



# A Policymaker's Guide to Feed-in Tariff Policy Design

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## **On the Cover**

Feed-in tariff (FIT) policies can apply to several renewable energy technologies and their applications including (top to bottom) solar photovoltaics (PV) on commercial buildings (Art Institute of Chicago – Chicago, Illinois); on-site wind energy (Great Lakes Science Center – Cleveland, Ohio); rooftop PV on residences (Glastonbury, Connecticut); solar power tower (Solar One – Barstow, California); and dry-steam geothermal plant (The Geysers – Calistoga, California).

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## List of Acronyms

ART – advanced renewable tariff  
C-BED – Community-Based Energy Development (program)  
CHP – combined heat and power (also co-generation)  
CPI – consumer price index (also inflation)  
CSP – concentrating solar power  
DG – distributed generation  
DOE – Department of Energy (U.S.)  
EEG – Erneuerbare Energien Gesetz (German Renewable Energy Sources Act)  
EU – European Union  
FIT – feed-in tariff  
IOU – investor-owned utility  
IPP – independent power producer  
ISO – independent system operator  
kW – kilowatt  
kWh – kilowatt-hour  
LSE – load-serving entity  
MPR – market price referent  
MW – megawatt  
MWh – megawatt-hour  
NIMBY – not in my back yard  
O&M – Operations and Maintenance  
PBI – production-based incentive  
PPA – power purchase agreement  
PTC – production tax credit  
PUC – public utilities commission  
PURPA – Public Utility Regulatory Policies Act  
PV - photovoltaic  
QF – qualifying facilities  
RD – Royal Decree (title of Spanish policy decree)  
RE – renewable energy  
REC – renewable energy certificate  
RES – renewable energy sources  
RESOP – Renewable Energy Standard Offer Program (Ontario)  
RPS – renewable portfolio standard  
SBC - system benefit charge  
SOC – standard offer contract  
SOP – Standing Offer Program (British Columbia)  
StrEG – Stromeinspeisungsgesetz (early German “feed-in law”)  
TGC – tradable green certificate  
TWh – terawatt-hour (billion kilowatt hours)  
U.S. – United States  
VAT – value-added tax

## Executive Summary

Feed-in tariffs (FITs) are the most widely used policy in the world for accelerating renewable energy (RE) deployment, accounting for a greater share of RE development than either tax incentives or renewable portfolio standard (RPS) policies (REN21 2009). FITs have generated significant RE deployment, helping bring the countries that have implemented them successfully to the forefront of the global RE industry. In the European Union (EU), FIT policies have led to the deployment of more than 15,000 MW of solar photovoltaic (PV) power and more than 55,000 MW of wind power between 2000 and the end of 2009<sup>1</sup> (EPIA 2010, GWEC 2010). In total, FITs are responsible for approximately 75% of global PV and 45% of global wind deployment (Deutsche Bank 2010). Countries such as Germany, in particular, have demonstrated that FITs can be used as a powerful policy tool to drive RE deployment and help meet combined energy security and emissions reductions objectives (Germany BMU 2007).

This policymaker's guide provides a detailed analysis of FIT policy design and implementation and identifies a set of best practices that have been effective at quickly stimulating the deployment of large amounts of RE generation. Although the discussion is aimed primarily at decision makers who have decided that a FIT policy best suits their needs, exploration of FIT policies can also help inform a choice among alternative renewable energy policies. This paper builds on previous analyses of feed-in tariff policy design, most notably by Resch et al. 2006, Klein et al. 2008, Held et al. 2007, Ragwitz et al. 2007, Grace et al. 2008, Mendonça 2007, and Mendonça et al. 2009a. It also provides a more detailed evaluation of a number of policy design options than is currently found elsewhere in the literature. This report considers both the relative advantages and disadvantages of various design options for FITs.

Drawing on the literature cited above, this paper explores experience with feed-in tariff policies from the European Union, where the policy has been used for approximately two decades, as well as recent examples of FIT policies in Canada and the United States. The focus on previous implementation provides valuable lessons for FIT policy design that could help improve future policy application.

A feed-in tariff drives market growth by providing developers long-term purchase agreements for the sale of electricity generated from RE sources<sup>2</sup> (Menanteau et al. 2003, IEA 2008). These purchase agreements, which aim to be both effective and cost-efficient,<sup>3</sup> typically offer a specified price for every kilowatt-hour (kWh) of electricity produced and are structured with contracts ranging from 10-25 years (Klein 2008, Lipp 2007). In order to tailor FITs to a range of policy goals, the payment level can be differentiated by technology type, project size, resource quality, and project location. The payment levels can also be designed to decline for installations in subsequent years both to track and to encourage technological change<sup>4</sup> (Langniss et al. 2009,

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<sup>1</sup> This figure for PV refers solely to grid-connected systems.

<sup>2</sup> Note that due to the presence of renewable energy certificate (REC) markets in the United States, it may be necessary to define FITs as both the sale of electricity and RECs (Cory et al. 2009, Couture and Cory 2009, see also Lesser and Su 2008).

<sup>3</sup> For the purposes of this paper, *effective* refers to the success of the policy framework at encouraging RE deployment and increasing overall levels of RE generation. *Cost-efficient* refers to offering per-kWh payment levels that are sufficient to cover project costs, while allowing for a reasonable return.

<sup>4</sup> This design feature is referred to as "tariff depression."

Fouquet and Johansson 2008). As an alternative to a fixed tariff level, FIT payments can be offered as a premium, or bonus, above the prevailing market price (IEA 2008, Rickerson et al. 2007).

Criteria for judging the success of feed-in tariffs depend on the policy goals of the jurisdiction. In the EU, national energy policies are evaluated against a comprehensive set of objectives laid out within EU-wide Directives, and include (among others) long-term RE targets, increased economic and export market opportunities, sustainable job creation, the enhanced use of forestry and agricultural wastes, and the expansion of innovative RE technologies (see European Commission, 2009/28/EC). Naturally, different jurisdictions may have different objectives, or may attribute different strategic importance to those same objectives. This notwithstanding, it is a common goal of FIT policies in both the EU and around the world to encourage RE deployment. Successful feed-in tariffs can, therefore, be understood as policies that encourage rapid, sustained, and widespread RE development.<sup>5</sup>

FIT policies typically include three key provisions: (1) guaranteed access to the grid; (2) stable, long-term purchase agreements (typically, about 15-20 years); and (3) payment levels based on the costs of RE generation<sup>6</sup> (Mendonça 2007). In countries such as Germany, they include streamlined administrative procedures that can help shorten lead times, reduce bureaucratic overhead, minimize project costs, and accelerate the pace of RE deployment (Fell 2009, see also de Jager and Rathmann 2008). Many European countries have committed to using FIT policies to achieve their long-term RE targets out to and beyond 2020, which indicates a long-term commitment. In addition, European policies typically extend eligibility to anyone with the ability to invest, including – but not limited to – homeowners; business owners; federal, state, and local government agencies; private investors; utilities and nonprofit organizations (Germany BMU 2007, Lipp 2007, Mendonça et al. 2009b).

The following sections provide an overview of FIT payment design options, FIT implementation options, and various approaches to funding the policy.

### **FIT Payment Design Options**

Policymakers interested in creating FIT policies need to consider a number of options. These choices include how to structure the FIT payments, as well as whether and how to differentiate them (e.g., by technology, size of project, quality of resource, etc.).

There are four main approaches used to set the overall FIT payment to RE developers. The first is to base the FIT payments on the **levelized cost of RE generation**, plus a targeted return (typically set by the policymakers or regulators). The second is by estimating the **value of the renewable energy generation** either to society or to the utility. Value to society is typically interpreted in terms of the value of the electricity plus climate change mitigation, health impacts, energy security, and other externalities. Value to the utility is generally understood in terms of

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<sup>5</sup> A jurisdiction may layer additional goals on top of this primary objective of encouraging RE development, goals such as local manufacturing, the targeted development of solar PV, minimizing over-payment for producers, etc. These considerations may influence the precise definition of “success” employed in different jurisdictions.

<sup>6</sup> Cost-based payment levels are designed to provide sufficient revenues to make projects profitable, while also limiting over-payment. Ways of differentiating FIT payments to offer cost-based payment levels to different project types are explored in Section 4.

avoided generation costs, and the time and location-specific value of electricity supply (Klein 2008, Grace et al. 2008). A third category of approaches sets FIT payments as a simple, **fixed-price incentive** that offers a purchase price for renewable electricity that is based neither on generation costs, nor on the notion of value (Couture and Cory 2009). Finally, **auction-based mechanisms** represent a fourth way to set payment levels. Both India and China are experimenting with this approach, and a few U.S. jurisdictions have expressed interest as well (Kann 2010, Han et al. 2009, Vermont 2009).

A comparison of FIT policies suggests that those that are most effective in meeting deployment objectives have designed their FIT payments to cover the RE project cost, plus an estimated profit (Klein et al. 2008, Mendonça et al. 2009a, REN21 2009). This effectiveness arises from the fact that developers are reluctant to invest unless they are relatively certain that the revenue streams generated from overall electricity sales are adequate to cover costs and ensure a return (Dinica 2006, Deutsche Bank 2009). If maximizing deployment is the primary objective, the tariffs can be set aggressively.<sup>7</sup> If a further objective is to limit policy costs, FIT policymakers may want to establish payment levels targeting only the most cost-effective technologies, or limit deployment to areas with the best combination of attributes, including resource, proximity to transmission, etc. Whether payments are set aggressively or more conservatively, policymakers can cast the net wider to capture a greater spectrum of RE projects by designing tariffs for a greater variety of technologies, project sizes, geographic locations, etc.

Another main FIT payment design choice is whether or not the FIT payment depends on the market price of electricity. These two different policy options are often characterized as fixed-price or premium-price policy designs (Held et al. 2007, Klein et al. 2008, also referred to as “feed-in premiums” or FIPs in IEA 2008). In a **fixed-price FIT payment**, the total per-kWh payment is independent of the market price and constant over a fixed period of time. By offering reliable, long-term revenue streams, this fixed approach creates stable investment conditions, which can lead to lower project financing costs (Fouquet and Johansson 2008, Lipp 2007, Butler and Neuhoff 2008, Guillet and Midden 2009, Deutsche Bank 2009). In the **premium-price FIT payment** option, the total payment is determined by adding a premium tariff to the spot market electricity price. In this approach, the premium can be designed to approximate the avoided externalities of RE generation, or so that the total payment approximates the RE generation cost. Most countries with FIT policies choose the fixed-price approach, but more are beginning to offer both options (Klein 2008).

Premium-price FIT payments can be designed to be either **constant** (as a fixed, predetermined adder), or **sliding** (where the premium varies as a function of the spot market electricity price). Although a constant premium is simpler in design, it risks creating windfall profits for RE developers if spot market prices for electricity increase significantly (Mendonça et al. 2009a, Ragwitz et al. 2007, Klein 2008). On the other hand, the risk of low electricity prices, and correspondingly low feed-in tariffs, could drive away potential investors. Variations on the

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<sup>7</sup> The term aggressive in relation to FIT payment levels refers to payment levels that are set high (i.e., that target a higher average rate of return). In addition to increasing potential returns at favorable sites, aggressive FIT payments are likely to allow a wider spectrum of projects to be profitably developed (i.e., make less favorable sites financially viable), thereby attracting a greater number of investors to market. However, there is a tension between increased deployment on one hand, and the possibility of over-compensation if rates are set too high on the other.

premium-price FIT designs attempt to address these challenges by more closely targeting compensation based on estimated renewable energy project costs. For example, Spain has introduced a sliding premium-price FIT design with both a **price cap** and a **price floor** as part of its Royal Decree 661/2007 (Held et al. 2007). On an hourly basis, it ensures that the FIT premium payment declines as electricity prices increase, and vice versa (Klein et al. 2008). The Netherlands uses a second option, where the government guarantees projects will receive a minimum payment through two separate revenue streams: (1) the prevailing spot market price of electricity and (2) a sliding FIT premium that covers the real-time difference between the guaranteed minimum FIT price and the spot market price (van Erck 2008). Overall, premium price FIT models can be considered a more “market-oriented” FIT design because the tariff payment fluctuates with the market price, and no purchase guarantee is offered (Ragwitz et al. 2007, Held et al. 2007).

### **FIT Payment Differentiation**

Policy goals often include elements beyond the total amount of new installed capacity, including diversity in technologies, project sizes, and locations. To achieve such goals, FIT payments can be differentiated by **technology type**, the **project size**, the **resource quality** at that particular site (primarily targeted at wind power to limit windfall profits at the windiest sites), or the **specific location** of the project (e.g., building integrated PV or offshore wind) (Mendonça 2007, Klein et al. 2008). Bonus payments represent another approach to encouraging particular technologies or applications. There are also a number of ancillary design elements, the most important of which are tariff depression and inflation adjustment.

### **FIT Implementation Options**

Once the FIT payment structure is established, implementation options should be considered.

**Eligibility.** This factor determines which entities can participate (e.g., citizens, corporations, nonprofit organizations, government entities, etc.) and whether there are limitations on which project types qualify (e.g., technology, project size, location, and in-service date). Many European FITs do not limit who can own RE projects and sell their electricity to the grid, enabling a range of sizes and types of projects to participate (Grace et al. 2008). Some jurisdictions extend the eligibility to utilities, which are typically provided the same purchase guarantee as other developers (Jacobsson and Lauber 2006).

**Utility role.** Many FIT implementation options center on the utility’s role. Several countries use a FIT policy **purchase obligation** that requires utilities, load-serving entities (LSEs) or transmission system operators (TSOs) to purchase the entire output from eligible projects (Klein et al. 2008). In addition, jurisdictions often require utilities or TSOs to offer **guaranteed grid connection**, which guarantees eligible project owners that they will be able to interconnect their projects to the grid (Mendonça et al. 2009a).

**Contract duration.** It is important to clearly outline the contract duration during which the FIT payments are awarded.<sup>8</sup> Contract periods generally vary between 5-25 years, with the majority being 15-20 years. Longer contract periods help lower levelized payments, ensure cost recovery,

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<sup>8</sup> In Germany, a contract is not required; the purchase guarantee is established in the law itself (Lauber 2009).



lower the cost of financing, and increase investor confidence (de Jager and Rathmann 2008, Guillet and Midden 2009).

**Caps.** Policymakers must also decide whether the FIT policy will include **program** or **project caps**. Caps can be imposed either on the total capacity of RE allowed (usually differentiated by technology type), on the maximum individual project size (also often differentiated by technology type), or according to the total program cost (either total dollars per year, or for the multiyear program).

**Forecasting.** In addition, a **forecast obligation** can be imposed on project operators to help utilities and system operators deal with variable output from hydroelectricity, as well as large solar and wind power projects (Klein et al. 2008). Spain requires that RE projects larger than 10 MW provide supply forecasts on a daily basis to the regional system operator, which they are able to update – without penalty – up to one hour before delivery (Spain 2007, Klein 2008). Penalties can even be levied for deviations beyond a certain amount. Forecasting is particularly important for integration of large renewable projects, or multiple projects near each other, and can help significantly in balancing the variable output of renewable power on the grid. Introducing penalties for deviation can create an incentive to improve the accuracy of forecasts, which can increase penetration of variable RE generation.

**Grid access.** Finally, it is important to provide clear protocols surrounding **transmission and interconnection issues**, which ensure that RE projects can be connected to the grid in a timely way that minimizes bureaucratic overhead and fosters more efficient project siting.

### **FIT Policy Adjustments**

FIT policy designers can plan adjustments to program design as part of the policy framework. The most frequent adjustments are to change payment levels for new projects in order to address changes in RE generation costs over time. These adjustments can be done administratively on a set schedule (quarterly, annually, or on a multiyear basis). Another approach is to adjust tariff levels when predetermined capacity milestones are met. It is also possible to introduce **comprehensive revisions** to the FIT program, which tend to occur every 2-4 years. These revisions deal with the broader revision of the FIT policy, including changes to eligibility protocols, and the inclusion of new technology types.

### **Funding the FIT Policy**

In addition to FIT payment structure and implementation options, it is important to consider how to fund the policy, and whether to incorporate a cost-sharing mechanism that spreads any electricity rate increases across rate classes.

FIT policies can be funded by incorporating the added incremental costs directly into the rate base (e.g., Germany), using tax revenue (e.g., the Netherlands), through a combination of both (e.g., Spain), or by alternative means, such as carbon auction revenues and utility tax credits. In addition, FIT policy designers can include provisions to ensure that any added costs are shared across utilities and across different regions of a given jurisdiction. Sharing the costs across all

ratepayers helps avoid the problem of free-ridership,<sup>9</sup> while the second provision reduces the chance of distorting the competitive playing field among utilities in restructured electricity markets.

### **Controlling the Cost of FIT Policies**

Because FITs can provide such a strong incentive for RE producers and manufacturers, policymakers need to ensure that the policy includes a means to control the overall costs at the outset. The recent experience of Spain's solar PV market in 2008 provides an example: Generous tariffs, combined with a high-quality solar resource and insufficient oversight, led to a rush of development that overwhelmed regulators and prompted a drastic policy change (see Spain 2008, Deutsche Bank 2009). Experience suggests that it is advisable to design policies with an eye to cost containment.

### **Summary**

Contemporary FIT policies offer a number of design options to achieve policy goals for renewable energy deployment. However, careful policy design is crucial to ensuring success (Mendonça et al. 2009a, Ragwitz et al. 2007). Policy designers must weigh how different design options will function together as an integrated framework. This evaluation can help ensure that renewable energy develops at both the pace and scale desired and can help avoid unintended consequences such as runaway program cost.

As this report demonstrates, FIT policy structures can differ widely among jurisdictions, reflecting a broad spectrum of policy objectives. This ability to adapt to particular situations – and address particular policy goals – is an important element in the success of FIT policies. Their ongoing success at fostering rapid RE growth is likely to continue to fuel interest in these policies worldwide.

Table ES-1 summarizes a variety of FIT policy design and implementation options.

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<sup>9</sup> Free-ridership occurs when some parties obtain the benefits of a given service or investment without paying for them. In this instance, it refers to some ratepayers not paying for RE, while still getting the benefits, measured in terms of increased energy security, reduced environmental pollution, etc.

**Table ES-1. Summary of Feed-in Tariff Design and Implementation Options**

<b>FIT Payment Levels</b>				
<b>Design Options</b>		<b>Notes</b>	<b>Fixed*</b>	<b>Premium*</b>
<b>Price setting based on</b> (one of the following):	Cost of generation	Determined in relation to the actual cost of developing the technology, plus a targeted return.	X	X
	Value to the system	Based on either time of delivery, avoided costs, grid benefits, or other supplementary values.	X	X
	Fixed price incentive	Fixed payment level, established without regard to RE generation costs or to avoided costs.	X	**
	Auction-based price discovery	Periodic auction or bidding process, which can help set technology- and/or size-specific FIT payment levels	X	**
<b>Payment differentiated based on</b> (one or more of the following):	Technology and fuel type	Tailors the FIT policy to target desired technologies and/or fuel. Payment levels broken out to recognize differences in cost, by project	X	X
	Project Size (kW or MW)	Helps stimulate both large and small projects by offering different prices for each. Lower payments are awarded to large generators to account for economies of scale.	X	X
	Resource quality	Can be used to limit windfall profits and dispersing projects and benefits across jurisdictions.	X	**
	Location (or application)	Can help target specific applications such as rooftop PV or offshore wind energy.	X	**
<b>Ancillary Design Elements</b> (one or more of the following)	Pre-established Tariff Degression	Pre-determined downward adjustments (typically annual) for subsequent projects to track, and encourage, cost reduction	X	**
	Responsive Tariff Degression	Enables the rate of market growth to determine the future rate of degression, and thus, the future FIT payment level	X	**
	Inflation adjustment	Protects the real value of RE project revenues from changes in the broader economy (i.e. CPI)	X	X
	Front-end loading	Higher tariff for an initial period, replaced by lower levels afterwards; helps financing.	X	X
	Time of Delivery	Tiered payment levels according to times of high and low demand (by day/season); encourages market-orientation	X	X
<b>Further differentiated with bonus payments to encourage:</b>	<b>High efficiency</b> systems (e.g. cogeneration), use of specific <b>waste streams</b> (e.g. farm wastes, municipal wastes, construction and demolition waste, etc.), <b>physical location of systems</b> (e.g. building-integrated), <b>repowering</b> of old wind and hydro-electricity projects, certain <b>ownership structures</b> (e.g. community-ownership), use of innovative technologies, etc.		X	X
<b>Implementation Options</b>				
<b>Implementation Options and Notes</b>			<b>Fixed*</b>	<b>Premium*</b>
<b>Eligibility</b>	<b>Project Owner:</b> can be limited to certain investor or owner types		X	X
	<b>Technology:</b> can include all renewable technologies or a subset		X	X
	<b>Size:</b> can be designed for all project sizes or a subset		X	X
	<b>Location:</b> can be limited to certain areas on the grid		X	X
<b>Purchase Obligation</b>	Yes – requires the utility to purchase the power generated from the project		X	
	No – the RE developer sells the power into an active spot market			X
<b>FIT Policy Adjustments</b>	<b>FIT Payment Adjustments:</b> Adjustments to FIT payment levels over time (e.g. annually)			Optional
	<b>FIT Program Adjustments:</b> Adjustments to FIT policy structure and design (e.g. 2-4 years)			Optional
<b>Caps</b>	Program-wide total capacity cap (MW, often by technology)			Optional
	Individual project size (MW by project, usually technology-specific)			
	Total program cost (either total dollars per year, or in sum)			
Give renewables <b>grid interconnection and/or dispatch priority</b> , to the extent possible				Optional
<b>Obligate</b> the project owner to provide a forecast (day-ahead or hour-ahead) to help with balancing				Optional
<b>Transmission/interconnection</b>	<b>Shallow:</b> Only the costs to connect to nearest transmission point, not including upgrades			Optional
	<b>Deep:</b> All costs required for grid connection, including trans. & substation upgrades			
	<b>Mixed:</b> Includes cost of connection and sharing of trans. & substation upgrade costs			
<b>Funding options</b>	Ratepayer funded (e.g. rate base or through system benefit charge)			Must choose one or more ways to fund the FIT policy
	Taxpayer funded (e.g. a specific allocation from the country's treasury)			
	Supplementary options (carbon auction revenues, etc.)			
<b>Inter-utility cost sharing</b>	Any marginal cost increases are shared across utilities in a jurisdiction			Optional

\* Fixed FIT policies offer a guaranteed price for a fixed period of time for renewable energy; premium FIT policies offer either a sliding or a constant premium payment on top of the spot market price. They represent two different ways of designing a feed-in tariff policy.

\*\* Incorporating such a design in a premium-price policy is theoretically possible, but has not yet been implemented.

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## 1.0 Introduction

Two policies dominate renewable energy (RE) policy worldwide: feed-in tariff (FIT) and renewable portfolio standard (RPS) policies, also known as quota-obligation systems (IEA 2008). While RPS requirements that use competitive solicitations for renewable energy procurement are more common in the United States, FITs are the most widely used policy mechanism to procure RE generation globally (REN21 2009).

This report provides U.S. policymakers who have decided to enact FIT policies with a roadmap to the design options: It explains the policy and how it works, explores the variety of design options available, and discusses the numerous ways in which it can be implemented. This report also highlights best practices identified by European analysts that are said to contribute to FIT policy success (Mendonça et al. 2009a, Klein et al. 2008, Ragwitz et al. 2007, Held et al. 2007, Langniss et al. 2009, IEA 2008).

Analysts can only evaluate notions such as “success” and “best practices” in relation to particular policy objectives. While FITs can fulfill a variety of policy goals, it is assumed throughout this report that the primary objective of FIT policies is first and foremost the deployment of renewable energy technologies and the expansion of RE generation. This relates to other goals such as increasing energy security, climate mitigation, environmental protection, and job creation, each of which can play a role in determining the particular objectives of the FIT policy. Ultimately, it is these objectives that will determine what constitutes policy success and, therefore, what qualify as “best practices.”

The analysis draws on examples of FIT policies from the European Union (EU), Canada, and the United States (U.S.); as well as from jurisdictions such as South Africa, India, and China. Due to a greater continuity of experience and the more sophisticated FIT design in the EU on average, this report draws primarily on policy design in a number of EU member states,<sup>10</sup> supplementing this with examples from elsewhere in the world.

This report introduces new distinctions in FIT policy design and implementation, which help clarify certain policy nuances that do not appear in the current literature – or that can cause confusion when used without the appropriate context. This new framework is intended to help foster better public and legislative understanding of FIT policies both in the United States and around the world.

### 1.1. Policymaker’s Guide: Linking Goals with Policy Designs

If designed carefully and implemented properly, feed-in tariffs can help policymakers target a variety of policy goals. This section divides these goals into three categories: primary, secondary, and tertiary goals. The representation is merely meant to be indicative of renewable energy policy goals as expressed by various U.S. jurisdictions. These goals are not prescriptive – specific jurisdictions might decide to place a particular FIT policy goal higher (or lower) than presented here. However, by identifying specific goals and linking FIT policy design elements to them, this section helps policymakers identify the parts of the report that may be of greatest interest to them.

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<sup>10</sup> Plus Switzerland (SFOE 2008).

Table 1 shows the first broad category of primary policy goals. These include those goals most often cited as reasons for undertaking policies to promote renewable energy deployment. They include rapid renewable energy deployment, as well as local economic benefits and related environmental benefits.

**Table 1. Primary Renewable Energy Policy Goals**

Goal	Design Elements	Notes
<i>Rapid renewable development to meet RE goals or targets</i>	<ul style="list-style-type: none"> <li>- Tariff prices based on RE project cost plus profit</li> <li>- Universal eligibility (including IPPs, IOUs, federal, state and local government agencies, non-profit agencies, and residential, commercial and industrial customers)</li> <li>- Long contract terms (e.g. 15-25 years)</li> <li>- Tariff degression (higher payments this year than next)</li> <li>- No project size caps</li> <li>- Program caps based on long-term RE goals (i.e. not annual targets)</li> <li>- Inclusion of a broad diversity of RE technology types</li> <li>- Reduced administrative burden and streamlined approval processes</li> </ul>	<ul style="list-style-type: none"> <li>- In order to attract many investors and lots of capital to develop renewables rapidly, minimizing financial risk and maximizing options for generators is important</li> <li>- A diverse technology portfolio encourages a broader investor base</li> <li>- Stable and aggressive RE policies can help draw in-state manufacturing, which can accelerate deployment</li> </ul>
<i>Jobs and economic development</i>	<ul style="list-style-type: none"> <li>- Long-term policy stability</li> <li>- Local content requirements</li> <li>- Preferential terms and/or tariffs for local ownership;</li> <li>- Tariff differentiation, according to project size and technology type, ensures a broader diversity of projects are developed in a wider variety of technology sectors, particularly distributed generation (DG)</li> </ul>	<ul style="list-style-type: none"> <li>- A strong and stable FIT policy that uses bonus payments can maximize local economic benefits. Incentives can also be offered to create a favorable environment for green manufacturing</li> </ul>
<i>Greenhouse gas reduction</i>	<ul style="list-style-type: none"> <li>- Aggressive tariff rates and terms</li> <li>- High tariffs for biomass co-firing with coal as well as for efficient CHP</li> <li>- Bonus payments for high efficiency systems</li> <li>- <i>Note: GHG design elements are likely to be more effective in regions that currently have high carbon electricity production</i></li> </ul>	<ul style="list-style-type: none"> <li>- Bioenergy, some hydro and concentrated solar thermal power (with storage) have the potential to displace high carbon coal electricity, because the technologies are used primarily for base load generation</li> </ul>

Secondary goals (cited as important, but not the primary drivers) are shown in Table 2. These goals include cost minimization and policy transparency. Achieving these goals depends not only on how the tariff is set, but also on what complementary policies and administrative protocols are enacted.

**Table 2. Secondary Renewable Energy Policy Goals**

Goal	Policy Design	Notes
<i>Minimize policy costs and ratepayer impact</i>	<ul style="list-style-type: none"> <li>- Tariff degression (to encourage downward pressure on costs due to technology advancements, learning, etc.)</li> <li>- Long-term policy stability (the more stable the policy, the lower the cost of capital, and thus, the levelized cost)</li> <li>- Capping or eliminating inflation adjustments</li> <li>- Caps on total customer rate impacts for the program</li> <li>- Caps on the total funding for the program</li> <li>- Program or project size caps, particularly for emerging or high cost RE technologies</li> <li>- Protocols for transmission queues, including application fees (to eliminate bottlenecks, minimize litigation)</li> <li>- Streamlined approval procedures to minimize transaction costs, and increase efficiency (e.g., standard contracts)</li> </ul>	<ul style="list-style-type: none"> <li>- Transmission protocols must be effective and administrative efforts must be streamlined to reduce wasted time and money</li> <li>- Higher policy transparency minimizes costs due to lower risk</li> <li>- Cost minimization may be achieved by imposing capacity caps on costlier technologies</li> </ul>
<i>Policy Transparency</i>	<ul style="list-style-type: none"> <li>- Tariff rates that are stable, transparent and non-discriminatory</li> <li>- Public consultation on tariff determination, policy design, etc.</li> <li>- Simplicity in overall policy design</li> <li>- Long-term policy stability</li> <li>- Announcement of planned adjustments to FIT payment levels in advance of enactment</li> <li>- Public guidance document (or model) that includes any formulas used to arrive at FIT payment levels, so RE developers and investors can anticipate updates</li> <li>- Predictability of program revisions</li> <li>- Clear protocols for tariff as well as program revisions</li> </ul>	<ul style="list-style-type: none"> <li>- Transparency can influence how many people take advantage of the policy</li> </ul>

Finally, Table 3 shows the tertiary considerations, which target a diverse array of policy goals that can also be addressed with a well-designed FIT. This includes displacing base load capacity, peak shaving, distributed generation, community ownership, waste stream management, and targeting specific innovative or desirable technologies.

**Table 3. Tertiary Renewable Energy Policy Goals**

Goal	Design Elements	Notes
<i>Displacing base load (e.g. to phase out coal fired generation)</i>	<ul style="list-style-type: none"> <li>- Aggressive tariffs for biomass co-firing</li> <li>- Aggressive tariffs for new hydro power</li> <li>- Aggressive tariffs for geothermal plants</li> <li>- Aggressive tariffs for concentrated solar power (CSP) plants with storage</li> <li>- Bonus payments for storage capacity alone, or the use of innovative technologies</li> </ul>	<ul style="list-style-type: none"> <li>- Replacing other conventional base load technologies may help reduce carbon, particularly in regions that depend heavily on coal generation (e.g., carbon reductions will not be as effective in the Pacific Northwest, which has a lot of hydro)</li> </ul>
<i>Peak shaving</i>	<ul style="list-style-type: none"> <li>- Time of day or seasonal pricing</li> <li>- Higher tariffs for technologies that can modulate their supply to better coincide with peak demand</li> <li>- Special tariffs for PV or other distributed generation in congested load centers with significant demand peaks</li> <li>- Tariffs for CSP projects with storage</li> </ul>	<ul style="list-style-type: none"> <li>- Peak shaving can reduce costs to society significantly, alleviate stresses on the grid, and reduce emissions</li> </ul>
<i>Targeting distributed generation</i>	<ul style="list-style-type: none"> <li>- Universal eligibility (including IOUs owning projects on customer sites, third parties owning projects on customer sites, federal, state and local government agencies, non-profit agencies, and residential, commercial and industrial customers)</li> <li>- Higher tariffs for customer-sited and/or smaller systems</li> <li>- Bonus payments for CHP</li> <li>- Tariff differentiation for different project sizes</li> </ul>	<ul style="list-style-type: none"> <li>- Differentiating tariffs appropriately for project size can help RE developers better scale their projects to the optimal size for grid and DG benefits. It can also broaden participation</li> </ul>
<i>Community ownership</i>	<ul style="list-style-type: none"> <li>- Higher tariffs for community-based projects</li> <li>- Cap on maximum share that any one individual can have to promote partnerships and broader ownership; can even require that the community must be part-owners</li> </ul>	<ul style="list-style-type: none"> <li>- Community-owned projects tend to generate greater local economic benefits and job impacts than projects owned by outside investors</li> </ul>
<i>Waste stream management:</i>  <i>- Farm</i> <i>- Forestry</i> <i>- Municipal</i>	<ul style="list-style-type: none"> <li>- Bonus payments for use of a particular waste stream (with a focus on waste streams in a particular jurisdiction):               <ol style="list-style-type: none"> <li>a) Biogas, anaerobic digesters or agricultural waste</li> <li>b) Solid biomass</li> <li>c) Landfill gas</li> <li>d) Construction and demolition wastes, etc.</li> </ol> </li> </ul>	<ul style="list-style-type: none"> <li>- Targeting particular waste streams can provide an efficient means of harnessing resources that are currently unused, or that pose public health issues, like landfill, sewage, and wastewater treatment facilities</li> </ul>
<i>Targeting high efficiency systems</i>	<ul style="list-style-type: none"> <li>- Bonus payments for CHP</li> <li>- Bonus payments for repowering</li> </ul>	<ul style="list-style-type: none"> <li>- Encouraging high efficiency systems is also a means of addressing air quality issues, or particular categories of pollutants</li> </ul>
<i>Innovation and early adoption of technologies</i>	<ul style="list-style-type: none"> <li>- Bonus payments for innovative project designs</li> <li>- Tariffs designed for emerging technologies (e.g. ocean, wave, thermal, storage etc.)</li> <li>- Tariff degression</li> <li>- Specific premiums for offshore (depending on distance from shore and depth of water)</li> <li>- Bonus payments for wind projects using state-of-the-art grid integration technology, voltage controls, etc.</li> </ul>	<ul style="list-style-type: none"> <li>- A jurisdiction that wants to encourage innovation in particular technologies, or that wants to create an incentive for the adoption of new technologies, can choose bonus payments to help achieve this end</li> </ul>

## **1.2 Overview of Report Organization**

Section 2 provides a background on the feed-in tariff policy, including the definition and how FIT payment levels are determined. It also briefly explores the historical evolution of feed-in tariff policies around the world and the policy's advantages and disadvantages. Section 3 explores U.S. electricity market considerations, briefly examines interactions with RPS policies, and provides an overview of current FIT policies in the United States.

Section 4, which is the core of the report, provides a detailed analysis of the variety of feed-in tariff design elements available, including specific examples from jurisdictions around the world. Because the options are numerous, this section aggregates and categorizes similar design elements and explores their relative advantages and challenges. Section 5 explores a number of implementation options that policymakers may want to consider when designing a FIT policy, ranging from eligibility criteria to interconnection issues. Section 6 addresses the issue of cost control, exploring the ways in which a jurisdiction can better contain policy costs, while Section 7 discusses various ways of funding the FIT policy. Section 8 offers lessons learned identified from FIT policies around the world. Section 9 closes the report with conclusions and suggestions for future research.

## 2.0 FIT Policy Background

This section examines the definition of a FIT policy and presents an overview of the three basic ways to determine payment levels. It also explores the history of the feed-in tariff in both the United States and the EU, highlighting the key FIT policy design improvements that have occurred during the policy's evolution. Finally, it explores advantages and disadvantages of the policy.

### 2.1 FIT Policy Definition

A feed-in tariff (FIT) is an energy supply policy focused on supporting the development of new renewable energy projects by offering long-term purchase agreements for the sale of RE electricity<sup>11</sup> (Menanteau et al. 2003, Lipp 2007, Rickerson et al. 2007, Fouquet and Johansson 2008, Mendonça 2007, IEA 2008). These purchase agreements are typically offered within contracts ranging from 10-25 years and are extended for every kilowatt-hour of electricity produced (Klein 2008, Lipp 2007). The payment levels offered for each kilowatt-hour can be differentiated by technology type, project size, resource quality, and project location to better reflect actual project costs. Policy designers can also adjust the payment levels to decline for installations in subsequent years, which will both track and encourage technological change (Langniss et al. 2009, Fouquet and Johansson 2008). In an alternative approach, FIT payments can be offered as a premium, or bonus, above the prevailing market price (IEA 2008, Rickerson et al. 2007).

Successful feed-in tariff policies typically include three key provisions: (1) guaranteed access to the grid; (2) stable, long-term purchase agreements (typically, 15-20 years); and (3) payment levels based on the costs of RE generation (Mendonça 2007). In countries such as Germany, policies include streamlined administrative procedures to shorten lead times, reduce bureaucratic overhead, minimize project costs, and accelerate the pace of RE deployment (Fell 2009, see also de Jager and Rathmann 2008). In addition, eligibility is typically extended to anyone with the ability to invest, including but not limited to homeowners; business owners; federal, state, and local government agencies; private investors; utilities and nonprofit organizations (Germany BMU 2007, Lipp 2007, Mendonça et al. 2009b).<sup>12</sup>

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<sup>11</sup> Due to the presence of renewable energy certificate (REC)<sup>11</sup> markets in the United States, policymakers should consider whether to define FITs as the sale of electricity, or as the sale of electricity and RECs (Cory et al. 2009, Couture and Cory 2009, see also Lesser and Su 2008).

<sup>12</sup> Note that not all RE policies that are referred to as FITs necessarily share these characteristics. Due to the early stage of the policy in North America, there is still considerable confusion as to what exactly constitutes a FIT. For example, a number of jurisdictions in the United States offer policies that share certain features with FIT policies, such as fixed purchase prices, differentiation by technology type, etc. (Rickerson et al. 2007). The latter have been referred to as “fixed-price incentives” or “fixed-price payment policies” to distinguish them from full-fledged FITs (Rickerson and Grace 2007, Mendonça 2007). These typically include additional provisions such as a long-term purchase guarantee, the assurance of grid access, and a payment level that is based on the cost of RE generation (Mendonça et al. 2009a). To account for the lack of consistency in the use of the term, it is possible to distinguish between different types of FITs, some of which are cost-based, while others are based on other considerations, such as avoided costs or the notion of value.

## 2.2 FIT Terminology

Since their inception, feed-in tariffs have evolved significantly; and a number of different terms have been used to describe them. Germany's 1990 Stromeinspeisungsgesetz (StrEG) was translated into English literally as the "Electricity Feed-in Law," which implied that electricity was being "fed in" to the grid (Jacobsson and Lauber 2006). It is this concept that defined the term in the English-speaking world, and continues to define it today. However, an array of terms has emerged, including "standard offer contracts," "fixed-price policies," "minimum price policies," "feed laws," "feed-in laws," and "advanced renewable tariffs." In the United States, they have recently been referred to simply as "renewable energy payments" (U.S. Congress 2008) or "renewable energy dividends" (Powers 2009). This multiplication of terms to describe the same policy has complicated the policy debate and contributed to confusion among investors and policymakers.

As mentioned above, the umbrella term that has prevailed over these variations is "feed-in tariff."

## 2.3 FIT Payment Calculation Methodology

One of the most fundamental design challenges for a FIT policymaker is how to determine the actual FIT payments awarded to project developers for the electricity they produce. A worldwide overview of FIT policies reveals that a variety of approaches are used, which reflects diversity in the policy goals (see Section 1.1). These different approaches can be divided into four basic categories.

**(1) Based on the actual levelized cost of renewable energy generation.** This approach is the most commonly used in the EU, and has been the most successful at driving RE development around the world (Klein et al. 2008, REN21 2009).

**(2) Based on the "value" of renewable energy generation** either to society, or to the utility, generally expressed in terms of "avoided costs." This approach is used in California, as well as in British Columbia (CPUC 2008a, DSIRE 2009b, BC Hydro 2008).

**(3) Offered as a fixed-price incentive** without regard to levelized RE generation costs or avoided costs. This approach is used by certain utilities in the U.S. (Couture and Cory 2009).

**(4) Based on the results of an auction or bidding process,** which can help inform price discovery by appealing to the market directly. An auction-based mechanism can be applied and differentiated based on different technologies, project sizes, etc. and is a variant on the cost-based approach.

Each of these approaches can be considered a different way of establishing FIT prices. Due to the greater prominence of FIT policies structured to cover the cost of RE generation, this report focuses primarily on cost-based FIT policies. It is important to note that there are different ways of adopting a cost-based approach and, therefore, of establishing cost-based FIT payment levels.

First, it is possible to use detailed **market research and empirical analysis** of current renewable energy costs to establish FIT payment levels. This ensures that the latter are adequate to allow efficiently operated projects to be profitable. This approach is used in countries including Germany and Spain, and in the Canadian province of Ontario.

The second cost-based approach is an **auction-based mechanism**.<sup>13</sup> Auctions are a different way to establish FIT prices, one that appeals to the market directly rather than through third-party analysis. This approach is when an auction (separate from the FIT policy itself) is used to inform FIT price setting for projects of various kinds. Variants on this approach are being introduced in a few jurisdictions around the world, including in Spain for solar PV (Spain 2008), China for wind and solar power (Han et al. 2009), and in India for a variety of RE technologies (Kann 2010). It has also been discussed in certain U.S. states as an alternative to administratively established FIT prices.

The third cost-based approach considered here is the **profitability index method (PIM)**, which would establish FIT prices based on the targeted profitability of a specific RE project. This method was used to develop wind power FIT prices in France previously and represents a comprehensive methodology for establishing resource-adjusted FIT payment levels sufficient to ensure profitability (Chabot et al. 2002).

The first method (market research and empirical analysis) is the most widely used of these three approaches. Market research (conducted either by consultants or directly by government agencies) provides the price data required to establish cost-based FIT payment levels. Due to changing market conditions, the payment levels must be revised over time to ensure that they continue to reflect both industry and market realities.

In contrast to cost-based approaches, the value-based and fixed-price incentive approaches have been employed less widely, and are primarily used in the United States (see Couture and Cory 2009). The value-based approach allows FIT prices to be established based on an estimation of the **value of the renewable energy generation** either to society (e.g., climate change mitigation, health impacts, and energy security, among others) or the value to the utility (e.g., based on time and location at which electricity is fed into the grid, or on utility-avoided costs) (Klein 2008, Grace et al. 2008). This approach is used in Portugal, where a number of adders are compiled to determine the final FIT payment. This includes adders for avoided environmental externalities, as well as the avoided cost of investments in new conventional generation (Klein et al. 2008).

Finally, it is possible to design FIT payments as a simple, **fixed-price incentive** that offers a purchase price for renewable electricity based neither on generation costs, nor on the notion of value (Couture and Cory 2009). This approach is used by certain utilities in the United States, but it has proved relatively unsuccessful at encouraging significant amounts of RE generation; therefore, it is not covered in any greater detail in this report.

A recent analysis by the International Energy Agency (IEA) suggests that a certain minimum payment level appears to be required to stimulate substantial RE development (IEA 2008). Because both the value-based approach and the fixed-price incentive method provide this

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<sup>13</sup> These are also referred to as competitive benchmarks (see Grace et al. 2008).



minimum amount only incidentally, they are less likely than a cost-based approach to lead to substantial investments in RE development. This is arguably why FITs that are empirically or methodologically based on RE generation costs have experienced greater success than those based on other approaches – they are more likely to provide this minimum payment level in a consistent fashion.

## 2.4 History of the FIT Policy

This section provides a brief history of FIT policies, examining the broad outlines of their development since their first implementation in the U.S. “National Energy Plan” of 1978 (Hirsh 1999). The primary focus is on the key developments that have occurred over time, providing context on how early FIT policies differ from the more sophisticated frameworks implemented today.

- **The Public Utility Regulatory Policies Act (PURPA)** is sometimes considered the first feed-in tariff policy (Lipp 2007, Rickerson and Grace 2007). Among other things, PURPA required utilities to buy electricity from qualifying facilities (QF) at rates that were based on utilities’ “avoided costs,”<sup>14</sup> (Hirsh 1999). Determining what constituted avoided costs was left to the individual states (Lipp 2007, Hirsh 1999).<sup>15</sup>
- In December 1990, the first national feed-in tariff legislation in Europe was adopted in **Germany’s Electricity Feed-in Law** (Stromeinspeisungsgesetz or StrEG). As of January 1, 1991, utilities in Germany were **required by law to buy electricity from non-utility RE generators at a fixed percentage of the retail electricity price** (Germany 1990, Rickerson and Grace 2007). The StrEG included a **purchase obligation** for this electricity and the percentage ranged from 65-90% depending on the technology type and the project size. A **project size cap of 5 MW was also imposed** on hydropower, landfill gas, sewage gas, and biomass facilities (Germany 1990). Denmark and Spain followed suit with similar provisions in 1992 and 1997, respectively (Nielsen 2005, del Rio Gonzalez 2008).
- In a significant development, certain **municipal utilities in Germany began offering FIT prices based on the actual costs** of RE generation (a model pioneered by the cities of Hammelburg, Freising, and Aachen), primarily to encourage solar PV (Fell 2009). This approach was in contrast to an avoided cost or “value-based” approach to tariff calculation, or one in which the prices were tied to the prevailing retail price. This cost-based framework enabled efficiently run projects to be profitably operated (Germany 2000), and this design feature continues to be identified as one of the most

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<sup>14</sup> “Avoided costs” are defined in a number of ways across different utilities and jurisdictions. At the most basic level, they are designed to reflect what it would cost to supply power to a particular area with alternative supply sources (Hirsh 1999).

<sup>15</sup> There are a few key reasons why the PURPA policy of 1978 is considered to be the first FIT policy: First, it required utilities to buy electricity generated from qualifying RE facilities at pre-established rates (Lipp 2007); it was production-based, awarding per-kWh payments for the all electricity generated from the facility, rather than simply the surplus; in certain cases, the payment levels were differentiated by technology type; and finally, in some jurisdictions such as California, it was implemented using long-term contracts for electricity sales (Hirsh 1999). PURPA contracts slowed down with electricity restructuring in the late 1990s, and few are signed today because utilities have turned to other means of procuring electricity from renewable energy sources.

important elements of successful FIT policies (Klein 2008, Lipp 2007, IEA 2008, Mendonça 2007, Ragwitz et al. 2007, Resch et al. 2006).

- The Renewable Energy Sources Act (*Erneuerbare Energien Gesetz*, EEG) was adopted by the German Parliament in April 2000 (Germany RES Act 2000).<sup>16</sup> This legislation signaled a number of important developments: 1) **FIT prices were decoupled from electricity prices** at the national level; 2) in contrast to previous FIT policies, which focused primarily on fostering non-utility generation, **utilities were allowed to participate**; 3) RE sources were granted **priority access to the grid**; 4) **FIT payments for wind power became differentiated by the quality of the resource** at different locations; and 5) **FIT prices became methodologically based on the costs of generation** for all technology types (Lauber 2004).<sup>17</sup>
- Since the adoption of Germany's RES Act, a clear trend has emerged both within Germany and in other countries – there is **a higher degree of differentiation in the tariff amounts** (Germany RES Act 2000, 2004, and 2008; Lauber 2004). This includes differentiations based on technology type, project size, and project location, as well as the quality of the resource in a particular area (Klein et al. 2008). Differentiating FIT payments in this way helps ensure that a broader array of RE project types can be profitably developed.
- **Spain's RD 661/2007 introduced an innovative “sliding premium” option.** This design offers a variable FIT payment or premium above the spot market price, which effectively ensures that project revenues will remain within a range sufficient to ensure profitability. Policymakers use this option to increase the market integration of RE sources, because electricity is sold directly on the spot market and receives an additional FIT payment. This market integration may become more important as the share of RE sources increases (Spain 2007, see also Held et al. 2007). In April 2008, the Netherlands adopted a similar framework, where a sliding premium covers the difference between prevailing spot market price and the guaranteed FIT price (van Erck 2008).

This overview of the history of FIT policies and their maturation over time provides important insights into the design of successful FIT policy frameworks. A closer look at the history of FIT policies also underscores their adaptability to particular circumstances – they are adjusted over time according to market trends and evolving political priorities. As FIT policies have become

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<sup>16</sup> Germany describes its cost-covering approach in an addendum to its RES Act 2000: “*The compensation rates specified in the RES Act have been determined by means of scientific studies, subject to the proviso that the rates identified should make it possible for an installation – when managed efficiently – to be operated cost-effectively, based on the use of state-of-the-art technology and depending on the renewable energy sources naturally available in a given geographical area.*” (Germany RES Act 2000, Explanatory Memorandum A).

<sup>17</sup> One of the features that is evident from an analysis of how feed-in tariff policies have changed over time is that there has been a clear increase in the number of different FIT payment levels that are offered. Earlier FIT policies typically offered only one or a few different prices to encourage either different technologies, or projects of different sizes. Now, an analysis of Spanish and German tariff policies reveals a high degree of differentiation, which results in more than 50 different tariff levels and a wider array of RE project types to be profitably developed (see Appendices A and B).

more sophisticated, they have demonstrated the ability to encourage project development for many different technologies, in an array of locations, and at a variety of scales (distributed, mid-scale, and utility-scale).

However, in spite of changes to the policy over time, one of the reasons commonly cited for the success of FITs (most notably in countries such as Germany), is the overall **stability and continuity** of the policy framework (Fell 2009, Ragwitz et al. 2007, IEA 2008). Despite modifications and improvements to the details of the policy, the German framework, for instance, has fostered a high level of investor certainty by framing its FIT policy as a central part of a long-term strategy to meet its overall objectives (Fell 2009). This stability is critical to ensuring a steady and continuous influx of investment in both the upstream and downstream sides of the RE sector, while creating the conditions required for continued project-level investment.

## 2.5 Advantages and Disadvantages of FIT Policies

As the previous section demonstrated, FIT policies have evolved considerably. This section examines a number of arguments both for and against FIT policies that have emerged during this evolution, beginning with the advantages.<sup>18</sup>

The arguments in favor of a FIT policy are primarily economic in nature. These include the ability to:

- offer a **secure and stable market for investors** (Fouquet and Johansson 2008, IEA 2008, Lipp 2007, Lesser and Su 2008, Ragwitz et al. 2007);
- stimulate significant and quantifiable **growth of local industry and job creation** (Germany BMU 2009 and 2008b, Mendonça et al. 2009b, Fell 2009, Lipp 2007, Diekmann 2008, Langniss et al. 2009);
- **only cost money if projects actually operate** (i.e., FITs are performance-based);
- provide **lower transaction costs** (Menanteau et al. 2003, Fell 2009);
- can secure the **fixed-price benefits** of RE generation for the utility's customers by acting as a hedge against volatility (de Miera et al. 2008, Munksgaard and Morthorst 2008, Lesser and Su 2008);
- distribute **costs and development benefits** equitably across geographic areas (Lauber 2004, Fell 2009);
- **settle uncertainties related to grid access and interconnection** (Lauber 2009, Mendonça 2007); and
- **enhance market access** for investors and participants (Grace et al. 2008).

Other benefits are that FIT policies:

- have a measurable **impact on RE generation and capacity** (IEA 2008, Germany BMU 2009, REN21 2009);
- tailor the policies using a range of design elements that will **achieve a wide range of policy goals** (IEA 2008, Mendonça 2007, Lipp 2007).
- **encourage technologies at different stages of maturity**, including emerging

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<sup>18</sup> The authors acknowledge that this is not an exhaustive list, and that the list itself is subject to debate.

technologies (Mendonça 2007, Klein 2008, Lipp 2007, Ragwitz et al. 2007);<sup>19</sup>

- customize the policy to **support various market conditions**, including regulated and competitive electricity markets (Rickerson et al. 2007);
- do not constrain the timing of project development through rigid solicitation schedules (Grace et al. 2008);
- are **compatible with RPS mandates** (Rickerson et al. 2007);
- **can help utilities meet their RPS mandates**<sup>20</sup> (Rickerson et al. 2007, Grace et al. 2008);
- can provide a purchase price to renewable energy generators that is **not linked to avoided costs** (Jacobsson and Lauber 2006); and,
- demonstrate a flexible project-specific design that allows for adjustments to ensure **high levels of cost efficiency**<sup>21</sup> and **effectiveness** (Ragwitz et al. 2007, IEA 2008).

A number of the arguments against FIT policies are largely economic in nature:

- FITs can lead to **near-term upward pressure on electricity prices**, particularly if they lead to rapid growth in emerging (i.e., higher-cost) RE technologies (Mendonça 2007, Lipp 2007, Lesser and Su 2008, Couture and Cory 2009, see also Germany BMU 2008a);
- FITs may **distort wholesale electricity market prices** (Lesser and Su 2008, Menanteau et al. 2003);
- **FITs do not directly address the high up-front costs of RE technologies** – instead, they are generally designed to offer stable revenue streams over a period of 15-25 years, which enables the high up-front costs to be amortized over time (Lantz and Doris 2009);
- **FITs are not “market-oriented,”** primarily because FITs often involve must-take provisions for the electricity generated, and the payment levels offered are frequently independent from market price signals (see Fouquet and Johansson 2008, Lesser and Su 2008);
- Due to the fact that RE investments are generally limited to citizens with disposable (i.e., investable) income, as well as with property on which to install RE systems, **FITs may exclude lower-income individuals from participating** (Barclay 2009). Because these individuals are generally required to share the cost burden via higher bills, this can create or exacerbate social inequity (Barclay 2009);
- It may be **difficult to control overall policy costs** under FIT policies, because it is difficult to predict the rate of market uptake without intermediate caps or capacity-based depression (Menanteau et al. 2003, Mendonça et al. 2009a);
- FITs **do not encourage direct price competition between project developers**<sup>22</sup> (Zisler 2006; see also Fouquet and Johansson 2008, Butler and Neuhoff 2008);
- It can be **challenging to incorporate FITs within existing policy frameworks and regulatory environments** (Mendonça et al. 2009a).

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<sup>19</sup> Note that quota systems with technology-specific bands offer a related but not nearly as fine-tuned approach (Lauber 2009).

<sup>20</sup> This is particularly true in jurisdictions where RE developers are unable to secure the long-term contracts necessary to secure financing.

<sup>21</sup> For the purposes of this report, when a renewable energy policy is described as being “cost efficient,” it offers a levelized payment level that is sufficient to encourage investment without exceeding the requirements of a particular RE technology (see IEA 2008). In other words, cost efficiency can be understood as offering a reasonable, risk-adjusted return on investment, while protecting ratepayers from excessive costs.

<sup>22</sup> Note that some price-setting approaches, such as auction mechanisms, can allow for direct price competition.

- It can be **difficult to equitably share costs** across ratepayer classes, as well as between different geographic areas (Mendonça et al. 2009a).

In addition to these economic issues, there could be other limitations due to the political requirements for successful FIT policy implementation. For example:

- FITs accompanied by guaranteed grid interconnection, regardless of where projects are located on the grid, could lead to **less-than-optimal project siting**, and thus impact grid reliability, while not using existing transmission effectively (Couture and Cory 2009).
- **FITs require an up-front and continuous administrative commitment** to set the payments accurately (Lesser and Su 2008). If the FIT payments are set too high, they could result in a higher overall policy cost; and if too low, it could result in little or no new RE generation (Menanteau et al. 2003);
- FITs have been shown to function best when **a long-term policy commitment** is made to renewable energy development; if this commitment is absent, start-and-stop policy implementation could hinder policy success;
- As a result of rapid technology and cost changes within the RE industry, policymakers may be **tempted to over-exercise the flexible nature of the FIT policy**. If these amendments are too sudden and/or too large, they could directly decrease the stability (and hence attractiveness) of the renewable energy market for potential investors (see Wang 2009, PV News 2009)
- As FIT policies are created to promote growth and expansion of RE technologies, it is possible that RE industries could **develop a reliance on the policy**.

As described in this section, FIT policies can be complex – and they have followed a long evolution since their first implementation in 1978 under the U.S. PURPA policy. While feed-in tariffs have many advantages, including the ability to target a variety of policy goals, they also entail a number of challenges if they are to be implemented successfully. If the policy is to meet its objectives in a timely and cost-effective manner, these challenges must be directly addressed during design and implementation.

## 3.0 Application of FIT Policies in the U.S.

Half a dozen U.S. states have already implemented policies that share a number of key features with FITs; and a number of other states are also considering these policies (Rickerson et al. 2008, Couture and Cory 2009). This section briefly explores U.S. electricity market considerations and then explores the interactions between FIT policies and RPS policies. Finally, it identifies U.S. states where FIT policies are being employed as well as where they are being proposed.

### 3.1 U.S. Electricity Market Structure Considerations

In the United States, the success of FIT policy implementation may depend on how well the policy accounts for the structure of the electric generation market. At the state level, regulatory regimes vary widely. For example, the different market structures in the United States could influence who would award the payments under the FIT policy, and who would distribute the costs to different rate classes as well different geographic areas. Similarly, it is likely that the policy would operate differently in markets that allow retail competition than in jurisdictions with regulated monopolies. While a successful FIT policy can be designed to work in either regulated or restructured electricity market structures, the details are important to consider in ensuring policy success.

### 3.2 FITs and RPS Policies

The renewable portfolio standard<sup>23</sup> (RPS) is one of the most common state-level renewable energy policies in the United States today. It is designed to encourage new renewable energy development by establishing a target or quota on the proportion of electricity generation that must come from renewable energy sources by a certain date (Rader and Norgaard 1996, Wisser et al. 2007, Hurlbut 2008). RPS policies often use a process of competitive solicitations to procure supply and promote competition between project developers. And most track compliance using renewable energy certificates<sup>24</sup> (RECs), which provide a supplementary revenue stream in addition to electricity sales (Wisser and Barbose 2008, Fouquet and Johansson 2008).

Twenty-nine states and the District of Columbia have enacted mandatory RPS policies (DSIRE 2010a), while an additional six have voluntary targets (Sullivan et al. 2009). A number of other states (as well as the federal government) are considering implementing them as well.

As such, one of the first questions asked when a FIT policy is considered in the United States is how it would interact with existing RPS frameworks. While the design of each policy will determine the answer, it is clear that the two policies can be structured to work together, and can even do so synergistically (Rickerson et al. 2007, Grace et al. 2008, Cory et al. 2009, Couture and Cory 2009).

RPS policies, which establish a mandated target for new RE deployment, are in many ways analogous to EU-wide directives found in the European Union. These directives impose certain

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<sup>23</sup> In the European Union, RPS policies are known as quota-based policies, or quota obligations schemes (Lauber 2004, Fouquet and Johansson 2008, IEA 2008).

<sup>24</sup> Renewable energy certificates (RECs) represent the environmental attributes of electricity generated from renewable energy sources, and represent a second commodity in addition to the electricity itself. They are designed to offer additional revenues for project developers; and, they are often traded or sold within bilateral contracts (Sawin 2004). One REC typically represents 1 megawatt-hour (MWh) of electricity generated from RE sources.

minimum targets for renewable energy (including electricity, heat, and fuel targets) on all EU Member States (EU 77/2001/EC, 28/2009/EC). In contrast to the United States, where competitive solicitations or tradable REC markets are most commonly used to meet RPS targets, the most common procurement mechanism to reach directive targets in the EU is FITs (Cory et al. 2009, Rickerson et al. 2007, Grace et al. 2008). This suggests that FITs could be used to complement RPS policies, by providing a procurement mechanism through which new RE capacity can be developed over time.

Some RPS policies that depend on competitive solicitations have encountered challenges encouraging new and rapid RE development in the United States, most notably in California (Wiser et al. 2005). These include uncertainties associated with project financing (Wiser and Barbose 2008), transmission interconnection (Hurlbut 2008), relatively high contract failure rates in states such as California (Wiser et al. 2005, Wiser and Barbose 2008), a high level of market concentration due to the limited number of investors (Chadbourne and Parke 2009, Karcher 2008), and little local and community-scale involvement in renewable energy development (Bolinger 2001 and 2004). These challenges (combined with the fact that certain states are not meeting their RPS targets) are likely contributing to increased U.S. interest in alternative RE policies and procurement mechanisms, such as feed-in tariffs.

A series of analyses in the past few years suggest that European RE policies that use tradable green certificates, or TGCs (analogous to REC markets) can have higher costs than feed-in tariffs, due primarily to the less predictable revenue streams, which increases overall investment risks (de Jager and Rathmann 2008, Ragwitz et al. 2007, Klein et al. 2008, Fouquet and Johansson 2008, Guillet and Midden 2009, Chadbourne and Parke 2009).

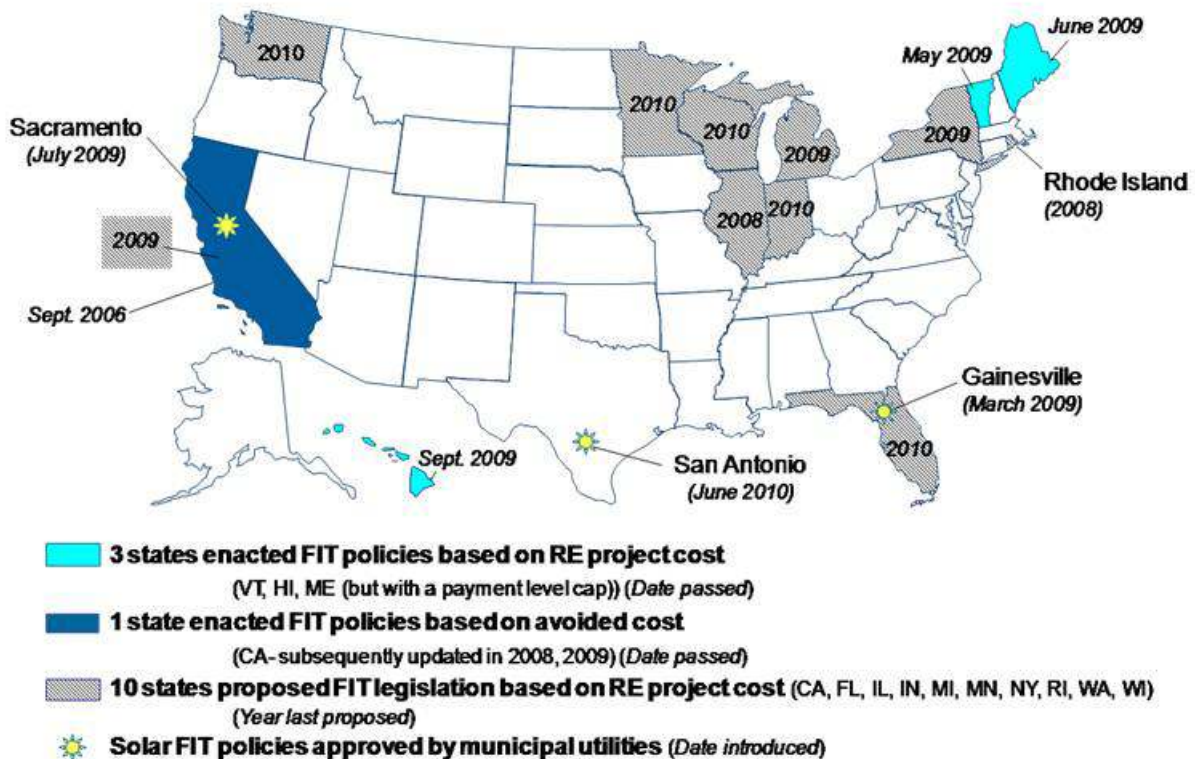
It is unclear whether these European conclusions can be directly applied in the United States. A number of differences exist between the market design of RECs in the United States and TGCs in the EU, as well as between the RE requirement schemes within the United States (RPS) and the EU Directives. One important distinction is that European TGC markets are traded in an open market that includes a spot market, and do not tend to make use of long-term contracts (Lipp 2007, Agnolucci 2007). These differences make it difficult to make broad comparisons between the features and overall risk characteristics of both. However, it does appear that markets in the EU have demonstrated greater price transparency in certain instances than those in the United States, where most RECs are sold in private, bilateral transactions. More research and analysis is needed to determine whether the conclusions of European analysts about the uncertainty of TGC markets can be directly applied to the United States, so policymakers should be cautious when making such comparisons.

Regardless of the policy instrument used, recent findings suggest that complex revenue streams with multiple components (especially if they are not fixed) tend to reduce the transparency and predictability of the investment environment. This can likely lead to higher return on equity requirements, less investment, or both (Dinica 2006, de Jager and Rathmann 2008, Deutsche Bank 2009). To the extent that FITs provide a single long-term revenue stream, they can reduce investment risks and increase the rate of RE deployment. However, other procurement mechanisms can theoretically achieve the same objective, provided they offer the same, or similar, foundational elements.

### 3.3 Brief Overview of FIT Policies and Proposals in the U.S.

As of June 2010, Gainesville Regional Utilities, Hawaii, and Vermont have adopted feed-in tariff policies based on the cost of generation (GRU 2009, Hawaii 2009, Oregon 2010, Vermont 2009). Maine has also adopted a cost-based FIT, but it includes a cap on the total payment level allowed (Maine 2009). California has a feed-in tariff based on avoided cost, which is defined according to the utilities' market price referent (MPR) (CPUC 2008a). In addition, representatives in 10 different state legislatures have proposed cost-based feed-in tariffs, and both Sacramento Municipal Utility District (SMUD) and San Antonio's City Public Service (CPS) Energy have implemented their own FITs to encourage solar PV (Gipe 2010, CPS Energy 2010).

Figure 1 shows the status of enacted and proposed state-level and enacted municipal-utility level FIT policies in the United States as of June 2009. A proposal for a FIT has also been advanced at the federal level (H.R. 6401) by U.S. Representative Jay Inslee (D-WA) (U.S. Congress, 2008).



Sources: NREL June 2010, Adapted from Gipe 2010

Figure 1. Feed-in tariff policy application within the United States



### 3.4 Federal Law Constraints for U.S. FIT Policies

There are specific legal and regulatory precedents that constrain a state's ability to execute a European-style FIT policy in the United States. These constraints primarily stem from the U.S. Federal Power Act (FPA), and also from the Public Utility Regulatory Policies Act (PURPA).

As detailed in a recent NREL technical report (Hempling et al. 2010), there are only limited instances when a cost-based FIT policy can be implemented in the United States, without any subsequent applications or approvals (at the state or federal level). It is clear that FIT policies can be executed within municipal utility jurisdictions, and also in regions whose electric systems are not connected to the continental U.S. grid (such as Hawaii and Alaska) or that have a weak connection, such as the majority of Texas (a.k.a the ERCOT region). These jurisdictions and states are not subject to the FPA and, therefore, do not require any additional contract approval from the Federal Energy Regulatory Commission (FERC).

Outside of these explicit FPA exclusions, FIT implementation can also occur under PURPA (which is exempt from the FPA requirement to file contracts with FERC). Projects certified as PURPA-qualifying facilities<sup>25</sup> can receive the utility's "avoided cost" for their power (the calculation methodologies are well-established at the state or utility level). However, for most renewable technologies in most U.S. locations, the avoided cost payment is insufficient to make RE projects financially viable, so supplemental revenue is necessary. Under PURPA, FERC has clarified that specific supplements to the avoided cost are outside of FERC's jurisdiction (Hempling et al. 2010).<sup>26</sup> Therefore, these can be used to create cost-based FIT payments. They include:

- (1) providing production-based incentives (PBIs) or direct cash grants – as long as they are funded from a system benefit charge fund or state tax revenues;
- (2) offering state tax credits to utilities; or
- (3) awarding the project renewable energy certificates.

The challenge is that some utilities are no longer subject to PURPA (the Energy Policy Act of 2005 allowed utilities to apply for an exemption); therefore, their contracts are subject to the FPA.

According to Hempling et al., there is no existing pathway for cost-based FIT implementation under the FPA, without supplemental actions or applications. Outside of PURPA, states must rely on state laws to establish FIT policies, but the contracts are still subject to the FPA. As such, FERC's approval of "just and reasonable" contracts is required either on a contract-by-contract basis, or developers can request blanket approval (with proof that they do not have market power in the markets in which they participate).

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<sup>25</sup> Qualifying facilities (QF) have a specific definition under PURPA, that includes only specific renewable technologies (including solar) and projects that are less than or equal to 80 MW. In addition, QFs must certify with the Federal Energy Regulatory Commission (FERC), either through self-certification or through an application to FERC.

<sup>26</sup> This path may also be available under state law (which is subject to the FPA) – and outside of PURPA – although FERC has not ruled on their jurisdiction over these supplemental payments in an FPA context.

FERC could take regulatory action to allow for cost-based FIT implementation under the FPA in one of several ways. However, each would require a FERC investigation (that either FERC initiates, or an outside party requests), as well as a rulemaking or declaratory order. First, FERC could change existing FPA precedent, such that under state law, facilities with 20 MW capacity and less could be exempt from the avoided cost limitation (currently in place for PURPA QFs, even if they are not subject to PURPA). In that case, payments for these facilities could be set at whatever level the state viewed was appropriate, provided they are deemed just and reasonable.

Second, FERC could create presumptions, “safe harbors,” or other guidance that could allow states to establish specific “offer price caps” (i.e., purchase prices) for specific technologies, projects, or regions. Under this structure, FERC would issue a rule that wholesale sales under a state-set tariff automatically comply with the FPA if they are consistent with the defined safe harbors (Hempling et al. 2010).

Beyond FERC clarification of the FPA, Congress could also take action. The language in the draft American Clean Energy and Security Act of 2009 (commonly called the “Waxman-Markey climate bill” – as of November 2009), appears to clarify and address some of these issues, but not all of them (Hempling et al. 2010).

## 4.0 FIT Payment Design Options

Policymakers interested in developing and implementing a new FIT policy have a variety of design choices to consider. For this analysis, the focus is on FIT policies that are methodologically based on the cost of renewable energy generation. While other FITs based on avoided costs, for instance, could employ some of these design options, the emphasis of the next two sections is on cost-based FIT policies.

Section 4 dissects the variety of FIT payment design components. The design of the FIT payment – as part of the overall FIT policy structure – determines the overall effectiveness and efficiency of the policy. If the payment levels are not set high enough to ensure a return on investment, little deployment is likely to occur; if they are set too high, the costs for ratepayers and/or taxpayers are likely to be substantially larger, both through higher per-kWh payments and through a greater market uptake. Therefore, the FIT payment structure should be closely tied to the goal that the policy is intended to achieve.

FIT policy designers can structure FITs to offer payment levels that are adjusted for different technology types, project sizes, resource qualities, and project locations. To highlight these differences and provide a guide for policymakers, this report is organized by design element, rather than by individual country. Each subsection includes a brief evaluation of the advantages and disadvantages of the design element. Note that a number of appendices are included at the end of the report that provide one-page summaries of the FIT payments offered in Germany, Spain, Switzerland, Ontario, and a proposed design for the state of Minnesota.

Sections 4 and 5 consider the major design and implementation options, respectively. Section 6 explores specific ways that policy makers can control the cost of the FIT policy, through design and implementation elements. Section 7 considers how to fund a FIT policy and share any incremental costs across different utilities and ratepayer classes, and Section 8 summarizes *best practices*, as identified by European analysts.

### 4.1 FIT Policy Foundation: FIT Payment Structure

A central element of FIT policy design is determining the payment structure. This section provides brief overviews of the three FIT payment structures used to-date. While early FIT policies in Europe determined the FIT payment levels as a percentage of prevailing retail rates, both fixed-price and premium price policies structures are more common today.

#### 4.1.1 Percentage of Retail Price Policies

The first national feed-in tariffs to make significant impacts in Europe were based on providing RE developers a FIT payment that was a percentage (usually less than 100%) of the retail price, shown in Figure 2. As mentioned, this structure is no longer in use today.

Under this approach, payments remain directly tied to the spot market price, thus creating an incentive to produce electricity at peak times. Under its 1990 Feed-in Law (StrEG), Germany offered a FIT payment of 90% of the retail price for renewable resources such as wind and solar that were less than 5 MW (Germany 1990, see also Jacobsson and Lauber 2006).

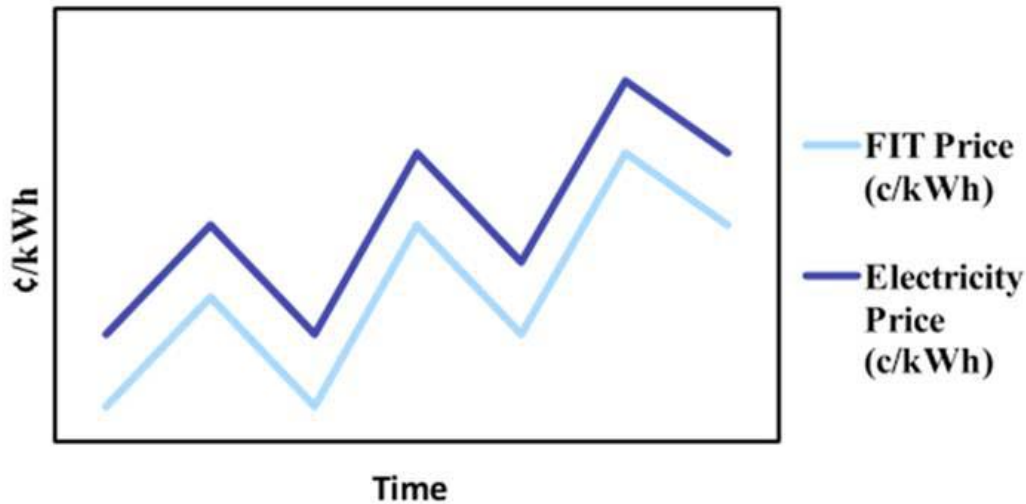


Figure 2. Percentage of retail-price FIT model

Beginning in 1992, Denmark implemented a similar policy, which allowed buying electricity generated from wind turbines up to a maximum of 85% of the average retail price<sup>27</sup> (Nielsen 2005, Mendonça et al. 2009b, also see Section 2.4.2). As in Germany, this policy was abandoned in 2000 in favor of a different FIT policy framework (Mendonça et al. 2009b).

In 1997, in its Law on the Electricity Sector (Spain 1997), Spain implemented a FIT policy based on a percentage of the retail price – tariffs were established at 80-90% of the retail rate (Spain 1997, del Rio Gonzalez 2008). Spain replaced this policy framework in 1998 with the RD 2818/1998, which established a framework that offered both a fixed and a premium FIT option (Spain 1998). However, in April 2004, Spain reintroduced a FIT policy that employed a percentage-based design, adding for the first time the possibility that the premium amount could exceed 100% of the retail price, in particular to encourage solar PV and solar thermal development (Spain 2004). Spain ended its percentage-based policy in 2006 in favor of its current framework, which offers the option of both a fixed price and a sliding premium option (del Rio Gonzalez 2008, Spain 2007).<sup>28</sup>

<sup>27</sup> This is reported to have amounted to approximately \$0.051/kWh USD (Mendonça et al. 2009b).

<sup>28</sup> The names of the two options introduced in Spain's RD 436/2004 are in conflict with respect to the terminology used in this report. In the literature, Spain's policy options are referred to as "fixed" and "premium price" options (Klein et al. 2008, del Rio Gonzalez 2008, Held et al. 2007). However, both are based on the percentage of the spot market price – in the first case, the *total payment* is a percentage of the total spot market price; in the second, the *premium itself* is defined as a percentage of the spot market price. To preserve the clarity of the fixed and premium price distinctions, the terminology used in this paper categorizes the first design as a "percentage-based" FIT policy; because, strictly speaking, the FIT payment level referred to in the literature as "fixed" does not remain at a constant level, as the term "fixed" implies. The only part of it that is fixed is the percentage value – the actual payment fluctuates along with the electricity price. The second design, where the *premium* is defined as a percentage of the retail price, is categorized here as a variant of the premium price model (see Section 4.3.2.4). The authors acknowledge that this distinction may be debated.

## **Evaluation of Percentage-based FIT Payment Models**

There are a few advantages to the percentage-based model. Before Spain adopted its second percentage-based framework in 2004, a number of market participants argued that moving away from bureaucratically established tariffs and premiums would remove some of the “discretionary” of FIT policy price setting (del Rio Gonzalez 2008). Certain participants argued that the tariff-setting process was too arbitrary. This position led to a shift in Spain’s FIT policy: The country moved from offering administratively determined fixed and premium price options toward an option where actual payments were indexed to an “objective” referent – in this case, the prevailing electricity price (del Rio Gonzalez 2008).<sup>29</sup> As a result, it could be argued that the percentage-based model is administratively easier to implement, because it requires less analysis of RE technology costs; administrators must simply set the percentage amount in the hopes that it will be adequate to drive market growth. Another advantage of percentage-based frameworks is that they are sensitive to market demand. Consequently, they create an incentive for RE developers to supply electricity when demand (and, hence, prices) are highest.

Percentage-based FIT models do pose a number of challenges. First, they proved inadequate to encourage the broad-based development of non-wind RE resources, primarily because the prices offered were insufficient to ensure cost recovery (Jacobsson and Lauber 2006, Lesser and Su 2008). As discussed above, they were abandoned by both Germany and Denmark in 2000, and by Spain in 2006 in favor of more sophisticated, cost-based FIT frameworks (Jacobsson and Lauber 2006, Nielsen 2005, del Rio Gonzalez and Gual 2007).

Second, because the payment levels were pegged to the prevailing electricity price, they are significantly more likely to lead to windfall profits in the event that electricity prices increase (Ragwitz et al. 2007, Klein 2008, Held et al. 2007). Policy designers have found it challenging to ensure that FIT payment levels that are under a percentage-based premium price model remain close to the cost of RE generation. This is because the conventional electricity market price changes independently of renewable energy generation costs.

Third, because the payment prices were tied to the market price, this created significantly greater risk for investors. This makes percentage-based FIT models less likely to lead to the stable and sustained growth of RE markets, primarily due to the increased revenue uncertainty they entail.

Due to the numerous problems inherent with percentage-based feed-in tariff policies – including a lower degree of effectiveness and a higher degree of risk – they are unlikely to reappear as a viable policy option to stimulate RE deployment.

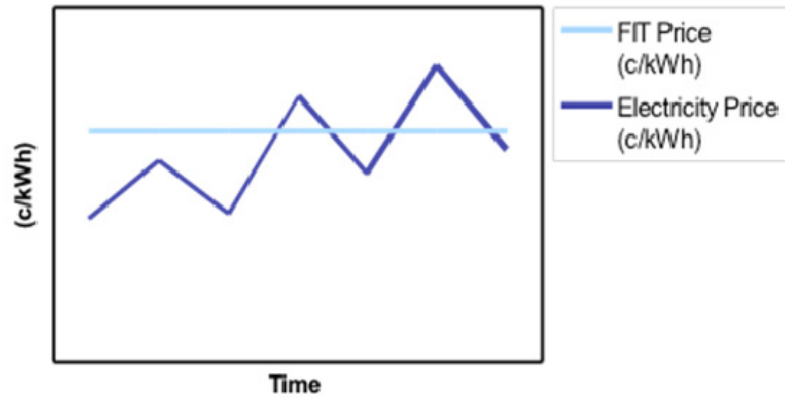
### **4.1.2 Description of Fixed-Price FIT Design and Premium FIT Design**

The main FIT payment level design choice is whether the payment level is tied to fluctuations in the actual market price of electricity. Therefore, FIT policies can be categorized as either independent or dependent from the market price. The majority of countries with FITs currently choose the market-independent, fixed-price approach (Klein 2008).

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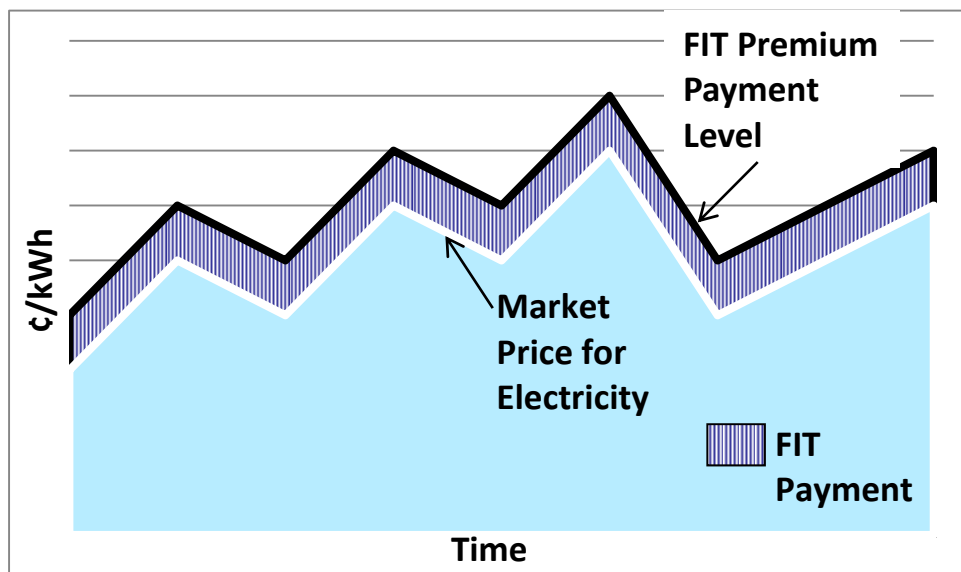
<sup>29</sup> It isn’t clear whether establishing the percentage amount involves less discretion than actually establishing the payment level.

Figure 3 illustrates a fixed-price FIT policy. In this policy design, the payment levels remain independent from the market price, offering a guaranteed payment for a pre-determined period of time. As described below, a number of adjustments can be made to this basic fixed price to track inflation, adjust for cost reductions, encourage certain choices and behaviors, and address other factors.



**Figure 3. Fixed-price FIT model**

The second option for FIT policy design (shown in Figure 4) is the premium-price option, which offers a premium on top of the spot market electricity price. This achieves one of two objectives: 1) to explicitly account for the environmental and societal attributes of RE, or 2) to help approximate RE generation costs. In this market-dependent model, the payment level is directly tied to the electricity market price, rewarding RE developers when market prices increase, and potentially penalizing them when they drop. These two approaches to FIT policy design will be explored in greater depth in the sections ahead.



**Figure 4. Premium-price FIT model**

Premium-price FIT policies have recently incorporated mechanisms that index the premium amount to prevailing electricity prices (see Section 4.3.2). This can create a range within which the premium fluctuates and reduces the chances of overcompensation that can result if electricity prices increase significantly. For a detailed evaluation of the advantages and disadvantages of both fixed-price and premium-price FIT policies, see Section 4.5.

The specific design choices for both fixed-price FIT payment models and premium-price FIT payment models are explored in greater detail below.

## 4.2 Fixed-Price FIT Payment Models

Fixed-price feed-in tariff policies are the most widely implemented of all FIT policy designs (Klein 2008). They are used in more than 40 countries around the world, including Germany, France, Switzerland, and Canada (REN21 2009). Based on experience in these countries, fixed-price FIT payments have demonstrated a higher level of cost efficiency compared to premium-price FIT payments; and have created, on average, lower risk and more transparent market conditions for RE development (Klein 2008, Ragwitz et al. 2007).

Fixed-price feed-in tariff policies can be differentiated in several ways, which explains why they are sometimes described as employing a “stepped” or “tiered” design<sup>30</sup> (Mendonça 2007, Ragwitz et al. 2007, Held et al. 2007, Klein et al. 2008). This section analyzes the range of differentiations used worldwide, based on examples from particular jurisdictions. In some instances, the considerations that apply to the fixed-price FIT design are different from those that apply to the premium-price designs. (Because some of the elements overlap, variations for the premium-price designs are only described briefly, and are explored in more detail in Section 4.3).

There are four key elements of the **project-specific tariff design (Section 4.2.1)**:

- a) the type of technology and/or fuel used,
- b) the size of the installation (total capacity),
- c) the quality of the resource at the particular site, and
- d) the value of generation to the market or utility, based on the particular project location,

Second, there are a number of **ancillary design elements (Section 4.2.2)**:

- a) predetermined tariff degression
- b) responsive tariff degression
- c) annual inflation adjustment,
- d) front-end loading (i.e., higher tariffs initially, lower tariffs later on),
- e) time of delivery (coincidence with demand to encourage peak shaving).

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<sup>30</sup> One of the defining characteristics of successful European FITs is that the payment level is differentiated in several ways based on the cost of RE generation (Langniss et al. 2009, Klein 2008). Policies that differentiate the FIT prices paid to electricity generated by the same RE technology have frequently been referred to as “stepped” or tiered feed-in tariff designs (IEA 2008, Klein et al. 2008, Ragwitz et al. 2007). This report chooses instead to refer to this design element (including all design elements whose purpose it is to distinguish between different RE projects) as “differentiations,” and distinguishes between different kinds of differentiation including project size, technology type, resource quality, and location.

Third, there are the **bonus payment options (Section 4.2.3)**, each designed to target specific goals and encourage certain types of choices and behaviors on the part of the RE developer:

- a) high-efficiency systems (e.g., CHP),
- b) use of particular waste streams,
- c) repowering (i.e., replacing older wind turbine models, or hydro sites, with newer, larger or more efficient ones.)
- d) specific ownership structures (e.g., community-owned),
- e) use of innovative technologies, and
- f) vintage of installation (where a bonus is awarded if a project is installed before a certain date).

For a summary of these FIT design options, see Table ES-1 in the Executive Summary.

#### **4.2.1 Analysis of Project-Specific Tariff Design**

There are several project-specific tariff design aspects that can be used to differentiate tariff payment levels, including technology, capacity size of the installation, the quality of the resource, and the value of generation to the market or utility (Klein et al. 2008, Mendonça et al. 2009a). By differentiating the payment structure according to the features and specific costs of RE installations, policymakers can establish a **cost-based payment structure**.

Note that tariff differentiation, as described below, is typically driven by additional policy goals such as encouraging different project sizes, targeting specific locations, or fostering different technology types, and that it can sometimes be at odds with other goals, such as cost minimization (see Section 6). These trade-offs must be considered as a central part of FIT policy design.

##### **4.2.1.1 Differentiation by Technology or Fuel Type**

Offering different tariffs according to technology or fuel type is one of the most basic ways to differentiate FIT payment levels. FITs based on the cost of generation consider the fact that not all RE technologies are created equal – some have a higher cost of generation than others, and most differ in their level of commercial maturity.

As highlighted throughout, certain feed-in tariffs differentiate the payments to a high degree to account for differences in the relative costs of each technology type. For instance, wind power projects are generally awarded a lower tariff than PV projects, due to the significant difference in their respective costs. In the case of biogas, producing electricity from anaerobic digesters installed at livestock operations is generally more expensive than doing so from landfill gas; similarly, in the case of biomass, a number of countries with FITs now distinguish between different fuel supplies, such as forestry wastes, agricultural wastes, farm wastes, etc. in an attempt to mirror the cost differences (Germany RES Act 2008, Spain 2007, SFOE 2008).

However, some jurisdictions have opted to leave tariffs undifferentiated, arguing that this makes the policy more “technology-neutral.” In British Columbia’s Standing Offer Program (SOP), for example, one payment level is offered to all types renewable energy projects competing within a given area of the region (BC Hydro 2008). It is argued that this will create more cost-effective RE development because only the least costly types will be deployed. In a similar example, in its 2006 Standard Offer Program, the Canadian Province of Ontario offered the same “standard”



price for wind, biogas, and small hydro systems – CAN \$ 0.11/kWh (RESOP 2006). This lack of differentiation made it difficult to attract capital and stimulate investment in non-wind projects and biogas projects, in particular (Gipe 2007).

### **Evaluation of Differentiation by Technology or Fuel Type**

If encouraging diversity of RE technologies is one of the policy objectives, it is necessary to differentiate the payments levels according to technology type. Technology-specific differentiation also allows policymakers to select the portfolio of renewable energy technologies that is most suitable to their area, available resources (particularly for wind and solar), policy goals, etc., and to offer each a tariff amount that is consistent with cost recovery for each technology type.

Furthermore, differentiation by technology enables RE industry and manufacturing development to occur for a variety of technologies, which potentially increases the domestic economic benefits of the policy framework. Insisting on technology neutrality may lead to renewable energy development dominated by one or a few technology types. Therefore, the undifferentiated FIT policies' claim to technology "neutrality" can be viewed as problematic in practice, because it implicitly favors one or a few RE technologies.

There are challenges: Differentiating FITs by technology type can increase the overall costs of the policy framework, particularly if higher-cost RE sources are included. For these and other reasons, including a variety of different RE technologies may require a commitment to "reasonable cost" as opposed to "least-cost" development. This acknowledges that costlier technologies may require greater support for near-term market deployment to enable them to move down the cost curve (Ragwitz et al. 2007). Ultimately, the costs and benefits of encouraging higher-cost RE sources have to be considered in relation to the overall policy objectives.

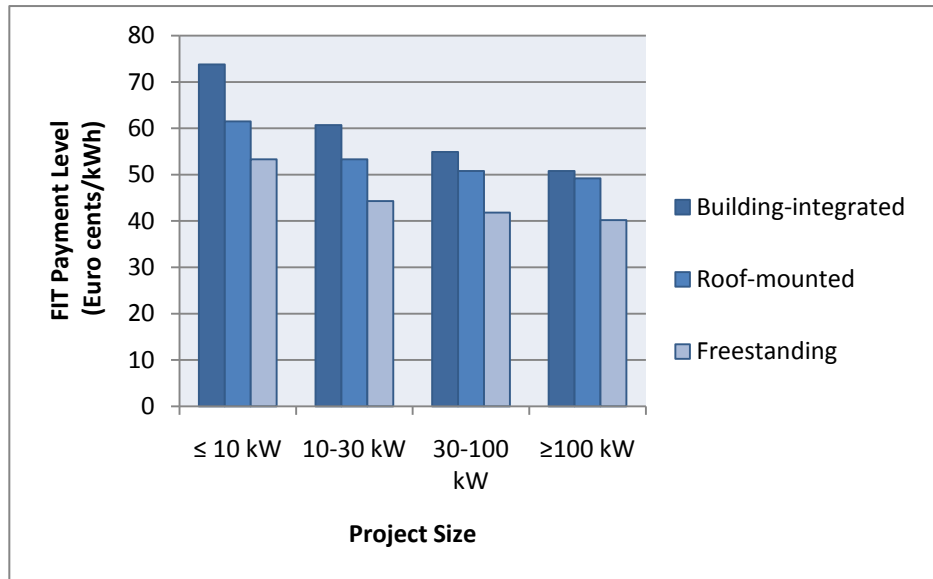
#### **4.2.1.2 Differentiation by Project Size (i.e., kW or MW Capacity)**

Some feed-in tariff structures are differentiated according to the project size, represented in terms of total installed capacity. The lowest payment level is typically offered to the largest plants, reflecting the gains that result from economies of scale. Differentiating FIT payments by project size is another means of offering FIT payments that reflect actual project costs.

As an example, countries such as France, Germany, Switzerland, and Italy provide the highest tariff amounts for the smallest PV installations, which helps match the tariff amount to the actual generation cost (plus a reasonable rate of return). The goal of such a structure is to approximate about the same rate of return, no matter the size of the project (although slightly higher returns for larger projects provides a slight advantage, to try to capture economies of scale and reduce gaming – described below).

Germany also offers size-differentiated FIT payments for biogas, biomass, hydropower, solar, and geothermal (Germany 2008), while Switzerland offers a special payment level for small wind turbines that are less than 10 kW (SFOE 2008, 2010). A similar treatment of small wind power has been included in the United Kingdom's recent FIT policy framework for projects less than 5 MW (Great Britain 2010). A number of U.S. state FIT proposals also include a special FIT payment for wind projects under 20 kW (Gipe 2010).

If the policymaker commits to differentiating the FIT prices by project size, there are a few ways to do so. One is to adjust payment levels in a stepped manner by establishing capacity increments at which payment levels drop. Switzerland has opted for this approach, offering different FIT payment amounts for larger projects (SFOE 2008, 2010). The 2010 payment levels for PV systems in Switzerland are shown in Figure 5.



Source: SFOE 2010

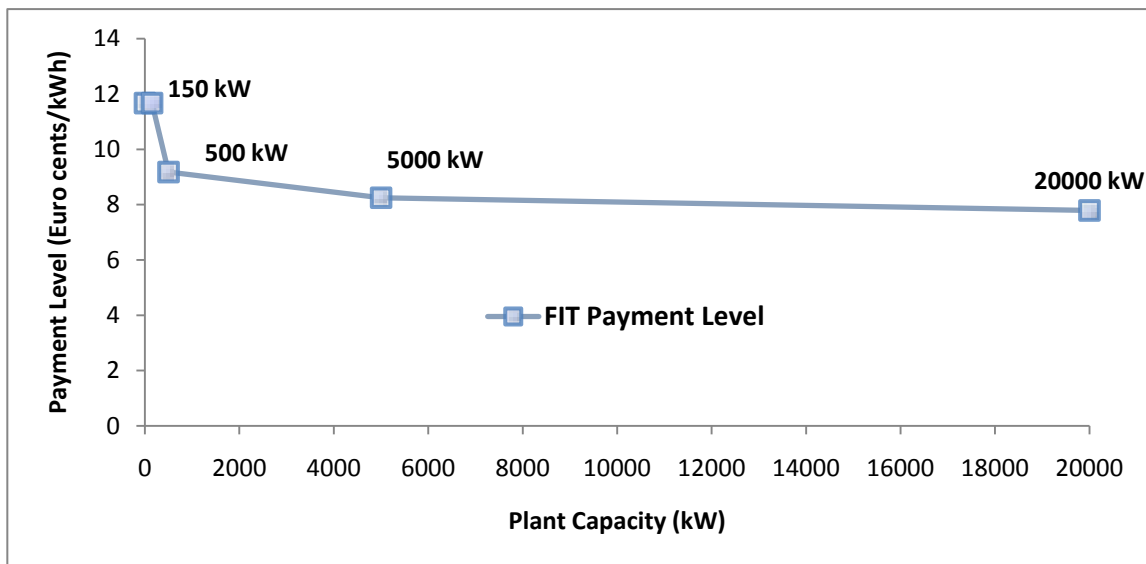
**Figure 5. Differentiation by project size and application in Switzerland's solar PV payment levels, (Euro cents/kWh)**

In another approach, Denmark differentiates by project size in its FIT policy for wind turbines that were connected to the grid before January 1, 2000 (Munksgaard and Morthorst 2008). A distinction was also made between small (<200 kW), medium (201-599 kW), and large (>600 kW) wind turbines, and each was offered a different FIT payment amount. These stepped levels provide one way of tracking the changes in overall generation costs that result from economies of scale.

Although the actual payment amount is less for larger systems, FITs can be designed to ensure that larger projects receive slightly higher rates of return than smaller projects (Lauber 2009). This is important to ensure that RE developers do not string together a number of smaller projects at adjacent sites to exploit the higher per-kWh payments offered.<sup>31</sup>

<sup>31</sup> The practice of bypassing these provisions by stringing together small plants was reportedly tolerated in Germany for solar and biogas until recently (Lauber 2009). However, it was recently prohibited under the 2008 RES Act and made retroactive by a court decision (Germany RES Act 2008).

In contrast, some jurisdictions choose to differentiate the payment levels for project size according to a linear function,<sup>32</sup> rather than one based on stepwise capacity increments. For example, Germany’s FIT policy framework applies a linear interpolation to determine the tariff amount awarded to projects that lie between the capacity thresholds. These values effectively act as reference points for the FIT payment curve, which is interpolated between each of the posted capacities (EEG Payment Provisions 2008). Figure 6 outlines Germany’s linear interpolation method for establishing FIT payment levels for biomass projects, differentiated between increments of 0 kW, 150 kW, 500 kW, 5 MW, and 20 MW.<sup>33</sup> A tabular overview of the full German FIT policy – with its differentiations by project size, technology type, resource quality, and a number of other design features – is found in Appendix A.

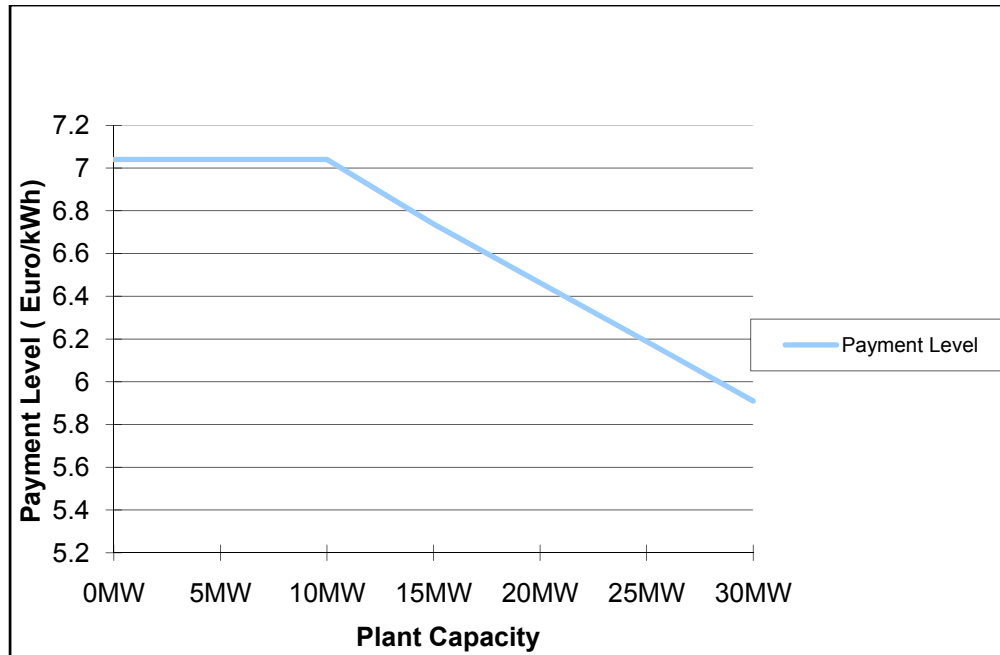


**Figure 6. Differentiation of Germany’s biomass FIT payment levels, by project size (Germany 2008)**

Portugal’s approach to factoring in economies of scale from hydropower projects is shown in Figure 7. Portugal offers a higher payment for the first 10 MW of installed capacity, adjusting the payment downward for projects that exceed this limit. This linear function provides a different way of adjusting for project size.

<sup>32</sup> A linear function for FIT project size continuously decreases payments as the size of RE project capacity increases, such that a developer can mathematically interpolate between the defined end points for any size project. See Figure 6 for a visual representation. In contrast, a stepwise increment provides the same FIT payment for all projects within a capacity range (e.g., Figure 5 shows that all projects between 10kW and 30 kW receive the same payment, then the FIT payment level “steps” down for projects 30 kW – 100 kW).

<sup>33</sup> A number of additional bonuses are included in Germany’s biomass FIT framework for high efficiency systems and other desirable project characteristics, which means that the actual FIT payments offered to a particular biomass project can be higher than the ones shown. Also, Germany applies tariff degression to biomass projects installed in subsequent years, so the payments shown have decreased since coming into effect in January 2009.



**Figure 7. FIT payment level for hydropower in Portugal (Klein 2008)**

### **Evaluation of Tariff Differentiation by Project Size**

By differentiating FIT payment levels by project size, policymakers can simultaneously encourage a variety of project sizes. This approach has a number of benefits.

First, investors can participate at different scales, from the homeowner seeking to install a PV system on their rooftop, to the institutional investor seeking to invest in large, commercial or utility-scale projects. Smaller projects can provide a number of distributed benefits, such as deferring the need for new grid upgrades, reducing line losses, and contributing to peak shaving (many more benefits are described in Lovins 2002). Larger projects can play a greater role in altering the overall generation mix, and may displace conventional generation (which could reduce carbon emissions – depending on the local resource mix).

Differentiating FIT payments by project size helps a jurisdiction capture the benefits of both large- and small-scale deployment by enabling deployment to occur at both scales. If a wide range of project capacity sizes are eligible, failing to introduce differentiation by project size could lead to windfall profits for large projects, or could leave insufficient returns for smaller projects.

Project size differentiation can be challenging to implement. Offering proportionally higher payments to smaller RE projects could increase the costs of the policy. Policy objectives will affect whether and to what extent a policymaker wants to differentiate the payments based on project size.

When designing tariff differentiation by project size, there are also challenges with the stepped model (which establishes flat, fixed capacity increments within a range). If the ranges are wide

enough, the developer has an incentive to size a project to just below the upper capacity threshold of a lower step (that has a slightly higher tariff level). This could result in project developers creating smaller projects to profit from the higher payment level, a situation that could increase the overall costs of the policy.

Using interpolation helps avoid this problem by differentiating the payment amount in a continuous and transparent way. Germany's approach of employing a linear interpolation between several specific data points creates a continuous curve that is not linear, but can more closely approximate the actual gains from economies of scale by relying on a set of project-size benchmarks. This could be particularly useful for highly scalable technologies such as hydropower and solar PV, where each individual site's characteristics play a decisive role in determining the final size of the installation. A payment design that uses interpolation and is tied closely to empirically demonstrated economies of scale could help provide project developers with a payment level more finely tuned to project-specific costs. However, it remains a challenge to establish the curve's function correctly, and to adjust it over time to consider technological change and cost reductions.

#### *4.2.1.3 Differentiation by Resource Quality*

Differentiating FITs by resource quality offers different payments to projects in areas with a different cost of production (Klein 2008). It is done to encourage development in a wider variety of areas, which can bring a number of benefits both to the grid and to society. As with technology and project size, differentiation by resource quality can be used to match the payment levels as closely as possible to RE generation costs. For example, areas with a high-quality wind resource will produce more electricity from the same capital investment, all else being equal,<sup>34</sup> leading to a lower levelized cost. A number of jurisdictions in Europe – including Cyprus, Denmark, France, Germany, Portugal, and Switzerland – have implemented resource-adjusted payment levels, though most choose to do so in different ways (Klein 2008).

The first approach is the reference turbine approach, employed by Germany and Switzerland. Germany awards the same incentive amount of €0.092/kWh to all wind energy producers for five years (Germany RES Act 2008). After five years, the individual turbine's output is compared to a hypothetical "reference" turbine with a hub height of 30 meters in a region with an average wind speed of 5.5m/s (Germany RES Act 2000). This "reference turbine" would generate a hypothetical "reference yield" over a five-year period. If a given wind turbine produces more than 150% of this reference yield in its first five years, the tariff for the remaining 15 years is reduced to €0.0502/kWh (Germany RES Act 2008). However, for every 0.75% shortfall from the 150% of the reference yield, the higher tariff is paid for an additional two months, effectively extending the higher payment to certain projects for a longer period of time.

For instance, a given wind turbine might generate 10 GWh of electricity over five years at the reference height and wind speed (this must be evaluated by an authorized verification agency). If, at the end of five years, the turbine generated 15 GWh and above, it would then, at the beginning of year six, drop to the lower tariff amount immediately. However, if it only generated 14.8875 GWh (i.e., 0.75% less than 150% of the reference yield), it would receive that tariff payment for five years plus two months. By extension, if it only generated 13.875 GWh (7.5%

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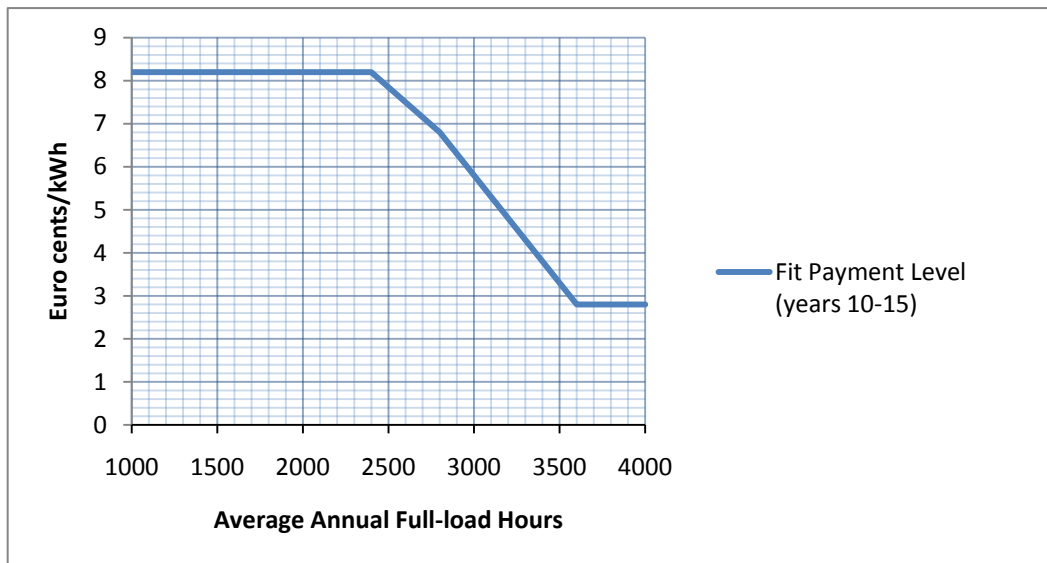
<sup>34</sup> This assumes similar installed costs (including equipment, grid interconnection, roads, and other components).

less than 150% of the reference yield), it would receive the higher payments for five years plus 20 months). After this period, the payments drop to €0.0502/kWh.

This formula encourages geographically dispersed wind development by ensuring that less windy sites can be profitably developed. However, a lower floor of 60% of the reference yield is also included as a minimum benchmark. If a given wind project<sup>35</sup> cannot demonstrate that it meets this minimum level, the transmission system operator is no longer required to award the FIT payments specified under the RES Act. Switzerland has recently developed its own reference turbine model that adopts a similar methodology (see SFOE 2008, 2010).

France provides another methodology for resource quality differentiation. For the first 10 years, France provides the same incentive payment to all of its onshore wind producers. After that, the incentive rate is adjusted according to the actual wind resource performance data from that particular site (Chabot et al. 2002, Klein 2008). In contrast to Germany and Switzerland, which use a reference turbine, France’s FIT policy adjusts its final tariff amount (offered between years 10 and 15) according to the average number of full-load hours in which the turbines *at a particular project* are effectively producing electricity (Chabot et al. 2002, Klein 2008).

Figure 8 demonstrates the decline in the payment level for onshore wind in France that occurs after the initial 10-year period elapses.



Source: France 2006, NREL 2010

**Figure 8. Onshore wind FIT payments in France, years 10-15 (France 2006)<sup>36</sup>**

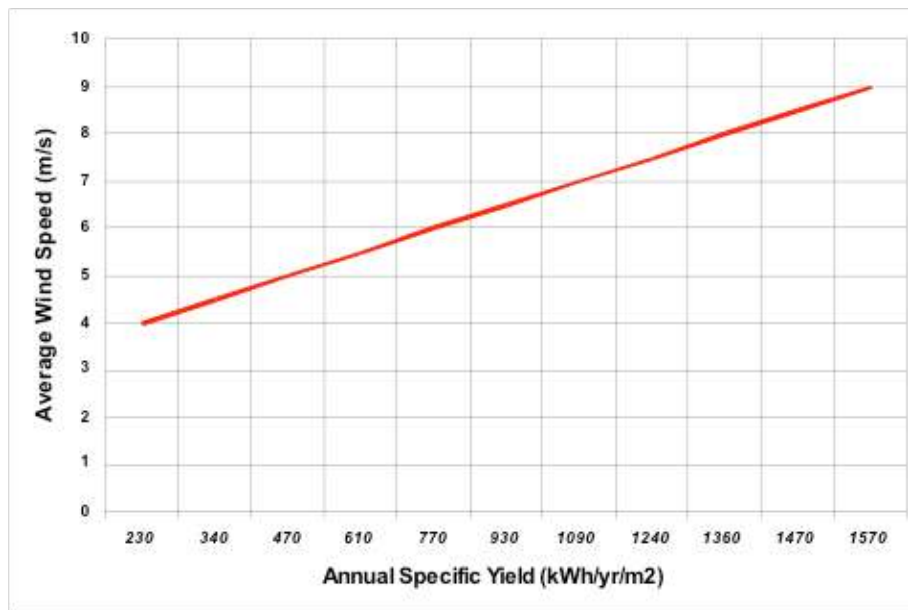
As shown here, France’s resource adjustment formula averages the wind performance over the initial 10-year period, yielding an average number of annual full load hours. Projects that produced electricity less than 24,000 full load hours over the 10-year period (i.e., 2,400 hours per year, or roughly a 27.4% capacity factor) receive the full tariff amount for the full 15 years

<sup>35</sup> This only applies to systems above 50 kW of installed capacity (Germany RES Act 2008).

<sup>36</sup> This depiction assumes a 20-year amortization period, 6.6% interest rate, an up-front installed capacity cost of approximately \$1,500/kW, O&M costs of 3% of total investment, and an annual inflation rate of 1.6%.

(France 2006). Those that produce greater than 36,000 full load hours after 10 years, in contrast, only receive €0.028 Euro cents between years 10-15, while those in between receive an intermediary amount. If a project averaged 3,100 full load hours, for instance, the payment level between years 10-15 would be approximately €0.055/kWh, according to the linear interpolation depicted in Figure 8.<sup>37</sup>

Some U.S. states have proposed a third way of resource quality differentiation of FIT payments, called the “annual specific yield” method. Annual specific yield is the annual electricity production considered in relation to the actual “swept area” of the wind turbine blades, measured in kWh/year/m<sup>2</sup>. Actual wind turbine power generation depends more on swept area than generator motor size; the annual specific yield tries to capture this by determining the productivity of wind turbines (Gipe 2004, 2006).<sup>38</sup> By basing the payment levels on annual specific yield, a jurisdiction is more likely to encourage the most efficient turbine models for maximizing electricity generation at each particular wind site, based on the nature and quality of the wind resource (Gipe 2006).<sup>39</sup> Figure 9 demonstrates the average electricity production for wind turbines in relation to the quality of the wind resource (Gipe 2006).



Source: Gipe 2006

**Figure 9. Annual specific yield (ASY) for large wind**

Resource quality differentiation is most often seen for wind power in Europe, but it can be used for other technologies as well. France recently approved a policy framework for solar PV where the payment levels can vary within a range of 20% from the highest payments to the lowest for

<sup>37</sup> Note that France includes a degression as well as an inflation adjustment on its wind tariffs, so the numbers portrayed here are no longer accurate.

<sup>38</sup> For a more detailed discussion of the benefits of annual specific yield over conventional measures such as capacity factor, see Gipe 2006.

<sup>39</sup> This problem occurred in California with a turbine model that had a generator too large for its blade span, or “swept area.” Rated at 95 kW, they performed scarcely better than other 25 kW models installed at the same time and in areas with comparable wind resources (Gipe 2006).

projects larger than 250 kW. This design leads to higher payments in the north (where it is less sunny) and lower payments in the south (France 2010a, CLER and Hespul 2009). In France, differentiating tariffs by resource quality is done by establishing a base tariff and assigning a particular multiplier to different regions. While applicable to smaller countries, this could be particularly valuable for large countries with a significant disparity in local solar resource potential such as Australia, the United States, and China; a similar proposal already has been made in Australia (Zahedi 2009). Note that it may be possible to differentiate FIT payments for geothermal, wave power, and tidal power sites based on varying resource quality as well.

### **Evaluation of Differentiation by Resource Quality**

Although differentiating FIT payments by resource quality appears to violate the principle of comparative advantage (see below), an increasing number of countries are beginning to adopt this approach. This suggests that it can be useful in meeting certain policy goals.<sup>40</sup>

First, differentiation by resource quality can encourage deployment in a wider geographic area, with diverse renewable energy resource regimes. For example, because RE resource quality can vary significantly from one location to another, a single price for wind generation would tend to encourage wind projects only in the windiest sites. This would allow projects in certain areas to capture large scarcity rents (see Butler and Neuhoff 2008). But differentiation by resource quality allows less windy sites to also develop economically viable projects.

Second, this design option can help avoid excess remuneration at the best quality sites. The German legislation that first introduced the principle of resource-adjusted FIT payments explains that “*the purpose of these new provisions is to avoid payment of compensation rates that are higher than what is required for a cost-effective operation of [wind power] installations*” (Germany RES Act 2000, Explanatory Memorandum B, Section 7). In other words, a flat, unadjusted wind payment could result in substantially higher profits for projects in windy areas, while providing marginal or insufficient returns at less windy sites that may still have commercially viable potential. Therefore, differentiated tariffs for resources such as wind power can provide payment levels that more accurately reflect actual, site-specific generation costs. As a result, this resource-adjusted payment scheme is intended to bound project returns to approximate those targeted by FIT policy administrators, a feature that could help *reduce* the potential for overpayment in high-quality resource areas.

Third, if structured well, resource-adjusted tariffs can potentially provide more flexibility in project siting. For example, they can make it easier to site projects away from scenic coastal areas, mountaintops, or other areas where land-use conflicts are likely to be greatest. This can result in lower overall project costs by reducing land-lease costs, associated legal costs, and by avoiding other land-use issues. This approach can ultimately help reduce “social friction” (a.k.a. NIMBYism) by allowing project siting in a more context-sensitive manner without significantly compromising project profitability.

Fourth, differentiating FITs by resource quality can potentially reduce balancing costs, by alleviating stresses and bottlenecks that can develop in the grid near windy areas. Geographically

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<sup>40</sup> Note that many of these arguments are based on the potential benefits of differentiation by resource quality. They are not guaranteed consequences of implementing a FIT policy that incorporates this design feature.



dispersed wind development may be easier to integrate within the grid, while synchronous, region-wide dips in wind power production are less likely when wind parks are distributed across a large and interconnected area, which can improve overall reliability.

And finally, offering resource-adjusted FIT payments can also allow a greater number of regions to participate, which may increase the level of investment and can potentially lead to more domestic RE resource development in the near term.

However, there are challenges with offering resource-differentiated payment levels in feed-in tariff policies. First, the concept of offering higher tariffs for less windy sites violates the principle of comparative advantage, which would have wind projects developed only in the windiest sites. In other words, wind sites able to produce the most electricity at the lowest cost<sup>41</sup> should be the ones to do so.

Second, by violating comparative advantage, it simultaneously counters “least-cost” planning for electricity procurement. By offering a higher per-kWh purchase price for areas with lower wind yields, policies that incorporate differentiation by resource quality may pay a higher price for renewable energy than is available elsewhere (i.e., at windier sites). This is not the optimal outcome from an economic standpoint.

Third, if not designed properly (with slightly higher returns at sites with the best resources), there is also the chance that RE developers will choose to only develop projects at lower-quality sites to benefit from higher per-kWh payment amounts. This would reduce the overall cost-effectiveness of the policy framework.

Finally, differentiating the payment levels based on the quality of the resource introduces another layer of complexity to the policy design, which could reduce the transparency of the framework for investors.

If offering resource-adjusted tariffs is considered desirable to meet overall policy objectives, it is important to ensure that the mechanism is properly designed and that it avoids some of the pitfalls identified above.

#### *4.2.1.4 Differentiation by Project Location*

Another differentiation that can be included within a FIT policy is offering varied payments to projects mounted in different physical locations (without regard to resource quality). This can be done to encourage project development in particular applications, encourage multi-functionality (particularly for solar PV), target particular owner types such as homeowners, and meet a number of other policy goals. As shown in Table 4, France differentiates its tariffs for PV installations according to whether they are free-standing, or building-integrated (a.k.a. BIPV), including three categories of building integration with a number of specifications applying to each (France 2010a).

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<sup>41</sup> Or lowest opportunity cost, as the case may be.

**Table 4. France FIT Payment Differentiation by Location for PV Systems (2010)**

System Location	Payment Level (€ cents/kWh)
<b>BIPV on recently constructed<sup>42</sup> residential buildings, schools, &amp; health facilities</b>	58
<b>BIPV (on other recently constructed buildings)</b>	50
<b>Simplified BIPV</b>	42
<b>Freestanding PV (&gt;250 kW)<sup>43</sup></b>	31.4

Source: France 2010a

France, therefore, offers higher payments to BIPV projects installed in particular building types – including residential, educational, and health facilities – to encourage development in these locations. It also includes a number of specifications for eligibility in each BIPV category. For instance, the building on which the PV system is installed must be used to shelter people, livestock, goods, or activities; the PV system has to be integrated into the roof in such a way as to effectively *replace* the roof function; PV systems must be parallel to the roof plane; projects must be larger than 3kW in installed capacity, etc. (France 2010a).

One of the reasons for the significant premium offered to building-integrated PV systems is the desire to encourage multi-functionality. An incentive is created to integrate PV systems directly *into* a wide variety of locations in new construction, rather than simply mounting them *on top of* existing construction. In addition, by targeting BIPV systems and limiting the tariffs to new construction, France is simultaneously limiting the pace of uptake. Taken together, these factors reduce the risks of gaming (e.g. building make-shift structures to benefit from higher roof-mounted tariffs), and mitigate the risks of an unanticipated boom in PV development by effectively linking PV applications to the building permit process. Note that these limitations only apply to building-integrated PV systems.

Greece uses a different approach, which France has also adopted – both countries award higher tariffs to projects installed on its islands that remain isolated from the mainland grid (Greece 2006, France 2010a). These higher tariffs reflect the importance of distributed generation on islands and encourage investment in electricity generation where it is needed most.

In a similar approach, the Canadian province of British Columbia offers higher payment levels based on project value (BC Hydro 2008). Under its Standing Offer Program (SOP) policy, the province offers a fixed price to all renewable energy technologies, but the fixed price varies depending on where the projects are developed on the province’s electrical grid. Higher fixed prices are offered to projects on Vancouver Island (CAN \$84.23/MWh) than in the Central

<sup>42</sup> “Recently constructed” in France’s current FIT legislation means that it has been built within two years of the installation of the PV system (France 2010a).

<sup>43</sup> Ground-mounted projects larger than 250kW are benchmarked at 31.4 Euro cents/kWh, and adjusted according to a regional multiplier that ranges from 1.0 to 1.2. This means that the tariff for ground-mounted projects reaches 37.68 Euro cents/kWh in the least-sunny areas of France (see Section 4.2.1.3). For projects ≤250 kW, the multiplier is 1 (France 2010a).

Interior region (CAN \$77.53/MWh). This structure better reflects the avoided costs of electricity delivery in each area<sup>44</sup> (BC Hydro 2008).

Finally, with the decrease in readily available onshore sites suitable for wind development, a number of European jurisdictions (including Spain, Germany, and Denmark) are beginning to offer higher tariff levels for offshore wind projects (Spain 2007, Germany RES Act 2004, DWIA 2004). For example, in its 2004 RES Act, Germany established a higher tariff level for offshore wind compared to onshore sites – €0.091/kWh for 20 years versus the initial rate of €0.084/kWh offered to onshore wind projects (Germany RES Act 2004). In addition, Germany offered higher tariff levels (over a longer duration) for every nautical mile beyond 12 miles offshore. The payment level also varied based on the depth of water in which the project was developed. In its 2009 Amendments, the German RES Act retained the previous specifications but increased its payment level, specifying a new tariff level of €0.13/kWh for offshore projects, which includes an additional bonus payment of €0.02/kWh if the project is developed before December 31, 2015 (Germany RES Act 2008; see Section 4.2.3.7).

### **Evaluation of Tariff Differentiation by Project Location**

Differentiating tariffs by project location can create higher payment levels for higher-cost applications, such as roof-mounted and building-integrated systems; and can help increase PV integration in urban load centers, while potentially deferring the need for new transmission and/or distribution upgrades. It can also encourage broader participation in the policy by offering slightly higher payments for rooftop systems. This also fosters renewable energy development in a way that optimizes the use of existing infrastructure while potentially avoiding conflicts with other land uses. In addition, offering higher payments for projects in remote areas such as wind in offshore locations can also help a jurisdiction attain higher levels of RE penetration, by making it possible to harness difficult-to-access resources.

However, offering higher payments to projects installed in certain locations can increase the cost of the policy. It can also increase the number of applications in certain areas, which could lead to bottlenecks if transmission and distribution capacity are not planned accordingly.

### **Summary of Feed-in Tariff Differentiation**

As shown in this section, there are several ways to differentiate FIT payment levels based on the specific characteristics of a particular RE project, including technology, project size, quality of resource, and project location. These design options can be used in various configurations to achieve particular policy goals. A careful examination of policymakers' goals can determine whether a given design option is desirable.

If properly structured, FIT payment differentiation can increase the cost efficiency of the policy, broaden the number of project types that can be profitably developed, and allow value-based considerations to be taken into account, while helping increase the share of existing RE potential that is effectively harnessed.

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<sup>44</sup> Note that in contrast to most European FITs, where the policy is developed by the government, British Columbia's FIT was developed by BC Hydro, the province's utility.

## 4.2.2 Ancillary Feed-in Tariff Design Elements

In addition to the various differentiations explored above, there are a number of other, ancillary design elements that can be used to achieve different policy objectives. This section explores these supplementary elements, including predetermined and responsive tariff degression, inflation adjustment, front-end loading, and coincidence with electricity demand (referred to here as “time of delivery”).

### 4.2.2.1 Predetermined Tariff Degression

Tariff degression is used to keep tariffs in line with evolving cost realities through decreases in the payment level, at either specific points in time, or as capacity targets are reached. Tariff degression can be established transparently ahead of time, over several years, according to fixed annual percentage declines, or according to a “responsive” formula that allows the rate of degression to respond to the rate of market growth. This section considers the first approach, while Section 4.2.2.2 examines the second, “responsive” design.

Predetermined tariff degression requires an incremental reduction in the FIT payment levels for projects that become operational after initial implementation (Langniss et al. 2009, Mendonça 2007, Fell 2009, Klein 2008). In other words, if the increment is implemented on an annual basis, projects in year two will receive incrementally lower FIT payments than projects installed in year one; and this would continue for subsequent years. Tariff degression is typically applied as an annual percentage reduction.<sup>45</sup> It can also be applied based on capacity, where automatic adjustments occur when a certain amount of installed capacity is achieved.

Table 5 shows the tariff degression schedule for landfill gas systems in Germany, based on an annual degression of 1.5%. The numbers reflect the payment levels offered in subsequent years, represented here in € cents/kWh through 2014 (Germany RES Act 2008).

**Table 5. Tariff Degression for Landfill Gas Facilities in Germany (Germany RES Act 2008)**

Project Size	Payment levels (€ cents/kWh)					
	In-Service Year					
	2009	2010	2011	2012	2013	2014
0-500 kW	9.00	8.87	8.73	8.60	8.47	8.34
500 kW-5 MW	6.16	6.07	5.98	5.89	5.80	5.71

Tariff degression is based on the concept of “experience curves,” where technological learning leads to gradual and relatively predictable cost reductions over time (Klein 2008). These cost reductions tend to require a downward adjustment to the FIT payment in future years if the policy is to remain cost-efficient over time.<sup>46</sup> Tariff degression is applied because the total costs

<sup>45</sup> This section refers explicitly to “pre-established” tariff degression, because the rate of the tariff adjustments is established in advance and enforced until the following program revision (typically two-four years later). This clarification is important because it is possible to adjust for technological change and cost reductions annually based on administrative policy revisions, instead of according to a pre-established schedule. It is also referred to as “predetermined” tariff degression to distinguish it from the option discussed in Section 4.2.2.2, “responsive” tariff degression.

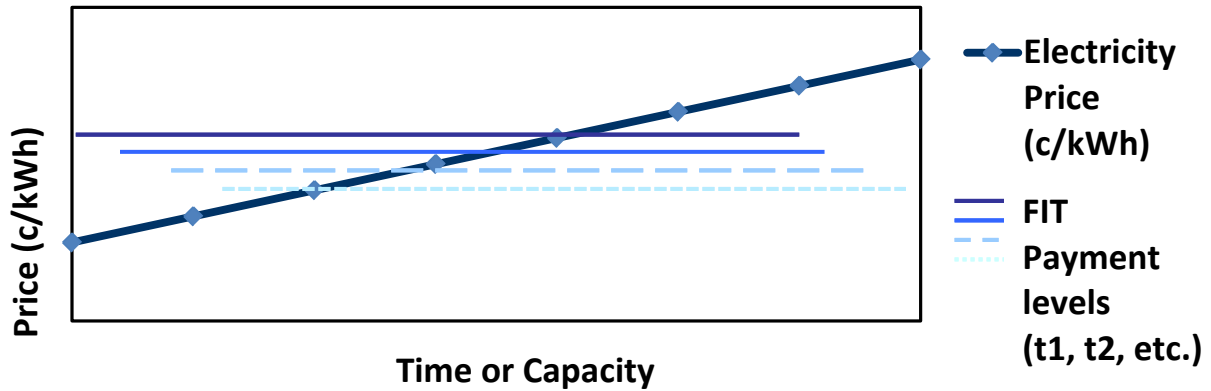
<sup>46</sup> Note that costs can also increase over time due to shortages of materials, increasing labor costs, etc.

of a technology (which include labor, capital, research, marketing, administrative costs, etc.) tend to decrease in a relatively predictable way. This is based on the observation that for every doubling in output in a given industry, there tends to be a proportional decrease in the unit cost over time. Following this reasoning, one can derive a “progress ratio,” based on which costs decrease due to factors such as technological learning, economies of scale, technical progress, and rationalization (Klein 2008).

Naturally, degression rates will be greater for rapidly evolving RE technologies such as PV, than those found in more mature technologies such as wind and hydropower. For example, Germany uses this system for several renewable energy sources included in its policy, ranging from 1% per year for hydropower installations to up to 10% for freestanding solar PV systems (Germany 2008). While progress ratios can be estimated as percentages of cost decline, this method does not perfectly match the actual progress in a particular industry. If progress is made more quickly than expected (e.g., a doubling of output in half the time), tariff degression based on time will likely not be accurate (because it will still ramp down annually). Tariff degression based on capacity installed will be more likely to keep up with rapidly changing market conditions.

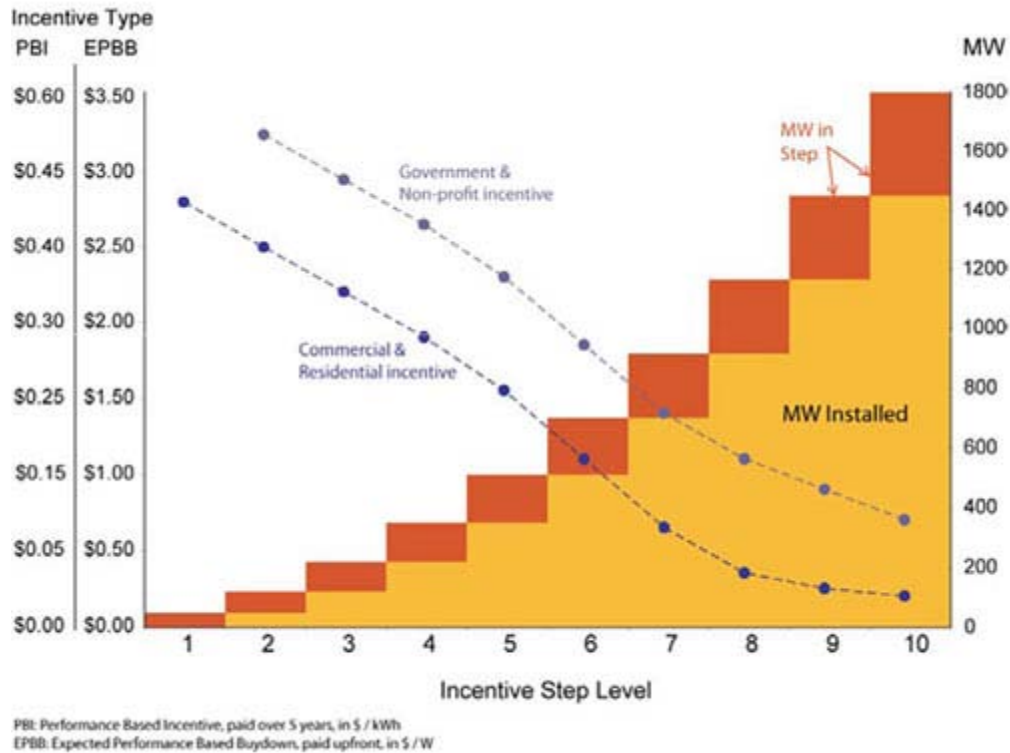
This policy design option is becoming more widely implemented in the EU and is found in countries including Germany, France, Italy, and Switzerland, as well as more recently in the United States in Gainesville, Florida (Klein 2008, SFOE 2008, GRU 2009). Tariff degression has gained support since Germany first introduced it in its RES Act of 2000, and the concept is now considered among best practices in FIT policy design (Diekmann 2008, Klein et al. 2008, Ragwitz et al. 2007, Langniss et al. 2009). Figure 10 illustrates this annual decline in FIT payments.

Policy designers can also defer tariff degression to begin at a fixed date. For example, Switzerland defers degression on the tariffs offered to geothermal systems until 2018, while deferring the initiation of its 8% degression for PV installations to 2010 (SFOE 2008, 2010). Similarly, the 2008 amendments to the German RES Act (which became effective January 1, 2009) indicate that tariff degression for offshore wind projects begins in 2015, at a rate of 5% per year (Germany 2008). This helps RE developers and investors anticipate the date at which degression begins, which provides a grace period to encourage early adoption and increase project development.



**Figure 10. Tariff degression representation**

While not a feed-in tariff, the California Solar Initiative offers production-based incentives (PBIs) that offer predetermined payment degression, based on capacity targets. The financial incentives for solar installations decrease over 10 steps, as capacity installations and applications are met. The overall goal of 1,750 MW was divided by 10 declining steps, where each step has separate megawatt allocations by utility territory and customer class. Once the total capacity level for each step is reached, the utility offers the next lower incentive for that customer class in its territory. Figure 11 shows how, as capacity targets are met, the incentive levels decrease over the life of the program.



Note: The orange box in each "Incentive Step Level" represents the available megawatts at that incentive value. The yellow box represents the cumulative installed megawatts as the program proceeds through the steps.

Source: Go Solar California 2010

**Figure 11. California Solar Initiative – capacity-based degression**

### Evaluation of Predetermined Tariff Degression

There are several arguments in favor of incorporating pre-established tariff degression into a feed-in tariff policy. First, degression creates greater investor security by removing the uncertainty associated with annual program revisions and adjustments. If the degression rates are known in advance, and are transparent to all participants, it is easier to factor them into investment decisions (Fell 2009) – this helps foster greater planning security.

A second advantage is the transparent framework, which can provide a clearer signal to manufacturers, who then have an incentive to reduce the marginal cost of their product. This allows manufacturers to keep up with the planned degression scheme, while vying to remain competitive with other manufacturers seeking to do the same. This system simultaneously creates a stimulus for further investments in R&D, because market competition drives improvements in efficiencies and increased investments in innovation. Thus, tariff degression can track and encourage technological innovation; the latter is referred to as increasing “dynamic efficiency” (Menanteau 2003, Ragwitz et al. 2007, Jacobsson et al. 2009).

There are a few other general advantages that apply to tariff degression. Reducing the payment levels also reduces the marginal costs of RE deployment to society (Fell 2009). Additionally,

tariff depression can encourage more rapid RE deployment (Klein 2008). If the initial tariff offered (in year one or for an established amount of capacity) is higher than the next payment level (in year two or for the next capacity target), an incentive is created to develop projects earlier to benefit from the marginally higher rate.<sup>47</sup> This can lead to more robust rates of market growth, which can result in further cost reductions as markets mature and reach economies of scale.

However, predetermined depression can be problematic, because it is very difficult to predict how the cost profile of a given technology will change over time (Jacobs and Pfeiffer 2009). For example, with the costs of metals and labor increasing –compounded by tightening supply conditions and rapidly growing demand – costs of offshore wind projects have increased by up to 60% between 2005 and 2008 (Odedra 2008). A recent Department of Energy (DOE) report broadly confirms a similar trend for onshore wind, finding average real-price increases of more than 40% from 2004-2007 in the United States (U.S. DOE 2008). If these cost increases occurred under a policy framework that included pre-established depression rates, they would not be accounted for and could dampen growth in the regional wind market until either depression rates, or tariff levels, were revised.

While the intent of pre-established depression is to track changes in technology costs over time, it can only track them in one way – downward. This can increase market uncertainty if actual technology costs begin to trend in the other direction (upward) more quickly than anticipated.

Solar PV poses another challenge for FIT policy designers. Recently, solar PV prices have rapidly decreased, which means that annual predetermined depression rates for a long period of time can also *underestimate* the level of technology and cost advancements. Retail solar module prices (not including labor, installation, and balance of system) decreased rapidly in 2009. In the United States, they started at \$4.84/watt in January 2009 and are currently at \$4.30/watt in January 2010 (Solarbuzz 2010). Therefore, jurisdictions with annual predetermined depression for multiple years, such as Germany, did not capture this rapid and unexpected decrease in overall prices; some are revisiting their FIT payment levels for PV earlier than anticipated. It is important to note that capacity-based depression rates would be expected to temper these rapid decreases, because the payment levels would adjust down more quickly as specific capacity levels are achieved.

Therefore, for technologies that are still experiencing rapid changes in cost, whether up or down, a pre-established depression scheme set over a long time period could pose substantial challenges for the FIT policy designer. As such, Ontario has opted not to use depression at all and is relying on revisions that occur every two years to adjust for cost changes.

#### ***4.2.2.2 Responsive Depression***

In an attempt to address the problems with pre-established depression rates, Germany has recently introduced “responsive depression” schemes for solar PV. In this design, the rate of

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<sup>47</sup> Naturally, this also depends on market expectations of technological cost reduction; if costs are expected to decline faster than the predetermined depression rate, there would be an incentive to defer project investments accordingly.



degression is adjusted according to the rate of market growth (Germany RES Act 2008; see also Jacobs and Pfeiffer 2009).<sup>48</sup>

In Germany’s case, if the annual installed PV capacity in a given year exceeds a certain amount, the percentage rate of annual degression is increased by 1%; if it falls short of a certain annual installed capacity, the degression rate is decreased by 1% (Germany 2008). This scheme, described in detail in Table 6, provides a means by which the payment levels can be adjusted in relation to the actual rate of technology deployment, while also lowering the marginal costs of renewable development when growth rates are high (as of July 1, 2010, Germany has adopted a new responsive degression framework).

**Table 6. German Responsive Degression Rates**

Year	Market Condition (this year)	Next year’s annual degression rate
2009:	< 1,000 MW installed	Declines 1% (e.g. 8% to 7%)
	Between 1,000-1,500 MW installed	No change
	1,500+ MW installed	Increases 1% (e.g. 8% to 9%)
2010	< 1,100 MW installed	Declines 1% (e.g. 8% to 7%)
	Between 1,100-1,700 MW installed	No change
	1,700+ MW installed	Increases 1% (e.g. 8% to 9%)
2011	< 1,200 MW installed	Declines 1% (e.g. 8% to 7%)
	Between 1,200-1,900 MW installed	No change
	1,900+ MW installed	Increases 1% (e.g. 8% to 9%)

Source: Adapted from Jacobs and Pfeiffer 2009; see also Germany 2008 and 2010

### Evaluation of Responsive Degression

As shown in the previous section, pre-established degression schemes may fail to accurately track market changes, and may not be sufficient to adjust payment levels to moderate the pace of market growth. This is particularly true for predetermined degression that is based on time/annual increments, and less so for capacity-based degression. However, both predetermined degression methodologies only adjust downward and do not respond to unique situations when costs actually increase.

Responsive degression schemes provide a potential solution by introducing a self-adjusting element in the policy design. In the German approach, if market growth does not meet expectations, the rate at which the tariff degression occurs can be revised upward or downward to stimulate greater investment. This effectively allows the adjustment of the degression rate to occur automatically, based on a transparent formula. This may reduce the need for administrative adjustments to the degression amounts, as well as to the FIT payments.

However, responsive schemes increase the complexity of the policy framework, and may only be suitable for large RE markets, particularly those in which substantial cost reductions are still

<sup>48</sup> Jacobs and Pfeiffer refer to this policy design as “flexible” degression. The authors have chosen instead to use the term “responsive” degression to reflect the self-adjusting nature of the mechanism. The authors acknowledge that this is open to debate.

expected to occur (Jacobs and Pfeiffer 2009). In addition, it is not clear that the 1% adjustment to the payment level in the German case (for instance), will be adequate to effectively influence the rate of market growth; nor is it clear that such an adjustment will be adequate to track changes in technological costs over time. Given recent trends in solar PV markets, in particular, current designs of responsive degression schemes appear unable to track the full bandwidth of PV cost volatility. However, the authors acknowledge that it may be possible to create a responsive degression structure that is sufficiently flexible to do so. This may lead either to the design of even more flexible degression schemes (either of capacity-based predetermined degression, or some other form of responsive degression), or to an abandonment of degression itself in favor of annual (or biannual) FIT payment level revisions. Ontario, for example, has decided not to adopt tariff degression and is choosing direct adjustments based on a biannual analysis of cost realities.

#### 4.2.2.3 *Inflation Adjustment*

To provide added investment security, some jurisdictions index FIT payment levels either fully or partially to the consumer price index (CPI), similar to conventional power purchase agreements (PPA). This inflation adjustment provides added security for investors, by protecting the real value of renewable energy project revenues from changes in the broader economy (Couture and Gagnon 2010).<sup>49</sup>

Policy designers use different approaches to adjust for changes in the CPI. Some jurisdictions adjust the full tariff price to the annual changes in the CPI, while others peg only a portion of the tariff price to track these changes. Both methods protect the value of project revenues from changes in the broader economy.

For example, Ireland adjusts the entire FIT prices for inflation (Ireland 2006). The Canadian Province of Ontario opted only to adjust 20% of the tariff price to inflation, based on an estimate of the proportion of project costs that are likely to be impacted by changes in the CPI (OPA 2009a).

Germany does not adjust its tariff prices for inflation explicitly every year. Instead, it assumes a 2% annual inflation rate in its FIT calculation methodology and establishes the fixed, levelized FIT payments using this assumption – and with the goal of meeting the targeted return at the end of 20 years (Germany RES Act 2008, Fell 2009).

Without accounting for inflation, FIT payment levels could, be subject to two forms of depreciation over time: the first caused by tariff degression (see Section 4.2.2.1), and the second caused by the depreciation in the real value of project revenues caused by the overall rate of inflation. Providing inflation adjustment can be more critical to ensuring investor security, especially in economies experiencing high rates of change in the CPI (i.e., emerging market economies). Similarly, jurisdictions that have historically experienced a highly variable rate of inflation may adjust for inflation annually, rather than assuming a certain average rate of inflation in the future, as is done in Germany.

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<sup>49</sup> This must be distinguished from adjustments to tariff prices that are a result of tariff degression. Inflation adjustment can be understood as a form of “internal” tariff adjustment (i.e., which occurs over the course of the contract) as opposed to one that takes place “externally” (i.e., for contracts signed in subsequent years) such as tariff degression. The authors thank Wilson Rickerson of Meister Consulting Group for this distinction.

## Evaluation of Inflation Adjustment

Because of the greater protection offered on the value of project revenues, adjusting FITs for inflation can reduce the perceived risk of the policy for investors. When using 15- to 20-year contracts, this added protection from inflation adjustment may be particularly important when encouraging larger-scale RE investments and attracting certain types of investors. Moreover, inflation is commonly factored into utility and regulator decisions (including traditional PPAs); thus, not adjusting for inflation could be considered a break with traditional utility procurement policy.

On the other hand, *not* adjusting FIT payments for inflation can be a way to minimize overall costs for society, by allowing the value of the FIT payments to depreciate. This can ensure that the payments awarded under the policy will have a proportionally smaller impact on electricity prices in the medium to long term. This consideration is likely to be particularly important toward the end of the contract term and in economies with high rates of inflation.

### 4.2.2.4 Front-end Loading

Another ancillary FIT design option is to offer a proportionally higher tariff for an initial period (e.g., 5-10 years), and a proportionally lower tariff for the remainder of the project's useful life – this design is known as front-end loading. Although the notion of front-end loading is found in a number of different jurisdictions, the reasons for its implementation appear to differ considerably from one area to another (Couture and Gagnon 2010).

For instance, Minnesota's Community-based Energy Development (C-BED) program (which is not technically a FIT program) applies a form of front-end loading<sup>50</sup> (Minnesota 2005, Couture and Gagnon 2010). In this policy, a higher purchase price is offered for the first 10 years than in the last 10 years (20 years total), which helps investors obtain their target yield within the first 10-year period; after that, projects may be “flipped” to local owners. This design works in conjunction with the federal production tax credit (PTC) in the United States, which operates on a 10-year structure (Bolinger 2004, Mendonça et al. 2009b).

Slovenia uses a slightly different approach to front-end loading. A predetermined drop in the tariff amount of 5% is introduced after five years in operation, and another 10% drop after 10 years (Held et al. 2007). This leads to a predictable decline in FIT payments over time.

In a further variation, Spain uses a form of front-end loading to clarify what occurs when the period of the purchase agreement ends.<sup>51</sup> At the end of the specified period in which the purchase guarantee is offered (which ranges from 15-25 years), Spain reduces its tariffs for projects that have chosen the fixed-price option, while reducing or dropping entirely its premium amounts for those who chose the premium option (Spain 2007, Held et al. 2007). In Spain's fixed-price option, the payments offered for wind power decline from €0.073/kWh to €0.061/kWh after the initial 20-year period. This reduces the long-term electricity price impacts of the FIT by reducing the payments received during the final years of a project's productive life.

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<sup>50</sup> While the C-BED program is not officially a FIT, it provides a framework through which community-owned projects can obtain a negotiated contract price for RE electricity. Note that a FIT policy has been proposed in Minnesota (see Minnesota 2008).

<sup>51</sup> See Appendix B for a full description of the Spanish FIT model.

Another approach to front-end loading was discussed in the section on tariff differentiation by resource quality (Section 4.2.1.3). In this approach, a higher payment is typically offered for 5-10 years, after which it is adjusted downward for the remaining years on the basis of site productivity. Although there are a number of reasons for implementing this design (see Section 4.2.1.3), it is used primarily to ensure that projects in highly windy areas are not overcompensated (Germany 2000, Butler and Neuhoff 2008).

### **Evaluation of Front-end Loading**

Front-end loading has many benefits. It enables project loans to be paid off more quickly by offering higher per-kWh payments in the early years when they are needed most. This may be particularly suitable for renewable energy projects, which tend to be characterized by high up-front costs (Couture and Gagnon 2010).

Second, this approach can increase the real project returns by reducing the amount of interest paid. For projects financed primarily with equity, this can help investors obtain their target yields more quickly, while projects financed primarily with debt will see positive cash flows earlier in the project's life than under a flat, long-term FIT price.

Third, front-end loading can provide one way of adjusting FIT payments to account for different renewable resource potentials between projects, offering a higher payment in the early years to all projects and a lower payment for the remainder (which is differentiated based on actual production at the site).

Finally, it can help with projects that have fuel costs and cannot secure a fuel supply at a predetermined price during the entire FIT period. For example, biomass projects in the United States can typically secure fuel contracts for three-five years. However, an uncertainty for developers and investors is what the cost of biomass fuel (particularly forestry wastes) will be beyond that initial contract. By front-loading a FIT payment for biomass, most of the project's costs (and investor returns) can be covered during the initial period, when the fuel costs are known. This makes the projects much more appealing to investors, in general, and addresses one of the main challenges for biomass projects – fuel costs during the life of the project. Adjustments to account for fuel costs can also be dealt with using a shorter contract duration (see Section 5.4.2) or providing an incremental fuel price adjustment (explored in Section 5.5.1.2).

The main disadvantage is that front-end loading can lead to greater upward pressure on policy costs in the near term, by awarding proportionally higher payments in the early years. In addition to front-end loading the FIT payments, it also leads to front-loaded ratepayer impacts. This can make it politically less viable, despite its potential benefits for RE project finance.

#### ***4.2.2.5 Coincidence with Demand (Time of Delivery)***

Some jurisdictions provide higher payment levels to encourage electricity generation at times of high demand. Because electricity is more valuable during these times, this incentive structure is one way of aligning the FIT payment structure to be more market-oriented (Klein et al. 2008). Naturally, this kind of incentive structure applies primarily to RE technologies that can adjust their time of generation – this includes biomass, solar thermal power with storage capacity, and hydropower sources. Policy designers consider this design an attempt to incorporate value-based

considerations into the FIT payment structure and increase the market orientation of the overall policy framework (Held et al. 2007).

Portugal implemented a variation of this design, which offers two different tariff levels for daytime and nighttime. With the exception of hydropower (which must adopt this option), RE producers can choose whether they want to receive the differentiated tariff price (Klein et al. 2008).

In another approach, Hungary’s FIT distinguishes between RE resources that depend on ambient weather conditions (solar and wind), from those that do not (biomass, biogas, and geothermal) (Klein et al. 2008). For those that are not dependent on weather conditions, each project is offered a combined set of three tariff levels, distinguishing between peak, off-peak, and deep off-peak. The highest payment level at peak times is more than 275% of the deep off-peak tariff price for geothermal, biomass, small hydro (<5 MW), and biogas installations. Table 7 represents the FIT payment levels in Hungary. A significantly higher payment level for peak production creates a strong incentive for suppliers who can efficiently moderate their supply to produce at times of high demand.

**Table 7. Tariff Levels Differentiated by Technology and Time of Day in Hungary**

Technology	Tariff level [€ cents/ kWh]		
	peak	off-peak	deep off-peak
Solar, wind	9.44	9.44	9.44
Geothermal, biomass, biogas, small hydro (≤ 5 MW)	10.72	9.44	3.85
Hydro (> 5 MW)	6.90	3.45	3.45

Source: Klein et al. 2008

In Slovenia, RE developers that choose the fixed-price option<sup>52</sup> can also choose whether they would like to receive the single tariff or the “double tariff” (Klein 2008). The single tariff offers a flat tariff price regardless of the time of day or season. The “double tariff” distinguishes between three seasons and two different times of day. Higher tariffs are offered during the high-demand season (December to February), than during the low-demand season (May through September); the period in between is awarded an intermediary tariff. In addition, Slovenia also distinguishes between peak periods during the day and night by having a time-of-day tariff differentiation. The country’s lowest tariff is during the night between May and September, when the tariff is 70% of the regular tariff price. Conversely, the highest tariff is during the day, from December through February, when RE generators receive 140% of the regular tariff price. Table 8 shows the specific Slovenian tariff.

<sup>52</sup> Slovenia offers both a premium- and a fixed-price option.

**Table 8. Multipliers for the “Double Tariff” Option in Slovenia**

	Daily peak tariff (i.e. daytime)	Daily off-peak tariff (i.e. night)
High demand season (Jan, Feb, Dec)	1.4	1
Intermediate demand season (Mar, Apr, Oct, Nov)	1.2	0.85
Low demand season (May - Sept)	1	0.7

Source: Klein et al. 2008

Finally, Spain takes a similar approach under its fixed-price option.<sup>53</sup> It offers a 1.0462 multiplier for electricity produced during daily and seasonal peak times (11 a.m. – 9 p.m. in winter, and noon – 10 p.m. in summer), and 0.9670 for off-peak times (Spain 2007, Held et al. 2007). This is offered as a voluntary option for hydropower, biomass, and biogas installations.

### **Evaluation of Coincidence with Peak Demand**

Offering proportionally higher tariff levels to generators during peak demand periods can provide a number of benefits. First, by becoming responsive to these price signals, operators of dispatchable RE projects can provide a range of added benefits for system operators, ratepayers, and society through reduced balancing costs, peak shaving, and related environmental benefits.

In addition, this design helps producers of renewable electricity create greater value for utilities, while potentially helping create a more efficient electricity market where supply correlates more closely with demand (Held et al. 2007). Encouraging this kind of demand sensitivity to encourage peak shaving could also promote the use of innovative technologies, such as pumped, battery, or compressed air storage, which helps better correlate variable renewable supply with demand.

Finally, this time-of-delivery factor arguably reflects the introduction of value-based elements into the cost-based FIT framework. This can be seen as one way of making fixed-price FIT policies more sensitive to market demand – and, therefore, more compatible with competitive electricity markets – while retaining a broadly cost-based FIT policy.

However, this type of incentive is not as applicable to non-dispatchable renewable energy resources such as solar and wind (Klein et al. 2008). Although solar supply curves tend to correlate relatively well with peak demand in most jurisdictions, wind generation often does not correlate as closely. This means that this incentive structure is most applicable to a subset of dispatchable RE technologies, namely those that can adjust their time of delivery to overall market demand.

### **Summary of Ancillary Feed-in Tariff Design Elements**

In summary, there are several ancillary ways to fine-tune FIT payment levels to better meet different policy goals. FIT policies can incorporate the design elements such as tariff depression,

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<sup>53</sup> Spain offers both a premium and a fixed-price option.

inflation adjustment, front-end loading, as well as coincidence with demand (i.e., time of delivery) to better achieve these objectives (see Section 1.1).

### **4.2.3 Analysis of Bonus Payment Options**

In addition to the FIT policy design options explored above, it is also possible to add specific bonus payments to encourage certain kinds of technologies, as well as certain behaviors by plant operators. This section provides an overview and brief analysis of a number of bonus payments offered in FIT policies. Due to the number of bonus payments offered in Germany, this section focuses primarily on these, with some additional examples where applicable.

#### **4.2.3.1 High-Efficiency Systems**

Both France and Germany have technology-specific bonus payments for the use of high-efficiency systems, specifically in the biomass, biogas, and geothermal sectors. For example, France offers a variable bonus of up to €0.012/kWh for highly efficient biomass generators using combined heat and power (CHP), while offering a maximum bonus up to €0.03/kWh for high-efficiency biogas and geothermal systems (each of which are specifically defined) (Klein 2008). For biomass projects up to 20 MW in size, Germany also offers a €0.03/kWh bonus for the use of CHP, while offering a similar bonus for biogas facilities (Germany 2008). In addition, Germany includes a €0.04/kWh bonus for geothermal facilities that make use of cogeneration.

Each of these bonus options encourages the use of high-efficiency technology, while encouraging the creation of a more efficient electricity supply infrastructure. Therefore, RE developers have an added incentive to use the most efficient technology, and to make the most efficient use of existing resources.

#### **4.2.3.2 Use of Specific Fuel Streams**

Germany has perhaps the most sophisticated differentiation in tariff levels for different fuel input streams. It differentiates between the various permutations of biomass (including solid, liquid, and gaseous forms), as well as plant and forestry wastes, wood grown for harvesting, and farmyard wastes. Each waste stream is assigned a specific bonus amount above the specified tariff price, which is determined by the size of the installation. The bonus payments range from €0.01/kWh up to €0.07/kWh (Germany 2008). These differentiations can target specific streams that may be in abundance from different agricultural, forestry, or other industrial operations and can allow a diversity of farmers and forestry operators to profitably participate in generation of renewable electricity.

#### **4.2.3.3 Repowering of Existing Wind and Hydro Facilities**

While most feed-in tariffs are used to encourage new renewable energy deployment, feed-in tariff policies may also be used to revitalize old projects or installations.

Countries including Germany and Denmark, and states such as California, all have wind turbines that were installed from the 1970s through the 1990s that could be replaced with larger, more efficient turbines. FITs can be structured to encourage the replacement and repowering of these older wind farms. For example, in Germany, wind generators that started commercial operation before 1995 and enlarge their capacity by at least threefold can benefit from a higher tariff level for a specific period of time, depending on the relationship of the turbines to the reference

turbine<sup>54</sup> (Germany 2008). In a different approach, Denmark guarantees an extra premium of up to €0.016/kWh for the first 12,000 load hours generated by the new, larger turbine model. To be eligible for the bonus in Denmark, the old turbines must be decommissioned between December 15, 2004, and December 15, 2009 (Klein et al. 2008). Similarly, Spain offers a repowering bonus that is determined on a case-by-case basis, up to a total maximum bonus payment of €0.007/kWh (Spain 2007, Held et al. 2007).

Similar provisions apply to repowering old hydropower facilities. Switzerland offers the FIT payments to renovated hydro facilities that increase their production by more than 20% from the two previous years. It also allows old facilities that have been decommissioned prior to 2006 to benefit from the FIT payments, provided these are repowered to increase their annual production by more than 10% when compared to their last two years of commercial operation (SFOE 2008).

Promoting the repowering of existing wind projects enables capacity upgrades to occur with fewer siting and permitting hurdles, because the land is already secured and facilities have typically already been there for some time. Absent planning regulations that limit height or other similar factors, repowering of wind turbines provides an efficient way to upgrade older wind farms with newer, more efficient technologies. Newer turbine models also often are better adapted for grid management and typically have a slower and smoother rotation than older designs, which brings added environmental benefits (e.g., lower impacts on birds and bats). Also, because the first projects were likely installed near the windiest sites (or, in the case of hydro, near good hydrological sites), repowering them with newer and more efficient designs can help increase renewable energy generation.

FIT policy designers need to determine whether repowering is a policy goal. If so, and a specific repowering payment is established, then project developers need to determine whether it makes economic sense to repower existing projects on a project-by-project basis (IEA 2009). While many projects may not be ready to be repowered, this incentive will likely grow in importance when older generators are ready to be decommissioned.

#### **4.2.3.4 Specific Ownership Structures**

Because of the greater local economic benefits of developing RE projects at the local or regional level, certain jurisdictions offer preferential tariffs to promote greater local ownership (Bolinger 2004, OPA 2009a and 2009b). For example, Ontario recently incorporated a bonus for community-led projects into its new feed-in tariff policy (OPA 2009b). In this program, projects led by communities can benefit from a special adder, offered as a bonus in cents/kWh. This adder is also extended to aboriginal communities, and is differentiated by technology type, with a larger adder awarded to solar and wind power and a smaller adder awarded to other RE technologies such as biogas and biomass (OPA 2009b).

These bonus provisions typically encourage the maximum community participation and foster greater community economic development. This enables smaller, community-based projects to be viable, while keeping more of the profits from electricity sales within communities.

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<sup>54</sup> See Section 4.2.1.3 for more information on Germany's reference turbine model.



#### *4.2.3.5 Use of Innovative Technologies*

Certain jurisdictions have introduced bonus payments to stimulate the use of innovative technologies. For example, the German FIT framework offers a bonus of €0.02/kWh above the posted FIT payment for the use of fuel cells, organic Rankine cycles, multi-fuel installations, and Stirling engines (Germany 2008).

As of 2009, Germany also offers a bonus premium of €0.005/kWh for wind facilities that use advanced grid integration technologies, which improve overall grid stability (Germany 2008, Klein 2008). These technologies foster greater control of both real and reactive power from wind turbines and can help the country reach higher levels of wind penetration (see DENA 2005).

With the rapid increase in wind power development globally, it is likely that more jurisdictions will implement policies that foster higher grid compatibility and control. This can help better integrate the variable output of large amounts of wind-generated electricity. Once this technology has become standardized across the industry, the bonus could be replaced by a regulatory requirement (Lauber 2009).

Bonuses that promote innovative technologies can bring new designs to market, while potentially bridging the gap between R&D and market commercialization. Targeting these innovative technologies with specific incentives can also provide a variety of social, economic, and environmental benefits.

#### *4.2.3.6 Vintage of Installation*

In its 2008 RES Act, Germany offers a higher payment level for near-term offshore wind projects, which creates a stronger incentive for the early implementation of the technology (Germany 2008). Offshore wind projects developed before December 31, 2015, will receive an additional bonus payment of €0.02/kWh, above the €0.13/kWh already in place. Germany guarantees this higher tariff level for the first 12 years of the project's life, which accelerates cost recovery and compensates for the added risk of developing offshore wind projects. After the initial 12-year period, the bonus payment zeros out and the FIT payment level drops to €0.035/kWh.

This approach can provide an added incentive to bring innovative projects online before a certain date. This also can create added competition and promote the commercialization of particular RE technologies.

#### **Evaluation of Offering Bonus Payment Options**

Targeted bonus payments can promote a number of policy objectives. Whether promoting innovative technologies, or helping foster certain forms of ownership, targeted bonus payments can foster a variety of social, environmental, and economic benefits.

Conversely, offering additional bonuses above the FIT payments can increase the costs of the policy. When targeting particular technologies, it can also be accused of "picking winners." Offering added bonus payments should be weighed carefully to ensure that the benefits outweigh the costs.

#### **4.2.4 Summary of Fixed-Price FIT Payment Models**

As described in Section 4.2, fixed-price feed-in tariff policies have an extremely diverse and complex set of design choices from which policymakers can choose. While not all design options need to be used, it is clear that multiple policy goals can be targeted simultaneously. Therefore, fixed-price FIT policies can be designed to achieve a variety of policy goals, to be transparent to investors and RE developers alike (thus lowering investment risk), and to uphold a high level of cost efficiency by matching FIT payments closely to levelized generation costs. Partly due to this design flexibility, the fixed-price FIT payment model is the most widely implemented of all FIT policy designs.

There are also a few design options that can make the market-independent fixed-price model more market-oriented by adding value-based considerations such as time-of-delivery pricing (see Section 4.2.2.5). This option allows the advantages of the cost-of-generation framework to be combined with a greater sensitivity to market demand.

Although the considerations that apply to the fixed-price FIT design are different from those that apply to the premium-price designs (described in Section 4.3), some of their design elements overlap. For a more detailed evaluation of the advantages and disadvantages of fixed-price and premium-price FIT designs, see Section 4.4.

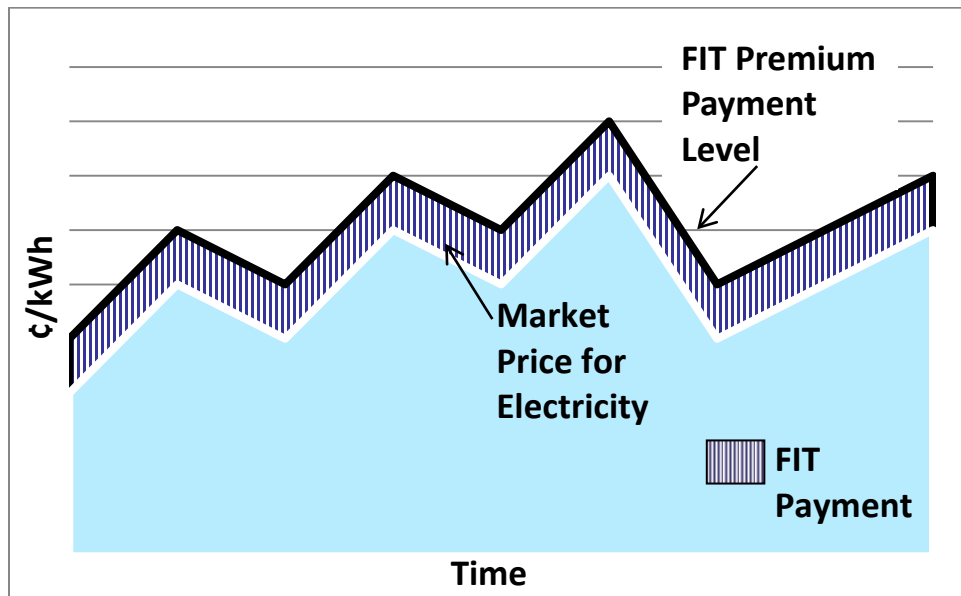
#### **4.3 Premium-Price FIT Payment Policies**

Premium-price FIT policies offer a premium above the average spot electricity market price (see Figure 12), which distinguishes them from the fixed-price FIT payment structure.<sup>55</sup> Fixed-price FIT payments are independent of market prices; however, for premium-price FIT payments, either the premium or the total payment is dependent on the market price for electricity. The premium payment can be designed to achieve two objectives: 1) to represent the environmental and/or societal attributes of RE generation, or 2) to better approximate RE generation costs. In the premium-price approach, electricity generated from RE sources is typically sold on the spot market, and producers receive a FIT premium above the market price. This is in contrast to the fixed-price approach, where a purchase guarantee is typically included and keeps the RE generation separate from spot market dynamics.

Premium-price FIT policies are offered in Spain, the Czech Republic, Estonia, Slovenia, the Netherlands, as well as Denmark for onshore wind energy (Klein 2008). Some areas offer both a fixed- and premium-price option, which provides a choice for electricity producers. Spain, Slovenia, Estonia, and the Czech Republic offer a premium-price option (Klein 2008). In Spain, the choice is valid for one year, after which the operator must decide which payment option they would like for the following year (Held et al. 2007). More European countries choose fixed-price policies over premium-price FIT payments.

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<sup>55</sup> Note that Figure 12 and Figure 4 are the same, but are provided in two places to help the reader.



**Figure 12. Premium-price FIT model**

Similar to the fixed-price FIT policies, premium-price FITs can be differentiated to allow for a more cost-based payment level for each technology type, fuel type, and project size. Many of the design choices described in Section 4.2 can apply, in a slightly modified way, to premium-price FIT payments. However, because the total revenues of the project are dependent not only on the FIT premium but also on the market price of electricity, different considerations apply.

First, the FIT premiums can be constant or sliding (see Section 4.3.1). Constant premium policies typically provide a “constant” (i.e., non-variable) adder on top of the spot market price. In this design, the bonus rides on top of the market price and remains unresponsive to changes over time and continues to be offered even if electricity prices increase. In several sources, these premium payments are called “fixed-premium” FIT policies (Klein et al. 2008, Held et al. 2007, Ragwitz et al. 2007). The term “constant” is used here to avoid confusion with the term “fixed-price FIT policies,” where the total payment is fixed over the life of the contract (instead of just the increment above the spot market).

Certain jurisdictions have introduced sliding premium designs to address some of the challenges with the constant premium design. In this approach, the FIT premium varies with the market price. FIT policy designers can also introduce payment “caps” and payment “floors” on either the total premium amount or on the total payment amount. If market prices increase, the policy can respond through the sliding premium option, which will potentially help minimize overall policy costs by providing a more cost-based payment structure.

#### **4.3.1 Description of Constant Premium-Price FIT Policies**

There are several ways to determine the premium FIT payment. The first structure examined here defines the premium as a constant, predetermined adder on top of the spot market.

Between 1998 and 2004, Spain offered RE developers a choice between a long-term fixed FIT payment (Section 4.2) and a constant premium FIT payment (i.e., above the spot market price) (del Rio Gonzalez 2008). Spain discontinued this option in 2004 to make room for a new FIT policy structure in which both were defined as a percentage of the prevailing market price (del Rio Gonzalez 2008; see Section 4.1.1). The Czech Republic also offers the option of both a fixed-price FIT and a constant premium-price option (Klein 2008). In this case, the payment levels offer higher payments under the premium-price FIT payment option, which encourages participation in the spot market. Slovenia also offers both a fixed-price and a constant premium-price option, but the payment level is designed to be approximately the same under both. RE developers can also sell a portion of their electricity under the fixed option, and the rest on the open market (Held et al. 2007).

### **Evaluation of Constant Premium-Price FIT Policies**

Constant premium-price FIT policies create an incentive to generate electricity in times of high demand and when market prices are high. The high spot prices, combined with a fixed adder on top, tend to encourage supply when it is needed most. The prospect of higher payments (the upside potential) may be understood as a compensation for the added market risk.

However, because a constant premium is added to the spot market price, the incremental payment remains agnostic to spot market prices. This can result in higher average payment levels when electricity prices increase, which puts upward pressure on overall policy costs. This is confirmed in an analysis of constant premium-price FIT policies, where payment levels average 1-3 cents/kWh higher than those under fixed-price FIT policies (see Ragwitz et al. 2007). In addition, the constant-premium model does not consider that electricity prices can decline suddenly as well, which causes projects with high up-front capital costs to struggle with revenues insufficient to cover project costs. This can significantly increase the risks of the FIT policy framework to the project developer. This uncertainty over future revenue streams creates an additional risk for the investor, who is likely to increase the required equity returns and potentially the debt interest rates, which increases the marginal costs of RE deployment (de Jager and Rathmann 2008).

#### **4.3.2 Description of Sliding Premium-Price FIT Payments**

In response to the potential problems created by the constant-premium approach, certain jurisdictions allow the FIT premium payments to vary based on market price. In this approach, as the market price increases, the premium amount can be designed to decline (and vice versa) to minimize windfall profits (Held et al. 2007). There are four examples of sliding premium-price FIT policies, which are described in the sections below.

##### **4.3.2.1 Sliding Premium-Price FIT Payments: Caps and Floors on the Total Premium Amount**

In its Royal Decree 661/2007, Spain introduced a sliding premium option that includes both a payment cap and a payment floor<sup>56</sup> on the *premium amount* (in €/MWh). With its new sliding premium FIT policy, Spain hopes to mitigate problems experienced with its previous FIT policy (Spain 2004), where both the fixed FITs and the premium FITs were tied directly to the spot

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<sup>56</sup> A “cap” is a maximum payment provided to project owners and a “floor” is a guaranteed minimum payment. They can be designed to be either a cap/floor on the premium itself, or on the total payment.

market price. The old approach led to rapidly increasing policy costs when marginal electricity generation costs increased unexpectedly (Held et al. 2007).

The new Spanish FIT, which introduces a range within which the premium varies, is applicable to all technologies except solar PV (which is only offered the fixed-price option). In this new approach, if average electricity market prices increase, the premium paid begins to decline. A floor price is provided, below which the combined revenues of the premium price and the market price cannot drop – this provides added investment security. In this way, the premium slides between an upper and a lower range in response to changes in the spot market price. Figure 13 illustrates Spain’s FIT premium payment levels for onshore wind in 2008. This floor price is set at €73.66/MWh, which means that if electricity market prices drop below that level, the premium amount must increase to ensure that minimum payment level. As the electricity “pool” price increases, the premium amount declines until the average electricity market price rises above €87.79/MWh. At this point, the premium offered falls to zero and RE developers receive the spot market price.

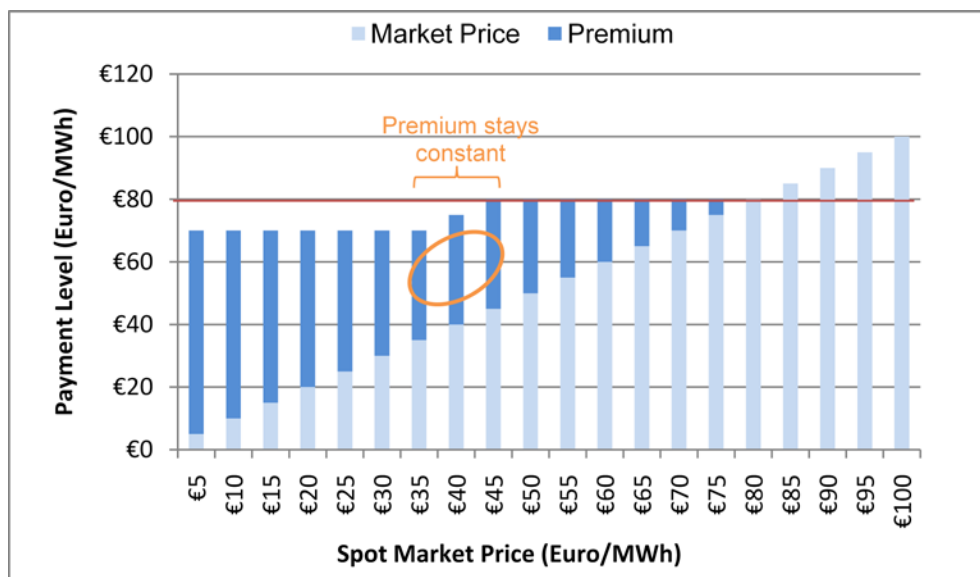


Figure 13. Spanish sliding FIT for offshore wind (2008), with a cap and floor on the total premium amount

### Evaluation of Caps and Floors on the Total Premium Amount

The new Spanish premium model represents a potential solution to the problem of under- or overcompensation that could result from tying FIT payments to spot market prices. A premium that varies between two limits creates stability and provides some protection for ratepayers on the upper end, while helping provide revenue security to investors through a minimum floor payment on the lower end (Held et al. 2007). If the payment level is set accurately, sliding premiums can offer a means of retaining some of the strengths of the premium-price option, without some of the pitfalls.

However, it remains challenging to establish what the “correct” caps and floors should be, and to adjust them over time if technology costs change significantly. Furthermore, if only the premium amount is capped, the total payment received by RE developers is still able to track the spot

market when electricity prices increase. This effectively removes any hedge benefit that renewable energy could provide to help stabilize and/or lower electricity prices.

#### ***4.3.2.2 Sliding Premium-Price FIT Payments: Caps and Floors on the Total Payment Amount***

An alternative approach to introducing a cap and a floor on the total *premium* amount (\$/MWh) is to do the same for the entire allowable *payment* amount (\$/MWh). This provides a way of limiting the total FIT payment, while still allowing it to vary within a range sufficient to allow profitability.

For a short time in 2003 and 2004, Denmark used a cap on the total payment amount for onshore wind (Mendonça et al. 2009b). A premium was offered to plants that were connected to the grid after December 31, 2002, which decreased based on market price so that the sum of the market price and the premium did not exceed €0.0483/kWh (Klein et al. 2008). This made the policy effectively a sliding premium policy with a cap on the total allowable payment amount. In 2005, this cap was abolished (Munksgaard and Morthorst 2008) and the policy reverted to a premium structure in which operators received a constant premium of €0.0134/kWh (Klein et al. 2008).

#### **Evaluation of Caps and Floors on the Total Payment Amount**

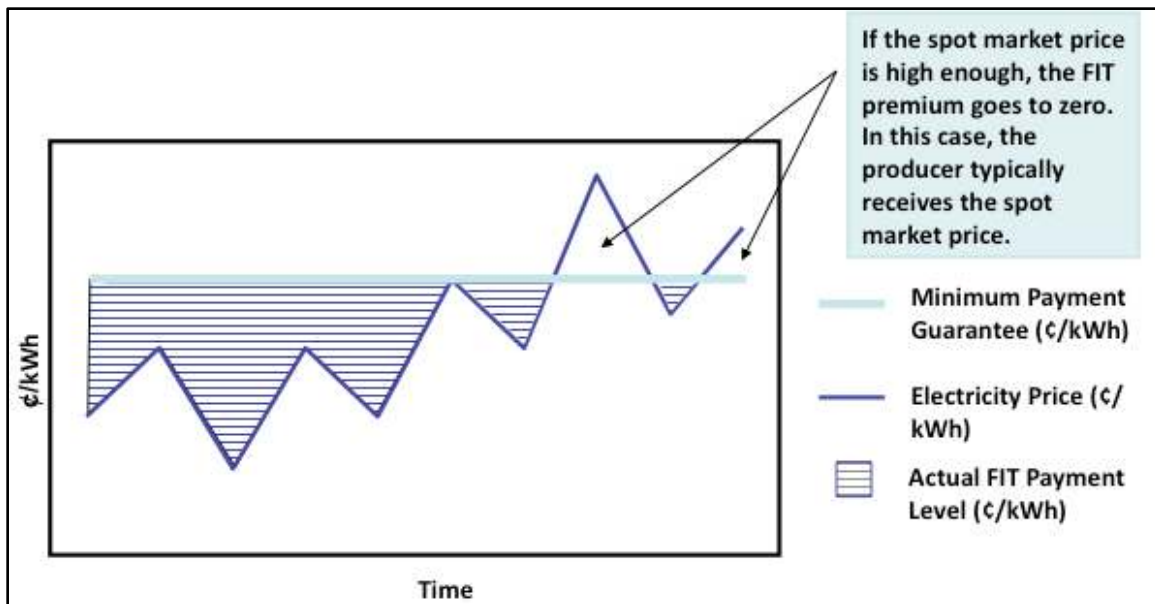
Introducing caps and floors on the total payment amount is one way of ensuring that revenues under the premium price option remain within a range sufficient to encourage investment, while securing the hedge benefit of renewable energy resources if electricity prices increase. The floor on the payment amount can offer a guarantee that project revenues will not drop below a certain specified level, which increases transparency and diminishes risks for RE developers and investors. A cap on the upper end of the total payment limits the problem of overcompensation (which occurred in Spain in 2005, 2006, and 2008) and can reduce the overall costs for ratepayers (Klein 2008). Again, provided the range is determined appropriately, sliding premiums defined with caps and floors on the total payment amount offer a means of retaining some of the benefits of premium-price policies, while avoiding some of the pitfalls.

There are some challenges with this approach. While a floor price provides protection against the risks of downward electricity price movements, a cap on the upper end may be perceived as an arbitrary tax on renewable energy developers because it awards them a lower payment level than is available on the spot market (Klein et al. 2008). Therefore, a cap on the total allowable payment amount may reduce the total number of investors, by reducing the potential upside gains that could result from electricity price increases. This could also be considered a discriminatory policy design because amortized fossil fuel generators with low marginal production costs can still receive the spot market prices; while in this model, RE producers could not.

#### ***4.3.2.3 Sliding Premium-Price FIT Payments: Spot Market Gap Model***

The spot market gap model represents a different approach to implementing a sliding premium FIT policy. This model offers a total guaranteed payment level (which can be differentiated by technology and size of project), similar to the fixed-FIT design examined above. This provides revenue certainty for the RE developer and associated investors. However, instead of having the FIT payment cover the total amount, the sliding FIT payment only covers the difference between

the guaranteed payment level and the average spot market price (Figure 14). This means that the premium payment varies based on the prevailing electricity price. Unlike other premium-price policies, RE developers receive a guaranteed total price for their output. The Netherlands and Switzerland use a variation of this model (van Erck 2008, SFOE 2008).



**Figure 14. Spot market gap model**

The Netherlands uses the spot market gap design (van Erck 2008), but does not guarantee a minimum revenue stream. If the electricity price drops below two-thirds of the expected electricity market price, the tariff level drops as well (van Erck 2008). Because the Netherlands pays its FIT through government treasury, this approach reduces the rate at which the subsidy pool is reduced in the event that electricity prices decrease significantly. While this limits the overall cost of the policy, it creates an additional risk for investors.

Switzerland applies the spot market gap model for its FIT policy (SFOE 2008, Geissmann 2009). The spot market price is based on an average of the previous month's exchange price, and the gap is calculated as the difference between this average and the posted technology-differentiated FIT price. For example, the "gap" payment for solar could be 40 cents/kWh, while it could be 2-3 cents for wind power, depending on the spot price movements. Switzerland's FIT is financed through a nationwide system benefit charge (SBC), which is applied as a SFr 0.006/kWh surcharge on electricity consumers.<sup>57</sup> This SBC creates an annual pool of approximately SFr \$360 million, depending on overall electricity consumption. This is then apportioned to different technology classes to cover the "spot market gap" in each technology, and for each applicable project size (SFOE 2008, Geissmann 2009).

<sup>57</sup> An exemption is offered for electricity-intensive industries.

### **Evaluation of the Spot Market Gap Design**

The spot market gap model has a few main benefits. First, if the minimum payment is assured, it provides investors with the same price certainty as the fixed-price model by offering a guaranteed minimum price for the electricity sold. This retains some of the benefits of the fixed-price approach, while retaining the upside benefit of any upward price movements. Second, it provides a more transparent format for the calculation of policy costs. By offering a premium on top of the market price, any upward pressure on overall electricity prices that is directly caused by the FIT policy can be quantified by taking the sum of the spot market gap payments awarded to project developers. Third, this approach can help limit policy costs, because no FIT payment is awarded if the spot market price increases above the guaranteed payment level. The FIT payment goes to zero and the RE project receives the market clearing price. Finally, this methodology is simpler than applying both a cap and a floor to the premium payment level, because there is a floor to the total payment amount (which is good for investors), and yet the project can take advantage of the upside benefit (while the FIT payment goes to zero).

Similar to the sliding premium model with caps and floors on the total premium amount, the potential hedge value of renewable energy sources is lost because projects receive the spot price when prices increase. This also could increase the overall costs of RE deployment if electricity prices increase because projects receive spot price payments rather than a fixed contract price.

#### ***4.3.2.4 Sliding Premium-Price FIT Payments: Percentage-Based Premium-Price FIT Model***

Under Spain's RD 436/2004, both the fixed-price FITs and the premium-price FITs were defined as a percentage of the spot market price (Spain 2004). This meant that the actual FIT payments could increase and decrease suddenly in response to market price trends (del Rio Gonzalez 2008). For solar thermal power projects, for example, the premium was established at 300% of the spot price during the course of a 25-year contract (del Rio Gonzalez 2008). Spain abandoned this policy in 2006 and introduced a new sliding premium FIT policy in 2007 (Held et al. 2007, del Rio Gonzalez 2008, Gual 2007; see also Spain 2007).

### **Evaluation of Percentage-based Premium Price Policies**

Policy designers adopted the percentage-based premium-price model to increase the "market-orientation" of the policy framework. This meant that the FIT payments were directly dependent on the electricity spot market price and would create stronger incentives to supply electricity in times of high demand.

A primary challenge with this model is that it led to much higher overall policy costs, because electricity prices increased significantly in Spain in 2005-06 (Held et al. 2007). The direct tie to spot prices means that any volatility in the spot market price affects the FIT amount, which leads to more volatile FIT payments. This volatility increases the risks of the policy, while increasing the chances of overcompensation if electricity prices increase (Held et al. 2007). This is one of the primary reasons that Spain introduced payment caps and floors on the premium amount in RD 661/2007, and it is arguably one of the reasons the percentage-based model is no longer used.



### **Summary Evaluation of Sliding Premium Price FIT Policies**

As discussed briefly above, when the premium is added as a predetermined constant quantity, it could result in overpayment if electricity market prices increase significantly. This could have the undesirable consequence of higher FIT payment levels, while leading to higher overall costs for society because the total FIT payment is higher than is needed to be to drive investment. There is also the risk that electricity prices drop, which could undermine the profitability of existing projects. Detailed EU analyses suggest that constant premium-price policies, therefore, may be less cost-efficient than the basic fixed-price model, partly because of added investor risks.

Sliding-premium FIT policies address some of these challenges. First, by allowing the premium amount to vary based on market price, they reduce the chances of overcompensation. In addition, where caps and floors are introduced, they can be designed to reduce both the upside and downside price risks by providing a guaranteed minimum range within which the FIT payments will fluctuate. This reduces the possibility of wide divergences between FIT payment levels and actual generation costs, which improves cost efficiency.

Third, because FIT payments still respond to market prices under sliding-premium structures, they retain the market orientation of the premium-price designs, which offer proportionally higher payments if electricity prices increase. This can help retain the incentive to produce electricity in times of high demand, while removing the artificial separation between RE and conventional electricity within electricity markets. The sliding-premium model enables the first portion of the total payment to be determined by the spot market price, while awarding a sliding payment to make up the difference and ensure project profitability. This means that RE electricity is still sold on the spot market, rather than in the context of separate, fixed-price purchase guarantees. This has been touted as one way of furthering the “integration” of RE electricity into conventional electricity markets and may prove increasingly important as the share of renewable energy increases in proportion to conventional electricity generation (Langniss et al. 2009, Klein et al. 2008).

While a sliding premium-price FIT introduces increased complexity, it can help avoid some of the pitfalls of having a constant adder on top of a volatile electricity market price (Klein et al. 2008).

#### **4.3.3 FIT Premium-Price Differentiation**

Similar to fixed-price feed-in tariff policies, it is possible to differentiate the premium amount to better reflect RE generation costs. The differentiation of premiums is arguably as important as the differentiation of the tariff levels in the fixed-price option (described thoroughly in Section 4.2). It allows the total expected payment amount to better approximate the actual levelized costs of developing the technology, while still retaining the market orientation. By differentiating the premium amount, countries using premium policies can differentiate the payment level awarded per kilowatt-hour with greater accuracy, even though it is unlikely that the actual payment levels will match the generation costs as closely as the fixed-price option.

This section briefly examines the advantages and disadvantages of differentiating premium-price payments. The two primary ways to differentiate the premium levels are by technology type and project size.

Because several design options explored in the fixed-price FIT section above apply to premium-price policies, the descriptions of how to differentiate premium-price policy designs are kept brief. For a more thorough examination of all these design options, see Section 4.2.

#### ***4.3.3.1 Premium Differentiation by Technology Type***

To ensure that the premium option encourages an array of RE technologies, the premiums awarded to RE developers can be differentiated according to technology type. This differentiation allows policy designers to offer higher premiums to less mature technologies, which more accurately reflects the payment levels required to allow project profitability. For instance, Spain offers a reference premium above the spot market price of electricity of €0.254/kWh for solar thermal projects, a premium of €0.0843/kWh for offshore wind, and only €0.0293/kWh for onshore wind power projects (Spain 2007; see also Held et al. 2007). These differentiations in the premium amount reflect an attempt to match the FIT payments to the different costs of developing each technology, while offering additional compensation for the higher market risk.

#### **Evaluation of Premium Differentiation by Technology Type**

By differentiating premiums, policy designers allow the total project payments (the sum of the spot market price and the FIT premium amount) to more closely approximate levelized RE generation costs. This can target technologies that are at different levels of maturity and at different points of the cost curve by offering technology-specific payment levels. This approach can also foster economic activity in a wider variety of sectors by creating a framework that includes a greater portfolio of RE technologies.

However, this design can put upward pressure on policy costs if costlier emerging technologies are included.

#### ***4.3.3.2 Premium Differentiation by Project Size (i.e., Capacity)***

Similar to fixed-price FIT policies, premium-price FIT policies are also generally differentiated according to the size of the installation. This allows the premium levels to reflect the cost reductions gained from economies of scale.

For example, Spain offers different premium levels for hydro projects that are less than 10 MW than for those that are more than 10 MW; the country also differentiates its biomass categories based on whether they are smaller or larger than 2 MW (Spain 2007; see also Held et al. 2007). Smaller projects receive a correspondingly higher premium, while larger projects receive a slightly lower premium. For anaerobic digesters, the premium is differentiated based on whether the installation is larger or smaller than 500 kW (Held et al. 2007).

#### **Evaluation of Premium Differentiation by Project Size**

By differentiating the premium amounts by project size, the policy designer can increase the viability of a larger spectrum of projects, which encourages both distributed and commercial-scale project development. This can increase participation from investors, including homeowners

and small business owners, which can increase the economic benefits of renewable energy development, while also increasing the geographic dispersion of RE projects. At the same time, project size differentiation provides total payments that are closer to the actual cost for both large and small projects, which reduces the incremental costs caused by the FIT payments. It may also allow more projects to be sited within urban centers, which may provide a number of distributed benefits (Lovins 2002).

However, by differentiating the FIT premiums to allow for smaller projects, designers are likely to increase the overall costs of the policy. Smaller projects do not capture economies of scale, and their eligibility could require higher per-kWh payments to encourage the same amount of RE generation. The advantages and disadvantages of differentiating FIT payments by project size need to be weighed against one another, and viewed in relation to overall policy objectives (see Section 1.1).

#### **4.3.4 Summary of Premium-Price FIT Payment Models**

Section 4.3 provided a brief overview of the critical design elements of a premium-price FIT model that provides a FIT payment above the spot market price for electricity. Policy designers can use some of the same design options, such as technology and project size differentiation, that are used for fixed-price FIT policies. While not all of the design options were covered in this section, Section 4.2 can be used as a supplementary design guide for premium-price FIT policies. Similar to fixed-price FIT policies, policymakers can design premium-price FIT policies to achieve a variety of policy goals, to be transparent to investors and RE developers alike (thus lowering investment risk), and to achieve a moderate level of cost efficiency through design options such as a sliding premium.

### **4.4 Evaluation of Fixed-price vs. Premium Price FIT Policies**

The two dominant ways to structure FIT policy payments are as fixed, long-term prices (which may or may not be indexed to inflation) and premium prices, which are offered as a bonus above market prices. While Sections 4.2 and 4.3 looked at each individually, this section compares the two policy structures in more detail.

#### **4.4.1 Fixed-Price FIT Policy Advantages and Challenges**

This section explores the advantages and disadvantages of fixed-price FITs; it is followed by a similar analysis that explores premium-price FIT designs.

1. **Remove price risk.** Detailed analyses of average payment levels for a number of FIT policies in the EU have shown that fixed-price FIT policies have demonstrated, on average, a higher degree of cost efficiency than premium-price designs – this leads to lower per-kWh payments for renewable energy (Ragwitz et al. 2007). The stability of the long-term fixed-price payments involves lower risks for both RE project developers and investors, and is therefore likely to lower the costs of financing (de Jager and Rathmann 2008, Couture and Gagnon 2010). Understood in this way, fixed-price FIT policies are a way of removing price risk, which can lower the per-kWh costs of RE deployment.
2. **Better approximate actual project costs.** Fixed-price FITs are likely to better approximate actual RE generation costs if the FIT prices are established appropriately.

This cost-based payment structure is likely to encourage more investment in RE projects, due to better targeting of actual project costs.

3. **Reduce market risk.** Fixed-price FITs are typically accompanied by a purchase guarantee, which further reduces market risk (Mendonça 2007, Couture and Gagnon 2010). The guarantee that a reliable counterparty will purchase the electricity reduces risks by providing greater revenue certainty (Guillet and Midden 2009).
4. **Hedge against electricity price volatility.** Fixed-price FITs can more effectively act as a hedge against energy and electricity price volatility by introducing fixed-price supply into the electricity supply mix (Lesser and Su 2008, Langniss et al. 2009). This effect can help reduce wholesale electricity prices at times when the cost of RE supply is lower than the marginal cost of conventional supply (Germany BMU 2007, Sensfuss et al. 2008, de Miera et al. 2008, Wiser and Bolinger 2007). Therefore, by having a portfolio of electricity generation that includes fixed-price renewable energy resources, a jurisdiction can protect ratepayers through reduced exposure to energy price volatility. This is likely to be particularly important in electricity markets where a substantial share of generation comes from natural gas.
5. **Encourage distributed RE generation.** Fixed-price FITs are likely to encourage smaller RE project developers to develop distributed RE generation. Homeowners and community groups are likely to prefer the stability and reliability of fixed-price policies because of the transparency of the revenue streams they generate. This transparency makes financial calculations easier and could encourage a larger diversity of participants (including residents and municipalities) to invest. By allowing more local residents to invest in RE generation, more of the economic benefits are retained within the communities where the electricity is generated – this can have positive economic multiplier effects (Bolinger 2001 and 2004, Lantz and Tegen 2008 and 2009, OPA 2009a, Farrell 2008).
6. **Support emerging technologies.** Finally, fixed-price policies may also benefit emerging technologies by offering stability through guaranteed minimum prices. This approach also attracts investors during the commercialization and deployment phase.

These advantages create a lower-risk environment for both RE developers and investors, which puts downward pressure on the rate of return requirements and the subsequent cost of capital. Taken together, these factors can ultimately help lower overall RE project costs.

In spite of these advantages, fixed-price FIT policies have several disadvantages.

1. **Unresponsive to market prices.** Fixed-price FIT policies typically do not adjust in response to the market price of electricity (Mendonça 2007). The prices are locked in, often in long-term contracts, and typically do not create an incentive for project operators to adjust their production according to demand (Langniss et al. 2009). Certain countries have addressed this issue by adjusting the tariff amount based on the time of day or season (Klein et al. 2008; see Section 4.2.2.3).

2. **Distort electricity markets.** It has been argued that fixed-price FIT policies, which offer long-term fixed-price contracts for electricity sales, may distort wholesale and retail electricity markets (Lesser and Su 2008).
3. **High public cost.** Fixed-price payments could lead to high costs for society in the long term, particularly if they are targeted at higher cost RE technologies and structured with full (i.e., 100%) inflation adjustment over 20 to 25 years (Langniss et al. 2009).
4. **Little incentive to optimize project location.** Unless tariffs are differentiated by project location, it is possible that fixed-price policies will fail to create an incentive for developing electrical resources where they are needed most. In particular, fixed-priced FIT policies that guarantee grid interconnection may not provide the incentive to develop in high-load or congested areas, where spot market prices tend to be higher, or alternatively, where the marginal value of new generation is highest.

Table 9 summarizes the advantages and disadvantages of fixed-price FIT policies.

**Table 9. Advantages and Disadvantages of Fixed-Price FIT Policies**

FIT Policy Design	Advantages	Disadvantages
<b>Fixed-Price FITs</b>	<ul style="list-style-type: none"> <li>- They have proved less costly, per kWh, than premium price FIT policies</li> <li>- The payment is more closely tied to the actual cost of RE generation, increasing cost efficiency</li> <li>-Purchase obligation reduces counterparty risk</li> <li>- They harness the hedge benefit of RE resources</li> <li>- Higher level of transparency in the payment levels, which could increase the diversity of investors</li> <li>- Stability of pricing combined with purchase guarantee could be beneficial for emerging technologies during the early stages of commercialization</li> </ul>	<ul style="list-style-type: none"> <li>- Do not create an incentive to adjust supply to demand</li> <li>- Could “distort” wholesale electricity markets</li> <li>- Could prove costly over time, particularly if the long-term fixed-price contracts are adjusted fully for inflation</li> <li>- May not create an incentive to develop electrical resources where they are needed most (i.e. in congested areas and load centers)</li> </ul>

#### **4.4.2 Premium-Price FIT Policy Advantages and Disadvantages**

Premium-price policies have several advantages that are not captured by the fixed-price approach.

1. **Better for optimizing market participation.** Premium-price FIT policies are arguably more “market-oriented” than fixed-price designs because the FIT payments are dependent

on the prevailing electricity price (Mendonça 2007, Couture and Gagnon 2010). As a consequence, this structure can create incentives to produce electricity in times of high demand and to install new generation in areas with higher average market prices because of locational pricing structures (Langniss et al. 2009, Held et al. 2007).

2. **Target more efficient grid management.** Second, this market orientation could help alleviate pre-existing stresses on the grid, which could lead to more efficient grid management and a better provision of ancillary services (Mendonça 2007).
3. **More compatible with deregulated generation markets.** Premium-price FIT policies arguably demonstrate a higher degree of compatibility with deregulated (or liberalized) electricity generation markets, by allowing both renewable and conventional generation to be sold directly on the spot market (Klein et al. 2008, Langniss et al. 2009).
4. **Encourage competition between new generation.** Generators are typically required to market their electricity on the spot market under premium-price FIT policies, so that RE generators compete with one another and with conventional generators. Therefore, it is also argued that premium-price FIT frameworks are more likely to encourage competition among electricity producers (IEA 2008).

**Premium-price FITs have higher average prices**

In a series of analyses, researchers in the EU demonstrated that premium-price FITs tend to provide higher total payments than fixed-price FITs. Spain and the Czech Republic offer a choice between fixed and premium policy options. In these countries, the expected profits were incrementally higher for the premium option than the fixed-price FIT structure, ranging from an additional premium of €0.01/kWh to €0.03/kWh (Ragwitz et al. 2007). The greater investor risk, compounded by the greater uncertainty over the policy costs for society, are likely to make premium FIT policies a costlier policy design choice. These policy risks can be partly mitigated by introducing a sliding premium design, as described in Section 4.3.2.

In spite of these advantages, premium-price FITs also have a number of challenges.

1. **Higher average payments per kWh.** Premium-price FIT policies have demonstrated a lower degree of cost efficiency than fixed-price FITs, which results in higher average payments per kilowatt-hour (Ragwitz et al. 2007). This is primarily because the premium-price option requires greater risks due to the less-predictable revenue streams. These increased risks are likely to lead to higher required returns and result in greater costs per kWh for society, if the same levels of RE deployment are to be reached (Mendonça 2007).
2. **Increased risk without a purchase guarantee.** Premium-price FIT policies do not typically include a purchase guarantee. Those participating in the premium option sell their electricity on the spot market and receive the corresponding market price, with an added FIT premium. Investors see the absence of a purchase guarantee as an added risk in the premium option, which will tend to put further upward pressure on the required returns (Couture and Gagnon 2010).

3. **Decreased emphasis on wind and solar PV.** Because most wind and solar PV projects cannot readily influence the time they supply electricity into the grid, these technologies will be less likely to benefit from a premium-price framework in which electricity is sold on the spot market (or with time-of-delivery pricing) (Mendonça 2007). Thus, while it may provide useful incentives for developers of hydropower, solar thermal electric, biogas, and biomass projects – for instance – wind and solar PV power are unlikely to be able to cost-effectively adapt to these market price signals by adjusting their supply.<sup>58</sup>
4. **Loses the hedge value of fixed-price renewables.** Any hedge value provided by renewable energy sources against volatile and/or increasing fossil fuel prices is lost because the total payment levels increase in tandem with electricity prices under premium-price policies. This removes a valuable benefit of renewable energy generation, and fails to capitalize on the rate stabilization value that a diverse, fixed-price renewable generation portfolio can deliver.

Despite these downsides, there are ways to mitigate the risks – and, therefore, reduce the costs – of premium-price FIT policies (see Section 4.3.2). These include introducing a payment cap and a payment floor on the total premium amounts, which Spain does in its FIT policy (Spain 2007). Caps and floors can also be introduced on the total allowable payment amount, which was done in Denmark (Klein 2008). This provides flexibility within a range of electricity price variability, and limits windfall profits while protecting RE developers against unanticipated drops in spot market prices. Table 10 summarizes the advantages and disadvantages of premium-price FIT policies:

**Table 10. Advantages and Disadvantages of Premium-Price FIT Policies**

	<b>Advantages</b>	<b>Disadvantages</b>
<b>Premium-Price FIT Policies</b>	<ul style="list-style-type: none"> <li>- More market-oriented (i.e. more likely to respond to market demand)</li> <li>- More likely to help alleviate stresses on the grid</li> <li>- Demonstrate a greater compatibility with deregulated (liberalized) electricity markets</li> <li>- Allow for a greater market integration of RE sources, while encouraging competition between RE project developers</li> </ul>	<ul style="list-style-type: none"> <li>- Less cost-efficient than fixed-price FIT policies, leading to higher average per-kWh costs</li> <li>- No purchase guarantee, which leads to greater investor risks</li> <li>- RE sources like wind and solar cannot readily adjust their time of supply to benefit from the spot market price fluctuations</li> <li>- The hedge value of fixed-price RE resources is lost, by allowing the payment levels to track the market price</li> </ul>

<sup>58</sup> Note that this could change with the addition of advanced storage technologies.

#### **4.5 Summary of FIT Payment Design Options**

Section 4 primarily explored the variety of design options available for FIT payment structures, which is a key component of the overall policy design. Because it determines the overall effectiveness and cost efficiency of the policy, detailed analysis should be conducted when designing FIT payment levels.

As described, FIT policies allow for a high degree of differentiation and sophistication to determine tariff prices, but also provide varying degrees of certainty and price transparency. Policy designers can offer prices that are specifically designed to match different market contexts, project sizes, and technology types. Several countries employ the same design elements, structured in slightly differentiated ways. Tables 11 and 12 provide a summary of the advantages and disadvantages of fixed-price and premium-price FIT designs by examining each design option. Note that some advantages and disadvantages included in the tables are not discussed above.

While both have their merits, experience has shown that the per-kWh costs required to encourage every new kWh of production in a given technology category are lower under fixed-price policies, largely due to the lower risks for both RE developers and investors. However, some of the recent experiments with sliding premium-price FITs have decreased the overall cost of premium-price policies. More innovation in designing the sliding formulas could result in costs that can better react to market conditions, while also approximating RE project cost.

Section 5 focuses on FIT implementation options, Section 6 explores ways of controlling the costs of FIT policies, and Section 7 discusses the various ways of funding the policy. Section 8 concludes with an overview of best practices in FIT policy design.



**Table 11. FIT Policy Design Summary – Fixed-Price FIT Payment Level**

	<b><u>FIT Policy Design Element</u></b>	<b><u>Possible Design Elements</u></b>	<b><u>Advantages</u></b>	<b><u>Disadvantages</u></b>
<b>Fixed-Price FIT Policies</b>	<b>Project-specific tariff design</b> (4.2.1)  The payment level is differentiated based on the principle of <u>cost-recovery</u> .	<b>Differentiation by technology and fuel type</b>	<ul style="list-style-type: none"> <li>- Encourages emerging technologies</li> <li>- Leads to greater technological diversity</li> <li>- Allows higher overall RE penetration to be achieved</li> <li>- Allows job creation in a greater number of sectors</li> </ul>	<ul style="list-style-type: none"> <li>- Including higher cost technologies like PV can increase policy costs</li> <li>- Deriving accurate cost data to set payment levels for emerging technologies remains challenging</li> </ul>
		<b>Differentiation by project size</b> (stepped levels of capacity, or by linear function)	<ul style="list-style-type: none"> <li>- Allows revenues to be adjusted for economies of scale</li> <li>- Fosters a wider diversity of projects and sites</li> <li>- Enables a jurisdiction to promote DG systems and better capture grid-side benefits</li> <li>- Makes RE feasible in residential areas &amp; urban centers</li> </ul>	<ul style="list-style-type: none"> <li>- Can be costlier to encourage smaller projects, putting upward pressure on policy costs</li> <li>- Smaller projects mean more interconnection points which can be costlier to the system</li> </ul>
		<b>Differentiation by resource quality</b> (FIT payment guaranteed; adjusted for actual production, or based on swept area)	<ul style="list-style-type: none"> <li>- Reduces pressure to get the prices “right”</li> <li>- Fosters flexibility in project siting</li> <li>- Helps alleviate transmission bottlenecks</li> <li>- Allows projects to be sited closer to load centers</li> <li>- Facilitates grid integration and regional balancing (projects not concentrated in one location).</li> </ul>	<ul style="list-style-type: none"> <li>- Violates the principles of comparative advantage, and least-cost development</li> <li>- Risks encouraging RE development in much less windy/sunny areas if not designed properly</li> <li>- Increases FIT policy complexity</li> <li>- Can increase policy costs</li> </ul>
		<b>Differentiation by location: value to grid</b> (fixed or locational adder)	<ul style="list-style-type: none"> <li>- Helps optimize the use of existing transmission infrastructure,</li> <li>- Encourages electricity supply closer to load</li> <li>- Can help reflect avoided costs of electricity delivery</li> <li>- Can help projects in remote locations (eg: offshore wind)</li> </ul>	<ul style="list-style-type: none"> <li>- Risks encouraging RE development in less cost-effective areas</li> <li>- Reduces the transparency of the policy for RE developers</li> </ul>
	<b>Ancillary Tariff Design Elements</b> (4.2.2)  Supplementary designs that can help achieve a variety of policy goals.	<b>Pre-determined tariff depression</b>	<ul style="list-style-type: none"> <li>- Helps track technological change</li> <li>- Encourages technological advancement</li> <li>- Can help reduce long-run policy costs</li> </ul>	<ul style="list-style-type: none"> <li>- It is difficult to accurately anticipate RE cost reductions</li> <li>- Risk of setting depression too high or too low</li> </ul>
		<b>Responsive tariff depression</b>	<ul style="list-style-type: none"> <li>- Allows the FIT payment to be adjusted automatically in response to market growth</li> <li>- Provides a flexible approach to tariff adjustments</li> <li>- Can help increase investor security</li> </ul>	<ul style="list-style-type: none"> <li>- Less transparent policy design</li> <li>- Difficult to predict the level of adjustment required in advance</li> <li>- May not be accurate to adjust for significant changes in technology costs</li> </ul>
		<b>Inflation adjustment</b>	<ul style="list-style-type: none"> <li>- Guarantees more robust revenue streams</li> <li>- Increases investor confidence by reducing revenue risk</li> </ul>	<ul style="list-style-type: none"> <li>- Risks overcompensating at the end of contract term</li> <li>- Leads to higher “real” policy costs</li> </ul>
		<b>Front-end loading</b>	<ul style="list-style-type: none"> <li>- Leads to higher net profits from identical net revenues</li> <li>- Can help smaller RE project developers obtain financing</li> <li>- Helpful for biomass, with short fuel supply contracts</li> </ul>	<ul style="list-style-type: none"> <li>- Leads to higher near-term costs to society, by simultaneously “front-loading” rate impacts</li> </ul>
		<b>Coincidence with demand</b> (time of delivery)	<ul style="list-style-type: none"> <li>- Encourages electricity supply in times of higher demand</li> <li>- Can help alleviate pressure on the grid</li> <li>- Helps encourage greater market efficiency</li> </ul>	<ul style="list-style-type: none"> <li>- Increases the complexity of the policy</li> <li>- No benefit for wind and solar power (neither is dispatchable, so they do not address peak shaving without some storage)</li> </ul>
	<b>Bonus payment options</b> (4.2.3)  Encourage certain choices.	<b>High-efficiency generation; repowering; innovative technologies, etc.</b>	<ul style="list-style-type: none"> <li>- Helps target specific choices and behaviors on the part of generators that benefit the overall system</li> <li>- Allows a greater sophistication in the policy design</li> <li>- Can help foster higher levels of RE penetration</li> </ul>	<ul style="list-style-type: none"> <li>- Increases the complexity of the policy</li> <li>- Risks overcompensating certain systems if bonus payments are too generous</li> <li>- Can increase the cost of the policy</li> </ul>

**Table 12. FIT Policy Design Summary – Premium-Price FIT Payment Level**

	<u>FIT Policy Design Component</u>	<u>Possible Design Elements</u>	<u>Advantages</u>	<u>Disadvantages</u>
<b>Premium Price FIT Policies</b>	<b>Constant premium policies (4.3.1)</b> Enables RE to compete w/ conventional gen. in spot markets.	<b>Fixed premium over the market price</b>	- Recognizes the premium value of RE technologies - Helps level the playing field between RE and conventional generation	- Increases the risks of both over/under payment if electricity prices fluctuate significantly - Not necessarily tied to the cost of generation -Increases investor risk due to increased price uncertainty - Requires an active spot market, or other electricity price indicator onto which to add the premium
	<b>Sliding Premium Policies (4.3.2)</b> Can be better attuned to the costs of generation & minimize over/under payment	<b>Caps and floors on total premium</b>	- Reduces the possibility of over/under payment - Increases investor certainty	- Increases the complexity of the policy - Requires electricity market price transparency
		<b>Caps and floors on total payment</b>	- Reduces the possibility of over/under payment - Increases investor certainty	- Increases the complexity of the policy - Greater administrative intervention
		<b>Spot market gap model</b>	-Provides investor certainty while reducing real FIT payments as market prices increase	- Policy costs come to depend on the evolution of the market price. If evolution is slow, the total policy cost will be high and if fast, the policy cost could be low.
	<b>Premium Differentiation (4.3.3)</b> Better adjusted to the costs of generation and helps encourage a diverse RE portfolio	<b>Technology Type</b>	- Allows emerging and mature technologies to flourish - Encourages job creation under more RE tech. - Harnesses greater range of domestic RE resources	- Can put upward pressure on policy costs if costlier emerging technologies are included
		<b>Project size</b>	- Enables prices to track economies of scale - Minimizes the chances of over/under payment - Allows RE systems to be scaled to match nearby loads	- Can put upward pressure on policy costs if payment levels are significantly higher for smaller project sizes

## 5.0 FIT Policy Implementation Options

There are several FIT policy design considerations that deserve specific treatment and that are separate from setting the payment price of a FIT policy. This section explores some of those implementation options, including:

1. Eligibility criteria,
2. Purchase obligation,
3. Non-utility purchase agreements,
4. Contract-related design elements,
5. FIT policy adjustments,
6. Caps on FIT policies,
7. Forecast obligation, and
8. Transmission and interconnection issues

### 5.1 Eligibility Criteria

Eligibility criteria play an important role in determining the scope of FIT policies. This section explores four different criteria, including who is eligible to receive FIT payments, as well as eligible technology type, project size, and the location of interconnection with the grid.

Feed-in tariff policies in the European Union typically allow participation by all utilities, RE developers, community groups, citizens, cooperatives, private investors, etc. without discrimination. However, this is not always the case. For example, in Germany's initial FIT policy (Germany 1990), utilities could not participate (Germany 1990); this exclusion was lifted in the 2000 RES Act (Jacobsson and Lauber 2006); generators with a federal or state ownership stake of more than 25% have been allowed to participate since 2004 (Germany 2004). More recently, in the United States, Central Vermont Public Service (CVPS) offered a premium-price FIT exclusively for farm-sited anaerobic digesters (DSIRE 2009a and Dunn 2010).

Some U.S. states have similar types of location-specific restrictions (Couture and Cory 2009). For example, California's Public Utilities Code 399.20 (enacted in 2006) created a feed-in tariff for all renewable technologies defined under Public Utilities Code 399.12. This law includes projects up to 1.5 MW that are developed by a water or wastewater facility that is a customer of an investor-owned utility (CPUC 2006). In 2007, the California Public Utilities Commission (CPUC) expanded eligibility to all customers in the service territories of two major investor-owned utilities and increased the program cap to 478 MW for all non-water or wastewater facilities (CPUC 2007, CPUC 2008b). In the United States, utilities still are not eligible to participate in FIT policies, which focus instead on encouraging non-utility generation.

Another important issue is whether, and to what extent, eligibility is expanded to include a variety of technology types. Gainesville Regional Utilities' (GRU) FIT policy extends eligibility only to solar PV systems (GRU 2009), while Ontario's Standard Offer Contract program initially offered eligibility only to wind, biogas, small hydro, and solar PV systems (OPA 2006). The choice of technology eligibility can also be determined based on local resource potential. For instance, Germany includes a FIT payment for geothermal electricity, but does not have one for

tidal energy or concentrating solar power (CSP) (Germany 2008), primarily because these two renewable resources hold little potential in the country. In contrast, Spain includes a FIT payment for both tidal and CSP (Spain 2007), but not for geothermal – again, reflecting the available resource potential.

Some jurisdictions include eligibility requirements by introducing project size caps, which limit the benefits of FIT payments for larger projects (see Section 5.6.2). For instance, GRU's FIT caps the total program size at 4 MW per year (GRU 2009), which limits the maximum project size that can qualify for a FIT contract. In changes to its solar PV FIT policy, Spain included a project size cap of 10 MW for ground-mounted PV systems (and 2 MW for rooftop and BIPV), and also introduced a 400-500 MW cap on total annual capacity (Spain 2008). This latter cap restricts eligibility on a first-come, first-serve basis, until the annual allotment is met (Spain 2008). Ontario, Canada imposed a 10 MW project size cap on all four renewable energy technologies included in its SOC program (wind, hydro, biogas, and PV) (OPA 2006).

Ontario's SOC program in 2006 was another example of limiting eligibility (OPA 2006). It limited the level of development allowed in certain areas of the grid that were deemed unsuitable for new RE capacity additions because of grid constraints. This was resolved initially by breaking the grid into green, yellow, and orange zones with different restrictions for each (OPA 2006).<sup>59</sup>

### **Evaluation of Eligibility Restrictions**

There are a number of ways to limit project eligibility; this section briefly examines the arguments for and against broader eligibility, based on the four restrictions outlined above.

1. **Eligible participants.** Having fewer restrictions on who can participate can help a jurisdiction reach higher levels of RE penetration, while creating broader support for greater RE deployment (Mendonça et al. 2009b, Fell 2009). In general, jurisdictions where citizens, farmers, communities, etc. are able to participate in RE development tend to demonstrate higher levels of both public and political support for greater RE deployment (Mendonça et al. 2009b). More diverse ownership can also increase the local economic benefits of RE deployment (Bolinger 2001 and 2004, Farrell 2008); and allowing utilities to participate can reduce institutional opposition and help jurisdictions capture a greater share of domestically available RE potential (Stenzel and Frenzel 2008).
2. **Eligible technologies.** FIT policies that include a diversity of technology types can help counterbalance the introduction of variable sources such as solar and wind with more dispatchable sources such as biomass and more base-load sources such as biogas and geothermal. Furthermore, expanding eligibility to emerging technologies (or technologies that are simply costlier) can help new industries reduce costs through economies of scale and technological innovation. This can increase overall cost-effectiveness of RE development in the medium to long term by pushing the costs of more technologies

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<sup>59</sup> Note that the OPA's new FIT framework includes a more comprehensive set of provisions to deal with transmission and distribution issues (OPA 2009a).

toward grid parity<sup>60</sup> (Ragwitz et al. 2007). Including less mature technologies can also allow more available RE potential to be harnessed by diversifying the types of RE that are developed. As a result, expanding technological eligibility can help a jurisdiction attract new industries and create new forms of employment in more renewable energy sectors, including those with substantial potential for job creation. Failure to encourage less mature technologies may therefore be considered an opportunity cost.

3. **Project size eligibility.** Restricting eligibility on the basis of project size can limit the potential of a FIT policy to stimulate large amounts of RE development, because it imposes an artificial upper limit on the size of eligible projects. It also risks decreasing cost efficiency because larger projects can be divided into smaller ones to comply with the size restriction (see Section 4.2.1.2). By extension, expanding eligibility to different project sizes also allows wider participation for investors. By including both small-scale and large-scale systems, residents as well as larger investors and utilities can participate, which further increases the opportunities for RE deployment.
4. **Geographic eligibility.** Extending eligibility to different areas on the grid can also lead to broader RE deployment, and will avoid discriminating against particular areas that may not have available transmission or distribution capacity. Extending eligibility to certain regions may require grid upgrades, but it can also help increase the level of RE penetration and harness valuable resources in areas not served by transmission access.

There are also disadvantages to expanding FIT eligibility requirements to include a wider variety of investors, technologies, project sizes, and locations.

1. **Eligible participants.** By allowing more investors to participate (including utilities, for instance) expanded eligibility could help service providers extend their monopoly status to the development of FIT-eligible projects. And if allowed to give themselves preferential treatment, utilities may be able to constrain access for non-utility participants. Regarding the scope of eligibility, FIT policy designers must carefully consider who can benefit from the payment levels and must ensure that the policy framework is consistent with the overall policy objectives.
2. **Eligible technologies.** Including less-mature and costlier RE technologies may result in higher costs for ratepayers in the near term, even though encouraging these technologies may be more cost-effective in the medium to long term (Ragwitz et al. 2007). For example, locking in large amounts of solar PV generation in 20-year contracts could be considered cost-inefficient based on the rapid cost reductions occurring in solar module manufacturing (Wiser et al. 2009, Frondel et al. 2008). For this reason, such support can be considered cost-inefficient and may lead to a higher societal cost, particularly if large amounts of costlier resources are deployed. This has led certain jurisdictions such as Spain to cap the allowable near-term capacity additions of costlier RE technologies such as PV, which will reduce the cost burden of locking in large amounts of costlier resources (Spain 2008).

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<sup>60</sup> Such that more renewable technologies are cost-competitive with conventional electricity generation, particularly the cost of the existing mix of electricity generation.

3. **Project size eligibility.** Expanding eligibility to include projects of different sizes (for instance, by differentiating the FIT payments according to project size, ranging from rooftop PV to large ground-mounted arrays) can also put upward pressure on the total costs of the policy. Smaller projects will tend to be costlier (per-kWh) than larger projects that benefit from economies of scale and will also tend to increase the marginal cost of RE generation. Once again, the policy design will depend significantly on the overall policy goals and whether these goals include encouraging local and community participation.
4. **Geographic eligibility.** Finally, introducing few eligibility restrictions based on grid considerations could lead to development in areas that are costlier to reach; which, if the costs are passed on to ratepayers, could increase the marginal costs of RE deployment. It may also be advantageous to limit development to areas on the grid where new supply is needed, either to fulfill a projected supply shortfall in a given area, or to displace existing conventional generation from a particular generating station.

Overall, eligibility criteria play an important role in determining the success of FIT policies. FIT policy designers should ensure that the eligibility protocols are consistent with their goals.

## 5.2 Purchase Obligation

The second FIT implementation option is to include a purchase obligation on the electricity generated from RE projects. In general, fixed-price FIT policies include purchase obligations, which are an important part of increasing investment security and reducing risk. A purchase obligation guarantees project developers that grid operators or energy supply companies will buy the renewable electricity that they generate. The obligated party must administer the tariff and payments, and dispatch the renewable electricity. In Europe, most countries provide some form of purchase obligation – but there are exceptions. The Spanish FIT framework allows generators to choose at the beginning of each year whether they want to sell the electricity as part of a bundled fixed-price FIT tariff or on the spot market (where they would fall under the premium FIT option). While the fixed-tariff design guarantees a purchase obligation, there is none for generators who choose the premium option. Under the latter, electricity is sold on the spot market instead, or via bilateral contracts<sup>61</sup>.

Proposed statewide feed-in tariff policies in the United States generally follow Europe’s lead by including purchase obligations or “must-take” provisions. However, two existing programs that share certain features with FIT policies (but are not FIT policies) do not require purchase obligations. Minnesota’s current C-BED program does not require utilities to enter contracts with RE project developers; the law states instead that they must make a “good faith” effort to do so (Minnesota 2005). In Washington State, utilities are not required to purchase renewable electricity; however, utilities that comply are compensated through state tax credits up to a \$5,000 limit per project (Couture and Cory 2009).

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<sup>61</sup> A bilateral contract ends up providing a negotiated purchase guarantee, while still benefiting from the FIT premium (see Section 5.4).

### **Evaluation of Purchase Obligations**

Policies that include a purchase obligation increase the level of certainty for RE generators and investors, by guaranteeing that any and all electricity produced from the RE system will be bought. This reduces the counterparty risk, and is likely to lower the costs of financing as a result. Including a purchase obligation can also increase the chances that RE electricity will begin to displace conventional generation within electricity markets, which may help meet complementary policy goals such as emissions reduction targets.

However, including a purchase obligation may be considered inconsistent with competitive electricity market structures because the electricity has to be purchased irrespective of demand (Mendonça 2007, Lesser and Su 2008). This is one reason that FIT models without a purchase guarantee – such as the premium-price model – are viewed as increasing the “market-compatibility” of FIT policy frameworks because both RE and conventional electricity are sold on the spot market (Langniss et al. 2009) – therefore, an active spot market is required.

The decision of whether to include a purchase obligation as part of the FIT policy will depend on how aggressive the policy is intended to be and the extent to which it is effectively intended to displace conventional generation within existing electricity markets.

### **5.3 Non-Utility Purchase Agreements**

Although electricity generated under a FIT is typically sold to utilities, some jurisdictions allow bilateral contracts with entities other than the load-serving entity. This is the third implementation option. In its RD 436/2004, Spain introduced this possibility, allowing electricity sales through bilateral contracts with customers. It also allowed forwarding electricity through traders in the form of forward supply contracts, rather than on the open market (Ragwitz et al. 2007, del Rio Gonzalez 2008). Spain retained this possibility in its 2007 energy law (Spain 2007). Germany has also introduced this possibility with the RES Act 2008, which allows operators to sell electricity directly to third parties on a monthly basis (Germany 2008, Section 17).

#### **Evaluation of Non-Utility Purchase Agreements**

Investors favor this option of selling through bilateral contracts, especially with creditworthy counterparties. Customers in good standing and with solid credit can increase the certainty of revenue streams; and, in cases where premium-price policies are used, this option can provide a purchase guarantee that is generally not included within the policy framework. In addition, this option allows RE generators to sell electricity directly to customers at rates that may be lower than the retail price offered. This may provide benefits for consumers without significantly increasing the risks for producers.

On the other hand, allowing sales contracts to bypass utilities may make it more difficult to track the total amount of RE generation produced. Utilities typically provide annual reports on the total number of projects and their resulting generation. Unless the non-utility contracts are tracked and reported, their results will not be captured. It may also make it more challenging for FIT administrators as well as grid operators to monitor the impact of the policy. And if high RE penetration results in a particular area, it could make it challenging for the utility to balance supply and demand on the local grid. The decision on whether RE generators can sign bilateral electricity supply agreements will depend partly on the existing electricity market structure. For

instance, this option may not be allowed in U.S. states that remain under a regulated monopoly structure. The adoption of this particular policy option will depend on the individual jurisdiction and overall policy goals.

#### **5.4 Contract-related Design Elements**

The fourth set of FIT implementation options involves the actual FIT contract. The contract structure can affect investor security and have a significant impact on the overall success of a FIT policy to achieve the policymaker's goals. These considerations include the provision of a standardized PPA, as well as an up-front specification of the length of the contracts. To date, formal contracts with purchase guarantees have generally only been provided under fixed-price FIT policies (Klein 2008).

##### **5.4.1 Standard Power Purchase Agreement**

To streamline the procedure for project approval, several jurisdictions require that all project developers use a standardized and transparent power purchase agreement. The PPA includes considerations regarding project size, point of interconnection, technology type, ownership structure, expected annual generation, and other factors.

##### **Evaluation of Standard Power Purchase Agreements**

By offering a uniform structure for project approvals, policy designers can make the policy more efficient. Rather than negotiating all of the details of every contract, the terms are standard, which reduces lead times for RE developers by minimizing time lost in approval processes. This can reduce administrative costs and accelerate the pace of RE project development. It also provides greater security for the RE project developer and for the contracting utility, because the terms are transparent.

However, a standard PPA can limit the profitability of a project by constraining the ability of the producer to sell on the spot market when electricity prices increase. This transfers the upside benefit, as well as the hedge value, to the purchasing counterparty (typically, the utility). In addition, experience in countries such as Germany suggests that a legally binding purchase obligation can effectively fulfill the same purpose as a standard PPA without requiring a formal contract. This can reduce paperwork as well as administrative and transaction costs (Fell 2009). However, Germany's approach (that can be binding without a formal contract) cannot be used in most of the United States, due to interactions between state and federal laws (Hempling 2010); but a standardized PPA can be used – or even required. Whichever approach is taken, it is likely that a conflict resolution mechanism will be required to ensure that any disagreements can be resolved in a timely and effective manner.

##### **5.4.2 Contract Duration**

Typically, a FIT is a long-term policy commitment, involving contracts that span 15-25 years. The duration of a feed-in tariff payment is closely linked to the goal of the particular policy.

For example, Spain offers contract terms of 25 years for solar PV and small hydro projects; 20 years for geothermal, ocean power, and wind power; and 15 years for the other RE technologies, including biomass and biogas resources (Spain 2007). Germany offers a purchase guarantee for 20 years on all of the RE technologies included within its policy, with the exception of small



hydro systems, which are now awarded 15-year guarantees (Germany 2008). Ontario's SOC program included 20-year contracts for all eligible technologies (OPA 2006), while FIT contracts in France last for 15 years for both biomass and wind projects. Opting for slightly shorter contract lengths, Austria offers a contract of 13 years to wind projects, while Slovenia only offers 10-year contracts to all eligible technology types (Klein et al. 2008).

### **Evaluation of Contract Duration**

There are a several advantages to implementing relatively long (i.e., 15- to 25-year) contract terms.

Longer contract terms provide stability, security, and risk reduction to the RE developers and their investors. The contract length is generally considered essential in minimizing financial risks, with longer contract terms generally leading to a lower cost of capital and a higher degree of investment security (Wiser and Pickle 1997, de Jager and Rathmann 2008, Guillet and Midden 2009, Deutsche Bank 2009). The length of the contract under a feed-in tariff is also central to ensuring reliable cost recovery for investors. If contract terms are too short, investors may perceive the policy to be too risky or insufficient to ensure profitability, and may direct their investments elsewhere (Chadbourne and Parke 2009). Longer contract terms are particularly important for technologies with proportionally higher up-front costs (PV and hydro), which generally require longer amortization periods.

Second, longer contract terms for fixed-price FIT policies can provide a hedge against volatility in future energy and electricity prices. By locking in long-term purchase agreements, utilities can also hedge against these volatilities and help secure a higher degree of price stability for their customers (de Miera et al. 2008).

Third, longer contract terms can also help reduce the incremental cost of RE deployment, because cost recovery occurs over a longer horizon. When amortized over a longer time period, the levelized cost of energy – and the required FIT payment – is reduced. If the goal of a specific FIT policy is to target a precise rate of return for a renewable energy generator, shorter timeframes will lead to higher incentive amounts to reach the prescribed rate of return, and vice versa (Grace et al. 2008). Thus, if the goal is to minimize annual FIT payments per project, then a longer time period can help reduce incremental costs.

There are advantages to shorter contract terms as well. Developers of RE technologies that use a fuel source –particularly biomass – prefer shorter timeframes. In general, it is difficult to secure biomass fuel supply contracts beyond 3-5 years, which means it is difficult to project what future fuel prices will be. By providing a higher FIT payment during a shorter FIT contract, legislators can be confident that a given biomass plant will get the revenues required to pay off initial capital costs quickly.

Shorter contracts can also reduce the risk of overcompensation. If guaranteed contract terms are too long (e.g., 25-plus years), there is a risk of overcompensation at the end of the contract, particularly if full or partial inflation adjustments are included.

## 5.5. FIT Policy Adjustments

The fifth implementation design option relates to how often and in what way the overall FIT policy is adjusted over time. This can involve two different kinds of adjustments: 1) incremental *payment adjustments* and 2) comprehensive *program revisions*. This section explores both and provides a brief evaluation of each.

### 5.5.1 FIT Payment Adjustments

Adjustments to FIT payments are generally minor, are often pre-determined, and do not change the fundamental nature of the FIT program design. They are smaller than wholesale program revisions (Section 5.5.2) and they are generally made to adjust for technological cost reductions or changes in the broader economy. These types of adjustments include administrative FIT payment adjustments such as periodic changes and fuel price adjustments, as well as automatic adjustments such as inflation indexing and tariff degression (established in advance on the expectation of changing market conditions). Due to the fact that some of these design options are discussed earlier, this section is kept brief, and the reader is directed to earlier sections such as Section 4.2.2. However, because of its importance, the issue of FIT payment adjustments is treated here as a single issue.

#### 5.5.1.1 Incremental FIT Payment Adjustments

Some countries adjust the FIT payments administratively – this can be done either automatically, or after a specified period of time. For example, the Energy Regulatory Office in the Czech Republic performs annual revisions to FIT payment levels (Klein et al. 2008). In addition, the Czech Republic safeguards investor security by ensuring any revisions to tariff prices can only alter the tariff level by a maximum of 5% (Klein et al. 2008). This provides investors and RE project developers with a higher degree of certainty for future FIT payment levels. In a similar approach, Greece adjusts its full set of FIT payments annually according to a decision from the Ministry of Development, which is based on analysis from the energy regulator (Greece 2006). Ireland's FIT policy introduces an annual adjustment to track inflation, adjusting them fully to annual changes in the CPI (Ireland 2006). FIT payment adjustments also include design elements such as inflation adjustments (see Section 4.2.2.3).

In its new royal decree for solar PV, Spain introduces another approach to adjusting tariff amounts specifically for PV technologies – it involves a formula for automatic adjustments based on the amount of capacity that responded to the call for PV from the previous quarter (Spain 2008). The new FIT policy establishes an annual cap on the amount of solar PV capacity that can be installed in a given year, allowing 267 MW to be shared between small (<20 kW) and large (>20 kW) rooftop systems, and another 133 MW for large ground-mounted systems. These capacity limits are met by a series of smaller “calls” that will award contracts to projects on a first-come, first-serve basis (Spain 2008).

In this design, an adjustment to the actual FIT payment amount is triggered if more than 75% of the capacity target is reached in the previous call, according to the following formula:

$$[(1-0.9^{1/m}) \times (P_0 - P) / (0.25 \times P_0) + 0.9^{1/m}] = \text{percentage adjustment to actual FIT payment (if triggered)}$$

where  $P_0$  is the capacity target for the given call,  $P$  is the pre-registered capacity signed up during the previous call, and  $m$  is the number of annual calls (Spain 2008, Jacobs and Pfeiffer 2009). If the capacity that responds to any call meets between 50% and 75% of a given call, the tariff level for the next call remains unchanged. And if the capacity that responds is less than 50% of a given call for two consecutive calls, then the FIT payment is actually increased. This is detailed in Table 13.

**Table 13. Spain Tariff Adjustment Mechanism**

<b>Spain Tariff Adjustment Mechanism for Solar PV (Spain 2008)</b>	
<b>Market Condition</b>	<b>Impact on Payment Level</b>
If between 75% and 100% of a given call is reached...	Downward revision to the FIT payment level by 2.6%.
If less than 75% of a given call is reached...	No change to the FIT payment level.
If less than 50% of the call is reached in two consecutive calls...	Upward revision to the FIT payment level by 2.6%.

Source: Spain 2008, Jacobs and Pfeiffer 2009

According to this formula, the maximum change that can occur to the tariff after a given call is 2.6%. Assuming four calls occur per year, the maximum downward annual tariff adjustment that can occur is a little more than 10%.<sup>62</sup> For example, if the expected capacity amount for every call in a year is met by a response of at least 75% of the expected amount, this brings the initial tariff down by 10% total in that year.

However, if less than 50% of the target is reached in two consecutive calls, the payment level is increased by 2.6%. If, as a result of one of the FIT payment adjustments, the tariff drops below the required level to ensure profitability, it is likely that the quota in subsequent calls will not be met, which leads to an automatic upward revision in the payment amount.

This responsive scheme provides a way for tariff adjustments to occur automatically, which can simultaneously adjust for technological cost reductions and help modulate the rate of market growth without direct administrative intervention.

<sup>62</sup> A 2.6% decline repeated four times leads to a net tariff decline of approximately 10%.

## **Evaluation of Incremental FIT Payment Adjustments**

The rapid pace of renewable technology advancement, combined with changes in the costs of different renewable energy technologies, can make adjustments to FIT payments necessary to ensure the cost efficiency of the policy over time. Therefore, the provisions surrounding payment adjustments are a central component of a well-designed FIT policy.

As noted above, these can include either an automatic adjustment, which occur according to a pre-established formula (e.g., tariff degression, inflation adjustment); or they can be an administrative adjustment, which can occur on a periodic basis (e.g., quarterly, annually, or every three or four years). Note that these adjustments can allow prices to be tracked both downward (due to decreases in technology costs, improved operational efficiencies, technological learning, etc.), as well as upward (due to slower-than-desired rates of growth; increases in technology, labor, and/or materials costs; a tightening of supply and demand, etc.)

Automatic adjustments can help foster greater investor certainty, primarily because they are transparent and established in advance. They also provide a clear signal to manufacturers, who have to continually improve products to keep up with the planned tariff adjustment schedule. In the Spanish approach, they adjust their solar PV tariffs via a transparent formula. This allows the adjustments to occur automatically based on market growth and the desired annual amount of a given RE resource, while reducing the need for direct administrative intervention in the future.

Administrative revisions could provide a more adaptable pricing framework by tracking market trends more closely than one based on a predetermined formula, or a fixed adjustment schedule. These incremental, administrative revisions could allow tariff levels to be adjusted in direct response to changing market trends in order to reduce the risks of both over- and under-compensation.

Either way, if FIT payment adjustments are too large, too often, or too sudden, they could jeopardize investor confidence, which increases market uncertainty – both of which could significantly slow the rate of renewable energy development and increase the future costs of deployment (Deutsche Bank 2009). Periodic revisions that require administrative oversight every year, and especially quarterly, are also likely to increase the administrative burden of the program. Whichever approach is used to implement FIT program revisions, the challenge is to strike a balance between overall policy stability and flexibility. This ensures that the payment levels accurately reflect renewable energy project costs but still allow for a reasonable return.

### ***5.5.1.2 Incremental Fuel Price Adjustment***

For renewable energy resources dependent on a fuel (such as biomass), it is possible to introduce a fuel adjustment clause that allows the market price fluctuations to be tracked in a more flexible manner. For example, Spain applies a fuel price adjustment every three months for resources dependent on a fuel (Spain 2007).

## **Evaluation of Incremental Fuel Price Adjustment**

By allowing fuel price adjustments to occur more frequently, policy designers can better track the market trends for the resource price and provide investors with a revenue stream that is more closely adjusted to actual price fluctuations. This also provides the RE developer with greater flexibility by adjusting the FIT price to compensate for changing market conditions. Because

future biomass fuel prices are hard to predict, contracts with built-in fuel price adjustments, more frequent revisions, or both may be desirable for renewable resources that are dependent on a fuel. This can be done by automatic adjustments based on an agreed-on formula or by administrative revisions.

However, the unpredictability of future fuel prices can make it challenging to design accurate fuel adjustment mechanisms. FIT policy designers can address this through shorter contract terms or more flexible pricing arrangements for the electricity generated from biomass sources.

### **5.5.2 Comprehensive FIT Program Adjustments**

Comprehensive FIT program adjustments require a more detailed revision of the policy framework than the FIT payment adjustments examined above – they involve a more detailed consideration of policy goals and overall policy structure. These adjustments can include program eligibility, the duration of support, the presence of caps or targets, and other factors. Comprehensive program revisions typically involve a more detailed review of the policy’s success, while highlighting where changes need to be made based on both evolving policy goals and changing technology costs and market conditions. FIT program revisions allow prices to be tracked both downward (due to decreases in technology costs, improved operational efficiencies, technological learning, etc.), as well as upward (due to slower-than-desired rates of growth; increases in technology, labor, and/or materials costs; a tightening of supply and demand, etc.) in a way that is supplementary to FIT payment adjustments.

These broader changes to the FIT program structure generally happen less frequently (typically every two to four years). This is important because it sends a more reliable market signal to project developers and, more important, to RE investors, who tend to prefer stability and predictability of policy changes (Deutsche Bank 2009, Dinica 2006, Wang 2009). These can be broken down into periodic revisions (which occur at fixed intervals) or be based on the attainment of capacity milestones. The advantages and disadvantages of program adjustments are explored at the end.

#### **5.5.2.1 Periodic Program Revisions**

Periodic revisions establish a fixed schedule for FIT program revisions, which are typically scheduled to occur every few years.

For example, Germany has program revisions planned every four years, and the German Parliament has to approve amendments to the tariff levels before they can be enacted into law (Germany BMU 2007). The OPA in Ontario plans to perform comprehensive program revisions every two years in its FIT framework (OPA 2009a). This predictable revision period creates a stable investment environment during the four-year period, while ensuring that the policy retains the ability to track market cost trends and technological improvements.

#### **Evaluation of Periodic Program Revisions**

By setting predetermined revision dates, policy designers can increase the overall transparency of the FIT policy for investors, while providing a stable schedule for tariff and policy revisions. This stability can foster investor confidence and drive more rapid RE deployment.

If technology costs or market conditions change significantly, periodic revisions may be insufficient to adjust in a timely manner. In this case, the policy could lead to overpayment and consequently to higher policy costs; or, conversely, to underpayment and reduced RE deployment. Therefore, it is important to ensure that the policy framework remains adaptable in a way that doesn't unduly jeopardize investor confidence.

#### **5.5.2.2 Program Revisions Triggered by Capacity Milestones**

Instead of providing a fixed date or timeframe for program policy revisions, some jurisdictions have these revisions triggered by the attainment of certain capacity milestones by technology. Capacity-dependent program revisions allow payment adjustments to occur once a particular political target is met. This adjustment can occur automatically according to a pre-established formula (or pre-defined, incremental steps), or the attainment of the capacity milestone can trigger an administrative review, which can lead to a tariff adjustment. As renewable energy targets are reached, these cumulative capacity-based milestones can be progressively raised, which helps RE deployment occur in a more controlled manner. Note that these *program* revisions are triggered by technology-specific program-wide milestones, which are different than the adjustments to *payment* levels based on capacity milestones (see Section 4.2.2.1 on Predetermined Tariff Degression).

For example, Portugal revises its policy when a certain total renewable energy capacity target is met in each technology class (Klein 2008). In a similar approach, Spain has designed its policy so that the attainment of the capacity milestone triggers a policy review, a situation that has recently occurred with solar PV deployment (Wang 2009).

In Spain, the milestones were established with its Renewable Energy Plan (REP) 2005-2010, which was approved in August 2005 (Spain 2008). This document established a capacity target of 400 MW of solar PV development by 2010 and included the provision that the attainment of the target would trigger a revision of the FIT policy, which was the primary mechanism for reaching the renewable energy targets. Due to the rapid pace of solar development in Spain in 2007-08, the capacity milestone was surpassed in fall 2007, which triggered a review to be completed within the following year, by September 2008. This revision led to the Spanish RD 1578/2008.

#### **Evaluation of Program Revisions Triggered by Capacity Milestones**

Capacity-based program revisions improve the flexibility of the policy design, while enabling a jurisdiction to closely monitor price changes on an ongoing basis. If development happens more quickly than anticipated because project costs decrease rapidly, they can allow for a quicker response time by the program administrators. This reduction can be particularly important in years when project costs decrease rapidly (e.g., the cost of solar PV modules in 2009). Capacity-based program revisions introduce a structured means of adjusting tariff levels to cost realities. They also allow legislators to revise policies only when certain targets are met, which reduces the threat of unexpected policy changes for investors. In addition, they provide a way to control the pace of RE deployment by requiring amendments when targets are attained. If the capacity targets are set at high enough levels, they can provide enough incentive for sustained development over several years, while providing the safeguards to ensure that actual deployment remains in line with policy objectives.

However, capacity-dependent program revisions may fail to provide an accurate way to track technological cost reductions, if there is a large time-lag between when a capacity target is reached and when a new set of FIT payment levels is established (e.g., one year in Spain from September 2007 to September 2008). Additionally, introducing capacity-dependent revisions could create uncertainty for developers and investors as the milestone nears. This uncertainty could lead to a development rush as developers seek to install projects before the policy changes occur – this happened in Spain in 2007 and 2008 (Wang 2009, Deutsche Bank 2009). While revising the policy only when predetermined targets are attained promotes policy stability, it is not clear that technological change, improvements in economies of scale, or any of several other factors that contribute to cost reductions will occur in step with the pre-established capacity milestones.

### **Summary Evaluation of FIT Policy Adjustments**

Incremental payment level revisions and comprehensive program revisions can both be important components of a successful and cost-efficient feed-in tariff policy. RE technologies and markets are changing rapidly, and the respective costs of each technology are also changing in response to technological improvement; supply and demand factors; and the costs of materials, labor, etc. Incremental payment level revisions can include either automatic adjustments according to a pre-established formula (e.g., tariff degression, inflation adjustment), or they can be periodic, administrative adjustments (e.g., quarterly, annually, or every three or four years). Note that these adjustments can allow prices to be tracked both downward (due to decreases in technology costs, improved operational efficiencies, technological learning, etc.), as well as upward (due to slower-than-desired rates of growth; increases in technology, labor, and/or materials costs; a tightening of supply and demand, etc.)

Comprehensive revisions to FIT program structure allow larger program-wide adjustments to occur in a way that tracks market trends, and can act as a higher, “macro-level” adjustment to the FIT policy. These comprehensive revisions ensure that the policy framework continues to meet the policy goals for which it was designed. For all of these reasons, FIT payment adjustments and periodic program revisions are considered crucial to the design of successful FIT policies.

Whichever approach is used to adjust FIT policies, it is critical to ensure that the methodology for adjustments is clear and transparent to all market participants. In addition, the framework for FIT *payment* adjustments and FIT *policy* adjustments should be sufficiently flexible to ensure that it can accurately track changes in technology costs over time. This is key to ensuring the policy remains effective and cost-efficient, while continuing to deliver on its objectives.

### **5.6 Caps on FIT Policies**

The sixth implementation option considers the various ways in which FIT policies can be capped.

To better control market growth in RE and the total costs of their FIT policy, some jurisdictions impose various caps. Caps can control the policy beyond the scope provided by the eligibility criteria and can provide a means of limiting both the short-term and the long-term impacts of the policy on electricity prices or government coffers.

Four types of cap structures are examined:<sup>63</sup>

- 1) caps imposed on total **program size**, which include capacity caps (MW) and total generation caps (GWh);
- 2) caps imposed on the individual **project size**;
- 3) caps on the total rate impact on electricity customers, or on the **total policy costs**;
- 4) and finally, “**cap-less**” FIT policies are also considered.

### **5.6.1 Program-Wide Caps**

Program-wide caps impose an upper limit on the total amount of renewable energy capacity or electricity generation that can be developed under the FIT policy framework. These caps can be established either in the form of an increasing schedule of short-term (i.e., annual) increments, or as larger, overall program caps that are to be met over several years.<sup>64</sup>

For instance, Gainesville Regional Utilities’ (GRU) FIT policy introduces an annual cap of 4 MW on the total installations of solar PV projects (GRU 2009). This provides an incremental schedule for renewable energy procurement, which allows the utility to control the pace of development while monitoring overall policy performance.

In another example, Germany’s initial feed-in tariff only required utilities to purchase electricity up to 5% of their total sales (Germany 1990). This is an example of a cap on the total amount of RE generation that qualifies for the FIT payment,<sup>65</sup> as opposed to a cap on total installed capacity.

France used to have program-wide caps on overall development of wind (17,000 MW), biomass and hydropower (2,000 MW each), and PV (500 MW) (Grace et al. 2008). More recently, France established a set of targets for RE development within each technology class, similar to RPS targets in the United States. These targets create goals and no longer cap the development of each technology under their FIT program (see Table 14).

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<sup>63</sup> The authors acknowledge that there are numerous ways of imposing caps on FIT policies, and that this is not an exhaustive overview.

<sup>64</sup> Note that RPS policies in the United States sometimes employ a hybrid of these approaches, establishing annual increments as well as longer-term policy goals that span 10 years or more (Wiser and Barbose 2008).

<sup>65</sup> In practice, utilities could purchase more than 5% of their total sales from FIT projects, but the obligation to accept FIT projects beyond this amount no longer applied (Germany 1990). This 5% “cap” was lifted in Germany’s RES Act 2000.



**Table 14. France’s RE Targets, by Technology**

Technology Type	Target by 12/31/2012	Target by 12/31/2020
Solar (PV & Thermal)	1,100 MW	5,400 MW
Biomass	520 MW	2,300 MW
Onshore Wind	10,500 MW	19,000 MW
Offshore Wind	1,000 MW	6,000 MW
Hydro	No target	3,000 MW (incremental)

Source: France 2010b

### **Evaluation of Program-Wide Caps**

Program caps provide specific structural boundaries to the renewable energy market, outlining the objectives for renewable energy development. These objectives can encompass broad goals for all renewable sources, as well as individual targets by technology type, as seen in France.

If caps are large enough relative to the size of the potential market, they can provide a valuable signal to RE project developers and investors, while providing manufacturers with important information about the extent of future market growth in a given technology sector. Caps can also help policymakers control overall policy costs by providing firm limits on the amount of renewable energy development. This can include lower caps on costlier resources such as solar PV, and higher caps on lower-cost RE resources such as wind and biomass power.

However, caps can introduce a number of problems for RE development. If capacity caps are set too low, they can create uncertainty for investors, who are unlikely to know how quickly the caps will be reached and whether their particular project will make the cut before the cap is subscribed. Investor uncertainty can also develop before the actual cap is met.

In addition, caps on program size may result in “queuing” as projects line up to fill the specified allotment. In these instances, it is possible that the project-development pipeline could become filled with a number of unviable projects as RE developers enter speculative bids to secure their place in the queue (Grace et al. 2008; see Section 5.8.3 on Queuing Procedures). To respond to this problem, some jurisdictions design their FIT policy so that meeting a specified capacity target triggers a revision in the policy (del Rio Gonzalez 2008, Grace et al. 2008). While this practice reduces uncertainty, it does not remove it altogether, because there is still uncertainty over what changes will take place as a result of the revision.

Unless issues such as these are addressed within the FIT program design, a program-wide cap (particularly one with a shorter timeframe or smaller capacity scale) can create uncertainty for investors – program revisions are seldom transparent, and the precise date at which a given capacity target will be met is unknown. Hard caps also limit the amount of renewable energy development that can occur, which reduces the prospects for market growth and creates a

disincentive for manufacturers to build new facilities. This can also reduce the chances that RE targets will be met on schedule.

### **5.6.2 Project Size Caps**

Project size caps are limits imposed on the eligible size of individual RE projects, and they are typically differentiated by technology type. For example, policies may allow higher project size caps for larger-scale resources such as wind power, while imposing smaller caps on costlier resources such as solar PV. FIT policies can introduce caps on project size to keep costs down and to limit the extent of market growth by preventing larger projects from being eligible.<sup>66</sup>

Ontario's first Standard Offer Program initially imposed a 10 MW cap on all renewable energy facilities in its policy (OPA 2006). The Ontario approach provided a little flexibility, allowing project sizes to exceed the 10 MW limit in the case where the next additional generator would put the project over 10 MW (e.g.: 4 X 3 MW wind turbines = 12 MW project).<sup>67</sup> Spain, while opting not to include caps on most of its RE projects, has introduced a cap of 10 MW on solar PV installations (Held et al. 2007, Spain 2008). In its recently approved FIT policy, Great Britain imposed a cap of 5 MW on individual project size (including most RE technologies), while the U.S. state of Vermont has opted for a project cap of 2.2 MW (Great Britain 2010 and DSIRE 2010b, respectively).

### **Evaluation of Project Size Caps**

Imposing caps on individual project size provides another way to limit the pace of renewable energy development and to control overall policy costs. Project caps can also focus a FIT policy on distributed generation, where the technical and administrative costs of interconnection to the distribution grid are lower, and where greater local and community ownership is likely to occur. Limiting project size may be particularly appealing to jurisdictions with successful programs to support mid-size or utility-scale renewable energy projects.

Introducing restrictive caps on project size may add additional barriers to renewable energy development. Project-level caps administratively prescribe which projects can be developed, rather than allowing project size determinations to be made based on local resource potential or land availability. Project-size caps can also lead to costlier renewable electricity, in general, by limiting the ability of RE projects under the FIT policy to harness economies of scale. Furthermore, there is a possibility that size constraints can be gamed by dividing large projects into smaller projects at the same site, which leads to a greater number of interconnection points and/or substations and can significantly increase overall RE development costs. This can reduce the cost efficiency of the policy and divert decision-making from a consideration of financial resources and RE potential to administrative limits and restrictions instead.

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<sup>66</sup> Note that some feed-in tariffs do not include project size caps, choosing instead to differentiate the payment levels to account for economies of scale. This also enables both small-scale as well as larger, commercial-scale renewable energy development to be captured within one policy framework, which may reduce the administrative costs of managing two separate policies for renewable energy.

<sup>67</sup> Note that Ontario also included a voltage cap of 50 kV on projects interconnecting to the grid (OPA 2006).

### **5.6.3 Program Cost Caps**

Caps can also limit the total program cost of a FIT policy – imposing an upper limit on the total ratepayer impact is one way to accomplish this. Alternatively, where FITs are financed from treasury, the FIT framework can be limited by budgetary allocation. Either of these forms of cost caps may be applied to FIT policies to better control and monitor overall policy costs.

For example, the Netherlands has a FIT policy funded directly from taxes in which a specific amount of government funds is awarded to each technology type (van Erck 2008; see Section 4.3.2.3). The amounts allocated to each technology are based on a target amount of desired capacity (and estimates of annual output), in this case between 2008 and 2011. The budget allocated is based on the desired quantity: for onshore wind it is 2,000 MW and offshore wind is 450 MW; the target for biomass is 200-250 MW and solar is 70-90 MW (van Erck 2008).

Switzerland takes a similar approach, except that the added marginal costs are funded through a nationwide system benefit charge (SBC). This surcharge is SFr \$0.006/kWh and is levied on electricity customers, with special exemptions extended to electricity-intensive sectors (SFOE 2008). At this rate, the annual pool of funds raised is approximately SFr \$360 million, which is used to finance the FIT law (Geissmann 2009). Distribution of these funds is determined by specific provisions in the law and allocations for each technology type (SFOE 2008).

### **Evaluation of Program Cost Caps**

Specific FIT program cost caps can provide several advantages to program administrators. Through either limiting ratepayer impact or limiting total program budget, policymakers can closely control the costs of a given FIT policy either to the ratepayer or taxpayer. This also provides a clear and transparent way to monitor policy costs.

However, there are some disadvantages to programmatic cost caps. By introducing fixed limits on the total costs of the policy, this approach can significantly limit renewable energy deployment. It can also lead to queuing challenges, because developers might try to be first in line to receive limited funds. It might also risk focusing a disproportionate amount of attention on the monetary costs of the policy at the expense of the benefits (e.g., job creation, manufacturing, innovation, export market development, reduced emissions, etc.). In addition, imposing caps on total policy costs could contribute to stop-and-go development, which makes it more difficult to develop a sustainable domestic renewable industry (e.g., Germany, Denmark, and Spain).

### **5.6.4 Cap-less FIT Policies**

The previous examples notwithstanding, it is possible to design FIT policies without caps. This means that projects of any size can be built with no upper limit on the total amount of RE capacity and no limits imposed on the total added costs. In these instances, the only restrictions are based on objective factors, such as the condition of the grid, the existing resource potential, etc., rather than administratively imposed limits or barriers.

For example, in their FIT policies, jurisdictions such as Germany and Ontario have chosen not to impose caps on the total amount of RE developed (Germany BMU 2007, OPA 2006 and 2009a). This rate of growth and the total extent of RE deployment are left up to the market. With the exception of a 20 MW project-size cap for biomass and biogas types (e.g., landfill gas and

sewage gas),<sup>68</sup> Germany does not impose caps on project size (Germany RES Act 2000, 2004, and 2008). And, in its initial SOC program, Ontario imposed a project-level cap of 10 MW on all technologies (OPA 2006). However, in its new program rules, it has removed this cap, leaving one in place only for solar PV projects (OPA 2009a).

Instead of imposing caps on project sizes, both Germany and Ontario have opted to differentiate their FIT payment levels to account for economies of scale, which supports renewable energy development at all scales. And finally, because both jurisdictions integrate incremental costs into electricity prices, they have opted not to impose a cap on the total costs of the policy. These incremental costs are expected to diminish as fossil fuel prices increase and renewable energy sources move closer to grid parity.

### **Evaluation of Cap-less FIT Policies**

Political priorities and overall policy goals will affect whether a jurisdiction chooses to introduce caps. Caps on FIT policies can be directed at individual project size, overall program capacity, or at the cost of the FIT (total program cost or incremental impact on rates).

While Ontario's framework is quite recent, experience in Germany has shown that a "cap-less" policy environment can create positive results for job creation, manufacturing, export market growth, and avoided environmental costs (Germany BMU 2007, 2008b). Germany has deployed more PV capacity than any other country in the world (9,779 MW at the end of 2009) (EPIA 2010) and has been developing an aggressive export strategy for RE technologies. After the United States, Germany has the third largest total installed wind capacity with 25,777 MW at the end of 2009 (GWEC 2010). According to the German Federal Environment Ministry, approximately 278,000 jobs have been created through the end of 2008 in the renewable energy industry, with more than 150,000 directly attributable to their RES Act (Germany BMU 2009).

In certain jurisdictions, it may not be politically or economically possible to have a project or program-wide cap. Cap-less FIT policies are likely to lead to higher near-term costs, particularly if costlier technologies such as solar PV are left uncapped for project size or cumulative capacity. This is partly why certain jurisdictions such as Spain and Ontario have imposed a 10 MW cap on the size of individual PV projects.

Regardless of the kinds of caps imposed, policy designers should consider the near-term and long-term costs and benefits to society.

### **5.7 Forecast Obligation**

The seventh implementation option is forecast obligations, which specifically targets highly weather-dependent resources such as wind power (and potentially large-scale deployment of solar power). For renewable energy sources that are highly variable and can contribute significantly to the total electricity supply (wind power), some jurisdictions require that operators forecast their production to help grid operators better balance the total supply on the system. This

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<sup>68</sup> Certain biomass and biogas projects are unlikely to be built larger than a certain size due to local resource availability or because of conflicts with other laws. This could also be because projects larger than a certain size in certain technologies do not need policy support. For instance, a cap used to be included on hydropower projects eligible for the FIT framework in Germany because they were believed to be profitable without the FIT (Lauber 2009).

is particularly important for larger wind projects, where fluctuations of several hundred megawatt-hours and thousands of volts can occur rapidly – and could pose problems for load-following and grid reliability if not anticipated. To encourage forecast accuracy, some jurisdictions also impose a fee for deviations (Klein 2008).

Under its fixed-price option, Spain requires all RE projects larger than 10 MW to forecast their anticipated supply 30 hours before a day starts by contacting the regional grid operator (OMEL) (Spain 2007, Klein 2008). It is still possible to correct one's forecasted amount up to one hour before the hourly deadline. However, if the final hour-ahead electricity forecast differs from the actual electricity supplied by more than 20% for solar and wind, and more than 5% for other technologies, the owners are charged a fee of 10% of the average electricity price on every kilowatt-hour of deviation (Spain 2007). Renewable energy developers with multiple projects at different sites can offset some of these deviations with surplus production elsewhere on the grid. Under the market-oriented premium option, Spain employs the market rules, which requires all renewable energy producers to forecast their anticipated supply, regardless of plant size (Klein et al. 2008). Both Slovenia and Estonia also require that all RE generation owners who are operating facilities larger than 1 MW forecast their supply, but they do not have to pay a penalty for deviations (Klein et al. 2008).

### **Evaluation of Forecast Obligations**

Forecast obligations can help grid operators better balance the total electricity supply on the system, which helps maintain a reliable and uninterrupted supply. Such forecast obligations are common for other participants in the electricity industry, because they help match supply more closely to demand over time. As renewable energy sources occupy a larger proportion of electricity sold on the grid, it is likely that RE developers will need to develop increased forecasting capabilities, to improve the quality of grid management, and to better integrate renewable energy resources on a system-wide basis. Forecasting can help significantly in improving renewable energy integration and can allow for a higher level of penetration in target areas. Including a penalty for deviations can improve the accuracy of forecasts and further improve grid management.

Imposing a forecasting obligation on smaller project developers may create additional costs that make smaller projects developed by noncommercial participants unviable. It is likely to be more challenging for smaller and community-level developers to meet this added requirement because they lack the associated expertise to perform reliable forecasts. Therefore, imposing a fee for deviations can discriminate against smaller project developers. This is partly why countries such as Spain only require the forecast of projects that are larger than 10 MW, which reduces the burden for projects under a certain size, while reducing administrative costs both for system operators and project developers.

### **5.8 Transmission and Interconnection Issues**

The final implementation options deal with transmission and interconnection issues. Investments in transmission are typically required to accommodate any large-scale additions to the electricity supply network.

### **5.8.1 Transmission Considerations**

Naturally, the need for transmission investments applies primarily to large-scale renewable energy projects. This may require system-wide planning and coordination to ensure that there is sufficient transmission capacity to bring online the desired level of renewable energy deployment.

In general, it can take about 5-10 years to get new transmission planned, permitted, and constructed (CPUC 2009). However, large-scale renewable energy projects typically require anywhere from nine months to a few years to be developed; it may only take 12-15 months for a wind farm to be built (Lehr 2007). This means that both the utility and the developer are subject to significant risk regarding the availability of transmission capacity. If the utility starts to build the transmission, but the new renewable project does not come online as promised, then the costs incurred could be considered imprudent by their regulators and would have to be absorbed by their shareholders. On the other hand, it is unlikely that renewable developers will build a project if they must wait an additional 5-10 years for their project to be interconnected.

This raises the familiar “chicken-and-egg” issue common to transmission-level build-outs: Transmission lines are unlikely to get built without the assurance that the electric generation will be there to fill them, and individual projects are unlikely to get built without the assurance that transmission lines will be there to deliver their product to market. This makes the issue of system-wide planning critical to the successful, wide-scale development of new electricity supply resources, including RE sources. This issue is likely to require more detailed grid-level analysis so that grid operators can create the most efficient solutions to transmission needs based on resource availability, RE developer interest, project submissions, etc. For areas that are rich in renewable resources – but lack sufficient transmission – a supplementary transmission policy may be required. This was done to support wind development under RPS policies in Texas and in the western United States (ERCOT 2006, Woodfin 2008, CPUC 2009).

In a relatively recent development, Ontario implemented a transmission strategy to accommodate new project development under its FIT policy (OPA 2009a). According to the OPA, the strategy now allows the grid to evolve “organically” to respond to new project proposals and develop transmission ties as the need arises. This is part of a broader strategy to facilitate RE deployment in the province.

As a further solution to the problem of system-wide planning, grid operators can improve the efficiency of grid integration studies by grouping applications together, and considering entire areas separately for transmission purposes. By grouping projects that desire interconnection in the same region according to geographic clusters, the required studies could consider areas of the grid as components of a system, rather than reconsidering whole system impacts for individual project applications. This can help reduce the number of studies required and accelerate the approval and project development process.

Building the desired transmission capacity naturally carries significant costs, because projects must typically clear lengthy planning, permitting, and other legal hurdles before construction can even begin (CPUC 2009). It is important to clarify cost-allocation protocols in advance to reduce uncertainty and promote timely and orderly project development. Where applicable, costs can be

paid by the RE project developer, the utility (via ratepayers), or via a cost-sharing mechanisms between the two (Klein et al. 2008). This section explores these issues, looking first at transmission cost allocation and then queuing procedures.

### **5.8.2 Cost Allocation for Grid Connection**

Setting clear protocols for cost-sharing and queuing is an important factor in tapping the renewable energy potential that exists in certain areas. Transmission-related considerations are particularly important in the U.S. context, with a significant landmass and often little correlation between renewable energy resource potential and electricity load centers. To meet aggressive renewable energy targets, the United States will require significant upgrades to its transmission and distribution infrastructure (U.S. DOE 2008).

Costs for grid-related issues can be divided in two ways: First, the cost to physically connect the renewable energy installation to the grid, which is usually paid by the generator; second, the cost of any grid transmission upgrades required to allow the generator to connect to the system. The question of who pays for transmission grid upgrades under a FIT policy can be dealt with using a variety of structures.<sup>69</sup>

The first is shallow connection charging. In this approach, RE developers are required to pay for costs of any equipment required to physically connect the renewable energy facility to the *nearest point of the transmission grid*. As a result of this new generation capacity, the grid operator must provide and pay for required reinforcements to the grid; the operator can recuperate these costs by imposing system-use charges to all users (Klein 2008).

A second approach is deep connection charging. In this structure, the generators have to cover all the costs related to connecting their facility to the grid. This includes both direct connection costs for linking the system to the nearest point on the grid, as well as any upgrades required to accommodate the new capacity (Klein 2008).

The third approach is a hybrid of the two, referred to as mixed connection charging. The generator has to pay for the costs of physically connecting to the grid, and shares the costs of any required upgrades with the grid operator. In this instance, a formula is typically provided for cost-sharing between the grid operator and the RE developer to foster fair and transparent procedures.

### **Evaluation of Interconnection Cost Allocation Methods**

Due to the limited burden on renewable energy developers from shallow connection charging, this approach is generally considered best for smaller developers. There is also a higher degree of transparency concerning grid connection costs, which reduces risk and minimizes unpredictable costs. Conversely, because developers do not have to pay for the costs of actual upgrades to surrounding grid infrastructure, they will not necessarily consider how to site projects in a way that would optimize the use of the existing grid.

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<sup>69</sup> These structures consider cost allocation between the project developer and the utility or grid operator and do not consider the important issue of social equity (i.e., whether low income ratepayers should contribute to paying for these incremental costs).

One of the advantages of deep connection charging is that renewable energy developers do not pay for use charges because the grid operator hasn't incurred any supplementary expense. This approach also encourages producers to choose sites that are considered more efficient for the electricity system.

However, the added costs on the generator are likely to be much higher than the shallow connection method, which could create a barrier to renewable energy development or create a disincentive to produce in certain areas where the grid capacity is insufficient. This may also limit the ability of the framework to tap the significant potential that exists in areas not serviced by the transmission network. Furthermore, if each grid tie is considered separately, there is the risk that one RE project developer will pay for upgrades that another RE developer can then exploit – this demonstrates the importance of system-level planning. Finally, it is not always clear whether grid capacity in a given area will be sufficient, which could increase uncertainty for RE developers and make it difficult for them to optimize project siting.

Mixed connection charging arguably strikes a middle ground between the two previous approaches, because it retains the incentive for the RE project developer to choose a lower-cost interconnection point, while requiring that the RE developer pay a portion of any upgrades required.

Different approaches may be applied to different project sizes, or for distribution-level projects vs. transmission-level projects. For example, the cumulative sum of smaller projects may make distribution-level upgrades necessary, even though no single project is directly responsible. In this case, a shallow connection method may be selected for small applications, while a mixed connection charging may be applied for larger, transmission-level projects.

### **5.8.3 Queuing Procedures**

Queuing procedures are an important component of FIT policy design, particularly in policies where a cap is imposed on the total program capacity (see Section 5.6.1). Due to competition between RE developers for a portion of the program cap, there is an increased likelihood of speculative queuing under FIT policies that impose caps on the overall program. This applies whether the cap is structured annually or cumulatively over a longer time frame, although the problem is likely to be more acute where a shorter time frame is imposed.

Speculative queuing occurs when RE project developers get in line to “reserve” a spot in the queue for projects that may or may not be developed (Grace et al. 2008). These projects then block space in the project development pipeline from other projects that may have a greater likelihood of success.

In response to this challenge, there are a number of policy measures that can be introduced to help mitigate speculative queuing. These include:

- introducing or increasing the financial commitment required by the interconnection application for projects above a certain size,
- requiring a security deposit accompanied by project milestones (the deposit is returned as milestones are achieved), or



- requiring a further deposit scheme by which extensions of time can be purchased if a generator is not able to attain the original milestone date.

Note that countries such as Germany that do not include caps on the total amount of RE deployment do not have explicit queuing procedures; all projects are accepted and are connected on a first-come, first-served basis (Fell 2009).

### **Evaluation of Queuing Procedures**

Queuing procedures are important in most FIT policy frameworks. Queuing can help reduce the chances of unnecessary litigation and improve the continuity of project development. Requiring some form of deposit with the application can help reduce speculative queuing, and further improve the likelihood of policy success. By having some “skin in the game,” it is also more likely that RE developers will submit honest applications and that the proposed projects will be developed in a timely and efficient manner (Grace et al. 2008).

Queuing procedures can impose significant administrative costs as administrators deal with a growing list of proposed projects. Program size caps are likely to increase the costs as administrators field calls from RE developers wanting to know where they stand in relation to other projects in the queue and when they can begin construction (Geissmann 2009).

Regardless of whether program size caps are included, queuing procedures are likely to head off more problems than they cause because they help foster more orderly and timely project development. Alternatively, by not introducing caps on total RE deployment, FIT policy designers can remove the need for queuing procedures, and the first-come, first-served principle can apply.

### **5.9 Summary of FIT Policy Implementation Options**

FIT policy design includes a number of implementation options that deserve specific treatment and that are separate from setting the FIT payment level (see Section 4). This section considered a number of these implementation options, including eligibility criteria, purchase obligations, contractual issues, program revisions, caps, forecast obligations, and transmission and interconnection issues. Each of these design options can help policymakers target a wide variety of goals, while increasing the chances that policy outcomes will match expectations.

## 6.0 Controlling the Costs of FIT Policies

Because FITs can provide such a strong incentive for RE producers and manufacturers, policymakers need to ensure that their policy includes a means to control the overall costs at the outset. The recent experience of Spain's solar PV market in 2008 is a primary example. Generous tariffs, combined with a high-quality solar resource and insufficient oversight, led to a rush of development that overwhelmed regulators, which prompted a drastic policy change (see RD 1578/2008, Deutsche Bank 2009). Higher-than-expected levels of solar deployment<sup>70</sup> were also recently seen in Germany and the Czech Republic (EPIA 2010).

Cost control is a particularly important consideration for FIT policies that include solar PV. Because PV tends to be higher cost than other technologies, targeting it can lead to greater upward pressure on consumer electricity costs. In addition, both solar PV manufacturing and deployment can be quickly scaled so that they can react more quickly to generous incentives – particularly aggressive payment levels that will be in place for a year or more. For programs that do not have some form of cost control, the total cost could be much greater than anticipated.

Together, these experiences have led to a greater focus on mechanisms to control policy costs (see Section 5).

First, policymakers can introduce direct caps on the total program size, which limits the total number of megawatts that can be installed by a certain date. Second, tighter caps can be imposed on individual project size, which reduces the risks of a larger-than-expected volume response in a short period of time.<sup>71</sup> These two approaches have been adopted by Spain in its 2008 amendments to its solar PV policy<sup>72</sup> (Spain 2008, see also Section 5.5.1.1).

In a third approach, caps can be imposed on the actual expenditures authorized under the policy. This can be done either by imposing a maximum percentage on the total allowable rate increase, or by stipulating a dollar amount for total policy expenditures, after which FIT payments will end.

A fourth approach to control policy costs is to shape the *composition* of RE deployment by imposing tighter caps on costlier technologies. This can allow a greater portion of overall RE development to be comprised of lower-cost technologies. However, it should be noted that this approach is unlikely to provide a firm cap on costs.

Cost control can also be approached in ways other than caps. For example, a complementary means of controlling market growth is to introduce more frequent adjustments to the FIT

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<sup>70</sup> Note that this pattern of FIT policies “over-performing” and triggering greater deployment than intended, also occurred in the mid-1980s under California’s implementation of PURPA (Hirsh 1999).

<sup>71</sup> It is not clear whether this option can be effective on its own, because it could lead to a large number of projects just under the size threshold. This could have the unintended consequence of *increasing* overall policy costs due to the loss of economies of scale. For these reasons, a project size cap alone may not be an adequate tool to control costs.

<sup>72</sup> In fact, during the Spanish solar boom in 2008, certain industry organizations in Spain began arguing in *favor* of caps on market growth, in a bid to salvage some degree of continuity in the marketplace and avoid more drastic measures.

payment levels. For example, payment adjustments could be based either on the amount of capacity deployed (e.g., the California Solar Initiative – see Section 4.2.2), or by revisiting the payment levels more often than once a year (e.g., Spain – see Section 5.5.1.1). Either approach could help prevent a situation in which tariffs are out of synch with market realities, and payments awarded are too high compared to the actual cost of the technology. The promise of higher returns is likely to attract a greater number of investors to the market, compounding the problem of over-deployment with that of over-payment.

Naturally, keeping tariff levels in line with market realities can be challenging due to rapid changes to commodity input costs (e.g., steel costs for wind power, or silicon for certain PV technologies) and to constant interplay of supply and demand. Such factors can either squeeze margins, which slows deployment; or boost them, which leads to a rush of development.

To address this issue, certain jurisdictions are experimenting with auction-based mechanisms to determine FIT payment levels. For example, Spain has introduced a quarterly auction for specific blocks of solar PV capacity in response to its 2008 boom (Spain 2008, see Section 5.5.1.1). Auction-based mechanisms are being used in China and in certain provinces of India, as well as in Oregon<sup>73</sup> (Han et al. 2009, Kann et al. 2010, Oregon 2010). They have also been considered in a few U.S. states, such as California and Vermont (Grace et al. 2008a, Vermont 2009).

Measures to control policy costs are critical not only to protecting ratepayers, but also to fostering stability for investors and manufacturers. Sudden, reactive changes to the policy framework generate significant uncertainty among market participants, and can have negative impacts on investment and on the RE sector more broadly. This is particularly true for domestic manufacturing and related activities, which are typically characterized by lower capital mobility than downstream activities such as project development.

Taken together, these considerations underscore the importance of designing the policy with the issue of cost control in mind. This can help avoid booms and bust cycles of development, as well as the capital flight that can result from sudden or reactive policy changes.

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<sup>73</sup> Ultimately, Vermont did not move forward with an auction-based mechanism. Oregon has recently opted to implement an auction-based bidding process for its “volumetric incentive rate” pilot program for solar PV projects between 100-500 kW (Oregon 2010). While this policy is not identified as a FIT, it shares certain features with FIT policies and represents an example of auction-based price discovery.

## 7.0 Funding the FIT Policy

A FIT policy takes money to operate successfully – both in terms of policy administration, as well as paying for the FIT payments to eligible projects. The way these funds are gathered will significantly depend on how the FIT legislation is proposed, as well as on the long-term vision of the policy. The type of funding used for the renewable energy law can greatly impact investor security, and have significant impacts (positive or negative) on market growth. If the policy is perceived to be vulnerable – or its budget allocation underfunded – growth in renewable energy markets could be compromised because investors factor in the added regulatory risks. The perceived stability and longevity of the policy are crucial to its success, particularly in rapidly changing economic circumstances.

There are several ways to fund a feed-in tariff policy: by the ratepayer; by the taxpayer; and/or by supplementary means, such as the auction of carbon allowances. This section briefly examines these types of funding and provides an evaluation of each. It also explores the issue of inter-utility cost sharing.

### 7.1 Ratepayer Funding

Most jurisdictions that have implemented FITs have integrated any added costs directly into the rate base, and share them among all electricity customers and classes (Klein 2008). This removes the risk that the funding could be removed or re-appropriated for other budgetary needs, while spreading the cost burden to society at large.

Whichever option the jurisdiction uses to pass on the costs to ratepayers, it is important that it includes provisions to ensure that any cost *savings* that occur from RE deployment are also passed on. This could become particularly important if the costs of conventional generation increase significantly above the marginal costs of RE supply, which has occurred for cost-competitive RE technologies in Spain (de Miera et al. 2008), Denmark (Munksgaard and Morthorst 2008), and Germany (Sensfuss et al. 2008). These cost savings could accrue due either to high fossil fuel prices, the merit order effect (see Sensfuss et al. 2008), a maturation of existing RE technologies, or innovations in RE technology that bring costs below the marginal costs of conventional supply.

There are several ways to approach ratepayer funding: (1) they can be distributed evenly across each individual customer class, (2) shared differentially depending on the customer class, or (3) funded by means of a specific system benefits charge (SBC) added to electricity customers' bills.

#### 7.1.1 Equivalent Distribution

Under an equivalent distribution approach, any supplementary costs are added incrementally as a percentage on each customer's monthly bill or simply integrated into the average electricity price and distributed accordingly. This approach includes provisions to distribute the policy costs evenly across different customer classes (residential, commercial, or industrial), and oversight ensures that these costs are passed on fairly.

## **Evaluation of Equivalent Distribution**

One of the advantages of this approach is that everyone who benefits from renewable electricity shares in financing it, which avoids the problem of free-ridership. One of the disadvantages is that it fails to account for the different impact that even a slight rise in electricity prices can have on certain customers at both ends of the spectrum: low income families and the electricity-intensive components of the industrial and manufacturing sectors.

### **7.1.2 Customer Differentiation**

Certain jurisdictions include limits on the total rate impact for certain sectors of the economy, which effectively shelters them from some/all of the electricity rate increases that result from a FIT policy. In most cases, customer differentiation shelters energy-intensive industries from these rate increases. These customers are of particular concern to policymakers because they would experience a greater relative burden on their budget as a direct result of increases in electricity rates. Some jurisdictions, such as Spain, are already adopting such exemptions for low income residents (Spain 2009).

To shelter certain customers from these impacts, some jurisdictions opt to distribute the added marginal costs differently, particularly to minimize rate increases on key sectors of the economy (Klein 2008). Electricity consumers can be distinguished in many different ways, based on:

- the class and type of their electricity tariff (e.g., commercial rate “X-1”),
- a specific designation for the customer (e.g., “low income”),
- the voltage level at which a customer is connected, or
- a customer’s total annual electricity consumption (measured as a proportion of total electricity costs to overall expenses, revenue, or in relation to the firm’s gross value).

## **Evaluation of Customer Differentiation**

Based on this approach, a jurisdiction can ensure that the competitiveness of a given sector is not unduly affected by the introduction of a FIT policy. This effectively diminishes the proportional impact on particular sectors, which mitigates some/all of the impacts on their competitiveness vis-à-vis similar industries in other countries or jurisdictions (Klein 2008). Similarly, this approach can address social equity and cross subsidization issues for low income ratepayers. Low income ratepayers are less likely to participate in FIT programs because (1) less of the population owns homes or property on which projects can be developed and (2) they do not have the income or credit rating to cover the up-front capital costs. The issue of social equity arises because many who pay higher rates as a result of a FIT may not be able to participate in the policy. For some of the same reasons, policymakers are also concerned with cross-subsidization between rate classes, particularly when the cost of a technology is higher than “least-cost” (e.g., PV).

However, this can be considered preferential treatment and could be controversial if certain sectors are shielded entirely.

### **7.1.3. System Benefit Charge Fund**

A third means of funding a FIT is to add a system benefit charge (SBC)<sup>74</sup> on customer rates, and use the revenues generated to finance the FIT policy. A SBC is typically paid on a cents/kWh

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<sup>74</sup> Also called a public benefit fund.

basis; and, therefore, the more a customer uses, the greater their burden. It can be structured in a number of ways: 1) a percentage adder, b) a fixed adder on top of the electricity price, c) differentiated by customer class.

Switzerland funds its FIT law via a nationwide SBC of SFr \$0.006/kWh (SFOE 2008; Geissmann 2009). The charge is levied on all electricity customers, with special exemptions for electricity intensive industries.

In another example, the City of Boulder, Colorado, differentiates its SBC according to the three major classes of electricity users: residential, commercial, and industrial (DSIRE 2009c). Boulder outlines maximum per-kWh rate increases for each customer class: residential customers have to pay a maximum added fee of \$0.0049/kWh, commercial customers pay \$0.0009/kWh, and industrial customers pay up to \$0.0003/kWh on every kilowatt-hour consumed.

### **Evaluation of a System Benefit Charge**

SBC funds are a transparent way to raise funds for RE deployment from electricity customers, and they have been used for several years to promote energy efficiency and renewable energy initiatives, among others. In addition, they can also be differentiated by customer class, which increases their adaptability to different jurisdictions. It also means that the same advantages with customer differentiation apply here – it might be desirable to exclude specific types of customers, such as low income or energy-intensive industry, to minimize the impact of the FIT program on their rates. Finally, they generate a reasonably predictable<sup>75</sup> sum of money that can be invested toward RE deployment.

On the other hand, due to the limited nature of an SBC, it is difficult to fund the kind of broad-based RE deployment seen in countries similar to Germany, where added marginal costs are not capped by the size of a fund. Thus, an SBC inherently limits the available pool of funds, which can constrain project development. Because an SBC sets an upper limit on the total capital available to finance the FIT, it is likely to create issues surrounding queuing, which risks increasing administrative costs (Geissmann 2009). Moreover, due to the uncertainty over long-run electricity demand, a limited SBC does not provide a reliable, long-term pool of dollars to fund RE deployment. A downturn in the economy, for instance, can lead to a significant drop in electricity demand, which then significantly reduces the funds available to finance projects under the FIT.

## **7.2 Taxpayer Funding**

Instead of integrating any added costs into the rate base, some jurisdictions have imposed an additional tax, or financed a feed-in tariff directly out of existing government revenues. An example of this in Europe is the Netherlands (see Section 4.3.2.3).

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<sup>75</sup> Predictable, to the extent that historical data on average electricity sales provides an indication of future expected budget. These average sales numbers can provide a useful approximation of the size of the pool of money that will be generated annually as a result of the SBC.

While it is widely believed that Spain finances its FIT partly out of general tax revenues, this is inaccurate.<sup>76</sup>

In the taxpayer-funded approach, funds can be allocated to a new budget category. Unless new revenue streams are generated, this requires a reallocation of existing funds, which can increase the political sensitivity of the policy. In its 2008 amendments to its renewable energy policy, the Netherlands introduced a FIT policy that is funded directly out of the government budget (van Erck 2008). Different renewable energy technologies are given a specific budgetary allocation, pegged to an expected amount of installed capacity per technology type; and the difference between the retail price and the required FIT payment price is financed by the annual allocation (van Erck 2008). For instance, if retail prices are 6 cents/kWh, and the required FIT payment is 8 cents/kWh, the difference of 2 cents/kWh is funded out of the state budget until the budget for that technology type is exhausted. However, because the electricity market price varies, the required subsidy amount varies as well.

An alternative approach is to impose a specific tax – either a carbon tax, an energy tax, or some other value-added tax (VAT) that can then help finance the renewable energy policy. This provides one way of distributing the cost of renewable energy development across all members of society. According to this principle, those who pay the least taxes would bear a smaller portion of the burden, while those who pay the most would bear a larger portion.

### **Evaluation of Taxpayer Funding**

Using taxpayer funds for RE development is one way of funding the added costs of RE deployment. It provides a transparent way of monitoring policy costs and allows the amount to be increased over time to encourage expanded RE deployment. A further advantage of the taxpayer-funded approach is that it does not lead to an increase in electricity prices, one of the grounds on which FIT policies are sometimes criticized. By fulfilling the renewable energy payment through the taxpayer, the ratepayer is protected from electricity rate impacts.

However, taxpayer funding can be considered controversial (see Fell 2009). The taxpayer-funded model is arguably much riskier from an investor's perspective, because the stability of the policy environment can change with political and budgetary priorities. Taxes are also unlikely to be popular, which further increases the risks of this funding approach. There is also the problem of uncertainty over the duration of the budget allocation – if renewable energy development begins to happen very quickly, the budget will be more quickly exhausted, dampening investment appetite as renewable energy development picks up. Also, if no new government revenues are generated to help finance the renewable energy policy, funding can put further strain on the state budget and make it more vulnerable to cuts during difficult economic times.

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<sup>76</sup> Because electricity rates for certain customer classes in Spain remain regulated, electricity prices can only increase a certain amount each year. This inadvertently generates a shortfall, or a “deficit,” in the electricity system resulting from the increased costs of RE supply on the grid. The previous approach of financing this deficit through the capital markets ran into difficulties in 2008/09, due partly to the financial crisis. In 2009, a special securitization fund was created to issue government-backed bonds to finance the outstanding deficit, which currently is at more than €10 billion. Beginning in 2013, the remaining deficit will be paid by a combination of increases on electricity rates, and by increases to grid interconnection charges, which effectively passes on the deferred costs to ratepayers. Special provisions are planned to help low income ratepayers with the added incremental costs (see Spain 2009).

This dependence on tax revenues is also likely to make it difficult for the policy to become part of a long-term framework for renewable energy development, which reduces the chances of sustained, long-term growth in the RE sector (Fell 2009). The way in which the policy is funded will depend to a significant extent on policy objectives, and on a host of other jurisdiction-specific factors.

### **7.3 Supplementary Funding Possibilities**

In addition to ratepayer and taxpayer funding approaches, there are alternative possibilities for funding a feed-in tariff policy. These approaches fund the FIT through supplementary means, which could include revenues generated from the auction of emissions permits under a greenhouse gas (GHG) cap-and-trade system, or from utility tax credits.

#### **7.3.1 Greenhouse Gas Auction Revenue**

In this approach, the proceeds of a carbon auction could be put into a state fund and distributed to utilities to fund renewable development; or it could be administered at the federal level and distributed to the states. In the federal approach, a portion of the auction revenues could then be reallocated to fund the added near-term cost of implementing a FIT policy. As a consequence of using auction revenues, the areas of the country that are most GHG-intensive (i.e., that are paying the largest proportional amount to the GHG revenue fund) could reduce their exposure by investing in RE technologies and be eligible to receive a compensatory allocation through the GHG auction revenues.

#### **Evaluation of Funding via GHG Auction Revenues**

Some jurisdictions may prefer funding the FIT using a supplementary mechanism such as carbon auction revenues instead of integrating the cost of a FIT into the rate base. This is partly because it's logical to use GHG price allocations for clean energy development and partly because it is a discrete fund that neither impacts ratepayers nor taxpayers directly.

However, it should be noted that using revenues from a GHG auction could cap the quantity of RE development that can occur, which potentially limits the impact of the FIT policy as well as the pace and scale of RE deployment. There would also be considerable uncertainty concerning the amount of funding available, which would likely have a negative impact on investor security because carbon prices fluctuate. While an expansion of the revenues from GHG auctions is likely as the emissions reduction requirements get more stringent, it is challenging to estimate how much money will be available in the medium to long term. Another possible objection to this approach is that the cost burden is not equally shared as it is with a ratepayer-funded policy. Only parties that must achieve compliance are taxed with the cost of renewable energy development, which is likely to generate considerable opposition from both utilities and other GHG-intensive sectors of the economy (although this could address social equity and cross-subsidization concerns for low income individuals). Finally, the challenge of equitably allocating the funds to utilities, not to mention to individual states, should not be underestimated.



### **7.3.2 Utility Tax Credit**

Another approach to financing a FIT is to allow utilities to offset their tax liabilities so that they can purchase renewable electricity. Implementing a tax credit targeted at utilities is one way to do this.

The state of Washington allows utilities to offset \$5,000 of tax liability per renewable energy project connected to their system (DSIRE 2009d). This means they can pay the owner of an RE system up to that amount per year for the renewable electricity they produce, making the tax credit suitable for small systems like PV.

### **Evaluation of Utility Tax Credits**

One advantage of using utility tax credits to fund a FIT policy is that the added costs are not passed on to electricity ratepayers. This prevents any effects from electricity price impacts.

The disadvantage of this approach is that it imposes an implicit cap on program size based on the size of utilities' tax liability within that state. This could make it difficult to fund large and sustained amounts of RE deployment, except in the case of the largest utilities. This approach can also erode state tax revenues, particularly if large amounts of RE are developed.

### **7.4 Inter-utility Cost Sharing**

In response to aggressive development in certain regions with excellent renewable resources such as wind power, certain jurisdictions have introduced ways to distribute the extra costs of that development over a wider area. In this approach, utilities or load-serving entities operating in high-wind districts do not shoulder the full burden of any supplementary costs.

For instance, in its RES Act of 2000, Germany included a mechanism by which costs could be shared among all German ratepayers (whether located near RE development or not), thereby equalizing the investment costs across the country (Germany RES Act 2000). This was called the "National Equalization Scheme" (Jacobsson and Lauber 2006). This scheme offers detailed provisions for cost sharing among all major independent system operators (ISOs), as well as utility companies. Under this arrangement, each entity must disclose how much electricity they bought from RE generators in the previous calendar year. This amount is then compared to a national average and equalized accordingly; the costs are distributed across all German ratepayers according to a pre-established formula. Because Germany has a large and economically significant industrial base, it also differentiates the cost burden to minimize the impact on certain key sectors of the economy. The same can be done for low income residential customers (see Section 7.1.2). Spain and Slovenia have both opted to share a portion of the incremental costs of RE development equally across all electricity ratepayers and rate classes (Held et al. 2007), although Spain does include provisions to help low income ratepayers with the added incremental costs (Spain 2009).

In a deregulated or restructured electricity marketplace – where retail customers can freely choose their supplier – this consideration becomes particularly important. Utilities that accept a larger number of feed-in tariff producers could have a competitive disadvantage that could result in customers taking their business to other suppliers and stranding the cost increases with a

shrinking group of customers. This would be a disincentive for utilities to encourage renewable energy development.

### **Evaluation of Inter-Utility Cost Sharing**

Inter-utility cost sharing allows the contribution to renewable energy deployment to be shared among the ratepayers of a jurisdiction, which avoids the problem of free-ridership. It also reduces the cost burden on any one load-serving entity (LSE). In competitive electricity markets, this approach could help avoid the problem of stranded costs with a shrinking subset of ratepayers. Cost sharing can also help a jurisdiction attain higher levels of RE penetration because the costs are distributed to a wider customer base and over a larger geographic area – this means that a jurisdiction’s renewable energy potential can be more widely harnessed.

Cost-sharing provisions could be controversial and create an impediment if there is disagreement among LSEs or different constituencies in a given jurisdiction regarding the importance of new RE deployment. For example, certain LSEs may want to move more aggressively than others in response to their particular market position, their generation assets, or customer demand. And, unless addressed in the FIT policy design, there could be a disproportionate burden on low income ratepayers (see section 7.1.2.).

## **8.0 Best Practices for FIT Policy Design and Implementation**

With more than three decades of experience with feed-in tariffs worldwide, there is a growing body of evidence and case studies that identify best practices in FIT policy design. The following best practices have been drawn from a series of analyses on FIT policies, including COM 2008, de Jager and Rathmann 2008, Dinica 2006, Fell 2009, Held et al. 2007, IEA 2008, Klein et al. 2008, Langniss et al. 2009, Lipp 2007, Menanteau et al. 2003, Mendonça 2007, Mendonça et al. 2009a, Ragwitz et al. 2007, and Sawin 2004.

The best practices presented here represent a synthesis of this body of research. Naturally, some design choices such as differentiation by technology type are more fundamental than others, and it must be emphasized that a feed-in tariff requires the convergence of a number of different design elements in an integrated policy package to be highly successful (Mendonça et al. 2009a). In addition, best practices have to be weighed in a jurisdiction-specific manner, and will depend on political priorities and specific policy objectives (see Section 1.1).

### **8.1 Analysis of Best Practices in FIT Payment Structure**

This section provides an overview of best practices in FIT policy design that relate to FIT payment structure, according to leading European policy analysts.

#### **8.1.1 Ensure Policy Stability**

One of the most important elements of FIT policy success is the long-term stability of the policy (Klein et al. 2008, Dinica 2006, Diekmann 2008, Fouquet and Johansson 2008, Ragwitz et al. 2007, COM 2008, Deutsche Bank 2009). Rapid or unexpected changes in payment levels or policy structure can damage investor confidence and significantly impede the pace of renewable energy growth (Lüthi 2010, Dinica 2006). Both price certainty and policy certainty are, therefore, important. Without this stability, investors will be more reluctant to participate, both on the upstream and downstream sides of renewable energy supply chains, which can hinder a jurisdiction's ability to meet RE targets (Deutsche Bank 2009, Lüthi 2010, Dinica 2006).

#### **8.1.2 Differentiate FIT Payments According to RE Generation Costs**

Differentiating the tariff levels according to RE generation costs encourages RE deployment in a variety of technology types (Mendonça 2007, Klein et al. 2008, Diekmann 2008, Ragwitz et al. 2007; see Section 4.2.1). This is the principle of “cost-covering compensation,” which has become a defining feature of successful FIT policies and has helped countries such as Germany move to the forefront of the global RE industry (Fell 2009).

By introducing a high degree of demarcation in setting payment levels (e.g., by technology, by project size, by location – like onshore or offshore wind – and by resource quality), a jurisdiction can ensure that diverse RE investments are fostered. This high level of differentiation also ensures that jobs, manufacturing opportunities, and associated economic activities are created in several renewable energy technology sectors (Diekmann 2008, Ragwitz et al. 2007, COM 2008, Germany BMU 2009 and 2007). However, failure to set payment levels based on leveled RE generation costs is likely to result either in minimal RE development (if the payments are set too low), or in costlier RE development (if they are set too high).

### **8.1.3 Encourage Innovation and Technological Change**

Because of the cost reductions that occur through economies of scale, technological learning, and technological change, policy analysts generally agree that introducing tariff degression in the payment levels is advisable (Mendonça 2007, Klein et al. 2008, Ragwitz et al. 2007, Diekmann 2008, Held et al. 2007, Lesser and Su 2008; see Section 4.2.2.1). Tariff degression helps anticipate cost reductions in the future, while reducing the risk of overcompensation in the long term. It creates a clear incentive to further reduce costs and improve efficiencies, while encouraging manufacturers to further invest in R&D and stimulate further cost reductions through improved operational efficiencies and technological innovation (Diekmann 2008). Degression rates may also be differentiated to reflect the relative maturity of technology types, with higher levels of degression assigned to less mature technologies because greater cost reductions are expected. It is possible to adjust FIT payment levels by scale of deployment (i.e., as a jurisdiction reaches capacity targets), or by elapsed time (e.g., annually or biennially). Both can be geared to ensure that FIT payment levels continue to track actual technology costs.

### **8.1.4 Differentiate FIT Prices by Time of Delivery (for Dispatchable RE Resources)**

It is possible to offer slightly higher payment levels for electricity that is produced when demand is highest (Klein et al. 2008, Mendonça et al. 2009a; see Section 4.2.2.5). Differentiating payments according to the time of delivery can create an incentive to match generation more closely to demand (Langniss et al. 2009). This can be implemented either by the time of day or the season where important seasonal differences exist (Klein et al. 2008, Held et al. 2007). It can also help create a more efficient electricity system, while providing a means to encourage peak shaving – this can create a number of benefits for electricity customers, grid operators, and society (Langniss et al. 2009). Note that incentives to encourage coincidence with demand generally only apply to resources that can modulate their supply, such as biomass, biogas, and certain types of hydropower projects.

### **8.1.5 Target Certain Policy Objectives via Bonus Payments**

As feed-in tariffs have become more refined, policy designers are offering a number of bonus payments to encourage certain kinds of choices or behaviors from RE project developers (Klein et al. 2008, Mendonça et al. 2009a; see Section 4.2.3). Bonus payments can target certain policy objectives by encouraging, among other things, the use of innovative technologies, or the use of combined heat and power (CHP) on biomass and biogas systems (Klein et al. 2008). These bonus payments can encourage technological improvement and the development of a more efficient electricity supply infrastructure. They can also target particular initiatives such as repowering for old wind and hydropower sites, which helps RE developers replace older installations with newer, larger, and more efficient technologies (Mendonça 2007). Bonus payments can be useful in achieving a variety of policy goals, but they should be selected carefully to ensure that the benefits outweigh the costs.

### **8.1.6 If Using a Premium-Price FIT Policy, Offer a Sliding Premium**

To keep premium-price FIT policies closely aligned with RE generation costs, certain jurisdictions are introducing sliding premiums policy designs (Held et al. 2007, van Erck 2008; see Section 4.3.2).

These sliding premium options offer more investment security than a constant premium price design and reduce the chances of both over- and under-compensation (Mendonça et al. 2009a).

They also represent a more market-oriented FIT design, primarily because the RE electricity is sold directly on the spot market, rather than through fixed-price purchase agreements (Langniss et al. 2009, Ragwitz et al. 2007, Klein et al. 2008). This “market integration” may become important as the share of RE electricity grows in the overall electricity supply mix (Langniss et al. 2009).

## **8.2. Analysis of Best Practices in FIT Implementation**

In addition to best practices for setting FIT payment levels, European Union countries have the most experience and, thus, the most examples of best practices in *FIT policy implementation*. This section provides an overview of these implementation options based on a series of analyses on FIT policies.

### **8.2.1 Guarantee Grid Access**

The European Union requires that every European country offer guaranteed, nondiscriminatory access to the grid for all renewable energy producers (COM 2001, 2009). This includes residential, commercial, and industrial customers; federal, state, and local government agencies; nonprofits; and utilities (Mendonça et al. 2009a, Fell 2009). This grid access guarantee is important for both small-scale and larger industrial developments at both transmission and distribution levels. The 2001 Directive played a significant role in increasing investor confidence in the market and helped reduce the administrative barriers to renewable energy development, notably over grid access (COM 2001, Diekmann 2008).

Additionally, according to these EU Directives (2001/77/EC; 2009/28/EC), renewable energy sources must be granted *priority* access to the grid throughout the European Union wherever possible (COM 2001, 2009). This ensures that when competing projects are vying for access to grid capacity, the electricity from RE generators will be granted priority. This practice can help accelerate renewable energy development (Mendonça et al. 2009a, Fell 2009).

### **8.2.2 Require Utility Purchase Obligation**

A number of jurisdictions include a utility purchase obligation for electricity from renewable energy sources in their FIT policy, which provides a higher degree of certainty for RE developers (Klein et al. 2008, Mendonça et al. 2009a). Without a purchase obligation, investor confidence decreases; and the perceived risk of the policy to banks and other financiers increases. A purchase obligation guarantees that renewable electricity will be purchased wherever and whenever it is produced, which creates a market conducive to RE development (Mendonça et al. 2009a).

### **8.2.3 Clarify Transmission and Interconnection Rules**

Experience throughout EU countries suggests that transparency and uniformity in interconnection rules is a crucial factor for renewable energy developers considering FIT policies (Ragwitz et al. 2007, Fell 2009; see Section 5.8). To ensure streamlined procedures, grid operators are generally required to publish uniform and nondiscriminatory standards for grid interconnection, which solidifies any rules surrounding both distribution and transmission protocols (Klein et al. 2008). The greater the clarity at the outset, the lower the administrative costs will be to obtain information and execute rules for individual project applications. It is also important that interconnection standards be as uniform as possible to foster higher efficiencies and minimize duplication. For grid upgrades, it is also possible to reduce both costs and delays

by allowing independent companies to build grid extensions and/or improvements (Lauber 2009).

The application process is more efficient if it is different for large, utility-scale projects that require grid impact studies and environmental impact statements than for smaller systems. To reflect these differences, policy designers could add a streamlined interconnection procedure for smaller systems, which could prevent unnecessary bottlenecks and administrative complexity (Mendonça et al. 2009a). The more streamlined the procedures for project approvals, the more efficient the policy framework – this reduces wait times and delays, while reducing overall administrative costs (Mendonça et al. 2009a). An example of this is the OPA’s recent FIT program for Ontario, which includes a set of rules specifically for small, “micro FIT” projects (OPA 2009a).

#### **8.2.4 Share Costs Across All Electricity Customer Classes**

European experience identifies a fourth best practice: the implementation of a transparent mechanism for cost-sharing (particularly for transmission and its related costs) across jurisdictions (Klein et al. 2008, Fell 2009, Diekmann 2008, Jacobsson and Lauber 2006). A fair and transparent distribution of the incremental costs of new renewable energy capacity (including grid integration and balancing costs) can ensure the success of the policy because it mitigates the problem of free-ridership (Menanteau et al. 2003). This approach can establish clear protocols on cost sharing for any and all transmission and distribution upgrades required in the grid infrastructure (Germany 2007). This reduces the uncertainty for investors, can help address bottlenecks in the transmission infrastructure, and can prevent stagnation in the project development pipeline. In Germany, utilities share costs evenly, so that areas with excellent RE resources do not bear a disproportionate share of the costs (Germany 2007, Mendonça 2007).

The most common practice for cost sharing is to integrate any added costs directly into the rate base for all electricity consumers. This approach provides an equitable strategy for accounting for the benefits of renewable energy, while providing an intrinsic and uniform incentive for energy efficiency and conservation. Alternatively, some jurisdictions include provisions that limit the rate impact on certain electricity-intensive industries such as steel smelting and electric public transport (Klein 2008, Mendonça et al. 2009a). This type of exclusion could also be considered for low income residential customers, who would feel the rate impact more acutely than other ratepayers (Spain 2009).

#### **8.2.5 Require Generation Forecasts**

Some jurisdictions impose a generation forecast obligation on renewable energy projects with variable output, such as those using wind power (Spain 2007, Mendonça et al. 2009a, Klein et al. 2008). A forecast obligation, as a best practice, can help integrate renewable electricity, improve grid management, and achieve more aggressive renewable energy targets. Forecast obligations are generally imposed on the larger, more variable resources, although they can be extended to all generators based on a minimum size limit. By encouraging wind developers to forecast their anticipated supply on the basis of regional meteorological data, policy designers can help integrate larger amounts of variable renewable energy resources on the grid (Mendonça et al. 2009a).

Some jurisdictions include a penalty for deviations beyond a certain level (Klein et al. 2008, Held et al. 2007, Spain 2007). When a penalty is introduced, project developers have an incentive to make accurate predictions, which can help grid operators better manage the variable output of renewable resources.

### **8.2.6 Require Progress Reports**

As part of tracking overall FIT policy effectiveness, jurisdictions generally require that either utilities or authorities responsible for overseeing energy issues produce progress reports outlining milestones, anticipated revisions, any difficulties and unresolved issues, and any recommendations going forward. This requirement can also provide an opportunity for adjustments and self-corrections to be made as lessons from FIT policy implementation emerge (Mendonça et al. 2009a, see also Germany 2007).

Progress reports can be issued as often as is considered necessary to monitor program success. These reports provide a tool that can help residents and politicians better understand the development of renewable energy in their jurisdiction. Progress reports can also include information on GHG reduction impacts, as well as any new jobs and manufacturing impacts that have resulted from the policy (Germany 2007).

## 9.0 Conclusions and Future Directions

As this report has shown, feed-in tariff (FIT) policies demonstrate a variety of policy design options, which enable them to help achieve a wide range of policy goals. Due to the success of FIT policies, jurisdictions from countries as diverse as Australia, Brazil, China, Turkey, India, and South Africa have recently implemented policies, and their implementation continues to spread in both developed and emerging countries (REN21 2009). In addition, a number of states and municipalities in the United States are experimenting with FIT policies, as they begin to implement them in various forms. States are using FITs to meet their RPS targets, as well as advance their economic, environmental, and job creation objectives (Rickerson et al. 2007 and 2008, Couture and Cory 2009).

With their increasing worldwide adoption, feed-in tariffs are poised to play an important role in advancing the deployment of renewable energy technologies. Many early adopters of FIT policies have had success propelling their renewable energy (RE) sectors (measured in manufacturing capacity, job creation, etc.) and in rapidly expanding the share of RE in their overall electricity mix. In particular, the policy framework created by FIT policies has enabled certain countries such as Germany and Denmark to become incubators of RE technology and innovation, and create export opportunities in RE markets around the world. Combined with a long-term commitment to a renewable energy future, these countries have begun to lock in their strategic position in the energy economy of the 21<sup>st</sup> century. New sectors and technologies are beginning to emerge, which provides other jurisdictions with the opportunity to develop similar competitive advantages as the global marketplace for renewable energy technologies expands and evolves.

Through an overview of different policy practices found around the world, this report provides a comprehensive overview of FIT policy options, while highlighting a few key elements of policy success. These include:

- long-term policy stability;
- payments based on the costs of RE generation;
- differentiating the tariff prices to account for different technologies, project sizes, locations, and resource intensities;
- guaranteed grid access;
- eligibility for all end-users and RE project developers (and sometimes utilities); and
- a reliable must-take provision for the electricity generated.

These elements provide the policy design framework for effective FIT policy implementation. In addition to these broader design elements, policy designers can include a number of other policy nuances that tailor the policy to local goals, resource availability, and particular policy objectives.

The success of FIT policies has been attributed to the stability and certainty they offer for renewable energy investment (IEA 2008, Deutsche Bank 2009). These policies create an environment that is conducive to leveraging capital toward RE deployment, which provides an effective framework for the wider adoption of RE technologies. This translates into direct



benefits for both RE project developers and manufacturers, as well as for society at-large through increased RE deployment, fewer environmental impacts, and increased job creation.

The benefits for project financing and RE investment are particularly worth noting: First, RE developers benefit from the long-term stability of the revenue streams generated from electricity sales, which helps foster a high level of investment security. Well-designed feed-in tariffs can help reduce risk, which can also help reduce the overall costs of RE development for society. The stability of the framework makes it more likely for traditionally risk-averse investors to provide debt financing for RE projects, which can further improve the availability of capital.

Second, the transparent policy structure also creates an open and straightforward framework that residents, businesses and investors can understand. This helps both local project developers as well as investors from around the world evaluate the posted FIT prices when making their investment decisions.

Third, FITs allow efficiently operated projects to earn a reliable rate of return on renewable energy investments, which makes it possible for entrepreneurs, investors, and homeowners to invest in RE projects. This has proved to be a powerful way of unleashing capital toward deployment of renewable energy, and has enabled jurisdictions to harness a greater share of their domestically available RE potential.

In addition to the financing benefits, manufacturers can also benefit in other ways from the framework created by FITs. The long-term stability of well-designed FIT policies helps manufacturers develop longer planning horizons, which can be a significant factor in determining both the location and the quantity of new RE manufacturing (Diekman 2008). European Union (EU) experience suggests that the stability and longevity of the policy framework is essential to drawing large numbers of product manufacturers to an area. This has been a problem in the United States, because of the intermittence of the federal tax credits, which has been cited as a key barrier to the sustainable growth of the U.S. wind industry, in particular (Wiser et al. 2007, Kahn 1996, IEA 2008, Mendonça et al. 2009b). Another benefit is the direct competition for market share that is occurring under FIT policies in countries such as Germany, France, and Spain. This can drive greater private R&D investment, while helping spur further innovation and technological cost reduction (Diekman 2008, Hvelplund 2005).

And, finally, FIT policies can help reduce both economic and noneconomic barriers to renewable energy development. Overcoming these barriers allows RE deployment to occur more rapidly and cost-effectively (IEA 2008, Mendonça 2007, de Jager and Rathmann 2008, Ragwitz et al. 2007).

However, as with any energy policy, the benefits must be weighed against the challenges and costs. First, FIT policies can be complex and require significant analysis and consideration to develop a policy structure well-suited to meet the stated policy goals. Without careful consideration, it is possible to design an ineffective policy framework that fails to deliver on its objectives.

Second, FIT policies require short-term payment level adjustments as well as long-term program design evaluations to best incorporate technology advancements, changing market conditions, and other relevant factors. This requires vigilance on the part of policymakers, and a willingness to revise the policy as market conditions change.

Third, policy designers need to ensure that changes to the policy framework over time remain gradual and predictable, rather than abrupt and reactive. For example, Spain's solar PV market in 2008 saw unprecedented growth, partly due to aggressive FIT payments and also due to the rush to install projects before policy revisions occurred a year later (in September 2008). This led to approximately 2,600 MW of new solar PV capacity in 2008 and led to a drastic change to the policy framework, which included the imposition of annual caps on the total installed capacity of 500 MW for 2009 and 2010 (Spain 2008). This change has undermined investor and manufacturer confidence (Wang 2009), and increased the risk perception of the Spanish solar market (Deutsche Bank 2009).

One of the lessons of the Spanish experience is that sudden and unpredictable changes due to frequent bureaucratic interventions are likely to undermine investor confidence and lead to a flight of capital – experience suggests that it is better to design FIT policies with a long-term perspective in mind and to ensure that policy adjustments occur incrementally rather than reactively (Deutsche Bank 2009). Additionally, policymakers should give consideration to the scale of deployment desired – the Spanish case demonstrates that aggressive tariffs combined with a good resource and inadequate oversight can create an explosive policy combination. Care should be given to the design of FIT policy caps (or other cost containment mechanisms), particularly for costlier resources. On the positive side, Spain's experience demonstrates that FIT policies can yield significant RE deployment quickly and effectively and can, therefore, be useful to meet aggressive RE targets.

This report does not address a few key questions on FIT policies. First, it does not include a detailed analysis of the market and regulatory context that may influence FIT implementation within the United States. In particular, further analysis is required to examine FIT interactions with other policies (e.g., renewable portfolio standards, federal incentives, rules on net metering and interconnection, and state policies and incentives) and with different business models (e.g., third-party ownership).

Second, this report does not include a study that quantifies key impacts of FIT policies. These impacts range from increased renewable energy capacity and generation; associated economic impacts, including employment and industry growth; climate impacts; and the associated impacts on the electricity grid, especially how they relate to the high-penetration renewable energy scenarios that can result from effective FIT implementation.

Moreover, further research is required to analyze the costs of a comprehensive feed-in tariff policy in the United States and how these added costs would compare to the economic, environmental, and job creation benefits that result. A more detailed analysis of these impacts will help decision makers better understand the advantages and disadvantages of FIT policy implementation, and better evaluate the cost-benefit equation of particular policy designs.

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## Appendix A. Germany's Feed-in Tariff Payment Levels

Germany's FIT <sup>1</sup>								
Technology category		Installed Power (share of capacity)	Period (yrs)	2009 EEG (€ cent/kWh)	Bonuses		Degression	
Solar	Roof-mounted facilities	≤ 30kW	20	39.14			≤ 100kW 2010: 8.0% from 2011: 9.0% ≤ 100kW 2010: from 2011: 9.0% 2010: 10.0% From 2011: 9.0%	
		30 - 100kW	20	37.23				
		> 100kW	20	35.23				
	> 1000kW	20	29.37					
	Freestanding facilities	Irrespective of capacity	20	28.43				
Wind	Offshore	Initial Tariff*	12	13.00	Additional 2.00 € cents/kWh if commissioned by Dec. 31st 2015		Beginning in 2015: 5.0%	
		Final Tariff	8	3.50				
	Onshore	Initial Tariff (first 5 yrs)	5	9.11	Additional 0.50 € cents/kWh if equipped with advanced grid integration tech.		1.0%	
		Final Tariff**	15	4.97				
Geo-thermal		≤ 5MW	20	15.84	≤ 10MW, with heat cogeneration	3.00	1.0%	
		≤ 10MW	20	15.84	≤ 10MW, heat cogeneration with petrothermal technology	4.00		
		≤ 20MW	20	10.39				
		> 20MW	20	10.39				
Hydro	Facilities of up to 5MW - new	≤ 500kW	20	12.67			N/A	
		0.5 - 2MW	20	8.65				
		2 - 5MW	20	7.65				
	Facilities of up to 5MW - modernised / revitalized	≤ 500kW	20	11.67				
		0.5 - 2MW	20	8.65				
		2 - 5MW	20	8.65				
	Renewal of facilities of over 5MW (increments represent the net increase in capacity)	≤ 500kW	15	7.22				
		≤ 10MW	15	6.26				
		≤ 20MW	15	5.74				
		≤ 50MW	15	4.30				
		> 50MW	15	3.47				
Biomass		≤ 150kW	20	11.55	Biomass excluding biogas	6.00	1.0%	
					Biogas	7.00		
					Biogas w/ ≥ 30% manure/slurry	+4.0		
					Biogas w/ plant material mostly from landscape conservation	+2.0		
					Solid biomass	6.00		
		150kW - 500kW	20	9.09	Liquid biomass	0		
					Gas biomass	6.00		
					Biogas	7.00		
					Biogas w/ ≥ 30% manure	+1.0		
					Biogas w/ plant material mostly from landscape conservation	+2.0		
		500kW - 5MW	20	8.17	Solid biomass	4.00		
					Liquid biomass	0		
					Gas biomass	4.00		
					Where wood is burnt	2.50		
					Where wood from coppice and landscape management material is burnt	4.00		
5 - 20MW	20	7.71	≤ 5MW Gas reprocessing: ≤ 350	2.00				
			≤ 5MW Gas reprocessing ≤ 700 Nm <sup>3</sup> /hr	1.00				
			CHP Bonus (≤ 20MW)	3.00				
Landfill gas, sewage gas, and mine gas	Sewage gas	≤ 500kW	20	7.00	≤ 5MW Reprocessing facilities for landfill & sewage gas: ≤ 350 Nm <sup>3</sup> /hr	2.00		
		0.5 - 5MW	20	6.07				
	Landfill gas	≤ 500kW	20	8.87	≤ 5MW Reprocessing facilities for landfill & sewage gas: ≤ 700 Nm <sup>3</sup> /hr	1.00		
		0.5 - 5MW	20	6.07				
	Mine gas	≤ 500kW	20	7.05	≤ 5MW Innovative Plant Technology for sewage, landfill and mine gas	2.00		
		0.5 - 1MW	20	7.05				
		1MW - 5MW	20	5.08				
		> 5MW	20	4.10				

Sources: 2009 EEG Payment Provisions. [http://www.wind-energie.de/fileadmin/dokumente/English/eeg-payment\\_provison\\_2009.pdf](http://www.wind-energie.de/fileadmin/dokumente/English/eeg-payment_provison_2009.pdf)

<sup>1</sup> Note: Includes tariffs as of January 1 2010. Further reductions are expected for solar PV on July 1 2010.

\* The duration the initial tariff is awarded increases as a function of water depth and distance from shore

\*\*Based on output in relation to a hypothetical reference turbine

\*\*\* Nm<sup>3</sup>/hr represents the normal cubic meters throughput of gas per hour at a specified pressure and temperature

## Appendix B. Spain's Feed-in Tariff Payment Levels

				Fixed Price	Market Option		
Technology category		Installed Power	Period (years)	Fixed Tariff (€ Cent/kWh)	Reference premium (€ Cent)	Cap (€ Cent /kWh)	Floor (€ Cent /kWh)
Solar PV*	Ground-mounted Rooftop and BIPV	<10 MW < 2 MW	up to 25	*			
			up to 25	*			
Solar Thermal			1 - 25	26.9375	25.4000	34.3976	25.4038
			> 25	21.5498	20.3200		
Wind	Onshore		1 - 20	7.3228	2.9291	8.4944	7.1275
			> 20	6.1200			
Geothermal and Ocean			1 - 20	6.8900	3.8444		
			> 20	6.5100	3.0600		
Hydro	Small-scale	< 10MW	1 - 25	7.8000	2.5044	8.5200	6.5200
			> 25	7.0200	1.3444		
	Large-scale	10MW - 50MW	1 - 25	$6.60+1.20x(50-P)/40$	2.1044	8.0000	6.1200
			> 25	$5.94+1.08x(50-P)/40$	1.3444		
Biomass	Energy Crops	≤ 2MW	1 - 15	15.8890	11.5294	16.6300	15.4100
			> 15	11.7931	0		
		> 2MW	1 - 15	14.6590	10.0964	15.0900	14.2700
			> 15	12.3470	0		
	Agricultural wastes	≤ 2MW	1 - 15	12.5710	8.2114	13.3100	12.0900
			> 15	8.4752	0		
		> 2MW	1 - 15	10.7540	6.1914	11.1900	10.3790
			> 15	8.0660	0		
	Forestry wastes	≤ 2MW	1 - 15	12.5710	8.2114	13.3100	12.0900
			> 15	8.4752	0		
		> 2MW	1 - 15	11.8294	7.2674	12.2600	11.4400
			> 15	8.0660	0		
Biomass	Landfill gas		1 - 15	7.9920	3.7784	8.9600	7.4400
			> 15	6.5100	0		
	Gas from anaerobic digestion	≤ 0.5MW	1 - 15	13.0690	9.7696	15.3300	12.3500
			> 15	6.5100	0		
		> 0.5MW	1 - 15	9.6800	5.7774	11.0300	9.5500
			> 15	6.5100	0		
	Liquid biofuels, Manure		1 - 15	5.3600	3.0844	8.3300	5.1000
			> 15	5.3600	0		
Biomass from industrial processes	Agricultural wastes	≤ 2MW	1 - 15	12.5710	8.2114	13.3100	12.0900
			> 15	8.4752	0		
		> 2MW	1 - 15	10.7540	6.1914	11.1900	10.3790
			> 15	8.0660	0		
	Forestry wastes	≤ 2MW	1 - 15	9.2800	4.9214	10.0200	8.7900
			> 15	6.5100	0		
		> 2MW	1 - 15	6.5080	1.9454	6.9400	6.1200
			> 15	6.5080	0		
	Black Liquor	≤ 2MW	1 - 15	9.2800	5.1696	10.0200	8.7900
			> 15	6.5100	0		
		> 2MW	1 - 15	8.0000	3.2199	9.0000	7.5000
			> 15	6.5080	0		

\*Solar PV is now regulated by the Spanish RD 1578/2008, and includes an auction based price-discovery mechanism in which prices can be readjusted on a quarterly basis. For further details on Spain's PV policy, see Section 5.5.1.1.

Source: Spain 2007, based on Held et al. 2007

### Appendix C. Ontario's Feed-in Tariff Payment Levels

Technology category		Installed Power	Period (years)	Fixed rate (c/kWh)	Bonus Payments/ Adders (c/kWh)
Solar Radiation	Any Type	≤ 10 kW	20	80.2	
	Rooftop Project	> 10 kW, ≤ 250 kW	20	71.3	
		> 250 kW, ≤ 500 kW	20	63.5	
		> 500 kW, ≤ 10 MW	20	53.9	
	Freestanding facilities/ open	> 10 kW	20	44.3	Aboriginal 1.5, Community 1 c
Wind	Onshore	Any size	20	13.5	Aboriginal 1.5, Community 1
	Offshore	Any size	20	19.0	
Biomass		≤ 10 MW	20	13.8	Aboriginal 0.6, Community 0.4
		> 10 MW	20	13.0	
Biogas	On-Farm	≤ 100 kW	20	19.5	Aboriginal 0.6, Community 0.4
	On-Farm	> 100 kW, ≤ 250 kW	20	18.5	
	Biogas	≤ 500 kW	20	16.0	
	Biogas	> 500 kW, ≤ 10 MW	20	14.7	
	Biogas	> 10 MW	20	10.4	
Landfill gas		≤ 10 MW	20	11.1	Aboriginal 0.6, Community 0.4
		> 10 MW	20	10.3	
Water power		≤ 10 MW	40	13.1	Aboriginal 0.9, Community 0.6
		> 10 MW, ≤ 50 MW	40	12.2	

Source: OPA 2009a

### Appendix D. Switzerland's Feed-in Tariff Payment Levels

Technology category		Installed Power	Period (years)	Fixed Tariff (SWF/kWh)	Bonuses	Degression		
Solar: Photovolta	Ground Mounted	< 10kW	25	0.6500		8.0% (2010)		
		< 30kW	25	0.5400				
		< 100kW	25	0.5100				
		> 100kW	25	0.4900				
	Rooftop	< 10kW	25	0.7500				
		< 30kW	25	0.6500				
		< 100kW	25	0.6200				
		> 100kW	25	0.6000				
	Building Integrated	< 10kW	25	0.9000				
		< 30kW	25	0.7400				
		< 100kW	25	0.6700				
		> 100kW	25	0.6200				
Wind (capped at 30% of program)	Small wind	< 10kW	20	0.2000		1.5% (2013)		
	Large Wind*	> 10kW	60% Ref. Yield	20			0.2000	
			70% Ref. Yield	20			0.2000	
			80% Ref. Yield	20			0.2000	
			90% Ref. Yield	18.3			0.2000	
			100% Ref. Yield	16.1			0.2000	
			110% Ref. Yield	13.9			0.2000	
			120% Ref. Yield	11.7			0.2000	
			130% Ref. Yield	9.4			0.2000	
			140% Ref. Yield	7.2			0.2000	
			150% Ref. Yield	5			0.2000	
Afterwards	To Year 20	0.1700						
Geothermal		< 5MW	20	0.3000		0.5% (2018)		
		< 10MW	20	0.2700				
		< 20MW	20	0.1700				
Hydro (capped at 50% of program)		< 10kW	25	0.2600	<b>Pressure Bonus** (for the head of the penstock)</b>	0%		
		< 50kW	25	0.2000				
		< 300kW	25	0.1450			< 5 m	0.0450
		< 1MW	25	0.1100			< 10 m	0.0270
		< 10MW	25	0.0750			< 20 m	0.0200
							< 50 m	0.0150
							> 50 m	0.0100
<b>Maximum Tariff</b>				0.3500				
Biomass	Sewage gas maximum		20	0.2400		0%		
	Waste gas maximum		20	0.2000				
	Other biogas	< 50kW	20	0.2400			Bonus (Ag. Waste) < 50kW	0.1500
		< 100kW	20	0.2150			< 100kW	0.1350
		< 500kW	20	0.1900			< 500kW	0.1100
		< 5MW	20	0.1600			< 5MW	0.0400
		> 5MW	20	0.1500			> 5MW	0.0000
				Wood Burning bonus	0.0300			

\*Switzerland has opted for the German system of tariff differentiation by resource intensity. Unlike the French system, the German and Swiss systems extend the premium payment for a certain number of months as opposed to dropping the tariff in year six.

\*\*Water management bonus: A premium is offered if the costs of "water management" are greater than 20% of the total project cost, according to a formula, increasing up to 50%, at which point the full premium must be paid.

Source: SFOE 2008

## Appendix E. Minnesota Proposed Feed-in Tariff Payment Levels (2007-2008)

Technology category		Installed Power (share of capacity)	Period (years)	Fixed rate (USD/kWh)
Solar Radiation	Rooftop project	< 30kW	20	0.6500
		≥ 30kW, < 100kW	20	0.6200
		≥ 100kW	20	0.6100
	Freestanding facilities/open		20	0.5000
	Façade cladding project	< 30kW	20	0.7100
		≥ 30kW, < 100kW	20	0.6800
≥ 100kW		20	0.6700	
Wind*	Small Wind	Single turbine w/ rotar-swept area of no more than 1,000 sq/ft	20	0.2500
	Large Wind	All	Years 1 - 5	0.1050
		Avg. yield < 700 kWh per sq. meter per year	Years 6 - 20	0.1050
		Avg. yield > 1,100 kWh per sq. meter per year	Years 6 - 20	0.0800
		Between 700 and 1,100 kWh per sq. meter per year	Years 6 - 20	extrapolation between rates: .105 and .08
Hydro*	< 500kW	20	0.1000	
	≥ 500kW, < 10MW	20	0.0850	
	≥ 10MW, < 20MW	20	0.0650	
Biomass* (operates at an efficiency of 60% or greater)	< 150kW	20	0.1450	
	≥ 150kW, < 500kW	20	0.1250	
	≥ 500kW, < 5MW	20	0.1150	
	≥ 5MW, < 20MW	20	0.1050	
Landfill gas* (operates at an efficiency of 60% or greater)	< 500kW	20	0.1000	
	≥ 500kW	20	0.0850	

\*Note: The \*commission may not approve a rate under the tariff established in this section if a project owner receives or intends to receive federal or state subsidies, tax credits, or other financial incentives available to owners of renewable electric generation facilities, unless those subsidies, incentives or credits have been deducted from the rate\*.

Source: Minnesota H.F. No. 3537, as introduced - 85th Legislative Session (2007-2008)  
 Found at: <https://www.revisor.leg.state.mn.us/bin/bd/bill.php?bill=H3537.0.html&session=ls85>

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