Benchmarking Study of U.S. Regulated Utility Real Time Pricing Programs, Architecture and Design

Final Report

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Technical Update, March 2021

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This is an EPRI Technical Update report. A Technical Update report is intended as an informal report of continuing research, a meeting, or a topical study. It is not a final EPRI technical report.

NOTE

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ABSTRACT

The project sought to classify the ecosystem of time-varying pricing constructs, inclusive of dynamic pricing and time-of-use (TOU) structures and their derivatives, into a logical and applicable taxonomy. It also advanced a conceptual foundation to ascribe "building block" attributes of dynamic pricing plans. The project conducted a comprehensive review of the universe of RTP plans that have been offered by regulated utilities across the U.S. This was based on documented studies cited in the report. Due diligence was then conducted on the identified plans to (a) verify their accurate classification as RTP plans and (b) document structural attributes for sub-classification. As a further step, interviews were conducted with rate managers from selected utilities across the country with experience in RTP to better understand the motivations for developing the plans, customer uptake and persistence in the plans, customer satisfaction, and load shaping results. Finally, the project provided a conceptual illustration of designing an RTP plan to integrate into a utility pricing portfolio.

Keywords

Real time pricing
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EXECUTIVE SUMMARY

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PRIMARY AUDIENCE: Utility professionals in rate design and pricing products

SECONDARY AUDIENCE: Utility professionals in customer programs

KEY RESEARCH QUESTION

This study captures the current landscape of real time pricing (RTP) programs offered by regulated electricity suppliers in the United States. It characterizes RTP design principles and benchmarks design choices and utility experiences with RTP offerings in terms of practice, performance and lessons learned to inform better design of RTP plans and programs. This study further provides a framework for how to design and develop RTP offerings that can promote strategic load management objectives.

RESEARCH OVERVIEW

- Taxonomy of Pricing: The project first sought to classify the ecosystem of time-varying pricing constructs, inclusive of dynamic pricing and time-of-use (TOU) structures and their derivatives, into a logical and applicable taxonomy. It also advanced a conceptual foundation to ascribe "building block" attributes of dynamic pricing offerings, including RTP.
- Definition of RTP: RTP is a variant of dynamic pricing in which the price for electricity fluctuates hourly, and sometimes sub-hourly, reflecting changes in the wholesale price of electricity and is typically known to customers on a day-ahead or hour-ahead basis. Despite the "real-time" naming convention, the retail rate is distinguished from wholesale prices that may be transmitted from day-ahead or hour-ahead markets, in addition to more granular sub-hourly wholesale markets such as the California Independent System Operator (CAISO) Fifteen Minute Market (FFM) or five-minute Real Time Market (RTM). The study focused exclusively on "full requirements" RTP offerings that apply to all electricity use at a customer facility's, rather than applied to a specific end-use such as electric vehicle charging.
- Secondary Research on RTP: The project conducted a comprehensive review of the universe of RTP plans that have been offered by regulated electricity suppliers across the U.S. This was based on documented studies cited in the report. Due diligence was then conducted to (a) verify RTP classification, and (b) document structural attributes for sub-classification.
- Benchmarking RTP: As a further step, interviews were conducted with rate managers from selected utilities across the country with experience in RTP to better understand the motivations for developing the plans and plan attributes, customer uptake and persistence in the plans, customer satisfaction, and load shaping results. Finally, the project provided a conceptual illustration of designing an RTP plan to integrate into a utility pricing portfolio.
- Evaluating RTP Load Response
- Illustration of integrating RTP into an Electric Service Portfolio

KEY FINDINGS:

- RTP Program Availability and Eligibility
  - The study verified 55 currently active RTP offerings from 41 regulated U.S. utilities.
  - 51 of these RTP offerings are open for new enrollment while enrollment for the remaining 4 is capped are therefore not available for new subscribers.
  - Only two (2) active residential RTP offerings were identified, compared to 53 RTP offerings for non-residential customer classes. The reason that RTP has been scarcely applied to residential customers owes chiefly to a lack of technology to enable households to automate responses to price signals. By contrast, non-residential customers – particularly larger commercial and industrial customers – are more likely to have control systems in place to automate responses to RTP signals. Moreover, many larger non-residential customers have dedicated energy managers and staff who actively manage energy usage.
  - Availability and eligibility for RTP among non-residential customers is weighted towards larger commercial and industrial customers based on such factors as minimum monthly peak demand. 35 RTP offerings require a peak demand greater than 100 kW, with 15 of those requiring a peak demand greater than 1 MW.
  - All RTP programs identified were opt-in, except in jurisdictions with full retail competition for which RTP is default or mandatory for large customers who do not select an alternate retail electricity provider.
- Drivers:
  - The impetus for most utilities' RTP offerings was either compliance with a regulatory order (actual or anticipated), to promote economic development, or in response to restructured markets with customer choice.
  - A few of the earliest program were launched as pilots to gain experience with dynamic pricing but most were offered as an alternative to standard services. Currently, 43 of the 55 verified RTP offerings in the U.S. are permanent services, while 12 are either in the experiment or pilot phase.
- Price Elasticity:
  - The available studies have not shown significant price elasticity/load impact from RTP, although anecdotal evidence from interviews indicates some customers can consistently shift load and save money over the long run
- Rate Experience:
  - The majority of RTP offerings identified had very low enrollment with stagnant program growth. In many cases, RTP offerings are not actively marketed and promoted by the utility. Customers subscribing to the RTP tend to have been on the plan for a long period and have adjusted their operations and energy use to take advantage of hourly price variations.
  - Often significant investment in modifying or replacing metering, billing and other systems was necessary to accommodate RTP

- Customers on RTP rates have relatively high customer satisfaction
- Customer bill savings depends on customers' ability to respond to hourly price fluctuations (e.g., "savvy" customers and/or customers with technology to closely monitor prices)
- A concerted effort is required to help customers understand why RTP is different from their current service, what is required to benefit and how to associate a cost to those actions, and the risks associated with subscription
- Generally, customers were only provided an interval meter and in some cases equipment for receiving or retrieving posted prices.

SUMMARY

Taxonomy of Real Time Pricing

- A robust rate categorization schema includes a taxonomy for understanding the basic building blocks of rate structures, including: (a) energy flow (kWh) based on time-of-use or volume of consumption; (b) demand (kW); and (c) fixed charges.
- As a subset of time-varying or dynamic energy prices, real time pricing (RTP) can be differentiated between two sub-categories: one-part and two-part RTP
    - For one-part RTP plans, the posted energy price ($/kWh) is applied to all metered usage and with fixed costs collected either through a markup to the hourly energy price, assessing a demand charge, or both.
    - For two-part RTP plans, an access charge collects fixed supply costs while an energy charge settles hourly differences between actual metered energy use and the customer baseline load (CBL). Hourly deviations from the CBL are charged the prevailing RTP price reflecting the system marginal cost of supply for that hour.
- RTP plans can be distinguished on the basis of the following 12 key pricing design features: (1) Availability, Maturity and Eligibility; (2) Pricing Structure (including one-part or two-part construction); (3) Price Granularity – Temporal; (4) Marginal Price Granularity – Spatial; (5) Price Posting Notification; (6) Price Overcall of Posted Day-Ahead Prices; (7) Marginal Entry Price Formation; (8) Generation, Transmission and Distribution Capacity Pricing; (9) Marginal Cost Uplift; (10) Contract Term; (11) Hedging and Risk Management; and (12) Eligibility. These design features, used to categorize and characterize utility RTP plans, are defined in Section 3.

Benchmarking Results from RTP Tariff Sheet Analysis

- Verified 55 active RTP offerings from 41 regulated utilities in the U.S. out of an initial universe of 97 retail electricity providers previously documented to have implemented RTP
- The most common type of RTP program features hourly pricing with day-ahead notification targeted to commercial and industrial (C&I) customers with a specified minimum demand eligibility and no differentiation in prices within the service territory.
- Only 2 of the 55 verified active RTP offerings are available to residential customers

- 50 of the 55 verified active RTP offerings (over 90%) feature hourly pricing granularity; 3 plans assign varying rates to a block of hours, rather than hourly, while only 2 plan employs variable pricing at sub-hourly (e.g. 15-minute or 5-minute) intervals.
- 51 of the 55 verified active utility RTP offerings (93%) have no spatial price differentiation within the service territory. In other words, all eligible customers under an RTP service have the same hourly pricing levels irrespective of their spatial location on the utility system.
- 52 of the 55 verified active utility RTP offerings (82%) feature day-ahead pricing notification. One of the remaining RTP offerings features hour-ahead price notification while the remaining two post price notifications less than an hour ahead.
- 35 of the 55 verified active utility RTP offerings (64%) base hourly energy prices on regional wholesale energy market price postings (e.g. those posted by RTOs and ISOs). 11 RTP offerings base prices on the utility's own supply and demand forecasts, while the remaining 9 RTP offerings apply pre-set hourly pricing independent of any wholesale market.
- 18 of the verified active RTP offerings, representing one-third of all verified RTP offerings, employ a customer baseline load (CBL) as a basis for RTP structure, whereby participants effectively subscribe to a baseline level of usage with hourly deviations from that baseline either debited or credited at that hour's applicable price. 28 utility RTP offerings employ a pricing structure either based on marginal energy price alone (5) or marginal energy price with a charge for demand (23). The remaining 9 RTP offerings feature pre-set pricing.
- 21 of the 55 verified active RTP offerings have been confirmed to provide any sort of price protection mechanism for customers to hedge their price risk, including the 18 which feature a CBL structure.
- 51 of the 55 verified active RTP offerings are currently open for enrollment. The remaining 4 are limited to existing subscribers and not available to new subscribers.
- 41 of the 55 verified active RTP offerings do not have any enrollment cap. 10 of the RTP offerings have enrollment caps based on a maximum number of subscribers allowed, enrollment for another 3 RTP offerings is capped based on a maximum aggregate monthly demand. Reasons for enrollment caps are speculative but may include utility interest in limiting unintended or unanticipated consequences for customers who may not be adequately positioned to modify usage accordingly. The basis of the enrollment cap for the remaining RTP offering is unspecified.
- 44 of the 55 verified active RTP offerings are established tariffs while 11 are in the pilot or experimental phase. Many of the latter have been in this phase for multiple years as customer programmatic experience, bill impacts and load shaping impacts are assessed.

Insights from Utility Interviews

- RTP plans remain the exception rather than rule as a pricing option, even among larger commercial and industrial (C&I) customers for whom RTP has been a long-held option. Based on interviews with utility rate professionals, only 2% of customers eligible for RTP are actually enrolled in an RTP plan.
- Most (80%) of the RTP programs discussed are opt-in with a few default/opt-out for larger commercial and industrial customers who do not shop for an alternate service provider.

- Participation in RTP programs among the utilities interviewed is relatively low – anywhere from 0 to an estimated 13% of eligible customers are enrolled in RTP with an average of 4.7% and a median of 2% participation.
- No real growth nor decline in RTP subscription since programs were introduced and initially subscribed.
- The impetus for most utilities' RTP offerings was either: (a) compliance with a regulatory order (actual or anticipated), or (b) preparation for, or response to, retail competition.
- Many utilities do not regularly monitor the price responsiveness of their customers on RTP because there is negligible impact on overall load, possibly due to a lack of price volatility in recent years.
- Several utilities mentioned significant investment in modifying or replacing metering, billing and other systems was necessary to accommodate RTP.
- All but one of the RTP programs discussed with utility representatives are currently active and considered "open for enrollment", yet most RTP programs for large commercial and industrial customers do not have high market penetration.
- The majority of utilities are either indifferent to their RTP offerings or think that their program needs improvement.
- Most utilities review RTP in preparation for their regular rate cases, but few have made or plan to make any significant programmatic changes at this time and none have formal sunset dates.
- RTP is a "niche product" for large commercial and industrial customers who are able to manage their usage on a meaningful scale, according to several interviewees. High load factor was indicated as a typical attribute of customers on RTP…
- Customers on RTP generally express high satisfaction to their utility account managers.
- Only a few utilities have plans or see any likelihood to offer RTP to other customer classes in the future, e.g., in lieu of or in addition to TOU electricity pricing for residential customers.
- Marketing to residential customers requires significant investment to increase market penetration that would still be relatively low.
- A concerted effort is required to help customers understand why RTP is different from their current service, what is required to benefit and how to associate a cost to those actions, and the risks associated with subscription.

RTP Price Response

- Low price response was found. Of secondary research available, elasticity estimates varied from zero (RTP prices had no effect on electricity usage) to over 0.58, an outlier as no other value above .30 was reported and only two others were above 0.20.[1] Most were under 0.10 and the majority under 0.05, especially those involving residences.
- Higher elasticities were reported for some customer circumstances, for example government and educational facilities, electricity intensive facilities like arc furnaces and refineries, and when the RTP design allows for day-ahead prices to be revised within day, particularly to post much higher prices to reflect supply conditions not anticipated the day before.

RTP Design

- Designing an RTP service involves numerous sequential, data-driven decisions. This requires acquiring, in many cases, detailed-level data about the physical nature of how the electric system is designed and dispatched. A screening process using high-level characterizations allows making some of the higher-level design decisions to reduce the analytical requirements a final design requires.
- Little research has been conducted specifically to answer the question of preferences for pricing intervals and posting. If the intent is to design an RTP service that has expansive subscription preference research maybe required to understand what design or designs to offer.
- In organized markets (ISOs/RTOs) there are still questions when prices posted are provisional or final, and what marginal energy and outage cost to use.

WHY THIS MATTERS

This study provides a comprehensive understanding of utility RTP experience, benchmarking performance and lessons learned from those implementations. It also provides a framework to inform the design of dynamic pricing and RTP plans to meet the needs of distinct customer classes. As such, it can serve as a resource reference and primer for RTP plan design.

HOW TO APPLY RESULTS

This study can help utilities determine the appropriateness of developing RTP plans and inform the design of RTP plans with attributes aligned with utility objective and suitable for particular classes of customers.

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PROGRAM: Customer Insights (Program 182)

[1] Elasticities are measured as ratios of changes which means that only the price ratio effects consumption. An elastic value of 0.20 means that a 100% change in the price ratio produces a 20% change in usage ratio.

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INTRODUCTION

Study Objectives

This study sought to classify the ecosystem of time-varying pricing constructs, inclusive of dynamic pricing and time-of-use (TOU) structures and their derivatives, into a logical and applicable taxonomy. It also advanced a conceptual foundation to ascribe "building block" attributes of dynamic pricing plans. The project conducted a comprehensive review of the universe of real time pricing (RTP) plans that have been offered by regulated utilities across the U.S. This was based on documented RTP studies by Lawrence Berkeley National Labs (LBNL) and annual survey data collected by the Energy Information Association (EIA). Due diligence was then conducted on identified RTP plans to (a) verify their accurate classification as RTP plans, and (b) document structural attributes for sub-classification. As a further step, interviews were conducted with rate managers from selected utilities across the country with experience in RTP to better understand the motivations for developing the plans, customer uptake and persistence in the plans, customer satisfaction, and load shaping results. A review of price elasticity studies conducted for RTP programs provide another perspective on the success of RTP programs.

Finally, the project provided a conceptual illustration of designing an RTP plan to integrate into a utility pricing portfolio.

Background

The design of electricity pricing plans, often simply referred to as "rate design", affects how and when customers use electricity, which is inextricably linked to numerous policy goals such as:

- encouraging less consumption (i.e. conservation)
- promoting more efficient consumption (i.e. purchase and use of energy-efficient devices)
- increasing electrification to promote decarbonization (i.e. emissions reductions) and economic growth
- stimulating and sustaining local on-site generation (i.e. to promote energy diversity and sustainability)

At the same time, electricity providers and regulators recognize that customers are increasingly seeking choices among electricity pricing plans that are understandable and differentiable. Customers expect the information to select the most suitable pricing plan. Accommodating these interests makes it challenging to structure and design pricing plans.

A modernized electricity grid enables suppliers to offer dynamic pricing in ways that previously were difficult if not impossible to achieve. Advances in system dispatch, that include recognizing transmission and distribution congestion, allow electricity providers to set market-clearing prices with spatial and temporal granularity. Advanced metering technologies (AMI) enable the quick and accurate measurement of electricity consumption over very short time periods, with readings available to both customers and system operators. Finally, a considerable and growing body of experience is available from pilots and large-scale implementation of dynamic pricing services to guide utility planners and designers of pricing services. This experience can help inform an appropriate balance between highly dynamic pricing and hedging against the risks of price volatility (hedged services) to align short-term and long-term supply conditions with customers' ability and inclination to manage their electricity consumption.

These changes in how electricity is supplied and delivered, including customer-sited generation, open up the opportunity for dynamic pricing plans to become an important part of a diverse portfolio of electric service offerings. Realizing the environmental benefits attributable to many electrification opportunities, like electric vehicles and heat pumps, requires sending consumers price signals that reflect prevailing system conditions. Accordingly, it is prudent to align rate design with these needs and opportunities to best serve customers and meet both utility and societal goals going forward.

Diversifying electricity service offerings requires comparing and contrasting alternative pricing structures to ascertain how they contribute to the performance of a portfolio of electric service offerings. Portfolio optimization requires establishing strategic and tactical goals and measuring how pricing structures contribute to the portfolio, how demand elasticity is altered and impacts on electricity supply.

In addition, the industry-wide practice of adopting unique names for these pricing plans often makes it difficult to understand their structure and intended purposes. Examples of electricity pricing naming jargon include:

- Locational Marginal Pricing (LMP)
- Real-time Pricing (RTP)
- Hourly Integrated Pricing Program (HIPP)
- Contracts for Differences (CFDs)
- 2-Part Real Time Pricing (2-Part RTP)
- Voluntary Interruptible Pricing Program (VIPP)
- Peak Time Rebate (PTR)
- Critical Peak Pricing (CPP)
- Optional Binding Mandatory Curtailment (OBMC)
- Interruptible/Curtailable Pricing (I/C)
- Variable Price Interruptible (VPI)

In this report, EPRI defines a systematic process to determine tradeoffs among electricity pricing plan structural features. It includes a categorization structure with consistent semantics that can foster meaningful dialogue and debate and is intended to make the process of comparing different design attributes more transparent with respect to policy goals.

This remainder of this report is structured as follows:

Chapter 2: Anatomy of Electricity Pricing Structures

Chapter 3: Real-time Pricing Design Attributes and Review of Utility Experience

Chapter 4: Synopsis of Utility and Stakeholder Interviews on RTP Experience

Chapter 5: Estimates of Price Elasticity of Electricity Demand

Chapter 6: Illustration of Integrating RTP into an Electric Service Portfolio

2
ANATOMY OF ELECTRICITY PRICING STRUCTURES

Section Summary

Introduction

This section provides background and general context for how electricity pricing plans are structured, inclusive of dynamic and real-time pricing constructs. It describes a rate categorization schema that includes a taxonomy for understanding the basic building blocks of rate structures:

- Energy flow (kWh) based on time-of-use or volume of consumption
- Demand (kW)
- Fixed charges

Subcategories within each block are defined and described. Special attention is devoted to time-varying pricing constructs, particularly the distinction between one-part and two-part Real Time Pricing (RTP) plans.

Key Findings

While time-varying rates in general differ based on how energy flows during time of day, and usually seasonally, dynamic pricing structures reflect market conditions by introducing the element of price volatility and can also include exposure to marginal electricity costs from wholesale generation markets. Dynamic pricing differs from conventional retail time of use (TOU) tariffs which are based on prices that are fixed for months or years at a time to reflect average, embedded supply costs. Dynamic pricing rates include temperature triggered offerings such as critical peak pricing (CPP).

RTP is a variant of dynamic pricing and is a retail rate in which the price for electricity fluctuates hourly, and sometimes sub-hourly, reflecting changes in the wholesale price of electricity and is typically known to customers on a day-ahead or hour-ahead basis. Despite the “real-time” naming convention, the retail rate is distinguished from wholesale prices that may be transmitted from day-ahead (DA) or hour-ahead (HA) markets, in addition to more granular sub-hourly wholesale markets such as the California A Independent System Operator (CAISO) Fifteen Minute Market (FFM) or five-minute Real Time Market (RTM).

There are two main types of real-time pricing (RTP) constructs:

- A "one-part" RTP includes a markup to the posted hourly energy price ($/kWh) to recover fixed costs of electric service, assesses a demand charge, or both. In either case the usage price is not equal to marginal supply cost.[2]

- A "two-part" RTP recovers costs for a subscription level of usage through a fixed monthly access charge separate from the hourly energy price. The customer subscribes to a fixed daily load shape called customer baseline load (CBL) which is charged at the customer's other applicable rate to calculate the monthly access charge. Energy charges are then calculated by multiplying the difference between the CBL and the customer's actual metered energy use for each hour by the prevailing hourly RTP price, which reflects the system's hourly marginal cost of supply. If the actual energy use for a given hour is greater than the CBL, then the additional usage multiped by the hourly price is added to the customer bill. Conversely, if the actual energy use for a given hour is less than the CBL, then the reduced usage multiplied by the hourly price is deducted from the customer bill.

Schema for Categorizing Rate Structures

Electric rate structures are often difficult to understand because they can contain provisions that result from a complex series of design tradeoffs. As a result, public dialogues about the relative merits of alternative structures can be daunting. A system or syntax is essential to using rate structures to achieve ever more complicated resource allocation objectives.

A comprehensive system for characterizing pricing plans and services begins by constructing a framework that defines the basic building blocks that measure use of the electric system. Additional structural elements further define and refine how prices influence electricity consumption, allow for customization for particular supply situations, and adapt to customers' willingness to accept various degrees of price variation.

What follows is an attribute-based means for characterizing and comparing different pricing structures. Such a system provides an orderly arrangement and common basis for characterizing rates by how they affect electricity demand. Moreover, it can serve as the foundation for the development of a portfolio of pricing structures that accommodates diverse consumer needs in ways that improve the utilization of available supply resources.

To help utility planners determine how to augment their electric service plan (ESP) portfolio to achieve a specific strategic goal, a pricing structure categorization schema can be employed. The schema summarized herein is intended to facilitate the development of a utility's strategic portfolio of retail pricing offerings to fulfill service responsibilities and achieve strategic enterprise goals.

The schema illustrated in Figure 2-1 begins with three structural building blocks that sort pricing attributes into groups that have common elements that effect how prices are set and how

[2] A separate demand charge may also be assessed to cover fixed costs.

electricity demand is influenced. The distinguishers are how the flow and stock of power is measured and the assessment of fixed (i.e., usage-independent) system connection charges. Subcategories under each building block further refine the pricing structure to reflect specific spatial and temporal differences in the cost of electric supply that may influence electricity demand.

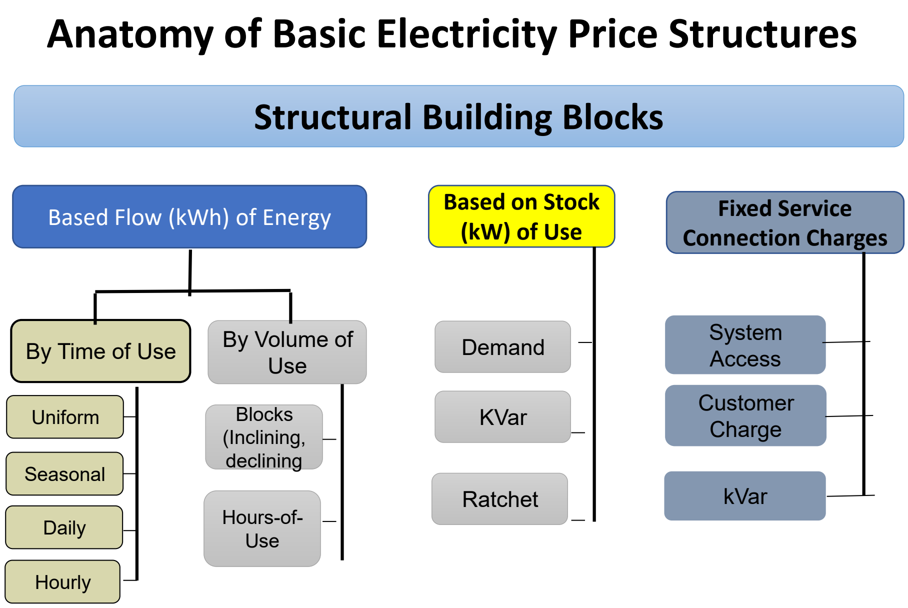

Figure 2-1
Structural Building Blocks of Electricity Pricing

This categorization schema, with sequential screening, can help system planners, customer advocates, rate designers and administrators determine how best to achieve strategic goals and fulfill service obligations. Each pricing structure is described in terms of what elements of service are measured and billed to reflect power supply costs, along with expected effect on demand. What follows are high-level descriptions of the structural building blocks of electricity pricing illustrated in Figure 2-1.

Based on Flow of Energy

By Time of Use or Time Differentiated (Time-varying)

Retail prices for metered energy usage can vary from time-insensitive to highly time-dependent.

- **Uniform**: No temporal variation in the usage price except potentially by season.
  - Time-invariant: Subset of uniform energy rate that features no temporal or spatial differentiation (e.g., $0.11/kWh). Generally, that rate is fixed for an extended period, i.e. a year or more. Adjustments in the nominal rate made be made routinely (monthly or quarterly) to account for changes in fuel supply costs.
  - Seasonal: A uniform rate that varies across months of the year, typically by season, to reflect important differences in the level of electricity usage and the associated cost of supply. For example, $0.08 in spring and fall and $0.15 in summer and winter.

- **Daily rate schedule (TOU)**: A price schedule that distinguishes the energy price among groups of hours of the day, most often between peak hours (usually afternoon hours) and off-peak hours (the rest of the day) that reflect system power demand and therefore warrant a price difference based on the cost of supply. Usually all weekend hours are designated as off-peak. Some rates employ three daily periods, adding a shoulder. peak period to reflect how supply cost ramp up and down in the morning and evening hours resulting in step-up and step-down price profile. Another design option is for the TOU prices to vary across seasons, for example between summer and winter months (including different peak definitions, different period prices, or both) and some months may be priced under a uniform rate (fall and spring, perhaps), a hybrid uniform and TOU rate.

- **Hourly price schedule**: Two basic variations of hourly pricing (i.e. real-time pricing or "RTP") can be used to vary the cost of electricity hourly to track variable supply costs. In both cases, hourly prices can be posted on a day-ahead schedule basis or in real time at hourly or sub-hourly intervals.

    - RTP – One Part: The hourly energy price ($/kWh) posted is applied to all metered usage and includes a markup to recover fixed costs of electric service, including capacity costs.
    - RTP – Two Part: Recovers fixed costs through an access charge separate from the hourly energy price. The customer essentially subscribes to a specific daily load shape called customer baseline load (CBL) for a fixed monthly charge. Energy charges are calculated by multiplying the difference between the CBL and the customer's actual metered energy use each hour by the prevailing hourly RTP price, which reflects the system's hourly marginal cost of supply. If the actual energy use for a given hour is greater than the CBL, then the additional usage is added to the customer bill. Conversely, if the actual energy use for a given hour is less than the CBL, then the reduced usage is deducted from the customer bill.

By Volume of Use

- **Blocks (inclining or declining):** The rate charged for metered usage depends on the metered volume of kWh usage. In a two-block structure, the first block used (e.g., the first 400 kWh) in the billing period is charged one rate and the subsequent block a higher (inclining block) or lower (declining block) energy rate ($/kWh). The number of blocks is a design choice.

- **Hours of Use (HOU):** A load-factor rate that employs metered demand to determine how to sort billing period metered kWh usage into blocks with different energy prices (i.e. a "block rate").

Based on Stock of Use

Customers are charged for the stock of power (i.e. capacity) they utilize, measured as maximum demand (kW).

- **Demand**: A charge for the capacity that the customer uses in the billing period, measured by the metered maximum demand (kW) as a means for collecting that cost to build and operate the system that is designed to meet maximum power demand. Demand can be measured as:

    - Coincident demand. The highest measured kW usage in hours designed as the peak period for the system (e.g. weekday noon to 9:00 pm).

- Non-coincident demand. The highest measured kW usage in any hour of the month.

- **Reactive power**: Measures a customer's usage of power that deviates in wave form from a power quality standard (e.g., kVA lag) by separately metering and charging for reactive demand usage below that standard. Usually only deviations below the reactive power standard are charged.

Fixed Service Connection Charges

These refer to billing charges not based on measured power usage. In principle, they can be used with any of the basic structures described above, although in practice some are only used for certain rate classes.

- **Customer charge**: A monthly charge to collect some of the fixed cost of service, conventionally costs associated with connecting the customer to the grid and administrative and general costs, like billing and customer service.

- **System access (subscription) charge**: However, some argue that the proper rate design collects all fixed costs (capacity, delivery, customer and general administration) through a system access charge and energy costs through the variable energy rate (when demand is not separately metered and charged for). The energy rate structure can be any of those described previously. A variation is where a demand charge collects some fixed cost (generation capacity, for example) so the access charge collects only the other fixed costs, another Stock/Flow hybrid with many possible variations.

These charges are used to modify one or more measured billable elements to achieve specific modifications of electric demand, or to tailor a service to exact customer and supply specifications, or to collect costs that are difficult to forecast because of their inherent variability.

Finally, another subcategory includes price inducements, feedback and information to help customers alter their usage to their benefit, and system restoration information to reduce the inconvenience of power outages.

Dynamic Pricing and Real Time Pricing

While time-varying rates differ based on time of day, and usually seasonally, Dynamic Pricing structures reflect market conditions by introducing the element of price volatility and can include exposure to marginal electricity costs from wholesale generation markets. Dynamic Pricing differs from conventional retail tariffs which are based on prices that are fixed for months or years at a time to reflect average, embedded supply costs. Dynamic Pricing rates include temperature triggered offerings such as Critical Peak Pricing.

A variant of Dynamic pricing is RTP, which, stealing from the definition of the Federal Energy Regulatory Commission, [3] is a retail rate in which the price for electricity typically fluctuates hourly reflecting changes in the wholesale price of electricity and is typically known to customers on a day-ahead or hour-ahead basis. Despite the "real-time" naming convention, the

[3] https://www.ferc.gov/sites/default/files/2020-06/2008-glossary.pdf

retail rate is distinguished from wholesale prices in that wholesale prices may be forecasted and transmitted from either day-ahead (DA) or hour-ahead (HA), and can be more granular that the rate for retail customers (e.g., hourly or sub-hourly).

RTP Plans Included in this Study

RTP Plans included in this study are defined as follows:

1. A full requirements electricity service
2. Offered by a regulated utility
3. Energy usage prices ($/kWh) are set for blocks of hours, hourly or for shorter periods (e.g. 15-minute intervals)
4. Prices are posted to subscribers a day or less in advance of their effective time
5. Prices apply for every day of the week throughout the year (rather than solely during events for selected days or hours of the year, which characterize critical peak pricing or variable peak pricing)
6. Posted prices apply to metered kWh usage corresponding to the pricing interval
7. Posted prices reflect the contemporary marginal cost of electricity supply

"Full requirements" means that the RTP service plan applies to all energy usage at the customer's facility, rather than just for selected end-uses (e.g. electric vehicle charging) that are separately metered. For the purpose of this study, benchmarking was limited to full requirements services offered to customers as an alternative to their incumbent electricity tariff. RTP services offered only to a specific individually-metered end use (e.g. electric vehicle charging) were not included.[4]

The second distinction is invoked to focus the study's benchmarking to services whose provisions and features are readily ascertained by reviewing regulatory approved tariffs. The details of RTP services offered by competitive energy suppliers in states with customer choice are difficult to obtain and are subject to frequent change.

Establishing the frequency of pricing change eliminates from consideration dynamic pricing programs offered by RTOs such as price-cap load bidding and demand response programs

[4] Full requirements might be less that the total facility usage if the customer has on-site generation, but would be considered full requirement serve for this study as would cases where the facility uses power for only one purpose, like irrigation and pipeline stations which are eligible for RTP in some utilities.

available to retail customers directly or through a utility or competitive supplier.[5] RTP services offered in vertically integrated markets are included.

The remaining characteristics distinguish RTP from other utility dynamic pricing structures like variable peak pricing, critical peak pricing, and load curtailment programs because RTP sets a price for every hour based on prevailing or expected market conditions and the corresponding marginal supply cost. The others are event driven terms of service changes where customers otherwise served on a less dynamic tariff are exposed to large price changes as penalties or incentives. The motivation for employing RTP in electricity markets is to induce customers to alter their usage based on the prevailing marginal cost and the value of electricity consumption at that time.

Chapter 3 provides further detail on RTP design and the results of EPRI's benchmarking study of U.S. regulated utility RTP offerings.

[5] Price Cap Load Bidding allows end-use customers to submit a buy price to the day ahead wholesale market (or stepped series of paired price and quantities) to the day-ahead RTP market and bid load that clears at the market hourly price it is treated as a firm purchase, deviations from which are settled in the real-time market. Demand response program are event-triggered payments for recuing load or elevated prices to purchase power that may be in the form of a non-compliance penalty.

3
REAL-TIME PRICING DESIGN ATTRIBUTES AND REVIEW OF UTILITY EXPERIENCE

Section Summary

Introduction

This section defines and describes key design features for RTP plans which determine how prices are set, what services are measured, and the corresponding range of usage levels.[6] This framework clarifies distinctions in designing an RTP program based on foundational EPRI works on the subject.[7] Chapter 6 provides more expansive distinctions between electricity pricing structures and attribute levels to help characterize RTP programs and construct and analyze alternative designs.

This section uses this framework to characterize and categorize 55 verified active real-time pricing (RTP) offerings implemented by 41 regulated U.S. electric utilities in 21 states, based on a detailed review of tariff sheets and additional information gathered through interviews discussed in more detail in Chapter 4.

Key Findings

1. EPRI identified an initial universe of 97 retail electricity providers in the U.S. that were cited in prior published sources as having RTP plans. EPRI was able to verify that 41 regulated utilities collectively have 55 active RTP offerings.

   Offerings from unregulated competitive retailers who are not required to file tariffs with state regulatory commissions could not be validated or verified through the due diligence process and were therefore excluded from further consideration. Similar exclusions applied to municipalities, cooperatives, and public power entities without verifiable tariff sheets. Among regulated utilities, the project team determined that some offerings are either misclassified as RTP or simply could not be verified as RTP based on the tariff sheets. In some cases, investigation of tariff sheets revealed that some offerings classified as RTP are actually other dynamic pricing variants, such as critical peak pricing (CPP) or peak time rebate (PTR), and therefore misclassified as RTP.

2. The most common type of RTP program features hourly pricing based on regional wholesale energy market postings (RTOs/ISOs), with day-ahead notification targeted to commercial

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[6] The attributes and levels described herein are not exhaustive; other attributes can be added, and attribute levels can have finer gradation.

[7] EPRI. Quantifying the Impacts of Time-Based Rates, Enabling Technology, and Other Treatments in Consumer Behavior Studies: Protocols and Guidelines. Palo Alto, CA. 2013.

and industrial (C&I) customers with a minimum demand eligibility and no intra-territory spatial differentiation.

- Only 2 of the 55 verified active RTP plans are available to residential customers with the remaining 53 offerings available to only to non-residential customers, typically targeted to distinct customer commercial, industrial and agricultural customer classes on the basis of such metrics such as peak demand.
- 50 of the 55 active RTP offerings (91%) feature hourly pricing granularity and 43 of those feature day-ahead notification. Only 2 RTP plans offer sub-hourly pricing; 3 plans assign varying rates to blocks of hours, rather than hourly.
- 7 plans feature pre-determined sets of prices, whether hourly or by blocks of hours, based on pre-defined day-types selected based on day-ahead temperature forecasts.
- Only 4 of the 55 verified active RTP offerings feature spatial price differentiation within the service territory, meaning pricing differs based on the customer's spatial location on the utility system; the remaining 51 plans provide the same pricing levels irrespective of the customer's spatial location on the utility system.
- 35 of the 55 verified active RTP offerings have hourly energy prices based on regional wholesale energy market price postings (RTOs /ISOs); 11 RTP offerings base their hourly prices on supplier forecasts, while the remaining 9 have a pre-set pricing schedule based on hours or blocks of hours.

3. Nearly one-third of the verified active RTP offerings (18 of 55) employ a customer baseline load (CBL) as a basis for RTP structure, with the time-varying pricing applying only to hourly consumption above (bill increase) or below (bill decrease) the customer's established CBL.

4. 23 of the 55 verified active RTP offerings employ a pricing structure based on marginal energy price and metered demand; 5 RTP offerings roll all cost recovery into the energy price.

5. 21 of the 55 verified active RTP offerings explicitly have some form of price protection mechanism in the tariff to hedge customer price risk, including the 18 with a CBL structure.

6. 41 of the 55 verified active RTP offerings do not have any enrollment cap; 10 have enrollment caps based on a maximum number of subscribers while 3 are based on a maximum aggregate demand.

7. 51 of the 55 verified active RTP plans are currently open for enrollment; the remaining 4 are only open to existing subscribers and therefore closed to new subscribers.

8. 44 of the 55 verified active RTP offerings are established tariffs while 11 are in the pilot or experimental phase. Many of the latter have been in this phase for multiple years as customer programmatic experience, bill impacts and load shaping impacts are assessed.

9. The most predominant eligibility factor is customer size, as measured by either minimum monthly peak demand. 35 of the 55 verified active RTP offerings are available to non-residential customers with a peak demand greater than 100 kW; 15 of those require a minimum demand greater than 1 MW.

RTP Pricing Design Features

The following design features have been established to characterize RTP offerings, and are described further in the remainder of this chapter.

Table 3-1
Key Design Features for RTP Plans

Key Design Features for RTP Plans	
1. Availability and Maturity	7. Price Overcall of Posted Day-Ahead Prices
2. Eligibility	8. Entry Price Formation
3. Pricing Structure	9. Capacity Pricing (Gen., Trans. & Dist.)
4. Temporal Price Granularity	10. Marginal Cost Uplift
5. Spatial Price Granularity	11. Contract Term
6. Price Posting Notification	12. Hedging and Risk Management

Review of US Utility RTP Programs[8]

EPRI conducted a comprehensive review of the universe of RTP plans that have been offered by utilities across the U.S. The project team developed an initial master list of 97 distinct retail electricity providers in the U.S. understood to either currently offer, or have once offered, an RTP plan to at least one class of customer. This list was compiled from a combination of sources, principally a 2004 study on RTP programs by Lawrence Berkeley National Laboratory (LBNL)[9] and listings of RTP plans compiled by the U.S. Energy Information Administration (EIA)[10] in 2015 and 2019 as self-identified by utility filings.

Due diligence was then conducted on this universe of identified retail electricity providers to: (a) resolving listings and track changes in utility names and ownerships through mergers, acquisitions, and consolidations; (b) verify accurate classifications of RTP offerings and (c) document structural attributes for sub-classification. This involved researching utility tariff sheets to determine whether RTP offerings were actually present. Offerings from unregulated competitive retailers who are not required to file tariffs with state regulatory commissions could not be validated or verified through the due diligence process and were therefore excluded from

[8] The focus of this review was utility RTP programs. This study did not attempt to identify or evaluate RTP offerings from suppliers in competitive electricity markets.

[9] Lawrence Berkeley National Laboratory. "Customer Response to Day-ahead Wholesale Market Electricity Prices: Case Study of RTP Program Experience in New York", C. Goldman and B. Neenan, (July 1, 2004). Paper LBNL-54761. http://repositories.cdlib.org/lbnl/LBNL-54761

[10] Cite

further consideration. Similar exclusions applied to municipalities, cooperatives and public power entities without verifiable tariff sheets.

Among regulated U.S. utilities, the project team determined that some offerings are either misclassified as RTP or simply could not be verified as RTP based on the tariff sheets. In some cases, investigation of tariff sheets revealed that some offerings classified as RTP are actually other dynamic pricing variants, such as critical peak pricing (CPP) or peak time rebate (PTR), and therefore misclassified as RTP. Finally, the project team excluded RTP offerings that have been closed or superseding, focusing only on regulated U.S. utilities with active RTP offerings. The project team was ultimately able to verify that 41 regulated utilities in the U.S. collectively have 55 active RTP offerings. A visual summary of the screening process is illustrated in Figure 3-1

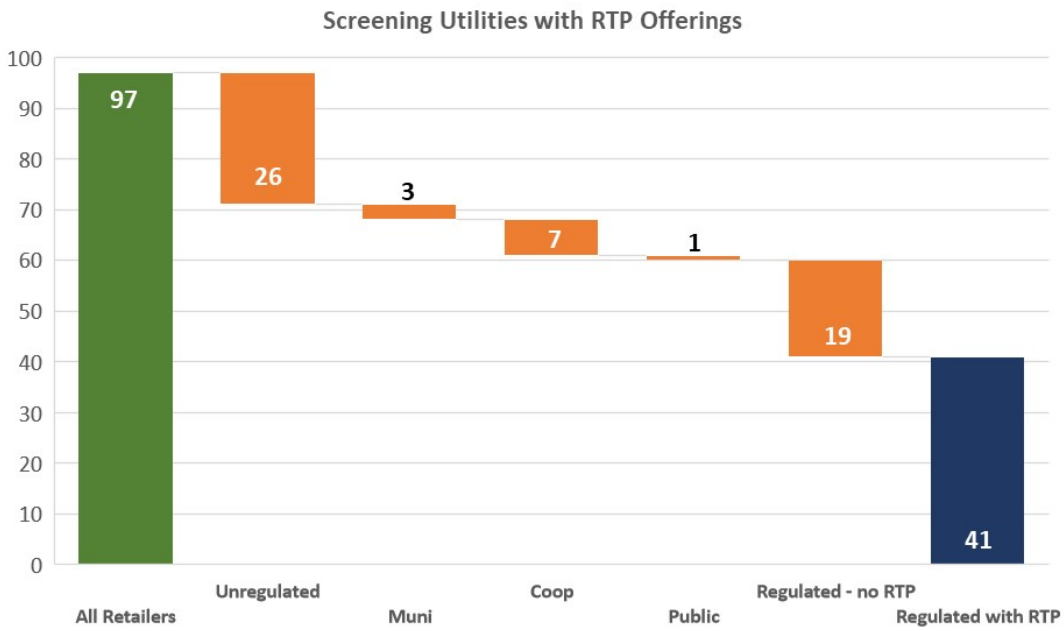

Figure 3-1
Screening of U.S. Utilities with RTP Offerings

As a further step, the team conducted 16 interviews with a total of 24 individuals collectively representing 19 distinct utility jurisdictions with a total of 24 RTP programs to better understand the motivations for developing the plans, customer uptake and persistence in the plans, customer satisfaction, and load shaping results. Participating utilities/stakeholders included current and former utility executives, program managers and consultants. These interviews are summarized in Chapter 4 - Synopsis of Utility and Stakeholder Interview on RTP Experience.

1. Availability and Maturity

A primary consideration is whether an RTP service will be available to a specific population to discover, through experience, customer subscription, persistence, and load and bill impacts. There are two basic options for making a service plan available to customers:

- Open enrollment – service is available to all eligible customers. Explanatory material should explain ways that customers could benefit from the rate so that customers can assess its potential benefits and risks.
- Capped Enrollment – service is available to all eligible customers, but enrollment is capped by either a limited number of participants or maximum amount of aggregate peak demand. This can serve the utility by keeping the participant pool manageable for an initial trial and can dually provide an incentive for customers to participate in an exclusive beneficial service before the opportunity expires.

Availability Findings

The vast majority of verified active RTP offerings (51 of 55) are currently open for enrollment, with 4 limited to existing subscribers and therefore closed to new subscribers.

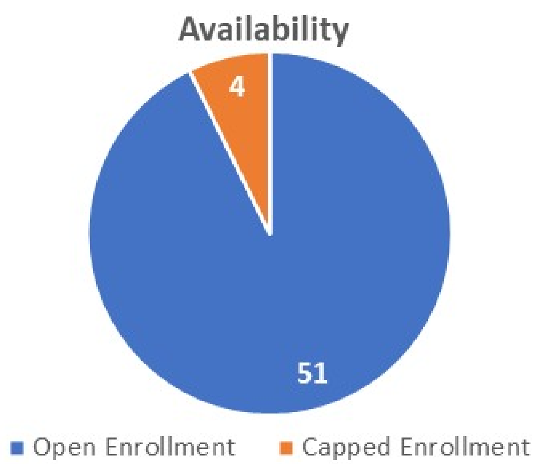

Figure 3-2
Availability of Verified Utility RTP Plans

In a similar vein, a related operational decision is whether to roll out an RTP service initially as an experiment or pilot versus a full-fledged tariff program. This can be referred to as the *maturity* of the offering.

In a pricing experiment, candidates are selected from the population of eligible customers and recruited to participate either in a controlled or self-selected manner. In a controlled experiment, selected participants are sorted randomly into control and treatment groups, with treatments required to enroll, and controls not allowed to enroll. Alternatively, in a self-selection experiment any of those customers randomly selected to participate has the freedom to enroll.

A limited or targeted pilot is similar to an experiment but at a larger scale with subscription either targeted to specific customer classes, to customers of specified circumstances or those considered to be best candidates. Pilots often employ targeted subscription to confirm expectations for those anticipated to find value in the service to verify their price responsiveness. These results are not generally attributable to the larger population of customers, but rather just to those who are similar to the pilot participants.

By contrast, a full-fledged tariffed service plan, whether RTP or otherwise, is open to all eligible customers and implies conformance with *revenue neutrality*, meaning that the subscriber would pay the same under the new plan as under the incumbent tariff if energy consumption patterns remained unchanged. This intends to prevent cross-subsidization that results from subscribers realizing reduced power costs without responding to hourly prices. As such, tariffed service plans undergo considerable scrutiny within a utility rates departments, utility executive management and regulatory commissions.

Maturity Findings

44 of the 55 verified active RTP offerings are established, permanent service tariffs while 11 are in the pilot or experimental phase. Many of the latter have been in this phase for multiple years as customer programmatic experience, bill impacts and load shaping impacts are assessed.

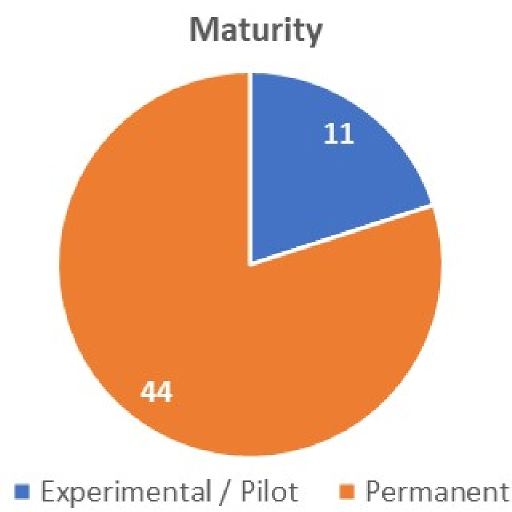

Figure 3-3
Maturity Status of Verified RTP Plans

Enrollment Cap Findings

The vast majority (41 of 55) of verified active RTP offerings do not have any enrollment cap. While Figure 3-2 shows that only 4 active utility RTP offerings are currently capped to new subscribers, a total of 14 RTP offerings are subject to some enrollment cap. 3 RTP offerings are capped based on a maximum aggregate demand under subscription; 9 are capped by a maximum number of customers who can be on the plan, including 1 RTP offering that exists solely for the use of an individual customer. The remaining RTP offering is capped on an unspecified basis. These findings are illustrated in Figure 3-4.

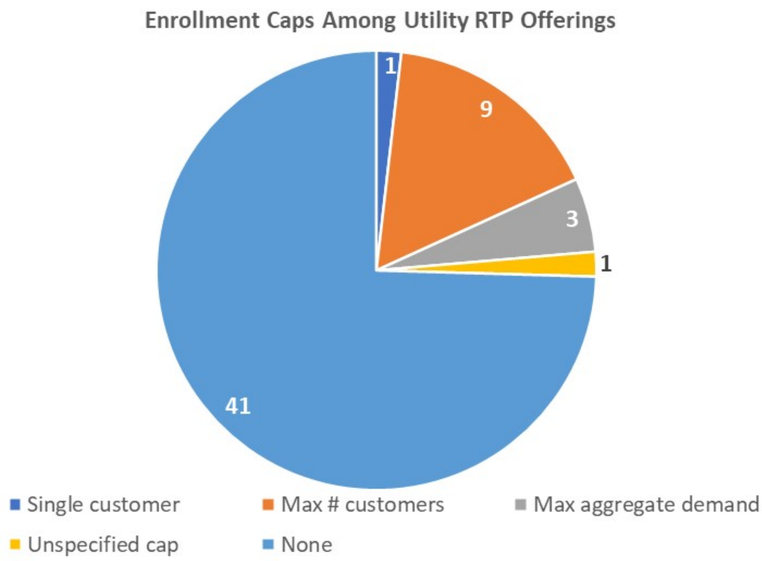

Figure 3-4
Enrollment Caps Among Verified Utility RTP Offerings

2. Eligibility

Eligibility is typically based on customer class, which is a function of customer segment and peak monthly demand. For example, a typical set of customer classes for a utility to distinguish rate option eligibility may include:

- Large Commercial & Industrial (C&I) customer (over 1 MW)
- Commercial and Light Industrial Customers (50 kW to 1 MW)
- Small Commercial Customers under 50 kW
- Residential

Eligibility Findings

Figure 3-5 below illustrates the distribution of verified active RTP offerings on the basis of customer eligibility criteria. They vary based on factors such as peak monthly demand, incumbent pricing plan and selected other factors.

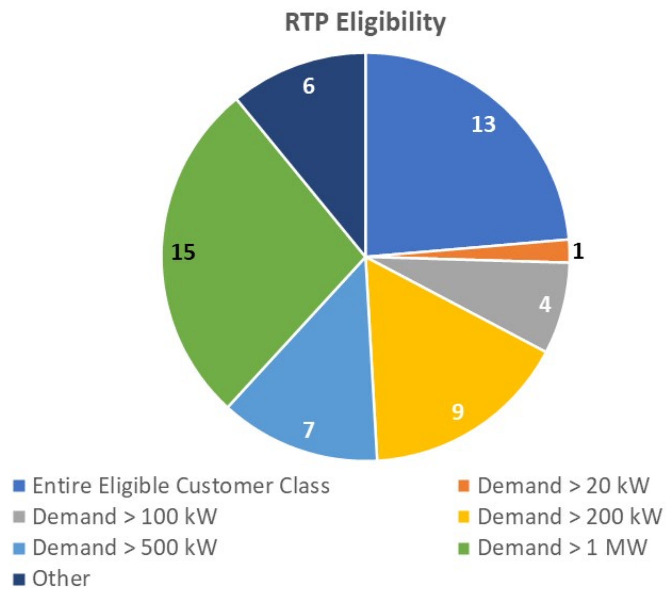

Figure 3-5
Customer Eligibility Criteria of Verified RTP Offerings

Customer eligibility for 35 RTP offerings is predicated on a minimum demand threshold of 100 kW, while 15 of those offerings have a minimum demand requirement of 1 MW. For 13 of the RTP offerings, all customers in the designated customer class are eligible. Eligibility for the remaining 13 RTP offerings is based on a variety of other factors, including medium- to high-voltage service, as defined by the utility. Only two RTP offerings are available for residential customers.

3. Pricing Structure

The most fundamental distinction in RTP design is pricing structure, which determines the extent to which prices align with forecasted marginal supply costs. It also distinguishes whether an RTP service is designed to be revenue-neutral for an individual customer or for an aggregated class or subclass of customers.

There are two main types of real-time pricing (RTP) constructs: "one-part" and "two-part".

- A "one-part" RTP includes a markup to the posted hourly energy price ($/kWh) to recover fixed costs of electric service[11]. In other words, fixed cost recovery is bundled together with the hourly energy price.
- A "two-part" RTP recovers costs for a subscription level of usage through a fixed monthly access charge separate from the hourly energy price.

[11] A separate demand charge may also be assessed to cover fixed costs.

Customer Baseline Load (CBL)

For a two-part RTP construct, the customer subscribes to a fixed daily load shape called the customer baseline load (CBL), which is established prior to subscription based on the customer's historical usage adjusted for abnormalities to represent a customer's expected energy usage without RTP subscription. The CBL sets a baseline load for each hour of the year to which the customer commits for the duration of subscription.

Energy charges are calculated by multiplying the difference each hour between the customer's actual metered energy use and the CBL by the corresponding price for that hour, which reflects the system's hourly marginal cost of supply. If the actual energy use for a given hour is greater than the CBL, then the additional usage multiped by the hourly price is added (debited) to the customer bill. Conversely, if the actual energy use for a given hour is less than the CBL, then the reduced usage multiplied by the hourly price is deducted (credited) from the customer bill. The resulting cumulative amount for the month represents the billing energy charge.

For each billing period, the fixed access charge is calculated by pricing out the month's CBL at the customer's standard (i.e. "otherwise applicable") rate. The monthly access charge is not influenced by actual metered usage.

Because the CBL is subscriber-specific, in effect each subscriber pays its revenue requirements based on cost-of-service allocations and there is no cross-subsidization.

A CBL can be calculated in one of three basic ways: historic-based, self-selecting, and hybrid.

Historic-based

CBL is based on a subscriber's historic energy usage adjusted for abnormalities to represent typical load on the prior rate schedule. Some applications of this CBL configuration allow for changing the CBL over time to reflect permanent changes in usage, for example lowering the CBL to reflect energy efficiency investments that reduce the load potential or adding CBL for plant expansions or for residential electric vehicle charging.

Self-selecting

The subscriber selects the CBL level of energy usage for each hour, which can be less than, equal to, or greater than historic usage for any given hours. Typically historic usage is a starting point from which subscribers can adjust their CBL depending on their circumstances and expectations for RTP prices, if allowed under the tariff. Those anticipating lower prices might shed CBL and those expecting higher prices and load growth might add CBL, in effect hedging against price outcomes. The electricity provider may allow customers to adjust their CBL either at no charge or for a fee. In the latter case, the CBL might be sold or purchased at the original applicable rate or a hedging premium devised by the suppliers.

Hybrid

The CBL can be auctioned off in what amounts to a capacity purchase market or subscribers could be required to specify for each hour load blocks priced at declining prices. The subscriber would be informed of what was scheduled (i.e. blocks up to the market-clearing price) with the price locked in, with provision for settling overages in the next day, real-time market. This structure follows the Priority Service concept developed by Wilson and Chao (1987).

As it pertains to a two-part RTP structure, a CBL may remain unchanged throughout the term of subscription or may be renegotiated in some cases depending upon the terms and conditions of the service plan. Provisions to adjust CBL may cover such contingencies as the subscriber adopting energy efficiency measures that reduce energy usage, or undergoing a change in operations, such as an expansion of scope or shifts, that alters its energy usage profile. Some provisions allow for resetting the CBL each year by formulation, such as a prescribed percentage of the difference between the previous year's actual metered usage and the existing CBL, or seasonally adjusted based on historic load at a level selected by the subscriber.

Marginal Energy Price Only

In this structure, the energy price collects both the marginal energy cost and fixed costs, rather than the latter being collected through a demand charge or other fixed charge (although there may be a relatively small customer charge). Posted hourly energy prices apply to all hourly metered usage, with no charge assessed for metered demand. As a result, during hours when fixed costs are collected through an uplift to the $/kWh charge (which could be all hours or some hours, such as peak demand hours), the real time price exceeds the marginal supply costs and over-induces reducing electricity usage.

Marginal Energy Prices plus Demand Charge

The primary variation on the energy-only rate is the imposition of demand charge based on metered monthly demand or a ratcheted demand value. Another option is imposing a minimum bill for highly seasonal usage customers. Another variation is to charge customers for usage above the CBL but not for usage below it. This results in a subscription structure similar to telephone calling plans or internet services. It could be combined with a demand response program such as peak-time rebate, whereby payment for reduction from the CBL is only offered when an event is declared. The credit payment could post each event based on prevailing market prices (or rationing needs) or be chosen from a prearranged schedule of event prices. The result is a structure more closely related to CPP than RTP since prices for load curtailment are episodic rather that predictably systematic.

Pre-Set Prices

Some utility RTP plans establish pre-set hourly prices for specific seasonal day-types, as determined a day ahead based on weather- and/or demand- forecasts.

Pricing Structure Findings

As illustrated in Figure 3-6, 18 RTP offerings, representing nearly one-third of all verified active utility RTP offerings, employ a customer baseline load (CBL) as a basis for RTP structure. 23 utility RTP offerings employ a pricing structure based on marginal energy price plus a demand charge, while 5 RTP offerings roll all cost recovery into the hourly energy price.

Earlier utility implementations of RTP service predominantly employed two-part subscription-based CBL structures, i.e. subscription-based plans. By contrast, more recently developed RTP services tend to employ a one-part structure for dynamic energy charges with or without a separate demand charge.

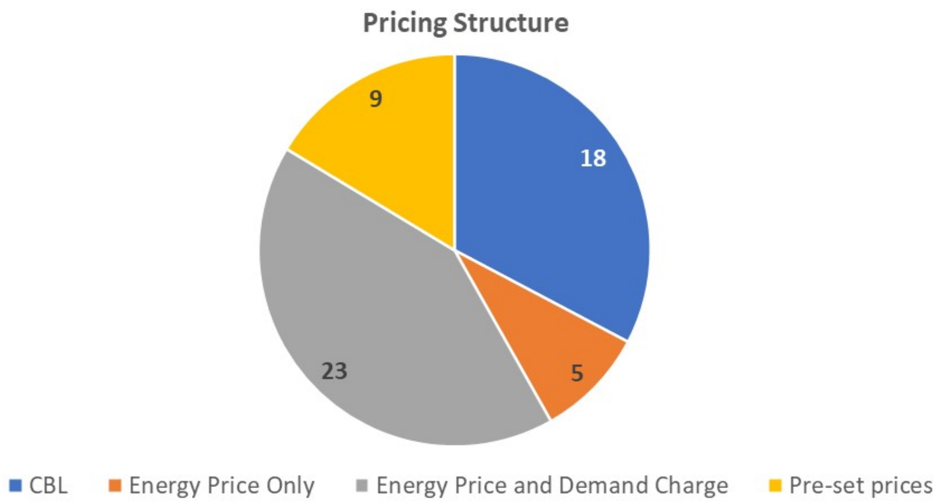

Figure 3-6
Pricing Structure of Verified RTP Offerings

Of the 18 verified utility RTP programs that utilize a CBL, i.e. two-part RTP structures, 14 of them include provisions to revise the CBL during the subscription term. 3 do not include any explicit provision, while the tariff sheet for the remaining offerings does not specify this point.

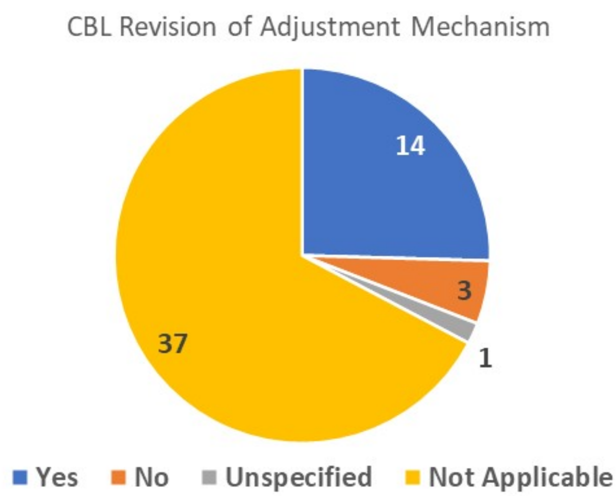

Figure 3-7
RTP Offerings by Ability to Revise CBL

4. Temporal Price Granularity

This attribute describes how often prices are reset. This not only affects how well actual supply prices are passed on to RTP subscribers but also customers' willingness to manage the resulting level of price volatility. RTP designers typically seek a balance between an efficient pricing and customer manageability and appeal.

Hourly

An energy price is set for each hour of each day. If the reference for supply prices is at a finer time granularity (for example ISO real time prices established every five minutes) then some form of averaging is required, either simple or weighted. Most retail RTP programs employ hourly prices.

Blocked Hours

To better balance design tradeoffs, hourly prices may be averaged over blocks of hours, for example creating six four-hour blocks with the price per block equal to the average of the hourly prices. Alternatively, the day could be divided between peak and non-peak hours with block prices representing the average of the constituent hours. RTP price blocking requires that the CBL in a two-part rate be correspondingly blocked. The blocks should be stipulated (like TOU distinctions) not customized or else the synchronizing of supply price and customer usage decision is undermined. Blocking could be offered as an alternative to an hourly CBL formulation

Sub-hourly

An energy price is set for each sub-hourly period of each hour of each day (e.g. 30-minute, 15-minute or even 5-minute). Very narrow pricing intervals such as 5-minute may require unconventional metering that would expand the requirement to collect and process usage data for billing.

Temporal Price Granularity Findings

50 of the 55 verified active RTP offerings (over 90%) employ hourly pricing granularity, as shown in Figure 3-8. 3 RTP offerings assign varying rates to blocks of hours, rather than hourly, while 2 RTP offering employs variable pricing at sub-hourly intervals.

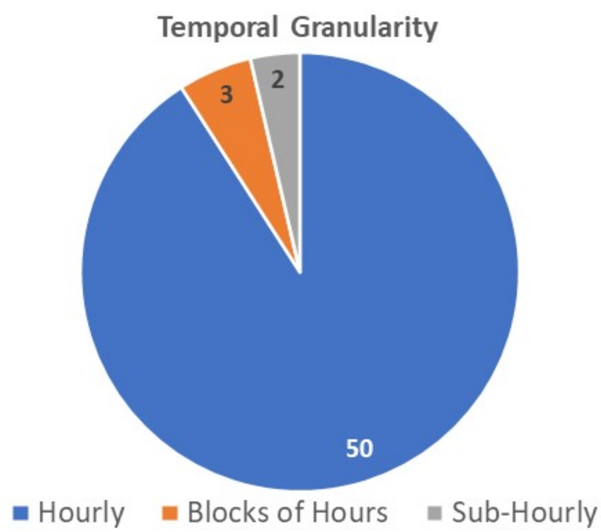

Figure 3-8
Temporal Price Granularity of Verified RTP Plans

In conjunction with the information presented in Figure 3-9 and Figure 3-10, the most common form of RTP plan is an hourly pricing structure with day-ahead pricing notification and no intra-territory spatial differentiation.

5. Spatial Pricing Granularity

Uniform and Universally Available

Prices are the same for all subscribers in the eligible customer class regardless of geographic location. However, there may be taxes or other uplift factors that are called or location-specific.

Spatially Differentiated

RTP may constructed with spatial differentiation to vary prices over defined areas to reflect differences in marginal supply cost because of local power congestion or other zonal distinctions. This differentiation may coincide with contiguous RTO pricing zones or similar distinctions made by the utility to reflect transmission congestion.

Spatial Price Granularity Findings

As show in Figure 3-9, 51 of the 55 verified active utility RTP plans have no spatial price differentiation within the service territory. In other words, all eligible customers under the RTP plan have the same hourly pricing levels irrespective of their spatial location on the utility system.

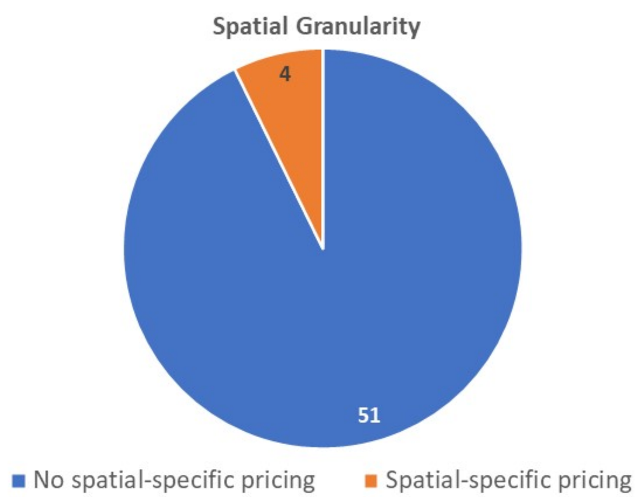

Figure 3-9
Spatial Price Granularity of Verified RTP Plans

6. Price Posting Notification

Close alignment of price formation and RTP price setting notification is required to promote efficiency. Day-ahead RTP posting of the next day's hourly prices requires forecasting the next day's supply conditions, which is standard practice among U.S. utilities, and ISO markets post wholesale closing prices for the day-ahead market. Both are available in the early afternoon and can be sent to RTP subscribers almost instantaneously so they can plan the next day's power usage accordingly.

Day-ahead

Final usage prices ($/kWh) for hours to which they apply are posted, usually for utility-based programs, sometime the afternoon before (e.g. by 4:00 pm). Services that use ISO/RTO prices may have day-ahead prices available as early as 10:00 am. For prices to be considered "posted" means that they are made available at a utility-maintained site and transmitted over one or more media (telephone, internet, fax, cell) to subscribers. Generally, receipt is deemed to have been affected unless the subscriber notifies otherwise by a stipulated time.

Hourly

The effective price for each hour is always posted an hour ahead.

Sub-Hourly

The effective price for each hour is always posted less than an hour ahead. For example, ISO/RTO real-time prices (using their definition) are formulated five-minutes ahead of each hour (or shorter) rating period, so they may be posted but not received in advance of their time of effect.

Pre-set or Other Pricing

RTP programs that feature pre-set pricing based on seasonal day-types only post notification of the day-type for the following day but do not post hourly prices per-se because 24-hour pricing for any given day-type is stipulated by contract. All of the programs that feature pre-set hourly pricing post the following day-type on a day-ahead basis.

Price Posting Notification Findings

As shown in Figure 3-10, 52 of 55 verified active RTP offerings feature day-ahead pricing notification. Of the remaining RTP offerings one features uses hour-ahead pricing and two apply sub-hourly "real-time" posting of prices.

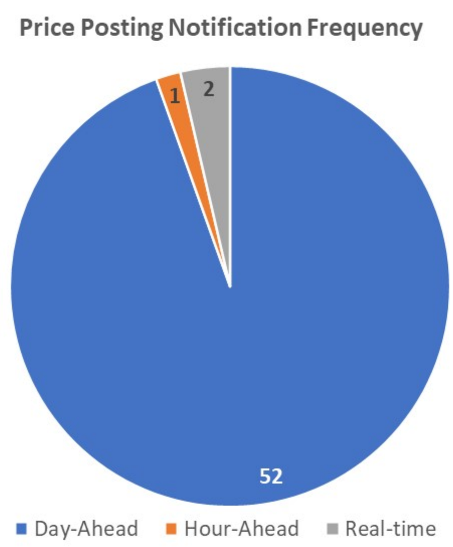

Figure 3-10
Price Posting Notification of Verified RTP Offerings

7. Price Overcall of Posted Day-Ahead Prices

Some RTP programs may have a provision for the utility to change posted day-ahead prices based on day-of changes in demand and supply conditions to better reflect prevailing conditions. With this provision, day-ahead prices are subject to retraction or "overcall" by the RTP service provider, usually for some hours (e.g. peak period) with notification sent the same morning. Overcall is usually limited to specific and verifiable circumstances such as unanticipated changes in weather or supply shortfalls (e.g. generation- or transmission- outages).

Overcall of Posted Day-Ahead Prices – Findings

Only 5 of the 55 verified active RTP offerings include some provisions for overcalling posted prices. 9 RTP offerings feature pre-set pricing for which price overcall is not applicable. Tariff sheets for another 5 RTP offerings did not specify a price overcall mechanism.

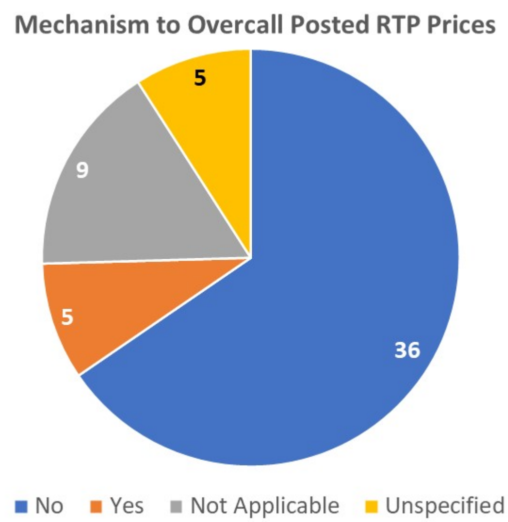

Figure 3-11
Mechanisms to Overcall Posted Prices

8. Energy Price Formation

The source of hourly prices can be the marginal cost of supply as determined by an individual utility's day-ahead (or real-time) scheduling process, prices posted by an ISO/RTO, or a confirmation of enterprise and wider market supply forecasts of supply cost.

Supplier's Forecast

The RTP supplier has a fleet of generation plants and contracts which are used to develop a day-ahead (or real time) dispatch that produces a reference internal marginal supply cost. Marginal cost for each hour, or blocks thereof, is derived directly from the enterprise supply dispatch. The hourly RTP prices can be calculated directly from the dispatch model before or after any wholesale trading.

Regional Market Energy Posting

For this, the source of hourly prices is the regional RTO/ISO hourly energy price.

Energy Price Formation Findings

As shown in Figure 3-12, 35 of the 55 verified RTP plans feature hourly energy prices based on regional wholesale energy market price postings (e.g. those posted by RTOs and ISOs). These break down as follows:

- PJM – 17
- MISO – 8
- NYISO – 7
- SPP – 2
- CAISO – 1

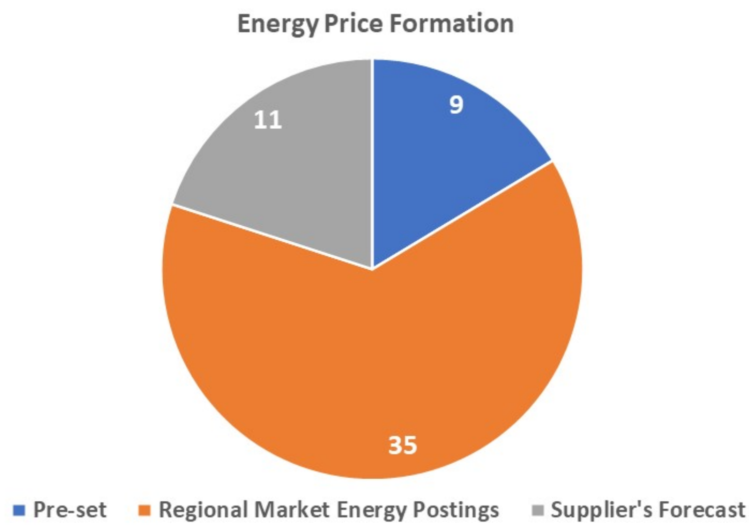

Figure 3-12
Energy Price Formation Basis of Verified RTP Plans

11 of the RTP programs apply the utility's own demand and supply forecasts as the basis for hourly energy price formation. The remaining 9 programs apply pre-set pricing as the basis for energy price formation.

9. Capacity Pricing (Generation and Transmission and Distribution)

This applies only to one-part rates that do not use an access charge to collect all fixed cost obligations through a CBL. Capacity costs would be collected though an uplift factor applied to the hourly marginal energy charge, of through another mechanism.

Energy Uplift (Collected in the Marginal Energy Price)

The marginal energy charge may be derived such that it reflects capacity costs (generation, transmission, and distribution so no separate charge is required. ISO/RTO wholesale prices are set to reflect the marginal energy generation cost of supply which include a transmission component and congestion (outage) costs. As long as the sub-elements prices are separately set and settlements distribute revenues accordingly, then the RTP supplier may or may not recover its fixed T&D costs. If high prices induce load reductions that are not consumed at another, low-cost time (usage in excess of what would be typical), then the RTP provider may experience a shortfall in T&D revenues. These could be recovered from other customers assuming that the load reduction reduced outage likelihoods and all other customers benefitted.

Demand Uplift (Collected through a Demand or other Metered Usage Charge)

A separate T&D capacity charge could be assessed, for example as a demand charge, which reduces the efficiency gains if usage decision is based not just on the prevailing marginal cost but also the potential demand charges that result.

Collected in the Access Charge – Two-part RTP

Capacity Pricing Findings

As shown in Figure 3-13, the basis for capturing non-energy charges for capacity (e.g. generation, transmission, and distribution charges) corresponds to the pricing structures detailed in Figure 3-6. As such, these charges are covered through access charges for the 18 RTP offerings that employ a CBL structure, while 5 RTP programs include all cost recovery into the energy price. The remaining two categories reflect how the 9 RTP offerings that feature pre-set pricing account for such charges, with 2 added to the count of the 23 RTP offerings that employ demand charges (for a total of 25), while the remaining 7 apply other delivery service charges.

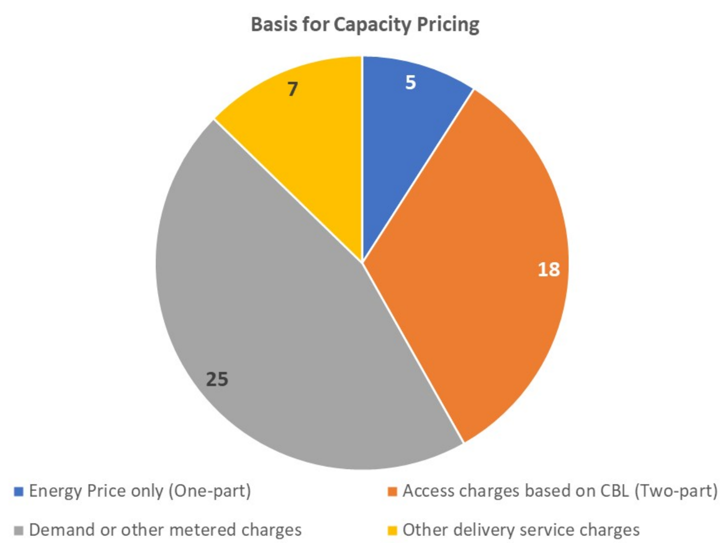

Figure 3-13
Treatment of Non-Energy Charges of Verified RTP Plans

10. Marginal Price Uplift for Administrative Costs

Uplift collects revenues by marking up the derived hourly marginal energy prices to cover RTP program development and implementation costs and may include a risk premium. A risk premium may be warranted because the utility prices usage at forecasted marginal costs but incurs cost based on real-time conditions. Underestimating RTP prices could result in no recovery of costs from RTP subscribers who consume above the CBL. The utility tariff sheets reviewed in this study did not generally specify the inclusion of this feature.

None

Provision for collecting program costs is made elsewhere in electric tariffs and risks are assumed to be inconsequential or the benefit inure to utility shareholders.

Low-priced hours

Adding uplift only to hours when RTP prices are likely lowest minimizes the efficiency loss of hourly RTP prices that are above realized marginal supply cost.

All hours

An uplift factor is added to the formulated RTP marginal cost. This spreads out the collection of the revenue targeted for collection through the RTP price, minimizing the effect on efficiency gains from prices that exceed the contemporaneous marginal supply cost.

Marginal Price Uplift Findings

Tariff sheets for 34 of the 55 verified active RTP offerings reviewed in this study do not specify the inclusion of an uplift provision to cover administrative or other costs in the energy price. 11 of the remaining RTP offerings do explicitly include some coverage of administrative and other costs through an uplift to the marginal energy price. The remaining 10 RTP offerings do not have a mechanism to cover administrative or other costs through an uplift to the marginal price.

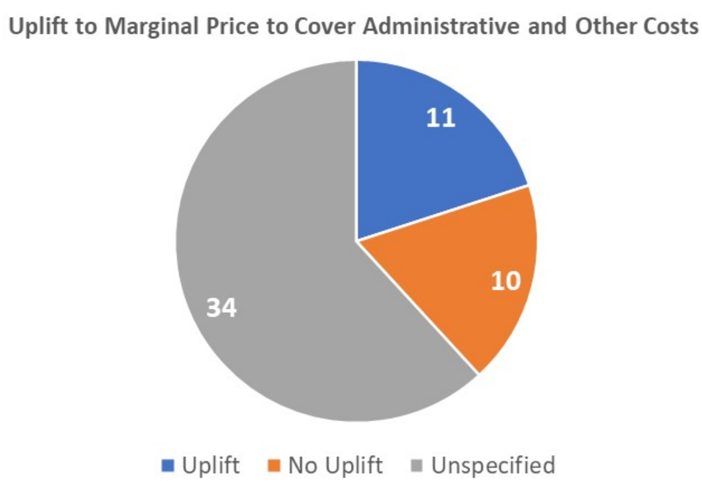

Figure 3-14
Uplift to Marginal Price to Cover Administrative and other Costs

11. Contract Term

Subscribers may be contractually obligated under a RTP service provision for a specified period. If they are unsubscribed at the end to that period, they may be assigned to a rate class to which they qualify and there may be provision for how they continue under that service. For example, if that service charged is for ratcheted demand, upon returning the ratchet provision may revert back to the conditions at the time they transferred to RTP.

Yearly

Subscriber agrees to take RTP service for one year and after that may continue with RTP or transfer to any other service to which it qualifies. A caveat may be that they must return to the original service from which they migrated to RTP.

Monthly or Seasonal

Customers may subscribe for a shorter period, for example a season or fewer consecutive months each year. Limits maybe placed on the duration and how often a customer can switch between a standard rate and RTP rate to avoid opportunistic participation that results in benefits without altering usage in response to prices.

Other

Multi-year subscriptions might be attractive under two-part pricing to a customer that wants to preserve the initial CBL because it provides opportunities for both load growth and price response. The utility gains from revenue security (based on the CBL) and benefits from price response.

Contract Term Findings

19 of the 55 verified active RTP offerings have a year-to-year contract term, as illustrated in Figure 3-15. Tariff sheets for 22 RTP offerings do not specify the contract term. The remaining RTP offerings include from five 5-year terms, two 3-year terms and seven monthly terms.

Figure 3-15
Contract Terms of Verified RTP Plans

12. Hedging and Risk Management

No Hedging

With no hedging, an RTP subscriber is fully exposed to the full range of prices. Subscribers with the ability to adjust their inter-day and intra-day power usage can take advantage of such pricing volatility. Price-inelastic subscribers with limited ability to adjust usage may be require some means to hedge against some of the adverse effects of price volatility as a condition of subscription.

CBL Hedge – Two-part RTP

A two-part RTP provides the subscriber with a hedge against price volatility because only the load variation from the hourly CBL is exposed to that hour's RTP price. When hourly prices are low, variation in usage from the CBL results in relatively small bill changes and may be attractive for expanding electricity usage in those hours. When prices are high, the CBL acts as a hedge since usage at or below the CBL reduces price exposure or produces bill reductions, respectively. On the other hand, if the subscriber's usage fluctuates considerably above the CBL, or a change in usage has been enacted in expectation of low prices, elevated RTP prices can erode or eliminate expected savings, or raise power cost detrimentally.

Subscribers may find value in CBL hedges that allow them to either add to the CBL or reduce the CBL. The former protects against high RTP prices, since CBL is priced according to the original applicable tariff, locking in a favorable margin. For example, a CBL hedge might be considered for a month for those hours with metered usage routinely above the CBL. To be attractive, the price of a CBL hedge should be less than the expected cost of the exposure and not too far above the cost of usage under the original applicable tariff. CBL hedging involve risks for subscribers and the RTP service supplier.

Price Level Hedge

Price caps or collars are a common form of limiting exposure to price volatility. A cap establishes a price threshold such that no price higher than that level is ever posted. For example, a cap of $1.00/kWh would protect against prices might be as high a $5.00/kWh. Many early RTP programs employed algorithms that allowed a price that high, even though its occurring was highly unlikely. A common experience was that prices would rise to $1.00/kWh but only rarely and then for only a few hours. More common was episodes where prices during the afternoon and early evening hours were $0.50/kWh, several times the typical RTP prices in those hours. A price cap of $1.00 would provide protection but against unlikely adverse situations. A cap of $0.25/kWh would be triggered more often. How these are priced determines how customers value them. Price caps produce monetary savings only when prices are elevated, and usage is above the CBL.

There appears to be no case where price caps were offered by utilities as part of an RTP service. Doing so requires constructing a financial mechanism to set the cost of the cap, regulatory approval to offer the cap, and a subscription is the utility's willingness to undertake the risks.

A price collar allows for prices that vary around a specified strike price but places a floor and ceiling beyond that band. For example, the strike price might be set at $0.15/kWh and the collar +/- $0.05. These are more complex to develop because setting the strike price determines the extent and nature of price exposure, and hence the value of the collar to the utility and to subscribers. To be acceptable, collars may have to be set for relative short durations – a season or a month for example – to accommodate changing customer and market conditions.

Hedging and Risk Management Findings

As shown in Figure 3-16, 21 of the 55 verified active RTP offerings have some form of price protection or hedging, including 18 of those with a CBL structure. Tariff sheets for 13 of the RTP offerings do not include any mechanism to hedge customer price risk. The issue is unspecified on the tariff sheets for the remaining 21 RTP offerings.

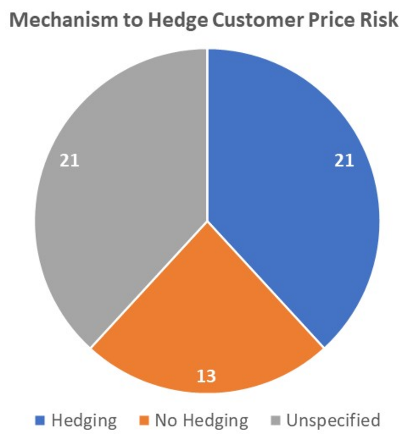

Figure 3-16
Hedging Provisions Among Verified RTP Plans

While helpful to acquire basic metrics and attributes regarding RTP plans, tariff sheets are not sufficient to capture the detail necessary to acquire deeper insights into these plans. For that, interviews were conducted with utility rate experts with RTP experiences, as detailed in the next section.

4

SYNOPSIS OF UTILITY AND STAKEHOLDER INTERVIEWS ON RTP EXPERIENCE

Section Summary

This section summarizes the process by which the project team conducted interviews with utility rate design and pricing plan professionals on their RTP plans and provides insights from those sessions. The interviews provided a level of color and context for the utility programs beyond what can be ascertained through analysis of tariff sheets, particularly with respect to customer participation, i.e. uptake rates.

Key takeaways from the interviews include:

- The impetus for most utilities' RTP offerings was either: (a) compliance with a regulatory order (actual or anticipated), or (b) preparation for, or response to, retail competition.
- All but one of the RTP programs discussed with utility representatives are currently active and considered "open for enrollment", yet most RTP programs for large commercial and industrial customers do not have high market penetration.
- Most (80%) of the RTP programs discussed are opt-in with a few default/opt-out for larger commercial and industrial customers who do not shop for an alternate service provider.
- Participation in RTP programs is relatively low – anywhere from 0 to an estimated 13% of eligible customers are enrolled in RTP with an average of 4.7% and a median of 2% participation.
- Many utilities do not regularly monitor the price responsiveness of their customers on RTP because there is negligible impact on overall load, possibly due to a lack of price volatility in recent years.
- Several utilities mentioned significant investment in modifying or replacing metering, billing and other systems was necessary to accommodate RTP.
- The majority of utilities are either indifferent to their RTP offerings or think that their program needs improvement.
- Most utilities review RTP in preparation for their regular rate cases, but few have made or plan to make any significant programmatic changes at this time and none have formal sunset dates.
- No real growth nor decline in RTP subscription since programs were introduced and initially subscribed.
- RTP is a "niche product" for large commercial and industrial customers who are able to manage their usage on a meaningful scale, according to several interviewees.

- Customers on RTP generally express high satisfaction to their utility account managers.
- Only a few utilities have plans or see any likelihood to offer RTP to other customer classes in the future, e.g., in lieu of or in addition to TOU electricity pricing for residential customers.
- Marketing to residential customers requires significant investment to increase market penetration that would still be relatively low.

Introduction

Based on the definition of RTP and dynamic pricing described previously, the research team compiled a list of active and inactive, actual, and pilot RTP programs from various sources, including a 2004 LBNL report, EIA listing, previous EPRI research, internet search, and other sources. Next, the information was sorted, and rate attributes inventoried, from publicly available tariff sheets and other public sources as described in the previous chapter.

From the resulting list of verified RTP programs, the team prioritized a list of about 20 utilities from Groups A and E that they would approach within a limited three-month project timeframe to identify knowledgeable program spokespeople and schedule a qualitative discussion about RTP program implementation and lessons learned. These utilities were selected to represent a cross section of RTP program offerings in the U.S. by geographic region, utility size, customer class, various rate design attributes, etc. The interview guide was modeled after the questionnaire in the 2004 LBNL report with some modifications and additions, then applied in interviews with representatives of some recent, mature/still active, and a few inactive RTP programs.

Altogether, the team conducted 16 interviews with a total of 24 individuals representing 19 distinct utility jurisdictions with a total of 24 RTP programs in 18 states. Participating utilities/stakeholders include current and former executives, program managers and consultants with:

1. Ameren Illinois
2. Commonwealth Edison (ComEd)
3. Citizens Utility Board of Illinois
4. Duke Energy Carolinas
5. Duke Energy Midwest (includes Duke Indiana, Duke Ohio, and Duke Kentucky)
6. Duquesne Light Company
7. FirstEnergy (Ohio Edison, Toledo Edison, Illuminating Company, Jersey Central Power & Light, Penn Power, Metropolitan Edison, Penelec, West Penn Power)
8. Georgia Power
9. Oklahoma Gas & Electric (OG&E)
10. PECO
11. San Diego Gas & Electric (SDGE)

12. Upper Peninsula Power Company (UPPCO)

Considerations in Developing Interview Script

The interviews were intended to reveal aspects of utility RTP offerings beyond their structural design and other facts obtainable from tariff sheets, such as:

- Motivations for developing the service
- Regulatory approval process
- Operational protocols
- Implementation infrastructure
- Recruitment and enrollment of subscribers
- Customer satisfaction and retention
- Lessons learned

The following questions, which elaborate these aspects, were the basis for the interview guide, which is provided in its entirety in Appendix A:

Enterprise Motivation for Developing the Service

- What motivated development of the RTP service? A regulatory mandate, success with RTP elsewhere, or customer requests?
- Who was responsible for developing the program, establishing requirements, and setting resources across several departments?
- What internal buy-in (level of approval) was required and how was it accomplished?

Regulatory Approvals

- Who prepared and filed the tariff sheets for the service?
- What regulatory approval was required to implement the program, tariff, and program mechanisms?
- What program/service reporting was required on subscription, price responses, process activities, drop-outs, and new subscribers?
- How were program expenditures recovered – from RTP subscribers or all customers?

Service Availability

- When was the RTP service first offered?
- Was it offered as a pilot, experiment, or as generally available?
- To whom was it offered? For how long is continuous subscription allowed?

- If already offered, is service still available under the initial structure, closed to subscription, or discontinued?
- If the service was closed or discontinued, what were the reasons?
- Who was responsible for preparing documents and agreements to execute?
- If a CBL (customer baseline load) was required, who was responsible for its initial development and for any adjustments made during the recruitment process?

Recruitment

- How was the population frame – which determines customers eligible for immediate participation – identified?
- What research was undertaken to establish which customers to target for subscription?
- How were recruitment materials developed and implemented?
- How were customers contacted to explain and be offered subscription?
- How were the subscription agreements executing?

Hourly Price Formation

- What process, methods and models were used to set levels of each element of the hourly price, e.g. marginal energy cost, outage or congestion costs, uplift, taxes, collections, and other adders?
- How were the procedures and analytics to calculate hourly marginal prices developed?
- How were hourly price schedules for each day developed?
- How was the posting of short-notice price overcalls determined?

Price Posting and Delivery

- How were daily prices transmitted to subscribers? What alternative mechanisms were available? How was receipt of prices confirmed?
- Were daily prices made publicly available when posted? If so, when were they posted – at a later time or not at all?
- If short notice overcalls were used, when were they transmitted to subscribers? How were they confirmed?

Measuring Power Usage

- How was power usage measured?
- How was usage metered and transmitted to those responsible for billing?
- What data verification procedures were used? Were they automated?

- Was hourly usage made available immediately to subscribers? If not, when was usage information available – within a short delay, a day later or other?

Financial and Accounting Protocols

- What changes to billing procedures and practices were required?
- What changes to financial accounting procedures and practices were required?

Cost of Service Treatment

- Were RTP subscribers treated as a separate class or did they remain in their prior class?
- What changes, if any, to cost of service protocols were required?
- What changes, if any, to fuel adjustment mechanisms were required?
- How were load changes associated with price changes incorporated into the creation of class load profiles?

Performance Evaluation Considerations

- What analyses were used to quantify how RTP impacted power demand?
- What analyses were used to quantify how power supply was affected by changes in customers' consumption due to RTP and whether those changes affected the utility's aggregate load profile?
- Are the results of these analyses made public or kept proprietary to the customer and the utility? If made public, how is the data accessed?

Key Findings from Interviews

RTP program history and outlook

Most utilities interviewed indicated the impetus for their RTP program offerings was related to compliance with a regulatory order (actual or anticipated) and/or in preparation for, or response to, retail competition. A few indicated their RTP program was developed in response to customer interest. When asked to indicate the primary goal of their RTP program, the responses varied from regulatory compliance to load growth/economic development to peak demand reduction to environmental benefits and cost savings and increased satisfaction for customers.

Figure 4-1
Utility Motivation for Developing RTP Plans

Figure 4-2
Utility Goals for Developing RTP Plans

All but one of the RTP programs we discussed with utility representatives are currently active and considered "open for enrollment." However, one is fully subscribed so new enrollment would depend on a facility closure by a currently enrolled customer to make room for a new subscriber to the program. Most RTP programs for large commercial and industrial customers do not have high market penetration. Similarly, the two residential RTP programs in Illinois have a lot of room for growth in customer participation. Note that end-use rates such as hourly pricing specifically for EV charging are not considered RTP for the purposes of this study.

A few utilities indicated they had modified their RTP offerings slightly over the years since introduction (most pre-2004). Changes include the addition of pricing protection mechanisms, and the review and adjustment of original customer baseline loads (CBLs) to reflect current electricity usage more accurately. Several utilities shared that they have installed advanced metering infrastructure and upgraded other systems since their RTP programs were first introduced and have offered or are investigating opportunities to provide enabling technology to customers on RTP.

The utilities' current level of enthusiasm for their RTP programs varied widely – from "very happy with it" and "high level of enthusiasm" to "lukewarm, at best" to "indifferent," seeing it as a "just a pass through" or "requirement." However, the majority were either indifferent or thought their program needs improvement. Most utilities review RTP in preparation for their regular rate cases, but few have made or plan to make any significant programmatic changes at this time and none have formal sunset dates.

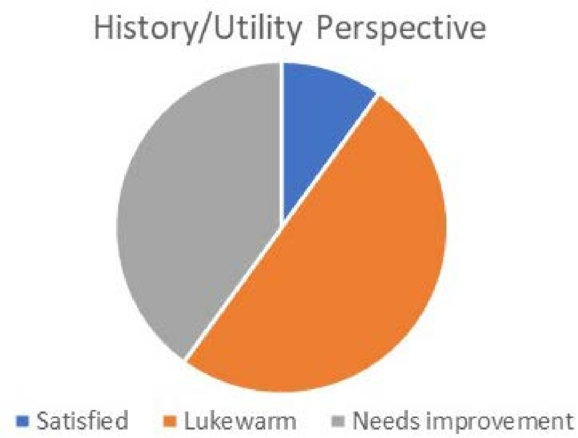

Figure 4-3
Utility Satisfaction with RTP Plans

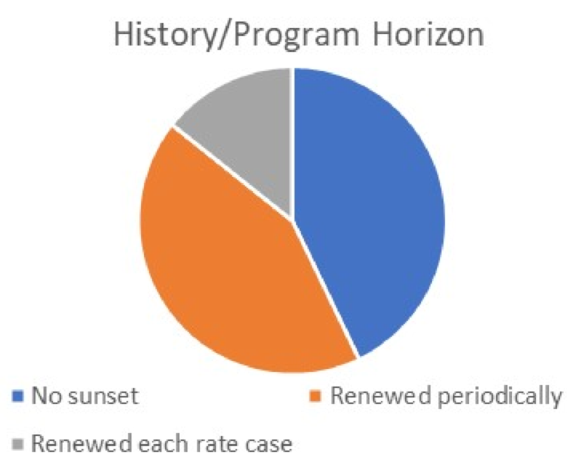

Figure 4-4
RTP Program Horizon

Marketing/customer outreach

Most (80%) of the RTP programs discussed in these interviews are opt-in with a few default/opt-out for larger commercial and industrial customers who do not shop for an alternate service provider. Most utilities said they did some outreach in the early years of their programs, e.g., account managers would meet directly with larger commercial and industrial customers about RTP programs, but marketing activity has waned since then. Notable exceptions are the residential RTP programs in Illinois, which have been marketed and evaluated by a third-party company using a variety of communication tactics and educational outreach, and for which there is interest in promoting and increasing subscription levels over the next several years.

Interviewees acknowledge that marketing to the residential customer class requires significant investment to increase market penetration that would still be relatively low, and they also are investigating pricing protection mechanisms and whether an opt-out strategy would be more cost effective while still offering customer choice.

When asked whether solar or solar and storage customers are eligible to participate in their RTP programs, two thirds of the utilities interviewed indicated yes, but that few customers in their service territories had solar resources (low solar penetration and very low storage penetration overall) and also met other eligibility criteria for the RTP programs.

Participation and Performance including price response

Among the utilities interviewed, there is relatively low participation in RTP programs – anywhere from 0 to an estimated 13% of eligible customers are enrolled in RTP with an average of 4.7% and a median of 2% participation. Some interviewees expected these relatively low participation levels since their goal was to encourage customers to shop for pricing in competitive markets. Some utilities saw initial success with customer participation and economic development with expanding and new businesses, but most utilities indicate no real growth or a decline in subscription since the program was introduced and initially subscribed. Several interviewees characterized RTP as a niche product for large commercial and industrial customers who are able to manage their usage on a meaningful scale.

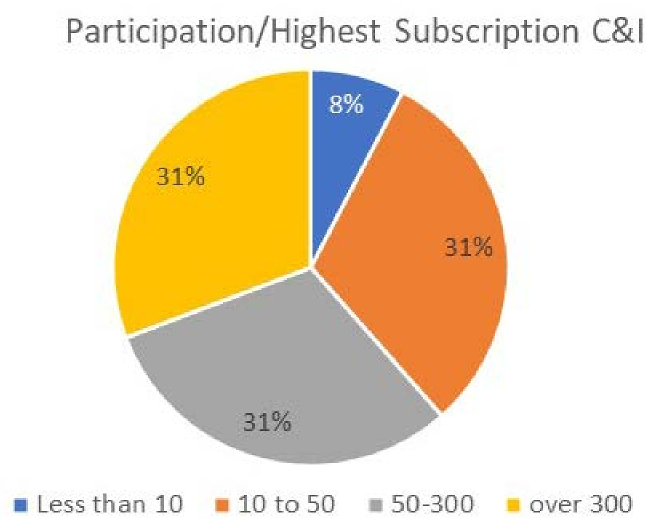

Figure 4-5
Participation – Highest C&I Customer Subscription in RTP Plans

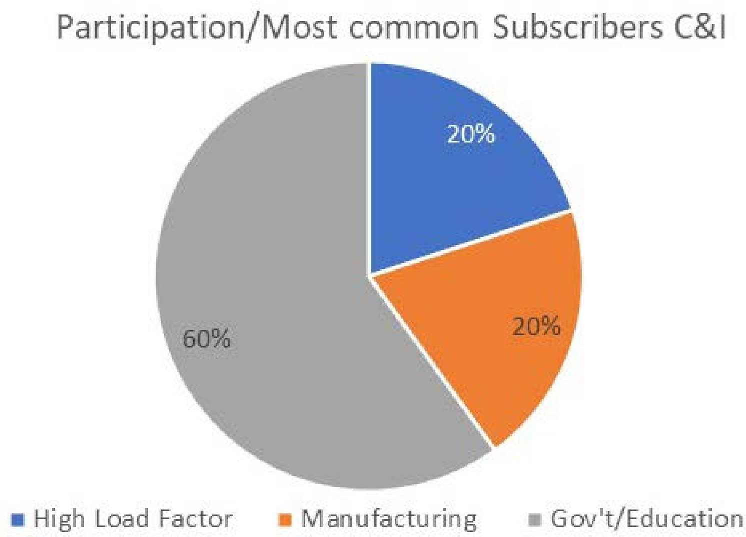

Figure 4-6
Participation – Most Common C&I Subscribers to RTP Plans

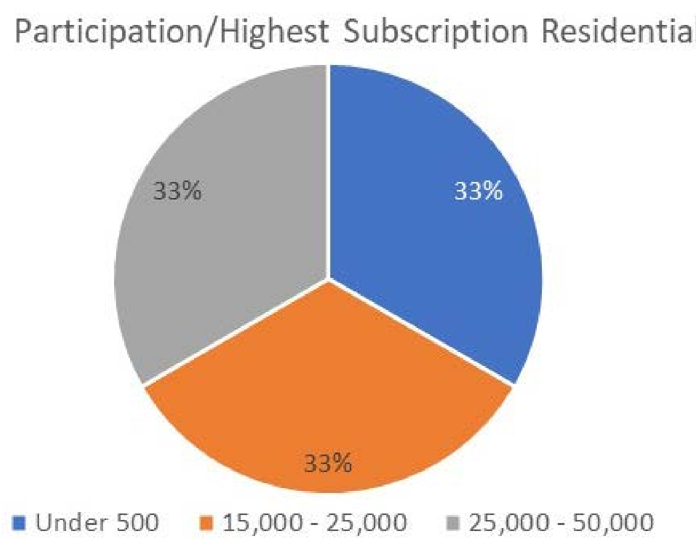

Figure 4-7
Participation – Tiers of Residential Subscribers to RTP Plans

While participation in residential programs in Illinois has been steadily increasing and may see a boost from promotion planned for the next several years, the new target of twice the current enrollment is still about two percent of all residential customers. According to Elevate Energy's 2019 Annual Report of ComEd's Hourly Pricing Program for residential customers:

In 2019, ComEd's Hourly Pricing program had 34,465 participants and generated more than $11,000,000 in net benefits from a societal perspective, a more than 18% increase from 2018. Hourly Pricing participants realized strong bill savings from favorable market conditions and by maintaining a high rate of conservation. In 2019, participants averaged annual savings of $92 when compared to ComEd's standard fixed-price rate. Participants netted an average reduction of 601 kWh from conservation efforts in 2019, adding another $40 per participant to their annual savings.

Customer feedback is not often formally solicited or reported by utilities with RTP programs for large commercial and industrial customers, but those utilities said they are in regular contact with RTP customers through their account managers who report high customer satisfaction overall.

Many utilities do not regularly monitor the price responsiveness of their customers on RTP because there is negligible impact on overall load, possibly due to a lack of price volatility in recent years. These utilities aren't sure if or why a large C&I customer may have altered operations in response to price or in spite of it – based on the economics of customer orders in production, for example. Similarly, few offered a guess at estimated bill impacts for customers on RTP compared with other pricing programs. Those few utilities that do monitor RTP program results more closely shared that while bill impacts vary by customer, most customers save money on the RTP rate. However, how much those customers save depends on their level of response and ability to respond to hourly price fluctuations (e.g., "savvy" customers and/or customers with technology to closely monitor prices).

Only a few utilities have plans or see any likelihood that RTP would be offered to other customer classes in the future, e.g., in lieu of or in addition to TOU electricity pricing for residential customers.

Implementation experience/lessons learned

When utilities were asked about their overall experience with RTP program implementation – what went well and areas for improvement – their responses ranged from tactically specific to higher level strategy, objective-setting and long-term planning. For example, one utility representative noted, "We didn't think it would last 25 years" and recommended that utilities considering RTP "think about long term success" and "figure out if there's a difference by region [in case you] might be able to have different retail prices by node or zone and have customers be comfortable with it." Other utility representatives recommended that utilities "go to opt-out to get higher subscription" from residential customers and avoid high marketing costs to meet modest market penetration with an opt-in program. A few utility representatives recommended utilities planning to offer RTP for commercial and industrial customers should consider scale to justify the expense of administering the program due to the level of personal attention required from account managers.

Several utilities mentioned significant investment in modifying or replacing metering, billing and other systems was necessary to accommodate RTP. Several utility representatives also reiterated that they view RTP as one of many tools in a pricing portfolio, characterizing it as a niche product for commercial and industrial customers with the ability to respond to pricing signals, and adding that RTP has very limited potential in their view due to low price responsiveness of customers generally. Some interviewees commented positively that RTP programs can be difficult to administer but are worth the effort for the utility and subscribers based on customer satisfaction, economic development and some load management benefits, while others offered more pessimistically that RTP programs are "a lot of effort for little benefit" unless there is capacity shortfall and demand response is needed.

5 ESTIMATES OF PRICE ELASTICITY OF ELECTRICITY DEMAND

Section Summary

Key Findings

- Review of thirty-one reported RTP elasticity[12] estimates indicated low load response, with most elasticity estimates under 0.10 and the majority under 0.05, especially those involving residences.
- Higher elasticities were reported in some circumstances, for example government and educational facilities, electricity intensive facilities like arc furnaces and refineries, and when the RTP design allows for day-ahead prices to be revised within day, particularly to post much higher prices to reflect supply conditions not anticipated the day before.

Introduction

Real-time pricing (RTP) has been as argued to be an effective way to equate variable marginal supply cost with electricity consumption decisions. It is believed that there is great potential for RTP services to improve the electricity sector operational and investment efficiency, provided that at least some customers subscribe and exhibit at least a modest level of price response to price variations. This chapter provides a way to gauge RTP potential and provide insights into which customers are the most responsive by measuring their price elasticity.

Elasticities are measured as rations of changes which means that only the price ratio effects consumption. The force of price change is diluted because customers are unable or not inclined to alter usage. An elastic value of 0.20 means that a 100% change in the price ratio produces a 20% change in usage ratio.

Findings

EPRI identified studies that reported price responsiveness, or price elasticity of electric utility customers on a retail RTP service. The intent was to comparably measure the effectiveness of RTP at inducing changes in electricity usage. EPRI's review summarizes how price affects participants' electricity usage, across RTP designs.

We identified eight utility-offered RTP programs that met those criteria: five for large commercial and industrial customers and three for residential customers. Four of the eight RTP programs are two-part, such that participants pay a non-bypassable monthly subscription fee

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[12] Elasticities are measured as ratios of changes which means that only the price ratio effects consumption. An elastic value of 0.20 means that a 100% change in the price ratio produces a 20% change in usage ratio.

based on an hourly baseline usage profile (CBL),with the difference from actual metered energy usage (kWh) settled at each hour's RTP price ($/kWh). The other four RTP programs employed a one-part approach utilizing either a demand charge or an RTP price adder to collect capacity costs not covered by hourly RTP prices.

Studies varied in how they characterized the causal link between hourly RTP price changes and customer usage of electricity. Some studies aggregated hours to reflect substitution possibilities. Other studies of RTP targeted to C&I customers extended the substitution possibilities to other days of the month. Some studies estimated own- and cross- price elasticities of demand, quantifying how hourly usage changes with hourly price changes and during other hours. One residential RTP program reported only estimated substitution elasticities, either between intra-day or inter-day hours, which simplifies the estimation of elasticities by assuming that RTP only shifts when electricity is used but that aggregate electricity usage remains constant. Two other RTP programs reported own-price elasticities, but their estimation methodologies lack sufficient rigor for comparison.

Comparisons of nominal elasticity estimates among the studies are instructive, e despite the fact they may not be measuring the same behaviors. However, all elasticities are relative measures of how changes in RTP prices invoke changes in electricity usage, so comparing their absolute values can provide insights into the RTP experience.

Thirty-one reported RTP elasticity estimates are summarized in Table 5-1. An elasticity of zero means that RTP price changes had no effect on electricity usage. .

Table 5-1
Distribution of Elasticity Estimates Among Studies

Distribution of Elasticity Estimates (Absolute Values)	
0.00 to 0.05	12
0.06 to 0.10	9
0.11 to 0.20	6
0.20 to 0.30	2
Over 0.30	2

Most elasticities were under 0.10, meaning that a 10% change in price resulted in less than a 1% change in electricity usage.

While the results generally indicate low degree price responsiveness, higher elasticities were reported for government and educational facilities, and electricity-intensive facilities like arc furnaces and refineries. In addition, higher elasticities were reported where RTP design allowed intra-day revisions of day-ahead prices. This allowed the posting of higher prices to reflect supply conditions not anticipated on the prior day. This variation allows customers to take advantage of day-ahead hourly price postings for the vast majority of hours each year when marginal supply costs are low. RTP enables utilities to match prices with prevailing supply conditions, benefitting those customers who respond.

Table 5-2 lists the 31 price elasticities of utility RTP programs that were studied.

Table 5-2
Estimated Price Elasticities for RTP – Absolute Values

Study	Subjects	Column Reference	Type of Elasticity Estimated	Figure 1 Reference	Absolute Value
HP&L	C&I	A	Own-price L	OP-Low	0.03
HP&L	C&I	A	Own-price H	OP-High	0.22
HP&L	C&I	A	Cross-price L	CP-Low	0.04
HP&L	C&I	A	Cross Price H	CP-High	0.06
NMPC	C&I	B	Within day L	WD Low	0.042
NMPC	C&I	B	Within day mean	WD Mean	0.093
NMPC	C&I	B	Within day H	WD High	0.136
NMCP	C&I	B	Between day L	BD-Low	0.01
NMPC	C&I	B	Between day mean	BD-Mean	0.163
NMPC	C&I	B	Between day H	BD-High	0.56
Duke	C&I	C	Own-price L	OP-Low	0.09
Duke	C&I	C	Own-price H	OP-High	0.26
Duke	C&I	C	Cross-price L	CP-Low	0.001
Duke	C&I	C	Cross Price H	CP-High	0.02
CSW	C&I	D	RTP-HA Within day L	WD-HA Low	0.238
CSW	C&I	D	RTP-HA Within day mean	WD-HA Mean	0.249
CSW	C&I	D	RTP-HA Within day HL	WD-HA High	0.304
CSW	C&I	D	RTP-HA Within day L	WD-DA Low	0.161
CSW	C&I	D	RTP-HA Within day mean	WD-DA Mean	0.169
CSW	C&I	D	RTP-HA Within day high	WD-DA High	0.198
NMPC/DS	C&I	E	Govt/Education Within day	WD-DS Gov	0.31
NMPC/DS	C&I	E	Mean Within day	WD-DS Mean	0.14
NMPC/DS	C&I	E	Indusrtial Within day	WD-DS Indust	0.11
NMPC/DS	C&I	E	Commercial Within day	WD-DS Com	0
ComEd	R	F	One-Price	R OP	0.042
Ameren	R	G	One-Price 2008	R OP-2008	0.043
Ameren	R	G	One-Price 2009	R OP-2009	0.023
ComEd	R	H	CPP Event day within	R WD CPP Event	0.127
ComEd	R	H	PTR event day within	R WD PTR Event	0.062
ComEd	R	H	CP non-event day within	R WD CPP no event	0.015
ComEd	R	H	CP non-event day within	R WD PTR no event	0.055

HP&L: Houston Power & Light
NMPC: Niagara Mohawk Power Company
CSW: Central and Southwest

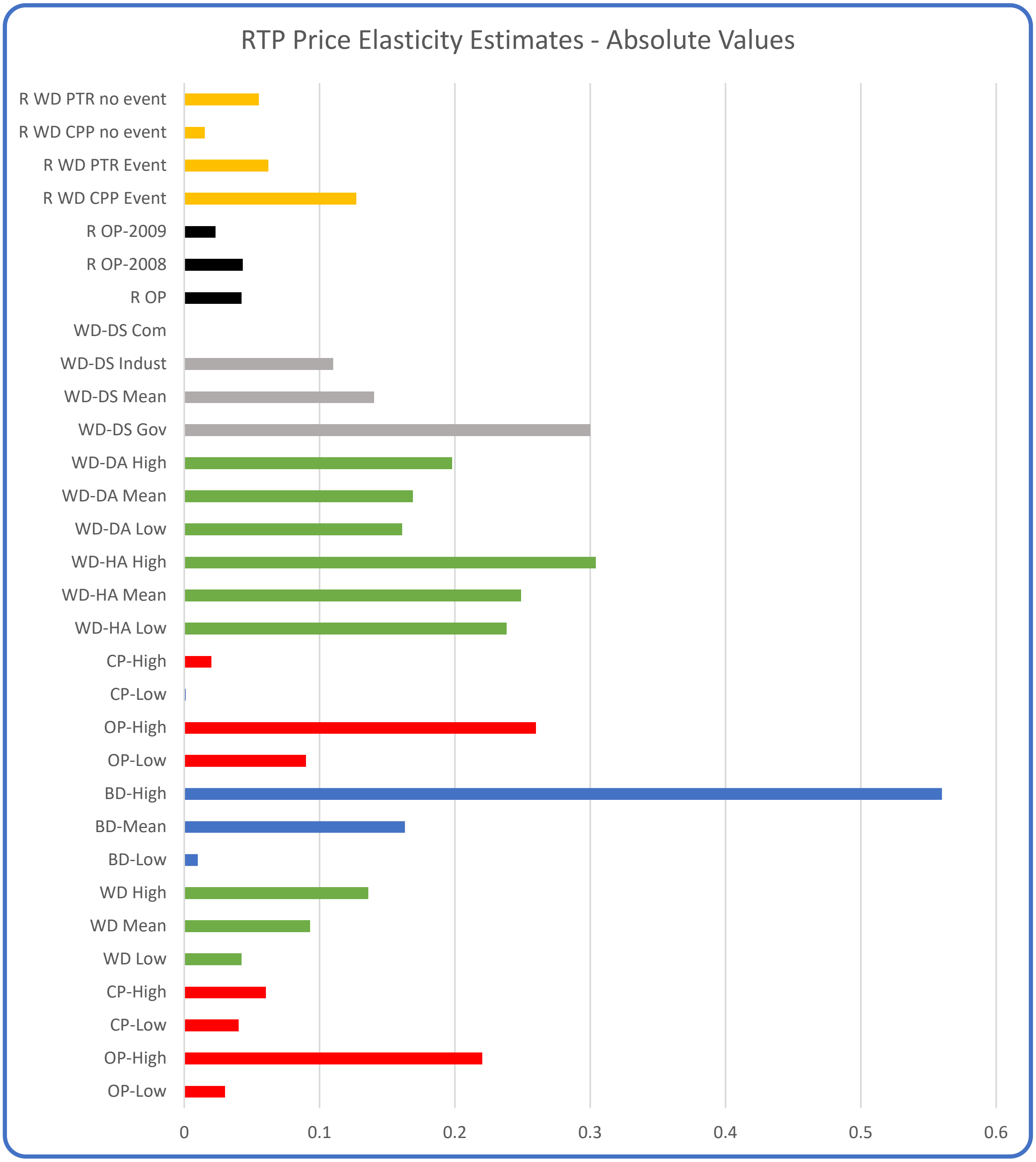

Figure 5-1
RTP Price Elasticity Estimates

6
ILLUSTRATION OF INTEGRATING RTP INTO AN ELECTRIC SERVICE PORTFOLIO

Section Summary

This section illustrates (a) a process to developing an RTP design that fulfils overarching objectives and (b) practical considerations to accommodate market circumstances.

Key Findings:

- Constructing and evaluating an RTP service requires accounting for a wide array of interests, including system and market characteristics.
- Little research has been conducted to understand customer preferences for real-time pricing intervals and advance posting periods.
- Customer preference research is critically important to inform the design of RTP services intended for expansive subscription.
- Constructing and evaluating an RTP service requires accounting for a wide array of interests, including system and market characteristics.
- Even in organized markets (i.e. ISOs/RTOs), determining whether posted prices are provisional or final can be ambiguous. A utility could develop a mechanism to forecast marginal energy and outage costs or elect to set up a state-driven schedule.
- A concerted effort is needed to help customers understand: (a) why RTP is different from their current service; (b) what actions are required to benefit from RTP; (c) what costs are associated with those actions; and (d) what risks are associated with RTP subscription.
- Pilots can play a pivotal role in providing insights into customer acceptance of various RTP design options to inform final design for broad roll-out.
- Deriving prices from utility system dispatch operations may require investments in those systems to extract the marginal operating prices and if employed, generate marginal outage costs.

Introduction

Previous sections have discussed the variety of ways real time pricing is defined and how services implemented by utilities have taken different forms. This chapter provides a strategic decision-making framework for stakeholders to design an RTP offering. Figure 6-1 illustrates a sequential decision framework to guide RTP design, with associated data requirements.

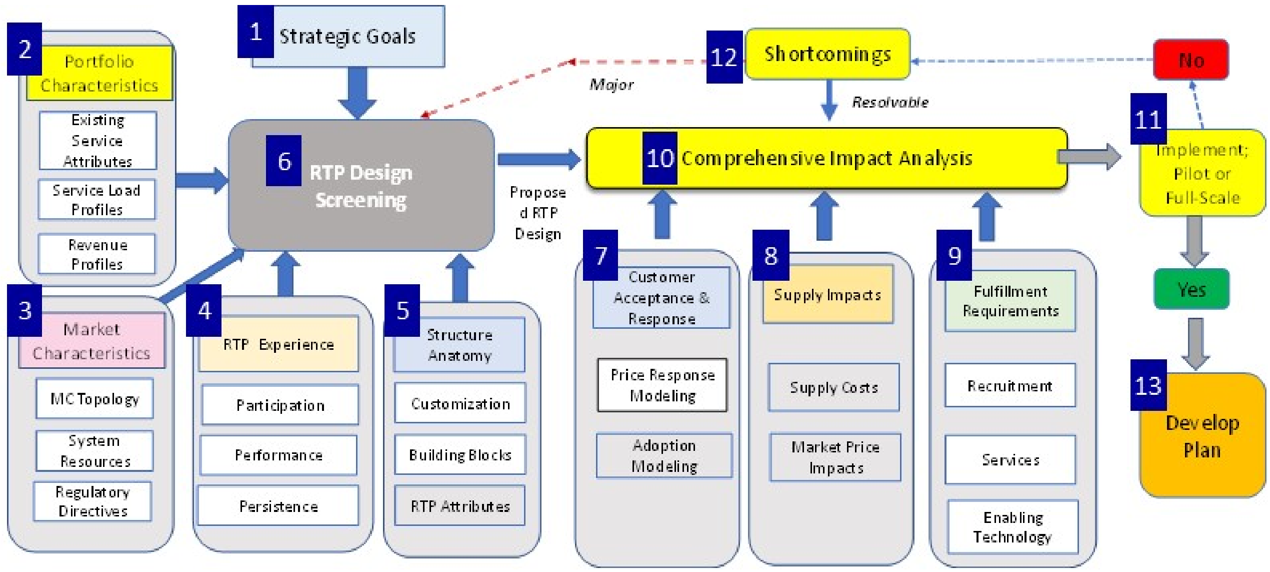

Figure 6-1
Flow Diagram Illustrating Decision Sequence for RTP Design

The remainder of this chapter provides further details on each component of the RTP decision sequence:

1. Strategic Goals
2. Portfolio Characteristics
3. Market Characteristics
4. RTP Experience
5. Structure Anatomy
6. RTP Design Screening Requirements
7. Customer Acceptance & Response
8. Supply Impacts
9. Fulfillment Requirements
10. Comprehensive Impact Analysis
11. Implementation: Pilot or Full Scale
12. Shortcomings: Redesign
13. Develop Plan

[1] Strategic Goals

Strategic goals for RTP may include any combination of the following load-shaping objectives based on the circumstances of the particular utility the wholesale market in which it operates:

- Reduce consumption and demand during peak periods
- Shift usage from peak hours to off-peak hours
- Reduce congestion of power delivery at the transmission level
- Reduce congestion of power delivery at the distribution level
- Encourage flexible consumption to maximize utilization of zero- or low- carbon renewable generation sources
- Promoting more efficient consumption (i.e. purchase and use of energy-efficient devices)
- Promote electrification to advance decarbonization and economic growth
- Stimulate and sustain customer-sited generation to promote energy diversity and sustainability

A utility considering design of RTP plans for customers should begin with the first-principles of which strategic goals to advance.

[2] Portfolio Characteristics

Whether RTP would be added or be a revision to the retail service portfolio – the criterion should be how RTP would benefit the portfolio. This starts by characterizing how it could contribute to the goals for portfolio performance. The overall effectiveness of a design must consider the impact of migration from existing services (both physical and financial) so they can be compared to the benefits that could be realized from an RTP subscription.

Existing Service Attributes

The RTP attribute template described earlier in the report serves as a starting point. To that add categorically the attributes of the existing services to highlight differences and tradeoffs to consider. As an example, is to what extent are usage prices linked to wholesale, market-clearing prices or by utility-equivalent dispatch. Establishing the spatial and temporal characteristics of existing prices provides the basis for comparing them to the marginal cost topology developed in the market characteristics sections. Prices that change regularly and are highly variable must be contrasted to price schedules like TOU or uniform energy and demand charges in terms of how electricity usage is affected and the implications for the financial efficacy and customer acceptance of RTP.

Service-level Load Profiles

Load profiles for each service class are required for initial screening and the subsequent detailed analyses. They must be constructed at the level of usage measurement consistent with RTP designs, some of which measure and price usage hourly, but others utilize shorter time intervals to price energy usage, for example every five minutes. Classes that have been metered and billed hourly for several years are compatible with an hourly RTP service. If hourly data is available but not used for billing, then a judgement must made about what would be required to develop a class hourly profile and can it be broken down into customer-specific profiles. This characterization should include what would be required produce these profiles; what new metering and data management capacities would be required so that the screenings can be balanced with other considerations.

Revenue Profiles

Construct a multi-year synopsis of the revenues associated with each class/pricing structures distinguishing them by what measures of service are priced. This provides insights into the importance of cost recovery from measured energy usage (the flow of energy) compared to collections from use of the stock of system supply and delivery assets. RTP can be constructed to isolate the recovery of fixed and variable costs to variable degrees and the extent to which a specific design does. This revenue topology provides a perspective on the risks associated with the migration of customer from existing services to an RTP services that likely requires additional and detailed analysis of any service proposal that emerges from the screenings process.

[3] Market Characteristics

RTP services take advantage of existing and future market conditions and circumstance can may be limited or mandated by them.

Marginal Cost Derivation and Topology

RTP prices energy usage at marginal costs. A primary RTP design building block is to determine how those prices are generated each hour for each day, using posted wholesale market prices, prices derived from internal system dispatch operations, or specified by an established schedule that associates the level and profile of daily marginal cost with observable conditions (e.g., weather, scheduling a peaking unit, or the likelihood of an abundance or shortfall of intermittent resources). Screening RTP alternatives requires a characterization of the current availability of prices form each source and an assessment of how that might change over time. If the utility is part of an RTO that produces hourly market-clearing prices and day-ahead prices and has done so for years, for example, the a price topology can be constructed that provides annual overviews such as: average price by hour and the mean and variance, a price distribution that shows the frequency of prices (how often a price occurs at or above price tranches), the pattern and sequencing of high and low prices (how often to prices sustain for a specified period (six hour), and other temporal and if applicable, temporal price regimes. These can be compared to the price variation developed in the portfolio characteristics to link existing service prices to marginal costs that reflect prevailing market prices.

If RTO or equivalent prices are not available, the suitability of systems available to provide hourly or shorten interval prices, and if not available, what is required to develop and implement them. Most utilities operate system dispatch algorithms that indicate the unit at the margin each hour that when associated with the unit's heat rate and accounting cost provides an estimate of marginal energy supply cost. Using historical data or simulating dispatch over forecast scenarios provides hourly data to develop price topologies as discussed above. An additional consideration is how to establish congestion or shortage cost. A review of mechanisms that have been developed and used for RTP services by others provides alternatives that can be evaluated in terms of applicability and requirements to develop that are passed on to the screening process.

If neither of these is available currently, then this characterization requires as assessment of when either (or both) price-determining mechanism will be available to set prices for an RTP service.

System Resources

A general assessment of what resources are available to serve electricity supply and delivery and the potential shortcomings provides insight into capacity needs which informs valuing an RTP service; could it forestall or even eliminate a future investment requirement, provide better information as to what capacity will be needed, or would a RTP service speed up, increase, or both, capacity addition. The latter might be the result of an RTP design that results in customers served on interruptible service to migrating to RTP because it offers firm service at an acceptable premium.

Regulatory Directives and Stakeholder Interests

A mandate to consider RTP by regulators may be a driving force to design and evaluate service alternatives. The directive may be general but characterizing the reasons for the directive will ensure that those considerations are employed in the screenings and resulting proposals responsive. A customer or group of customers may request that RTP be given consideration as an addition to the portfolio. It is essential to work with such entities so that they articulate their expected benefits. They may have in mind a specific formulation; they may be relying on substantiated or unsubstantiated estimates of the benefits they might realize or using the term RTP very generally and have in mind a different form of dynamic pricing. The results more likely to be accepted if these interests and concerns are properly formulated, considered, and addressed explicitly justifying a proposed design.

[4] RTP Experience

When designing an RTP program it is useful to learn from utility experience with implementing RTP. This can be done through reviewing published studies on the subject. For example, Chapters 3 and 4 of this report summarize the collective experience of US regulated electric utilities that have implemented RTP, through reviews of RTP tariff sheets and interviews of utility rate managers, respectively. These chapters describe utility experiences to-date with RTP, including a comparison of programs by their choice of building blocks, attributes included, and customizations to adapt designs to customer- and market- circumstances. While the analysis of tariff sheets in Chapter 3 provided structural details, the interviews with utility professionals provided valuable additional insights and perspectives on how customers were recruited, what motivated subscription, what support services were offered, observed and measured price response, and other programmatic features.

Figure 6-2 illustrates three dimensions of customer response: participation, performance and persistence.

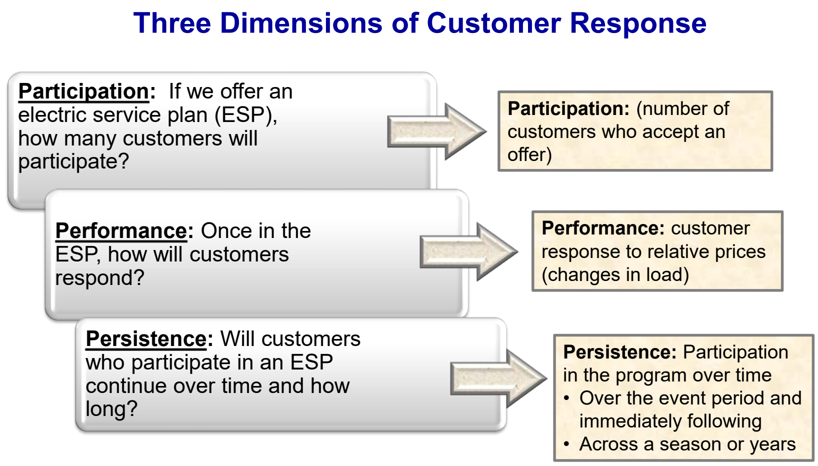

Figure 6-2
Three Dimensions of Customer Response

Participation

Participation describes the motivation for participation in an RTP service, including factors that the RTP design team proposes are important and what is gleaned for the experience of others. They include measurements such as the percent of customers invited to join who subscribed, broken down into distinguishing factors that support segmentation like business activity (primary metals fabrication and refining, manufacturing, retail, government and education), previous experience with a dynamic pricing service (CPP, PTR), an on-site generation facility, etc. These provide a first approximation of how design features affect subscription.

Performance

Performance measures gleaned from the experience catalogue, distinguishing the RTP design that are accounted with the design, provide the means for estimating the degree of price response expected from those hypothesized to subscribe. When available, estimated price elasticities combined with RTP price topologies developed under market characteristics produce estimates of RTP price-induced changes that can be transformed into utility and market supply impacts, utility financial impacts, and subscriber benefits that to be used in the screening process.

Persistence

Persistence measures how long RTP subscribers remain on the service, assuming that they have the option to return to a more conventional service plan. Our review of utility RTP experience shows that programs allow migration after an initial contract period, and most programs allowed subscribers to renew the contract for additional years; notable exceptions were RTP pilots or fixed-term experiments. Subscription persistence information allows for more realistic forecasting of RTP impacts by considering the possibility that some subscribers will drop out.

[5] Structure Anatomy

Section 2 described a structural characterization of RTP as utilizing a set of descriptive attributes, basic structural building blocks, and customization. These are functional elements of screenings process used to construct designs that are assessed according to strategic goals.

[6] RTP Design Screening

Constructing and evaluating an RTP service requires accounting and screening for all of the preceding considerations – [1] through [5].

- Strategic goals
- Portfolio characteristics
- Market characteristics
- RTP experience
- Structure anatomy

The screening process filters the possible RTP designs to a select few that pass an initial test of suitability, achievability, and responsibility.

A planner can construct an evaluation template to sort these inputs into categories amenable to rating, rankings, or some criteria for quantitative scoring for the screenings process.

The goal of the screening exercise is proposing an RTP design for further, more in-depth analysis. The information gathered, interpreted, and synthesized in this process provides a basis for evaluation. Because subsequent design analyses are resource-intensive and time consuming, it is imperative to select a basic design or identify a key decision factor to focus the additional analyses.

Ideally, a cross-functional team with expertise in RTP design and in the constituent technical, portfolio and market areas will collaborate on the RTP design screening process. Diverse expertise is needed because many of the customer, market, and supply considerations defy definitive weighed scoring.

A fundamental screening decision is what degree of customer RTP subscription is required. This drives all subsequent building block decisions and customizations.

A second decision for the screening team is whether the advantages of the historic customer baseline load (HCBL) or nominated customer baseline load (NCBL) design merit the added complexity of developing and managing baseline loads. Related questions to consider include:

- *Is linking RTP price to market or system marginal supply cost to achieve the greatest efficiency benefit a preemptive priority*? If so, then HCBL is the better design choice.
  - Usage price always reflects marginal supply cost, and since it applies to changes in usage from the HCBL, subscribers make efficient decisions about energy use.
  - Collection of fixed cost is achieved by a non-bypassable access charge so there are no structural winners who benefit from cross subsidization or structural losers who pay a premium just to participate.
  - Several implemented HCBL programs provide insights into how to administer the HCBL, gauge its effectiveness in inducing price response, and reveal any shortcomings that caused program to wane or close.

- *Would allowing customers to nominate the CBL periodically improve customer acceptance at the expense of lower efficiency gain, greater complexity in administering the program, and the need to add a way to collect each customer's fixed cost obligation?*
  - Potential subscribers are skeptical of a fixed HCBL over several years
  - Potential subscribers' power demands fluctuate seasonally or monthly, or even daily
  - Potential subscribers want to be able to expose more load to or hedge load against RTP price volatility
- *Is either subscription model deemed beyond the utility's' capability to administer, or is efficiency is a lower priority than realizing some improvement over conventional rates?*
  - Utility rates staff are experienced in setting charge specifically to collect fixed costs that are not recovered without the rate charged for energy.
  - RTP subscribers migrate from existing services which provides a base for establish a cost recovery factor that is aligned with the cost-of-service foundation for the service portfolio.
  - Potential subscribers are averse to the concept of a HCBL or NCBL and are willing to forego the potential benefits of a HCBL or NCBL

A third screening decision is RTP pricing and price posting interval. This may be determined by prevailing market conditions. A utility operating in an RTO market (for example, CAIOS, PJM, NYISO) that posts market-clearing prices would argue strongly for using those prices, but still leaves open the question of the measurement and pricing interval, when prices are posted and if they are provisional or final. Otherwise, the utility develops a marginal energy and outage costs forecast mechanism or elects to set up a state driven schedule.

Given what can be provided, the determining factor in choosing the pricing interval is what will be acceptable to RTP service providers. For organized markets, the choice of the pricing interval is restricted to what the ISO/RTO provides (i.e., day-ahead and real-time). Utility-dispatch pricing will be determined by the capability of existing systems or what can be developed and implemented.

The experience of others provides no definitive conclusion since most use hourly day-ahead prices, but others post prices on very short notice, some of which are provisional. Little research has been conducted specifically to answer the question of preferences for pricing intervals and posting. The limited subscription in many programs may be because customer preferences are diverse but only a single interval is offered. If the intent is to design an RTP service that has expansive subscription preference research maybe required to understand what design or designs to offer.

The NCBL and no subscriptions obligation designs required collecting some or all of subscribers' fixed cost obligation through a demand charge or as an uplift to RTP usage prices.

Customizations to a basic RTP design provide a means for adapting the design to local market and customer circumstances. For the initial screening, these are less important considerations because their efficacy and effectiveness require more in-depth analyses that are undertaken subsequently in the comprehensive impact analysis applied to the design or designs screenings recommends moving forward on.

The primary purpose of screening is to establish the functional and process requirements for implementing and RTP service and select the one that best fulfills the established goals and comports with what is technically feasible and acceptable to customers, using high-level characterizations. Before a final decision is made, a comprehensive analyst is required that raises the bar in term of the analyses required and their scale and scope that vary among RTP designs. Screening should be focused on making a preliminary design recommendation of which one to move forward on, or if that cannot be determined because of uncertainties, indicate what additional information so required to do so and provide direction as to what additional research is required.

[7] Customer Acceptance and Response

A more detailed characterization of RTP effects involves modeling subscription and price response in greater detail, which may require undertaking field research to establish value for the behavioral characterization these platforms utilize.

Price Response Modeling

Price response simulations are helpful when deciding whether or not to implement an RTP if they are conducted only for likely subscribers. Price elasticity summarizes how electricity usage changes as price changes, providing a metric that can be used to evaluate a prospective RTP design. For RTP, a convenient characterization is to divide days into peak and off-peak periods that correspond to time when RTP prices are likely to be much higher than the overall average price (price peak hours) and to when they vary only occasionally and modestly from the average price. Since high prices are most likely to induce usage changes by subscribers, and because studies suggest that most load shifting induced by RTP pricing is within day, this structure provides a way to estimate how an RTP structure affects the diurnal load profile.[13]

Estimating hourly (or shorter interval) impacts requires constructing an analytical framework that uses as inputs a baseline load profile and corresponding price changes. In this structure, the relative change in both load and price is defined by the difference in the peak and off-peak values which determines the load change. The price elasticity model produces a simulated load change for every day modeled that in turn produces a stream of benefits to the estimated subscribe. The simulation can be performed using a class load profile, the load profile for selected customers, or for each customer. The second option is more useful when likely subscribers have been identified. Modeling individual customers is a more daunting undertaking because elasticities have to be assigned to each.[14]

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[13] As the forementioned review discussed, more complex characterizations of price response can be used to reflect hourly shifting among adjacent or distant hours of the day or even a subsequent day. They require many more elasticity estimates for which there are few reliable sources that makes simulating price effects more speculative with little additional insight. Hence a relatively simple platform is recommended.

[14] A large number of customers modelled individually is tedious but in this simplified response structure the analytical mechanics of the simulation can be done in Excel quickly; the tedium is organizing and assessing the outputs.

Adoption Modeling

Before a utility offers a new service, it should ideally know how many customers are likely to elect it over other available options. Load profiles will not be enough. A utility should also seek to segment customers for direct engagement and implementation campaigns. Customer preferences must be distinguished by observable demographics and premise characteristics so that outreach and marketing efforts can be conducted effectively. [15] Pilots can play a pivotal role in providing insights into customer acceptance of various RTP design options to inform final design for broad roll-out. Targeting an effective value proposition to those customers cost-effectively is paramount for success.

Discrete choice experiments (DCE) are well suited for estimating preferences for ESP.[16] A DCE is a structured way to elicit from customers detailed information about how the features (attributes) of a product or service contribute to the overall utility or value they assign to it. Its application to ESP involves breaking services down into their constituent parts, attributes, and measuring how those attributes contribute to consumer preferences for the services. Demographic and premise correlations facilitate associating preferences with observable customer characteristics, to develop segments that can be mapped to an electric service territory.

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[15] Estimating the level of Participation in a service when it is offered is only part the story. A utility needs to be able to estimate how participants alter electricity demand (Performance), and how long that participation and performance will be sustained (Persistence). EPRI is developing methods and models to address all of three elements, referred to as The Three Ps. Additional research is underway to round out the suite of methods and practices needed to provide customer with choices in a financially and socially responsible way. It begins by developing a strategic vision to align supply cost and considerations with services that comport with them, and effectively managing the portfolio of services that result.

[16] *Methods for Characterizing Customer Preferences for Electric Service Plans*. EPRI. 2012. 1024401.

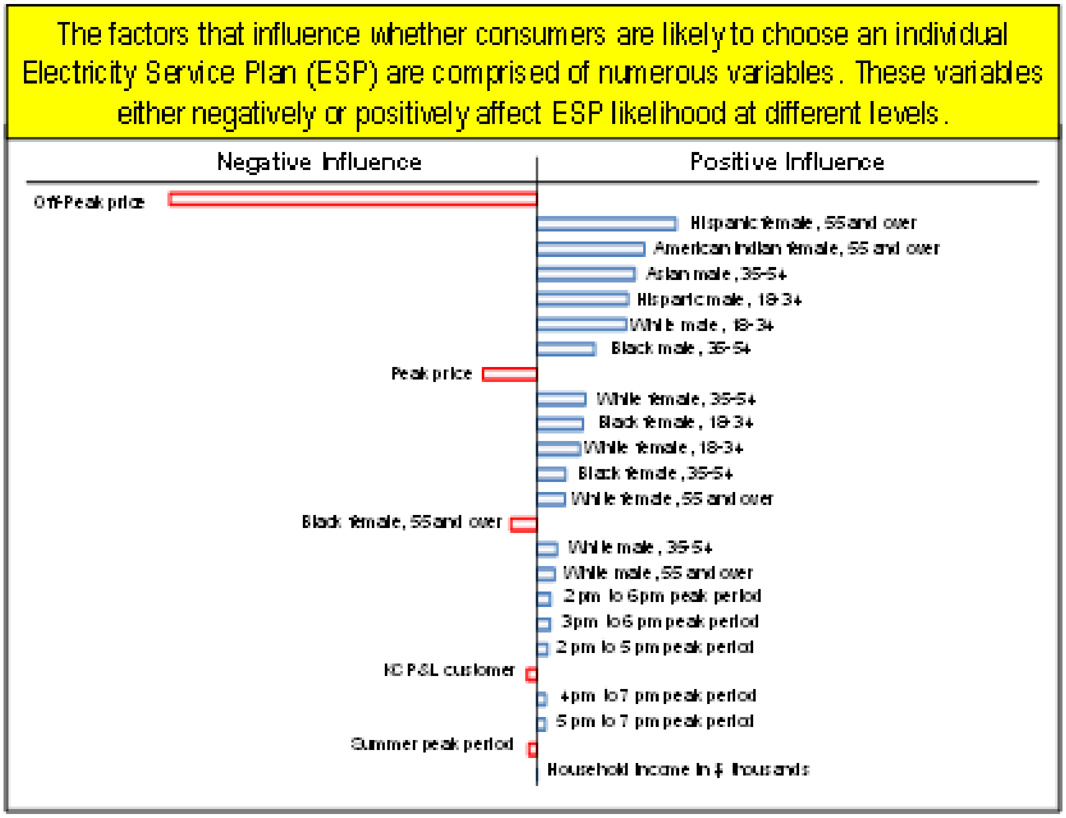

Figure 6-3
Factors Influencing Consumer Choice of Electricity Service Plan

DCE was developed to elicit preferences for new and novel products and services. It is well suited to elicit customer (residential customer) preferences for RTP. An example of its application to residential choices among TOU and uniform rates (Electric Service Plans) revealed the extent to which service design feature and demographics influence the likelihood of adoption, as illustrated in Figure 6-3.[17] A study undertaken by Oklahoma Gas and Electric reported preferences for alternative pricing designs from its study and a prior study by Public Service Oklahoma (PSO), including RTP as illustrated in Figure 6-4; 7 to 10% preferred RTP to alternatives involve less dynamic pricing like TOU, and about 25% indicated a preference for a full hedged service (fixed bill) where the subscriber agrees to pay an annual subscription fee ($/years) that does not change as a result of its usage during that period.

[17] Neenan, B., Bingham, M., Kinnell, J. Hickman, S. May 2016. Consumer Preferences for Electric Service Alternatives. Electricity Journal Vol. 29 Issue 5, pp. 62-71.

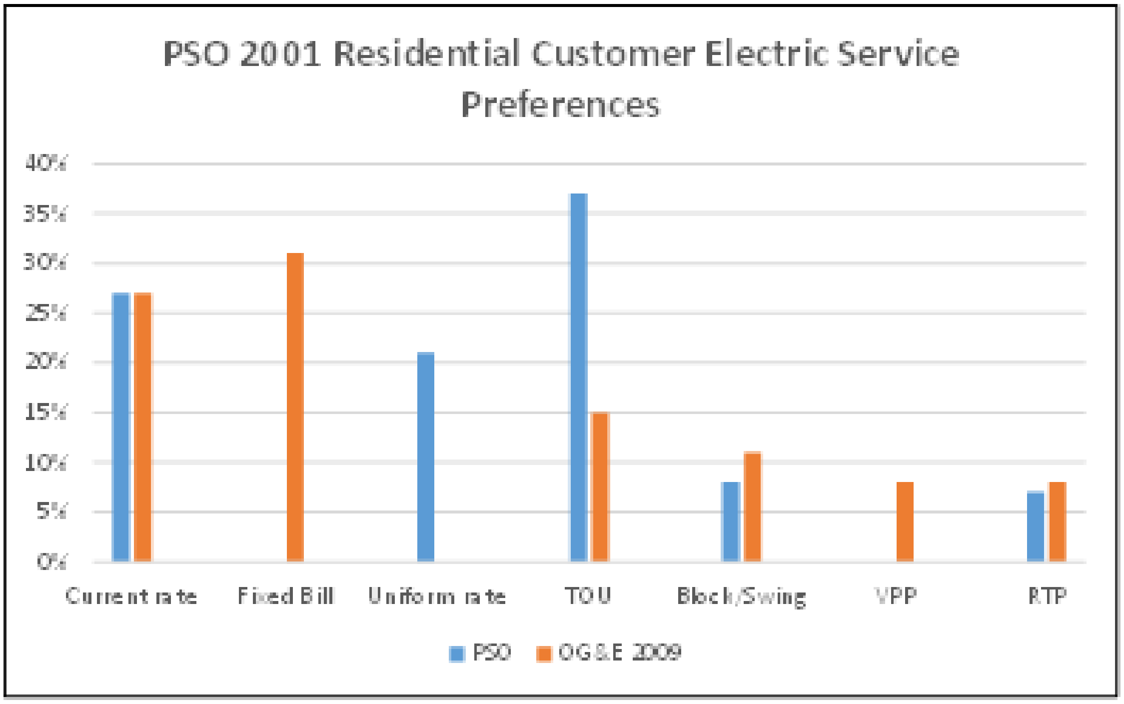

Figure 6-4
PSO 2001 Residential Customer Electric Service Preferences

Only a few such studies are available to provide this detailed characterization. A utility may conclude that those findings are inadequate to represent their customer circumstances, or that they are informative but not conclusive enough to support the RTP implementation decision. A field study may be required to collect date to construct an adoption platform.

Such studies require extensive time and resources to undertake, delaying RTP implementation. A key decision for a full impact analysis and using the results to decide on RTP implementation hinges on the degree to which the characterization of adoption is deemed adequate. If implementation depends on the realization of a specified threshold level of participation eventually, then an in-depth RTP adoption study may be required as part of the full impact analysis. Alternatively, the initial RTP implementation may be seen as the means for resolving uncertainties about the rate of adoption, and price response and persistence, and provisions are made as part of the launch to conduct research specifically to resolve uncertainties by limiting or targeting the subscription drive or implementing a pilot or experiment.

[8] Supply Impacts

Supply Costs

A measure of the benefit of RTP is how supply costs are affected. In the short run those benefits are captured though a welfare analysis as described above as the improved utilization of existing resources. The long-term implication is that RTP prices better equate consumption to the cost of supply, revealing the nature of electricity demand so that investment decisions in capital assets to supply power are more effectively used; the choice of generation assets to build and delivery improvements to serve demand. The need for peaking units that are seldom is reduced. Base load unit additions benefit from the more precise knowledge of demand and its time topology resulting in less surplus capacity that raises average costs. Establishing the change in investments in physical assets requires employing capacity planning models that forecast system asset investment needs over several years. These models are an integral component of utilities' system planning tools, and those of RTOs, that can trace out the implications of changes in electricity demand attributed to RTP.

Market Price Impacts

RTP is promoted as improving the efficiency of utilization of electricity sector assets. That comes from reduced usage when prices are high by shifting load to another, lower priced period. Expanded electricity consumption (the result of RTP average prices being lower than what would be charged under the OAT) also contributes to efficiency as available resources are utilized that otherwise would not. Measuring how RTP price response behaviors affect electricity supply captures these benefits.

One way to do so is to calculate the impact on the overall cost of supplying all customers' usage by comparing the change in the average cost of supply. Load shifting from high to low priced periods contributes to reducing the average supply cost. The benefit of increased usage during lower priced periods is more difficult to measure as there is no basis for equivalency. RTP price above the standard rate may provide incentive to expand usage because of the value realized by the subscribers from greater services powered by electricity. Using the difference between the RTP price and the OAT price would result in an increase in the average cost under RTP and could be sufficiently large to substantially reduce the load shifting benefits.

Alternatively, the benefits associated with RTP can be measured as the change in net welfare that results, where welfare is measured assessing the value of changes in electricity demand and the cost to do so. This involves constructing market supply and demand curves, imposing changes in supply over time to determine the resulting price change, and then interpreting. Ruff describes the foundation for such a measure of price changes and Boisvert and Neenan provide a way to employ this concept to measure the market benefits of dynamic pricing.[18] An example of its application to wholesale is provided in Boisvert et al. [19]

[9] Fulfillment Requirements

Implementing an RTP service requires recruiting customers to participate and constructing and operating systems to manage the processes.

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[18] Ruff, L. October 2002. Economic Principles of Demand Response. Prepared for the Edison Electric Institute. Boisvert, R. Neenan. B. 2002. Establishing the Social Welfare Implications of Price Responsive Load (PRL) Programs in Competitive Electricity Markets.

[19] UtiliPoint International, Inc. May 29, 2007. The Benefits of Linking Massachusetts Retail Basic Service Prices to Wholesale LMPs. Prepared for: Massachusetts Division of Energy Resources: Boisvert, R., Neenan, B. August 2003. [8]Social Welfare Implications of Demand Response Programs in Competitive Electricity Markets. Lawrence Berkeley National Laboratory Report No. LBNL-52530. Available at http://www.lbl.gov/.

Recruitment

The experience of utilities that have implemented RTP is that customer recruitment requires a concerted effort. Customers need to understand why RTP is different from their current service, what actions are required to benefit from RTP, what costs are associated with those actions, and what the risks associated with RTP. Subscription campaigns generally prepare materials to introduce the concept and highlight the potential benefits to identify candidates. Subsequently, customers are typically provided detailed contractual descriptions of the RTP service and more detailed analyses of both the risks and benefits they can expect. The benefits can be illustrated by simulating example load changes using the customer offers as a possible response the customers' load profile using a representative (forecast of historic) RTP hourly price profile. Augmenting this with the experience of other customers that have benefited from RTP subscription reinforces the potential for benefits. These are time-consuming activities the cost of which in time and resources is an important input to the decision to proceed with implementation.

Services

Several new services are required to implement RTP that vary according to the design selected. Using RTP day-ahead prices as posted requires only establishing the means for retrieving them and sending them to subscribers. If the RTP prices are adjusted to create the RTPs prices, then processes and models are required that operate daily with a high degree of reliability. Deriving prices from utility system dispatch operations may require investments in those systems to extract the marginal operating prices and if employed, generate marginal outage costs. Setting prices for a state-driven schedule is relatively easy but setting up the schedule may require an investment in models to develop the marginal cost and observed conditions (state) relationships. Estimating the requirement for all these regimes is daunting, which emphasizes why the screening process is important so that all primary design decisions have bene made and only a single structural design proceeds to full analysis.

Enabling Technology

The review of RTP experience reveals that generally customers that subscribed were provided only the necessities; an interval meter to measure usage and in some cases equipment for receiving or retrieving posted prices. Most provided customer with hourly data to support response planning, in almost all cases in the form of monthly data sets. Some made the reading available regularly (daily) or directly from meter on demand. A few provided subscribers with software tools to help them develop scripts for how to reopen when prices hit a level where response might be beneficial.

The rudimental nature of these support technologies reflects time when many RTP programs were launched, the late 1980 and 1990 when technologies to implement load changes automatically, or at least assist accomplishing load changes, were limited to expensive controls intended for large business operations. Today, a wide variety of electricity device control technologies are available to control many aspects of a business (production processes and support services) and individual electric services at residences (like an HVCA systems, pool pumps, water heaters). These make carrying out price response actions easier and more effective, which makes subscription more attractive if the benefits realized exceed the costs to acquire and operate them. Regardless of which RTP basic structure is considered, the decision to implement should be informed by identifying which technologies are most likely to enhance RTP responsiveness and the ownership costs. A deciding factor maybe whether RTP produces sufficient benefit to warrant providing subscribers with enabling technology at reduced or no cost.

Consolidated Results – Benefit/Cost Analysis

Benefit/Cost Analysis (BCA) is an additional activity under Fulfillment Requirements, which provides a means for consolidating and synthetizing the impact, cost, and benefits, associated with a policy that effects an enterprise, a public or private entity. The difference is that a public policy BCA considers the impacts on all element of society while a BCA for a private firm generally limit the scope to factors that directly affect enterprise costs and benefits. Because the decision to implement RTP is strategic in nature, a BCA is warranted. Because it involves RTP subscribers and all other utility customers, and though the price impacts that effect regional markets and those that supply power to them, some societal impacts may warrant inclusion. EPRI developed a BCA framework for evaluating smart grid investments and provide a framework and template for identifying which cost and benefits to include in the RTP BCA, and how portray to inform the policy decision: should RTP be added to the service portfolio. [20]

EPRI has also investigated how a service portfolio can be optimized, which goes beyond a BCA by directly characterizing risks and incorporated risk preferences into portfolio addition decisions. [21] With further development utility ratemaking will progress from cost-based accounting decisions to consideration of how to optimize the service portfolio to maximize the use of societal and private resources.

[10] Comprehensive Impact Assessment

Design screening used available data that summarizes the experience of others with RTP, which might include that of a utility considering a redesign or extension of its RTP service. Screening alternatives may be sufficient to identify a single design for more in-depth analyses or propose several designs to evaluate because the screening distinguishers were insufficient to select on or rule out RTP launching an RTP service altogether. A full impact analysis extends the scope and scale of the impact analyses to provide more detailed estimate for load, financial and market impacts This requires developing behavioral analysis platforms that involve more extensive characterization of what factors (and their relative importance) influence subscription (participation), how subscriber respond to RTP prices and other influences that affect electricity demand. Original field research maybe required to construct these models.

An additional consideration is how wholesale electricity markets are affected, which in turn influences the topology of RTP prices. An equivalent analysis is appropriate when RTP prices are generated from utility dispatch operations or set using a state-variable schedule; how subscribers respond to posted prices affects how these pricing mechanisms evolve over time.

[20] The basic of BCA as applied to utility decisions, which can be adapted to service portfolio changes, are laid out in: *The Integrated Grid: A Benefit/Cost Framework*. EPRI 3002004878.

[21] *Specifications for and Design of an Electric Service Plan Portfolio Management System*. EPRI 3002001266

Finally, fulfilment costs are incurred to launch and support an RTP service. They must be identified and quantified as originating and ongoing costs which will vary in nature and level depending on the design chosen.

The estimated costs and benefits measure what to expect from implementing an RTP service, summarized as net benefits over the study period.

[11] Implement: Pilot or Full-Scale

The comprehensive impact assessment informs whether to implement the RTP as a full-scale rate offering or a pilot. A pilot can help establish a platform to learn about customer uptake for various design options and resultant bill and load impacts. As one of the considerations, the BCA can help stakeholders understand the cost that would be incurred to implement a specific RTP design, the benefits that are expected to accrue for that program, and the fulfillment requirements, all portrayed over an extended time period (for example 5 years). It also indicates constraints that effect the timing for implementation, and an overall assessment of the certainty associated with this characterization. In particular, it identifies elements whose outcome are uncertain and the consequences for the net benefits estimate.

[12] Shortcomings: Redesign

If the proposed and full configured and evaluated design is deemed not sufficient for testing or full adoption, stakeholders should determine if shortcomings are resolvable. Risks may be not resolvable though a pilot and may require additional analyses, including customer acceptance and response, supply impacts, fulfillment requirements. It may require re-piloting or it may mean RTP does not provide sufficient benefit to warrant the articulated risks, and consideration is shelved. As a result, the portfolio stands as is unless in the process of considering RTP shortcomings in existing dynamic service are revealed that warrant attention. The process described herein can be used to consider ways to improve their contribution to strategic goals.

[13] Develop Plan

A directive to move forward requires additional planning to accomplish. An experiment or pilot must be designed to address specific hypotheses about outcomes (acceptance, response, and persistence, market price impacts, etc.). A full-scale implementation may require a staged implementation that sets priorities for what customers to offer service to and how to prepare the fulfillment requirements, which may involve substantial development of analytical and software tools and technologies to support RTP-interval measurement, pricing, and accounting, and acquiring and installing enabling technologies at subscriber’s premises. The schedule created for the impact analysis must identify and arrange all of the technology, systems, process, and staff requirements sequentially to define the workflow over time. Refinement of resource requirements is also necessary and regulatory filings must be identified and undertaken.

A
UTILITY INTERVIEW GUIDE

Section Summary

What follows is the interview guide used to structure the telephone interviews with utility rates professionals, the results of which are summarized in Section 4. Rather than serving as strict interview script, this document provided parameters to guide the discussions to ensure coverage of fundamental points while allowing flexible narrative pathways as the conversations unfolded.

Introduction

Hello and thank you again for agreeing to participate in EPRI's Real Time Pricing research. As a token of our appreciation for your time, you'll receive a complimentary summary of study findings, available in the first quarter of 2021.

Today's discussion is anticipated to take approximately 45 minutes to one hour. We understand your time is valuable and will respect it. If there are any questions, you're unable to answer today and would like to get back to us later with more information, we'd be happy to schedule a follow-up conversation with you or another member of your staff or collect additional information via email.

<u>Privacy</u>

Your responses and comments today will not be attributed to you by name in our report; rather, information gathered in these utility interviews will be used in aggregate to inform our findings and only publicly available tariff filings and other public information will be attributed to your utility, if appropriate. Just a reminder: I'll be taking notes and recording our conversation for reference and accuracy, but the recording will not be distributed externally.

Do I have your permission to record this call? [yes/no - if yes, start recording; if no, discuss options, reschedule, or terminate.]

RTP Tariff History

(1) What was the initial motivation for the tariff?
   a. Compliance with regulatory order and reasoning for regulatory order (please describe requirements or name order for further review)
   b. Preparation for, or response to, retail competition
   c. Response to customer interest
   d. Replace conventional interruptible rates
   e. Other:

(2) What was the <u>primary</u> program goal?
   a. To encourage peak demand reductions
   b. To encourage load growth
   c. Other load management objectives

d. To retain existing and/or attract new customers
e. Whatever results from efficient pricing
f. To measure customers' price elasticity
g. To gain experience with market-based pricing
h. To recover revenue requirements more equitably
i. To reduce costs for utility, customer, system
j. Other:

(3) Is the program still active? Available to new subscribers? If so...

(4) What is your company's current attitude and level of enthusiasm for the program? Any plans to modify the program?

(5) When is the program set to expire? Will it be renewed?

(6) If the program has closed, when? Briefly describe the primary reason(s) why.
a. Tariff term expired
b. No subscribers or too few to warrant continuation
c. Replaced with another dynamic pricing service. What was it (tariff name and type, like CPP/PRT/TOU)?
d. Other

Marketing Strategy

(7) Is this a default pricing program for some customers, e.g., mandatory or opt-out? Or is this a choice in a portfolio of pricing plans, i.e., opt-in?

(8) Has the tariff been or was it pro-actively marketed (for example, by identifying likely participants and arranging meetings)?

(9) To which customer classes was the program marketed? What criteria are used to identify prospective participants? Are solar customers able to participate in the RTP program? Do you think RTP will be attractive for customers with solar + storage, or storage only? How theoretical is this idea?

(10) How were customers informed of the tariff offering (check all that apply)?
a. Email marketing
b. Brochures/bill inserts
c. website content
d. Workshops
e. Customer Meetings organized by account representatives
f. Meetings sponsored by Public Service Commission or other entity
g. Other? Please specify.

Participation

(11) How many customers are currently enrolled? And how do you define customers? (e.g. one meter = one customer? other?)

a. If the program is closed, how many customers were enrolled when it closed?
b. What was the highest level of subscription in any year – and for the year it ended?
c. And what is (or was) the program's total summer peak demand (MW) at the apex of the program, i.e. at the time of highest subscription? What percentage of total load did that represent?
d. If the program is closed, what was the total peak demand (MW) at closure?
e. What types of customers are enrolled? Any concentration by industry, size, etc.?

(12) Approximately how many customers are/were eligible for the tariff within your service territory (based on minimum size restrictions, etc.)? What is their combined summer peak demand?

(13) If eligible customers are able to take service from a competitive service provider, what portion chose to do so?

(14) Do any of the competitive service providers have an RTP rate?

(15) What is the utility's summer peak demand?

(16) Over the past several years of the program, how would you characterize the level of program subscription?
a. Enrollment has been increasing (absolute or percentage terms)
    i. Number of new enrollments?
b. Enrollment has been about the same with few new subscriptions or retirements
    i. Why have customers dropped out?

(17) What customer feedback have you received or gathered about the pricing program, e.g., anecdotal, survey or other? Was it generally positive, negative, or mixed? Please summarize the customer questions, concerns and/or feedback you've received about starting on and participating in the program.

Performance

(18) Are any published materials or regulatory proceedings available that report how RTP prices altered subscribers' electricity usage?

(19) What percent of enrolled customers appear to alter their usage based on posted RTP prices? How have marginal prices varied over the past several years (e.g., maximum price, frequency of price spikes, etc.)? Do you have a report or dataset with posted RTP prices for some or all of the years that services have been offered? If so, can you provide it?

(20) Is there some threshold marginal price above which customers that actively participate in the tariff begin to alter their electricity usage?

(21) What is the maximum load reduction due to high prices that the program has induced? At what posted RTP price did this occur?

(22) What level of load reduction would likely occur at prices of [insert range of prices appropriate for the interviewee's utility based on prevailing rates in the state or region, e.g.]?
   a. 10 ¢
   b. 20 ¢
   c. 50 ¢

(23) Are customers provided with access (e.g. via the internet) to their hourly electricity consumption? If so, when to they have access or receive notification?
   a. Real-time or near-real-time
   b. Day-after
   c. End of month

(24) What are typical bill impacts on the program?

(25) Have customers been provided with technical assistance to help identify strategies for responding to prices?

(26) How do customers take in the pricing signals? Do they have energy management systems that have been programmed to respond hourly? Is this generally a manual process (view the day ahead prices online and manually adjust operations the next day)?

(27) If only large customers are enrolled, what is the likelihood that this program would be extended to smaller customers and/or residential customers?

(28) Is price response from customers on the tariff incorporated into:
   a. Daily system scheduling/dispatch?
   b. The creation of RTP prices?
   c. Long-term planning (e.g., IRP), or other resource decisions?

(29) How were/are daily prices transmitted to subscribers; what alternative mechanisms were/are available? How was/is receipt of prices confirmed?

(30) Were/are daily prices made publicly available? If so, when were/are they posted?
   a. At a later time or not at all?
   b. RTP prices are not made publicly available

Implementation Experience/Lessons Learned

(31) Overall, what was the utility's experience in implementing this program? What went well? What were some areas for improvement?

(32) What changes were required to usage metering equipment, procedures, and practices?

(33) What changes were required to billing procedures and practices?

(34) What changes were required to financial, accounting procedures and practices?

(35) What were the main lessons learned from this program implementation?

Conclusion

(36) Is there anything else you'd like to add that we haven't already discussed?

This concludes today's interview. As we discussed at the beginning, if there is any additional information, you'd like some time to gather and share with us, please let me know. We can set another time to talk or we can exchange information by email, if that's easier for you.

Thank you very much for your time and insights today.

Goodbye.

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