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Market and welfare effects of renewable portfolio standards in United States electricity markets

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ABSTRACT

This study analyzes the market and welfare effects of the introduction of Renewable Portfolio Standards (RPS) while considering the empirically relevant (a) interaction of compliance with voluntary green power markets, (b) differences in consumer preferences, and (c) imperfect competition among electricity suppliers. The study accounts for both the supply and demand effects of RPS — i.e., increased costs and a higher consumer valuation for regular power. Our analysis shows that the regular power price always increases after the introduction of RPS, while the effect of RPS on the equilibrium price of green power, the quantities of regular and green power, the welfare of consumers, and suppliers' profits is case-specific and dependent on the relative magnitude of the cost and utility effects, the strength of consumer preference for green power, the suppliers' costs before RPS, the impact of RPS on green power costs, and the degree of competition among power suppliers. While the introduction of RPS aims at increasing the use of green energy in electricity production, our analysis shows that the introduction of the policy can end up reducing the total quantity of green power used. Intriguingly, this adverse policy impact will occur under seemingly optimal conditions for the green power sector; i.e., a high consumer valuation of green energy and/or low cost difference between the green power and its conventional counterpart. Finally, the analysis shows that the policy design can play a key role in determining the incidence of RPS, while the identification of the winners and losers of the policy can provide insights on the political economy of RPS and the positions held by different groups in policy negotiations.

Rising energy prices, dependence on foreign oil supplies, and alarming consequences of global warming have prompted governments worldwide to initiate green energy policies that can motivate a shift away from fossil fuels and toward renewables for electricity generation. Recognizing the fact that around 40% of carbon dioxide (CO_2) emissions in the United States come from fossil fuel combustion in the electricity sector, several policies have been adopted across states for reducing carbon emissions and stimulating renewable energy development.

One of the innovative policy instruments that stands out due to widespread adoption by states since the late 1990s is the Renewable Portfolio Standard (RPS). According to this policy, the electricity providers serving the end users in a state are required to procure green energy (such as wind, solar, biomass, or geothermal energy) for a portion of their electricity supplies.

To date, RPS has been a state-mandated program in the United States with Iowa and Minnesota being the first states to place minimum requirements for renewable energy on their electricity providers in 1983 and 1994, respectively. Since then, the policy has gained significant momentum and the adoption rate continued to increase with time. As of August 2016, 29 states, Washington DC, and three territories have adopted this policy while eight other states and one other territory have renewable portfolio goals (DSIRE, 2016a). Appendix 1 shows the RPS and non-RPS states for the eight North American Electric Reliability Corporation (NERC) regions.[2] However, due to state-specific patterns of

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[2] The North American Electric Reliability Corporation (NERC) is the electric reliability organization, certified by the Federal Energy Regulatory Commission to establish and enforce reliability standards for the bulk power system. It works with eight regional entities that are non-profit corporations and include members from all segments of the electric industry: investor-owned utilities, federal power agencies, rural electric cooperatives, state, municipal and provincial utilities, independent power producers, power marketers, and consumers. These entities are the Midwest Reliability Organization (MRO), Northeast Power Coordinating Council (NPCC), Reliability First Corporation (RFC), South East Reliability Corporation (SERC), Southwest Power Pool (SPP), Texas Regional Entity (TRE), Western Electricity Coordinating Council (WECC), and Florida Reliability Coordinating Council (FRCC), and account for virtually all the electricity supplied in the United States. The regional wholesale electricity markets fall under these eight different reliability regions.

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regulatory structure and other inherent characteristics such as natural resource endowments, generation potential of green energy, and political interest, there is considerable variation among the states in RPS goals, coverage, in-state requirements, and Renewable Energy Credit (REC)[3] trading (see Wiser et al., 2005, 2007; Wiser and Barbose, 2008).

In addition to an array of state RPS programs already in place, efforts have been made to advance a national RPS policy. Several bills with provisions for federal renewable electricity standards have been proposed since 2002. These bills have, so far, failed to become a law, however.[4] While the increased costs[5] associated with the inclusion of green energy in the electricity supply appears to be a key deterrent of a national RPS, proponents of the policy argue the existence of, in some cases, significant consumer support[6] that could ameliorate at least part of these costs. With the growing trend on RPS adoption across the country, debates on the implementation of federal RPS, and the potential for states to achieve the recently enacted Environmental Protection Agency's Clean Power Plan (CPP)[7] goals using RPS, the resurgence in research attention devoted to this policy has been anything but surprising.

Recent empirical studies analyzing the RPS policy focus either on evaluating the factors responsible for the adoption of this policy by some states (Lyon and Yin, 2010) or on examining its effects on the renewable energy supply in terms of an increase in generation or capacity (Menz and Vachon, 2006; Carley, 2009; Yin and Powers, 2010; Delmas and Montes-Sancho, 2011). All these studies ignore the demand effects of RPS, however, and, since RPS is expected to affect both demand and supply sides of the electricity market, fall short of depicting a comprehensive picture of the policy impact. While several analytical studies have evaluated the economic effects of the RPS introduction at the national level (Jensen and Skytte, 2002; Palmer and Burtraw, 2005; Fischer and Newell, 2004; Fischer, 2006; Bird et al., 2010), none of these studies account for the empirically relevant differences in consumer preferences for different types of energy, the potential for imperfect competition among the electricity suppliers, and the links and interactions between the markets for regular and green energy.

Explicitly accounting for the links and interactions between these markets is particularly important due to the coexistence of mandate-driven "compliance" markets (where regular power[8] containing a portion of renewables is sold to the end users) with "voluntary" markets (where consumers purchase green power from their electric suppliers on a voluntary basis).[9] While the presence of these voluntary green markets demonstrates a consumer support for renewables and can contribute to the passage of RPS, stringent RPS requirements can increase competition for renewable energy generation between the two markets (Bird and Lokey, 2007). In this context, explicitly considering the links and interactions of these markets is crucial in better understanding the system-wide effects of RPS.

The objective of this study is to determine the system-wide market and welfare effects of the introduction of RPS in U.S. electricity markets. In particular, the study analyzes the impact of RPS on the equilibrium prices and quantities of regular and green energy and the welfare of the interest groups involved — i.e., consumers and suppliers of the different types of energy.

To analyze the economic effects of RPS, the study develops a general theoretical framework of heterogeneous consumers and imperfectly competitive energy suppliers that takes into account both the supply and demand effects of RPS — i.e., increased costs and a higher consumer valuation for regular power. The theoretical analysis is complemented by a simulation analysis that is based on empirically derived parameter values to determine and quantify the effects of a RPS policy on the U.S. electricity market.

To our knowledge, this is the first study in the literature that builds an applied-theoretic model and conducts simulation analysis to determine the system-wide economic effects of an RPS policy, while considering the empirically relevant (a) interaction of compliance with voluntary markets, (b) differences in consumer preferences, and (c) imperfect competition among the electricity suppliers. Before concluding this section, it is also important to note that, while our analysis focuses on the market and welfare impacts of the introduction of an RPS policy, the analysis (and results) are directly relevant to cases where states with RPS increase the mandated share of renewable energy in the regular power mix. In fact, the impacts of increasing the mandated share on the prices, quantities, supplier profits and consumer welfare will be identical to the results presented in this study.

1. Theoretical framework

In our model, we consider two groups of market participants: power suppliers (regular and green), and consumers. When RPS is introduced in the regular power market, suppliers in this market either generate or purchase RECs from the wholesale market and provide regular power with a certain percentage of renewables to the

[3] 1 REC = 1 MWh of electricity generated from renewable sources.

[4] H.R. 5756, 107th Cong. (2002); H.R. 1294, 108th Cong. (2003); H.R. 983, 109th Cong. (2005); H.R. 969, 110th Cong. (2007); American Clean Energy and Security Act of 2009, H.R. 2454, 111th Cong. (2009); S 433, 111th Cong. (2009); S 741, 112th Cong. (2011); Renewable Electricity Standard Act of 2013, S 1595, 113th Cong. (2013).

[5] As shown in Table 1, the average difference between conventional and green energy is approximately 1 cent per kWh for wind and 21.1 cents per kWh for solar energy.

[6] Several studies (Champ and Bishop, 2001; Batley et al., 2000; Zarnikau, 2003; Borchers et al., 2007; Wiser et al., 2007; Bird et al., 2010) have shown that a number of consumers in different regions of the U.S. are willing to pay significant premiums to obtain green energy. The growing interest of residential consumers to participate in these markets has been attributed to environmental concerns, support for green technology, and conservation of resources for future generations. In addition to having the same concerns as residential consumers, non-residential consumers (such as business or institutions) may also seek to differentiate themselves or/and satisfy corporate environmental goals. Currently, PepsiCo, Wells Fargo, and Whole Foods are the largest purchasers of RECs. Participation in the EPA Green Power Partnership, which provides recognition for businesses that have made large renewable energy purchases, has surged in recent years, with annual purchase commitments increasing from 4 million MWh at the end of 2005 to 10 million MWh as of August 2007 (Bird and Lokey, 2007).

[7] The new Clean Power Plan, proposed by the EPA in 2014 and finalized in 2015, is the first federal policy to enact state-specific carbon emission limits. The CPP does not take the place of existing RPS programs. In fact, the two may be complementary, as state-based RPS policies may help individual states achieve the state-specific CPP goals. Thus, an assessment of RPS is highly relevant to states considering the use of RPS to achieve CPP goals.

[8] Regular power is defined here as the power generated from fossil fuels such as coal and natural gas, nuclear energy, and hydropower. With the implementation of RPS, the fuel mix used to generate regular power contains a mandated percent of renewables. Green power is the power generated from non-hydro renewable sources such as wind, solar, biomass, or geothermal.

[9] Consumers can either buy RECs with regular power through various green pricing programs (i.e., programs bundling RECs with regular power) offered by the electric utilities in regulated or competitive electricity markets or can purchase only RECs from the independent power marketers (i.e., firms that buy and sell electricity at the wholesale and retail levels without owning or operating generation, transmission, or distribution facilities). Green pricing programs offered in the regulated utility markets are usually referred as utility green pricing programs while those offered in competitive utility markets, where consumers have the choice to switch to alternative electric suppliers are known as competitive green power products. Today, over 860 utilities that cover more than half of U.S. electricity consumers offer voluntary green pricing programs. The top states in terms of total sales of green pricing products include California, Oregon, Washington, Colorado, New Mexico, Texas, Oklahoma, Minnesota, Wisconsin, New York and Pennsylvania (Heeter et al., 2012).