Rethinking Electric Rate Design:
A Policy Summary

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The impacts of climate change are no longer distant and uncertain. We have seen its effects in:

- The increasing intensity and slower post-landfall weakening of hurricanes, as illustrated by Hurricane Ida, which took out all the transmission lines serving New Orleans and led to 56 deaths in four Northeastern states, and in other extreme precipitation events;
- The impact of heat waves, such as the heat dome that settled over the Pacific Northwest in June, increasing temperatures in Seattle to 109^o, Portland to 116^o and towns in Eastern Washington and British Columbia to over 120^o;
- The severe and exceptional drought conditions and elevated wildfire risks across the Western U.S.; and
- Large areas experiencing unusually cold winter temperatures, as occurred in February 2021 during Winter Storm Uri, which led to 61.8 GW of unplanned generator outages and the shedding of 23.4 GW of firm load.

Utilities are responding, in part, by committing to reduce greenhouse gas emissions. More than 270 electric companies serving more than 70% of U.S. consumers have announced objectives to rely on 100% clean energy or to become carbon neutral no later than 2050.

These commitments follow a 90% decline in the unsubsidized cost of utility-scale solar photovoltaic (PV) and 70% reduction in the unsubsidized cost of on-shore wind generation since 2009. One result is a rapidly increasing reliance on variable renewable resources. Solar PV and wind projects accounted for more than 80%, and together with energy storage projects more than 90%, of the capacity in ISO/RTO and utility interconnection queues at the end of 2020. In every U.S. ISO/RTO except PJM, variable wind and solar are expected to supply more – in some markets much more – than 30% of total energy by 2030.

At expected levels of penetration, variable resources will present significant operational challenges. Rapid changes in wind speeds have already required MISO and SPP to compensate for declines in wind generation of more than 8 GW in four-hour periods. With wind and solar providing 28% of its energy in 2019, CAISO experienced three-hour ramps of more that 15 GW. Without offsetting changes in demand and other resources, such variability can produce rapid changes in power flows and impact system stability.

Fortunately, the U.S. is projected to add over 120 GW of new cost-effective flexible demand by 2030. Flexible demand is demand that can be shifted in time without impacting consumer services by managing thermal inertia in the provision of heating, cooling, refrigeration, and ventilation (38% of U.S. electricity use) or the timing of charging electric vehicles (EVs) and energy use in industrial or agricultural processes. Automation and smart technology can continuously optimize the timing of flexible demand to reduce costs while also meeting customer requirements. Flexible demand provides an efficient, low cost way to balance the variable output of renewable resources.

However, the incentives needed to encourage the continuous optimization of flexible demand are fundamentally different from those provided by existing Demand Response (DR) programs. DR programs reward participants only when an event is called and based on reductions in demand below that in a recent baseline period. Events typically can be called only a few times a year. Moreover, smart technology will anticipate DR events and increase use during the expected baseline period to maximize incentive payments. Enabling flexible demand requires continuous communication of relevant price signals, e.g., spot-market prices and / or short-run marginal costs that reflect changes in variable resource output.

For most consumers, electric rates are fixed and hide the impact on power costs of changes in the output of variable resources. Mobilizing flexible demand will require rate designs that, in addition to other functions, communicate timely and actionable information on the cost and value of electricity. Consumers then could then enable programming in the smart technologies in their homes and businesses to manage demand. This would provide consumers greater control over their bills, lower system costs, enhance reliability, and benefit most low income consumers who typically use less energy in peak periods.

This paper proposes a framework for designing efficient and equitable rates that will facilitate the integration of flexible demand, follows fundamental economic and equity principles, and can be adapted to the circumstances of different utilities, regulatory environments, and stakeholders. The major sections of the paper address on three important functions of electric rate design:

1. Communicating dynamic, efficient, and where feasible, market-based price signals thatreflect the marginal cost and value of electricity;
2. Equitably allocating transmission, distribution, and public policy costs that utilities cannot recover at market or marginal cost based rates; and
3. Providing customers cost-effective options for managing high bills and the risks associated with variable electricity prices.

Before turning to these three topics, the paper discusses historical technologies and practices that have shaped existing rate designs and summarizes developments that necessitate rethinking the design of electric rates.

Looking Back: Limited Technologies and Options

Most utility rates are based on designs introduced in the late nineteenth century, a two- or three-part rate structure, with a flat kWh usage rate, a customer charge that is uniform within the customer class, and / or a kW demand charge. These designs are an artifact of limited metering technology and billing systems that provided utilities information on only monthly consumption and, for some larger customers, maximum demand during the billing period.

The lack of information about when customers were using electricity made it impossible to identify the costs directly caused by individual customers or to distinguish those costs from what economists call “common costs.” A large portion of utility costs are “common costs,” investments in poles and wires and administrative costs that enable the delivery of power at different times to many different customers and are not the direct result of any individual customer’s use of the power system. The typical practice of recovering common costs in energy and demand charges, rarely, if ever, produces rates that reflect the incremental cost of using electricity or the time- and location-specific value of power supplied by distributed resources. Nonetheless, utilities are entitled to an opportunity to recover their reasonable revenue requirements; and costs that cannot be recovered at market prices have to be allocated among different customers. Cost of service studies that include both direct and common costs, in the absence of better information, provided a useful although inaccurate and inefficient way to allocate costs.

Looking Forward: New Technologies and Requirements

Today, more than 70% of U.S. households have advanced meters that enable two-way communications. Utilities and retail suppliers could charge efficient marginal cost or market based prices that communicate the time- and location-specific cost and value of electricity. Moreover, with advanced meters, utilities are no longer limited to using uniform service class customer charges to recover the remaining common costs. There are other ways to recover common costs that better align economic efficiency and equity objectives.

The rapid development and adoption of smart technology and intelligent systems – smart thermostats, water heater controls, building management systems, intelligent demand management in industry and agriculture, and smart charging of electric vehicles – has created large new categories of flexible demand that can automatically respond to anticipated price changes. These systems can shape,shift, and modulate energy use over multiple hours without materially impacting the services customers receive. Tapping this flexibility will be important to maintaining efficient and reliable power system operations. It would be difficult and much more expensive to balance the variability and multi-gigawatt ramps in the output of wind and solar resources without the continuous participation of flexible demand.

Rate Design Framework Part One: Efficient Dynamic Prices

The first function of efficient and equitable rate design is to communicate dynamic, where feasible market-based, price signals that reflect the marginal cost and value of using and producing electricity. To efficiently balance demand and supply, one component of rates should reflect spot market prices or short-run marginal costs. As noted economist and the former Chair of the New York Public Service Commission, the late Alfred Kahn, wrote, “It is short-run marginal cost to which price should at any given time - *hence always* - be equated, because it is short-run marginal cost that reflects the social opportunity cost of providing the additional unit that buyers are at any given time trying to decide whether to buy.” To operate efficiently, organized power markets price energy based on day ahead hourly and, in real time, on 5- or 15-minute Locational Marginal Prices (LMPs) that reflect market participant information on short-run marginal costs and value.

Communicating efficient price signals can start by pricing supply based on ISO / RTO spot-market prices (LMPs) or, outside organized markets, based on the marginal system supply costs (system lambda). This approach currently is being introduced in retail rates acrossthe European Union. A 2019 E.U. Electricity Directive requires larger electricity suppliers to offer a dynamic retail rate that includes day ahead and intraday spot market price changes and that such a dynamic rate be made available to all retail customers with smart meters regardless of supplier size.

Dynamic pricing offers significant benefits for consumers:

- It provides consumers greater control over their energy bills by enabling them to shift usage into lower price periods;
- It materially reduces supply costs when compared to competitively priced flat rates. Flat rates require electricity suppliers absorb correlated price and quantity risks. They and often include a 10% to 30% hedging premium. In most circumstances, a substantial majority of consumers could reduce their bills without changing their consumption patterns by buying power at wholesale spot prices. (The third part of the rate design framework will provide consumers less expensive options for mitigating price risks.)
- Low income consumers tend to have flatter, less peak oriented load profiles and use less energy during peak hours than the average residential customer. Low income customers also tend to be price responsive. As a result, most low income consumers can benefit from dynamic pricing.

With the growth in Distributed Energy Resources (DER) and increasing adoption of EVs, it may be appropriate to consider dynamic distribution rates that include the distribution components of locational marginal costs and identify the time- and location-specific distribution value of DER. In some circumstances, a distribution level market may be needed to coordinate the charging of EV clusters without overloading distribution transformers, operate multi-party microgrids, or balance demand and the output of distributed resources on circuits that have been temporarily isolated from the larger power grid.

Rate Design Framework Part Two: Equitably Allocating Residual Costs

The second function of rate design is to equitably allocate common costs that a utility cannot recover at market or marginal cost based rates. Electric transmission and distribution are natural monopolies. In natural monopolies, average costs are typically higher than marginal costs. This is characteristic of electric transmission and distribution utilities that have high fixed network costs that don’t change with the volume of power they deliver. Utility revenue requirements also may include additional costs as a result of public policies.

The allocation of residual revenue requirements to different customers should be governed primarily by equity principles, subject to any limitations that may be created by two potential efficiency impacts:

- Income elasticity: Some consumers with low or fixed incomes may change their consumption or lose access to power due to income or household budget constraints.This can be both an economic efficiency and an equity issue.

- Grid defection: Defection may occur when a customer's total bill provides an incentive to leave the grid by relying entirely on self-generation or not using electricity. For most consumers, the cost of separately maintaining a comparable level of service and reliability significantly exceeds the cost of utility service. However, the risk of customers exiting the system may limit the extent to which additional policy related costs can be recovered through electric rates.

Residual revenue requirements should be recovered in manner that avoids distorting the impact of efficient dynamic price signals (Part One prices). The best way to avoid such distortions is to recover residual costs in equitably differentiated fixed charges. Regulators and utilities are understandably sensitive to the impact of higher uniform service class customer charges on low use low income customers. However, with additional data, utilities have options for recovering these costs that may be better aligned with equity principles.

Three forms of equity should be considered when allocating residual costs:

- Allocative equity: Both Aristotle and Bonbright's treatise, *Principles of Public Utility Rates,* describe a principle that equals should be treated equally and unequals unequally, in proportion to their relevant similarities and differences. Two corollaries illustrate when shifting costs may conflict with this principle:
  - No ratepayer's demand should be uneconomically diverted away from an incumbent by a potential entrant (Bonbright's anonymous equity);
  - No consumer should be able to reduce an equitable allocation of residual common costs by changing their energy usage since common costs are not caused by individual customer usage.

  In applying allocative equity, regulators have discretion to identify different similarities and differences that may be relevant to the apportionment of common costs.
- Distributional Equity: Distributional equity reflects regulatory consideration of impacts on low income and disadvantaged customers. Distributional equity is often addressed by targeted programs or rates, such as a Percentage of Income Payment Plan or a discounted rate for income qualified customers. However, programs and rates that require income qualification may reach only a fraction of the potentially eligible population. To address this gap, utilities may consider allocating residual costs based on characteristics that are correlated with income.
- Transitional Equity: Transitional equity describes how changes in rates may interact with customer expectations and community standards of fairness. Perceptions of fairness are often based on comparisons to both a prior reference price and a reference profit level for the firm. Transitional equity can be addressed in part by managing customer expectations when implementing a change in rate design. Transitional considerations also could include that some customers may have made complementary investments based on their expectations of the price and quality of utility services. Any negative impacts on these customers will have to be balanced against the benefits of a new rate design. A clearly communicated commitment to more efficient rate design could encourage different complementary investments that create new sources of value and customer savings.

Some European electric utilities recover distribution costs through fixed demand based subscription charges. Similar access charges, often tiered by service level, are common in other network industries (e.g., cable TV, mobile phone, and internet), the dues structures of membership organizations (e.g., clubs, gyms, churches and synagogues), and charges for products with high fixed and low marginal costs (e.g., software).

Rate Design Framework Part Three: Options for Managing High Bills

A third function of rate design is to provide customers options for managing the risk of receiving a high bill, particularly a bill that is inconsistent with the customer's general experience and expectations. Efficient rate design provides customers (their smart technology, or a demand management service acting on their behalf) an incentive to shift flexible demand out of high price periods. However, customer acceptance of dynamic rates may require additional rate options that limit the potential variability in customers' monthly bills. Approaches for managing the risk of incurring a high bill could include: advanced budget payment programs, which incorporate real time bill tracking and notifications, price hedges such as the block and index pricing model common in commercial and industrial supply contracts, or other forms of insurance. Different approaches may be appropriate for utilities in different circumstances and customers with varied risk tolerances.

Case Study: Electric Distribution Utility Rate Analysis

In a recent client study, we analyzed AMI data from over 450,000 residential customers and statistically associated their usage patterns with income categories. We separately analyzed AMI data for customers on income qualified programs. Our analysis showed that most customers, including most low income consumers, would have been natural beneficiaries and experienced lower average bills on real-time pricing rates without making any changes the level or timing of their electric demand. The analysis also suggested that recovering residual revenue requirements through differentiated demand-based access charges, comparable to those used by many European electric companies, had the potential benefit lower income consumers when compared to the conventional practice of recovering such costs in kWh energy rates. While this study was specific to the customers of a specific utility, it illustrates the potential to use the three-part framework to design rates that support the development of flexible demand, are efficient and fair, and benefit consumers by giving them greater control over their bills and in many cases reducing costs even if they do not change their consumption patterns.

Conclusion

Achieving an affordable, resilient, environmentally sustainable energy future will require balancing variable solar and wind generation while integration the additional demand created by the electrification of transportation and other end uses. Enabling the efficient management of flexible demand is a promising way to meet these requirements. Considering the pace of renewable energy development, the industry should be implementing experiments to test the performance and consumer acceptance of different combinations of dynamic multi-part rates and smart technologies for managing flexible demand. The results of such experiments are needed before the growing reliance on variable resources starts to impact system reliability.