Distribution Network Pricing and Regulation with Significant Distributed Solar Photovoltaic Generation Capacity

by

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1. Introduction

Over the past decade, a number of jurisdictions have installed a substantial the amount of solar photovoltaic (PV) capacity in their distribution grids. This has produced a number of challenges for existing approaches to distribution network pricing and regulation. The lower volume of energy withdrawn from the distribution grid for the same annual fixed cost and operating cost for the grid requires increasing the per unit charge for withdrawing an additional kilowatt-hour from the distribution grid. Particularly for distribution grids with a large number of solar PV installations, investments in grid upgrades are required to manage the time periods when these solar installations make significant net injections to the distribution grid. Finally, the higher retail prices that account for the larger per unit distribution network charges and the above-market costs of meeting renewable portfolio standards goals make rooftop solar facilities increasingly attractive because they allow the consumer to avoid paying these retail prices for their electricity consumption.

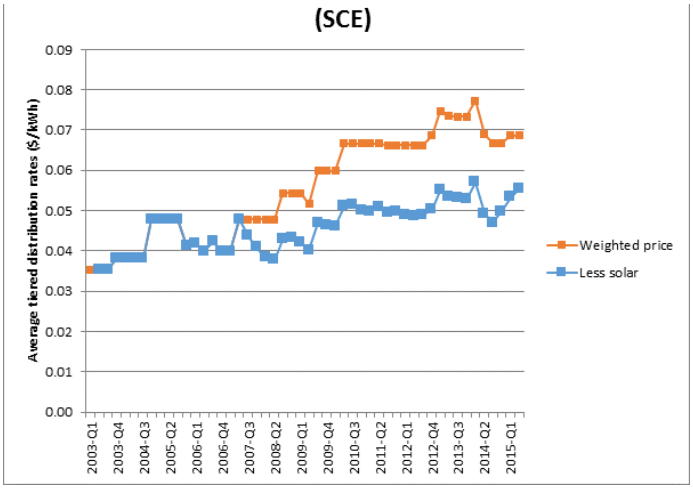
The goal of this research is first to quantify the impact of distribution-grid solar PV capacity installations on the per-unit distribution network charge for each of California's three investor-owned utilities. The second goal is to build on the lessons learned from the California experience to derive economically efficient prices for distribution network services for regions significant distributed solar PV capacity goals. The remainder of this proposal outlines these two research projects.

2. Measuring the Distribution Network Cost Implications of Distributed Solar PV

The first phase of this project uses data on quarterly solar PV installations from the California Solar Initiative from 2007 through 2015 and quarterly distribution network charges for three investor-owned utilities in California—San Diego Gas and Electric, Southern California Edison, and Pacific Gas & Electric—to quantify the impact of quarterly solar installations on quarterly distribution network charges. The econometric models estimated will be extensions of the following basic panel data regression model: $y_{it} = \alpha_i + \gamma_t + x_{it}\beta + \varepsilon_{it}$, where y_{it} is the natural log of the per unit distribution charge for utility i in quarter-of-sample t, α_i is a fixed effect for customer i, γ_t is the fixed-effect for quarter-of-sample t, x_{it} is the natural log of new solar PV installations measured in terms of number or total kilowatts of installed capacity for utility i in quarter t or quarter t-1, β is the unknown parameter to be estimated, and ε_{it} is zero mean disturbance that is orthogonal to the fixed effects and x_{it}.

Running this regression with a preliminary dataset of quarterly residential distribution network charges yields a positive and precisely estimated value for β, indicating that more solar PV installations in the utility's distribution network predicts a higher per unit distribution cost. Figure 1 plots actual per-unit distribution charge for residential consumers and the counterfactual residential distribution charge that takes out the impact of solar installations by subtracting $x_{it}b$, from on y_{it} each quarter, where b, is the ordinary least squares estimate of β for Southern California Edison (SCE). This graph demonstrates that an average of roughly 1.5 cents/KWh of the SCE's residential distribution charge is due to the installation of solar PV facilities in the distribution grid. The other two utilities show similar differences between the actual distribution charge and the counterfactual no-solar-PV distribution charge.

Figure 1: Actual versus No Solar PV Installations Distribution Network Prices



It is important to emphasize that these results are preliminary and further data collection efforts are currently in progress, but these results are at least suggestive of the impact of solar PV installations on residential distribution network charges in California. There is a significant amount of additional data collection and econometric analysis needed to refine this analysis. The distribution charges were collected the California Public Utilities Commission (CPUC). This data will need to be validated and updated through the end of 2015. I will also attempt to compute an estimate of the quarterly distribution charge for different customer classes to assess whether the impact of increasing solar PV deployment is different for different customer classes. In addition, the California Solar Initiative data set compiles information on the capacity of each the solar system as well as what kind of customer—commercial or residential—installed the system. This will allow an investigation of whether the various types of solar PV systems have different impacts on the distribution charges for different classes of customers.

Another line of inquiry currently in progress is an assessment of the impact of solar PV in the distribution grid on quarterly transmission network charges. Compiling this data can provide a "placebo" test of one component of the impact of solar PV installations in the distribution grid. Specifically, the per-unit transmission charge is expected to rise because the cost of the transmission grid remains largely unchanged, but the total amount of withdrawals from the transmission grid falls because of distributed grid solar PV installations. However, it is unlikely that additional transmission grid upgrades are needed to accommodate an increasing amount of distributed solar PV. This has the obvious implication that the impact of solar PV on the per-unit transmission charge should be smaller than that for the distribution charge. This hypothesis will be investigated empirically.

3. More Efficient Pricing of Distribution and Transmission Network Services

This phase of the project will consider the question of efficient pricing of transmission and distribution network services for regions with significant distributed renewable energy goals. The basic challenge is that the marginal cost of withdrawing a KWh from the transmission and distribution grid is virtually zero, but there is a significant pre-existing fixed-cost to both networks that must be recovered. There are also additional fixed costs associated with the investments in the distribution grid to accommodate an increasing amount of distributed solar PV generation capacity. Economically efficient prices for transmission and distribution network services would therefore significantly reduce the per unit charge and find other ways, such as monthly fixed charges or a monthly charge that depends on a customer's peak use of the

distribution grid, to recover the pre-existing fixed cost. Additional charges based on the where and how much solar PV capacity is connected to distribution is also consistent with the economic concept of cost causation.

Another approach to deriving an efficient distribution network price is to mandate an annual revenue requirement to the distribution grid owner but allow it the freedom to set distribution prices for different customer classes subject to only recovering this firm-wide annual revenue requirement. The economic efficiency and political viability of these approaches and similar approaches to transmission and distribution grid pricing with significant distributed generation will be assessed a part of this phase of the project.