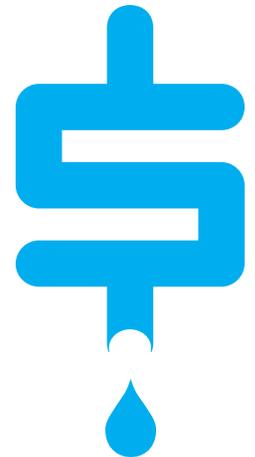


MEASURING & MITIGATING WATER REVENUE VARIABILITY

Understanding How Pricing Can Advance Conservation Without Undermining Utilities' Revenue Goals



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Executive Summary

As water utilities across North America undertake capital campaigns to finance the replacement and expansion of their systems, the need for confident revenue projections grows. Yet many water utilities are subject to factors that can affect revenue variability, including volatile weather patterns and a growing imperative to conserve scarce water resources. As a result, it is more important than ever to anticipate how changing water use patterns and rates drive revenue risk.

Despite being essential service providers, water utilities experience unavoidable variability in their revenue stream. This revenue variability is driven by many factors: changing population, varying customer demands, unpredictable weather patterns, and even rate structures. While it is unrealistic to expect utilities to eradicate revenue variability, utilities can understand its root causes and incorporate it into their overall resource and finance planning.

Utilities that are able to predict revenue fluctuations are in a better position to prepare for change without sacrificing important policy goals, such as the promotion of water conservation. Predicting the ways that pricing structures might affect customer water usage, and how that in turn may affect revenue, requires that utilities model prospective rate structures using their own customer data. By doing so, utilities can find the right balance of fixed and variable charges that will create predictable revenue streams while using pricing as a tool to drive water conservation. There is no universal pricing structure that will work for every utility. But there are pricing tools that should be considered by water utilities to advance the dual imperatives of providing revenue stability and deploying conservation as a strategy for long-term cost of service management and resource protection.

This report examines real financial and water use data from three North American water utilities to demonstrate how rate structures can mitigate or intensify revenue variability. It also introduces alternative financial and pricing strategies that can assist water utilities in stabilizing revenue without compromising the commitment to water conservation.

Findings at a Glance

Revenue Variability is an Inherent Component of Operating a Utility

- It is impossible to forecast exact revenues for a given year, but understanding factors that drive revenue variability allows a utility to project revenue risk exposure and prepare accordingly.
- Utilities have multiple strategies for “living” with revenue variability and with proper planning can still maintain a proactive rather than “reactive” response to variability that does not require sacrificing policy goals such as water conservation.

Revenue Variability Differs Significantly Across Utilities

- Pricing alone is not a complete predictor of revenue variability.
- Weather variability amplifies the inherent rate-induced revenue risk.
- Under aggressive conservation initiatives, pricing interacts with customer characteristics in influential ways. Based on its initial water use profile, a utility’s customer base has more or less potential to conserve. These differences can amplify revenue variability more than others.
- Because each utility faces a unique operating environment, utilities should individually model the potential effects of rate structures using their own customer and weather data. There are a number of free tools for undertaking this modeling exercise, including the Water Utility Revenue Risk Assessment Tool developed by the Environmental Finance Center at the University of North Carolina, Chapel Hill.^A

Utilities Can Influence Their Revenue Variability Through Rate Structures

- Pricing structures can mitigate the revenue impact of aggressive conservation initiatives.
- It is possible to construct a pricing strategy that incorporates financial incentives for water efficiency while at the same time providing revenue stability by assessing higher fixed base charges against a customer’s water use.
- Higher base charges reduce revenue risk (but may reduce the conservation signal).
- High base charges alone do not shield all utilities from revenue variability.
- Relying more heavily on variable rates as a conservation strategy can lead to significant revenue risk.
- Temporary pricing adjustments—such as drought surcharges—can provide an immediate relief to rapid demand curtailment.

There are Also Important Non-Price Strategies that Can Mitigate Revenue Risk

- Maintaining reserves has become one of the most common revenue volatility management strategies, but our analysis shows that specific reserve needs vary across utility environments and should be customized to meet local conditions.
- Maintaining reserves, combined with financial planning periods that are longer than a year, allow utilities to set rates that take into consideration unavoidable annual demand swings.
- Weather derivatives can provide external revenue hedging options as a strategy to deal with revenue variability and could shield water utilities from having to build considerable weather reserve funds.

DEFINITION

Revenue Variability

Based on pricing and local conditions, a utility’s total annual revenues from customer sales will fall within a specific range in a given year. The extent of the range between the minimum and maximum potential revenues for a utility is defined in this paper as the utility’s “revenue variability.” Revenue variability is unique for each utility. Revenues that have high variability are more sensitive to customer demands and are at a greater risk of revenue drops when customers reduce their water use.

A Available for download on the Water Research Foundation’s website at <http://www.waterrf.org/resources/pages/PublicWebTools-detail.aspx?ItemID=25>.



Introduction

Water utilities have an inherent, unavoidable variability in their revenue stream. Changing populations, varying customer demands, unpredictable weather patterns, and rate structures all contribute to revenue variability.^{1,2} In any given year, a utility's revenues from customer charges may be lower than originally projected because of a combination of these factors. Utilities unprepared for revenue variability and the risk of revenue losses may find themselves cash-strapped and unable to meet necessary infrastructure maintenance, construction, and other needs.³ Utilities that are better able to predict and prepare for revenue fluctuations are in a better position to address it without sacrificing important policy goals, including the promotion of water conservation.^{4,5}

In order to illustrate revenue variability and highlight the role of pricing and other factors, three real North American utilities with different pricing structures, demand patterns, and climates are analyzed using a recently developed "Water Utility Revenue Risk Assessment Tool".^B The results of the analysis are used to highlight variations in revenue variability.

This paper also outlines several emerging pricing structures and strategies that can help mitigate revenue variability without sacrificing all conservation pricing signals.

The goal of this paper is not to suggest that utilities can avoid revenue variability altogether, but to encourage utilities to understand it and plan for it by incorporating it into their overall resource and finance planning. Understanding revenue variability is particularly important for utilities in the process of modifying their rates significantly, embarking on a major conservation program, or in an area with increasing weather variability.

^B Developed by the Environmental Finance Center at the University of North Carolina, Chapel Hill, and available for download on the Water Research Foundation's website at <http://www.waterrf.org/resources/pages/PublicWebTools-detail.aspx?ItemID=25>.



Conditions & Characteristics of Three Utilities

Utility revenues from residential^C water sales are driven by an array of local factors specific to individual utilities. Understanding revenue variability and crafting a strategy to address it requires a detailed understanding of localized conditions, primarily the rate structure and pricing, customer demand profile, and local weather patterns.

The Water Utility Revenue Risk Assessment Tool is designed to use historic utility information to display potential residential revenue scenarios under various demand and specific changes, within the context of local conditions. The three utilities selected for analyses have different customer characteristics, weather conditions, and rate structures (see **Table 1**), leading to the expectation of different revenue risk profiles. Although anonymized, this analysis uses real financial and use data from the three utilities.

Understanding revenue variability and crafting a strategy to address it requires a detailed understanding of localized conditions.

Table 1: Characteristics of the Three Utilities					
Utility	Number of Residential Accounts ^D	2000-2012 Weather: Annual Precipitation & Annual Mean Temperature	Notes on Residential Rate Structure	Mean Residential Water Use in 2013 (Gallons/Month)	Percent of Bills Classified as Residential in 2013 with >25,000 Gallons/Month
Southeastern Coastal	62,000	63 - 66 °F 33 - 69 inches (avg. 64% Apr-Sep)	High base charge & uniform rates	4,300	0.4%
Mountain Resort	2,360	40 - 44 °F 19 - 28 inches (avg. 47% Apr-Sep)	Highest base charge & low increasing block rates	14,500	13.7%
Urban	227,000	33 - 41 °F 10 - 20 inches (avg. 75% Apr-Sep)	Low base charge & high increasing block rates	4,700	0.2%

C The term “residential” is used throughout the paper to refer to single family residential account data. The term account and customer are used interchangeably. The authors relied on single family residential billing data provided by two of the participating utilities for this analysis, and general residential billing data provided by the southeastern coastal utility.

D The authors used billing data provided by the utilities coded as “residential” or “single-family residential.” Utility categorization of customers was not quality-proofed; it is therefore possible that a small number of non-residential customers with high water use are included in the analysis.



Southeastern Coastal

The southeastern United States coastal utility serves approximately 62,000 residential accounts and more than 5,800 commercial properties. The utility has a mix of suburban and urban customer base. Summer tourists drive increased summer water demand, which is offset somewhat with a sizeable influx of university students during the academic year. There is also a large population of year-round residents.



Mountain Resort

The mountain resort utility, located in the western United States, serves approximately 6,500 customer accounts including 2,360 single-family residential customers, making it the smallest of the three utilities. Many of the customers of this utility only reside in the service area for a few months of the year, resulting in a substantially large number of zero volume bills. Unlike in the other two utilities, there is a large percentage of residential customers who use very large volumes of water (well over 100,000 gallons per month), skewing the utility-wide average residential water use to over 14,000 gallons per month, despite the large number of zero volume bills. By comparison, average residential water use was 4,300 gallons per month in the southeastern coastal utility and 4,700 gallons per month in the urban utility.



Urban

The urban utility, located in western Canada, serves approximately 227,000 residential customer accounts, considerably more than the other two utilities. This urban population has the highest population density and is the least transient of the three utilities. The permanent population in the utility's region has grown dramatically over the past several years.

Pricing & Rate Structure Considerations

Rates and rate structures clearly play a major role in determining a utility's revenue generation and variability. Given that utilities across the continent employ a huge variety of rate structures, it is essential to consider pricing when modeling revenue variability.

Water utility rate structures typically consist of two components: a base (fixed) charge and a volumetric (variable) charge. Base charges provide some revenue stability for the water utility because they do not change with customers' water use. Fixed charges are most typically based on the size of the service line, the customer type, or, in a few rare cases, characteristics of the individual customer (such as number of bathrooms or area of irrigated land). The larger the base charge, the more revenue stability for the utility since a greater proportion of its revenue does not fluctuate with customer demands. However, large base charges reduce the price incentives for water use conservation and efficiency.

Volumetric charges are based on the amount of water a customer uses. While volumetric rates incentivize customer water use conservation and efficiency, they have the unintended consequence of conveying to customers that a utility's cost of providing water is highly dependent on volume consumed. For most utilities, this is not the case, particularly in the short- and medium-term. Consequently, while volumetric charges give customers the price incentive to reduce water consumption, they may also influence customer consumption patterns so much that revenues fall below cost of operating the utility.

Typically the majority of a water utility’s revenue is generated through the volumetric charges. However, analysis has shown that the percentage of utilities’ revenue generated from base charges varies considerably among utilities.⁶ Volumetric rates can be structured in many different ways.⁷ Each volumetric rate structure design has its own implications on the utility’s revenue variability. How different rate structures affect revenue variability is analyzed later in this paper.

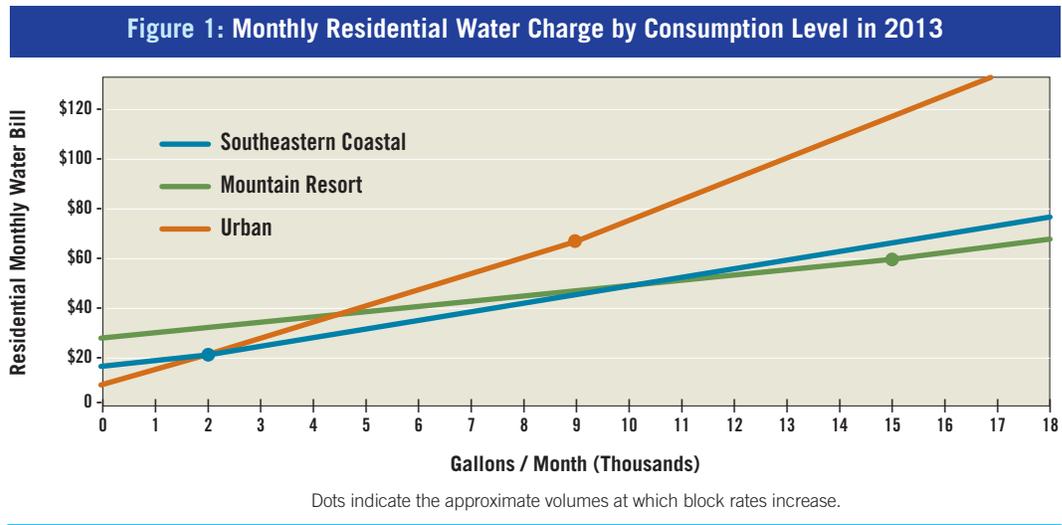
Utilities set rates that are projected to generate sufficient revenue to meet all of their operational and capital costs. The pricing structures used by the three utilities analyzed for this report are significantly different and described in more detail in the Appendix. The base charge amount, volumetric rates, and block sizes (if applicable) combine to produce unique rate structures and conservation pricing signals. The urban utility provided the highest conservation pricing signals to its residential customers in 2013, while the mountain resort provided the lowest, as shown in **Table 2**.

Table 2: Conservation Price Signals of the Three Utilities’ Residential Water Rates in 2013

Utility	Monthly Water Bill for 10,000 Gallons/Month	Increase in Monthly Water Bill from 5,000 - 10,000 Gallons/Month	Marginal Price for the Next 1,000 Gallons Above 10,000 Gallons/Month	Marginal Price as Percentage of Monthly Water Bill at 10,000 Gallons/Month
Southeastern Coastal	** \$47.11	** 57%	** \$3.42	** 7.3%
Mountain Resort	** \$47.15	* 30%	* \$2.20	* 4.7%
Urban	*** \$72.19	*** 91%	*** \$8.34	*** 11.6%

Key: *** Relatively high conservation pricing signal among the three utilities
 ** Relatively moderate conservation pricing signal
 * Relatively low conservation pricing signal among the three utilities

Figure 1 presents the difference in price signals for the three utilities by plotting the monthly residential water charges for various levels of consumption in 2013.^E



^E The monthly water bills for the mountain resort utility represent a weighted average charge across all residential customers based on actual billing records. The mountain resort utility’s rate structure is customized for each customer and is described in the Appendix. Furthermore, the rates and charges set by the Canadian urban utility have been converted to US dollars in this report.

Weather-Induced Usage Variation

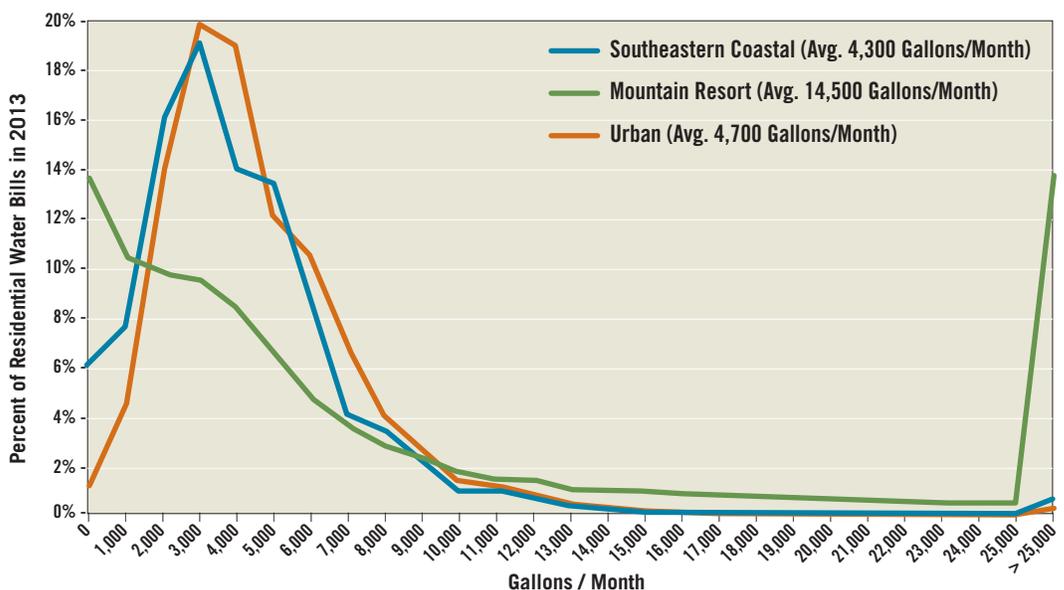
Weather conditions, particularly temperature and rainfall, can greatly affect a residential customer's water use.^{8,9} As temperatures rise, customers tend to use more water, and as precipitation increases, particularly in the summertime, customers tend to use less. Additional weather factors can also play a role in affecting customer demands, such as the number of consecutive days without rainfall or exceptionally high temperatures. Customers may respond to these weather changes on their own or may be forced to respond counterintuitively because of policies implemented by their utility. For example, during a drought period, some customers may tend to use more water because of the higher temperatures and lower precipitation, but the utility may implement a policy restricting outdoor water uses to force customers to decrease their use. Generally, utilities project revenues assuming water use under normal weather conditions.

As shown in **Table 1**, the southeastern coastal utility experiences the highest annual average temperatures and total precipitation levels of the three utilities. Its region experiences a humid subtropical climate, where the winters are mild and the summers are hot and humid. At the mountain resort, winters are cold with regular and significant snowfall (typically 26 inches/month) starting in November, while the summers are warm and dry. The high elevation causes the community to experience low humidity year round. Meanwhile, the urban utility in Canada is in the coldest and driest area of the three utilities. Winters are cold and dry, and 75% of the annual precipitation occurs in the late spring and summer months.

Customer Base Characteristics & Demand Profiles

Residential end uses affect total volume demanded, which affect utility revenue variability. Some utilities have more customers who average low volumes of water use year-round, with no outdoor irrigation or discretionary use. In these utilities, the vast majority of residential water bills will be for small, steady volumes. In other areas, some utility customers have more seasonal demands for water, increasing the spread of residential bills to include higher volumes. In some other utilities,

Figure 2: Distributions of Residential Water Bills by Volume in 2013



Average volume of all residential water bills >25,00 gallons/month was 38,700 gallons/month at the southeastern coastal utility, 73,100 gallons/month at the mountain resort, and 37,100 gallons/month at the urban utility.

the customer base itself might be seasonal, producing a high number of zero (or near-zero) use bills and an equal number of high volume bills. The mountain resort utility is one example of such a utility. **Figure 2** displays the distribution of residential water bills by volumes in 2013. The differences across the three utilities demonstrate the variation in customer demand profiles.

Existing demand distribution combined with water efficiency technology uptake, weather, pricing, and conservation policy initiatives drive a utility's revenue variability. In theory, higher-volume-water users are subject to higher use fluctuations than lower volume users, simply because they have more discretionary water use and more behavioral opportunities to reduce their consumption. For example, higher volume users may significantly reduce water use by changing out their landscaping. On the other hand, some customers may have difficulty changing their lifestyle to reduce consumption, particularly customers who are already low water users. A customer's change in water use also varies across income groups. For example, a lower income customer may reduce consumption more significantly than a higher income customer in reaction to a rate increase. Conversely, a higher income customer may be able to invest in high efficiency technology.



Assessing the Residential Sales Revenue Variability of Three Utilities

The tool uses simplifying assumptions, as well as detailed models built from hundreds of thousands of real customer water records, to predict changes in customer demand patterns.

The Water Utility Revenue Risk Assessment Tool was developed by the Environmental Finance Center at the University of North Carolina, Chapel Hill (EFC) for the Water Research Foundation (WRF). The tool is designed to allow utilities to carry out a basic self-assessment of how much of their residential water sales revenue is at risk should customers change their demand patterns. The tool takes into account price elasticity effects when rates are changed, normal year-to-year fluctuations in weather (temperature and precipitation only), and sudden and significant one-time water use reductions. The tool uses simplifying assumptions, as well as detailed models built from hundreds of thousands of real customer water records, to predict changes in customer demand patterns. Many utilities have developed their own analysis tools customized to their circumstances, but for those that have not, this model provides a starting point. The Alliance for Water Efficiency is working on a similar tool that will be released later in 2014 and can be used to model non-residential and residential revenues.^F

The EFC and WRF revenue risk tool is intentionally designed to be simple so that utilities themselves could use the tool to model their residential revenue variability with minimal data input. For this paper, one utility used the tool themselves and provided a copy of their results. The other two utilities provided the data required, and the Environmental Finance Center completed the modeling portion using version 1.1 of the tool.

The model was used to assess the revenue variability of the actual pricing structures used by the three utilities in 2013 and to test changes in the revenue variability under different (yet revenue neutral) pricing structures. Revenue-neutral pricing generated total expected revenues under a new rate structures identical to those collected under the actual 2013 rate structure, after accounting for price elasticity effects.

^F The Alliance for Water Efficiency Sales Forecasting and Rate Model will model the revenue and water use effects of rate structures under various scenarios. Accessed through: <http://www.allianceforwaterefficiency.org/>

Case Study Findings & Analysis

Based on the pricing models and actual residential customer billing records of the three utilities in 2013, the total residential water revenue estimates were calculated to be approximately:

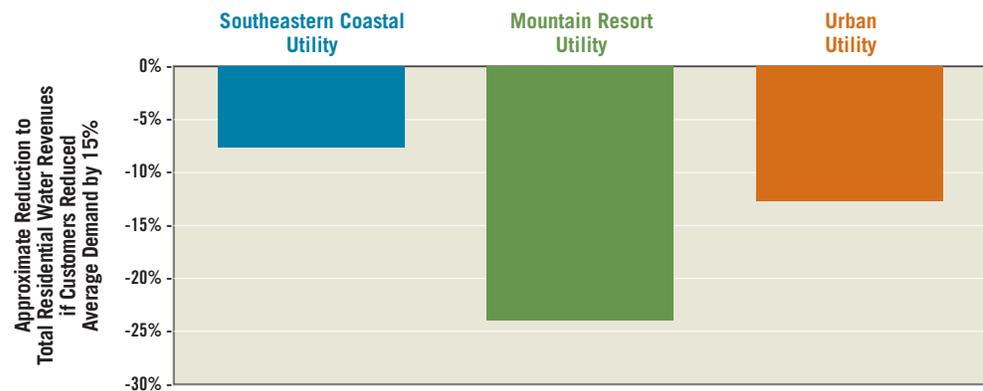
- ◆ \$19,787,000 for the southeastern coastal utility
- ◆ \$1,777,000 for the mountain resort
- ◆ \$98,964,000 for the urban utility

These estimates were considered the point of reference for analysis to analyze the compositions of revenues from fixed and variable charges, fluctuations of total revenues due to changing customer demands and pricing, and differences in pricing structures. The relationship between residential customer demands and weather factors were uniquely determined for each utility within the model using historic local weather and residential demand data. Key findings from this analysis are summarized below.

Revenue Variability Differs Significantly Across Utilities

Based on current pricing, demand profiles, and weather patterns, the three utilities are exposed to varying degrees of revenue variability. **Figure 3** displays the potential deficit in total residential revenues from 2013 levels if local conditions, such as a drought, caused a sudden and significant water conservation effort and a 15% reduction in average residential water use. The tool takes into account that during a period of intense water conservation, high use customers reduce their demands more significantly than low use customers, typically more than the net reduction in average water use.

Figure 3: Revenue Variability Due to One-Time Significant Declines in Residential Demands



The model estimates that the mountain resort would have lost 24.0% (\$426,000) of its total residential water revenues, compared to 7.6% (\$1,513,000) and 12.7% (\$12,522,000) lost by the southeastern coastal and urban utilities, respectively. The mountain resort utility experienced the greatest revenue losses when there was a significant decline in average water use due in large part to the large proportion of residential customers with very high-water use demands, that will likely decrease much more significantly than the rest of the service population.

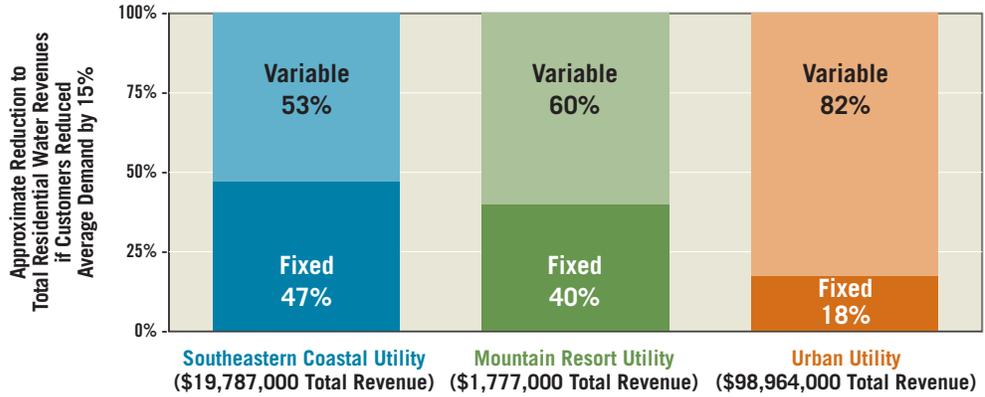
Because revenue variability can vary widely from utility to utility, there is no single “rule of thumb” that a utility can use in its planning purposes. Just as important, this result also means that utilities should not rely on other utilities’ assessment of revenue variability to inform their own plans. Each utility should conduct its own self-assessment to determine its unique revenue variability based on its pricing, customer demand profile, local weather patterns, and conditions. The Water Utility Revenue Risk Assessment Tool can help utilities with this task by modeling the risk of revenue losses for one year under different scenarios. Utilities can take this analysis further and consider longer-term trends that may affect demand and revenues. For example, climate change models may predict that a utility’s service area will experience higher levels of rainfall, which will further curtail residential water use.

Higher Base Charges Reduce Revenue Risk

The base charge plays a vital role in influencing a utility’s revenue variability and is one of the most important factors that the utility can directly control and adjust to affect its revenue variability. Overall, the southeastern coastal utility has the lowest revenue variability. A major contributor to this stability is the high percentage of total revenue generated from base charges (47%), as shown in Figure 4.

Because revenue variability can vary widely from utility to utility, there is no single “rule of thumb” that a utility can use in its planning purposes.... utilities should not rely on other utilities’ assessment of revenue variability to inform their own plans.

Figure 4: Proportions of Fixed and Variable Revenues across the Three Utilities in 2013



Fixed revenues are revenues from base charges. Variable revenues are revenues from volumetric rates.

On the other hand, both the urban utility has a much lower percentage of fixed revenue (18%), thus increasing its exposure to revenue variability. The southeastern coastal utility’s revenues are the most resilient against significant declines in customer demands, as shown in **Figure 3**.

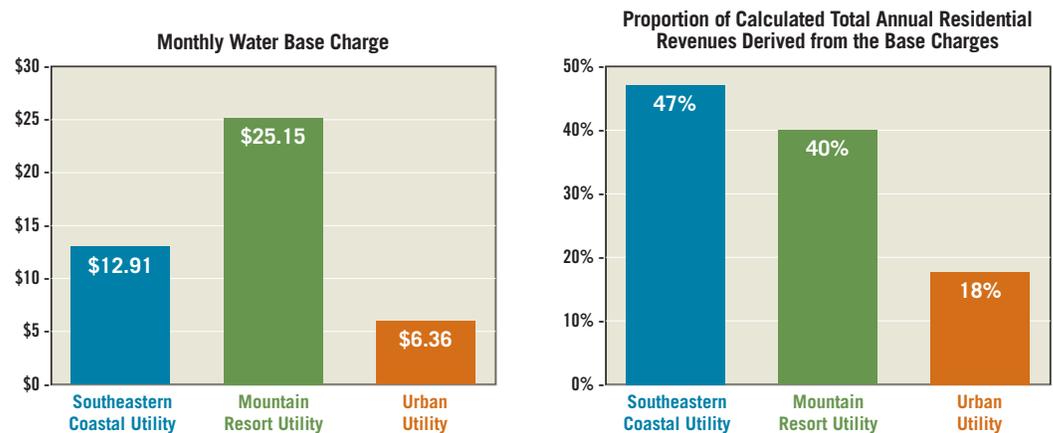
Utilities can lower their revenue variability by raising their base charges, however the methods used to determine base charges by most utilities do not incorporate financial incentives for efficiency. If conservation is a core utility objective, a utility wishing to increase base charges may want to consider changing the way base charges are calculated as described in the next section.

High Base Charges Alone Do Not Shield All Utilities from Revenue Variability

Although higher base charges will typically translate to greater revenue stability, high base charges alone are not be enough to guarantee revenue stability.

As shown in **Figure 5**, the mountain resort utility had the highest base charge among the three utilities. It charged a weighted average \$25.15 per month in base charges to residential customers, which was nearly twice as much as what the southeastern coastal utility charged (\$12.91 per month). Yet, the proportion of revenues generated from the base charges, and thus revenue stability, was actually lower for the mountain resort utility than for its southeastern coastal counterpart (40% compared to 47%, respectively). Furthermore, the mountain resort utility's high base charge did not prevent it from having the greatest revenue variability during periods of significant customer conservation, as shown in **Figure 3**. The reason behind this peculiar result is the large number of very high volume bills at the mountain resort utility. As shown in **Figure 2**, the mountain resort has, by far, the greatest proportion of bills that were for volumes greater than 25,000 gallons per month. During periods of significant conservation, these high-use customers will more significantly lower their demand, reducing total revenues by a disproportionately high amount, despite the high base charges that are unaffected by demand reduction.

Figure 5: Monthly Water Base Charge & the Proportion of Annual Revenues Derived from Base Charges in the Three Utilities in 2013



Utilities must examine the distribution of customer water use for their individual utility and carefully consider how to design and price their entire rate structure in order to minimize revenue variability, and not focus exclusively on a high base charge.

Pricing Structures Can Mitigate the Revenue Impact of Aggressive Conservation Initiatives

As shown in **Figure 3**, the potential revenue losses resulting from aggressive conservation initiatives varies significantly among the utilities. A 15% reduction in average residential water use would have resulted in an 8% loss to total residential revenue for the southeastern coastal utility, a 13% loss for the urban utility, and a 24% loss for the mountain resort utility. The differences are caused by variations in pricing and demand distributions. The simple fact that

the southeastern coastal utility's revenues would only decrease by around 8% for a 15% reduction in average residential water use (modeled based on customer demand response to aggressive conservation initiatives) demonstrates that utilities can design rate structures that provide a moderate conservation pricing signal (see **Table 2**) and still maintain relative revenue stability. The water resource and conservation planners at the southeastern coastal utility are in a good position to pursue aggressive conservation initiatives and not cause the finance director as much worry about catastrophic revenue losses as a result.

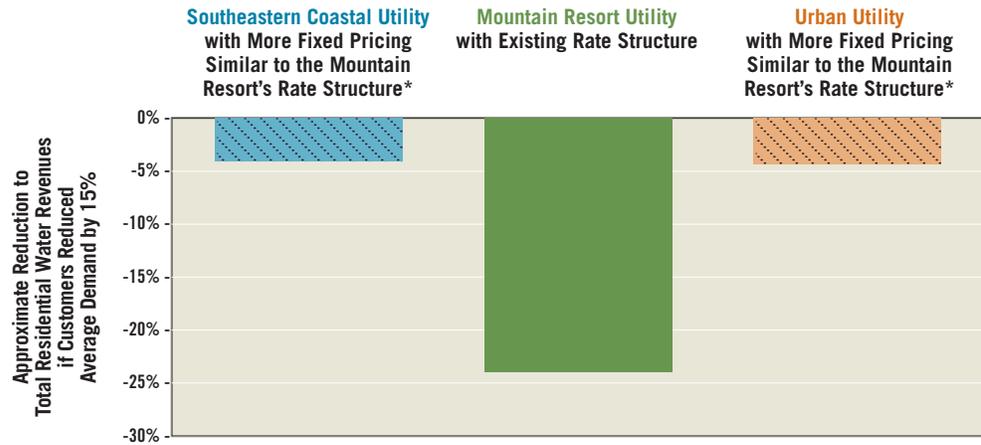
Under Aggressive Conservation Initiatives, Pricing Interacts with Customer Characteristics in Influential Ways

Because of the high base charge and low volumetric rates charged by the mountain resort utility, the fixed charge portion of a water bill at typical residential water consumption levels (under 25,000 gallons/month) are higher than at the other two utilities. Therefore, of the three rate structures, the mountain resort utility's rate structure would be expected to produce the most stable revenues under identical demand, weather, and customer characteristics conditions when compared to the other utility's rate structures.

However, as noted already, the mountain resort utility's revenues are the most variable of the three utilities when demand declines significantly highlighting how critical the utility-specific customer demand profile is in determining the revenue variability for the utility. In order to show the impact of customer base on demand, the same rate structure design was applied and modeled on each of the three utilities' customer bases. The increasing block rate structure of the mountain resort utility (the most fixed charge-reliant rate structure) was modeled for both the southeastern coastal utility and the urban utility in such a way that the balance between fixed and variable charges are identical to the mountain resort utility's rate structure. In order to maintain relativity, the rates are set to ensure that the total revenues produced for the southeastern coastal and urban utilities with the demonstrated rates are equal to those generated from their respective rate structures in 2013. In other words, the mountain resort utility's rate structure was mimicked for the other two utilities, but prices were adjusted to ensure revenue-neutrality.

The potential revenue losses that result from 15% reductions in average residential water use are shown in Figure 6. For both the southeastern coastal and urban utilities, the modeled rate structure produces highly stable revenues, potentially losing only 4.5% of residential water revenues for a 15% conservation effort. The potential revenue losses are similar in the two utilities because their customer demand patterns are similar (see **Figure 2**). By contrast, the mountain resort utility could stand to lose 24% of revenues for a 15% conservation effort, a direct result of the high proportion of high-water-using customers. This highlights how pricing and customer characteristics interact in influential ways to affect revenue variability.

Figure 6: Revenue Variability Due to One-Time Significant Declines in Residential Demands in the Three Utilities under the Same Rate Structure Design

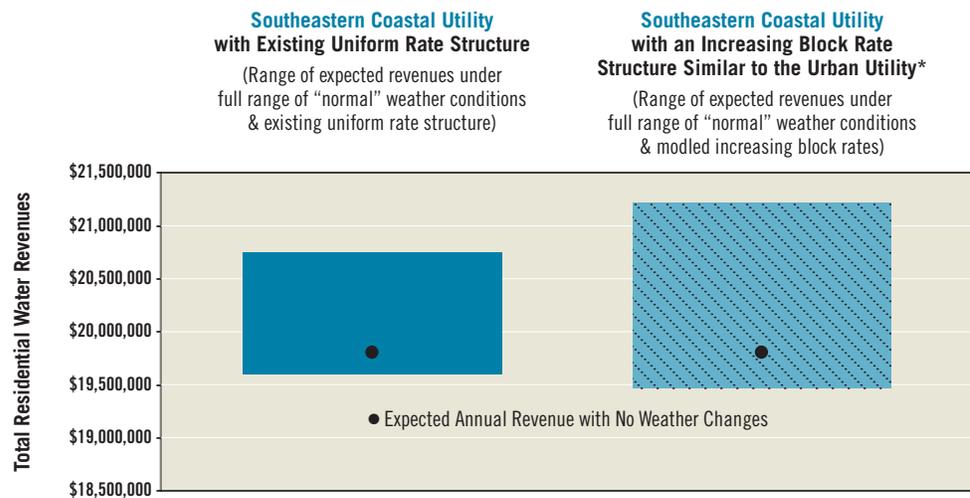


* Modeled to mimic the balance of fixed and variable rates used by the mountain resort utility (produces relatively stable revenues in normal weather conditions), but priced to be revenue-neutral, generating the same total revenues from the southeastern coastal and urban's customers as the existing rate structure, after accounting for price elasticity effects.

Weather Amplifies Inherent Rate-Induced Risk

Utilities in locations that have highly variable weather patterns and demand fluctuations have more financial incentive to consider revenue variability under different rate structure designs. For example, if the southeastern coastal utility had used an increasing block rate structure with a low base charge and high volumetric rates (similar to the urban utility's rate structure), their revenue variability would have been further exacerbated by their "normal" weather fluctuations than under their high base charge and moderate uniform rate structure, as shown in **Figure 7**.^G Although this

Figure 7: Range of Residential Water Revenues in the Southeastern Coastal Utility under Normal Weather Conditions with the Existing Uniform Rate Structure and a Highly-Volatile Increasing Block Rate Structure



* Modeled to mimic the increasing block rates and the balance of fixed and variable rates used by the urban utility, but priced to be revenue-neutral, generating the same total revenues from the southeastern coastal utility's customers as the existing uniform rate structure under actual weather patterns of 2013, after accounting for price elasticity effects.

G Normal ranges are defined as the range of temperatures and precipitations that occurred between 2000 and 2012.

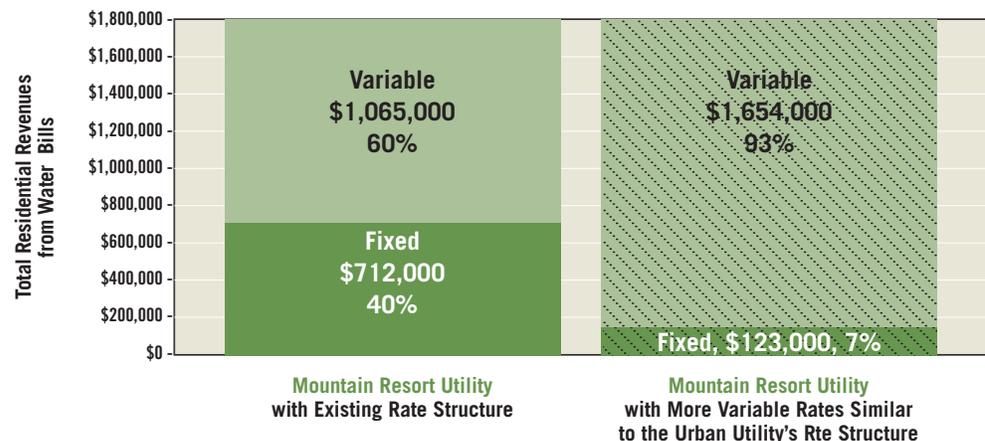
is a simplification and does not take into consideration greater climate change-induced weather variability, it shows that local weather amplifies inherent rate-induced risk. Utilities, obviously, do not have control over weather, but they do have a choice of what rate structure design to use.

Pricing Alone is Not a Predictor of Revenue Variability Risk

The results above show that it would be a mistake for a utility to assume that by copying another utility's rate model, they would be able to replicate the other utility's revenue profile. This finding is not just applicable to rate structures, but also rate levels. For example, although the mountain resort utility has much lower volumetric rates, both the mountain resort and urban utilities use increasing block rate structures. Under the existing rate structures, the mountain resort utility generates 40% of its residential revenues from base charges, compared to the 18% that the urban utility generates. If the mountain resort altered its rate levels by lowering its base charge and increasing its volumetric rates, to mimic the balance of fixed and variable charges that the urban utility employs in its rate structure, the mountain resort utility would only generate approximately 7% of its residential revenues from the base charges (see **Figure 8**). This would make the mountain resort utility's revenues much more variable than the urban utility's revenues, even under the same rate structure model and levels (when adjusted for revenue-neutrality). This finding further highlights the interaction between price and customer base since the large number of zero bills for the mountain resort utility amplifies the revenue losses associated with reducing base charges for that utility. Those customers only provide revenue through their base charge.

The results in Figure 7 show that it would be a mistake for a utility to assume that by copying another utility's rate model, they would be able to replicate the other utility's revenue profile.

Figure 8: Water Residential Revenues for the Mountain Resort Utility under its Existing Increasing Block Rate Structure and a More Variable Increasing Block Rate Structure



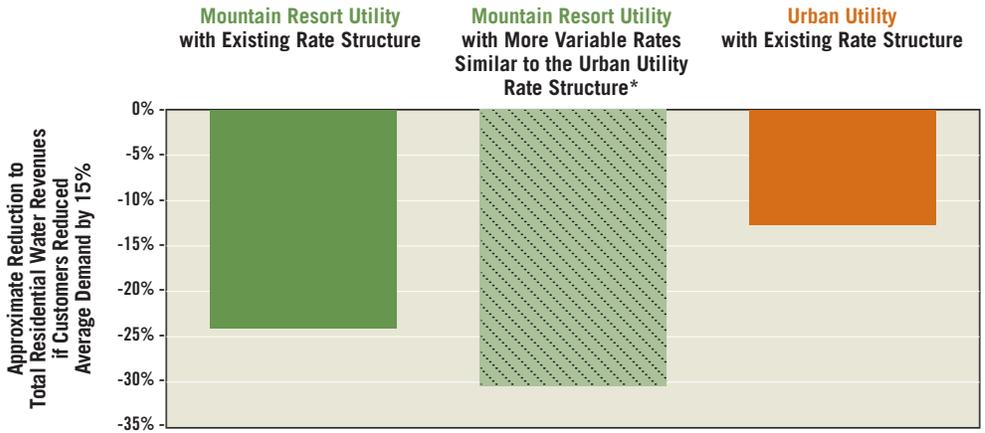
* Modeled to mimic the balance of fixed and variable rates used by the urban utility, but priced to be revenue-neutral, generating the same total revenues from the mountain resort's customers as the existing rate structure, after accounting for price elasticity effects. By comparison, the urban utility generates 18% of its revenues from its base (fixed) charges.

Relying More Heavily on Variable Rates as a Conservation Strategy Can Lead to Significant Revenue Risk

Promoting water use conservation is an important objective for many utilities attempting to control demand and water resources. Utilities often use pricing as a mechanism to promote conservation by providing customers with strong financial incentives to maintain low water use and/or avoid high water use. **Table 2** compares residential conservation price signal metrics between the three utilities. The mountain resort utility provides the lowest conservation price signals to its customers.

Utilities attempting to further incentivize water use conservation often raise volumetric rates and/or adjust the rate structure in an effort to increase the proportion of each customer’s bill influenced by consumption. Customers are further incentivized to reduce water use because it will result in greater savings for them. However, relying solely on volumetric rate increases to increase conservation efforts can also increase revenue risk exposure. If the mountain resort utility lowered its base charges and raised its increasing block rates to mimic the balance of fixed and variable charges that the urban utility (the utility with the strongest conservation price signals) uses, the residential revenues would be much more variable than those of the urban utility’s, as shown in **Figure 9**. By raising volumetric rates, the mountain resort utility would place 30% of its residential revenues at risk of loss if customers reduced average consumption by 15%, up from 24% potential losses. To raise volumetric rates in order to incentivize conservation, the mountain resort utility would be exposing a significant portion of its revenues to loss.

Figure 9: Revenue Variability Due to One-Time Significant Declines in Residential Demands in the Mountain Resort under Different Increasing Block Rate Structures



* Modeled to mimic the balance of fixed and variable rates used by the urban utility, but priced to be revenue-neutral, generating the same total revenues from the mountain resort’s customers as the existing rate structure, after accounting for price elasticity effects.



Alternative Strategies for Addressing Revenue Variability & Incentivizing Water Efficiency

Many utilities across the country cannot afford to entirely sacrifice customer conservation financial incentives in search of revenue stability. Fortunately, there are several established approaches that can protect utilities from the impacts of revenue swings even under the most aggressive pricing conservation pricing strategies.

Many utilities across the country cannot afford to entirely sacrifice customer conservation financial incentives in search of revenue stability. Fortunately, there are several established approaches that can protect utilities from the impacts of revenue swings even under the most aggressive pricing conservation pricing strategies. There are also several emerging pricing strategies that incorporate financial incentives for efficiency while at the same time providing relatively stable revenue streams. Brief descriptions of these strategies in the context of the three utilities are presented below.

Temporary Pricing Adjustments Can Provide an Immediate Relief to Rapid Demand Curtailment

Utilities across the country are considering and/or adopting temporary pricing modifications in response to water shortages, such as drought surcharges.¹⁰ These drought pricing structures typically involve a relatively sudden sharp increase in price linked to water supply conditions and/or other drought policies. The price change has the dual impact of generating supplemental revenue to replace revenue lost to mandatory sales restrictions and sending a stronger pricing signal to further curtail use. None of the three utilities analyzed have instituted these rates structures for an extended time, and they were not modeled for this study. Nonetheless, they may represent an option for utilities that are particularly susceptible to drought conditions and have existing rates with high revenue risk exposure. Of the utilities studied, the mountain resort utility would seem to benefit the most from this strategy with their exposure to revenue loss for rapid volume curtailments. Interestingly, significant extended periods of unseasonably wet weather can lead to similar revenue drops, yet we are not aware of any utilities that have indexed temporary rain surcharges to kick in after periods of excessive precipitation.

Customized Reserve Funds

Utilities can use reserves strategically to hedge against a variety of utility financial risks, including protection against revenue loss due to declines in sales (revenue stability reserves), unforeseen equipment/facility problems (operation and maintenance reserves), and political risk associated with “bumpy” annual price increases (rate stabilization/smoothing reserves).¹¹

By using a strategic reserve, a utility with high revenue variability does not have to forsake its aggressive conservation pricing strategy, but it does have to plan ahead.

As risks increase and become more complicated to model, utilities are faced with difficult decisions about how much to hold in reserves. Reserves can be effective at mitigating the impacts of temporary declines in sales. But, as this analysis shows, the level needed in reserves to address revenue risk varies considerably based on utility conditions. In other words, setting reserve targets, at least for the purpose of mitigating revenue risk, at uniform “rule of thumb” percentages may lead to over or under saving. **Table 3** shows the modeled cumulative revenue exposure for each of the three utilities over time.^H Each year’s revenue loss builds on the last. Using this type of analysis, a utility can better anticipate if its reserves should be or are enough to cover normal fluctuations in demand or more extreme water demand curtailments. By using a strategic reserve, a utility with high revenue variability does not have to forsake its aggressive conservation pricing strategy, but it does have to plan ahead.

Table 3: Cumulative Three-Year Revenue Exposure at the Utilities Due to Aggressive Conservation Reducing Average Residential Demand by 15% Each Year

Utility	Modeled Revenue Risk for 1 Year	Modeled Revenue Risk for 2 Years	Modeled Revenue Risk for 3 Years
Southeastern Coastal	\$1,513,000	\$2,666,000	\$3,548,000
Mountain Resort	\$426,000	\$604,000	\$702,000
Urban	\$12,522,000	\$22,285,000	\$29,739,000

Conservative Projections Combined with Efficiency Based Rebates/Dividends

One of the drawbacks of relying heavily on reserves is that it can lead to holding relatively large amounts of capital relatively dormant for extended periods of time. Reserves are extremely useful if a utility bases revenue projections on a “normal” year rather than a worst case (in terms of water sales) scenario since there will inevitably be below normal years. Conversely, a utility could make its rate calculations assuming a worst case year (e.g. 15% reduction to average residential water use), generating significant surplus most years under normal circumstances. This approach would lead to higher prices than a less conservative approach, but instead of holding on to the revenues likely to occur in most years, a utility could adopt a “dividend” model that returns some of the funds to the customers.

The Water Research Foundation Report outlines a version of this business model that returns funds to customers that exhibit a specific conservation behavior during the year and is called the “WaterWise Dividend” model. This approach is as much about changing the relationship a utility has with their customers as it is about revenue stability. The customer is treated as a more active participant in the business, making them more responsible for insuring sufficient revenues, but also providing them with an opportunity to share the benefits of conservative financial planning. As with the emerging pricing models introduced later in the report, more research is needed to understand how customers would react both in terms of water use and in their views of their utility. What is clear is that the current aggressive conservation pricing that does not take into consideration the possibility of extended periods of low sales leave many customers feeling penalized for conservation rather than rewarded.

This approach is as much about changing the relationship a utility has with their customers as it is about revenue stability.

^H Assumes no changes to rates or number of accounts over a three year period but that the residential customers curtail demand significantly each year resulting in a decline of 15% to average water use each subsequent year

Weather Derivatives

As this analysis showed, revenue swings can be excessive for some utilities; not all utilities will be able or willing to maintain the reserves to cover periods of below-expected revenues. There are many examples of weather-induced revenue volatility in other sectors including agriculture, tourism, and construction. Some of these sectors have developed external hedging mechanisms involving insurance and other risk sharing instruments. The Alliance for Water Efficiency and other organizations have begun exploring these instruments.¹² There may eventually be an additional tool for utilities to use and avoid relying solely on rates to mitigate variability.

Base Charges that Include Financial Incentives for Conservation Practices

Base charges are commonly set based on service line or meter size under the assumption that this is an accurate method of predicting a customer's potential cost burden on the water system. Since most customers use the smallest meter size, they have no incentive to reduce their base charge. Our past analyses show that peak monthly usage, varies considerably for residential accounts with the same meter size and that meter size alone is likely a poor indicator of the peaking cost burden of individual customers.¹³ Some customers with a 5/8" water meter may peak at over 100,000 gallons in a single month, while other customers never exceed 2,000 gallons/month. If peak monthly use was used to set the base charge itself, such that each customer was charged a unique base charge calculated from his/her highest month of water use, then customers would have a price incentive to reduce their peak water use, as well as the monthly bill. For administrative ease and to maintain revenue stability, the re-calculation of base charges for all customers could occur infrequently enough to avoid rapid changes to the revenue stream to the utility yet frequently enough to allow customers to see the nexus between their water use behavior and their water bills. This type of alternative rate model, titled "PeakSet Base", was described and analyzed among other innovative alternative rate models in a recent Water Research Foundation report.¹⁴ **Figure 10** compares charges for a "low seasonal water user" to that of a "high seasonal water user" under the southeastern coastal utility's uniform rate structure and an example PeakSet Base rate structure.

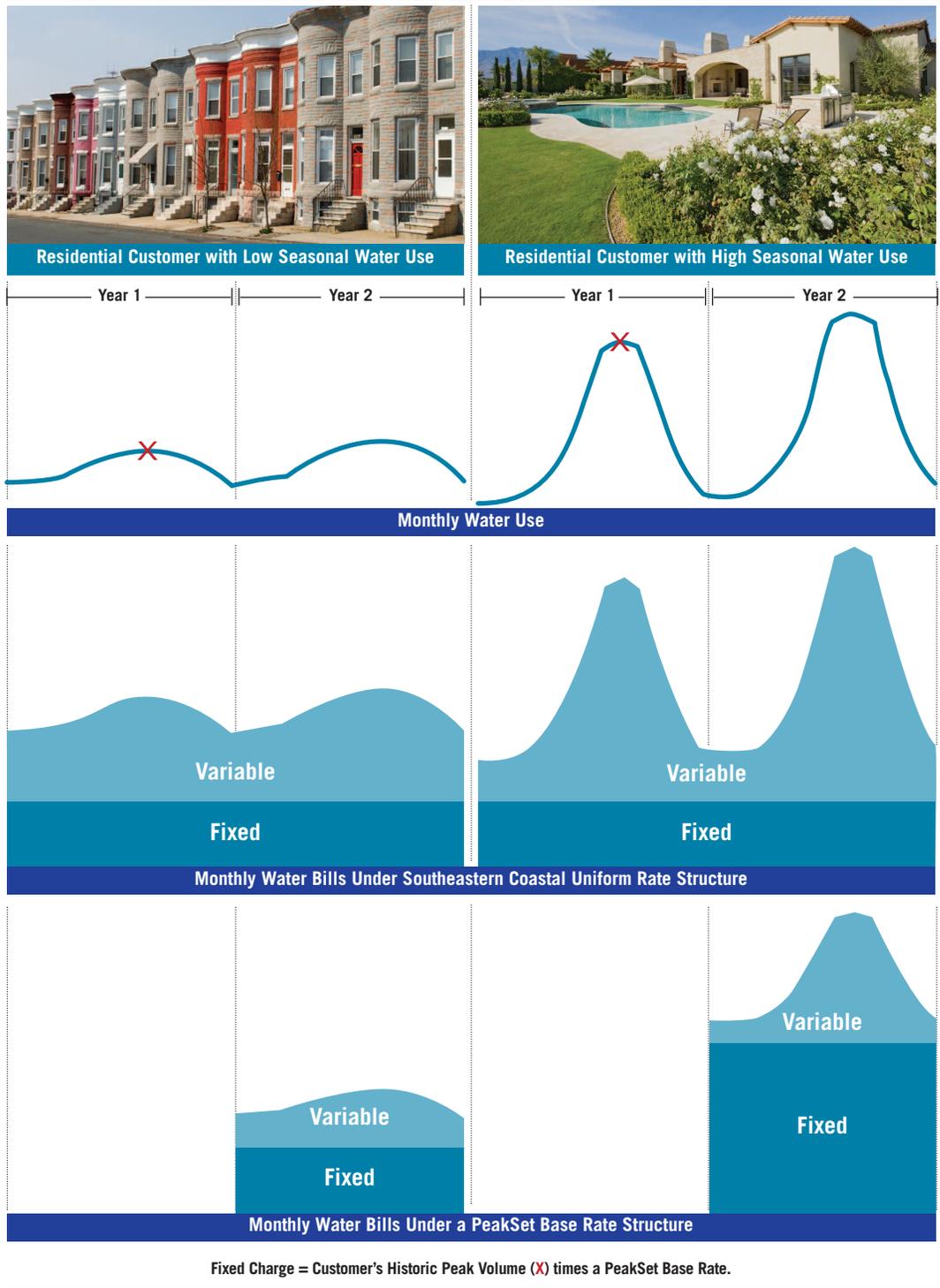
Consider the mountain resort utility which has relatively conservation price signals and 40% of current revenues coming from base charges. As **Figures 8 and 9** show, relying on a shift to a more aggressive increasing block rate structure such as used by the urban utility results in much more revenue variability. Adopting a PeakSet Base rate structure could allow the utility to collect the same fixed revenues from their customers, but could vary the base charge based on peak usage. Each year, the utility would recalculate base rates using its customers' historical monthly peaks, such that the total amount of base charge revenue would remain constant and predictable for the utility. Under this model, customers would have an increased incentive to reduce their peak knowing that it would impact their entire subsequent year's bill.

Alternatively, the southeastern coastal utility already is relatively revenue resilient, but its conservation price signals are moderate (as shown in **Table 2**). Because this utility serves a coastal community with a somewhat seasonal customer base and peak demand is one of the major drivers of overall system capacity and expenses,¹ the utility may be interested in promoting conservation that targets and lowers peak demands. A PeakSet Base rate structure would send a strong price incentive to the customers to reduce peak demands without forsaking its revenue resiliency.

Meter size alone is likely a poor indicator of the peaking cost burden of individual customers.

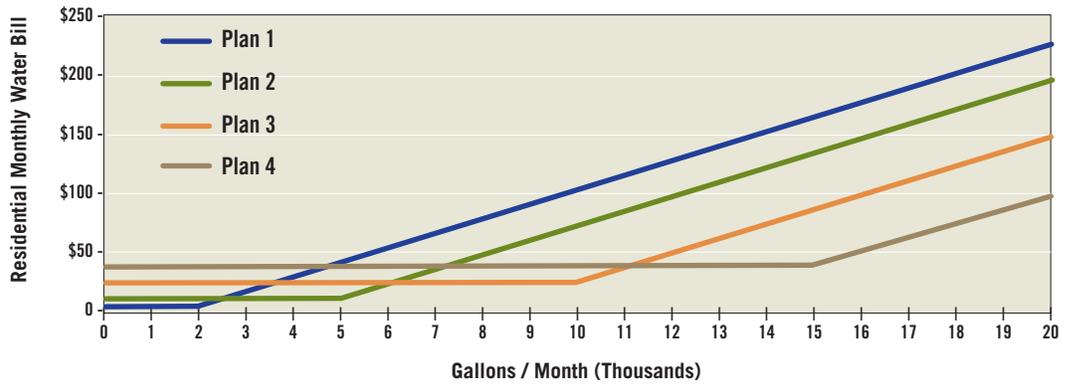
¹ Alongside fire protection needs and regulatory requirements that drive treatment techniques

Figure 10: Comparison of Monthly Water Bills for Two Types of Customers Under a Uniform Rate Structure & a PeakSet Base Rate Structure



The Water Research Foundation Report¹⁵ explains another rate structure that grants utilities more latitude in increasing fixed revenue in a manner more closely linked to consumption than meter size. The rate structure entitled CustomerSelect gives individual customers the choice to select an allotment of use that meets their particular water use needs. Customers are charged a fixed amount for all water use under that water use allotment. If they go over their plan's allotment in a given month, the utility charges a punitive overage fee in the form of a very high uniform volumetric rate. **Figure 11** displays an example of what residential water customer bills would look like if the utility offered four plans. A customer that almost always uses less than 5,000 gallons per month might choose Plan 2, and will try to avoid exceeding 5,000 gallons in order to avoid paying the overage charge beyond that point. A customer that almost always uses 6-7,000 gallons per month might find it financially worthy to invest in high efficiency technology or adjust behavior so that he/she could "fit" into Plan 2. This model allows a utility to collect much more revenue from a customer's fixed charge and incentivizes customers to choose the lowest plan they can realistically live within.

Figure 11: Monthly Residential Water Charge by Plan & Consumption Level in an Example of a CustomerSelect Rate Structure





Conclusion

By understanding relative revenue risk, utilities can plan accordingly to mitigate that risk through pricing and/or non-pricing measures.

For decades, utility practitioners have been challenged to find solutions to the so-called “conservation conundrum,” living with the fact that many utilities have long term benefits from reducing water demands but short term revenue disincentives. This analysis shows that this conservation conundrum is real but to different degrees for different utilities. By understanding relative revenue risk, utilities can plan accordingly to mitigate that risk through pricing and/or non-pricing measures. Although the analysis reinforces the adage that all predictions are likely to be wrong, that does not mean utilities should not project revenues. Projecting sales, and in turn revenues, as a likely range rather than as a single point can help a utility adopt mitigating approaches in-line with strategic direction.

Appendix

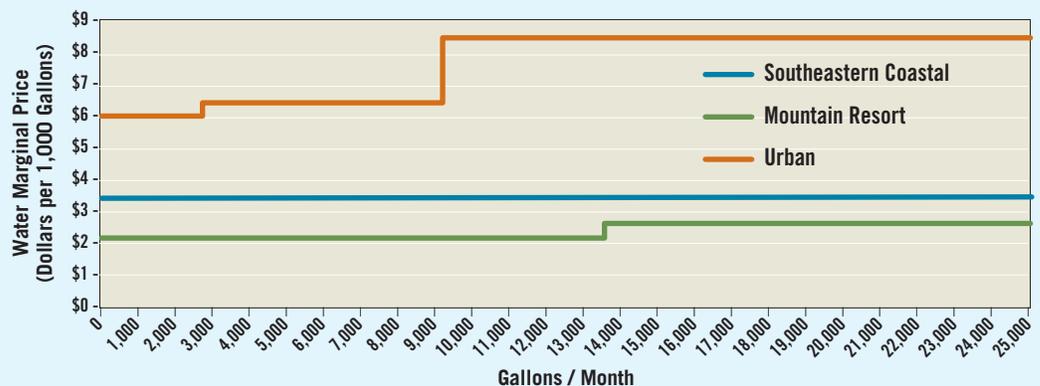
Description of the Utilities' Residential Rate Structures Used in 2013

The southeastern coastal utility had a uniform rate structure with a \$12.91 monthly base charge and a \$3.42 per 1,000 gallons variable charge.

The mountain resort utility had an increasing block rate structure with block sizes and rates customized to each customer's equivalent capacity unit (ECU). ECUs are calculated for each customer and are based on the housing characteristics, maximum number and type of water fixtures, maximum irrigated area, certain cooking facilities, or other water demand factors. The weighted average rates in 2013, based on actual single-family customer water bills, included a monthly fixed base charge of \$25.15 and variable block rates of approximately \$2.20 per 1,000 gallons for block 1, \$2.73 per 1,000 gallons for block 2, \$3.72 per 1,000 gallons for block 3, and \$5.37 per 1,000 gallons for block 4. The monthly base charge is calculated for each customer based on their billing area within the utility and their ECU. The weighted average monthly base charge among all residential customers in 2013 was \$25.15. For the variable charge, the utility uses equivalent capacity units to determine the specific water volume ranges for each block, adding on an ECU-based volumetric rate based on the number of pumping stations used to deliver water to the customer.

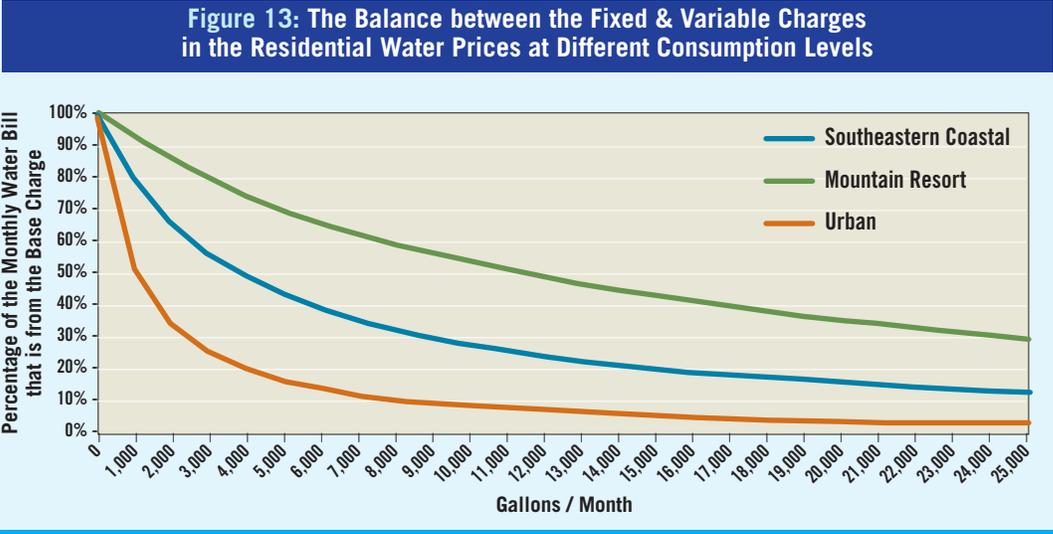
The urban utility had an increasing block rate structure with a \$6.36 monthly base charge and an increasing block rate structure. The block rates and sizes were \$6.04 per 1,000 gallons from 0 to 2,642 gallons per month, \$6.60 per 1,000 gallons from 2,642 gallons to 9,246 gallons per month, and \$8.34 per 1,000 gallons for more than 9,246 gallons per month. These rates are reported in US dollars, calculated at the 2013 yearly average exchange rate of 1 Canadian dollar to \$0.971 US dollars. The marginal rates for residential water bills for all three utilities are compared in **Figure 12**.

Figure 12: The Residential Water Marginal Price for the Next 1,000 Gallons at Different Consumption Levels in 2013



Rates for the Mountain Resort Utility reflect the weighted average rates charged to all residential customers.

The monthly water bill, including the base charge and volumetric charges, at various levels of consumption for each utility is displayed in the report in **Figure 1**. The balance between the fixed and variable charges at those consumption points is displayed in **Figure 13**. This figure demonstrates that, based on pricing levels alone, the residential rate structure of the mountain resort utility depended more heavily on the base charges than the other two utilities' rate structures. Conversely, the urban utility's rate structure depends more heavily on the volumetric charges than the other two utilities' rate structures. Thus, the urban utility's rate structure can be described as "the most variable" compared to the other two, and the mountain resort's rate structure can be described as "the most fixed."



Endnotes

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- 15 Ibid.

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