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Is green energy expensive? Empirical evidence from the Spanish electricity market

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HIGHLIGHTS

- The combination of feed-in tariffs and premiums has been an effective instrument in the promotion of renewable electricity in Spain.
- Significant reduction of the daily market price due to RES-E.
- Considering the subsidies to RES-E this energy might seem rather expensive for the Spanish electricity system since 2010.
- Substantial differences among technologies: wind energy implied the lowest net cost, while solar photovoltaic was the most expensive.

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ABSTRACT

Renewable energy promotion and its cost are at the heart of the energy policy debate in many countries. The question from an economic perspective is how expensive the promotion of renewable sources through price-based incentive schemes is. This paper addresses this issue empirically. We analyze the Spanish electricity market during the period 2008–2012, where renewable energy production rose by 57%. To determine how expensive it was, we first measure the savings due to the spot price reduction driven by the merit order effect and, second, we compute the amount paid as incentives to green energy by the electricity system; the difference between the two is the net cost of green energy to the electricity markets. We present aggregate results for renewable sources as a whole, as well as individual results for each technology. We show that at the initial stages, when renewable capacity was low, green energy promotion paid for itself (2008–2009); however, from 2010 on, when renewable production reached a relatively high level, it started to impose a positive net cost on the system. Finally, we found substantial differences among technologies: wind energy implied the lowest net cost, while solar photovoltaic was the most expensive.

1. Introduction

Renewable electricity deployment is currently one of the ongoing political priorities in developed countries because of its positive environmental and socio-economic externalities. However, there is widespread debate concerning the economic consequences of large scale renewable participation in electricity markets. On one hand, investment in Renewable Sources (RES, hereafter) is supported in many forums because of the resulting reduction on the daily market price, due to the merit order effect (Rathmann, 2007; Sensfuss et al., 2008; Felder, 2011, among other authors). On the other hand, one of the main criticisms of green generation is the cost imposed on the public support scheme (Morthorst, 2000; Menanteau et al., 2003; Lesser and Sue, 2008, among others).

One of the most popular instruments for fostering RES is the feed-in tariffs, which are price-based incentive schemes aimed to support RES until renewable technologies approach commercial readiness. With the feed-in tariff system, renewable generators sell their electricity in the market under a fixed tariff. These tariffs reduce the risk for investors setting a guaranteed long-term payment for RES. Consequently, feed-in tariffs are an effective instrument in overcoming the barriers for RES penetration, whose costs are still higher than those of the conventional sources; and they also result in an increased drive for technological innovation.

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However, since feed-in tariffs do not adjust automatically, getting the appropriate tariff rate is one of the most important and difficult tasks for policy makers. If tariffs are set too high, they would lead to windfall profits to renewable generators; but if they are set too low, little or none investment would be issued on RES.

As a consequence of the heavy burden imposed, many countries have already started to reduce or even suppress the incentives to renewable production, particularly to solar photovoltaic power. For instance, solar power subsidies have been reduced in France in 2011 (JORF, 2011) and in UK in 2012 (DECC, 2012), because of the rapidly increasing deployment of solar installations (at a rate much higher than projected), and they have been phased out for large solar projects in Canada in 2013 (ME, 2013).

From 2012 German support schemes for new installations will tend to decrease over time, depending on the previous year's additions to renewable capacity. In the case of solar power, this "degression" rate in feed-in tariffs is reviewed monthly and it depends on the excess of the annual capacity expansion target (BGBL, 2011). Additional regulatory changes in Germany include the introduction of a new premium to encourage the direct sale of renewable electricity to the spot market, setting the basis for the transition to a purely market-based regime.[1]

In Australia, subsidies have never supported large scale projects and the focus has mainly been on solar photovoltaic for residential producers. However, there have also been cutbacks in the last few years. From 2012 on, new generators connected to the network in New South Wales are no longer eligible for the Solar Bonus Scheme[2] and the incentive will end for all customers in 2016 (NSWGG, 2011). Furthermore, in Victoria feed-in tariffs to solar, wind, hydro or biomass generators under 100 kW in capacity have been lowered in 2013, and from now on, they will be reviewed on an annual basis until 2016 (VGG, 2012).

Feed-in tariffs are used to a limited extent in the United States, where incentives rely on other mechanisms, such as Renewable Portfolio Standards (RPS), tax incentives or net metering. And even in Japan, where feed-in tariffs came into operation in July 2012 (Ogimoto et al., 2013), tariffs for solar photovoltaic have already been lowered by about 10% in 2013 (METI, 2013).

In Spain, support to renewable energy used a combined system of feed-in tariffs and premiums from 2004 to 2012. This incentive scheme was aimed at the so-called Special Regime (SR, hereafter), which includes RES, such as wind power, solar photovoltaic, solar thermal, small hydropower (capacity lower than 50 MW), biomass, wastes and waste treatment; and cogeneration. The promotion scheme began offering a strong level of incentives, but it has been progressively reduced since 2010, due to the high renewable capacity installed. Finally, new regulation has been introduced in 2013[3] that substitutes those incentives for subsidies based on a fixed rate of return to investment.

This paper analyzes the net effect of renewable energy and cogeneration in Spain and computes the individual effects of each technology for the period 2008–2012. The question is relevant because the environmental benefits of renewable electricity production have to be compared to their economic costs in order to determine the optimal level of public support that these technologies should receive. Our contribution is to assess, both at the aggregate level and by technology, the economic impact of renewable electricity after the important regulatory changes introduced in mid 2007, when the Spanish–Portuguese market started to operate (in July 2007, specifically). Additionally, in 2008 retail and distribution activities were unbundled, which was an important step in the market liberalization process, facilitating small RES producers to participate in the wholesale market.

Using data for the day-ahead market, we first measure the reduction of the system marginal price (SMP, hereafter) of the spot market, driven by the merit order effect of Electricity from Renewable Energy Sources (RES-E, hereafter). We build an algorithm that computes the outcome of the hourly auction for the electricity wholesale market in two scenarios, with and without renewable sources. The comparison between the two scenarios, for renewable production and cogeneration as a whole and for each renewable technology separately, allows us to calculate the savings due to the merit order effect. Second, we compute the impact of the incentives on the total cost of the electricity system. We conclude that there was a breaking point at 2010 and after that year renewable energy started to impose a net cost on the system. We also provide results for each technology.

The paper is structured as follows. Section 2 summarizes some of the research evidence on the impact of renewable energy production on international electricity markets. Section 3 briefly describes the Spanish regulatory framework. Section 4 contains the empirical work, including data, specifications and computational algorithm. Simulations and results are presented in Section 5. Finally, Section 6 discusses the policy implications of the analysis and summarizes the main conclusions of our work.

2. The effect of renewable energy on international electricity markets

Despite the high cost that RES imposes on electricity systems, several studies, both theoretical and empirical, provide evidence of the positive effect of renewable deployment on market prices in different countries. Among the theoretical papers, Jensen and Skytte (2002) were the first authors to point out that as renewable energy generation has lower variable costs than conventional fossil-fuel electricity; it could reduce final electricity prices and therefore the total cost of electricity provision.

Empirical studies on the effect of RES-E include regression analysis of historical time series data and electricity price modeling. Jónsson et al. (2010) modeled the spot price dynamics in the Danish electricity market in order to analyze the effect of wind forecasts on spot prices; they use a non-parametric regression model for the period January 2006–October 2007 and found a significant price effect of wind generation.

From a different focus, O'Mahoney and Denny (2011) estimated the cost savings in 2009 arising from wind generation in the Irish electricity market. They found that the total costs for the system would have been around 12% higher had no wind energy been available and that these savings were significantly greater than the subsidy received for wind-generated electricity over the same time period.

Similarly, Cludius et al. (2013) estimated the merit order effect of both wind and photovoltaic electricity generation in Germany between 2008 and 2012. They showed that for each additional GW h of RES-E, the price of electricity on the day-ahead market was reduced by 1.10–1.30 EUR/MW h. They also found that the total merit order effect of wind and photovoltaic ranged from 5 EUR/MW h in 2010 to more than 11 EUR/MW h in 2012.

Martin (2004) modeled the impact of photovoltaic power generation on prices in New England. According to this study, if 1 GW of additional photovoltaic capacity had been installed in New England in 2002, average wholesale electricity prices would have been reduced by 2–5%.

Bode (2006) went further and studied the net effect of RES-E on the wholesale market and, based on the analysis of a synthetic power market in Germany, concluded that the power costs for

[1] 2012 Amendment of the Renewable Energy Sources Act (EEG, 2012).

[2] The Solar Bonus Scheme is a feed-in tariff aimed to small solar or wind generators connected to the grid.

[3] See Espinosa (2013).