Designing Compensation for Distributed Solar Generation:
Is Net Metering Ever Optimal?

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The distributed generation of electricity has increased dramatically in recent years. Distributed generation (DG) is popular in part because it can potentially reduce electricity distribution costs, improve system reliability, reduce generation externalities, and limit additional generation, transmission, and distribution capacity investments. However, there is substantial controversy and debate regarding the value of DG resources and the appropriate design of DG compensation policies.

One popular form of DG involves the production of electricity from solar panels installed on the roofs of residential, commercial, and industrial buildings. Owners of solar DG resources often are charged the prevailing retail price of electricity for the difference between the electricity they consume and the electricity they produce. Consequently, these consumers are effectively paid the prevailing retail price for the electricity they produce. Although such "net metering" policies are popular throughout the world, they have generated considerable controversy. Proponents of solar DG contend that, in light of its many benefits, DG should be encouraged via compensation that exceeds the prevailing retail price of electricity. Others argue that compensation for solar DG output at the prevailing retail rate is unduly generous.

Despite the prevalence of DG compensation policies and the controversy that surrounds them, the economic literature provides limited guidance on their optimal design. This paper begins to fill this void by characterizing the optimal DG compensation policy in a simple setting where a regulator can set a unit retail price ($r¿$ for electricity purchased from the utility and a separate compensation rate (w) for each unit of solar DG electricity that is generated. Some consumers can purchase and install solar DG capacity, while others are unable to do so. Installed DG capacity produces a stochastic supply of electricity, depending on prevailing weather patterns, for example. A vertically integrated utility adjusts its electricity supply to meet market demand net of the electricity supplied by solar DG resources. The regulator sets her policy instruments to maximize the difference between consumer welfare and the social losses from environmental externalities, while ensuring non-negative profit for the utility.

We find that the optimal unit DG compensation, w, reflects the corresponding reductions in the utility's generation, transmission, distribution, and network management costs and in the social losses from environmental externalities as solar DG replaces centralized electricity production. We demonstrate that net metering typically is not optimal. For instance, the retail rate r often exceeds w when the fixed costs of centralized electricity production and the network management costs of accommodating intermittent solar DG are large, when the marginal cost of centralized electricity generation varies little with the scale of the utility's operations, and when centralized generation and DG produce similar (pollution) externalities. When these conditions do not hold, though, w can optimally exceed r.

Our analysis demonstrates that there is no single optimal DG compensation policy. The ideal level of DG compensation varies substantially with prevailing industry characteristics.

We employ numerical simulations to illustrate that a net metering mandate can reduce aggregate welfare substantially and can produce pronounced distributional effects. When r exceeds w under the optimal DG policy, a net metering mandate can lead to substantial overinvestment in DG capacity and can increase the welfare of DG consumers at the expense of non-DG consumers. In contrast, when w is set above r to promote DG adoption under the optimal DG policy, a net metering mandate can induce substantial underinvestment in DG capacity and enhance the welfare of non-DG consumers at the expense of DG consumers.

The optimal DG compensation policies that we derive bear some resemblance to DG compensation policies have begun to emerge in practice. To illustrate, "value of solar" policies link DG payments to estimates of the amount by which solar DG reduces the utility's generation, transmission, and distribution costs and reduces the social losses from environmental externalities. Our analysis illustrates how such linkages can enhance consumer welfare above the levels achieved under net metering.