Energy Policy 36 (2008) 981–990

ENERGY POLICY

www.elsevier.com/locate/enpol

# Design of an economically efficient feed-in tariff structure for renewable energy development

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Received 27 June 2007; accepted 9 November 2007
Available online 26 December 2007

**Abstract**

Evidence suggests, albeit tentatively, that feed-in tariffs (FITs) are more effective than alternative support schemes in promoting renewable energy technologies (RETs). FITs provide long-term financial stability for investors in RETs, which, at the prevailing market price of electricity, are not currently cost-efficient enough to compete with traditional fossil fuel technologies. On the other hand, if not properly designed, FITs can be economically inefficient, as is widely regarded to have been the case under the Public Utility Regulatory Policies Act of 1978 (PURPA). Under PURPA, too high a guaranteed price led to the creation of so-called "PURPA machines"—poorly performing generating units that could survive financially only because of heavy subsidies that came at the expense of retail customers. Similarly, because of their adverse impacts on retail electricity rates, German FITs have been subject to increasing political pressure from utilities and customers. In this paper, we propose an innovative two-part FIT, consisting of both a capacity payment and a market-based energy payment, which can be used to meet the renewables policy goals of regulators. Our two-part tariff design draws on the strengths of traditional FITs, relies on market mechanisms, is easy to implement, and avoids the problems caused by distorting wholesale energy markets through above-market energy payments. The approach is modeled on forward capacity market designs that have been recently implemented by several regional transmission organizations in the USA to address needs for new generating capacity to ensure system reliability.
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*Keywords:* Renewables; Feed-in tariffs; Auctions

## 1. Introduction

Regulatory policy approaches to promote renewable energy technologies (RETs) have taken on increasing importance in many countries. Although the relative weight given to underlying reasons for accelerating RET development may vary (e.g., reducing global climate change, a desire to reduce dependence on imported fossil fuels, increased portfolio diversity, local economic development, etc.), ultimately policy instruments used to promote renewables must necessarily balance several competing objectives, including

(1) Specific positive environmental impacts, such as reduced emissions of air pollutants and greenhouse gases, versus perceived negative impacts on bird populations and landscape esthetics (in the case of wind turbines, for example).
(2) Reduced dependence on fossil fuels, greater portfolio diversity, and lower exposure to fuel price volatility, versus adverse economic impacts of higher retail electric rates, including lessened economic competitiveness and lack of affordability.

Consideration of the trade-offs within each of these objectives is unavoidable, and there are a number of multi-objective methodologies that can be employed to this end which are both efficient and consistent (Madlener and Stagl 2005).[1] Regardless of how policymakers evaluate such trade-offs, however, the policies they implement to encourage accelerated RET development should be as

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[1]For a rigorous development of multi-attribute methods, see Keeney and Raiffa (1976).

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doi:10.1016/j.enpol.2007.11.007

economically efficient as possible. In other words, while economic theory may not be able to fully answer whether government-mandated RET development or development of specific RETs are themselves *Pareto-superior* policies,[2] economic theory can help determine the most efficient, ''least-cost'' approaches to achieve the chosen policy goals.[3]

Increasingly, feed-in tariffs (FITs), rather than minimum percentage requirements for RETs used in the USA and Great Britain, have been argued to be a superior policy approach for promoting RETs (Rowlands, 2005, 2007; Sijm, 2002), especially in their ability to reduce financial risks for RET developers (Mitchell and Connor, 2004). Germany, for example, has been especially aggressive about FIT implementation. Germany's Renewable Energy Law (Erneuerbare Energien Gesetz, EEG) was implemented in 1991 and revised in 1998. By 2002, total generation by RETs in Germany had increased to over 20 terawatt-hours (TWh) per year (Mitchell et al., 2006). The payments schemes vary by technology, plant vintage, and location. For example, under the German system, payments for solar photovoltaic plants are over seven times greater than payments for geothermal plants.

Yet, FITs are not a panacea. In particular, one difficulty with the development of FITs compared with renewable portfolio standards (RPS) and ''renewables obligations'' (RO) is that they require policymakers to define administratively FIT attributes, specifically payments *amounts* for individual technologies (e.g., wind, solar, geothermal), payment *structures* (e.g., fixed or declining), and payment *duration*. All three attributes can require significant ''guesswork'' on the part of policymakers as to future market conditions and rates of technological improvements. Essentially, traditional FIT designs require government policymakers to substitute their judgment for that of markets in the selection of long-term, technological ''winners and losers.'' However, long-term forecasting is notoriously imprecise and inaccurate, given the multitude of uncertainties that affect the future. Moreover, once specific price paths (i.e., level, structure, and duration) are specified, changing those paths is both difficult and costly, as it creates excessive regulatory uncertainty that, in turn, increases investment costs.

FITs were first used in the guise of ''avoided cost'' payment schemes mandated as part of the US Public Utility Regulatory Policies Act of 1978 (PURPA). Under PURPA, US electric utilities were required to purchase all of the output from so-called ''qualifying facilities'' (QFs) at prices that reflected the utilities' long-term avoided costs. Since there were no direct market prices that could be used, such as futures markets, avoided costs were administratively established and approved by state energy regulators, who typically relied on various forecast models to estimate future fossil fuel prices and electric prices. For example, in the 1980s, it was not uncommon to see predictions that crude oil prices would reach more than $100 per barrel by the year 2000; the actual price turned out to be less than $30 per barrel. Moreover, during the entire decade of the 1990s, crude oil prices were less than $25 per barrel.[4]

QFs were either industrial plants using co-generation technologies or renewable resources, including hydroelectric facilities with less than 80 MW capacity, wind, biomass, and solar power. As a result of overestimated avoided costs, electric utilities and their retail ratepayers were saddled with sometimes copious amounts of high-priced generation, and this led to the derisive description of many co-generation facilities as ''PURPA machines'' (Barclay et al., 1989).[5] Moreover, several states, notably California, established a number of alternative ''Standard-Offer'' contracts for QFs, depending on the type and size of generator (Gipe, 2007). Some of these, especially the Standard Offer Four (SO 4) contract provided for even higher payments without regard for actual energy produced, and thus further distorted the electric markets.[6]

Like avoided cost rates set under PURPA, FITs whose prices are set too high or that last too long will needlessly subsidize RETs and create welfare losses for society. Not only do such subsidies distort electric markets and reward inefficient RET developers and operators; they negatively impact electricity consumers because they are a tax that increases as the overall share of RET increases. Even the highly successful German FIT—successful when measured in terms of renewable capacity developed—has been criticized for its adverse impact on electric rates,[7] and retail customers increasingly protest its implementation.

The challenge, therefore, is to develop a FIT mechanism that achieves the broader policy goals associated with accelerated renewables development at the least possible cost. Such an economically efficient FIT will provide incentives for owners of renewable generation to maximize their energy production, without distorting wholesale energy market prices. Finally, an efficient FIT mechanism should not work at cross purposes with other renewable energy policies, especially tradable green certificates (TGCs) and RPS.

The remainder of this paper is organized as follows: Section 2 compares FIT and other RET support schemes.

[2]A Pareto-superior policy is one that achieves greater benefit at the same cost, or equivalently, the same benefit at lower cost.

[3]We recognize that some may question whether the benefits of government intervention to promote RETs exceed the costs. Although we recognize this as an important policy question, in this paper our aims are more limited. Specifically, since such intervention already occurs, we focus on policy instruments that will achieve government goals at the lowest possible cost.

[4]US Energy Information Administration, Refiner acquisition cost of crude, available at: http://tonto.eia.doe.gov/dnav/pet/hist/r0000____3a.htm, accessed 28 May 2007.

[5]The Energy Policy Act of 2005 (EPAct 2005) made significant changes to PURPA, modifying co-generation rules to prevent ''PURPA machines'' and altering the requirements for electric utilities to purchase the output from QFs.

[6]See Morris (2000, pp. 8–10).

[7]See Butler and Neuhoff (2005, pp. 8–9) and Meyer (2003, pp. 5–6).

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