Title: Optimal Electricity Distribution Pricing under Risk and High Photovoltaics Penetration

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Abstract: We consider a reverse Stackelberg game between consumers and the regulator in the electricity market, where all players are rational and act merely in goal of the optimization of certain objective functions. We investigate consumers with stochastic electricity demands and different risk characteristics, who decide how much distributed Photovoltaics(PV) electricity they want to generate in order to reduce their net demand from the grid and the associated cost, and, when permitted, to possibly profit by selling their excess PV generation back to the grid. A typical consumer optimizes his PV generation such that his personal expected utility is maximized, as a function of his total cost including electricity generation and distribution costs and PV set-up price. The electricity generation price depends on the overall demand in the market, and thus on every individual's generation decision, which makes it worthwhile to consider the game and the resulting equilibrium among consumers.

We also assume a centralized regulator in the market which sets the electricity distribution fee, but has no direct control over the consumers' consumption. The consumers will then optimize their PV generation in order of maximizing their individual utility. The regulator in turn sets up the distribution fee so as to minimize the electric utility's generation cost to meet the electricity demand across the entire market, while ensuring that a fixed revenue is collected from the distribution fee to recover grid maintenance costs and that a lower bound is satisfied for the total amount of distributed generation. We study the existence and uniqueness of the Nash equilibrium for both the regulator and consumers, and present real-data calibrated simulations to illustrate the coupled decision making.