Energy Policy 39 (2011) 5243–5253

Contents lists available at ScienceDirect

Energy Policy

journal homepage: www.elsevier.com/locate/enpol

The impact of rate design and net metering on the bill savings from distributed PV for residential customers in California

Naïm R. Darghouth [a,b,*], Galen Barbose [a], Ryan Wiser [a]

[a] Lawrence Berkeley National Laboratory, One Cyclotron Road, MS 90R4000, Berkeley, CA 94720, USA
[b] Energy and Resources Group, 310 Barrows Hall, University of California, Berkeley, CA 94720, USA

ARTICLE INFO

Article history:
Received 4 January 2011
Accepted 21 May 2011
Available online 12 June 2011

Keywords:
Photovoltaics
Retail rate design
Net metering

ABSTRACT

Net metering has become a widespread mechanism in the U.S. for supporting customer adoption of distributed photovoltaics (PV), but has faced challenges as PV installations grow to a larger share of generation in a number of states. This paper examines the value of the bill savings that customers receive under net metering, and the associated role of retail rate design, based on a sample of approximately two hundred residential customers of California's two largest electric utilities. We find that the bill savings per kWh of PV electricity generated varies by more than a factor of four across the customers in the sample, which is largely attributable to the inclining block structure of the utilities' residential retail rates. We also compare the bill savings under net metering to that received under three potential alternative compensation mechanisms, based on California's Market Price Referent (MPR). We find that net metering provides significantly greater bill savings than a full MPR-based feed-in tariff, but only modestly greater savings than alternative mechanisms under which hourly or monthly net excess generation is compensated at the MPR rate.

1. Introduction

An increasing number of states use net metering to compensate electricity produced by photovoltaic (PV) system owners.[1] Though specific design details vary, net metering allows customers with PV systems to reduce their electric bills by offsetting their consumption with PV generation, independent of the timing of the generation relative to consumption—in effect, selling PV generation to the utility at the customer's marginal retail electricity rate (Rose et al., 2009).

Though net metering has played an important role in jump-starting the PV market in the United States (U.S.), challenges to net metering policies have emerged in a number of states and contexts, and alternative compensation methods are under consideration. Moreover, one inherent feature of net metering is that the value of the utility bill savings it provides to customers with PV depends heavily on the structure of the underlying retail electricity rate, as well as on the characteristics of the customer and PV system. Consequently, the bill-savings value of net metering – and the impact of moving to alternative compensation mechanisms – can vary substantially from one customer to the next. For these reasons, it is important for policymakers and others that seek to support the development of distributed PV to understand both how the bill savings benefits of PV vary under net metering, and how the bill savings under net metering compare to savings associated with other possible compensation mechanisms.[2]

To advance this understanding, we analyze the bill savings from PV for residential customers of California's two largest electric utilities, Pacific Gas and Electric (PG&E) and Southern California Edison (SCE), based on actual hourly load data from 215 customers within the two utilities' service territories. We focus on these two utilities, both because we had ready access to a sample of high temporal resolution load data, and because their service territories are the largest markets for residential PV in the country.

We first compute the bill savings based on current net metering rules and retail electricity rates, and then examine a number of critical underlying issues that influence the value of bill savings under net metering, including retail rate design, PV system size, PV orientation, and customer load characteristics. Next, we compare the value of the bill savings under net metering to three potential alternative compensation mechanisms, each of which credits some or all PV production at prices based on the

* Corresponding author at: Lawrence Berkeley National Laboratory, One Cyclotron Road, MS 90R4000, Berkeley, CA 94720, USA. Tel.: +1 510 486 4570.
E-mail address: ndarghouth@lbl.gov (N.R. Darghouth).

[1] As of November 2010, 43 states and Washington, DC required some or all utilities to offer net metering, and utilities in 3 additional states offered net metering voluntarily (DSIRE, 2010). Some states in Canada and Australia also offer net metering.

[2] We note that the customer economics of PV is just one of many issues and trade-offs that policy makers and state utility regulators consider with respect to rate design, net metering, and policies for supporting solar deployment.

0301-4215/$ - see front matter © 2011 Elsevier Ltd. All rights reserved.
doi:10.1016/j.enpol.2011.05.040

state's Market Price Referent (MPR)—the price intended to represent long-run avoided generation costs uses to evaluate wholesale contracts with renewable generators (CPUC, 2009).

The boundaries and limitations of the analysis presented in this article should be clearly acknowledged. First, the current residential retail rates offered by PG&E and SCE are unique in several respects, and thus the specific findings presented in this report cannot necessarily be generalized to apply to other utilities or states. Second, the analysis is based on a sample of customers that, while geographically diverse, may not be statistically representative of the entire population of residential customers in either PG&E's or SCE's service territories, and may not be representative of the current population of residential customers with PV systems. Third, the analysis focuses exclusively on the value of the bill savings provided to customers with PV; it does not consider the overall cost-effectiveness of distributed PV for an individual customer, nor does it consider the value or cost-effectiveness of distributed PV from the perspective of the utility, non-participating ratepayers, or society-at-large. Finally, in comparing net metering to several alternative compensation mechanisms, we focus exclusively on the value of the bill savings or bill credits provided to customers through each compensation mechanism; net metering may provide other advantages and disadvantages (both financial and otherwise) relative to the alternative compensation mechanisms considered, but these are not covered in the analysis presented here. For example, alternatives to net metering that entail explicit sales of electricity by the customer to the utility may be subject to income taxes, may give rise to federal regulatory compliance requirements, and could potentially interfere with common customer financing mechanisms like third-party power purchase agreements (PPAs)/leases and property assessed clean energy (PACE) financing.

The remainder of this article is organized as follows. Section 2 briefly summarizes the existing literature addressing the impact of retail rate design and net metering on the bill savings from PV. Section 3 describes the data used within our analysis and the basic analytical framework used to calculate customer utility bills and the value of the bill savings from PV under net metering and under each of the alternative compensation mechanisms. Section 4 presents intermediate results showing how the least-cost rate, among the set of residential retail rates offered by each utility, varies with PV system size for customers with net metered PV systems. Section 5 describes the value of the bill savings from PV under net metering and the associated variability across customers, including several sensitivity analyses to explore how different rate choices and PV panel orientations impact the bill savings. Section 4 also examines three alternative compensation mechanisms for distributed PV, and compares the value of the bill savings between each of these alternatives and net metering. Finally, conclusions and policy implications are presented in Section 6.

2. Literature review

This paper, which is based upon a more expansive analysis presented in Darghouth et al. (2010), builds on a body of literature that has approached different aspects of net metering, rate design, and renewable electricity generation. Most closely related, perhaps, is a recent cost-effectiveness study of net metering in California (Energy and Environmental Economics, 2010), which evaluated the total costs and benefits to the utility and its ratepayers of compensating hourly excess PV generation at retail rates, rather than at avoided costs. In comparison, the present paper estimates the total bill savings under net metering, including the bill savings both from directly offsetting contemporaneous usage and from compensating hourly excess PV generation at retail rates.

Other prior studies have investigated the customer economics of PV under net metering and its relationship to retail rate structures. Of particular note, Borenstein (2007) calculated the bill savings for net-metered residential customers of PG&E and SCE with 2 kW PV systems, in order to determine whether mandatory time-of-use (TOU) rates for PV customers would cause a reduction in bill savings. The present study relies on the same sample of customer load data as used in Borenstein (2007), updating the analysis based on the set of residential retail rates offered by PG&E and SCE in early 2010, and extending the analysis by evaluating bill savings under varying PV system sizes and by comparing the value of the bill savings between net metering and several alternative compensation mechanisms.

Other related studies include Hoff and Margolis (2004), Borenstein (2005), Borenstein (2008), and Bright Power Inc. et al. (2009), all of which show that net-metered time-of-use and/or real-time pricing rates can increase the value of PV generation to the customer. MRW and Associates (2007), meanwhile, evaluate which retail rate structures provide the greatest benefits to different classes of PV customers in California. Mills et al. (2008) investigate the impact of retail rate structure on the value of bill savings for commercial customers in California, focusing in part on the extent to which PV can reduce customer demand charges. VanGeet et al. (2008) calculate the rate impacts of demand charges and energy charges on the bills of commercial customers with PV systems in the city of San Diego. Finally, Cook and Cross (1999) estimate the costs and benefits of net metering in Maryland from the perspectives of participating customers, non-participants, and utility shareholders, based on a hypothetical net-metered PV customer.

3. Data and methodology

3.1. Utility tariff descriptions

The analysis presented in this paper is based on the residential retail electricity rates and net metering rules offered by PG&E and SCE, as of March 2010. For both utilities, the default residential tariff is a non-time-differentiated (i.e., "flat") inclining block rate, with five usage tiers and increasing prices for usage within each successive tier, the E-1 and D rate for PG&E and SCE, respectively. The lowest tier (Tier 1) is referred to as the baseline allotment; its size varies according to the region in which the customer is located and is designed to cover 50–60% of average monthly electricity consumption for customers in the region (CPUC, 2010). The other four tier levels are defined as percentages of the baseline, with Tier 5 defined as all usage $>300\%$ of the baseline. A unique feature of the two utilities' rates are that the prices for successive usage tiers are quite steeply inclined, rising from \$0.12/kWh in Tier 1 to \$0.50/kWh in Tier 5 for PG&E, and from \$0.13/kWh to \$0.31/kWh for SCE.

Both utilities also offer residential time-of-use (TOU) rates – the E-6 and the TOU-D-T rate for PG&E and SCE, respectively – under which prices vary according to both the season (summer vs. winter) and the time of day, with either two or three TOU periods during each day, depending on the utility. The TOU rates also include usage tiers within each TOU period, and monthly consumption within each TOU period is charged according to the tier within which it falls. One important difference between PG&E's and SCE's residential TOU rates is that PG&E's has five usage tiers within each TOU period (similar to its default residential tariff), whereas SCE's has only two usage tiers within each TOU period. Further details on the residential electricity rates offered by PG&E and SCE can be found in Appendix A.

The utilities' residential net metering tariffs allow customers to offset volumetric charges within each billing period, but fixed