

# **Interaction of Oligopolistic Transmission-Constrained Power Markets with Renewable Portfolio Standards, Green Power Pricing Programs and Emission Allowances**

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Abstract Submitted to the IAEE 2004 Washington, DC Meeting

Renewable portfolio standards and green pricing programs are two distinct approaches in power markets for promoting renewable generation. The cost of emissions allowances can also be an incentive to install renewables. The renewable portfolio standard is a mandatory requirement that a fixed percent of power delivered to customers from suppliers (or load service entities, LSE) has to be from renewable sources. In contrast, green pricing programs offer a voluntary opportunity for customers with a higher willingness-to-pay associated with environmental good to pay a premium to procure their power from renewable sources. An emerging issue is the interaction of green pricing programs, renewable portfolio standards and allowances markets. Such interactions can possibly decrease the competitiveness of power markets, and induce inefficiencies and welfare loss. An oligopolistic equilibrium model based on a complementarity formulation is applied to investigate such interactions. In the model, renewable generation is modeled as a differentiated product for which consumers have a demand curve, with assumed cross-elasticities relative to the demand for so-called “grey” (nonrenewable) energy. The renewable portfolio standards are formulated as a coupled constraint imposed over the compliance period with tradable credits. Suppliers with a substantial capacity share are designated as strategic players in the respective markets, exercising a Cournot strategy, while the remaining capacity is treated as a competitive fringe.

The application is to the USEPA NO<sub>x</sub> Budget Program and Pennsylvania – New Jersey – Maryland Interconnection (PJM) market during 2000, which is represented by a 14–node and 18–arc linearized “DC” transmission system. The results show that total energy consumption is constrained by renewable generation due to renewable portfolio standards. Substantial market power can be introduced if a supplier simultaneously exercises market power in the renewable and conventional power market. In comparison to a scenario in which suppliers only possess market power in the conventional power market, the power prices are higher given Cournot suppliers concurrently exercise market power in both power markets. However, the NO<sub>x</sub> allowance price is lower since the market power in renewable market suppresses the demand for allowances.

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