SEMI® WHITE PAPER

Advancing a Sustainable Solar Future

SEMI PV Group Policy Principles and Recommended Best Practices for Solar Feed-in Tariffs

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EXECUTIVE SUMMARY

This White Paper is intended to promote widespread awareness and understanding of public policy best practices in support of solar energy.

The PV Group is a SEMI special interest group dedicated to serving the global PV manufacturing supply chain. The PV Group's mission is to help lower costs for PV energy and foster the growth and profitability of SEMI members serving this essential industry. In pursuit of this goal, this White Paper was authorized by the SEMI Board of Directors, and produced under the guidance of members and Regional Advisory Groups from around the world.

The public policy principles that the PV Group hopes to advance with the White Paper include: stability and predictability to encourage private investment; transparent and streamlined policies to promote fair and honest outcomes; and open and accessible policies to enable distributed energy production. While other policy options are available that would meet these policy principles, this White Paper is focused on the best practices that would enable feed-in tariffs to be an effective approach to advance solar energy in most markets around the world.

The SEMI PV Group supports the development of feed-in tariffs as the most effective means to ensure sustained growth for the PV industry and rapidly realize the benefits of large-scale solar energy deployment. The PV Group believes that national feed-in tariffs are an optimum policy solution, and that feed-in tariffs should be tailored to the specific context and objectives of the country that is implementing them. Feed-in tariff design should take historical PV policy and market development experience into account and be benchmarked against both the policy principles and best practices described in this report. The continued spread of national feed-in tariffs that are stable, transparent, and substantial will fuel the rapid PV market growth the world requires and support new investment in the emerging solar economy.

Feed-in tariffs are also versatile in that they can be successfully integrated with existing polices such as rebates, renewable portfolio standards, tradable renewable energy credits, net metering, and tax credits. While there may be practical and pragmatic barriers to feed-in tariffs in some regions—and in these situations other policy options may be preferable to performance-based incentives—this set of characteristics has made feed-in tariffs an attractive policy solution for many national, state, and local governments.

The proliferation of feed-in tariffs is creating a common global policy language for the PV industry, and the PV Group is pleased to join other industry organizations that support feed-in tariffs, such as the International Solar Energy Society (2009), the European Photovoltaic Industries Association (2005), Solar Alliance (2009) and many others. Although there is an emerging consensus about the benefits of feed-in tariffs, it is important to note that feed-in tariff design varies widely from country to country. Today, no two feed-in tariff policies are exactly alike, and it is difficult to generalize about the structure and impact of feed-in tariff policies. However, this diversity of policy design and experience reveals a set of best practices against which future policy development can be benchmarked. The best practices encouraged by the White Paper include support for technology differentiation, generation cost-based rates, fair purchase and interconnection requirements, use of fixed price and long-term payments, and the use of predictable incentive declines.

INTRODUCTION

During the past decade, the global photovoltaics (PV) market has grown at rates typically associated with the personal computer and cellular phone industries, rather than the power sector. Over 5.5 gigawatts (GW) of PV were installed in 2008 alone, bringing the total global installed capacity to 14.7 GW—a fifteen-fold increase over the total amount installed a decade earlier (Fontaine, et al., 2009). Although the near-term growth path for PV is uncertain given the financial crisis and shifting market conditions, analysts have projected that 2012 installations could range anywhere from 11 GW to 53 GW (Jennings, 2008). The spread between these projections is attributable to a broad range of factors including manufacturing capability, raw material supply, conversion efficiency improvements, fossil fuel price trends, and government policy. The challenge for the global PV community as it navigates the recession will be to effectively coordinate the resources of industry, government, and the marketplace to enable the market to return to a strong, predictable, and sustainable growth trajectory.

As the PV market matures, the industry must mature alongside it. In the 2008 White Paper, *The Perfect Industry—the Race to Excellence in PV Manufacturing*, the SEMI PV Group (2008) laid out a set of principles to ensure and guide the growth of the PV industry in the near- and long-terms. These include:

- development of global manufacturing standards to ensure sustained profitability;
- adoption of corporate responsibility strategies to promote sustainable development;
- adherence to market and business practices that will enable a truly global industry; and
- creation of the market, workforce, and policy conditions necessary to support long-term growth.

At the core of the PV Group's vision is a recognition that the ultimate objective of the solar industry is to reduce "the world's dependence on fossil fuels and…the dangers of global warming." Given the principles set forth in the White Paper and the critical stakes involved with the success of the global PV industry, the PV Group concludes that "the overwhelming responsibility for the PV manufacturing supply chain is to deliver the lowest cost per kWh to the user." Unlike many electricity generation technologies, the cost per kWh of solar electricity is not driven by the price of fuel—sunlight is free. The key technical challenge to the solar economy of the future, therefore, is to reduce the costs associated with PV manufacturing and installation through improved process efficiency and automation, materials improvements, and cost reductions that result from economies of scale, while maintaining or enhancing lifetime energy yields from systems.

Manufacturing expansions and efficiency improvements require significant investments. New polysilicon manufacturing plants, for example, can cost from $500 million to well over $1 billion to build, and it has been estimated that the amount required to finance the growth projected through 2012 could range from $15 billion up to $67.9 billion (Jennings, 2008). In order to realize this level of investment, the global industry will need to work with financial and public sector partners to create stable and durable markets. Targeted and well-structured government policy incentives will be critical for accomplishing this goal. In this White Paper, the PV Group explores international PV incentives and identifies policy designs to create steady demand, support long-term industry growth, and ensure sustained profitability for the global PV industry.

DEFINING POLICY FOR THE PERFECT INDUSTRY

PV Policy Principles

At present, the vast majority of the global PV market is grid-connected. Since PV is not currently competitive with retail or wholesale electricity in most parts of the world, many governments provide market support through fiscal and regulatory instruments such as tax incentives, rebates and grants, loan programs, mandatory targets, premium prices for PV-generated electricity, and research and development funds. The regulatory landscape has evolved constantly during the last 30 years, and PV incentives have been implemented in a broad range of combinations and iterations. The most robust policy regimes, however, have demonstrated the same general set of characteristics, which provide a useful set of principles against which to evaluate PV incentive programs.[1] Generally speaking, successful incentives are:

Sufficient to Drive Predictable Demand. The incentives need to be substantial enough to affect fundamental market transformation, and drive PV technology costs down their experience curves. Historically, PV prices have dropped 20% for every doubling of installed power generating capacity (Poponi, 2003). Although module prices tracked upwards during the middle of this decade, primarily as a result of silicon shortages (Flynn & Bradford, 2006), shifting global market conditions have enabled supply to catch up with demand, resulting in a projected 43% decrease in PV module prices in 2009 (Greenwood, et al., 2009). In addition to sufficiency of demand, predictability of demand is also required to ensure that market growth to be within a range of growth rates viewed as desirable.

Stable and Predictable. Policy stability is critical to creating sustained PV market growth. Policies must be in place for a long enough period of time to attract investments in manufacturing and the development of a mature industry. Moreover, the "rules of the game" need to be clearly and believably established such that any changes or alterations in the policy can be understood and anticipated ahead of time. The prospect that the policy will be frequently revisited or subject to sudden change (or reversal) can deter strategic investments and create barriers to entry for developers and investors.

1 These principles are similar to those identified through efforts such as the International Energy Agency's *Deploying Renewables: Principles for Effective Policy* (Ölz, 2008), and through concepts such as Sustained Orderly Development and Commercialization of PV (Osborn, et al., 2005).

Transparent and Streamlined. Policies should be clearly defined and simple to understand. Transparent policies allow a broad range of market participants (including individuals) to easily assess risks and make investment decisions. Overly complex policies can increase project development timelines, decrease the pool of potential capital providers, and ultimately increase financing and policy costs unnecessarily. Closely related to this is the complexity and duration of the process required to access the incentive. Even if a policy is fairly straightforward to understand, the existence of unduly onerous applications, paperwork, approvals, etc. can create a barrier to market growth and a deterrent to investment (Lüthi & Wüstenhagen, 2009).

Accessible. The globalization of the PV industry has occurred at an extremely rapid rate during the past decade. Whereas component manufacturing was concentrated in a relatively few regional markets a few years ago, PV modules from around the world now trade freely on the open market. Consistent with the PV Group's commitment to support the development of a truly global industry, sound PV policy should be neither discriminatory nor protectionist. Policies that attempt to narrowly target outcomes such as domestic content or employment will undermine the primary objectives of fossil fuel replacement, solar power cost reduction, and solar power grid parity

Programmed to Sunset. PV incentives should be structured with a transition to grid parity in mind. Several of the leading global markets have attempted to achieve this[2] by building steady decreases into their PV incentive levels in order to both put continual downward pressure on PV prices, and to lower policy costs.

Finally, the recent financial crisis has brought another characteristic of successful policies into sharp focus: the ability to attract investment. The tightening of credit markets globally and the emergence of region-specific financial challenges, such as the contraction of tax equity in the United States, has inspired a re-evaluation of policies according to the ease with which they can be financed (Fritz-Morgenthal, et al., 2009; Schwabe, et al., 2009). Moving forward, incentives should be developed with the financial markets in mind—they should be designed to mitigate identifiable financial risks (thereby lowering financing costs), and structured to attract a diverse set of competitive capital providers.

Replicating Global Best Practices

When surveying global solar energy incentives, the policy that most closely matches the principles laid out in the section above is the feed-in tariff. Generally, feed-in tariffs are renewable electricity policies that typically guarantee renewable generators both a long-term, performance-based payment for electricity at a premium price, and interconnection to the grid (i.e. the right to "feed-in" electricity).

Feed-in tariffs have driven the majority of global PV installations to date as a result of their use in key European markets such as Germany and Spain. The impact of European feed-in tariffs has inspired the adoption of similar regulations by countries around the world, and feed-in tariffs are currently the most widespread national renewable energy policy. According to the REN21 Renewables Global Status Reports, there were 37 countries with feed-in tariff policies by the end of 2007 (Martinot, 2008). By 2008, the number of national feed-in tariff policies had grown to 45 (Martinot & Sawin, 2009). As will be discussed in Section 3, momentum for feed-in tariff policies has continued to grow in 2009, with India, South Africa, and the United Kingdom among the new countries that have announced feed-in tariffs for solar power.[3]

Feed-in tariffs have spread around the world not only because they have promoted rapid expansion of a broad portfolio of renewable resources, but because they have also been able to do so at a relatively low cost. Empirical studies in the European Union and elsewhere have demonstrated that feed-in tariffs, in the words of the Stern Review on the Economics of Change (2006), "achieve larger deployment at lower costs" than other policy types. As will be discussed in greater detail below, the stable, long-term revenues afforded by feed-in tariffs create a low-risk investment environment that reduces the cost of capital required to finance renewables, and reduces policy costs as a result. Moreover, feed-in tariffs are cash payments, rather than tax credits, and so they can be readily financed by a broader range of entities using debt, rather than tax equity (which is more expensive). Feed-in tariffs also minimize or eliminate transaction costs such as contract and interconnection negotiations and bid preparations that may prohibit smaller projects from moving forward. In other words, feed-in tariffs can provide an opportunity for diverse groups of investors, homeowners, and businesses to cost-effectively invest in, build, and reap the benefits of renewable energy installations. Feed-in tariffs are also versatile in that they can, and have been, successfully integrated with existing polices such as rebates, renewable portfolio standards, tradable renewable energy credits, net metering, and tax credits. This set of characteristics has made feed-in tariffs an attractive policy solution for many national, state, and local governments around the world.

The proliferation of feed-in tariffs is creating a common global policy language for the PV industry, and the SEMI PV Group is pleased to join other industry organizations that support feed-in tariffs, such as the International Solar Energy Society (2009), the European Photovoltaic Industries Association (2005), the Solar Alliance (2009), and many others. Although there is an emerging consensus about the benefits of feed-in tariffs, it is important to note that feed-in tariff design varies widely from country to country. During the 20 years since national feed-in tariffs were first enacted in Denmark and Germany, feed-in tariff design has steadily evolved as early adopters have revised

2 E.g. Germany, Japan, and California.

3 It is important to note that feed-in tariffs can, and have been, successfully implemented in developing countries. In crafting feed-in tariffs for the developing world, policy design must take into account both available grid infrastructure and national economic conditions. Developing countries may require additional support for national feed-in tariffs, such as feed-in tariffs coupled with the Clean Development Mechanism, the use of feed-in tariff caps that are tailored to specific resource and economic conditions, and the creation of funds supported by multi-lateral international donor organizations to help pay for feed-in tariff costs (Mendonça, et al., 2009).

their existing policies, and other countries have adapted feed-in tariffs to their own unique contexts. Today, no two feed-in tariff policies are exactly alike, and it is difficult to generalize about the structure and impact (and success or failure) of feed-in tariff policies. However, this diversity of policy design and experience reveals a set of best practices against which future policy development can be benchmarked.

There have been a number of recent efforts to catalogue and evaluate feed-in tariff design practices by organizations such as the International Feed-in Cooperation in Europe (Klein, et al., 2007), the National Renewable Energy Laboratory and the California Energy Commission in the U.S. (Couture & Cory, 2009; Grace, et al., 2008), the World Future Council and others (Mendonça, 2007; Mendonça, et al., 2009). Rather than restate the work of these reports, the sections below provides short overviews of the practices that are most important to enabling sustained solar energy industry growth.

Technology Differentiation

Climate stabilization will require that a full suite of renewable energy technologies be deployed in the coming decades. Recent studies have concluded that not only is it necessary to drive current renewable technologies down their cost-curves simultaneously, but that it will also be cheaper, in the long run, to do so (Huber, et al., 2004; Ölz, 2008). To achieve this goal, feed-in tariffs need to be tailored to target different technologies with specific rates. Policies that offer a single payment rate to all technologies—such as the current feed-in tariff in California—have not created diverse generation portfolios that include solar electricity.

Generation Cost-Based Rates

A clear best practice for feed-in tariff designs that are intended to support solar market growth is that the feed-in tariff rate should reflect the specific generation cost of PV, plus a reasonable profit. This ensures that the incentive level will be sufficient to drive demand. Accurately set, cost-based rates reduce price risk for developers, increase revenue certainty, reduce financing costs, and attract a broader base of investors. The majority of Europe's feed-in tariffs are, and have been, based on generation cost. A notable exception was Germany's early feed-in tariff, the *Stromeinspeisungsgesetz* (StrEG), which was in place from 1991 to 2000. The StrEG was technologically differentiated, but the payments were based on retail electricity rates,[4] which were insufficient to drive PV investment. While the national StrEG did not stimulate the PV market, German municipal utilities in cities such as Hammelburg and Aachen developed their own generation cost-based feed-in tariffs for solar power in 1993, which successfully drove local markets (Solarenergie-Förderverein, 1994). The practice spread rapidly among German municipal utilities and was eventually adopted at the national level with the passage of the revised feed-in tariff of 2000 (the *Erneuerbare-Energien-Gesetz* or EEG).

Basing PV incentive rates on generation cost also helps level the playing field with heavily-subsidized fossil fuel generation. The United Nations Environment Programme (United Nations Environment Programme, 2008) estimates that "worldwide, energy subsides…amount to $300 billion per year, or around 0.7 percent of world GDP, most of which go to fossil fuels." In the United States, a recent study found that fossil fuels received $72.5 billion in subsidies between 2002 and 2008, whereas non-ethanol renewables received just $12.2 billion during the same period (Environmental Law Institute, 2009). Generation-cost based rates avoid the need to index PV incentives to artificially low fossil fuel prices. As solar energy reaches grid parity, a generation-cost-based FIT may be lower than the retail price for electricity. In that case, feed-in tariffs should be programmed to sunset and polices to transition net metering should be in place.

Purchase and Interconnection Requirements

Feed-in tariffs are powerful policies not only because they guarantee a known price and mitigate revenue risk, but also because they typically require that solar electricity generators must be connected to the grid, and that any electricity fed onto the grid must be purchased. These "must-take" requirements limit the market power that individual stakeholders or interests might otherwise unduly exercise, and can significantly increase investor security by reducing market and operating risks.

Fixed Price Payments

Fixed price payments, especially when paired with long-term, generation cost-based payments can significantly lower investment risk and policy cost. According to recent analysis from the International Energy Agency (de Jager & Rathmann, 2008), the low risk profile of fixed price feed-in tariff policies can reduce financing costs by 10–30%. Specifically, the IEA states that "Countries with feed-in tariff schemes…are believed to have already realised a significant part of this reduction potential for…solar photovoltaic energy (e.g. more than 20%)." Premium payment feed-ins, under which generators receive a payment on top of the market price for power, have also been effective in driving PV markets, but provide less certainty to both investors and policy makers than fixed incentive levels (Couture & Gagnon, in press).

Long-Term Payments

Since PV systems have service lives of 25–30 years and beyond, long-term feed-in tariffs are advantageous for several reasons. First, longer-term payments allow the generation cost of PV systems to be amortized over a greater number years, enabling lower feed-in tariff rates and accelerating the timeline on which the hedge value of PV can be captured as electricity prices rise. Second, long-term payments more closely align with the service lives of PV systems, thereby reducing the risks associated with re-contracting after the feed-in tariff term ends.

Predictable Declines

There are many different approaches to adjusting and revising feed-in tariff rates over time. Some feed-in tariffs adjust automatically[5] after a certain period of time or after a certain capacity target is hit, some feed-in tariffs are adjusted only

4 Both wind and solar power were eligible for a payment set at 90% of the average retail rate of electricity.

5 It is important to note that adjustment in this case refers to the adjustment of the long-term rates available for a few installed systems from one year to the next. Once a generator is locked into a feed-in tariff rate, that rate should not significantly change.

after review by policy makers, and some combine automatic adjustments with periodic reviews. Of these options, adjustment schedules that occur after a certain period of time are preferable because they are more transparent and predictable than capacity-based declines or frequent review by policy makers. Although feed-in tariffs can be both adjusted upward and downward, the overall trend should be downward in order to place pressure on PV prices. The most notable example of downward tracking feed-in tariff rates for solar power is in Germany, where the German solar energy industry association (Bundesverband Solarwirtschaft) projects that the rate of decline, or "degression," embedded in the feed-in tariffs will bring PV to grid parity between 2012 and 2015 (see Figure 1).

From an investment perspective, declining incentives should not introduce undue risk if they are based on sound market and experience curve data. A recent survey of the banking industry, for example, determined that banks consider, "The principle of degression…a sound means to motivate increases in productivity and decreases in costs (Diekmann, et al., 2008)."

INVESTOR SECURITY: Predictability, Stability, and Durability

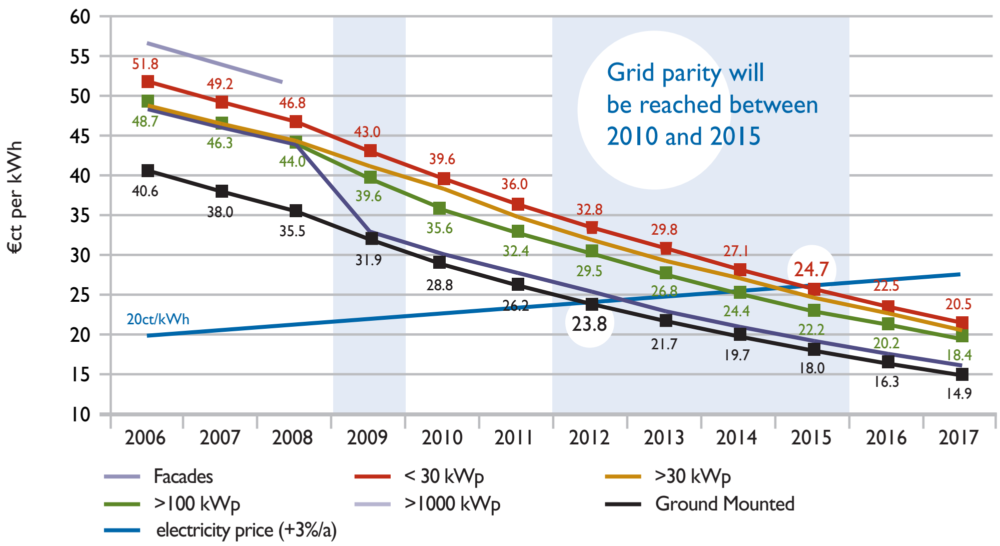
The set of feed-in tariff design characteristics described above conform closely to the policy principles outlined in Section 2.1, and their practical application around the world has generated impressive empirical results. There is now broad consensus among both the renewable energy policy making and the financing communities that feed-in tariffs are one of the most powerful solar energy policy tools available. In a comprehensive review of European Union renewable energy policies, the European Commission (2005) concluded that feed-in tariffs were not only the most effective policy for driving renewable markets, but were also the most cost-efficient because of their ability to minimize financial risk premiums, and therefore policy costs. These findings have been echoed in studies by the Stern Review (2006) and by the International Energy Agency (Ölz, 2008).

The ability of feed-in tariffs to attract low-cost capital from a broad range of different investor types has become even more important in the wake of the financial crisis. Renewable energy financing became more difficult (and more expensive) to source in nearly every PV market. The impacts have not been as severe in markets with feed-in tariffs, however, as they have been in markets that rely either on tax policy (and therefore a small base of tax equity investors) or on variable, high-risk incentives such as tradable credits (Guillet & Midden, 2009). A recent Deutsche Bank Group study found, for example, that countries with the lowest investment risk profiles for climate change and renewable energy investment are those that have strong incentives in place, and that "appropriately-designed and budgeted feed-in tariffs have demonstrated their ability to deliver renewable energy at scale" (DB Climate Change Advisors, 2009). The U.S., by contrast, was considered a moderate risk country due to its more unstable market, which has historically suffered from boom/bust cycles as a result of relying on policies such as short-term tax credits.

Another recent study by the United Nations Environment Programme's Sustainable Energy Finance Initiative (Fritz-Morgenthal, et al., 2009) reviewed the impacts of the financial crisis on the renewable energy industry found that "a clear majority" of the infrastructure providers, commercial bankers, and multilateral financial institution representatives viewed feed-in tariffs as the most effective for promoting renewable energy. A similar survey of private equity fund managers also returned the same results, with the majority of survey respondents ranking feed-in tariffs "higher than any other policy option provided" in terms their ability to inspire investment "in innovative clean energy technologies (Bürer & Wüstenhagen, in press)."

The simplicity, transparency, and certainty of feed-in tariffs can enable strong PV market growth. An important emerging issue, however, is the durability of feed-in tariff policies.

Figure 1 **Feed-in Tariffs for PV within the German Feed-in Tariff, Based on Degression Rates Decided on June 6th, 2008)**



Source: Gerhard Stryi-Hipp, Fraunhofer Institute for Solar Energy Systems ISE

Whereas revenue certainty enables low-risk investments at the project level, the perceived long-term viability of a given policy regime is what creates the conditions for larger-scale, strategic industry investments such as new market entry or expanded manufacturing. On the one hand, policy incentives are necessary to level the playing field with subsidized fossil fuels, and unlock the broad range of benefits of solar energy.[6] On the other hand, the creation of policy incentives inherently creates regulatory risk because whatever policy makers create, they can also take away.

In designing feed-in tariffs, it is not enough to create generous, long-term feed-in tariff payments—it is important to consider the stability and viability of the proposed policy. Recent research suggests that the perception of potential policy instability can outweigh the potential gain of higher feed-in tariff rates when industry investors are evaluating whether to enter a new solar market (Lüthi, 2008).

POLICY FLEXIBILITY

During the past decade, PV feed-in tariffs established a track record of being both stable and durable. After Germany revised its feed-in tariff in 2004, some analysts questioned the extent to which such a generous policy would be politically viable over the long-term (e.g., Rogol & Fisher, 2005), but most concluded that it would be difficult to significantly scale back the German feed-in tariff given strong public support and the political strength of the renewable energy industry. More recently, with the scaling back of the Spanish feed-in tariff and discussions in Germany about lower PV rate under the new government, some industry analysts have expressed anxiety about the durability of PV feed-in tariff regimes (Simonek & Chase, 2009). In general, such studies focus solely on the projected costs of feed-in tariff policies, and do not include an accounting of the significant wholesale electricity price savings generated by feed-in tariffs (Sensfuß, et al., 2008), or the significant environmental, societal, and economic development benefits that accompany rapid solar market growth. These benefits have been included in the calculus of the governments of both Germany and Spain,[7] and both countries appear committed to maintaining feed-in tariffs for photovoltaics.

Nevertheless, the shifting global market conditions and recent declines in PV module prices and installed costs have prompted evaluations of PV policy flexibility. There are a variety of approaches to feed-in tariff flexibility beyond the system of degression and periodic review employed by Germany's 2000 and 2004 feed-in tariffs. Both Germany and Spain are currently implementing more market-reactive adjustment mechanisms that accelerate or decelerate degression based on how much PV capacity was installed in a given year. For each increment that market growth exceeds expectation, the degression rate for the next year increases by a proportional amount. If market growth in Germany is higher than defined in a corridor, the digression rate might increase by 1% (from 8% to 9% for systems up to 100 kWp and 10% to 11% for systems above 100 kWp in the year 2010 if the market is bigger than 1,500 MWp and in the year 2011 if the market is bigger than 1,700 MWp). Spain has also implemented a form of flexible degression in the wake of its policy transition (Jacobs & Pfeiffer, 2009). Other jurisdictions have taken approaches, such as rates that decline automatically when a certain capacity amount is reach, or annual or overall caps.[8]

The issues of policy flexibility and durability will continue to evolve along with the solar market as policy makers seek to strike a balance between policy predictability and the ability of feed-in tariffs to react to changing market conditions. Ultimately, the approach to feed-in tariff flexibility will depend on the policy objectives in each individual country. In Spain, for example, the government has capped the market at 500 MW per year—still a significant amount of annual PV capacity. In Germany, meanwhile, it appears that the new government will continue to leave the PV market uncapped and will not lower the PV feed-in tariff dramatically. The experience in both countries can serve as important benchmarks as other countries evaluate how to build flexibility and durability into new generations of feed-in tariffs.

CONCLUSION

The SEMI PV Group supports the development of feed-in tariffs around the world as the most effective means to ensure sustained growth for the PV industry and rapidly realize the benefits of large-scale solar energy deployment. Although there have been recent calls for a global feed-in tariff regime,[9] SEMI PV Group believes that national feed-in tariffs are the optimum solution, and that feed-in tariffs should be tailored to the specific context and objectives of the country that is implementing them. Feed-in tariff design should take historical PV policy and market development experience into account and be benchmarked against both the policy principles and best practices described in this report. The continued spread of national feed-in tariffs that are stable, transparent, and substantial will fuel the rapid PV market growth that the world requires and support new investment in the emerging solar economy.

The PV Group understands there are practical and pragmatic limitations to feed-in tariffs in some regions and there are other policy options available to encourage solar power generation. In these cases, the PV Group supports policy options that conform to the principles that are sufficient to encourage predictable demand, encourage stability and predictability to encourage private investment; that are transparent and streamlined to promote fair and honest outcomes; and are open and accessible policies to enable distributed energy production.

6 For a discussion of the environmental and energy service benefits of photovoltaics, ***see e.g.*** (Contreras, et al., 2008; Letendre & Perez, 2006; Watt, 2001).

7 See, e.g. BMU (2009).

8 Caps and capacity declines must be carefully designed, however, in order to prevent "phantom" projects that may never be built from holding a place "in line." A discussion of feed-in tariff queue structure and management can be found in (Grace, et al., 2008).

9 The United Nations, for example, recently suggested a global feed-in tariff program that would be designed to "ensure a level playing field for all competing technologies and on-grid and off –grid operators and benefit targeted low-income consumers (Ahmad, et al., 2009)."

A SURVEY OF INTERNATIONAL SOLAR ENERGY FEED-IN TARIFF POLICIES

This section provides a high level review of current solar energy feed-in tariffs around the world. As discussed above, new feed-in tariffs are added, and existing feed-in tariff rates are adjusted, each year. This section is intended to be a snapshot, rather than a comprehensive review, of feed-in tariff policies. A brief overview of each continent or region is provided with the most current information available on solar feed-in tariff rates, including bulleted highlights of recent developments. It is important to note that this section focuses on feed-in tariffs for PV that are set within the range of generation cost in order to highlight those policies that are most likely to drive PV market development. Feed-in tariffs that are based on avoided cost, are applied only to net excess generation, or are not tailored specifically to PV are not discussed in detail.

Africa

PV development in Africa has historically been concentrated in off-grid applications, because of the limited grid infrastructure in many parts of the continent. To date, the number of national policies for grid-connected photovoltaics remains limited. Several countries have established feed-in tariffs for renewable energy,[10] but none of these have yet implemented specific PV feed-in tariffs.

- In October, 2009, South Africa announced that it would expand its existing feed-in tariff policy to include a rate for PV systems larger than 1 MW in size, set at 3.94 rand/kWh (€0.356/kWh) (van der Merwe, 2009).
- Several recent studies have also proposed feed-in tariffs for micro-grids in Africa and other parts of the developing world, but none have been implemented to date (Jacobs & Kiene, 2009; Moner-Girona, 2008).

Asia and Australia

During the past ten years, Asia has installed close to 20% of global PV capacity. The majority of these installations have been in Japan, which had installed 2 GW between 1999 and 2008, or approximately 15% of the global total. Recent feed-in tariff policy development activity in China, India, Japan and Taiwan has set the stage for significant possible PV market growth during the next few years.

- Although Japan relied on rebates to drive its PV market for many years, it introduced a net feed-in tariff for onsite PV generators in November, 2009, and the new government has announced its intent to develop a gross feed-in tariff.[11]
- In China, announcements of PV projects totaling 12.5 GW of development by 2020 have been made in recent months, but it remains unclear what type of policy will support this development (Hirshman & He, 2009). China recently established national wind feed-in tariffs, and the province of Jiangsu has established PV feed-in tariffs,[12] but no national PV feed-in tariff has been published to date.
- Taiwan's government passed feed-in tariff legislation on June 12, and the Bureau of Energy released proposed PV rates in September.[13] These rates have not been finalized as of the writing of this report, but the PV rates are scheduled to go into effect in January, 2010.
- In May 2009, India's Central Electricity Regulatory Commission (2009) initiated a regulatory process to develop feed-in tariffs for a range of renewable energy resources, including PV. The regulatory proceedings are ongoing, but it is clear that the PV rates will be based on generation cost over a 25-year contract term.
- Korea is thus far the only country in Asia to have instituted a gross PV feed-in tariff based on generation cost. In 2008, the PV feed-in tariff was set at 677 won/kWh (€0.39/kWh) for systems smaller than 30 kW and 711 won/kWh (€0.40/kWh) for systems larger than 30 kW, with an overall capacity cap of 500 MW by 2011, and an annual cap of 50 MW for 2009. The 2008 tariff supported the development of 276 MW of PV capacity. In 2009, the tariff has been revised to include five size categories, lower prices (428-589 won/kWh), and a choice between 15- and 20-year contract terms (Yoon & Kim, 2009). The annual caps for 2010 and 2011 will be 70 MW and 80 MW, respectively. In 2012, the feed-in tariff is scheduled to phase out in favor of a renewable portfolio standard (Hirshman, 2009c).

Australia has a national renewable electricity target of 20% by 2020, which it currently meets through a system of tradable renewable energy credits. Each of the Australian states and territories, however, is free to develop their own renewable energy policies and several have established feed-in tariff policies.

- Queensland, South Australia, and Victoria have each established net feed-in tariffs which only credit PV systems for excess generation above and beyond what is consumed onsite (Mendonça, et al., 2009).
- Australian Capital Territory (ACT) has established a 20-year gross feed-in tariff of AUS $0.5005/kWh for systems up to 10 kW and AUS $0.4004/kWh for systems up to 30 kW.
- In November, 2009, New South Wales became the second Australian government to establish a gross feed-in tariff for systems. The 7-year tariff of AUS $0.60/kWh for PV systems less than 10 kW can be combined with solar rebate program also available from the state (Hughes, 2009).

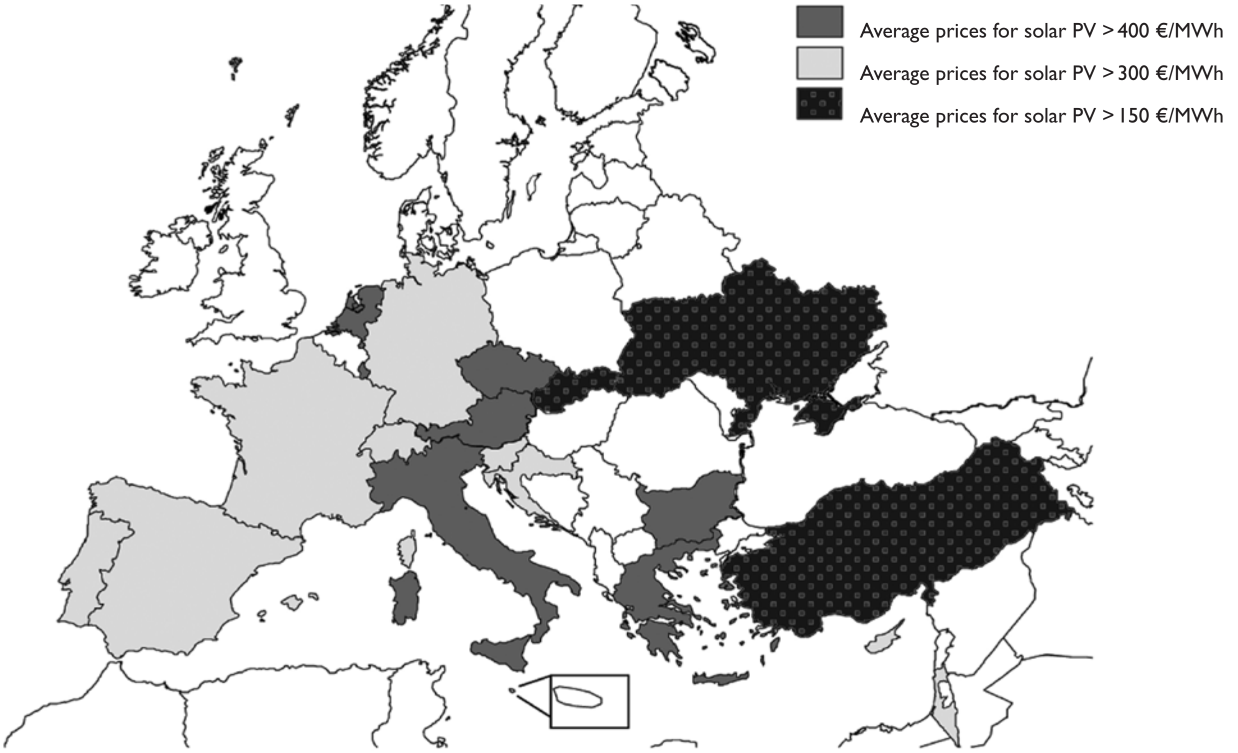
10 Algeria, Kenya, Mauritius, South Africa, and Uganda.

11 A net feed-in tariff provides a feed-in payment only for the generation that is not consumed on site, whereas a gross feed-in tariff provides a payment for all PV system output. Japan's 10-year net feed-in tariff is set at ¥0.48/kWh (€0.35/kWh) for residential systems, and ¥0.24/kWh (€0.175/kWh) for non-residential systems up to 500 kW (Hirshman, 2009a).

12 The Jiangsu feed-in tariff is set at 2.15 CNY/kWh (€0.21) for ground mounted systems and 3.70 CNY/kWh (€0.36) for rooftop systems, with a program target of 400 MW (Hirshman, 2009b).

13 The proposed PV rates are 8.12 TWD/kWh for 1–10 kW, 9.33 TWD/kWh for 10–500 kW, and 9.33 for projects larger than 500 kW.

Figure 2 **Average Prices for Solar PV in Europe**



Source: Fouquet et al. (2009)

Europe and the Middle East

Europe as been the epicenter of global photovoltaic market growth during the past ten years, installing 67% of the 13.7 GW installed globally between 1999 and 2008. This growth has been driven almost exclusively by feed-in tariff policies, which have rapidly diffused across the region. The map below provides an overview of current available feed-in tariffs, coded by the average PV feed-in tariff rate available in the country (Fouquet, 2009). In addition to the nineteen countries shown the map, the United Kingdom has also announced that it will implement feed-in tariffs for photovoltaic generators 5 MW and under in April 2010, with rates of between £0.26–£0.365/kWh (€0.287–€0.404/kWh) (Department of Energy and Climate Change, 2009).

North America

Although some areas of North America, such as California, were early global market leaders, North America's PV market has been slow to grow when compared to Europe. During the past ten years, North America only added 800 MW of PV capacity, or approximately 6% of the global total. Canada, Mexico, and the United States have not yet adopted federal PV policies that have driven rapid market growth nationwide to date. The U.S. Investment Tax Credit for Solar and tax related depreciation benefits provide as much as 50% of system costs in net present value to owners of commercial systems (Bolinger, 2009), but taking advantage of this credit requires a "tax appetite" by the owner and relatively complex ownership structures to fully extract the value. Most PV market growth has been driven primarily by targeted state or provincial policy. In both Canada and the U.S., subnational governments have begun to adopt feed-in tariffs.

- The first generation cost-based feed-in tariff for PV in North America was introduced in Ontario in 2006. The policy was revised in 2009 and now size differentiated in a manner similar to Germany's feed-in tariff, with rates that range from CAD 0.443/kWh (€0.28) to CAD 0.802/kWh (€0.51).[14]
- In the United States, the State of California passed a limited feed-in tariff in 2006 that offers the same feed-in tariff rate, based on avoided cost, to all renewable generators. This tariff has not yet supported the development of new PV generation.
- In 2009, the State of Vermont (PSB, 2009), and the cities of Gainesville, Florida and San Antonio, Texas each established limited PV feed-in tariffs based on generation cost. These were set at $0.30/kWh for 25 years, $0.32/kWh for 20 years, and $0.27/kWh for 20 years, respectively. Although these feed-in tariffs are capped, they have set a new national precedent for policy development.
- In 2009, the Hawaii Public Utilities Commission (2009) also announced preliminary rules for a forthcoming generation cost-based rate, and the State of Oregon passed solar feed-in tariff legislation, with rates to be determined.

South and Central America

Although some countries in Central and South America have implemented feed-in tariffs for renewable energy, none have implemented specific feed-in tariffs for PV to date.

14 Available online at: http://fit.powerauthority.on.ca/

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APPENDIX

Table A.1 **Current Solar Feed-in Tariff Rates by Region**

Region	Country/State/City	Rate (€/kWh)	Size	Length (years)	Notes
Asia	Republic of Korea	0.3405 0.3250 0.3095 0.2940 0.2476	< 30 kW < 200 kW < 1 MW < 3 MW > 3 MW	20	• 500 MW program cap • 15 year rates also available
	Jiangsu, China	0.3619 0.2103	Roof Mounted Ground Mounted	TBD	• 400 MW program target
	Taiwan (proposed)	0.1672 0.1920 0.1860	< 10 kW < 500 kW > 500 kW	TBD	
Australia	Australian Capital Territory	0.3105 0.2484	< 10 kW < 30 kW	20	
	New South Wales	0.3722	< 10 kW	7	• Can be claimed in tandem with rebate
North America	Ontario	0.5106 0.4540 0.4043 0.3432 0.2821	< 10 kW Any System Type > 10 < 250 kW Rooftop > 250 < 500 kW Rooftop > 500 kW Rooftop < 10 MW Ground Mounted	20	• Adders for aboriginal and community ownership
	Gainesville, Florida	0.2133 0.1866	Roof Mounted or Pavement Mounted, or Ground Mounted < 25 kW Ground Mounted > 25 kW	20	• 4 MW annual cap
	San Antonio, Texas	0.1800	50 kW Minimum 500 kW Maximum	20	• 10 MW program cap • 2 year program length
	Vermont	0.2000	< 2.2 MW	25	• 50 MW program cap

continued

Source: SEMI, November 2009

Table A.1 **Current Solar Feed-in Tariff Rates by Region** *continued*

Region	Country/State/City	Rate (€/kWh)	Size	Length (years)	Notes
European Union	Austria	0.4598 0.3998 0.2998	< 5 kW < 10 kW > 10 kW	12	
	Bulgaria	0.4208 0.3860	< 5 kW > 5 kW	25	
	Cyprus	0.36 0.34	< 20 kW < 150 kW	20	
	Czech Republic	0.4963 0.4925	< 30 kW > 30 kW	20	
	France	0.328 0.437 0.6018	Mainland Installations Overseas and Corsica BIPV	20	
	Germany	0.4301 0.4091 0.3958 0.33 0.3194	< 30 kW Rooftop <100 Rooftop < 1 MW > 1 MW Ground Mounted	20	
	Greece	0.45 0.4 0.5 0.45	< 100 kW Interconnected > 100 kW Interconnected < 100 kW Uninterconnected Islands > 100 kW Unitnerconnected Islands	20	
	Italy	0.48 0.431 0.392 0.451 0.412 0.372 0.431 0.392 0.353	1 kW–3 kW Full BIPV 1 kW–3 kW Partial BIPV 1 kW–3 kW Non-BIPV 3 kW–20 kW Full BIPV 3 kW–20 kW Partial BIPV 3 kW–20 kW Non BIPV > 20 kW Full BIPV > 20 kW Partial BIPV > 20 kW Non-BIPV	20	
	Luxembourg	0.42 0.37	< 30 kW 31–1000 kW	15	
	The Netherlands	383 353	0.6 kW–15 kW 15 kW–100 kW	15	
	Portugal	0.42 0.32	< 5 kW > 5 kW	15	
	Slovak Republic	0.2774		12	
	Slovenia	0.4154 0.38 0.315 0.4778 0.437 0.3626 0.3904 0.3597 0.2899	< 50 kW < 1 MW < 5 MW < 50 kW BIPV < 1 MW BIPV < 5 MW BIPV < 50 kW Ground Mounted < 1 MW Ground Mounted < 5 MW Ground Mounted	15	
	Spain	0.32–0.34 0.32	Rooftop Systems Ground Mounted	25	
	United Kingdom (proposed)	0.3457895 0.40713925 0.3457895 0.312326 0.290017 0.290017	< 4 kW (new construction) < 4 kW (retrofit) < 10 kW < 100 kW < 5 MW Stand Alone System	20	

continued

Source: SEMI, November 2009

Table A.1 **Current Solar Feed-in Tariff Rates by Region** ***continued***

Region	Country/State/City	Rate (€/kWh)	Size	Length (years)	Notes
Non-European Union	Croatia	0.46 0.41 0.26	< 10 kW < 30 kW > 30 kW	12	
	Israel	0.36 0.29	< 30 kW 50 kW–5 MW	20	• 50 MW program cap
	Switzerland	0.49 0.43 0.41 0.39 0.43 0.35 0.33 0.32 0.59 0.48 0.44 0.41	< 10 kW Roof Mounted < 30 kW Roof Mounted < 100 kW Roof Mounted > 100 kW Roof Mounted < 10 kW Ground Mounted < 30 kW Ground Mounted < 100 kW Ground Mounted > 100 kW Ground Mounted < 10 kW BIPV < 30 kW BIPV < 100 kW BIPV > 100 kW BIPV	25	• Program capped at 0.006% of electricity sales, with solar capped at 5% of that
	Turkey	0.28 0.22	First 10 Years Second 10 Years	20	
	Ukraine	0.23695357 0.247724187	< 100 kW > 100 kW	Through 2030	• Floor price set in Euros • 1.8 multiplier in peak hours

Source: SEMI, November 2009