ARTICLE IN PRESS

Utilities Policy xxx (xxxx) xxx–xxx

Contents lists available at ScienceDirect

Utilities Policy

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

Customer bill impacts of energy efficiency and net-metered photovoltaic system investments

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ARTICLE INFO

Keywords:
Utility regulation
Customer bills
Rate design

ABSTRACT

Utility regulators and policymakers are concerned about potential increases in retail rates driven by energy efficiency (EE) programs and distributed solar photovoltaic (PV) systems, which may adversely affect utility customers that do not invest in these technologies (i.e., non-participants) and more so than those that do (i.e., participants). We assess customer bill impacts of illustrative EE programs and net-metered PV systems for a prototypical northeast utility. We find that the timing of customer EE or PV investments matters and that modest energy savings may fail to yield financial benefits sufficient to offset concomitant increases in retail rates.

1. Introduction

Customer-funded energy efficiency (EE) spending in the United States almost tripled from 2007 to 2014 (CEE, 2016; CEE, 2008) and EE programs in 16 states each generated more than a 1.0% annual reduction in utility sales in 2015 (Gilleo et al., 2015).[1] These savings levels will likely increase with spending on EE programs projected to double again from 2010 levels by 2025 (Barbose et al., 2013). Similarly, though at a smaller scale,[2] distributed solar photovoltaic (PV) penetration is projected to reach 2.9% of U.S. retail electric sales in 2020, with several states expected to see penetration rates in excess of 5.0% (GTM and SEIA, 2015). Many of the states with greater EE savings levels (i.e., greater than 1.5% per year) are also expected to see higher PV penetration rates. While EE programs and distributed solar PV provide numerous utility, customer, and societal benefits (including utility cost reductions, lower customer bills, and achievement of clean energy public policy goals), they also contribute to potential stagnant or declining retail sales for electric utilities and put upward pressure on retail electricity rates in order to meet revenue requirements (Moskovitz, 1989; Eto et al., 1994; Moskovitz et al., 2000).

Utility regulators and policymakers are concerned about potential increases in retail rates, which may adversely affect customers that do not invest in EE measures or PV systems (i.e., non-participants) and more so than customers that do (i.e., participants). This potential for cost shifting has led to some hesitance about expanding ratepayer-funded EE program budgets or policies to advance the adoption of distributed generation (e.g., net energy metering).

Analyzing and understanding changes in utility rates and customer bills can inform the debate about the merits of promoting expanded adoption of EE and PV (SEE Action, 2011). Specifically, analyzing bill impacts on participating and non-participating customers illustrates how the outcomes associated with achieving broader societal goals may vary among distinct customer groups. In addition to assessing net financial benefits of clean energy policies, policymakers and regulators are also concerned about the distributional financial effects of alternative regulatory and ratemaking approaches on different groups of customers, including low-income customers.

The limited work to date quantifying the financial implications of EE and PV for both utility shareholders and ratepayers has focused on these investments in isolation (e.g., Cappers and Goldman, 2010; Cai et al., 2013; Satchwell et al., 2015a; Boero et al., 2016). However, many states with the highest level of savings from EE programs also have high rates of distributed solar PV adoption. For example, four of the top-ten ranked states for energy efficiency (CA, MD, NY, and MA) have PV penetration rates that are well above the national average (Gilleo et al., 2015; GTM and SEIA, 2015).[3]

Abbreviations: AEV, aggressive EE/PV; BAU, business-as-usual; C&I, commercial and industrial; DER, distributed energy resource; DOE, Department of Energy; EE, energy efficiency; LED, light emitting diode; NE, northeast; NEM, net energy metering; PV, solar photovoltaic; RECS, residential energy consumption survey

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[1] CEE (2008) reported electric and gas utility budgets of $2.6B for energy efficiency in 2007 and CEE (2016) reported $6.9B in spending in 2014. We exclude load management/demand response program spending.

[2] Barbose et al. (2016) estimated the cumulative impacts of EE to be 15 times greater than the cumulative impacts of distributed PV through 2014.

[3] Gilleo et al. (2015) ranked states by their level of efficiency savings and presence of enabling policies.

https://doi.org/10.1016/j.jup.2017.12.003
Received 27 July 2017; Received in revised form 12 December 2017; Accepted 13 December 2017

Please cite this article as: Satchwell, A., Utilities Policy (2017), https://doi.org/10.1016/j.jup.2017.12.003

A number of studies have looked at the impacts of EE or distributed solar PV on participant and non-participant bills, but never jointly. Several studies have examined customer bills under net energy metering (NEM) for distributed solar PV as compared to other compensation mechanisms for generation sold back to the electricity grid (such as feed-in-tariffs, value-of-solar tariffs, and wholesale market prices). These studies primarily focus on residential customers and are based on state-specific rates and policies (e.g., Darghouth et al., 2011, 2013, 2016). Woolf (2013) analyzed customer bill impacts among EE participating customers with quantitative examples illustrating foundational concepts.

This analysis takes into account several different perspectives on the types and timing of EE and distributed solar PV investments representing some of the key sources of variability in bill impacts. Specifically, we assess participating customer bills among cohorts representing different initial energy and peak demand levels. We also assess bills for customers that chose to invest earlier versus those that invest later in the analysis period. The choice of investment (EE measures or PV system) and the magnitude of the associated energy and demand savings also play a pivotal role in customer bill impacts. Finally, regulatory and ratemaking strategies that are intended to mitigate the effect of declining sales on a utility's ability to fully recover its revenue requirements, including fixed costs (IEI, 2014; NCCETC, 2016), may have varying bill impacts across the customer cohorts.

We note several key boundaries of the study scope and its methodology to distinguish our research from cost-benefit studies and to ensure that the findings are appropriately interpreted and applied. First, the present study is not a detailed analysis of the value of EE or distributed solar PV. In this study, we use a financial model that contains a relatively high level of detail in its representation of utility ratemaking and cost recovery processes, but less detail in its representation of the physical utility system. As a result, the impacts of EE or distributed solar PV on utility cost of service are based on a coarser set of assumptions than what might be possible with integrated and dynamic models of utility operations, including those used for planning.[4]

Second, the analysis is focused narrowly on changes in customer utility bills under existing models of utility regulation in the Northeast United States. Our analysis does not consider any broader societal benefits of EE and distributed PV (e.g., reduced emissions, economic development, and energy security). Furthermore, by limiting the scope of our analysis to net-metered PV, we do not address potential impacts to participating and non-participating customers that may occur under other compensation schemes, such as feed-in tariffs, value-of-solar tariffs, and wholesale market prices.

2. Approach

We quantify customer electricity bills based on changes in utility load, costs, and collected revenues for a northeastern, distribution-only utility that achieves aggressive EE savings and PV penetration levels driven by state clean energy policies compared to a business-as-usual (BAU) case. Our goal is to quantify the diversity of bill impacts on the present value of annual electric bills during the ten-year analysis period (2017–2026) based on a customer's decision whether or not to invest in EE measures or PV systems.

We chose to model a northeastern (NE) utility because the region has historically achieved high levels of energy savings from EE programs and substantial customer investments in their own PV systems. Six states in the region (Connecticut, Maine, Massachusetts, New York, Rhode Island, and Vermont) adopted EE resource standards that obligate utilities to achieve specified savings goals (Gilleo et al., 2015). Five NE states (Massachusetts, Vermont, Delaware, New Jersey, and New Hampshire) have relatively high PV penetration levels that are expected to significantly increase over the next five years (GTM and SEIA, 2015). All NE states have NEM policies in place in addition to various state-level incentives for distributed generation, which are key drivers for PV deployment (NCCETC, 2016).

This analysis uses annual class-level retail rates for energy (¢/kWh), demand ($/kW), customer ($/customer), and balancing accounts (¢/kWh) charges derived from a pro-forma financial model that takes into account a prototypical NE utility's financial, operational, and regulatory characteristics as well as class-level rate design. For the NE utility, we modeled the impacts of an aggressive EE and distributed solar PV portfolio, estimating changes to utility costs, revenues, retail rates, and shareholder profitability. While EE and net-metered PV result in impacts to utility shareholders, we limit our analysis herein to rate and bill impacts.[5]

The retail rate impacts used in this analysis were first assessed under a BAU scenario assuming a modest amount of energy savings from EE programs and PV systems pursuant to representative policies in several New England states, which establishes a reference point against which to measure impacts of a more aggressive EE and distributed solar PV (AEV) portfolio.

The AEV portfolio was based on goals associated with extrapolated EE savings and forecast distributed solar PV adoption for Massachusetts, which produced significant declines in the NE utility's forecast retail sales and peak demand (see Table 1 and Table 2). The AEV portfolio also produced reductions in NE utility total costs by 3% based on the modeled relationships among electricity sales, peak demand, and the utility's fixed and variable costs. In aggregate, total collected revenues from customer bills decrease by 5% for the AEV case compared to the BAU case.

All-in average retail rates for the NE utility in the AEV scenario increase by about 3% each year during the analysis period compared to a 2% annual average increase in all-in average retail rates in the BAU scenario. Fig. 1 shows the all-in average retail rates in the BAU and AEV scenarios for the ten-year period we used to calculate customer bill impacts and the more dramatic increase in all-in average retail rates in the AEV scenario, in particular. This significant increase in average all-in retail rates in the AEV scenario is driven by several factors. First, the utility's revenues decline more than their costs because the combined EE and PV portfolio reduces only a small portion of the NE utility's non-fuel costs, which tend to be fixed in the short term. Second, the utility's revenue requirements must be spread over significantly lower retail sales.[6]

2.1. Customer cohort assumptions

We develop an analytical approach intended to be illustrative of a range of potential customer bill impacts. We do not model the entire population of customers for the NE utility but instead develop representative customer cohorts that are likely to participate in various types of EE programs or invest in PV systems.

We first create sub-populations of customers that, based on their usage profiles relative to the class average, are eligible to participate in a single EE program (namely, a commercial rebate program targeted at smaller business or industrial customers, a custom rebate program targeted at large commercial and industrial (C&I) customers, a residential low-income program, and a residential consumer product rebate program) or install a PV system (see Fig. 2 and Fig. 3).[7] Each

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[4] Satchwell et al. (2015a) included numerous sensitivity analyses to examine how the financial impacts of distributed PV would vary with alternate assumptions related to avoided costs.

[5] Readers interested in impacts on utility shareholder profitability are referred to Satchwell et al. (2017).

[6] See Satchwell et al. (2017) for a characterization of the NE utility, a review of modeling assumptions, and a discussion of the key drivers for changes in utility sales, demand, costs, and revenues.

[7] This is a simplifying assumption that allows us to illustrate and isolate the impacts of decisions by participants to invest in specific EE or PV technologies. Customers of various consumption levels may invest in both.