The Electricity Journal 29 (2016) 15–21

Contents lists available at ScienceDirect

The Electricity Journal

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

Price interaction in state-level renewable energy credit trading programs

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ARTICLE INFO

Article history:
Available online 24 May 2016

Keywords:
Renewable energy credits
Renewable portfolio standards
Market integration
Vector error correction model

ABSTRACT

Renewable portfolio standards have been promoted and implemented as market-based incentives for encouraging renewable generation. Markets for RECs in Massachusetts and Connecticut do not consistently behave according to hypothesized fundamentals. Regardless of the reason for this divergence, one must be skeptical that the two state programs have created an efficient, fundamental-driven market.

1. Introduction

Numerous U.S. states have adopted policies for encouraging the use of renewable energy sources. As of June 2015, 29 states and the District of Columbia had some form of a renewable portfolio standard (RPS); eight more states had declared goals to achieve standards (Database of State Incentives for Renewables and Efficiency, 2015). RPS programs require retail electricity suppliers to provide a minimum portion of total generation from renewable sources; suppliers comply with the requirement by either redeeming renewable energy credits (RECs) or paying a non-compliance penalty. A utility whose electricity portfolio is entirely made up of fossil fuel sources, for example, will need to purchase an adequate number of RECs to achieve the RPS requirement or pay a penalty. A REC is a certificate equivalent to a unit of electricity generated from an approved renewable source. RECs are produced contemporaneously with the unit of qualified electricity, but they are bought and sold separately from the electricity. This creates a distinct market in which RECs may be traded before compliance submission.

There has been a marked expansion in the use of tradable rights programs to address environmental goals (Goulder, 2013). This trend shows no signs of abating. The efficiency of this approach, however, rests on the assumption that market forces will push participants to maximize net returns. If prices do not respond "rationally" to underlying fundamentals, tradable rights markets will not necessarily lead to efficient outcomes.

Empirical analyses of tradable rights programs are necessary to determine if such programs are a move toward efficiency, but there is a lack of such analyses (Felder, 2011; Fischer, 2010). Determining whether the dynamic relationships among various state's REC prices, natural gas, and electricity prices are consistent with economic theory is the objective of this study.

2. Literature review

Findings on whether RPS policies have affected the quantity of renewable energy generated vary (Basher et al., 2015). Yin and Powers (2010) find that RPS policies have increased renewable energy production, a finding refuted by Shrimali et al. (2012) who conclude that the stringency of state RPS policies has no discernible effect on renewable production. In a later analysis, Shrimali et al. (2014) find that state-level policies do have a positive effect.

Another avenue of research is determining relationships among RPS and input and electricity prices. Palmer and Burtraw (2005), employing the Haiku electricity market simulation model to evaluate national RPS scenarios, find that as the percentage requirement of the RPS increases electricity, REC prices increase, and coal and natural gas generation decline. Nogee et al. (2007) conclude that a national RPS system would reduce fossil-fuel prices (especially natural gas) and also reduce electricity prices. Wiser et al. (2007) estimate that RPS mandates caused retail electricity

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http://dx.doi.org/10.1016/j.tej.2016.04.010

rates to increase between zero and 1% for the seven states considered. Using historical utility-level data from 2001 to 2012, Tra (2016) finds that RPS mandates increase utility rates. Schmalensee (2011) concludes the high levels of price dispersion between state REC prices is a result of fragmented markets with high transaction costs, but does not conduct rigorous statistical analysis.

Chen et al. (2009) review 31 studies which were generally conducted during the proposed or adoption phase of RPS. They find that the majority of studies predict electricity rate increases of less than 1%, though they stress that there is large uncertainty in the estimates. Projected electricity rates impacts range from a decrease of 5.2% to an 8.8% increase.

Berry (2002) and Felder (2011) develop but do not statistically test hypotheses about price relationships, as well as the interaction of REC prices across states. Berry (2002) hypothesizes REC prices should be tied to the excess cost of electricity generation from renewable sources over nonrenewable sources. REC prices should represent the “cost premium” of renewable power. Felder (2011) explains how an RPS can have a “price-suppression effect.” This effect is the displacement of higher marginal cost resources with low marginal cost renewable sources, resulting in a decrease of the wholesale price of electricity.

One can conclude that empirical findings regarding the efficiency of RPS programs are inconclusive and contradictory. Particularly lacking are empirical analyses of RPS programs using market data (Chen et al., 2009; Felder 2011; Fischer 2010).

3. REC market fundamentals

The fundamentals of the REC market can be illustrated by considering the simplified case in which a state has an RPS requirement that 5% of its electricity must come from renewable sources. For each megawatt-hour (MWh) that a renewable source generates and sells, one REC is created. For every 20 MWh of total electricity sold one REC must be retired. Hence, a renewable source that generates 20 MWh will have 19 surplus RECs. These RECs may be bought by suppliers whose generation portfolio is composed of less than 5% renewables.

REC prices are determined by supply and demand conditions (Fig. 1). The key to understanding REC prices lies in the dependence of the supply and demand of RECs on the market for wholesale electricity (and in turn, on the markets for renewable and conventional generation). Marginal revenue received by a renewable electricity producer (vertical axis) is equal to the sum of the REC price and the electricity price ($P_R + P_E$). The demand for RECs is largely a function of the RPS requirement, which is determined by state legislatures (Felder and Loxley, 2012; Lamontagne, 2013). As a penalty for non-compliance, RPS programs allow emitters to pay an alternative compliance payment (ACP) to cover the extent to which suppliers fall short of their RPS requirement. Under these conditions, the annual aggregate demand curve faced by the renewable energy sector is a step function in which the REC price (P_R) is equal to the ACP for REC quantities (Q_R) less than the RPS requirement and falls to zero above the requirement.

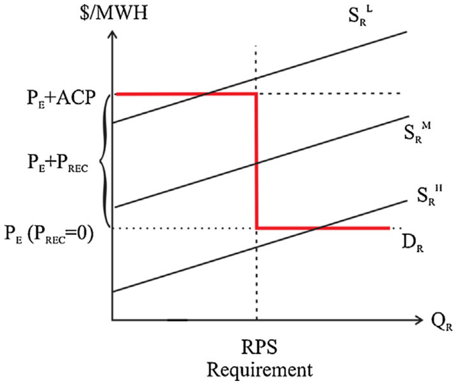

Fig. 1. REC market supply and demand fundamentals.

The quantity of RECs supplied is directly proportional to the amount of qualified renewable energy generation. In the case of relatively low levels of qualified renewable generation (S_R^L), the intersection of the supply and demand curves corresponds to REC prices that fall at or near the ACP. For high levels of renewable generation (S_R^H), renewable producers produce more than the RPS requirement, pushing P_R to zero. At medium levels (S_R^M), the supply curve intersects the vertical (inelastic) portion of the demand curve. Only in this case will the REC price respond to changes in electricity price or shifts in the REC supply or demand curves.

In the simple model of Fig. 1, the REC price is simply the cost premium of renewable sources over their conventional counterparts. As noted by Fischer (2010) and Felder (2011), the price of electricity is endogenously determined by market conditions. This complicates the effect of such an exogenous shock to renewable and/or conventional generation on REC price. Following Fischer’s (2010) framework to evaluate relationships in the electricity market when an RPS-REC system is present, the equilibrium impacts on REC prices for two exogenous shocks are derived in Appendix A. First, a shock to an input price, say natural gas, is considered. In this case the effect is unambiguous; an increase in a non-renewable input price will decrease REC prices. Second, a shock to electricity demand is considered. In this case the effect of such a shock on REC price cannot be signed unambiguously. In most cases, a positive shock to demand will decrease REC prices (see Appendix A). If the supply curve for renewable energy, however, is particularly steep when compared to that for nonrenewable energy or if a particularly high RPS standard is being pursued, the shock could have the opposite effect. In the range in which the REC price is between zero and the ACP, theory suggests that exogenous positive shocks to electricity demand will reduce REC prices.

4. Data and institutional details

The empirical analysis focuses on RPS programs in Connecticut and Massachusetts using data from March 2011 to December 2013. Institutional details of RPS programs vary across states. Connecticut and Massachusetts program details summarized here are from the Database of State Incentives for Renewables & Efficiency Sources (2015). Sources eligible for REC generation are divided into two classes. Electricity suppliers must meet two different percentage requirements: Class I and Class II sources. Class I RECs can be used for compliance with the Class II requirement, but not vice versa. Eligible Class I generation sources in the Massachusetts RPS must have been installed in 1998 or later and include geothermal, solar thermal, solar PV, wind, biomass, hydroelectric, and waste-to-energy. Connecticut accepts similar sources of electricity generation, but the Connecticut Class I distinction requires that the source be from solar, wind, fuel cells, geothermal, ocean thermal, tidal, small hydroelectric facilities, and a few other advanced technologies (but not waste-to-energy or older hydroelectric plants).

An important feature of both the Connecticut and Massachusetts RPS programs is that both Class I requirements can be met with RECs that are generated by qualified sources throughout the New England Independent System Operator regional transmission