 edition*, viewed 9 August 2009:  
<http://ccsl.iccip.net/co2highlights.pdf>
- International Energy Agency (IEA) 2010c, *Key world energy statistics 2009*, viewed 9 August 2009: [http://www.iea.org/textbase/nppdf/free/2009/key\\_stats\\_2009.pdf](http://www.iea.org/textbase/nppdf/free/2009/key_stats_2009.pdf)
- International Energy Agency (IEA) 2008, *Deploying renewables: principles for effective policies*, viewed 4 May 2011:  
<http://www.iea.org/textbase/nppdf/free/2008/DeployingRenewables2008.pdf>
- International Energy Agency (IEA) 2003, *Creating markets for energy technologies*, OECD/IEA.
- Jacobsson, S, Bergek, A, Finon, D, Lauber, V, Mitchell, C, Toke, D, & Verbruggen, A 2009, 'EU renewable energy support policy: faith or facts?', *Energy Policy*, 37, pp. 2143 – 2146.
- Liou, H 2010, 'Policies and legislation driving Taiwan's development of renewable energy', *Renewable and sustainable energy reviews*, 14, pp.1763-1781.
- Loa, L 2010, 'Danger to nuclear power plant sparks war of words', *Taipei Times*, 23 September, p.3.
- Mendonca, M, Jacobs, D, Sovacool, B 2010, *Powering the green economy: the feed-in-tariff handbook*, Earthscan, London.
- Ministry of Economic Affairs (MOEA) 2011a, *Draft Amendments for Renewable Energy Installations Approvals Process (再生能源發電設備認定辦法修正草案總說明)*, Taiwan (ROC), viewed 26 March 2011:  
<http://60.251.181.242/09920091230.pdf>

- Ministry of Economic Affairs (MOEA) 2011b, *Economic growth rate by industry*, Department of Statistics, Taiwan (ROC), viewed 26 March 2011:  
<http://2k3dmz2.moea.gov.tw/gnweb/English/Indicator/wFrmEnIndicator.aspx>
- Ministry of Economic Affairs (MOEA) 2010, Renewable energy policy directions, decision making, and implementation (再生能源之政策方向, 決策流程及執行情形), Taiwan (ROC), unpublished report, 23 December 2010.
- Ministry of Economic Affairs (MOEA) 2009, *Act Governing the Development of Renewable Energy* (再生能源發展條例), Taiwan (ROC).
- Ministry of Economic Affairs (MOEA) 2008, *Framework of Taiwan's Sustainable Energy Policy*, Taiwan (ROC), viewed 8 July 2010:  
[http://www.moea.gov.tw/Mns/english/content/ContentLink.aspx?menu\\_id=196&sub\\_menu\\_id=3886](http://www.moea.gov.tw/Mns/english/content/ContentLink.aspx?menu_id=196&sub_menu_id=3886)
- Ragwitz, M, Held, A, Resch, G, Faber, T, Huber, C, & Haas, R 2006, *Monitoring and evaluation of policy instruments to support renewable electricity in EU member states*, Fraunhofer Institute Systems and Innovation Research, Frieberg, viewed 4 May 2011:  
[http://www.erneuerbare-energien.de/files/erneuerbare\\_energien/downloads/application/pdf/isi\\_zwischenbericht.pdf](http://www.erneuerbare-energien.de/files/erneuerbare_energien/downloads/application/pdf/isi_zwischenbericht.pdf)
- REN 21 2010, *Renewables 2010 global status report*, Renewable Energy Policy Network for the 21<sup>st</sup> Century, viewed 4 May 2011:  
[http://www.ren21.net/Portals/97/documents/GSR/REN21\\_GSR\\_2010\\_full\\_revised%20Sept2010.pdf](http://www.ren21.net/Portals/97/documents/GSR/REN21_GSR_2010_full_revised%20Sept2010.pdf)
- Taipei Times* 2010, 'Activists mull coming of age of nuclear power', 10 September, p.3.
- Taiwan Power Corporation 2010, *Taiwan Power electricity procurement requirements* (台電力股份有限公司再生能源電能收購作業要點), viewed 28 February 2011:  
[http://www.taipower.com.tw/TaipowerWeb//upload/files/14/main\\_3\\_1\\_9\\_2.pdf](http://www.taipower.com.tw/TaipowerWeb//upload/files/14/main_3_1_9_2.pdf)
- Tan, J 2010, 'InfraVest Wind Power to leave Taiwanese market', *Taipei Times*, February 26, p.12.
- Yamamoto, M 2010, *National survey report of PV power applications in Japan 2009*, International Energy Agency Co-operative Program on Photovoltaic Power Systems.

- Yoon, K 2010, *National survey report of PV power applications in Korea 2009*, International Energy Agency Co-operative Program on Photovoltaic Power Systems.
- Wang, F 2009, 'Premier Denies Timetable Exists for Energy Tax', *Taipei Times*, 21 October, p.1.
- Wang, K 2006, 'The de-regulation of Taiwan's electricity supply industry', *Energy Policy*, 24(16), pp.2509-2520.
- Wissig, L 2010, *National Survey Report of PV Power Applications in Germany 2009*, International Energy Agency Co-operative Program on Photovoltaic Systems.

**On-line resources:**

- Bureau of Energy, Ministry of Economic Affairs (homepage),  
<http://www.moeaboe.gov.tw/Default.aspx?group=2>
- Bureau of Energy, Ministry of Economic Affairs (Act Governing the Development of Renewable Energy information portal),  
<http://www.moeaboe.gov.tw/Policy/Renewable/default.html>
- Taiwan Power Corporation,  
<http://www.taipower.com.tw/indexE.htm>
- Currency converter,  
<http://www.xe.com/ucc/>

## 9. Appendices

### 9.1. Appendix A

#### Calculating Solar PV Efficiency in Taiwan:

Total installed solar PV capacity was 9.5MWp in 2009.

Taiwan's installed 9.5MWp capacity produced 8GWh of energy in 2009.

$8\text{GWh per year} \times 3600 \text{ seconds (in an hour)} = 28,800 \text{ GJ/year}$

$28,800 \text{ GJ per year} \div 365 \text{ days} = 78.91 \text{ GJ/day}$

$78.91 \text{ GJ per day} \div 24 \text{ hours} = 3.29 \text{ GJ/hour}$

$3.29 \text{ GJ/hour} \div 3600 \text{ seconds} = 0.000913 \text{ GW or } 0.913 \text{ MW.}$

$0.913 \text{ MW} \div 9.5 \text{ MWp} = 0.096 \text{ or } 9.6\%.$

The average operating efficiency of solar PV in Taiwan (which factors in insolation potential, daily hours of sunlight, and energy lost through conversion) = 9.6%. Raw data supplied by the Bureau of Energy in its annual report (2010).

**9.2. Appendix B: FIT Formula (再生能源電能電躉購費率計算公式) as used by the Pricing Committee.**

$$\text{躉購費率} = \frac{\text{期初設置成本} \times \text{資本還原因子} + \text{年運轉維護費}}{\text{年售電量}}$$

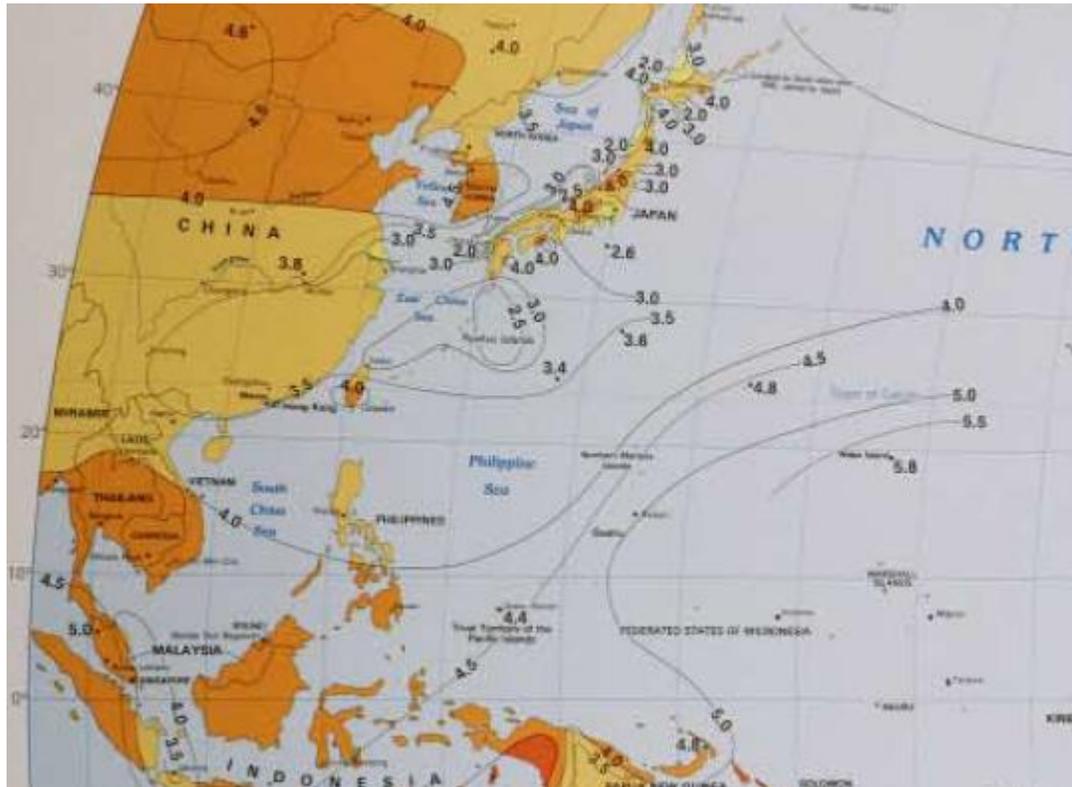
$$\text{資本還原因子} = \frac{\text{折現率} \times (1 + \text{折現率})^{\text{躉購期間}}}{(1 + \text{折現率})^{\text{躉購期間}} - 1}$$

$$\text{年運轉維護費} = \text{期初設置成本} \times \text{年運轉維護費占期初設置成本比例}$$



### 9.3. Appendix C: Regional Solar Insolation Potentials

#### N-E Asia



# Europe

