Leadership in Rate Design

A COMPENDIUM OF RATES ESSAYS

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Leadership in Rate Design

A compendium of rates essays

BY PAUL ZUMMO, DIRECTOR,
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Vast changes are occurring in the world of electricity. Distributed energy resources such as rooftop solar generation, electric vehicles, energy storage, and other technologies have made an impact on the traditional relationship between a utility and its customers. The reach of these resources is expected to grow exponentially as more customers seek greater control over their energy supply.

However, what hasn't changed is the need for an electric utility to recover the costs of serving its customers. The challenge is dealing with an electric grid that was designed for a much simpler, one-way utility-customer relationship.

Traditional rate design included a fixed monthly customer charge, an energy charge per kilowatt-hour sold for residential customers, and a demand charge for larger commercial and industrial customers. This design worked well for many years, especially as the demand for electricity was growing. However, stagnant sales and the growth of distributed energy resources mean that traditional rate design may no longer work in ensuring that utilities adequately recover their costs in a way that is fair to all customers.

How should you rethink your rate design strategies to overcome the limitations of traditional rate design in the face of evolving technologies and customer preferences?

The American Public Power Association has previously published papers exploring some of the rate design options that utilities have begun exploring.[i] This time, the Association has asked thought leaders in rate design — who have worked with many utilities to reshape their rate design strategies to keep up with the changing times — to weigh in. We present their perspectives, supplemented by public power utility examples, in this compendium of rates essays.

There is some commonality between the views of these thought leaders. For example, they all agree that some form of time-varying or time-of-use rates is an essential element of rate design. They disagree on other points, such as the appropriateness of increased fixed charges or residential demand charges.

The differences of opinion reflect a fundamental reality — there is no one-size-fits-all rate design option for all electric utilities. Public power utilities are especially diverse in terms of size, region, regulatory and market environment, and governance structure. Your customers also differ when it comes to tolerance for change. Some of you might not even have to change your rate structure at all.

Each of these essays might provoke some thought on what you should consider and address as you assess your rate design strategies and prepare for a new energy future. The insights and case studies may be valuable to share with your leadership, governance team, policymakers, and other stakeholders.

Wherever you are in your rates journey, this compendium is meant to offer you food for thought as you consider options for the future.

i. See *Rate Design for Distributed Generation,* available at https://www.publicpower.org/system/files/documents/ppf_rate_design_for_dg.pdf, and *Rate Design Options for Distributed Energy Resources,* available at https://www.publicpower.org/system/files/documents/ppf_rate_design_options_for_der.pdf

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What a Long-Term Rate Strategy Should Address

BY MARK BEAUCHAMP, PRESIDENT, UTILITY FINANCIAL SOLUTIONS

Electric rate structures have the potential to evolve and benefit utilities and customers. Advancements in technology have made it possible to recognize and charge customers based on their usage patterns, relay accurate price signals, and design rate structures that reflect the fixed and variable costs of providing electric service.

For many years, electric rate structures remained relatively unchanged, with a simple energy rate, sometimes a customer charge, and a demand charge (for larger customers). Given metering limitations, these rate structures were the most effective way to bill customers. Now, with data from new technologies, utilities have the opportunity to understand their customers in a way they previously could not and recognize areas where utility objectives are not being met.

There are at least three areas in which current rate structures do not achieve utility objectives.

- Price signals sent to customers are often inconsistent with the cost of providing electricity, and customers are offered little incentive to use electricity cost-effectively. For example, incorrect price signals have caused some customers to make uneconomical investments in technologies that shifted costs to other ratepayers.
- Rate structures may fulfill the utility's need for revenue but might not reflect how costs are incurred. Charging customers on the common two-part rate structure — with a customer charge and energy rate — is an example of a rate structure that is inconsistent with cost recovery and cost causation.
- Consistency between rate structures is an important consideration. For example, large general service customers might experience dramatic changes in bills when moving from a small general service rate to a demand-based large general service rate.

Rate-making objectives include fairness to customers, stable revenues for the utility, stable rates for customers, environmental and conservation objectives, and social concerns such as impacts on low-income customers or economic development for the community. Meeting these objectives and confronting industry challenges requires a long-term rate strategy that balances the needs of stakeholders with the objectives of the utility and community. This requires knowledge of rate structures and current rate design strategies.

Time-based rate structures provide an opportunity to achieve environmental objectives and allow customers greater control over their bills, resulting in more stable revenues for the utility.

The Energy Information Administration reported that as of 2016, more than half of the electricity customers in the United States had advanced metering infrastructure or smart meters. AMI gives utilities the opportunity to correct weaknesses in rate structures and balance the interests of all stakeholders. Unfortunately, the need to modify rate structures is not always fully understood because of the complexities of a utility's cost structure.

Since 2014, many utilities have recognized the problems and potential unfairness of outdated rate structures, such as low customer charges, and have developed simpler strategies to correct their rates over several years. Others have taken advantage of AMI to provide customers with rate options such as:

- Traditional two-part rate (customer and energy charges)
- Time-of-use rates
- Time-of-use rates combined with demand charges
- Peak demand charges based on customer usage during peak times of the day

Will multiple rate offerings overly complicate the rate structures, or will they ensure fairness and get all customers to pay their proportionate share for getting electricity into their homes and facilities? Will these rate offerings result in rate structures consistent with the utility's long-term objectives? Answering these questions requires a long-term view that includes input from customers, defining utility objectives, and educating all stakeholders.

Some community-owned systems have taken a long-term view on rates and have developed strategies to correct them. Utilities should identify key utility and community objectives, design rate structures to achieve these objectives, and develop a plan for implementation. Additional steps can be taken to implement rate strategies:

- Help staff and governing body members understand the relationship between customer usage and cost impacts on power supply, transmission, and distribution.
- Assess technologies needed to implement the strategy.
- Discuss how to implement the new rate offerings.
- Identify enabling technologies for customers to respond to the rate structure.
- Assess potential customer impacts.
- Educate customers and market the new rates.

Defining the Utility's Key Objectives

A one-size-fits-all approach does not always apply in our industry, and rate approvals by public service commissions are often not consistent with objectives of public power utilities. Utility rate-making key objectives often consider:

- Fairness to customers
- Social concerns and impacts on low-income customers
- Environmental protections
- Financial stability of the utility
- Stable rates for customers
- Consistent price signals to promote desired investments by customers
- Economic development for the community
- Sending price signals consistent with the utility's costs
- Providing customers greater control over their electric charges
- Providing reliable service to customers

None of these objectives should be considered in isolation, because achieving one objective may conflict with another. For example, several years ago, inclining block rate structures became a popular way to incentivize customers to conserve electricity. This structure resulted in unstable revenues for the utility, rate increases for customers, and price signals inconsistent with the costs of providing electricity.

The inclining block rates shifted fixed cost recovery from the first block of energy to outer blocks. When customers responded to the price signal, they reduced energy in the outer block, where the fixed recovery was placed, and caused the utility to under-recover costs.

Other rate designs, such as TOU rates or demand charges, may have achieved similar conservation more accurately, without affecting revenue stability. However, without proper technology or education, the industry was not able to implement these types of rate structures.

Time-of-use Rates

In some areas of the U.S, the lowest cost of electricity is in the afternoon, as solar production has had an impact on the cost of power supply during previously high-cost periods. In other areas, the lowest cost is at night, when wind production is greatest. Utilities in these areas can promote the installation of electric vehicle charging stations with proper cost-based price signals.

Time-based rate structures provide an opportunity to achieve environmental objectives and allow customers greater control over their bills, resulting in more stable revenues for the utility. These rates have been used in various forms for many years, such as time-based telephone charges in the 1980s and, more recently, Uber and Lyft prices that "surge" when demand for their services is high.

The concept of TOU rates is familiar to consumers, and many understand that costs are greater during peak usage times. Customers might not fully understand why electric costs are greater but know that costs increase. AMI installations have allowed many investor-owned utilities to offer TOU rates for residential and small general service customers. Some examples include optional TOU offerings by Consumers Energy, Detroit Edison, Duke Energy, Southern California Edison, Florida Power & Light, and many others. The trend of offering TOU rates will continue as more utilities install AMI and systems that can offer such rates.

Demand Charges

Capacity in the distribution system located near a customer's premises is sized to handle a customer's peak demand at any time, even if that capacity is used infrequently. When not used, the infrastructure remains in standby mode, waiting for that potential demand. Distribution costs for most residential and small commercial customers are recovered in energy rates. This results in a disassociation between how costs are incurred (peak demand) and how they are billed (energy). When a customer reduces energy consumption but not demands, the distribution costs will not be accurately recovered and the customer will be under-charged. For example, demands created by a customer with a rooftop solar array are often nearly identical to that customer's demand prior to installation of the array (load factor is reduced), and customers implementing energy efficiency tend to reduce both energy usage and demand and improve load factor. Demand charges provide incentives for customers to flatten their usage and possibly install batteries, and they create additional incentive for customers to take advantage of energy efficiency improvements.

Some utilities offer or require a three-part rate structure (customer, energy, and demand charges) for residential and small general service customers. The transition to demand charges is slow because of concern over a customer's understanding of what a demand charge is, how it's determined, and how it's controlled. Lack of understanding by utility staff increases the barrier to implementation. Successful implementation of demand charges often includes the education of utility staff and customers and a strategy to implement demand charges over time.

Several utilities in Nebraska have implemented mandatory demand charges for residential customers over time. Slow implementation limited the impact on customers and gave everyone time to understand demand charges. This resulted in successful implementation, with limited customer questions and almost no complaints.

Many utilities have implemented demand charges for customers with rooftop solar installations, while other utilities make it part of their rate offerings to residential customers. Demand charges are being considered by many utilities and may become a common rate structure for all customers in the future. Demand charge implementations will potentially occur after adoption of TOU rates, which are often better understood and easier to implement.

Grid Access Charges

Grid access charges are relatively new and used by only a few utilities. These charges attempt to ensure that customers pay for their potential impact on the infrastructure used to provide their electricity. At first glance, the charge resembles an inclining block customer charge, with rates increasing as they move to a higher block. In theory, the charge is designed to recover fixed customer charges and a portion of the capacity costs associated with power supply, transmission, and distribution.

An example of a grid access rate structure is shown below.

In this example, the utility phased in the grid access fee over a period of two years. At the start, all customers were billed a fixed customer charge of $11.83. In the first year, in conjunction with a rate adjustment, an inclining charge based on usage was established. In the second year, the rate for each block was adjusted, and the energy rate was reduced. Initial feedback on grid access charges has been positive, but any utility choosing this structure needs to review potential customer impacts. Often, the determination of a customer's block is based on the customer's peak usage over a 12-month period. Some utilities are considering grid access charges where AMI metering has not been implemented.

Customer Charges	Current Rates	Year One	Year Two
0 – 500 kWh	$11.83	$13.50	$17.32
501 – 2,000 kWh	$11.83	$16.90	$23.63
2001 – 4,000 kWh	$11.83	$16.90	$37.37
Excess kWh	$11.83	$31.40	$64.34
Energy Rate per kWh	**$0.1016**	**$0.1016**	**$0.0916**

Summary

Electric utilities are at different stages of offering more accurate rate structures and are largely dependent on metering investments or the desire to better align rates with fixed and variable costs.

When costs are aligned with rates:

- Customers pay the cost of their service.
- Price signals promote more cost-effective use of electricity.
- Price signals incentivize proper investments and changes in usage patterns.
- Customers are offered options to reduce their electric bills.
- Revenue stability for the utility is improved.
- Utilities are better able to achieve the objectives of the community.

A long-term rate strategy, along with an implementation plan, is needed to meet the evolving challenges of our industry. More accurate rate structures — including TOU rates, real-time pricing for larger customers, and demand charges for all customers — will become more common. The earlier a utility begins the process, the easier the transition to more accurate rate structures.

About the Author

Mark Beauchamp *has more than 38 years of utility experience and is a national expert on rate design. He has completed cost of service and rate studies for more than 300 public power utilities and investor-owned utilities around the U.S. and has served as an expert witness in rate cases.*

The Urgent Need for Retail Electricity Prices That Reflect Costs

BY ASHLEY BROWN, EXECUTIVE DIRECTOR, HARVARD ELECTRICITY POLICY GROUP

One of the most ironic aspects of electricity pricing in the United States is that we have invested a great deal of money, thought, and effort into designing wholesale market pricing — at least in the organized markets — that provides meaningful price signals on a real-time and location-relevant basis. However, at the same time, we have spent time and money to perpetuate policies and practices to make sure that few end-use consumers ever see those prices.

Our policies and practices fall short despite the availability of meters and other technologies that allow for both meaningful communication and easy utilization of the information, and despite the existence of demand response markets.

Retail rate design fails to incentivize energy efficiency, meaningfully capture the economic value of distributed generation, and incentivize subsidies and other price distortions in lieu of pricing that internalizes the value sought by policymakers. These failures of retail pricing are not economically sustainable in the face of the growth of distributed resources, the increased electrification of the economy (e.g., electric vehicles), and the growing need for sensitivity to environmental considerations.

The predominant pricing regime for retail pricing for residential and small commercial consumers[i] may best be described as "dumb" or "primitive" for a number of reasons, three of which merit specific reference.

- Pricing information is conveyed to customers in a manner that makes it useless for any purpose other than payment of the bill. The typical monthly bill provides no actionable or timely information and no hint of how one might more efficiently use energy. The bill offers no meaningful signal of how costs are incurred and how they might be reduced. Most significantly, given how sophisticated wholesale pricing has become, the customer bill offers none of the market information that is readily available.
- The bulk of the revenues are collected through the variable component of the bill, despite the fact that a substantial part of the variable component of the bill represents fixed and demand — not variable — costs. Thus, the price is divorced from the underlying costs.
- Even in regard to the variable costs themselves, most retail pricing regimes fail to reflect the market realities of supply and demand at specific times and locations.

The obvious question, then, is why we are continuing to deploy a wholly inadequate tariff design. It might be useful to begin with a bit of history that explains the current dominant form of rate design in the U.S. Historically, especially in the days of utility monopolies, we had declining costs, "dumb" meters and appliances, few meaningful wholesale price signals, and low market penetration by distributed resources.[ii] The primary focus of rate-making was revenue sufficiency for utilities and allocation of costs among customers. More sophisticated rate design, including meaningful price signals, was largely ignored (while perhaps not entirely disregarded). The reliance on volumetric pricing was intended to encourage sales of electricity as a means of accelerating cost recovery and expanding the benefits of electrification.

The practice of using a fixed/variable ratio in rates that were not reflective of the fixed/variable rate of cost causation stemmed from a social concern that rates weighted more toward fixed costs were socially regressive. Later, some people in the industry argued that disproportionate reliance on variable rates for cost recovery provided more of an incentive for conserving energy.[iii] There was no real pressure to change to a more sophisticated, cost-reflective rate design that balanced the need for cost recovery with the benefits of providing more accurate price signals to enable consumers to more effectively manage their own demand for energy.

The traditional pricing regime has been in place for many years and has developed constituencies that resist change and perpetuate the status quo, either because of a "the devil we know" frame of mind or because they've found financially attractive niches by taking advantage of the system's flaws.

However, it seems clear that without major changes in retail rate design, we will:

- Lose efficiencies in electricity markets and forego opportunities for serious innovation.
- Leave pricing at odds with many desirable social objectives.
- Deter movement toward electrification of heating and transportation.
- Leave ourselves vulnerable to market and price manipulation that may support some interests at the expense of others, such as the public.

In concrete terms, we can easily envision people charging their electric vehicles when they get home for dinner (in most places, dinnertime is coincident with peak demand) and paying no more for that than for off-peak charging. Similarly, we could continue paying a high price for excess rooftop solar energy at the off-peak times it usually is producing energy. Those are examples of the kind of inefficient behavior that is inevitable without tariff reform.

As technology continues to develop in ways we might not be able to foresee today (electrification of heating, for example, or advances in electricity storage), the penalties for pricing that does not reflect costs threaten to multiply.

As technology continues to develop in ways we might not be able to foresee today (electrification of heating, for example, or advances in electricity storage), the penalties for pricing that does not reflect costs threaten to multiply.

The time is ripe for more accurate retail pricing. The following conditions, while certainly not exhaustive, make more modern, accurate rate design possible and necessary:

- The existence of highly precise real-time and location-specific prices in the wholesale market that can now be conveyed to end users.
- The ready availability of smart meters, smart appliances, and other intelligent technologies capable of conveying price signals and making them meaningful and actionable for consumers.
- The existence of demand response markets, which makes it possible to effectively monetize intelligent energy use.
- The dramatic decline in the costs of many distributed energy resources, notably rooftop solar, that has enabled their rapid expansion.
- Increased electrification of the economy — perhaps best illustrated by the growing sales of electric vehicles — that requires reasonably precise price signals to avoid significant uneconomic and inefficient consequences.
- The political pressure to devise and/or perpetuate rate designs that take advantage of deficiencies in the existing rate structure. One example is net metering, which takes advantage of the disconnect between how fixed and variable costs are incurred and how they are passed through to customers, causing potentially severe cost shifting among customer classes, often in a socially regressive way.
- The rapid changes in technology that might be efficiently harnessed for optimizing individual use of energy, as well as the entire grid, if correct price signals were provided.

Customers should be able to translate the prices being communicated into actions that allow them to shape their load characteristics and control their costs and environmental footprint.

A reformed rate design should keep in mind a few key principles:

- Prices should, of course, reflect costs, but it is also critical that the bill sent to customers comprises three components: fixed, variable, and demand charges. The prices set out in each component should be derived from how those costs are incurred and how the underlying assets are deployed. Prudently incurred fixed, variable, and demand costs should be passed on to customers in ways that meaningfully signal how customers might be able to avoid incurring each element of those costs.
- Energy and other variable costs should be passed on to customers in dynamic prices that accurately reflect the real-time (or as close thereto as possible) locational prices in the wholesale market.
- Cross-subsidies in rates should be generally avoided, but where they are deemed necessary (e.g., for low-income households), they should be transparent, narrowly targeted, and implemented in ways that are minimally disruptive of overall prices.
- Price signals to customers should be actionable. Customers should be able to translate the prices being communicated into actions that allow them to shape their load characteristics and control their costs and environmental footprint.
- While customer classes may still provide a legitimate basis for cost allocation, it might well be that the traditional classes are no longer sufficiently granular. Residential customers, for example, might be distinguished based on whether they have distributed generation on premises, or if they have electric vehicles or use electricity in ways that make them different from other customers that are otherwise similarly situated.
- Customers who deploy distributed generation should be afforded full market access but should be recognized as a separate class of partial requirements customers whose rates should fully reflect their use of and dependence upon the system, and whose compensation for the energy they sell into the grid should be reflective of market prices (the locational market price at the time they are outputting energy). Any compensation for ancillary or other services they may provide should be based on actual services rendered, not simply on the possibility that they might provide such services.

The reality is that the electricity industry is undergoing rapid change — technologically, economically, and in regard to social expectations. To prepare for such change, utilities must have a tariff structure that is fully reflective of costs and cost causation. Having such a rate design positions the utility to adapt to change. It also enables customers to take full advantage of new opportunities without imposing added burden on the system and on those customers who are not able to avail themselves of these opportunities.

About the Author

Ashley Brown *is the executive director of the Harvard Electricity Policy Group at Harvard University's Kennedy School of Government. He is a former commissioner of the Public Utilities Commission of Ohio and former chair of the NARUC Electricity Committee.*

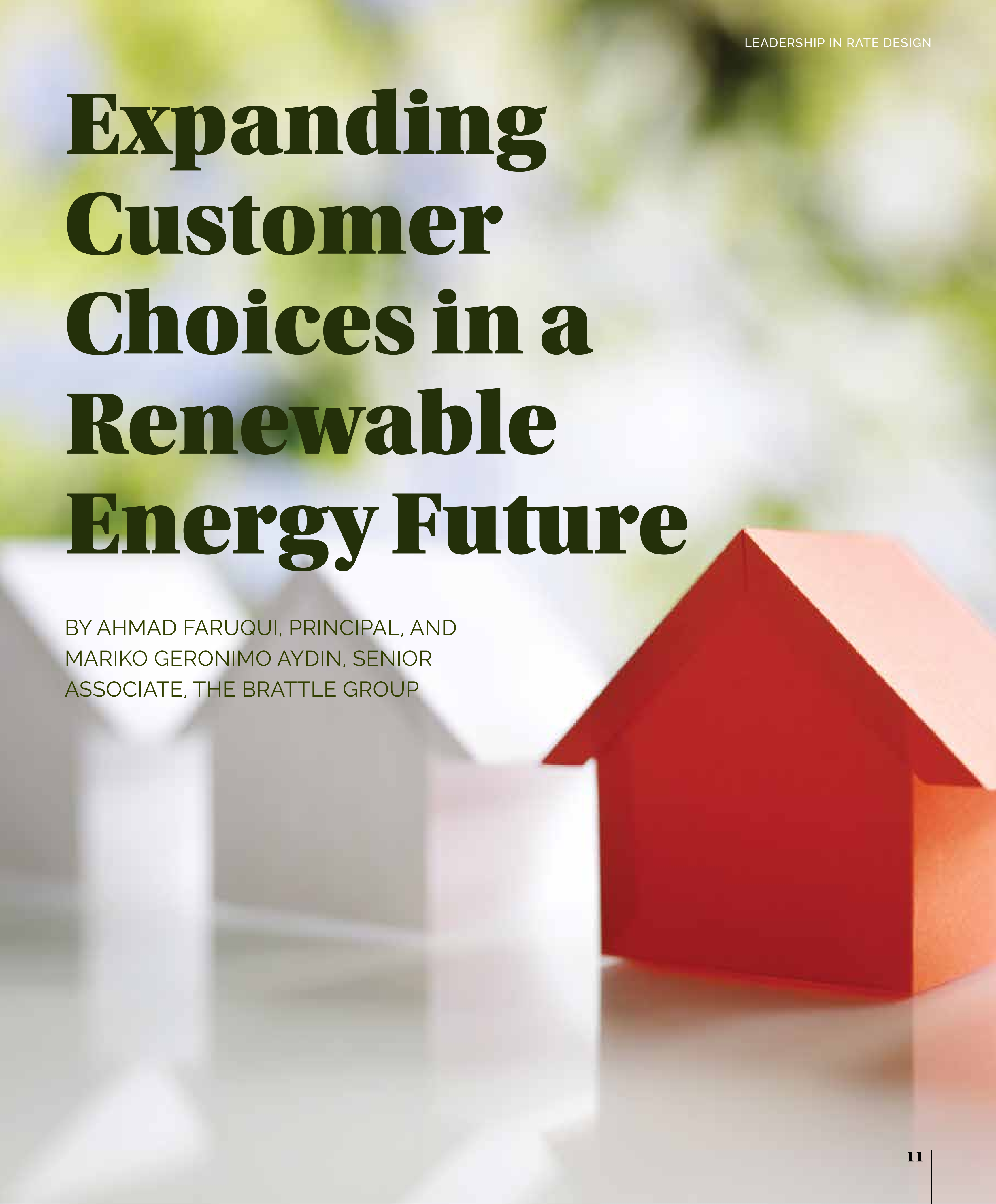
i The regime described is largely relevant to residential and small commercial consumers. Large industrial and commercial customers are often under quite different pricing regimes that do provide more meaningful price signals, so many of the reforms envisioned by this article may actually be in place for them.

ii Some distributed resources, such as rooftop solar, were too expensive to be financially viable, and others, while perhaps not prohibitively expensive, were effectively discouraged by poor price signals and/or the absence of smart technology to deploy them at higher levels of market penetration.

iii The absence of demand rates from residential and small commercial customers was the result of both similar reasons for the disconnect between the incurring of costs and passing on the rates to customers, and because small customers with "dumb" meters and "dumb" appliances could do nothing with demand price signals.

Expanding Customer Choices in a Renewable Energy Future

BY AHMAD FARUQUI, PRINCIPAL, AND MARIKO GERONIMO AYDIN, SENIOR ASSOCIATE, THE BRATTLE GROUP



For three years, Hawaii stood alone among other states in its commitment to reaching 100% renewable energy. In 2018 and early 2019, several large jurisdictions followed suit: California passed into law a policy of 100% clean energy by 2045; Washington, D.C.'s city council passed a standard for 100% renewables by 2032; New Mexico passed a 100% zero carbon requirement by 2045; and Puerto Rico adopted a policy for 100% renewable energy by 2050.[i] Many other states are considering and moving forward with similar policies and laws. Meanwhile, the number of cities and counties committed to 100% clean energy is growing dramatically.[ii] The 100% clean electricity supply that seemed impossible 10 years ago has now become a tangible and feasible future.

Figure 1 shows the end goal of state-level (plus Washington, D.C. and Puerto Rico) clean energy standards in terms of percent renewables or clean energy. [iii] Five more states are not far behind, with clean energy goals of 50% or more. With these policies, decarbonization of electricity is making great strides, with more to come as momentum builds.

The Value of Customer Flexibility in a High-Renewables World

In the first steps toward electricity decarbonization, going green is as straightforward as adding a solar or wind plant to the resource mix. In addition to forecasting peak demand as they have always done, resource planners and policymakers must determine when and where to build renewable resources and at what size these resources will be cost-effective.

With higher renewables penetration, planning for greener electricity becomes less about building individual resources and more about building a resource portfolio and system that — as a whole — is tuned to take advantage of clean power when it is available. One key challenge is what to do about the hour-to-hour and minute-to-minute mismatch between renewables output and electricity consumption. At times, electricity supply from renewables may be higher than consumption. At other times, supply may be lower than consumption. System operators must have the resources and tools they need to match supply and demand exactly.

In this context, customer flexibility becomes increasingly valuable. Any consumption that can be reasonably shifted to

Figure 1: End Goal of Clean Energy Standards by Jurisdiction

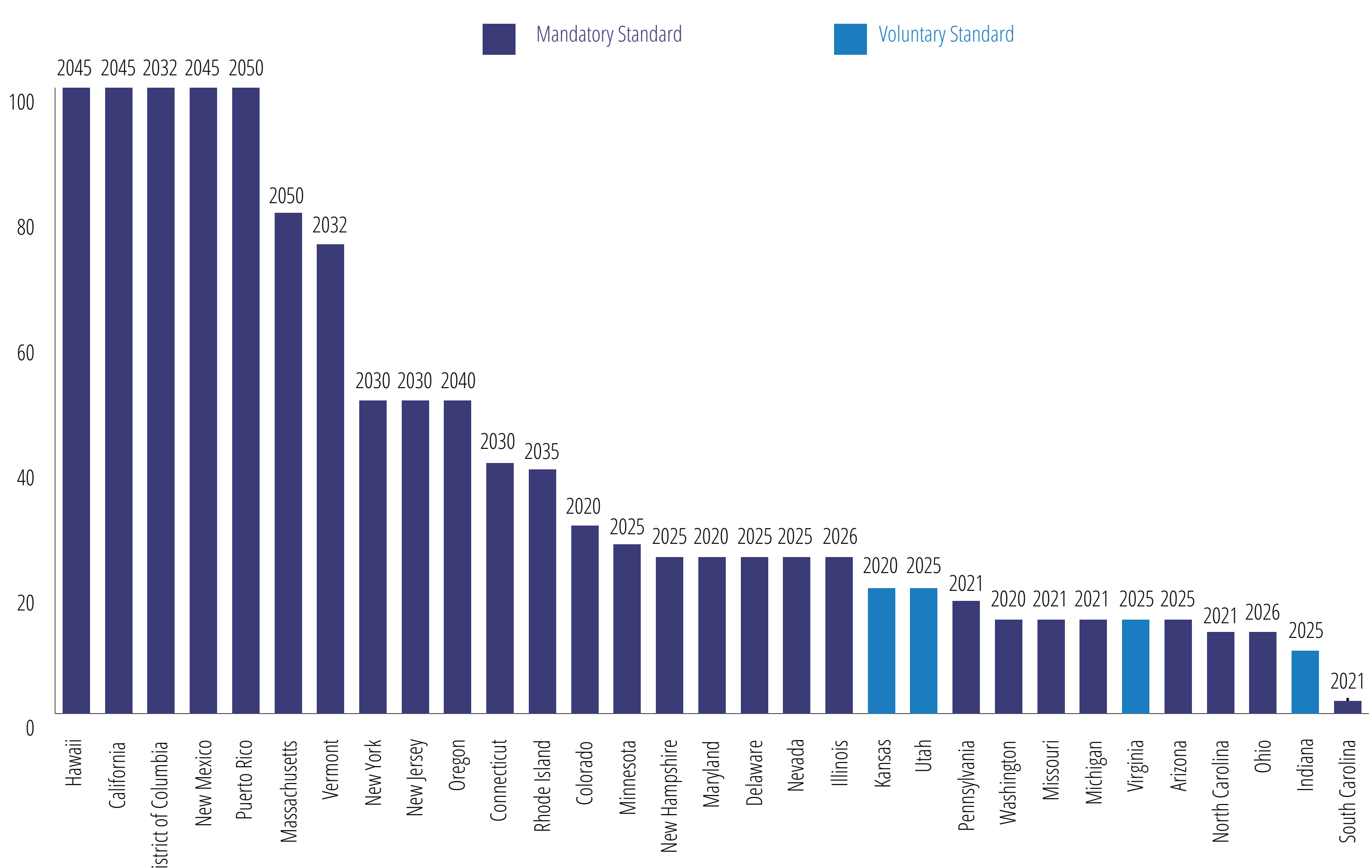
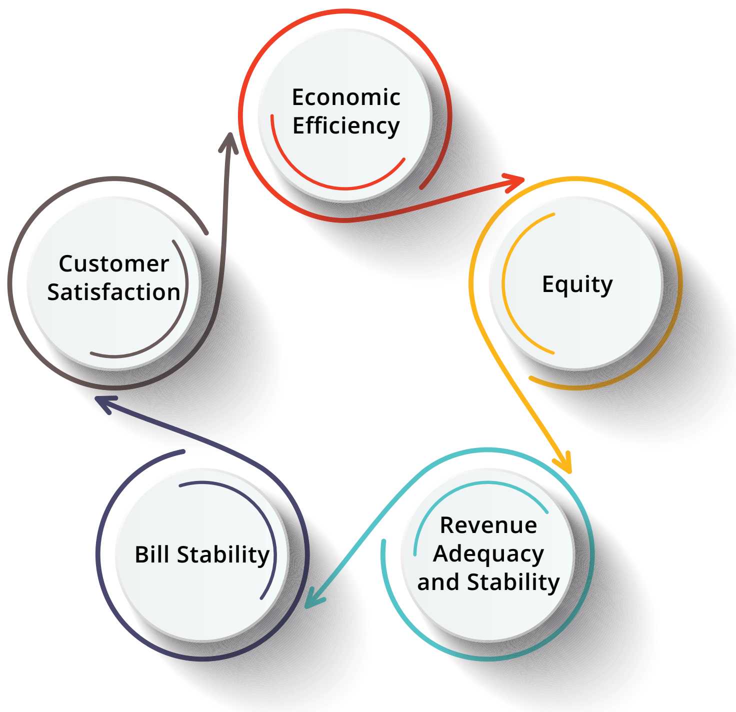


Figure 2: Objectives for Effective Retail Rates



Using customer flexibility as a resource in any and all hours is critical to getting the most out of a high-renewables system.

times when renewables-based supply is high will prevent loss or curtailment of renewables output when it is available. In doing so, customers also shift consumption away from times when renewables-based supply is lower, which can avoid the cost of power supplied by battery storage or even fossil fuel-based generation. This concept is expanding our traditional thinking about customer flexibility: from traditional "demand response" focused on moving consumption *away* from peak periods, to something more dynamic and including "load shift" *toward* low-cost periods.[iv]

Future studies and evaluations of demand response will need to broaden the definition of demand response and the scope of benefits it can provide.[v] Using customer flexibility as a resource in any and all hours is critical to getting the most out of a high-renewables system.

Principles for Meaningful Rate Options and Signals

Electricity is delivered (and sometimes produced) by a regulated natural monopoly, and customers pay for electricity through regulated retail rates. Given that framework, the principles of effective regulated rates hold true regardless of a high-renewables future. Effective rates should address and balance the regulator's high-level objectives for economic efficiency, equity, revenue adequacy and stability, bill stability, and customer satisfaction, as shown in Figure 2.[vi]

The objectives for retail rates are interrelated, and some can represent tangible tradeoffs for customers. One customer, for example, might want to see how power supply costs vary within a day, to moderate their air conditioner on the hottest days when costs are high and save money overall. Another customer might not have the same flexibility to cut air conditioning on the hottest days, might not want to feel penalized for that flexibility, and might prefer more bill stability and costs smoothed over time.

An in-between rate option with moderate cost variability over time — such as the traditional volumetric rates that dominate the industry today — might be meaningless to both customers. The first customer may feel that the cost variability they see is not a strong enough signal (or concentrated enough) to respond to. And the second customer may feel that the cost variability by month or season is not equitable nor helpful given that they can't respond to it. In either case, customers pay the total cost of service. How well rates are tailored to customers' preferences and their ability to respond can impact how effective the rates are in incentivizing customers to save money when they can reasonably do so, while increasing customers' satisfaction and sense of equity.

For customers of today and tomorrow, rate objectives need to be defined and addressed at a more granular level that is tailored to the diversity of customers and their preferences, possibly even at a customer-specific level. We now have better information technology and tools to understand customers' behaviors and preferences, and to help them receive and respond to signals so they can shape their consumption in a meaningful way.

An hourly real-time price signal... can help show customers exactly what hours contribute most (and least) to the cost to serve them.

The Diversity of Efficient Rate Options

How do customers weigh opportunities to reduce cost versus bill stability? Regulators and utilities have experimented with a wide range of rate options and signals, as demonstrated in Figure 3. Traditional volumetric rates (standard tariff) yield relatively low bill volatility. However, the potential for bill savings is limited — a customer is only empowered to reduce costs through bulk conservation (i.e., a customer reducing total kWh consumed over a month).

For even less bill volatility, utilities can offer a fixed monthly bill (e.g., budget billing plan), shown as the leftmost point in Figure 3. Under this approach, the utility estimates total seasonal or annual bills, then divides the total by the number of months, similar to a payment plan. For example, Ohio's regulated electric and natural gas distribution utilities offer annual budget billing.[vii] Customers may like this type of bill because it is easier to financially plan for. But they must accept the tradeoff of having no signal to consume power when it is economical to do so, which theoretically will yield higher costs to customers overall.

Customers might be willing to risk more bill volatility if they have the flexibility to move consumption away from high-priced periods. An hourly real-time price signal, shown as the rightmost point in Figure 3, can help show customers exactly what hours contribute most (and least) to the cost to serve them. To date, the U.S. has relatively little experience applying real-time prices to residential customers, but experience in other parts of the world may provide some insights.

For example, in early 2017, about 12 million small customers in Spain, or about half of those eligible, were enrolled in a real-time price-based electricity rate, as part of a regulatory redesign to incentivize more efficient customer behavior and lower costs.[viii,ix]

In a high renewables system in the U.S., a real-time price signal can also be simplified to indicate when fossil fuel is being burned to serve customers (relatively high cents per kilowatt-hour), versus when renewables output is plentiful (low or even negative ¢/kWh). Translating a real-time price signal into an emissions signal may be more meaningful for some customers.

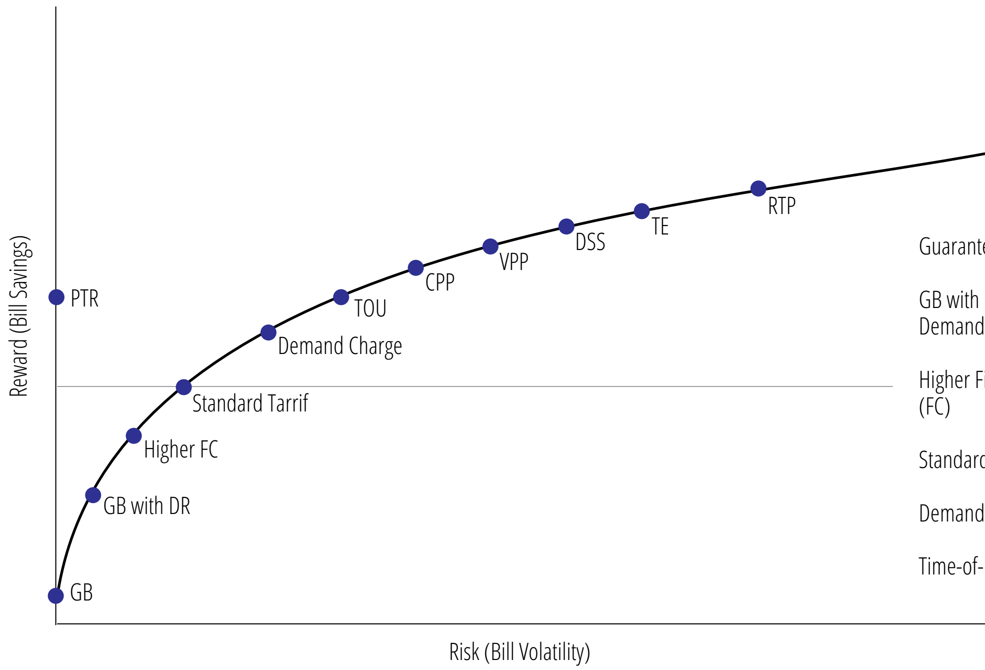
The tradeoff of higher bill volatility, however, can't completely be eliminated by the customer avoiding high-priced hours and consuming more in low-priced hours. There will always be the risk that prices are sometimes high when the customer can't or doesn't want to respond. More moderate time-varying price signals, like time-of-use rates and critical peak pricing, can also be quite effective if they are designed properly.[x]

Enabling Customer Flexibility through Tailored Retail Rates and Services

At its heart, traditional demand response is about giving better information to customers and letting them decide how to adjust (or not adjust) their consumption patterns. Studies on how electricity customers in the U.S. respond to cost signals — via retail rates and bills — have a history dating back to the late 1970s.[xi] Those studies affirm that customers care about cost and that they are willing and able to adjust their consumption away from high-cost periods.

Through subsequent decades of studies and experimentation, another thing is clear — customers have diverse preferences for types of cost signals they are willing to respond to. Preferences range from a flat guaranteed bill (low granularity cost signal) to retail rates that vary by hour in real time (high granularity cost signal), and many variations in between.

Figure 3: The Efficient Rate Frontier



Customers have shown that they will only respond to cost signals that are meaningful to them, and so customer options must be tailored carefully. To date, utilities and regulators have experimented with offering a handful of electricity rate options defined across broad customer classes. However, in other aspects of their lives, customers are getting used to having a world of options at their fingertips.

Today's customers have two important attributes that can affect their consumption patterns and must be considered along with retail rate design. First, customers have a heightened awareness of the electricity supply mix, and they may have stronger preferences for green attributes and where the power comes from (such as local or onsite power) than customers of yesterday. So, beyond cost signal options, customers might want options to choose a supply mix that better suits their preferences and values. There is growing evidence that customers want more control and options to tailor their power supply mix to their preferences.

Furthermore, customers are more comfortable with using technology and tools to make informed spending decisions. They use apps, search engines, web services and other tools on a daily basis to process and simplify an enormous amount of information to make even the simplest spending decisions. Advanced equipment like smart meters can improve the quality of cost, consumption, and supply mix data available to the customer. Tools and services including apps, price and consumption reports, and smart appliances can help the customer absorb that information quickly and adjust consumption patterns with more automation. Experiments with enabling technologies such as in-home displays and smart thermostats have already shown that customers can be more flexible if they are given better resources to do so.xii

The Path Forward

Electric utilities are well-poised to play a major role in providing tailored electricity services to customers in a new world where digital technologies and the internet of things are likely to be ubiquitous. To do so, utilities must continuously seek improved customer data to offer meaningful rate options and signals tailored to customer preferences. Utilities must also push forward with technology and tools that can help customers understand it all and respond with minimal effort.

The path to developing meaningful new rate structures and options for customers in a renewable energy future begins with better understanding how customer needs are changing. This can be done through focus groups and surveys that not only seek to understand preferences on cost versus bill stability, but also seek to understand preferences on power supply mix, environmental goals, and willingness to provide flexibility at different times of the day.

With customer preferences better understood, utilities can draw from the wealth of experience they already have in order to identify and test the effectiveness of different rate options. This includes field testing new rate designs, determining their acceptance and comprehension by customers, and evaluating the impact of the new rates on energy consumption and load shapes. Experience has shown that it would be best to carry out the tests using randomized control trials or similar methods to make sure the results are statistically valid and can be generalized to the population of interest. Tests should include considerations of technologies that enable customers to easily understand their rates and any price or environmental signals they are receiving, set preferences for responding to those signals, and respond automatically in a way that does not disturb customers' quality of life.

Utilities and regulators will then need to develop an implementation plan for new rates. They must determine if the new rates should be offered on an opt-in, opt-out, or mandatory basis and how that may change over time. There are many different approaches to this and each has its pros and cons. There may be useful lessons learned from other utilities that have already rolled out similar rates.

To quell fears of unexpected impacts, it will be useful to compute the bill changes that the new rates will bring about and find ways to mitigate any adverse impacts.

Finally, continuous customer education and outreach is crucial for customers to understand the array of rate options they have, and for them to make the best use of the rate they choose. In a sense, this effort both begins and ends with a conversation with customers. Through those conversations, electric utilities and regulators can help customers make great strides in realizing the benefits of their renewable energy future.

About the Authors

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i These policies and laws refer to the following legislative bills: HB 623 (Hawaii), SB 100 (California), B22-0904 (Washington, D.C.), SB 489 (New Mexico), and PS 1121 (Puerto Rico).

ii Note that 130 cities and counties have also committed to 100% clean energy. Sierra Club, "100% Commitments in Cities, Counties, & States," https://www.sierraclub.org/ready-for-100/commitments, Accessed April 2019.

iii DSIRE, "Detailed Summary Maps: Renewable Portfolio Standards (October 2018)," http://www.dsireusa.org/resources/detailed-summary-maps/, Accessed April 2019. Supplemented with research by The Brattle Group. Texas also has a voluntary target of 10,000 MW by 2025 for retail entities.

Massachusetts' goal of 80% by 2050 is based on its Clean Energy Standard. Massachusetts also has a separate Renewable Portfolio Standard with an implied target of 35% by 2030, and the Class I requirement growing by 1% per year thereafter.

iv Note that although the idea of flexible load shapes is gaining attention in the industry today, it is a concept that has been around for some time. See, for example, Gellings, Clark W., Pradep C. Gupta, and Ahmad Faruqui, "Strategic Implications of Demand-Side Planning," Chapter 8 in Plummer, James L., Eugene N. Oatman, and Pradeep C. Gupta (eds), Strategic Management and Planning for Electric Utilities, Prentice-Hall, Englewood Cliffs, 1985, pp. 137–150. See also, Schweppe, Fred C., Richard D. Tabors, and James L. Kirtley, "Homeostatic Control: The Utility/Customer Marketplace for Electric Power," MIT Energy Laboratory Report MIT-EL 81-033, September 1981.

v Faruqui, Ahmad, and Ryan Hledik, "Reinventing Demand Response for the Age of Renewable Energy," December 14, 2018, http://files.brattle.com/files/15059_reinventing_demand_response_for_the_age_of_renewable_energy_12-12-2018.pdf. Accessed April 2019.

vi Bonbright, James C., Albert L. Danielsen, and David R. Kamerschen, "Principles of Public Utility Rates," Arlington, Va: Public Utility Reports, 1988.

vii See The Public Utilities Commission of Ohio, "Budget Billing for Natural Gas and Electric Service," https://www.puco.ohio.gov/be-informed/consumer-topics/budget-billing-for-natural-gas-and-electric-service/, Accessed April 2019.

viii The rate is called the Voluntary Price for Small Consumers, or VPSC.

ix EURELECTRIC, "Dynamic Pricing in Electricity Supply," position paper, page 6, http://www.eemg-mediators.eu/downloads/dynamic_pricing_in_electricity_supply-2017-2520-0003-01-e.pdf. Accessed April 2019.

x Faruqui, Ahmad, Sanem Sergici, and Cody Warner, "Arcturus 2.0: A Meta-Analysis of Time-Varying Rates for Electricity," The Electricity Journal, Volume 30, Issue 10, December 2017.

xi Faruqui, Ahmad, and Mariko Geronimo Aydin, "Moving Forward with Electricity Tariff Reform," Regulation, Fall 2017, pp. 42–48.

xii Faruqui, Ahmad, Sanem Sergici, and Cody Warner, "Arcturus 2.0: A Meta-Analysis of Time-Varying Rates for Electricity," The Electricity Journal, Volume 30, Issue 10, December 2017.

Implementing the Three Principles of Smart Rate Design

BY JIM LAZAR, SENIOR ADVISOR,
REGULATORY ASSISTANCE PROJECT

The Regulatory Assistance Project is a global nonprofit nongovernmental organization that works with utility regulators and policymakers in the transition to a clean and reliable power future. RAP sets out three guiding principles for smart rate design in its handbook for rate analysts and utility oversight bodies:[i]

1. Customers should be able to connect to the grid for no more than the cost of connecting to the grid.
2. Customers should pay for grid services and power supply costs based on how much power they use and when they use it.
3. Customers supplying power or grid services to the utility should receive full and fair compensation, no more and no less.

What do these principles mean in practice?

Many utilities use inclining block rates — in fact, this is the most common residential rate form globally. In India, Indonesia, China, Mexico and many other countries, inclining block rates have been in place for decades.

Customer-specific costs only

Customers should be able to connect to the grid for no more than the cost of connecting to the grid.

The first principle of smart rate design tells us that customers should be able to connect to the grid for no more than the customer-specific costs of connection — up to, but not including, any components of the system that serve multiple customers. This usually includes the service drop to their home or business, plus the costs of metering and billing. On typical urban/suburban power systems, shared distribution system components such as poles, conductors, and transformers generally should not be included in the monthly fixed charge, as these costs will not change if the number of customers changes unless their combined usage changes.

The resulting analysis generally produces a per-month cost of about $5 for typical municipal utilities billing water, sewer, and other services on a single bill. It can run up to $10 per month for utilities billing for a single service, because the costs of billing and collection are not spread across multiple services. A cost study that produces customer costs above this level likely includes shared distribution costs, in violation of the first principle of smart rate design.

Volume and time of use

Customers should pay for grid services and power supply costs based on how much power they use and when they use it.

The second principle of smart rate design tells us that rates should recover costs based on the volume of usage, differentiated by season, usage level, and time of use (where advanced metering is in place). Seasonal rates and time-of-use rates directly concentrate cost recovery on users during high-cost periods.

Inclining block rates approximate the effect of TOU rates, because high-use customers tend to be electric heating and cooling users, and these end-uses are concentrated in the high-cost periods for most utilities.[ii] Inclining block rates are a good second-best solution where advanced metering is not in place. In addition, many utilities use inclining block rates to allocate a limited low-cost resource, such as hydro, equitably to all customers.

Full and fair compensation

Customers supplying power or grid services to the utility should receive full and fair compensation; no more and no less.

The third principle of smart rate design recognizes that many customers are now providing power and other grid services back to utilities. This began with solar photovoltaic systems and demand response providing surplus energy and peak load reduction. Today's customers — with smart inverters, smart electric vehicle chargers, and customer-side batteries — may provide a wider range of ancillary services, such as voltage support and frequency regulation. These system benefits are increasingly recognized by value-based compensation frameworks.[iii]

From Principles to Practice

Many consumer-owned and investor-owned utilities have rates that reflect these principles. We share examples of several public power utilities scattered across the United States that have implemented rates consistent with the three smart rate design principles. Each of these utilities has done so in a manner appropriate to local circumstances. In a few cases, we have simplified the tariff rates to help understand the principles we are illustrating.

Inclining block rates

An inclining block rate is a simple rate that does not require advanced metering. A higher rate is imposed on higher levels of usage, recognizing a well-understood (but not perfect) relationship between high levels of usage and high levels of peak orientation of loads, and between low levels of usage and closely-spaced dwelling units (apartments and multiplex units).

All residential customers have lights and appliances, typically consuming 200–400 kilowatt-hours per month. On a system-wide basis, these are highly diversified year-round loads, with load factors as high as 70%–80%. As a result, the first block of usage is relatively cheap to serve. Water heating is a year-round load, averaging about 300 kWh/month, but is concentrated in the morning and evening hours, when most utilities experience higher demand. Space heating and cooling, typically reflected in usage above 700 kWh/month, is both seasonal and peak oriented for winter-peaking utilities (heating) and summer-peaking utilities (air-conditioning). This leads to less efficient use of utility generation, transmission, and distribution capacity, for which some costs are incurred all year, but some of the investment is only needed for peak periods.

Apartments tend to have few residents per unit, but multiple units served by a single connection to grid. This reduces the cost per customer of distribution service. While some utilities reflect this lower cost of service in a separate (lower) rate for apartments, an inclining block rate design provides a similar benefit without the need for a separate rate.

With just this information, we can develop an inclining block based on a typical commercial demand charge rate. Commercial customers typically pay a separate demand charge that recovers a portion of the shared system costs needed to meet peak demands.

Many utilities use inclining block rates — in fact, this is the most common residential rate form globally. In India, Indonesia, China, Mexico and many other countries, inclining block rates have been in place for decades. We see these from coast to coast in the U.S. for both consumer-owned and investor-owned utilities. Three public power utility examples follow.

Seattle City Light

Seattle City Light is a hydropower-rich utility, with a winter-peaking residential load. Power costs in the Western interconnection are highest in summer, and the utility is nearly always a buyer or seller in this market. Its rate design reflects the limited hydro and seasonal cost structure.

Seattle City Light

Customer Charge	$5.90
First 300 kWh summer	$0.097
First 480 kWh winter	$0.097
Additional Usage	$0.142

Seattle also has a slightly higher rate that applies to service outside the city limits, reflecting the higher cost of service in suburban areas. This addresses a common element of utility rates: urban and multi-family customers, whose cost of service is lower, paying the same rates as single-family and ex-urban customers for whom the cost of service is higher. The inclining block rate in Seattle primarily benefits apartments, and the separate, higher suburban rate benefits urban consumers.

Example inclining block rate

Commercial rate	
Demand Charge	$10 kW
Energy Charge	$0.10 kWh

Residential Rate Based on Commercial Rate	Usage	Load Factor	Demand Costs	Energy Costs	Total Rate
Lights and Appliances	First 400	70%	$0.020	$0.100	$0.120
Water Heat	Next 300	40%	$0.035	$0.100	$0.135
Space Conditioning	>700	20%	$0.069	$0.100	$0.169

City of Palo Alto

Palo Alto is a California utility that provides both electricity and natural gas (plus water and sewer) through an efficient combination of services. As it bills multiple utility services together and its customer billing costs are low for each service, it has elected to have no fixed monthly charge for electricity.

Palo Alto

Customer Charge	None
Minimum Bill	$9.12
First 330 kWh	$0.129
Over 330 kWh	$0.193

Burlington Eelectric Department

Burlington Electric Department in Vermont serves the largest urbanized area in an otherwise rural state. It has a historical allocation of low-cost hydropower from projects built a century ago and gets much of the rest of its power in the relatively expensive New England ISO market. The rate design recognizes a per-customer allocation of the low-cost hydropower.

Customer Charge	$8.21
First 100 kWh	$0.118
Over 100 kWh	$0.157

Rates that vary by customer connection size

A few utilities have explicitly recognized that small and multi-family dwellings are less expensive to serve than larger homes. For small and multi-family homes, more customers are served per service connection line, and line transformers are sized based on an estimate of diversified load rather than the customer-specific load that drives rural and ex-urban system design. We use the example of Burbank, California.

Burbank Water and Power

Burbank is a small utility in the Los Angeles area. Half of its customers live in multi-family dwelling units. Many live in large, single-family homes with central air conditioning, swimming pools, and other high-usage electric appliances.

Burbank has divided its rate into a customer charge for billing, collection, and customer service costs; a "service size charge" for location-specific distribution capacity (final line transformers and the secondary service lines); and an energy charge for all distribution network and power supply costs. The service size charge is tied to the customer electrical panel capacity, recorded in the city's building records. The result is a rate that recognizes the lower cost of service for smaller customers and the higher cost of service for larger users. The 100-amp service panel is common for apartments; most single-family homes have 200-amp panels, and large homes sometimes have 400-amp panels. The utility also retains an inclining block rate form reflecting California's long-standing commitment to encouraging energy efficiency.

Burbank Water and Power

Customer Charge		$8.61
Service Size Charge	100 Amp	$1.36
	200 Amp	$2.73
	Over 200 Amp	$8.19
First 300 kWh		$0.112
Over 300 kWh		$0.163

TOU rates are particularly attractive to customers with energy storage capabilities. Electric water heaters on timer control or active utility control are common.

Time-of-use rates

Increasingly, utilities can measure customer usage by time period and can apply TOU rates to reflect generation, transmission, and distribution costs that are properly assigned to on-peak, mid-peak, and off-peak usage rather than the less accurate demand and energy classification methods commonly used in rate studies in the previous century. While many utilities offer optional TOU rates, only a few have moved all customers to a default or mandatory TOU rate form, but that is changing.

TOU rates are particularly attractive to customers with energy storage capabilities. Electric water heaters on timer control or active utility control are common. Electric vehicle owners can easily control when they charge their vehicles, and some utilities offer rates tailored to EV owners.

Tallahassee, Florida

Tallahassee has a simple, flat default rate design and a relatively simple optional TOU rate.

Tallahassee

Standard Rate	
Customer Charge	$7.77
All Energy	$0.101

Optional TOU Rate	
Customer Charge	$7.77
Off-Peak Energy	$0.056
On-Peak Energy	$0.213

One negative aspect of the Tallahassee rate is that the on-peak period runs from 7 a.m. to 7 p.m. This very long interval limits customers' ability to shift load to respond. Better TOU design limits the high-cost on-peak rate to the minimum number of hours needed.

Austin Energy

	Base Tariff	Adders	Effective Rate
Customer Charge			$10.00
First 500 kWh	$0.028	$0.049	$0.077
501 - 1000 kWh	$0.058	$0.049	$0.107
1,001 - 1,500 kWh	$0.078	$0.049	$0.127
1,501 - 2500 kWh	$0.093	$0.049	$0.142
Over 2,500 kWh	$0.108	$0.049	$0.157

Rates for compensating solar customers

Many utilities are seeing an increasing numbers of customers install residential and small business solar photovoltaic systems. Most of these utilities are offering simple net metering, an infant industry approach that works well up to about 5% penetration, as the impacts on other customers are very small. Once solar becomes common, a more cost-based solution might be appropriate.

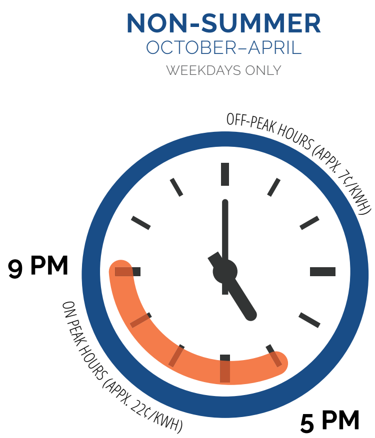
Austin Energy

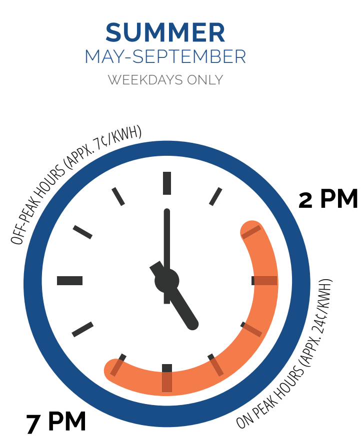
Austin Energy has been a leader in solar compensation, with an innovative "value of solar" approach that has been adopted in other states.

The VOS method carefully evaluates all components of the benefits to the society that solar produces, not just the short-term benefits to the utility. These benefits include generation, transmission, and distribution capacity; energy costs; and appropriate environmental and social values. A rolling five-year average is used to smooth volatile values. The resulting VOS credit for residential customers is $0.097, of which less than one-third represents the variable energy cost avoided by the utility.

Austin has an inclining block residential rate. Without the VOS approach, solar customers would not see the benefit of the low-cost initial blocks of power, as their solar system might entirely displace these purchases. Instead, Austin has a fixed price that it pays for all solar generation, and then it supplies all power used by the customer under the inclining block rate. The rate below shows the effect, after including various rate adders:

Solar customers receive a VOS credit of $0.097 per kWh for all output from their PV systems. For customers with usage under 500 kWh/month, the solar credit more than offsets the utility per-kWh rate, but for larger users, the solar credit is only a portion of the rate they pay for incremental usage.





Implementing All Three Smart Rate Design Principles

The public power utility of Fort Collins, Colorado, has been a national leader in innovative technology and pricing. It has what we consider the most creative and effective rate design in the U.S. today.

Fort Collins

Fort Collins recently concluded a multi-year pilot program and deployed universal TOU rates for residential customers. A "tier charge" on all usage over 700 kWh/month retains the effect of an inclining block rate within the framework of a TOU rate (electric heat customers pay a slightly higher base rate and are exempt from the tier charge). This rate design applies all three smart rate design principles, with the following characteristics:

- A customer charge that recovers only customer-specific costs (i.e., a customer can connect to the grid for no more than the cost of connecting to the grid).
- All other costs are in a TOU rate (i.e., all network and power supply costs are recovered on the basis of how much a customer uses, and when the customer uses it).
- Customers with on-site solar pay the standard rate for power consumed but get a slightly different credit than the retail rate for power delivered to the utility (i.e., customers supplying power to the grid are fully and fairly compensated).

Among the many good features of the Fort Collins rate are the narrow periods in which the on-peak rates apply — only five hours per day in summer and four hours per day in the non-summer months. Customers can more easily shift loads such as laundry, dishes, and water heating into the low-cost hours when the on-peak period is relatively short.

The Fort Collins off-peak rate, under $0.07/kWh, provides electric vehicle charging at the equivalent of less than a dollar per gallon of gasoline. Coupled with the Colorado and federal tax credits for electric vehicles, an EV is no more expensive to buy, and is much cheaper to operate, than an equivalent new gasoline-powered vehicle in Fort Collins.

For customers with solar PV systems, Fort Collins provides a rate credit for power flowed to the utility that is also time-differentiated and slightly lower than the retail rate for utility power consumed by the customer. This reflects the unique usage characteristics of solar customers.

Fort Collins Standard Residential Rate

Customer Charge	$6.78	
	Summer	**Winter**
Off-Peak	$0.069	$0.067
On-Peak	$0.241	$0.216
Tier Charge (Over 700 kWh)	+ $.0194 / kWh	

Fort Collins Solar Net Metering Rate Credits

	Summer	Winter
Off-Peak	$(0.065)	$(0.636)
On-Peak	$(0.227)	$(0.204)

Burbank EV Rate

Customer Charge		$8.61
Service Size Charge	100 Amp	$1.36
	200 Amp	$2.73
	Over 200 Amp	$8.19
Energy Charge		
Off-Peak	$0.081	
Mid-Peak	$0.162	
On-Peak	$0.244	

...small users have somewhat erratic usage as major appliances are turned on and off, but that the class of customers, as a whole, has fairly diverse and predictable usage.

Rates directed at EV charging

While any TOU rate can provide lower-cost energy for any load that can be controlled in a limited time period, many public utilities have gone a step further, offering a specific rate for electric vehicle customers. Some of these are "whole-house" rates, which require an EV for eligibility, while others are "second-meter" rates for the EV charging load alone.

Burbank Water and Power

Burbank is planning to extend TOU rates to all customers, but until that decision is made by its board and the city council, customers with EVs have access to a rate that provides an attractive charging price. The customer pays this rate for all usage but must have an EV to qualify for the rate. The key characteristic is the off-peak rate that is about half of the standard rate. Unlike standard rate customers, EV rate customers are not subject to the higher second-tier rate for usage over 300 kWh/month (an EV typically uses 200–300 kWh/month by itself). The standard inclining block rate, without a TOU element, would be a potential barrier to EV deployment.

The Burbank EV TOU rate has the same fixed charge as other residential customers and the same service-size charge. Only the per-kWh rate is different.

At $0.08/kWh, Burbank's off-peak EV rate is equivalent to about a dollar per gallon of gasoline.

Rates for small commercial customers

Small non-residential customers generally are served with rates that do not include demand charges, and most would not understand a separate demand charge. This recognizes that individual small users have somewhat erratic usage as major appliances are turned on and off, but that the class of customers, as a whole, has fairly diverse and predictable usage. A demand charge for this class of customers would unfairly shift costs to customers with intermittent usage who can share system capacity with other customers with complementary usage patterns. A TOU energy charge is more equitable, ensuring that customers with continuous usage in high-cost periods pay a larger share of system capacity costs.

We return to Burbank as an example of a smart rate for small commercial customers:

Burbank Schedule C

Customer Charge (single-phase)	$9.78
Energy Charge	
Off-Peak	$0.127
Mid-Peak	$0.158
On-Peak Summer 4-7 PM	$0.254

Today, with wind, solar, storage, and other options available to both the utility and the customer, traditional non-coincident demand rates make little sense.

This rate is easy for customers to understand. It incorporates most system capacity costs into the on-peak and mid-peak rates. The 2:1 ratio between on-peak and off-peak prices provides these customers a strong incentive to install ice-storage air conditioning or other load-shifting technology. The short three-hour on-peak period provides customers a reasonable opportunity to curtail load that can be deferred.

Rates for large commercial customers

Large commercial customers such as supermarkets, big box stores, and large office buildings have very diverse usage patterns. Most have been served with three-part rates for decades, with separately stated demand charges. In the past, these demand charges have generally applied to the customer's highest demand whenever it occurs (called the non-coincident demand).

Today, with wind, solar, storage and other options available to both the utility and the customer, traditional non-coincident demand rates make little sense. Neither generation nor network distribution capacity is planned or built based on non-coincident peak demand. Typically, these large customers have dedicated transformers sized to their individual demand — but nothing upstream of the final line transformer is.[iv]

A high demand charge provides commercial customers an incentive to curtail usage or add batteries to shave demand charges in the customers' highest-use hours. But the customers' highest-usage hours may not occur during the same hours that are most important for the grid. The hotel chain Extended Stay-America has installed battery systems at nearly all of its California properties, providing customer savings but not system savings.[v]

Sacramento Municipal Utility District has taken a significant step toward making rates for large commercial customers reflect today's cost realities. SMUD offers these customers a clear set of signals on how to modify their loads to minimize their bills and help minimize system costs.

This rate imposes a "site infrastructure" demand charge, based on the highest annual usage, to fully recover the site-specific distribution capacity cost. But this charge is less than $3 per kW per month, far lower than most utility demand charges, reflecting only local customer-specific infrastructure costs. And it has a summer super-on-peak charge to recover the cost of additional peaking capacity that the utility needs for summer afternoons. But all other costs are properly built into the volumetric TOU energy charges.

SMUD TOU-GS2 (500kW - 1,000 kW) Secondary Voltage

Customer Charge	$/mo	$109.05	
Site Infrastructure	$/kW/mo	$2.88	
		Summer	**Non-Summer**
Super Peak Demand	$/kW	$7.05	None
Energy Charge			
Off-Peak		$0.104	$0.082
Mid-Peak		$0.136	$0.104
On-Peak Summer 4-7 PM		$0.197	$0.104

Keeping Rates Competitive

The most important lesson is that one common rate design approach used by some utilities to reflect "fixed" distribution costs in fixed charges is NOT a part of smart rate design. Most state utility regulators have rejected cost allocation and rate design methods that include shared distribution costs (poles, conductors, and line transformers) in the category of "customer-related" costs, and fixed charges for major private electric utilities are in the $5–$10 per month range. The pioneering treatise on rate design, James C. Bonbright's *Principles of Public Utility Rates,* rejected including shared distribution costs in the category of "consumer-related" costs.[vi]

Simply stated, there is no economic basis for recovery of fixed costs through fixed charges. The smart rates discussed above respect this economic principle.

Most business enterprises exist to invest capital and employ labor and other resources to produce products and services that their customers purchase on a volumetric basis. Whether this is farmers growing broccoli, oil refineries producing gasoline, or supermarkets selling a wide variety of products, the principle is the same — fixed and variable costs are recovered in the unit prices for the products sold. Competitive businesses do not charge their customers a fixed fee to cover any portion of their infrastructure costs. If they did so, they would risk losing their smaller-usage customers to competitors.

The same effect is being observed now in the electric industry, where very small-use electric customers are leaving the utility grid. As an example, pedestrian crossing signals are increasingly solar-powered, primarily to avoid electric utility fixed charges that apply even to very small loads. These signals are usually adjacent to the grid serving schools, so there would be no additional distribution system expansion needed to serve them, but often, utility

Solar pedestrian crossing signal[vii]

rate design — imposing a fixed charge of $10–$20 per month — makes it uneconomical to connect to the grid. Today, these off-grid solar systems are economical for loads of a few kWh per month. With declining costs for solar and storage, they might soon be attractive for customers using a few hundred kWh per month. Utilities risk alienating and losing millions of customers, and the associated revenue, if they attempt to assign significant portions of distribution system cost on a per-customer basis.

One of the primary purposes for establishing utility regulation, including the statutory obligation of governing boards of consumer-owned utilities in most states, is to prevent the exercise of monopoly power in pricing. Utility prices should generally not vary from the kinds of pricing that would emerge under competition in competitive industries. The smart rate design principles meet this standard.

As the U.S. Supreme Court ruled in the landmark Market Street Railway case, "Even monopolies must sell their services in a market where there is competition for the consumer's dollar and the price of a commodity affects its demand and use."[viii] Smart utilities employing smart rate design principles will not run afoul of this guidance.

About the Author

***Jim Lazar** is an economist with more than 40 years of experience in electricity rate-making. He has appeared as an expert before many different regulatory and governing bodies. He is the author of Smart Rate Design for a Smart Future, Smart Non-Residential Rate Design, and Distribution System Pricing with Distributed Energy Resources, in addition to many other utility resource planning and pricing guidebooks.*

i Lazar and Gonzalez, Smart Rate Design for A Smart Future, Regulatory Assistance Project, 2015, available for free download at: https://www.raponline.org/knowledge-center/smart-rate-design-for-a-smart-future/

ii See Faruqui, A., "Inclining Towards Efficiency," Public Utilities Fortnightly, August 2008.

iii For a more detailed discussion of this opportunity and options for fair compensation, see Hledik, R. and Lazar, J., Distribution System Pricing With Distributed Energy Resources, Lawrence Berkeley National Laboratory, 2016, and Linvill, Shenot, and Lazar, Designing Distributed Generation Tariffs Well, Regulatory Assistance Project, 2013.

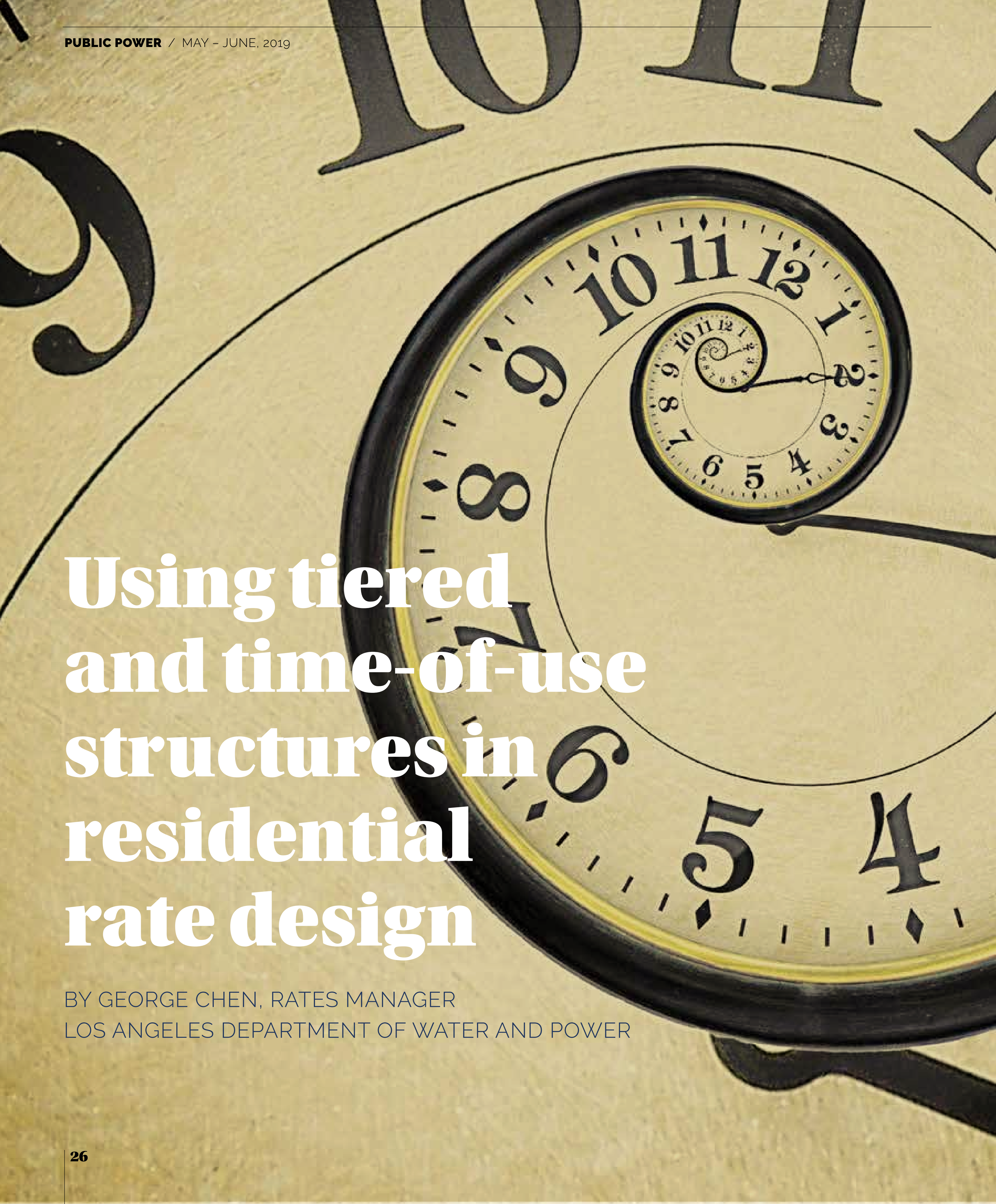
iv For a more detailed discussion of smart non-residential rates, see Linvill et. al., Smart Non-Residential Rate Design, Regulatory Assistance Project, 2017, available for free download at https://www.raponline.org/knowledge-center/smart-non-residential-rate-design/

v See Extended Stay America to Deploy Stem Systems Across 68 California Locations, at https://www.stem.com/extended-stay-america-to-deploy-stem-systems-across-68-california-locations/ (accessed 1/21/2019)

vi Bonbright, Principles of Public Utility Rates, 1969, at pp. 347-349

vii Photo by Dave Dugdale: Solar Powered School Traffic Light at Flickr (Source), CC BY-SA 2.0, https://commons.wikimedia.org/w/index.php?curid=49212163

viii Market St. Ry. Co. vs Railroad Commission of State of California, 324 US 58, 1945.



Using tiered and time-of-use structures in residential rate design

BY GEORGE CHEN, RATES MANAGER
LOS ANGELES DEPARTMENT OF WATER AND POWER

Public power retail rate design seeks to:

- Keep electricity affordable
- Encourage conservation and sustainable customer resources
- Assist in power supply transformation
- Meet legal requirements
- Ensure financial stability
- Use marginal cost of service in the rate design process

Two major rate structures for residential customers are being implemented in California — the increasing block tier rate structure and the time-of-use rate structure. Both structures are widely used and have strong attributes to meet the rate design goals listed above.

The increasing block tier rate is much easier to understand and implement and helps keep electricity bills affordable for low-use customers. The tier allocation is based on baseline consumption from essential household appliances and lighting. As long as customers maintain their energy usage for these essential energy needs, their bills remain stable, and they only pay a lower-tier rate. As the largest loads for these low-use customers tend to be from refrigeration and lighting, load-shifting opportunities are nearly nonexistent, so a TOU rate would not help to lower their bills.

Low energy users are mostly renters and retirees who constitute more than 50 percent of the Los Angeles Department of Water and Power's residential customers. If these customers are switched from an increasing block tier to a TOU rate, they will most likely see an increase in their bills, given that they are now enjoying the lowest-tier rate and not subject to peak pricing.

It will be challenging for low-use customers to adopt solutions suited to a TOU structure, such as solar and battery storage, to avoid the peak price, as most of them are renters and therefore unable to modify their building structures or make longer-term investments. The tiered rate structure is a perfect fit as it enables these customers to reduce greenhouse gas emissions by using less energy to take advantage of the tiered pricing structure.

If we gradually invest in utility-scale battery storage systems, we will solve the peaking issue in a few years.

A TOU rate structure carries a better pricing signal to encourage conservation and customer-sited renewable energy resources, especially for high-use customers, such as those living in single-family homes. TOU encourages customers to invest in energy conservation measures, load shifting, battery storage, and renewable generation.

LADWP has had a TOU rate since the 1990s, because we realized long ago that we serve a diverse population with varying needs and must provide a variety of options to meet those needs. The tier rate and TOU rate complement each other well. If the tier rate is not optimal for a particular customer, that customer can be covered by the TOU rate, especially in the high energy users segment.

Under the tier rate, once you reach the highest tier, there are no other choices to reduce the bill if you do not reduce usage. On the other hand, the TOU rate can help the customers shift load to the low price period or store energy during the low-price period to use later in the peak high price period.

A recent LADWP integrated resource planning study showed that commercial battery storage singular charge/discharge cost is around 20 cents per kilowatt-hour at an annual decrease rate of minus 5.5%. In 15 years, battery storage costs will be equivalent to a single combustion turbine capacity cost. This is similar to how solar generation costs dramatically dropped in the last 15 years. If we gradually invest in utility-scale battery storage systems, we will solve the peaking issue in a few years. It is also more cost-effective to install utility-scale battery storage systems that will increase energy use by sharing the energy storage assets among our customers. It is easier to implement demand response if utilities operate storage systems.

Based on customer usage patterns, we've seen that both tiered rates and TOU rates are important in serving Los Angeles' diverse residential customers. With the advancement of utility-scale battery storage systems, we can gradually reduce the complexity of our rate design.

The current combination of increasing block tier rate and TOU rate structures will slowly evolve to a simpler structure that will encourage conservation, energy efficiency, and sustainable energy resources.

About the Author

George Chen *has been with the Los Angeles Department of Water and Power for more than 28 years. He has managed metering system design, advanced metering infrastructure projects, forecasting of load profiles, and the implementation of complex billing systems. He has been the rates manager since 2006 and manages water and power rates, contributing to an annual revenue of $5 billion.*

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