STRATEGEN

Accelerating the Energy Transition

Through Advanced Rate Design

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I. Introduction

A. What is Advanced Rate Design?

Advanced rate design refers to a dedicated process outside of a traditional rate case in which an electric utility develops a comprehensive suite of tariffs to maximize load flexibility. Traditional utility rates often reflect simple pricing structures such as flat rates or tiered pricing. If offered at all, time-varying rate options are typically limited and unable to translate every customer's needs and capabilities into grid benefits. In addition, such rates may not be updated at a sufficient pace to reflect a rapidly evolving power grid. In contrast, advanced rate design aims to create more dynamic, flexible, and responsive pricing or direct load control mechanisms that can better accommodate customers while aligning with the changing dynamics of energy markets, consumer behavior, and grid management. Such an approach is becoming increasingly important as a transforming power grid, which must integrate increasing levels of variable, renewable generation while accommodating increased loads due to electrification, leads to a rapidly evolving distribution of costs throughout the day and year.

Advanced rate design may include various elements, such as time-of-use (TOU) pricing, real-time pricing, time-varying demand charges, critical peak pricing (CPP), and other incentive-based structures, as well as direct load control, as described further below. These tariffs are often leveraged to promote energy conservation, enhance grid reliability, and incentivize the adoption of technologies that are more efficient or capable of load shifting. Additionally, such tariffs play a central role in facilitating the integration of renewable energy sources by encouraging consumers to shift their energy consumption to times when renewable generation is abundant.

Implementing advanced rate design requires careful consideration of the regulatory environment, technological capabilities (such as smart meters and advanced metering infrastructure), and effective communication strategies to ensure consumers understand and can respond to the new pricing structures. By providing a structured process for consistent iteration, advanced rate design is critical to modernizing utility pricing to meet the evolving needs of energy systems and consumers.

1. Advanced Rate Design is Foundational for the Energy Transition

Advanced rate design is foundational for the energy transition as it provides a structured process for ensuring that price signals evolve with a power grid integrating more renewable resources. Traditional flat-rate pricing models are ill-suited to address the complexities and dynamic demands of the evolving power grid. Advanced rate design, characterized by innovative pricing structures, plays a central role in shaping consumer behavior, optimizing grid management, and fostering the integration of emerging technologies.

As increasing penetrations of variable renewable resources impact the time of day when system costs are lowest and renewable resources are abundant, advanced rate design provides a process to ensure changes in the power grid "flow through" to rate design.

In the context of electrification, advanced rate designs incentivize efficient and sustainable energy consumption practices. As various sectors shift towards building and transportation electrification, tailored pricing structures can encourage the adoption of cleaner energy sources, driving a more sustainable energy ecosystem.

Electric vehicles (EVs) represent a pivotal component of the energy transition, and advanced rate design is instrumental in incentivizing their widespread adoption. TOU pricing, dynamic pricing models, and demand-response mechanisms enable effective management of EV charging, encouraging off-peak usage and contributing to grid stability while providing savings opportunities that lower the cost of ownership for customers. These rate designs also position EVs as valuable assets in grid balancing efforts, allowing them to act as flexible loads that adapt to grid conditions. If sales volumes due to electrification increase during times that fall outside system peaks, the result is downward rate pressure for all—but only if loads are managed in ways that avoid contributing to existing peaks. Without incentives and other tools for shifting to off-peak charging, increased loads due to electrification could necessitate costly infrastructure upgrades to accommodate growing peaks, shifting costs to non-EV owners.

The proliferation of distributed energy resources (DERs), such as solar panels and energy storage systems, requires rate designs that accommodate their decentralized nature. Advanced rate structures can incentivize the strategic deployment of DERs by sending price signals incorporating locational and temporal value, fostering grid resilience, and supporting the transition towards a more decentralized and adaptive energy grid.

Traditional rate structures often fall short of managing peak demand effectively. Advanced rate designs, including time-varying demand charges and CPP, provide mechanisms to incentivize consumers to reduce or shift their energy consumption during peak periods, optimizing grid performance and avoiding the need for costly infrastructure expansions.

Advanced rate design provides opportunities for iteration, ensuring that pricing structures remain relevant and reflect evolving grid conditions over the short- and long-term. By aligning consumer behavior with broader energy goals and incentivizing sustainable practices, advanced rate design is a foundational element in the ongoing energy revolution, driving a more resilient, efficient, and environmentally conscious energy system.

The informed development of advanced rate designs requires collaboration between regulators, utilities, and stakeholders to comprehensively understand the grid's immediate and future needs. This includes a thorough analysis of capacity requirements, technological advancements, and the integration of smart grid solutions. By aligning rate design with the electric grid's evolving landscape, utilities and regulators can foster an environment that supports innovation, enhances grid reliability, and contributes to the overall resilience of the energy system in the face of future challenges and opportunities.

2. Comprehensive Evaluation of System Cost and Value

Advanced rate structures can reflect a comprehensive system cost and value perspective by incorporating forward-looking costs, aiming to align customer behavior with maximizing utility investments. Unlike traditional flat-rate structures, advanced rates, such as TOU or CPP models, account for the time-varying nature of electricity costs. By reflecting the real-time and forward-looking costs associated with generating, transmitting, and distributing electricity, these rates provide a more accurate representation of the economic value of electricity at different times.

Including forward-looking costs in advanced rate designs encourages customers to adjust their energy consumption patterns to align with periods of lower system costs. This, in turn, helps utilities manage demand more effectively, reducing the need for costly infrastructure investments to meet peak demand. Armed with pricing information that reflects the actual costs of electricity production, customers are incentivized to shift usage to times when electricity is more abundant and less expensive, fostering a more sustainable and cost-effective energy system.

Moreover, this holistic approach to developing advanced rates extends beyond immediate consumer cost savings. By aligning customer behavior with system needs, utilities can optimize the utilization of existing infrastructure, delay the need for costly upgrades, and enhance overall grid reliability. This integrated perspective considers the long-term sustainability of the energy system, promoting more efficient use of resources and minimizing the environmental and economic impacts associated with unnecessary utility investments.

3. Best Practices and Recommendations

Best practices and recommendations for advanced rate design in electric regulatory proceedings include:

+ **Stakeholder Engagement:** Robust engagement with stakeholders, including consumers, industry representatives, environmental advocates, and community organizations, is fundamental. Involving diverse perspectives ensures that the rate designs consider a broad range of interests, fostering transparency and building public trust.
+ **Comprehensive Cost Analysis:** Conducting a thorough cost analysis is crucial to attributing costs to the activities or behaviors that drive them. This analysis forms the foundation for designing rates that accurately reflect the underlying cost structures, promoting fairness and transparency.
+ **Equity and Affordability:** Prioritizing energy equity and affordability helps to ensure that rate structures do not disproportionately impact vulnerable or low-income communities. Implementing progressive rate structures or targeted assistance programs can mitigate the potential adverse effects on low-income and other vulnerable consumer groups.
+ **Long-Term Strategic Vision:** When rates are developed in isolation, they may not reflect consistent strategies, goals, and metrics. They also may not reflect a comprehensive analysis of load-shifting potential across all customer segments. Developing rate designs with a long-term strategic vision can facilitate consistency across tariffs and more intentional rate designs while ensuring alignment with broader energy goals, including sustainability, grid resilience, and technological advancements. Long-term strategies may consider how the rate structures can support the integration of renewable energy sources, EVs, and DERs.
+ **Flexibility and Agility:** Advanced rate design proceedings should provide a structure for consistent iteration to ensure that changes in a rapidly evolving power grid "flow-through" to rate design. In contrast to traditional rate case proceedings in which rates are launched and evaluated over long timespans, which may surpass the time the rate design reflects system conditions, advanced rate design proceedings can increase the speed of the rate design and implementation process while providing structure for regular iteration. Establishing a process for regular review and update of rate designs ensures that rate structures remain relevant, responsive, and aligned with the electric grid's and consumers' evolving needs.
+ **Pilot Programs and Iterative Approaches:** Advanced rate design proceedings may implement pilot programs to test their effectiveness before widespread implementation. Adopting an iterative approach allows adjustments based on real-world feedback and lessons learned from initial implementations.
+ **Regulatory Flexibility and Innovation:** Advanced rate design proceedings should foster a regulatory environment that encourages flexibility and innovation, allowing utilities to propose and implement new rate designs while maintaining oversight to ensure consumer protection and system reliability.
+ **Communication:** Effectively communicating rate changes to consumers requires emphasizing the rationale behind the adjustments and the potential benefits. Clear communication builds consumer understanding and support, reducing resistance to rate changes.

II. Dedicated Regulatory Proceedings and Stakeholder Processes

Advanced rate design should be treated as a distinct regulatory proceeding, separate from a traditional rate case, to ensure a comprehensive and deliberative approach to the evolving complexities of the energy landscape. While rate cases traditionally focus on recovering costs and revenue requirements, advanced rate design proceedings facilitate a more forward-looking and strategic evaluation. Introducing a separate advanced rate design process to advance alongside traditional rate case proceedings allows for dedicated attention to innovative pricing structures that align with evolving energy goals, technological advancements, and changing consumer behaviors. By having a standalone proceeding, stakeholders can engage in in-depth discussions with one another, consider long-term impacts, develop rate designs that incentivize policy goal achievement and accommodate new technologies, contribute to the resilience and sustainability of the energy grid, provide regular opportunities for iteration, and reflect consistent goals, strategies, and metrics. This separation acknowledges the unique challenges posed by an evolving power grid. It provides the regulatory space needed to explore and implement forward-thinking strategies that address the complexities of the energy transition.

Stakeholder engagement is pivotal in advanced rate design proceedings, contributing to developing effective and equitable energy pricing structures. In the context of evolving energy landscapes and the transition to more sophisticated rate designs, involving stakeholders ensures that the perspectives of various groups are considered, fostering a more inclusive decision-making process. Engaging with consumers, industry representatives, environmental advocates, and community organizations allows for a holistic understanding of advanced rate designs' potential impacts and benefits.

One key reason for stakeholder engagement is the wealth of diverse expertise and insights that different stakeholders bring to the table. Consumers, for instance, can provide valuable feedback on how rate changes might affect their behavior and consumption patterns, helping to anticipate and address potential challenges. Industry representatives can offer technical expertise, sharing insights into the practical implications of advanced rate designs on energy infrastructure and operations. Environmental advocates contribute perspectives on the sustainability and climate impacts of proposed rate structures, ensuring that environmental considerations are integrated into decision-making.

Moreover, stakeholder engagement fosters transparency and accountability in the rate design process. Regulatory bodies demonstrate a commitment to openness and fairness by involving those directly impacted by rate changes. This transparency builds trust among stakeholders and the public, helping to demystify complex rate design decisions and providing a platform for meaningful dialogue.

Stakeholder engagement is also essential for identifying unintended consequences and addressing potential disparities in the impacts of rate changes. Local communities may have unique socioeconomic dynamics, and engagement ensures that the rate design is sensitive to these nuances. This inclusive approach helps regulators anticipate challenges that might not be apparent through technical analyses alone, leading to more resilient and responsive rate structures.

Furthermore, public support is critical for the successful implementation of advanced rate designs. Stakeholder engagement facilitates communication between regulators and the public, allowing for the dissemination of information, clarification of concerns, and the incorporation of public preferences into the final rate design. This support is vital for the long-term success of any rate structure, as it reduces the likelihood of resistance or opposition from affected communities.

By providing a dedicated forum in which all load management offerings are considered in a single docket, advanced rate design proceedings can facilitate stakeholder participation by saving intervenors precious time and resources. When load management offerings are scattered across numerous, resource-intensive proceedings, it may be challenging for intervenors—many of whom face resource limitations—to participate. By consolidating all load management offerings into a single docket, advanced rate design proceedings can lower the cost of participating, enabling stakeholders to surface the need for rates and programs that a utility does not propose on its own.

Stakeholder engagement is a necessary and constructive element in advanced rate design proceedings. It leverages diverse perspectives, promotes transparency, helps identify potential challenges, and contributes to building the public support essential for developing rate structures that align with the evolving needs of communities and the broader energy landscape.

III. Rate Design Principles and Objectives

The objectives of advanced rate design and guiding principles should be set early in the process to lay the groundwork for developing rates that can achieve these objectives. Rate design principles may include topics like cost causation, gradualism, and affordability, while objectives may address policy goals such as electrification, efficiency and conservation, and emissions reduction.

A. Rate Design Principles

Common rate design principles may include cost causation, gradualism, affordability, and customer acceptability. Other common principles are that rates should encourage economically efficient decision-making and provide a sufficient opportunity for the utility to recover its revenue requirement while remaining revenue-neutral.

1. Cost Causation

Cost causation, a fundamental principle in utility rate design, asserts that the costs incurred by utilities should be allocated to and collected from consumers in a way that reflects those costs' drivers. In the context of advanced rate design, understanding cost causation facilitates the development of pricing structures that accurately attribute costs to their drivers. This helps facilitate a fair and transparent distribution of costs among consumers.[1]

However, while cost causation is a critical consideration, it is only a starting point in designing advanced rates that should be balanced with other rate design principles and policy goals. For example, while cost causation facilitates fairness by allocating costs based on the class that causes them, relying exclusively on this principle could contradict gradualism if dramatic increases in a class's cost to serve are found. Such an approach could also contradict fairness from an equity lens, as described below.

1 Faruqui, A.; Hledik, R.; Lam, L. Modernizing Distribution Rate Design. Mar. 2020. https://www.brattle.com/wp-content/uploads/2021/05/18380_modernizing_distribution_rate_design.pdf

2. Customer Acceptability

Promoting customer engagement in advanced rate design can be achieved through a combination of simplicity and choice. Simplifying rate structures ensures customers can easily understand and navigate their energy bills, fostering transparency and trust. Providing a range of options allows customers to choose plans that align with their needs and preferences, empowering them to make informed decisions based on their individual needs. By prioritizing simplicity and offering diverse options, advanced rate designs enhance customer understanding and actively involve consumers in managing their energy consumption, ultimately contributing to a more engaged and informed energy consumer base.

3. Gradualism and Affordability

Gradualism means minimizing “rate shocks” or abrupt spikes in a customer’s bill and clear communication to avoid surprising customers with sudden and significant price changes. Even if a cost-of-service study finds substantial increases in a given class’s cost to serve, regulators may opt against implementing the total rate increase to avoid rate shock and ensure affordability.

The principle of affordability also implies that time-varying rate options should be provided. Time-varying rates offer consumers more control over their electric bills by providing the opportunity to use energy during lower-priced periods. By strategically shifting their energy consumption to periods with lower rates, consumers can exercise greater control over their usage patterns while saving on their electric bills.

The flexibility granted by advanced rates empowers consumers to make informed choices based on their individual preferences and lifestyles. Those who can adapt energy-intensive activities, such as running appliances or charging EVs, to off-peak hours can experience notable bill savings. This not only results in financial benefits for customers enrolled in these rates but also contributes to a more efficient use of the overall energy infrastructure, potentially lowering costs for other customers as well.

Moreover, the opportunity for more control over electric bills fosters a heightened awareness of energy consumption habits. Customers become more attuned to the dynamic nature of energy prices, prompting them to adopt energy-efficient practices and invest in technologies that facilitate smarter energy use. As a result, advanced rates not only offer immediate bill savings but can also promote long-term energy consciousness and responsible consumption, aligning with broader sustainability objectives.

4. Efficiency

Efficiency is an economic concept regarding how price signals can lead customers to make decisions that lead to the socially optimal allocation of resources, meaning that resources are allocated in a way that corresponds with how customers value them and in which unnecessary costs to society are minimized. In economics, efficient price signals reflect marginal cost or the cost of producing the next unit of a good. As discussed further below, marginal cost studies can be used to inform rates that send economically efficient price signals. However, because a utility will not recover its substantial infrastructure investments (sunk costs) if rates are based only on marginal cost, subjective determinations are typically required to inform rate designs that must exceed marginal cost and will thus result in some inefficient resource allocation.

5. Revenue Sufficiency and Neutrality

A common rate design principle is that utilities are provided with an opportunity, though not necessarily a guarantee, to recover their revenue requirement. At the same time, rates should aim for revenue neutrality with existing rates. Revenue neutrality means that the implementation of new rate structures does not generate additional revenue for utilities but instead distributes and collects costs from consumers more equitably and efficiently. This approach is crucial for fostering customer trust and minimizing financial impacts on customer segments.

In transitioning to advanced rate designs, utilities must carefully analyze the potential financial implications and ensure that the overall revenue collected remains consistent with existing rate structures. Any rate adjustments should be offset by corresponding reductions or increases elsewhere, maintaining a balance that does not unduly burden consumers or provide windfall gains for the utility. Achieving revenue neutrality requires a comprehensive understanding of the current rate landscape and a transparent and collaborative approach to communicating changes to customers.

Ratemaking is an Art and a Science

Ratemaking is often considered more of an art than a strict science, blending quantitative analysis with judgment to create pricing structures that balance the needs and preferences of consumers, utilities, and regulators.

While scientific methodologies and data analytics play an important role in illuminating cost structures, predicting demand patterns, and assessing economic and financial implications, the art of ratemaking lies in the interpretation of these findings.

Regulators and utilities must consider various factors such as economic conditions, social equity, and the broader policy landscape, all of which involve subjective judgment. Crafting rates that are fair, transparent, and responsive to the dynamic nature of the energy sector requires a creative and adaptive approach. The artistry in ratemaking emerges from the ability to synthesize quantitative insights with policy considerations, acknowledging the complexity of the energy ecosystem and the diverse interests of stakeholders involved. This blending of science and art ensures that ratemaking reflects not only the technical realities of the industry but also the broader socio-economic and policy contexts in which it operates.

B. Rate Design Objectives

Rate design objectives, which should be considered alongside rate principles, may include advancing energy equity and justice, reducing environmental impacts, and promoting energy efficiency and conservation, electrification, reliability, and resilience.

1. Energy Equity and Justice

Energy equity recognizes the importance of fairness and affordability, particularly for vulnerable or low-income communities. As stated, allocating costs based solely on causation may disproportionately burden certain consumer groups, potentially exacerbating socioeconomic disparities.

Advanced rate design should thus strive for a delicate equilibrium, incorporating considerations of equity and justice alongside cost causation. This involves recognizing that certain consumers may have limited ability to respond to rate changes, invest in energy-efficient technologies, or shift their consumption patterns. Balancing cost causation with equity considerations enables rate structures that do not unduly burden vulnerable populations and ensures that the benefits of advanced rate designs are shared equitably across society.

One approach to achieving this balance is incorporating progressive rate structures or targeted assistance programs that provide financial relief to those facing energy affordability challenges. Additionally, robust stakeholder engagement processes can gather insights from diverse communities, ensuring that the concerns of all consumers are considered in the design and implementation of advanced rate structures.

While cost causation informs the allocation of costs in advanced rate design, a holistic and balanced approach must be taken. By integrating energy equity and justice principles, advanced rate design can contribute to a more inclusive and fair energy transition that benefits all consumers, irrespective of their socioeconomic circumstances.

2. Reducing Environmental Impacts

Reducing greenhouse gas (GHG) emissions is paramount in transitioning to a sustainable energy system. Advanced rate designs, particularly those incorporating load shifting and shedding mechanisms, offer a powerful strategy to minimize GHG emissions by curbing reliance on fossil fuel generation during peak demand periods.[2]

Load shifting involves encouraging consumers to adjust their energy consumption to off-peak hours when renewable energy sources are more abundant and, in some jurisdictions, the primary contributors to the energy mix. By incentivizing customers to shift their usage patterns through time-varying pricing models like TOU rates, utilities can flatten demand peaks, thereby reducing the need for additional fossil fuel-based power generation during high-demand periods. This not only optimizes the utilization of renewable resources but also diminishes the carbon footprint associated with conventional power plants.

Load shedding, another component of advanced rate designs, involves the controlled reduction of electricity demand during critical periods. This can be achieved through automated systems or voluntary actions by consumers in response to price signals. By strategically shedding load during times of peak demand, utilities can avert the need to fire up additional fossil fuel plants, which are often the least environmentally friendly sources of electricity. While load shifting typically refers to encouraging demand during off-peak hours when renewable generation is highest, shedding refers to encouraging customers to curtail load during emergency or contingency events.

3. Energy Efficiency and Conservation

Time-varying pricing structures provide customers with clear economic incentives to reduce consumption during peak periods and shift energy usage to off-peak hours. Regulatory Assistance Project (RAP) research indicates that time-varying pricing models create a more favorable economic environment for customers to invest in energy-efficient measures, such as smart thermostats, efficient appliances, and home energy management systems.[3] The exposure to varying electricity prices at different times of the day prompts consumers to seek long-term solutions to manage their energy costs effectively.

Rate designs that seek to advance energy efficiency and conservation may also have higher volumetric charges and correspondingly lower customer charges, as a higher volumetric price encourages customers to decrease their usage through conservation and decreases the payback period on efficient appliance upgrades.

RAP's research underscores the importance of aligning pricing structures with consumer behavior to drive sustainable energy practices. The findings suggest that time-varying rates not only benefit customers in the short term by reducing their electricity bills but also foster a mindset of energy consciousness and efficiency that leads to more substantial and enduring investments in energy-efficient assets. This research contributes valuable insights for policymakers, utilities, and consumers alike, emphasizing the role of time-varying pricing strategies in promoting a sustainable and resilient energy future.

2 Zohrabian, A.; Sanders, K.T. Emitting less without curbing usage? Exploring greenhouse gas mitigation strategies in the water industry through load shifting, Applied Energy, Volume 298, 2021, 117194, ISSN 0306-2619, https://doi.org/10.1016/j.apenergy.2021.117194

3 Lazar, J. and Gonzalez, W. Smart Rate Design for a Smart Future. Montpelier, VT: Regulatory Assistance Project. https://www.raponline.org/knowledge-center/smart-rate-design-for-a-smart-future/

4. Electrification

Time-varying rates also incentivize electrification. EVs and heating appliances are typically flexible sources of load, providing a window over which lower electricity prices allow customers to charge their vehicles or use their appliances when prices are lower, decreasing the total cost of owning an EV or appliance. Effective seasonal differentiation can serve as a powerful incentive for heating electrification in summer-peaking systems, which have excess capacity and thus lower costs in the winter. However, rates should be continuously re-evaluated as summer-peaking systems may eventually peak in the winter as heating electrification accelerates.

Another option for incentivizing electrification is to design optional rates with higher customer charges and correspondingly lower volumetric charges. These charges decrease the costs customers pay for their increased electricity usage and, thus, the payback on investment in electric appliances. Such rate schedules must remain optional to mitigate potential impacts on low-usage customers and price signals for efficiency, conservation, and distributed generation.

5. Promoting Reliability

In response to the price signals communicated by dynamic rates or CPP tariffs, consumers are incentivized to shift their energy usage to off-peak hours when electricity is less expensive. By voluntarily adjusting their behavior in alignment with pricing information, customers can collectively reduce the overall demand on the grid during peak periods, mitigating the need for additional capacity while enhancing grid reliability.

Furthermore, time-varying price signals can contribute to a more resilient and efficient grid by incentivizing the adoption of energy-efficient technologies and load-shifting practice, as stated.[4] While CPP tariffs can incentivize customers to shift load during the highest peak hours of the year, dynamic rates, which reflect the real-time or hourly price of electricity, can also serve as a powerful incentive for investment in load-shifting technologies by expanding the number of hours over which a customer benefits from shifting load.

Price signals empower consumers to play an active role in grid management by creating a direct link between pricing and grid conditions. This demand response not only reduces stress on the grid during peak hours but also minimizes the risk of capacity issues, fostering a more sustainable and reliable energy infrastructure.[5]

6. Resilience

The communication of price signals to consumers can significantly improve resilience as extreme weather events and power shutoffs due to wildfire risk become increasingly common. For example, when faced with supply shortages or unforeseen events such as natural disasters, dynamic pricing models can effectively manage demand in real time. By sending price signals that reflect the current state of the energy system, consumers are incentivized to adjust their electricity usage patterns, reducing strain on the grid during peak demand or supply shortages. This demand response capability helps prevent grid overloads and facilitates a faster recovery by ensuring a more balanced and efficient allocation of available resources. Price signals encourage consumers to act as partners in grid resilience, responding to market conditions and aiding in service restoration.

4 Bogdanova, O.; Viskuba, K.; Zem¯ıte, L. A Review of Barriers and Enables in Demand Response Performance Chain. Energies 2023, 16, 6699. https://doi.org/10.3390/en16186699

5 Shao, S.; Pipattanasomporn, M.; and Rahman S. An Approach for Demand Response to Alleviate Power System Stress Conditions. https://ari.vt.edu/content/ari_vt_edu/en/publications_archive/an-approach-for-demand-response-to-alleviate-power-system-stress/_jcr_content/content/download/file.res/06039852.pdf

IV. Design of New Advanced Rates

Advanced rates can optimize energy consumption patterns among consumers. These rates are designed to reflect time-varying costs more accurately, thus encouraging off-peak usage and mitigating strain on the grid during peak periods.

A. Types of Advanced Rates

By providing a menu of rate options that are as diverse as possible, electric utilities can ensure that every customer can translate their needs and capabilities into grid benefits. Advanced rate options, each of which offers different benefits to customers and the grid, include:

+ **Time-of-Use (TOU) Rates:** TOU rates vary based on the time of day, encouraging consumers to shift their energy consumption to off-peak hours when the demand on the grid is lower. TOU rates usually include two or three windows (peak, off-peak, and shoulder) reflecting the average electricity price during each window. By adjusting usage according to TOU price signals, customers can manage energy usage more effectively while providing grid benefits. While TOU rates are not a precise enough tool for targeting the small number of hours that drive peak demand costs, they are typically easier for customers to understand and allow customers to avoid exposure to price spikes, a feature of other rate designs.
+ **Critical Peak Pricing (CPP):** CPP tariffs involve much higher electricity rates during a few critical periods when demand on the grid is exceptionally high. Consumers are incentivized to reduce usage or shift it to other times to avoid very high costs during these critical events in exchange for lower rates outside of critical peak periods. Many CPP tariffs are combined with TOU rate structures, such that the energy services provided by TOU rates are supplemented by CPP capacity services that target the highest peak hours.
+ **Real-Time Pricing or Dynamic Rates:** Real-time pricing adjusts electricity prices in real time based on market conditions and actual grid demand. Consumers face prices that reflect the true cost of electricity at any given moment, promoting responsiveness to changing conditions. While such tariffs are more complex than simple TOU or CPP options and can expose customers to very high prices, they can also expand the opportunities available to customers to save on their bills.
+ **Subscription-Based Tariffs:** Subscription-based tariffs allow consumers to subscribe to a specific level of electricity service, with different subscription tiers offering varying levels of renewable energy content as well as other customized features.
+ **Time-Variant Incentives:** Time-variant incentives provide consumers with financial rewards or discounts for reducing energy consumption during specified periods, contributing to grid stability and efficiency.
+ **TOU with Critical Peak Rebate (CPR):** Combining TOU with CPR involves offering rebates to consumers who actively reduce energy usage during critical peak periods, providing a financial incentive for demand response. While CPP tariffs have higher prices during peak periods, CPR tariffs provide rebates to customers who reduce their usage. However, research has demonstrated that CPP tariffs typically incentivize much more significant demand reduction than CPR rates.[6]

6 Peter Cappers, Liesel Hans, Richard Scheer, *American Recovery and Reinvestment Act of 2009: Interim Report on Customer Acceptance, Retention, and Response to Time-Based Rates from the Consumer Behavior Studies*, Lawrence Berkeley National Laboratory (June 2015). https://eta-publications.lbl.gov/sites/default/files/lbnl-183029.pdf

+ **Export Tariffs:** Export tariffs typically combine TOU rates with compensation for customers who export energy to the grid from distributed resources such as solar, battery storage, or EVs.
+ **Direct Load Control:** Some customers may have schedules that prevent them from responding to price signals, or they may simply lack the commitment to doing so. Programs that directly control a customer's load, such as active EV-managed charging programs or tariffs that directly control a customer's heating appliances, can facilitate participation in load management for such customers.

B. Main Components of Advanced Rates

1. Rate Components

Advanced rate designs go beyond traditional flat-rate models, reflecting the time-varying nature of energy consumption. These components may include volumetric rates, demand charges, and other sophisticated mechanisms aimed at optimizing energy usage. The most common rate components of advanced rate designs include:

+ **Fixed or Customer Charges:** The fixed or customer charge is a flat fee applied regardless of the amount of electricity consumed. This charge is generally designed to recover the cost of connecting a customer to the grid. While customer charges provide revenue stability for utilities, they have raised discussions about equity, as increases to customer charges can disproportionately impact low-usage customers, who also tend to be low-income, and decrease a customer's control over their energy bill. In addition, because increases in customer charges are offset by decreases in volumetric rates or energy charges, customer charge increases can increase the payback period for recovering investment in more efficient appliances or DERs, thus disincentivizing investment in such technologies.
+ **Energy Charges:** Energy or volumetric charges represent the cost of electricity consumed and are typically measured in cents per kilowatt-hour (kWh). This component directly correlates with the amount of electricity a customer uses during a billing period. Advanced rate designs will typically implement time-varying energy charges.
+ **Demand Charges:** Demand charges are based on the highest rate of electricity consumption within a defined period, usually measured in kilowatts (kW). These charges reflect a customer's maximum load on the grid during a billing cycle, encouraging users to manage their peak demand. Demand charges are common in commercial and industrial rate structures, where a high demand at any point in time can necessitate additional infrastructure to meet capacity requirements. It is not typical for the residential class to have demand charges. While demand charges for residential customers may be justified from a cost perspective, most residential customers are not used to thinking about electric capacity. They may find demand charges challenging to understand. It is becoming increasingly common for advanced rate designs to implement time-varying demand charges such that customers effectively pay multiple demand charges, with higher rates for demand incurred during peak periods.
+ **Grid Access Charges:** A grid access charge is a $/customer or $/kW fee imposed on consumers to access and use the electric grid infrastructure. This charge is designed to recover the costs associated with building, maintaining, and upgrading the transmission and distribution system, which serves as the intricate network of power lines, transformers, substations, and related equipment that facilitates the delivery of electricity. These charges are typically included as a component of the overall electricity bill and are assessed based on their level of usage and the grid services required to deliver electricity to their premises. Grid access charges are increasingly being used in tariffs for customers with distributed technologies (net metering and successor

tariffs) to mitigate against intra-class cost shifts that can materialize if DER customers do not pay for the full cost of the distribution and transmission services they receive, which can occur under traditional net metering rate designs.

+ **Variable Charges:** Variable charges are additional fees recovered volumetrically (in cents per kWh), which may vary depending on factors such as fuel costs or environmental compliance. These charges are designed to account for fluctuations in the cost of producing electricity and are often subject to periodic adjustments.
+ **Minimum Bill:** The minimum bill is the lowest amount a customer must pay, regardless of actual energy consumption. This ensures utilities can cover operational costs, even if a customer's usage is minimal. Minimum bills are often associated with residential and small commercial rate structures.
+ **Other Rate Components (e.g., EV Metering):** Additional items on a utility bill may include charges or credits related to specific programs or services. For instance, EV metering charges might apply when customers use specialized meters to measure and manage electricity consumption related to charging EVs. These items reflect the evolving nature of the energy landscape and the incorporation of new technologies into rate structures.

2. Other Rate Design Considerations

With time-varying rates, energy charges (and increasingly demand charges) are defined through TOU periods, peak-to-off-peak ratios, and seasonal differentiation. By providing a structure for regular iteration, advanced rate design proceedings can ensure that each element is regularly updated to reflect the changes in a rapidly evolving power grid.

+ **Time-of-Use (TOU) Periods:** TOU periods divide the day into different time brackets, each with its corresponding electricity rate. These periods typically include on-peak, mid-peak (or shoulder), and off-peak hours, with rates varying to reflect the changing energy and capacity costs throughout the day. TOU pricing encourages consumers to shift their energy use to lower-cost periods, promoting grid efficiency. Shorter TOU periods typically allow for a higher on-to-off-peak ratio, as described below. In addition, residential customer surveys indicate a preference for shorter peak periods, even if that means peak prices will increase.[7]
+ **On-Peak to Mid-Peak to Off-Peak Ratios:** These ratios define the relative price differences within a TOU rate structure between on-peak, mid-peak, and off-peak periods. Typically, the size of the on- to off-peak ratio is strongly correlated with the customer's load-shifting response. For instance, a 2:1 peak ratio tends to produce a peak reduction of 5% vs. 10% for a 5:1 ratio. Some studies suggest diminishing returns with higher ratios.[8] However, a peak-to-off-peak ratio should typically be at least 2:1 (if not 3:1) to send strong price signals for shifting to off-peak usage. The need to send strong price signals should be balanced to protect customers from exposure to prices that are high enough to dissuade their participation in a TOU rate.
+ **Seasonal Differentiation:** Advanced rates may vary by time and season, with higher prices during the summer or non-summer months based on the season in which the utility peaks and must thus recover higher system costs. As stated, building electrification has necessitated regular re-evaluation of seasonal cost differences, as summer-peaking systems may eventually peak in the winter as electrification accelerates.

7 "SMUD SmartPricing Options Pilot Evaluation Submitted to Sacramento Municipal Utility," Nexant (August 6, 2014) https://www.smud.org/-/media/Documents/Corporate/About-Us/Energy-Research-and-Development/research-SmartPricing-options-final-evaluation.ashx at 98.

8 A. Faruqui and S. Sergici, "Arcturus: International Evidence on Dynamic Pricing," The Electricity Journal, vol.26, no. 7, pp. 55–65, Aug. 2013.

Integrating multipart rates in advanced rate design allows for a more nuanced and adaptable approach to pricing that aligns with the goals of grid optimization, sustainability, and consumer engagement. For example, a rate structure might include TOU rates to encourage load-shifting, customer charges for costs that vary with the number of customers on the system, and time-varying demand charges to address capacity-related expenses. The combination of these components creates a more sophisticated pricing model that supports both the financial viability of utilities and the efficient, sustainable use of energy resources by consumers. This multipart approach is crucial in transitioning to a more resilient and dynamic energy system.

C. Capacity Costs

Advanced rate design is significantly influenced by capacity costs, encompassing infrastructure and market dynamics. Capacity costs represent the expenses associated with ensuring sufficient generation, transmission, and distribution capacity to meet peak demand, which is crucial for maintaining grid reliability. In the context of advanced rate design, considering capacity costs is essential in shaping pricing structures that reflect the actual value of capacity and contribute to effective grid management.

Market dynamics influence capacity costs, particularly in regions with capacity markets. Capacity markets provide a mechanism for utilities to procure resources to meet peak demand, and these costs are factored into the overall pricing structure. Advanced rate design considers the intricacies of capacity markets, ensuring that the pricing models accurately reflect the costs associated with securing sufficient capacity to meet system reliability requirements.

In regions with competitive capacity markets, where generators bid to provide additional capacity, advanced rate designs may consider the market-clearing prices and mechanisms. Utilities and system operators may implement demand charges based on these market dynamics, influencing how costs are passed to consumers. The intricacies of market-driven capacity costs necessitate a nuanced approach in advanced rate design to ensure fairness, efficiency, and alignment with broader energy goals.

D. Marginal vs. Embedded Cost of Service

In the realm of advanced rate design, understanding the nuances between marginal and embedded cost of service is crucial for developing effective and equitable rate structures. These approaches represent distinct methodologies for assessing the cost of providing electricity and play a pivotal role in shaping energy pricing strategies.

The marginal cost of service studies focuses on evaluating the incremental cost associated with producing and delivering an additional unit of electricity and capacity to the grid. Such an approach considers both short-term variable costs (such as fuel and operational expenses) as well as long-term marginal infrastructure costs to determine the cost implications of incremental changes in energy and capacity to generate and deliver electricity. According to economic theory, economically efficient price signals (i.e., those incentivizing the socially optimal use of resources) are based on marginal cost. The marginal cost of service studies serves as a guide for designing rates that incentivize optimal resource utilization.

However, while marginal cost of service studies can facilitate the design of economically efficient rate designs, a utility will not recover its full revenue requirement if it recovers only its marginal costs. Thus, embedded cost of service studies consider the total costs associated with the entire electricity delivery infrastructure. The embedded cost of service study is more static and typically involves allocating costs over a predetermined period, often reflecting a historical perspective.[9] This approach ensures cost recovery for utilities based on their overall investment in infrastructure.

9 Wissman, K. Embedded Cost of Service. Presentation. NARUC. https://pubs.naruc.org/pub/537917B0-2354-D714-51AE-D7D4FCD8480B

The choice between marginal and embedded cost of service studies in advanced rate design depends on the specific objectives and policy goals. The marginal cost of service studies is favored in scenarios where the goal is to provide price signals that encourage efficient resource allocation and are particularly relevant in the context of integrating renewable energy sources and managing peak demand. Conversely, embedded cost-of-service studies are valuable for allocating and collecting a utility's entire revenue requirement and ensuring the financial viability and stability of the utility. However, such an approach may face challenges in accommodating the dynamic nature of modern energy systems, where factors like distributed generation, energy storage, and demand response programs are reshaping the traditional utility landscape.

Ultimately, a balanced approach that combines elements of marginal and embedded cost-of-service studies may be necessary for advanced rate design. This hybrid approach can optimize economic efficiency while ensuring utilities' financial viability.

E. Granularity of Interval Data

The granularity of interval data is instrumental in refining advanced rate design by providing a detailed and time-sensitive understanding of the factors influencing costs. Interval data, with its high temporal resolution, allows for the measurement of costs at specific times, enabling analysts to identify cost drivers and develop more precise rate structures that reflect the dynamic nature of energy consumption patterns and contribute to efficient resource allocation.

Interval data serves as a critical asset for utilities, offering precise measurement capabilities that facilitate the accurate allocation of costs to specific customer segments based on their unique energy consumption patterns. This granularity allows for a detailed and accurate assessment of the actual costs associated with serving different customer classes at various times. This level of precision is invaluable in optimizing resource allocation, ensuring that costs are distributed fairly and that rate structures align with the diverse needs of consumers.

Moreover, granular interval data enables analysts to identify peak demand periods, offering insights into when the system experiences the highest stress. With this information, utilities can develop rate structures that effectively target peak demand, reducing the necessity for costly infrastructure investments. Such an approach not only optimizes grid efficiency but also contributes to the overall reliability and resilience of the energy system.

Additionally, utilities can leverage interval data for targeted customer engagement. By understanding consumption patterns in detail, utilities can provide personalized information and incentives that encourage efficient consumption practices such as load shifting and other behaviors beneficial to the overall energy system. Interval data facilitates accurate cost recovery by ensuring that rates reflect the varying costs to serve different customer segments at various times of the day and year. This accuracy is essential for achieving a fair and equitable distribution and recovery of costs among consumers. Finally, granular interval data aids utilities in optimizing grid planning and infrastructure investments by identifying specific areas or customer segments with high demand during certain periods. This insight enables utilities to strategically plan investments, address capacity constraints, and enhance overall grid reliability in a targeted and efficient manner.

F. Net Load

Historically, power system planning focused on “building to the peak” through centralized, dispatchable generation, with cost causation as a function of variation in demand. In today’s power system, as variable, renewable generation becomes more common, cost causation has evolved to reflect the imbalance between supply and demand, also known as net load (aggregate load minus renewable generation). Because net load is more likely to drive system costs in today’s power system, time-varying rates should typically be informed by net load rather than aggregate load. Because the costliest hours typically occur when non-renewable resources are on the margin, designing time-varying rates based on net load can allow for price signals that incentivize electricity usage during the hours that are not only cheapest, but cleanest.

V. Example: Hawaii’s Default Residential TOU Offering: Hawaii Public Utilities Commission Docket 2019-0323

In an order issued in October of 2022, the Hawaii Public Utilities Commission approved a three-part volumetric time-varying rate with several fixed charges that accurately capture costs to serve residential customers. First, the customer charge is designed to cover metering and billing costs exclusively, providing a baseline fee irrespective of energy consumption. In addition, the grid access charge, quantified in dollars per kilowatt, accounts for the cost associated with connecting to the grid, focusing on service drops and final line transformers.

The TOU rate, featuring 1:2:3 ratios for off-peak, on-peak, and mid-peak periods, introduces a time-varying element to pricing. Off-peak hours from 9 AM to 5 PM, on-peak hours from 5 PM to 9 PM, and mid-peak hours from 9 PM to 9 AM reflect the varying demands on the grid throughout the day and reflect a short (four-hour) on-peak window that allows for strong peak to off-peak price differentials and is likely to be attractive to customers. Importantly, customers have the option to opt out of the TOU structure, providing flexibility based on individual preferences.

While the minimum bill for residential customers remains unchanged at $25 per month, introducing surcharges and tariff riders adds complexity to the billing structure. These additional charges mainly apply to TOU blocks and include mechanisms such as a decoupling true-up based on a percentage of the bill, green infrastructure charges per customer, and uniform public benefits charges per kilowatt-hour.

The proposed rate design seeks to balance fixed and variable costs, incorporating time-sensitive pricing through TOU rates. Including an opt-out option for customers and a minimum bill for residential users aims to provide flexibility and predictability. The introduction of surcharges and tariff riders further strengthens the pricing structure, aligning with broader policy goals such as promoting green infrastructure and supporting public benefits within the energy sector.

Summary of Hawaii's Advanced Rate Structure:	
Customer Charge	Metering and billing costs only
Grid Access Charge	$/kW for the cost of connecting to the grid. This charge applies to service drops and final line transformers only
All other costs in a TOU rate with 1:2:3 ratios	+ Off-Peak: 9 AM – 5 PM + On-Peak: 5 PM – 9 PM + Mid-Peak: 9 PM – 9 AM
Opt-out available for customers from TOU	
Minimum bill ($25/month for residential)	
Surcharges and Tariff Riders	+ Most surcharges follow TOU temporal blocks + Decoupling true-up on a percent of the bill + Green Infrastructure $/customer + Public Benefits uniform $/kWh

VI. Considerations - Default or Opt-in for Residential Advanced Rates

A key implementation design consideration includes the enrollment method or whether a time-varying rate should be opt-in or opt-out (default). Default rates have traditionally been flat (i.e., they are not time-varying), but there are emerging arguments that simple TOU rate designs are best suited as the default option.

Implementing a default enrollment strategy simplifies the onboarding process and ensures a broad and immediate impact on energy consumption patterns. The default option leverages the principle of inertia, assuming customers are more likely to stick with the rate option they were assigned. This can be advantageous for achieving widespread adoption of advanced rates, especially if the default rates are designed to be broadly beneficial and align with overall policy objectives. However, it is essential to communicate the changes to customers to avoid confusion or resistance.

While an opt-in model is typically intended to put the decision-making power in the hands of individual customers, as explained below, such models may actually sway customers against a decision that is in their best interests. Opt-out models mitigate against the risk that a customer who would not benefit from a TOU rate is automatically enrolled in one; however, the risk that customers may be harmed by automatic enrollment in flat rates may be more significant. Opt-in approaches may result in lower adoption rates if customers hesitate or lack awareness and information about the potential benefits. An effective communication strategy becomes crucial in an opt-in model to educate customers about the advantages of advanced rates and encourage their voluntary participation.

Recent literature has documented the positive effects of default TOU enrollment. A Lawrence Berkeley National Labs (LBNL) study found that "making time-varying pricing the default choice can significantly increase participation:" while only 20% of the participants in the study opted into TOU rates, 90% stayed with the TOU option when defaulted into it. "Passive" customers (i.e., those who neither opt-in nor out of TOU programs) nonetheless reduced usage during peak periods. The study also found "a striking lack of correlation between households' participation choices [to enroll in a TOU program] and the savings they stand to gain from participation, even in the presence of a program enrollment deadline," demonstrating the power of a default option in encouraging customers to pursue even those choices that are not aligned with their economic interests.[10] An additional LBNL study found that customers who have been defaulted onto TOU rates have overwhelmingly remained on those rates despite being provided the option to change.[11]

Before enrolling all customers in default rates, it is important to conduct a pilot to ensure that low-income customers are not unreasonably burdened. For example, one recent study prepared for the Maryland Public Service Commission found that low- and moderate-income (LMI) customers responded to TOU signals nearly as much as other customers and that, on average, all customers on the TOU rates (including LMI customers) benefited from bill savings of 5% to 10%.[12]

Ensuring energy equity is a critical aspect of modern energy policies, and one way to achieve this goal is to provide opportunities for all customers on default rates to save money by shifting energy use. By implementing time-varying pricing structures, such as TOU rates, as the default option, all customers, including those on default rates, can benefit from cost savings by adjusting their energy consumption patterns.[13] This framework promotes equity by democratizing access to financial savings derived from load-shifting practices.

There will always be some customers who will not benefit from default TOU enrollment—but this is also true for customers enrolled in flat rates by default. The subgroup of customers that declines to disenroll from rates from which they do not benefit is particularly vulnerable. However, given the widespread benefits of TOU rates, it is likely to be more cost-effective for a utility to focus its marketing efforts on targeting customers who should opt out of default rates rather than targeting customers to encourage them to opt in.[14]

Regardless of whether an opt-in or opt-out approach is selected, continuous monitoring and feedback mechanisms should be in place to assess the effectiveness of the chosen strategy and adjust as needed to optimize customer engagement and overall program success. Ultimately, the decision should be driven by a thorough understanding of customer behavior, effective communication strategies, and a commitment to achieving the desired outcomes regarding energy efficiency, grid optimization, and customer satisfaction.

10 Default Effects and Follow-on Behavior: Evidence from an Electric Pricing Program, Lawrence Berkeley National Lab at 3 (Aug. 21, 2020), https://haas.berkeley.edu/wp-content/uploads/WP280.pdf

11 Time-of-Use as a Default Rate for Residential Customers: Issues and Insights, Lawrence Berkeley National Laboratory (June 2016), https://eta-publications.lbl.gov/sites/default/files/lbnl-1005704.pdf

12 Study by Brattle Economists Evaluates Time-of-Use (TOU) Pilots for Maryland Utilities, Brattle Group (Sept. 15, 2020), https://www.brattle.com/insights-events/publications/study-by-brattle-economists-evaluates-time-of-use-tou-pilots-for-maryland-utilities/ ; PC44 Time of Use Pilots: Year One Evaluation, Brattle Group (Sept. 15, 2020), https://www.brattle.com/wp-content/uploads/2021/05/19973_pc44_time_of_use_pilots_-_year_one_evaluation.pdf

13 Fowlie, M.; Wolfram, C.; Spurlock, C.A.; Todd-Blick, A.; Baylis, T.; Cappers, P. Default Effects and Follow-On Behavior: Evidence from an Electricity Pricing Program. Aug. 2020. https://www.haas.berkeley.edu/wp-content/uploads/Default_Effects_and_Follow_on_Behaviour__Evidence_from_an_Electricity_Pricing_Program-2-2020.pdf

14 Time-of-Use as a Default Rate for Residential Customers: Issues and Insights, Lawrence Berkeley National Laboratory (June 2016), https://eta-publications.lbl.gov/sites/default/files/lbnl-1005704.pdf

VII. Conclusion

Advanced rate design proceedings can facilitate a cost-effective energy transition by providing a structured process for stakeholders to develop consistent strategies, goals, and metrics and ensure that rates are consistently re-evaluated to reflect a rapidly evolving power grid. Implementing a dedicated regulatory proceeding informed by diverse stakeholder perspectives is paramount in fostering collaboration and inclusivity in the design of advanced rate structures and can accelerate the speed at which rates are approved and evaluated.

Regulators should pursue a balanced approach in which cost causation is tempered with other rate design principles such as affordability and gradualism, as well as policy goals such as energy equity and justice, emissions reduction, electrification, energy efficiency and conservation, and other goals. Such guiding principles and policy goals provide a roadmap for effective rate design.

By providing a diverse menu of rate design options that reflect the time-varying nature of system costs and are attractive to various customer segments, regulators can ensure that every customer has the opportunity to translate their needs and capabilities into grid benefits that lead to savings on their electric bills and downward rate pressure for other customers. The granularity of interval data ensures that rates are designed to respond to the time-varying price of energy and capacity throughout the day and year. Stakeholders should carefully consider the choice between marginal and embedded cost of service studies to design rates that send efficient price signals while providing an opportunity for the utility to recover its revenue requirement. Typically, advanced rates should be informed by net load and should send price signals that incentivize load shifting (for instance, through strong peak-to-off-peak price ratios) while remaining attractive to customers (for example, by using relatively short on-peak windows). While enrollment methods should be piloted to study impacts on low-income customers, making TOU rates (rather than flat rates) the default option may expand opportunities for customers to save on their energy bills and require lower marketing costs than requiring customers to opt into TOU rates.

The design of advanced rates for residential, commercial, and industrial customers should be approached with a keen understanding of each customer segment's unique needs and dynamics. The success of advanced rates in attracting customers and maintaining their ongoing participation hinges on the collaborative efforts of industry stakeholders, regulators, and consumers.

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