What are the Welfare Consequences of Environmental Considerations in Power System Operations?

By ALBERTO J. LAMADRID AND DANIEL L. SHAWHAN[1]

I. OVERVIEW

Internalizing the pollution from electricity generation requires changes in the settlement considerations of the System Operator (SO). Moreover, an economic dispatch of the available generation is dependent on the SO's ability to elicit true cost estimates for energy, ancillary services and environmental services. With the increased adoption of Renewable Energy Sources (RES), the operational and planning challenges for System Operators (SO's) and Load Serving Entities (LSE's) are increasing, and the inherent characteristics of RES can lead to increased balancing reserves (Xu and Tretheway (2012); Navid and Rosenwald (2012)). This paper explores the tradeoffs of including in the objective function costs associated with emissions of CO_2, including the direct damage from energy production, the damage related to the inter-hour ramping of the units and the owner's cost of ramping their generators.

II. METHODS

We present a new simulation method for a hybrid stochastic-robust optimization (Birge (1982); Birge and Louveaux (1997)) that enable the study of environmental and other phenomena of importance for electricity policy analysis. These include a new type of power grid model of the Texas system (Li et al. (2012)), a new inter-temporal optimization engine to simulate the operation of a grid with Energy Storage Systems (ESS) (Lamadrid and Mount (2012)), a detailed new generator database, and empirical emission functions (Shawhan et al. (2014)), applied to the Texas generators and incorporating the effects of ramping and starting up. The theoretical analysis uses a stochastic maximization of the total welfare from the point of view of a social planner. The optimization uses CPLEX to find the solution with a Newton Raphson approximation. For the statistical analysis, we use a dataset that comes from the the Electric Reliability of Texas (ERCOT), with forecasts and realizations in hourly time steps.

III. RESULTS

Our preliminary results show that internalizing the cost emissions does not represent a net operating cost for some policies. This is driven by the net non-environmental benefits accrued in total welfare (producer plus consumer surplus). There are distributional consequences, including the transfers from consumers to producers, offsetting part of the 'missing money' due to reductions in income from RES adoption. The modeling of electrical flows using Kirchoff's laws also leads to reductions in wind generators' income, due to congestion in the transmission lines and price separation notably at peak times (Lamadrid et al. (2014)).

IV. CONCLUSIONS

We find that changes such as the use of storage after including ramping and energy CO_2 damages can lead to transfers benefitting consumers at the expense of generators, without significantly reducing the amount of wind dispatched. Overall, there are net operating benefits of

including environmental costs, as well as decreases in CO_2 emissions without affecting the reliability of the system. However such benefits require changes in the regulatory structure and the incentives faced by operators and generators in the system.

NOTES

1. Lehigh University, corresponding author ajlamadrid@lehigh.edu

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