Abstract

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Preliminary Attempt toward Better Understanding the Impact of Distributed Energy Generation: An Agent-Based Computational Economics Approach

The increasing adoption of small-scale electricity generation technologies represents a transition from a hub-and-spoke system of centralized electricity generation to distributed energy resources (DER). Many utilities understand the benefits of DER but are unsure of how to mitigate the associated challenges, including intermittent generation, stranded assets, inability to dispatch, and an inability to control when generation is produced ("must take" energy). Using a bottom-up agent-based computational economics approach, this paper studies the evolving dynamic behaviors that influence the DER investment decisions facing the associated stakeholders. Building off the existing agent-based modeling of electricity systems (AMES) model and using a hypothetical case study in evolving actual data from Tennessee, the New England region, and some other reasonably assumed and verified parameters from the literature the authors developed a proof-of-concept framework to account for the different system components associated with adoption of distributed solar generation (DSG). The interdependent steps included (1) incorporating different transmission and generation features from that of AMES, (2) allowing for customer electricity demand sensitivity to electricity rates, and (3) creating a new end-use customer agent type that allows for investigation of DSG investment behavior. Pursuant to a successful model testing processes including local sensitivity analysis, the model’s architectural design was able to represent the generic characteristics of the DSG domain problem and its potential future application to actual utility data. To this end, the authors present a benchmark simulation that was compared with two counterfactual scenario simulations. Although the results presented in this paper are illustrative and not prescriptive (i.e., the observations and discussions from the hypothetical case study are expected to—and should—change when applied to specific utility companies), they do still highlight a number of interesting trends. First, the declining cost of solar has not yet had a statistically significant impact on customer demand in six of the model’s largest utilities. Second, decreased load demand due to adoption of DSG technologies will have a large impact on high-cost generating units in the model but may have little impact on the lowest-cost generating units. Third, transmission line constraints matter. Despite the promising results, the model still needs more refinements to completely capture the feedback between customer adoption of DSG and utility investments in new generation resources and transmission assets. When complete, this research will result in a decision-support tool that will identify least-cost strategies that utility companies can use to respond to increasing penetration of DER.