Policy Brief

Designing Electric Utility Rates: Insights on Achieving Efficiency, Equity, and Environmental Goals

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Key Points: Guiding Principles for Utility Regulators

Pricing electricity so that it more accurately reflects the costs of its supply and delivery can help achieve efficient and effective mobilization of clean energy resources, more equitable outcomes, and less pollution. Technological innovations, which are changing how the electric grid is managed and operated and how prices can be communicated to electricity customers, offer regulators an opportunity to price and regulate electricity services in new ways. This policy brief aims to help regulators identify a path forward that takes advantage of this opportunity in order to reduce total electricity and environmental costs in ways that are both acceptable and fair. In particular, we urge regulators to use efficiency as a guiding principle in their rate setting in order to achieve cleaner and fairer outcomes.

- **Efficiency.** Economically efficient policies and regulations can be used to reduce the distortions caused by simplistic tariffs and integrate clean distributed energy resources (DERs)[1] into the system in a cost-effective and equitable manner. This requires applying the principle of cost causation[2] so that prices and rates for electric supply and delivery services reflect the underlying system costs and the environmental costs of electric consumption.
- **Equity.** The principle of efficiency can also be used to help achieve equitable outcomes, by, for example, eliminating cross-subsidies across different consumer groups. It can also be used to achieve distributional equity outcomes; in particular, implementing more cost-

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[1]DERs are resources owned or operated by the electric customer, rather than the utility, and can include a variety of resources, from technological ones (such as rooftop solar and batteries) to energy efficiency and demand response.
[2]Rates that achieve cost causation–priced electricity services based on the true costs of consumption.

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reflective time-varying prices can benefit low-income households that use less electricity during costly hours.

- **Environment.** Efficiency can also be used to reduce pollution such as carbon emissions from the electric sector. Imposing the social cost of pollution, such as the social cost of carbon (SCC),[3] on all emitters is the most efficient way to do this. This principle needs to be applied to all sources that contribute to supply—both large-scale generators and distributed generation sources.

An Opportunity and a Challenge

The electric industry worldwide is experiencing transformative technological change with the increasing penetration of renewables and DERs and the development of smart grid capabilities. These trends provide an opportunity to diversify and improve the reliability of electric service while increasing consumer choice, reducing pollution, and lowering total system costs. However, these developments also present a challenge to electric utilities because DERs create new categories of customers that are both receivers and providers of electric services. This conflicts with the traditional approach of rate setting for electricity services, which, for reasons of perceived fairness and simplicity as well as a lack of advanced metering infrastructure (AMI), divided customers into relatively homogeneous customer classes and charged all customers within a class the same simplistic non-cost-reflective rate (e.g., a flat volumetric rate, with a single price per each kilowatt-hour [kWh] consumed in the month). Equity concerns were frequently used to argue against more efficient cost-reflective pricing and, historically, simplistic rates made sense. In an environment with growing demand, a technological inability to distinguish different customer load patterns, and limited customer access to affordable distributed generation technologies, flat volumetric rates spoke to some notion of equity for most customers. However, such rates do not reflect cost causation across the electric system and, as DERs and AMI become more prevalent (see Edison Foundation 2014), it is neither necessary nor optimal to continue to rely on rate setting that favors such simplicity.

We will argue here that utilities should use efficiency as a guide for crafting more cost-reflective rates that take customer heterogeneity into account, while also allowing social goals such as distributional equity and environmental stewardship to be met. In fact, we argue that efficiency can be a guiding principle with which to achieve desired equity outcomes rather than one that reduces equity. In the remainder of this article we will first discuss the arguments for cost-reflective rates and then we will examine how to address compensation for DERs, equity concerns, and the social and environmental costs of pollution when designing tariffs. We conclude with recommendations for regulators and policymakers.

The Efficiency Principle—Arguments for Cost-Reflective Electricity Tariffs

Achieving cost-reflective rates requires understanding how electricity consumption drives underlying system and environmental costs. In this section we will discuss these underlying

[3]In the United States, the SCC has been estimated by the Interagency Working Group (2013) to enable agencies to incorporate the social benefits of reducing carbon dioxide (CO_2) emissions into benefit–cost analyses of regulatory actions.

costs and how both electricity consumption and the ownership and operation of DERs affect them.

Costs Vary with Time and Location

Due to fluctuations in the level of demand and—increasingly—fluctuations in supply from intermittent renewable generation sources, the cost of generating electricity and its associated environmental impact vary substantially over the course of the day (Joskow 2008; Borenstein 2011; Kaffine, McBee, and Lieskovsky 2013). In addition, many large distribution infrastructure costs are fixed in the short run, while in the long run, infrastructure is built up to meet maximum peak demand (kilowatts) rather than consumption (kilowatt-hours)[4] (Pérez-Arriaga and Bharatkumar 2014). With infrastructure capacity being fixed in the short run, costs also vary by both location and time due to transmission constraints and local distribution capacity constraints (Sotkiewicz and Vignolo 2005; Olmos and Pérez-Arriaga 2009). Because flat volumetric rates (which charge customers per kilowatt-hour of consumption) do not reflect locational or time differences in costs, they do not signal to customers when or where the costs of generation and distribution are highest. This lack of an accurate price signal results in suboptimally high peak demand, thereby driving more infrastructure investment and increased costs, as well as cross-subsidies between customers.[5] A more efficient, cost-reflective tariff can reduce costs by reducing peak demand and at the same time increase equity by reducing cross-subsidies.

The Role of New Technologies and Customer Heterogeneity

The disconnect between flat volumetric rates and cost causation was less of a problem in the past because customer classes were more homogeneous. However, as new technologies become available for managing customer load (e.g., smart thermostats, rooftop photovoltaics, batteries), customer classes will include increasingly diverse customers, challenging the idea that flat rates are fair. With the growing deployment of AMI, it is now becoming possible to identify customers with different load patterns and to charge them more sophisticated rates that more accurately reflect costs. Such rates would reduce the existing cross-subsidies between customers who use more electricity at peak times and those who use more at off-peak times and between customers who have installed a DER and those who have not. It is also important to emphasize that having more cost-reflective rates incentivizes customers to respond to peak prices by changing their load patterns and potentially investing in DERs in a way that will reduce total system costs in the long run, thus also reducing the total electricity bill facing electric ratepayers.

Two major challenges for regulators remain: how to efficiently compensate DERs in ways that will accurately reward the benefits these technologies provide to the system and the

[4]To use the example of household appliances, the wattage of an appliance (kilowatts) measures the amount of energy it utilizes per second, whereas kilowatt-hour measures the total amount of energy the appliance consumes over the course of an hour. Thus a customer utilizing two appliances at the same time will use more total kilowatts but the same amount of kilowatt-hours than if the two appliances were run at different times.

[5]These cross-subsidies can occur across locations or times. That is, customers with flat loads subsidize those who utilize a lot of peak demand and customers in noncongested areas subsidize customers in areas with more system constraints.

environment and how to ensure equity across all customer groups, especially the most vulnerable customers.

Efficient Compensation for DERs—The Role of Rate Design

DERs make it possible for customers to avoid paying for electric supply and delivery by generating their own electricity or by reducing their consumption (such as through energy efficiency or smart thermostats). In many places, residential and small commercial customers who generate their own electricity have also been able to export unused electricity to the grid and be credited at the retail rate of electricity—an approach called net energy metering (NEM). However, there is currently significant debate about NEM among U.S. utilities, regulators, solar companies, and consumer advocates (Cardwell 2016). NEM is controversial mainly because the underlying rate that customers pay for electricity (which, through NEM, is also the rate they are paid for their generation) does not accurately reflect the cost of that consumption.

Because electricity rates do not generally reflect utilities' actual costs, a customer's reduced bill due to DER ownership does not provide compensation that accurately reflects the benefit the DER provides to the system and the environment. If DERs are overcompensated,[6] then the resulting reductions in customer bills can cause a reduction in the utility's revenues without a corresponding reduction in its costs; this revenue shortfall is borne by other utility customers who will then face higher electricity rates. Fair compensation for DER owners requires that the utility accurately value the DERs' contribution to avoided or reduced system and environmental costs.

As NEM has become more controversial, it has spurred discussion about alternative approaches to DER compensation. One alternative to NEM that is already used in some areas is the "value of resource" approach, whereby the customer is charged one rate for consumption and paid another price for generation. However, to provide the right incentives for cost-effective long-term investments in DER, such an approach requires that the services that DERs provide be unbundled and accounted for separately when determining compensation. In addition to the generation of the energy commodity, DERs can provide a multitude of benefits, including, but not limited to, potential avoided infrastructure investments, voltage and ramping support, and, in the case of clean DERs, reductions in pollution. Because these benefits vary over time and space, the compensation for these benefits should also vary and be considered separately.

If done accurately, the value of resource approach could help bring about more efficient DER investment and utilization. However, the least-cost approach to DER integration is achieved by having customers face rates for both consumption and any electricity exports to the grid that are unbundled with respect to the different services received and provided (e.g., energy commodity and delivery services), thereby reflecting how costs vary over time and space. Because they would be avoiding such cost-reflective rates through self-generation or energy efficiency, DER customers would be compensated more accurately for their services.

Electricity tariffs that better reflect the underlying cost of electricity services and provide price signals that indicate where and when capacity is most constrained fairly value DERs and fairly compensate the investors. Furthermore, these tariffs provide an incentive to invest in DERs in

[6]Relative to the benefit they provide to the system.

locations where those resources are most valuable to both the customer and the electric system; in the long-run, this can help save money for all utility ratepayers. Thus cost-reflective rates can make the electric system more economically efficient and also address the fairness concerns regarding cross-subsidies between DER and non-DER customers.

It is often argued that basing DER compensation on cost causation is unfair because it could negatively affect some investors' rates of return (especially for distributed solar generation), which depend on current non-cost-reflective rate structures (O'Sullivan and Warren 2016). If the least-cost approach raises concerns for policymakers about potentially reducing DER investment below levels set by public policy goals, then an economically efficient policy would be to offer direct upfront subsidies to DERs that are not tied to the rates (Amatya et al. 2015). Subsidies coupled with a more cost-reflective tariff would help stimulate investments in DERs by increasing the return on investment while also providing accurate price signals that direct DER investments and use to times and locations where the social benefits are the greatest.

To summarize, economically efficient policies can be used to (1) avoid any cross-subsidies that may occur from NEM coupled with non-cost-reflective tariffs, (2) provide correct price signals to all electricity customers, and (3) allow the growing DER market to thrive, thus providing a clean alternative to dirty generation.

Addressing Equity Concerns—Rate Reform and Low-Income Customers

In addition to achieving equitable outcomes for both DER and non-DER owners, regulators face the challenge of ensuring equity across all customer groups, especially among the most economically vulnerable customers. Historically, special consideration has been given to low-income customers and other vulnerable customer groups (e.g., the elderly and sick) during the rate setting process.[7] For example, many utilities provide discounts for these customers, generally in the volumetric portion of the bill and often in the fixed charge as well. Although providing a volumetric price reduction makes electricity service more affordable for these customers, it also weakens the price signal and can thus reduce the incentives for these customers to conserve or buy energy efficient appliances. In addition, it discourages third parties (e.g., companies developing smart technologies) from offering these customers DER options that could help lower their electricity bills.

With the increased penetration of AMI, other options become available for adjusting tariffs to accommodate customers' ability to pay. For example, many utilities are now able to track their customers' load profiles with AMI and can consider implementing more efficient time-variant pricing (Badtke-Berkow et al. 2015). However, many consumer advocates reject such cost-reflective tariffs, arguing that vulnerable customers tend to be home during the day and are therefore less able to shift consumption away from the times of day when electricity costs are the highest,[8] resulting in higher bills for these customers (Utility Reform Network 2013). In fact, however, many low-income customers tend to have flatter load profiles (see, e.g., Faruqui, Sergici, and Palmer 2010), suggesting that under a non-time-variant rate, these customers are

[7] See Bonbright (1961, chap. 9) for a discussion of equity in rate setting.
[8] See e.g., http://stopsmartmeters.org/2011/08/09/why-%E2%80%9Csmart%E2%80%9D-meters-are-a-class-issue/.

actually subsidizing richer customers with more peaky load profiles, which is the very antithesis of equity. In such cases, these vulnerable customers would clearly gain under more cost-reflective tariffs. Moreover, several pilot programs have demonstrated that low-income customers were able to shift their load toward off-peak periods (Faruqui, Sergici, and Palmer 2010). Thus more cost-reflective tariffs may in fact help to achieve the principle of distributional equity.

Further pilot testing of cost-reflective rates is needed to ensure that these tariffs will indeed benefit vulnerable customers. If some cost-reflective tariffs were found to increase costs for vulnerable customers, utilities could still implement the more cost-reflective tariff but reduce fixed charges or provide flat sum bill credits to low-income customers so that their bills did not increase. Such lump sum benefits are efficient because they would help reduce the electric bill without distorting the price signal for electricity consumption. Thus efficient pricing can achieve the distributional equity principle while helping to reduce cross-subsidies across income groups.

Environmental Principles—Efficiency Requires a Price on Carbon and Other Pollutants

Pollution imposes costs on society. Thus to achieve economic efficiency, the price paid for electricity must also reflect the social and environmental costs of the pollution from electricity generation.

In the case of climate change, the additional damages imposed per ton of carbon dioxide (CO_2) emissions—known as the SCC—have been estimated to be at least \$40 per ton (Interagency Working Group 2013). This estimate is increasingly being applied in U.S. regulatory policy.[9] Other pollutants such as nitrogen oxides (NO_x), sulfur dioxide (SO_2), and particulate matter also impose measurable costs on human health and the environment, although the social costs of these pollutants vary significantly with location (EPA 2016a, 2016b, 2016c).

Including a price on pollution in the cost of electricity means that costs will increase for fossil fuel–fired generators relative to clean renewables. This causes the wholesale market price for electricity to increase during dirtier times of the day, encouraging customers to shift their use away from dirty, high-priced sources and times of day and thus reducing pollution. Without an economy-wide price on pollutants, regulators can attempt to correct for the resulting externalities, for example, by paying customers with clean DERs for the environmental benefits they provide to the system or charging customers with dirty DERs for the pollution they cause (NARUC 2016). However, this approach will not produce the same environmental benefits as would be produced by an economy-wide price on pollutants.

Depending on the local situation, additional action by the policymaker may be required to ensure that an implemented pollution pricing mechanism is effective in the electric sector:

(1) *An economy-wide pollution price is already in place that reflects the costs imposed on society from the pollutant*, achieved either by imposing a tax or creating a cap and trade system on all sectors of the economy. In this case, no further action is required by the regulator.

[9] See, e.g., the use of the SCC in the state of New York's benefit–cost analysis framework for electric utilities (State of New York Public Service Commission 2016, p. 18).

(2) *A price on pollution exists, but it is much lower than the social cost.* In this case, the policymaker should push for an increase in the tax or a reduction in the supply of allowances in the trading scheme, which will cause the allowance price to rise.

(3) *A price on pollution exists, but it is not implemented economy-wide.* Importantly, if the price applies only to large, central generation, then leakage towards dirty distributed resources (which are not covered by the policy) may occur (Christiansen and Stein 2016). Failure to account for the pollution from distributed sources will distort incentives to invest in clean sources and provide an implicit subsidy to polluting distributed generators. In this case, the price on pollution should be extended to the other sectors of the economy, or if this is not politically feasible, separate regulations should be introduced to control emissions from polluting DERs.

How to Make It Happen—Recommendations for Regulators and Policymakers

Regulators and policymakers should consider the following when structuring electric utility rates:

(1) **Efficiency can be used to achieve equitable outcomes:** Though ensuring distributional equity in rate making is an important social goal, it is important to do this in a way that does not distort customers' price signals. An efficient policy would pair a cost-reflective rate structure with fixed bill credits to low-income customers.

(2) **Efficiency can be used to achieve optimal DER investment:** If there is concern that adopting efficient rates would decrease the returns to DER investments, a cost-effective policy would be to pair a more efficient new rate structure with an upfront rebate to ensure that these types of technologies continue to be adopted at the level deemed socially desirable.

(3) **Efficiency can be used to achieve environmental goals:** Efficient pricing requires that the social cost of pollution caused by fossil fuel–based electricity generation be internalized into the electricity price, for both centralized and distributed sources, helping reduce the environmental impact of electricity to an efficient level.

(4) **More cost-reflective rates lead to a more efficient system**: Efficient rates reflect both short- and long-run marginal costs and provide clear and separate price signals for the electricity commodity and delivery services, which have very different cost structures. Ensuring that customers receive price signals that reflect the costs that their use imposes on the different parts of the system will result in more optimal use patterns.

(5) **More cost-reflective rates reduce system costs**: Having electricity prices reflect costs gives customers the ability to reduce their electricity bills by changing their use patterns and investing in DERs. These responses will decrease overall costs in the long run.

(6) **Advanced metering infrastructure is a prerequisite to cost-reflective rates:** More cost-reflective prices will require smarter meters to measure consumption patterns in a more granular fashion, as well as an investment in data management, data storage, and updated billing systems. If AMI is already installed, then introducing cost-reflective rates can increase the total benefits of the AMI investment for utility ratepayers.

(7) **Pilot programs can help:** To ensure that the expected outcomes are achievable, rigorous pilots programs are needed to test innovative, cost-efficient rate designs in terms of their impacts on loads and bills and to assess customer understanding and acceptance of the rate.

(8) **Cost-reflective tariffs should be opt-out:** If it is legally possible, the choices for customers should be framed as "opt-out" rather than "opt-in," because when customers must actively choose to participate in a program (i.e., opt-in), recruitment rates are much lower than when they are automatically enrolled but can opt-out.[10] This approach will help ensure that more customers participate in the program, leading to larger overall decreases in costs.

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[10]See, e.g., Potter, George, and Jimenez (2014).

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