Energy Policy 52 (2013) 385–401

Contents lists available at SciVerse ScienceDirect

Energy Policy

journal homepage: www.elsevier.com/locate/enpol

Assessing the strength and effectiveness of renewable electricity feed-in tariffs in European Union countries

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HIGHLIGHTS

- This is the first econometric study of feed-in tariff (FIT) efficacy in Europe.
- We test the impact of FIT's on photovoltaic (PV) and wind power from 1992 to 2008.
- We calculate country- and year-specific return on investment provided by each FIT.
- FIT policies increased PV installations by ~0.5% per ROI percentage point.
- Policy design, market traits, and ROI are more important factors than policy alone.

ARTICLE INFO

Article history:
Received 29 November 2011
Accepted 17 September 2012
Available online 22 October 2012

Keywords:
Renewable energy
Feed-in tariff
Panel data models

ABSTRACT

In the last two decades, feed-in tariffs (FIT) have emerged as one of the most popular policies for supporting renewable electricity (RES-E) generation. A few studies have assessed the effectiveness of RES-E policies, but most ignore policy design features and market characteristics (e.g. electricity price and production cost) that influence policy strength. We employ 1992–2008 panel data to conduct the first econometric analysis of the effectiveness of FIT policies in promoting solar photovoltaic (PV) and onshore wind power development in 26 European Union countries. We develop a new indicator for FIT strength that captures variability in tariff size, contract duration, digression rate, and electricity price and production cost to estimate the resulting return on investment. We regress this indicator on added RES-E capacity using a fixed effects specification and find that FIT policies have driven solar PV development in the EU. However, this effect is overstated without controlling for country characteristics and is concealed without accounting for policy design. We do not find robust evidence that FIT policies have driven wind power development. Overall, we show that the interaction of policy design, electricity price, and electricity production cost is a more important determinant of RES-E development than policy enactment alone.

1. Introduction

Many national, regional, and local governments have passed regulations to encourage renewable electricity (RES-E) generation in the last two decades. Motivations for regulatory support of RES-E include rising concerns over climate change and pollution, national security risks associated with fossil fuels, and a desire to promote innovation and increase the competitiveness of new energy sources (Schmalensee, 2011).

1.1. Varieties of renewable energy policy design

Policies that promote RES-E can be characterized along two dimensions. First, policies may regulate either the price of RES-E or the quantity produced, a distinction analyzed by Weitzman (1974). Second, policies may support investment in RES-E capacity or directly subsidize generation (Haas et al., 2004, 2008; Menanteau et al., 2003). Policies are categorized along these dimensions in Table 1.

Two of the most popular policy types for encouraging RES-E generation in the developed world are feed-in tariffs (FIT) and quotas, often called renewable portfolio standards (RPS). RPS is a form of command-and-control quantity regulation that requires utilities to generate a certain portion of their electricity from renewable sources. RPS tends to promote the lowest-cost RES-E

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http://dx.doi.org/10.1016/j.enpol.2012.09.046

Table 1
Renewable electricity support policies.
Modified from Haas et al. (2008).

	Price	Quantity
Investment	Investment subsidies Tax credits Low interest/soft loans	Tendering systems for investment grants
Generation	Fixed price feed-in tariffs Premium feed-in tariffs	Renewable energy portfolio standards (i.e. quotas) Tendering systems for long term contracts

technologies, as utilities can typically choose from a variety of technologies to meet their quota requirement. In contrast, a FIT is a form of price regulation under which producers of RES-E sign a contract that increases the payment they receive for each kilowatt-hour (kWh) generated. It provides a technology-specific subsidy to improve the competitiveness of RES-E generation relative to conventional sources. The effect is often to equalize attractiveness among energy technologies with different production costs.

Feed-in tariffs are the most popular RES-E support scheme in European countries. However, there is considerable variety in the design of individual FIT policies (Couture and Gagnon, 2010). Each FIT is unique in structure and, as we will show, in the investment incentive it provides.

FIT policies may differ in one or more of the following characteristics:

- **Fixed-price vs. premium tariff:** A FIT may be structured as either a fixed-price tariff, which guarantees that electricity generators can sell their electricity to the grid at a set price, or a premium tariff, which adds a bonus to the wholesale market price received by generators. In the EU, Denmark and Cyprus are the only countries that have implemented a premium tariff. All other countries with a FIT employ the fixed-price design.
- **Cost allocation:** Under a FIT, the generator signs a contract that entitles it to feed electricity into the grid prior to any other conventional source. The difference between the tariff and the actual market price is re-distributed among end-users or paid from state budgets in most countries.
- **Cost containment:** Some countries cap the total capacity that may be installed or total tariffs that may be awarded under a FIT policy each year. In the EU, Cyprus, Estonia, Ireland, Latvia, Portugal, and Spain have employed capacity limits while only Austria and the Netherlands have used total cost limits.
- **Contract duration:** The duration over which the FIT is paid to the generator varies between policies. There is often a tradeoff between duration and magnitude. Some countries provide a relatively high tariff for a short contract duration of 10 years only, while others provides a lower tariff for up to 25 years.
- **Tariff amount:** The tariff received by generators may differ in size between countries and energy technologies. Factors that influence the size of the tariff provided by a policy include generation cost, location, system size, receiving party, and the purpose of the host building.
- **Digression rate:** Many FIT policies have a built-in digression rate, a mechanism for gradually reducing the tariff value according to the number of years after policy enactment the contract is signed. The goal is to slowly adjust the incentive provided by the FIT to adapt to increasing economic viability of RES-E technologies over time.

Several other types of RES-E policies have emerged in the EU in the last two decades. These include tradable green certificate systems (six countries); tax incentives or investment grants (seven countries); net-metering policies (two countries); and tendering schemes (four countries). Tendering schemes are bidding systems in which developers compete for supply contracts to construct RES-E capacity (Haas et al., 2008). In 20% of the country-years with a tendering system in our sample period, there was also a FIT in place,[3] though a producer receiving a FIT typically cannot bid under a tendering system. In the U.S., RPS has emerged as the dominant RES-E policy tool at the state level, with 29 states and the District of Colombia implementing an RPS by 2011 (DSIRE, 2011). Worldwide, more than 80 countries employ policies to promote RES-E (REN21, 2010).

1.2. The question of RES-E development and FIT effectiveness in Europe

Between 1990 and 2011, 23 EU member countries implemented a FIT to support solar PV or onshore wind development. Table 2 displays the years of enactment for major RES-E policy types in Europe. Policy enactment is skewed over time: some countries such as Germany and Italy adopted RES-E policies very early, but most have done so within the last decade.

During this same period, RES-E capacity in EU 27 countries has developed rapidly and unevenly (Fig. 1). Previous studies have examined these dividing paths using an array of macroeconomic, ecological and socio-economic factors. A few quantitative studies have assessed the effectiveness of RES-E policies, but this is an area of surprisingly sparse research.

1.3. Research question and contribution

In light of the differences in both RES-E development and FIT enactment between countries and over time, a key question for policymakers is whether FIT policies have actually increased RES-E generation capacity beyond what would have occurred in their absence. In this paper, we develop the first rigorous econometric analysis of FIT effectiveness in Europe to date. The centerpiece of our analysis is a new indicator for the strength of FIT policies that takes into account differences in policy design and market. Specifically, this indicator captures heterogeneity in tariff size, contract duration, digression rate, electricity wholesale price, and electricity generation cost to construct a measure of the return on investment (ROI) for RES-E installations in each country-year. We develop a technology-specific fixed-effects regression model to test the significance of this indicator using historical data on solar PV and onshore wind power in EU countries. The model controls for fixed country-level characteristics that may be correlated with both policy implementation and RES-E development.

This paper improves and expands on the existing literature in three key ways. First, it focuses on a policy type and a region that have been largely ignored in previous econometric studies. Second, it accounts for unique policy design features that have often been ignored in econometric analyses of RES-E policies in general. Third, it provides a detailed literature review and summary of trends in econometric RES-E policy analysis, with a focus on methodology.

We find strong evidence that FIT policies have driven solar PV capacity growth. However, this effect is overstated without controlling for country characteristics and may not be observed at all without accounting for the unique design of each policy. We

[3] France in 2005; Ireland in 2005; Portugal from 2005 to 2007; and the Netherlands from 2003 to 2008 (RES-Legal, 2011).