Dr. Loge--The February 2015 issue of JAWWA is focussed on conservation. It makes a lot more sense to schedule your paper for that issue. Therefore, your paper "Consumption-Based Fixed Rates: Harmonizing Water Conservation and Revenue Stability" will be scheduled for February. I hope that you understand that this decision is made based on the overall editorial needs of the Journal. Because it will be part of our focus topic for February, I will be highlighting your paper in my column Inside Insight for that issue.

Thank you.

Mike

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-------- Original Message --------
Subject: 04042014-JAWWA0036R Decision Letter
From: "JAWWA Staff" <jawa@awwa.org>
Date: Mon, July 07, 2014 11:27 am
To: filoge@ucdavis.edu
Cc: mike@michaeljmcguire.com

July 7, 2014

Dear Dr. Loge:

RE: Consumption-Based Fixed Rates: Harmonizing Water Conservation and Revenue Stability

I am pleased to inform you that your paper has been approved for publication in Journal AWWA. It is tentatively scheduled for inclusion in the January 2015 issue. Your paper is assured of publication in the JOURNAL and cannot be withdrawn for publication elsewhere.

Because the full text of your article will be published online only (as explained below), we ask that you provide us with a two-page expanded summary of your article for publication in the print JOURNAL. (Guidelines for preparing the summary are included with this letter as an attachment.) We need to receive your Expanded Summary by August 7, 2014.

We are beginning the third year of our initiative to increase the number of peer-reviewed articles published each month by publishing all such articles online-only. This new publishing
Consumption-Based Fixed Rates:
Harmonizing Water Conservation and Revenue Stability

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ABSTRACT

Water utilities currently struggle with the need to promote water conservation while also maintaining financial solvency—a common challenge referred to as the "new normal." However, under typical cost and revenue structures, water utilities experience significant revenue shortfalls when water use lags projected customer consumption (either by conservation or other factors). Subsequently, water providers are obligated to raise rates more frequently and/or more dramatically than originally anticipated. This problem fundamentally arises when the fixed and variable portions of utility costs are not aligned with the fixed and variable portions of revenue. This paper presents a new water pricing mechanism, Consumption-Based Fixed Rates (CBFR), which harmonizes costs and revenues yet is still able to promote conservation through the innovative inclusion of volumetric fixed charges. As such, CBFR represents a potentially useful solution for water utilities to effectively balance conservation and revenue stability in an equitable and sustainable manner.
INTRODUCTION

A water utility must balance multiple objectives in determining how to charge customers for its services and the water it delivers. These goals usually include receiving stable and predictable revenue that is enough to repay the costs of providing water; promoting efficient water use; ensuring fairness, equity, and affordability in water bills; providing stability and understandability of charges on bills; and complying with applicable laws (AWWA, 2012).

In addition, water conservation is a critical goal for many water systems across the nation as they seek to defer the costs of developing new water supplies or replacing aging infrastructure, to adapt to greater variability in water availability due to climate change, and to maintain sufficient water availability for the natural environment (Jordan, 1993; USEPA, 2002). This paper addresses the two important, but often conflicting, objectives of ensuring stable revenue and sending a price-based conservation signal to customers.

Water-providing utilities that succeed in conserving more within their service territory than anticipated face a revenue penalty in terms of unrealized sales. In fact, water agencies can be left struggling to generate enough revenue to recoup the costs they incur for treating and providing water, including environmental and future costs. If utilities practice full-cost ratemaking, all these costs are recovered through water sales, so revenue loss leads to a subsequent water rate increase, meaning customers are, in essence, punished for using less water (Chesnutt & Beecher, 2004). This overall trend has been referred to as the “new normal” of water pricing—that a utility is either able to have stable revenue or promote conservation, but not both (AWWA & RFC, 2013).

The purpose of this paper is to both characterize and resolve the tension between utility revenue and customer conservation that defines the “new normal.” The analysis includes a
quantification of the structural instability of existing rate designs, including a discussion of the amplification of revenue lost due to reduced water demand, as well as a description and exploration of a new rate structure designed to balance the competing objectives of the “new normal,” called Consumption-Based Fixed Rates (CBFR).

WATER RATES OVERVIEW

A water rate structure Establishes customer charges or amounts billed, essentially defining the revenue received to match a utility’s costs (AWWA, 2012). Over the years, rates have evolved based on the needs of utilities and ratepayers, as well as parallel advances in technology. Toward the end of the 19th century, when water was relatively cheap and plentiful, utilities charged customers one flat fee for water use regardless of the amount consumed (Masten, 2010). However, as population and economic development increased overall demand for water, water agencies needed a way to both monitor and influence consumption within their service area. The adoption of water meters provides the mechanism to charge for water volumetrically, or based on the amount actually consumed by customers. With meters installed, utilities began to set a price per unit of water consumed (e.g. $/gal or $/ccf) and therefore were able to provide a price signal to the customer (i.e. use less water, save more money). The first volumetric rate structures were uniform (unit prices could differ between customer classes, but overall each customer in a class was billed using the same unit price per volume of water consumed) and decreasing block (essentially a “bulk discount” of lower unit prices to higher volume consumers). While both mechanisms do provide a price signal to consumers relative to a flat fee in that they use volumetric pricing, neither of these rate structures actively promotes much conservation (AWWA, 2012). As a result, they are increasingly being replaced by rate mechanisms with more aggressive conservation signals (i.e. price signals to use less water).
Conservation-oriented rate structures include the common increasing block tariff (and its variant, water-budget rates), as well as other mechanisms such as seasonal pricing. As the name implies, increasing block rates feature an increase in the unit price of water as more water is consumed and water budgets implement this concept at the customer scale by personalizing the blocks based on efficient use relative to an estimation of customer's consumption needs. As conservation has increasingly become a major objective of utilities and ratepayers alike, the utilization of increasing block structures has spread in the United States from 29% of rate structures in 2000 to 52% in 2012. At the same time, structures that are not as effective at sending conservation signals are being used less and less: decreasing blocks made up 35% of rate structures in the United States in 2000 and only 18% in 2012, while uniform rates usage dropped from 36% to 30% across the same timeframe (AWWA, 2013). As a conservation ethos is likely to persist, utilities must continue to attempt to ensure that rate structures chosen are able to both send a conservation signal to customers and ensure full recovery of system costs.

COST ACCOUNTING

Methods for calculating and categorizing the system-wide costs of a water agency are well established\(^1\). Often, both the capital and operational costs of a water agency extend into the future and, hence, require the incorporation of projections based on historical data of anticipated costs and corresponding desired revenue, along with estimations of future water consumption (AWWA, 2012). With utilities’ dependence on forecasting current trends into the future, rate structures assume the vulnerability associated with uncertainty in these projections. For example, an unanticipated and significant drop in water demand could result in problematic revenue shortfall. As mentioned in Hughes et al. (2014), utilities often over-estimate customer water demand due to historic trends predicting increased consumption, as well as a desire to err on the
side of caution to ensure constant water availability. However, this overestimation of demand introduces a significant risk of revenue shortfall.

Another important component of traditional cost accounting is that all costs and revenue are separated into two categories, “fixed” and “variable.” Fixed costs are generally defined as capital and operating costs that are incurred regardless of the amount of water delivered and generally include costs related to the operation and maintenance of facilities, as well as to debt repayments and system depreciation. In contrast, variable costs depend directly on the amount of water delivered by the utility, such as the costs of treatment chemicals, the energy used in pumping, and so forth (AWWA, 2012).

On the revenue side, fixed charges in a water bill are paid by customers irrespective of the amount of water used and are often associated with any customer-related costs that would occur even if zero water was delivered by the utility. There are several ways to incorporate fixed charges into rates, including billing charges (same fee for every customer), meter charges (fee varies with meter size), and minimum charges (sets a minimum bill amount based on some specified water allowance). Variable charges make up the remainder of a water bill and are directly tied to consumption, so the overall variable portion of the bill is usually volumetric, i.e. based on the amount of water used. Volumetric charges depend on the rate structure chosen, but in general equate to the price per unit of water (e.g. $/gal) multiplied by the total amount of water consumed (AWWA, 2012).

How a utility portions out its fixed and variable revenue heavily influences revenue stability, affordability, and the strength of the conservation signal sent. In general, a utility that receives revenue mainly from fixed charges can expect more stability in its ability to meet costs. However, a large fixed bill portion can intensify affordability concerns since customers are
unable to significantly reduce their bills by changing consumption habits (Gaur et al., 2013).

Meanwhile, a bill with a larger portion allocated to variable charges allows for greater uncertainty in the collection of revenue, but also provides the customer with a greater incentive to conserve since the volumetric cost changes directly with the amount of water used. Either way, revenue stability has more to do with the fundamental structure of how revenue is connected to costs than the pricing mechanism (i.e. increasing block, water budgets) itself.

REVENUE INSTABILITY

From the discussion of fixed and variable costs and revenue, it makes the most sense for a utility to maintain financial stability by aligning fixed costs with fixed revenue and variable costs with variable revenue so that total costs are perfectly aligned with total revenue from water bills. Water utilities, though, face costs that are primarily fixed (AWWA & RFC, 2013). For the purposes of discussion in this paper, costs are assumed to be 80% fixed and 20% variable, which is a reasonable estimate based on reports discussing finances of real agencies (Hampton Roads Planning District Commission, 2013; Hughes et al., 2014). Given these costs, revenue with this same breakdown would send a muted conservation signal (embedded as a volumetric charge within the variable portion of the revenue) relative to the larger fixed portion of the overall water bill. A large fixed portion, likewise, may cause issues with customer affordability (Hughes et al., 2014). To counteract these effects and amplify the conservation signal, many water agencies have chosen to offset the balance between fixed and variable costs and revenue by increasing the portion of the customer’s bill that is derived from variable charges. In fact, as a minimum to promote conservation, utilities are recommended by the California Urban Water Conservation Council (CUWCC)’s best management practices (BMPs) to structure water bills with at least 70% volumetric charges and therefore at most 30% fixed charges (CUWCC, 2008).
No matter the water pricing mechanism in place, a utility will experience revenue instability as long as conservation is promoted in the usual practice of decoupling fixed and variable costs from fixed and variable revenue (Figure 1). When a typical rate structure has the majority of its revenue dependent on the amount of water consumed by ratepayers, it relies upon this variable revenue to help recoup a large proportion of fixed costs. For instance, if costs are 80% fixed and 20% variable and revenue 30% fixed and 70% variable, the variable revenue is relied upon to make up 62.5% of the fixed costs as well as all of the variable revenue. This disconnect between the fixed and variable portions of costs and revenue places too much reliance on variable revenue and makes utilities vulnerable to revenue instability.

The lack of symmetry between fixed and variable costs and revenue is especially problematic in the context of a sudden and significant decrease in water demand, whether driven by external factors (e.g. economic downturn or extreme weather), increased efficiency due to a general conservation ethos or the implementation of water saving technology, or raising water prices (Donnelly and Christian-Smith 2013; American Water Works Association (AWWA) and Rafielis Financial Consultants 2013). Any unanticipated decreases in water demand will impact the utility’s ability to sufficiently recoup its fixed costs through variable revenue or, in other words, remain financially solvent.

Unless utilities accurately anticipate reduced water demand, they will get stuck in a negative feedback loop of “revenue catch-up” in an attempt to meet cost requirements. This phenomenon is the “new normal” introduced earlier, where any revenue loss is traditionally made up by increasing rates (specifically the price per unit water for the variable revenue). This can lead to further conservation and reduced water sales, which would only exacerbate the
revenue insufficiency. Furthermore, any revenue shortfall is considered a fixed cost component for the next cost accounting period, thus increasing the ratio of fixed to variable costs.

To quantify the revenue shortfall, a representative typical financial breakdown of 80% fixed costs, 20% variable costs, 30% fixed revenue, and 70% variable revenue was used to test the revenue response under different levels of unanticipated water usage for a theoretical water utility. As seen in the revenue loss graph in Figure 2, the more aggressive the conservation, the greater the revenue gap or shortfall.

Another way to view this figure is in terms of costs saved versus total revenue lost due to reduced demand shown, respectively, by the distances between the cost and revenue lines and the overall budget line. The ratio of these values (revenue lost over costs saved) can lead to a quantification of a utility’s financial instability when amplified by a mismatch between costs and revenue, discussed in detail below.

QUANTIFYING THE INSTABILITY

To develop a more universal quantification of revenue instability, an “amplification factor” was calculated for a full range of mismatched fixed and variable cost ratios in relation to fixed and variable revenue ratios. The amplification factor is simply the ratio of the variable portion of revenue to the variable portion of costs. It is a useful metric in that it effectively represents the amount of revenue that is lost relative to the costs that are saved with decreased water consumption. In other words, it shows how much the revenue losses from decreased water demand are “amplified” relative to cost savings when fixed and variable costs are not perfectly aligned with fixed and variable revenue.

Figure 3 shows the results of this analysis as calculated for 5% increments of the full spectrum of potential mismatches between fixed and variable costs and fixed and variable
revenue. The graphic only includes cases where the variable revenue is larger than the variable
cost since this is more common due to utilities using high volumetric rates to strengthen the
conservation signal.

The green line indicates a ratio of 1.00, where variable revenue and variable costs are
perfectly aligned, meaning fixed revenue and costs are likewise harmonized. The yellow and red
values below the green line demonstrate that any time variable revenue is larger than variable
costs, the amount lost in total revenue will be larger than the costs avoided due to reduced water
consumption. Utilities can use this graphic to determine the instability of their current rate
structure (i.e. the amplification of their revenue losses relative to cost savings) in comparison to
other options for apportioning fixed and variable revenue to fixed and variable costs.

The bolded value in the middle of the graphic shows an amplification factor of 3.5 for a
hypothetical water agency with 70% variable revenue and 20% variable cost. In this case, for
every $10 saved in variable costs due to conservation, there is a $35 loss in revenue for the
utility. This case was not selected randomly but represents the intersection of an assumed typical
fixed and variable cost ratio (80% fixed and 20% variable) relative to the suggested BMP for a
conservation rate structure (30% fixed and 70% variable) (CUWCC, 2008).

**A NEW HARMONY: CBFR**

As shown above, to maintain stable revenue a utility must keep the different portions of
costs and revenue aligned. However, limiting volumetric water use to the variable portion of the
bill (only 20% if aligned with the typical variable costs of a water agency) dampens the extent of
the conservation signal and potentially increases the issue of customer affordability. The
challenge of dealing with this conservation tradeoff was previously introduced as the “new
normal” for water utilities. However, these seemingly conflicting objectives need not be
structured as a zero sum game. The authors propose a solution in the form of a rate structure that
harmonizes fixed and variable costs with revenue, while providing a volumetric price signal, and
call this new rate structure Consumption-Based Fixed Rates (CBFR).

CBFR achieves this harmonized structure through a fundamental reimagining of the way
costs are allocated to customers. CBFR’s core innovation is to base not only the variable revenue
on volumetric water consumption, but also the majority of fixed revenue as well. More
specifically, CBFR splits the revenue requirement into three components: fixed–fixed, fixed–
volumetric, and variable. Fixed–volumetric is the portion of the fixed revenue based on
volumetric water use. Table 1 shows a sample allocation of how a utility’s costs may be
allocated to these three categories, described in further detail below.

The fixed–fixed component is similar in definition and application to the traditional fixed
portion of a water bill. This fixed–fixed portion is determined by dividing a percentage of the
total costs equally over all customers, or equally among customers within customer classes,
based on such characteristics as the size of the meter serving a property (AWWA, 2012).

Overall, this fixed–fixed revenue represents a small portion of the overall fixed costs of
providing water, as it is limited to only covering costs that do not vary in relation to total water
deliveries, including, for example, water meter installation, fire protection services, and
administrative costs related to meter reading and billing (City of Davis, 2013).

The previously fixed costs that are not allocated to the fixed-fixed portion of the bill are
reclassified as fixed–volumetric revenue. The fixed–volumetric portion recognizes that most
seemingly “fixed” costs actually vary with the amount of water used, especially in the context of
system-wide deliveries as opposed to individual consumption. If total system-wide peak demand
increases, then the total amount of fixed costs increase as the utility must build and maintain a
greater scale of infrastructure. These costs might include purchasing water rights or building and
subsequently maintaining a new water treatment facility. In both of these cases, the increase in
fixed costs is driven by the amount of water for the whole system and not the marginal cost of
supplying water to an individual customer.

If the total system-wide demand drives changes in a utility’s fixed costs, then why not
divide this portion of the fixed costs by each customer’s exact share of the demand? This is
exactly what CBFR seeks to accomplish. The fixed–volumetric revenue is distributed to
ratepayers based on their proportional share of total metered water use for a given time period.

Thus, each customer only pays for his or her share of use of the system during the period chosen.

In determining the allocation of fixed–volumetric charges for water customers, the time
period selected for estimating proportional use is an important decision. As one example, peak
seasonal use could be used as a baseline since this volume defines the maximum needed capacity
for the entire system. Alternatively, the customer’s portion of the fixed–volumetric rates could be
calculated and updated at the end of each billing cycle (i.e. in “real time”). Recalculating for
every billing cycle might increase the computational load on the utility, but it also increases the
inherent fairness of the charges (since no estimations or projections are involved) and decreases
the lag time until bills reflect any changes in customers’ water use habits. Both the fairness
aspect and other issues involving time lag are discussed later.

The variable revenue component is simply the direct cost of providing water to customers
for that time period. The variable cost to the water utility to provide any additional units of water
is passed through to the consumer as the variable portion of the water bill and is recouped as a
price per unit water that each customer pays for each unit of water used.
This new revenue breakdown translates to a bill with three charges (fixed–fixed, fixed–
volumetric, and variable) of which two are intrinsically tied to the volume of water consumed by
the customer and thus give customers control over more of their total bills. The CBFR
“equation” is further discussed below:

The revenue from one customer assuming fixed–volumetric recalculation takes place
each billing cycle is as follows:

\[
\text{Fixed–fixed charge} = \frac{FF}{X} = \left(\frac{s}{\text{customer}}\right) \quad (1)
\]

\[
\text{Fixed–volumetric charge} = FV \times \frac{A}{W} = (\$) \quad (2)
\]

\[
\text{Variable charge} = VC \times \frac{A}{W} = (\$) \quad (3)
\]

Where: \(FF = \text{fixed–fixed portion of fixed costs for billing cycle}\)

\(FV = \text{fixed–volumetric portion of fixed costs for billing cycle}\)

\(VC = \text{total variable costs for billing cycle}\)

\(X = \text{total number of customers served}\)

\(W = \text{total amount of water used by all customers during last billing cycle}\)

\(A = \text{amount of water used by one customer during last billing cycle}\)

If the fixed–volumetric charge is derived from customer consumption for some other time
period (e.g. the seasonal peak water usage) and then distributed over future billing cycles, the
fixed–volumetric calculation looks slightly different:

\[
\text{Fixed–volumetric charge} = \frac{FV \times \frac{B}{n}}{P} = (\$) \quad (4)
\]

Where: \(n = \text{number of billing cycles over which the fixed variable charge is distributed}\)

\(P = \text{total amount of water used by all customers during period of peak usage}\)

\(B = \text{amount of water used by one customer during period of peak usage}\)
In this case, the fixed–volumetric portion of the fixed costs is based on a cost projection for some predetermined rate horizon. Similarly, the fixed–fixed and variable charges in this case would also involve estimations of the future fixed–fixed revenue requirement, the total variable costs, and the quantity of water to be sold. This reliance on projections of the future can lead to some uncertainty in the balancing of revenue with costs. However, any revenue lost under this structure would not be as financially damaging as with a conventional rate structure since for CBFR only the variable charge portion is affected, which isn’t very large.

To explore the mechanics of CBFR implementation, the authors examined the case of a hypothetical water utility with assumed typical cost requirements of 80% fixed and 20% variable. Under CBFR, the revenue then will also be 80% fixed and 20% variable, with the fixed portion being split into fixed–fixed and fixed–volumetric, assumed to be 10% and 70% respectively. These values for fixed revenue breakdown are estimates based on the version of CBFR considered for implementation in the City of Davis, California (City of Davis, 2013).

Figure 4 depicts how a utility using CBFR would fare in the case of 10% conservation that was not anticipated compared to a utility with a conventional rate structure that offers a strong conservation signal and a utility with a rate structure that sends a low conservation signal and has affordability concerns, but has completely harmonized costs and revenue components.

The conventional rate structure is assumed to have 80% fixed and 20% variable costs and 30% fixed and 70% variable revenue to send a conservation signal. The harmonized rate structure has the same assumed costs breakdown and, due to alignment of costs and revenue, has revenue with the same fixed and variable portions.

For the conventional rate structure, a 10% reduction in demand from projected water use leads to a 10% reduction in variable costs and, therefore, a 2% reduction in total costs (due to a
10% reduction of variable costs which are originally 20% of total costs). However, on the revenue side, a 10% reduction in variable revenue represents a 7% loss in total revenue (due to a 10% reduction of variable revenue which is originally 70% of total revenue). Thus, the water utility saves 2% in costs but loses 7% in revenue, resulting in revenue shortfall and further instability of the rate structure. In the case of a utility with a $1,000,000 budget, this 10% reduction in water demand would mean a $50,000 deficit or revenue shortfall as shown in Figure 2.

CBFR, on the other hand, is comparably unaffected by errors in projection with fixed-volumetric recalculation each billing period and preserves the ability of the utility to fully recover costs no matter the conservation that occurs. For the same 10% reduction in water use in the context of CBFR, there is a 10% reduction in variable costs or 2% of total costs and a perfectly aligned 10% reduction in variable revenue or 2% of total revenue.

While a harmonized rate structure that matches fixed and variable costs to fixed and variable charges can also generate the revenue necessary to recoup costs, it does so at the cost of an effective conservation signal, along with potential affordability issues. The fixed–volumetric revenue helps CBFR send a better volumetric price signal to customers as discussed below.

Another hypothetical scenario can illuminate the impact of the CBFR conservation signal compared to that of a perfectly harmonized rate structure (see Table 2). A community of ten people each initially uses 10 mcf (1000 cubic feet) in Year 1. If one customer uses half as much water in Year 2 but everyone else’s consumption remains the same, under a harmonized rate structure the one customer will save 50% of the variable rate, corresponding to 10% of the total bill. Therefore, for an exceptional 50% reduction in personal water use, the user only saves 10% of their water bill. These variable portion savings are the same under both a harmonized rate and
CBFR, and demonstrate why the variable portion of the bill alone is insufficient for sending an appropriate price signal for conservation.

Along with savings in the variable portion, under CBFR the user is also rewarded for conservation through a recalculation of their fixed–volumetric rate (in this case assuming this occurs in “real time”). For Year 2, along with a reduction in variable charge, the efficient consumer will see an additional dip in his or her total annual water bill (~47% from Year 1) as the fixed–volumetric portion of the bill is recalculated to roughly half as much as it was the year before (due to the customer’s portion of total water use decreasing from 10 gallons out of a total 100 to 5 gallons out of a total 95). Therefore, under CBFR, a user who conserves sees his or her bill decrease due to a reduction of the variable charge, as well as the fixed–volumetric charge.

Table 2 shows how CBFR provides a price signal beyond that contained in the variable portion of the bill, and therefore sends a stronger conservation signal than a conventional rate structure that also harmonizes fixed and variable costs and revenue. While both rate structures show the same impact on the water bill in terms of the variable portion, CBFR provides an additional and even stronger price signal through the fixed–volumetric portion of the bill.

Thus, CBFR resolves the “new normal” by allowing a utility to maintain revenue stability while sending a strong conservation price signal. Further, implementation of CBFR has only a few requirements that are both straightforward and common to most water agencies. The utility must have a budget with fixed and variable costs accounted for, metered water infrastructure, access to customers’ volumetric water use data, and the ability to issue a water bill made up of three charges. As long as these requirements are fulfilled, and they already are for any utility that uses metered billing, this novel rate structure can be implemented to leverage the benefits of a financially stable, conservation-based rate structure.
DISCUSSION

Any change to a utility’s rate structure or unit prices can understandably be fraught with implementation issues, even when the proposed rate structure has long been in use in other agencies. CBFR is completely new, different, and innovative enough for utilities, rate analysts, politicians, and customers to have to overcome a broad range of potential hurdles before switching to this new structure. Discussed below are potential implementation issues and elaborations on the features of CBFR.

Proportionality, fairness, and affordability. Alluded to during the introduction of CBFR above, the innovation of the fixed–volumetric charge adds a certain amount of fairness to a customer’s bill since 90% of the charges (using the already assumed case of 10% fixed–fixed, 70% fixed–volumetric, and 20% variable charges) are volumetrically-based and directly dependent on the actual water use on the part of the customer. Furthermore, in the fixed–volumetric charge calculation, customers only pay for the share of total fixed–volumetric costs they are directly responsible for, based on their proportional water use during some pre-determined period.

With regards to proportionality, because 90% of the water bill is tied to actual water consumption, the amount one customer pays compared to a neighbor is almost entirely based on the amount of water each respectively used. What this means is that a water user who consumes twice as much water as another user will end up paying almost twice as much more. For example, if the water bill for a customer who uses 10 gallons is $10 ($1 fixed–fixed, $7 fixed–volumetric, and $2 variable), another customer who uses 20 gallons or double the amount of water receives a bill of $19 ($1 fixed–fixed, $14 fixed–volumetric, and $4 variable). This degree of proportionality indicates an inherent fairness in how customers are charged.
As already discussed, a conventional harmonized rate structure fixes a utility’s revenue instability issues by perfectly aligning fixed costs and revenue with variable costs and revenue. However, assuming 80% fixed and 20% variable costs means that the revenue and therefore water bill breakdown will be the same. A water bill that is 80% fixed can have significant issues with customer affordability since changes in consumption have little effect on the total bill amount (Hughes et al., 2014). Because of this, CBFR, with 90% of the bill volumetrically-dependent, is expected to have minor issues with affordability.

**Time lag.** Briefly introduced earlier, the period chosen for fixed–volumetric charge recalculation is a significant decision as it affects the time lag until a water bill reflects any change in a user’s water consumption. When water consumption declines, a utility’s fixed–volumetric revenue under CBFR doesn’t immediately decrease due to less water being delivered so the fixed costs (and therefore revenue requirement) remain the same in the short term. In other words, conservation on the part of the customer won’t be incorporated into rates charged until a new percentage of overall water use is calculated that shows that the customer is using less of a share of the system than before (essentially, there is a time lag in response of fixed–volumetric costs to reduced demand).

The time lag issue could be diminished through a recalculation of customer system usage at the end of each billing cycle using AMI (advanced metering infrastructure or “smart meters”), though this could increase a utility’s computational burden. Frequent recalculation, however, would affect bill stability since the utility would calculate costs only after the billing period ended. This could impact the efficiency of operations since the utility needs only to address actual costs incurred as opposed to adhering to a budget. In addition, rates for any given period would not be known in advance, either by the utility or the customer, since they are based on an
equation that is dependent on actual consumption in the previous period. Unpredictable rates could affect both the utility’s financial future (due to the volatility of forecasting future costs and revenue) as well as customer bill consistency. Also, having the water bill vary from month to month depending on proportional use may cause customer confusion during the implementation process.

**Individual and community conservation.** The conservation signal for CBFR is embedded both in the variable as well as the fixed–volumetric revenue. Though it is purely speculative whether the implementation of CBFR leads to any increased conservation, intuitively CBFR should send a strong conservation price signal due to the separation of fixed charges that are volumetrically-dependent. That CBFR sends a quantitatively stronger conservation signal than a conventional harmonized rate structure has already been shown.

On an individual basis, the incentive to conserve comes from the reduction of the fixed–volumetric charge on a bill that would occur if the customer conserved more water than the total system-wide conservation. Similarly, if a customer conserves on pace with the entire system, there is no change to the fixed–volumetric portion of the bill, since that customer’s share of the use of the system for the period used to calculate fixed–volumetric charges remains the same. Therefore, the success of conservation is tied directly to the entire community, rather than just individuals.

This discussion is quantified in Table 3 for the case of a community that achieves an overall 5% conservation in both Years 2 and 3. As shown in the analysis, a user who conserves 5% each year continues to see the same fixed–volumetric charge ($70) each year. However, users conserving either less (~5% or 0% in the table) or more (10%) than the community as a whole see inflated or reduced fixed–volumetric charges, respectively, each subsequent year.
There is an inherent fairness in this structure because users who consume more water pay more for their share of the system. Likewise, ratepayers are no longer collectively penalized for water conservation by rate hikes. Instead, users pay more or less based on their participation in any overall community-wide conservation achieved. Though across-the-board rate increases do occur under CBFR, these increases are not universal, but rather depend directly on the volumetric use by ratepayer.

Finally, because CBFR lessens utilities' financial risks due to conservation, utilities may have more incentive to implement “non-price” conservation programs such as public education on conservation techniques or leaflets mailed with water bills (Olmstead & Stavins, 2009).

Transparency and customer communication. Another objective for a rate structure, beyond promoting conservation and ensuring revenue is sufficient to repay costs, is that it should also be completely understandable to customers (AWWA, 2012). Implementing CBFR poses a challenge in explaining to customers how the bill is calculated.

With water meters now an industry standard, customers are accustomed to seeing volumetric water prices that involve a set unit price per volume of water used. For this reason, complicated rate structures such as increasing or decreasing block tariffs are potentially easier to implement for a utility undergoing a rate structure review. Water-budget rate structures involve a calculation, instead of a set unit price, to determine the budget for each customer as a function of a number of characteristics, including number of people in the household, lot size, and climate. Customers can request re-evaluations if any characteristics change, making the water-budget equation dynamic with time. These rate structures, gaining in popularity but still relatively uncommon, have been successfully implemented in many places despite the perceived difficulty
in getting customers to understand charges calculated in a more complicated manner (AWWA, 2012).

Similar to the water-budget structure, CBFR also involves an equation that is dynamic or changing over time based on metered use (due to the fixed–volumetric charge). This dynamic equation may be difficult to explain to water users due to the time-variability of the fixed–volumetric charges. However, customers, whether or not they know it, are already acclimated to dynamics in their bills. Even though in the short term, all of a utility’s costs are assumed to be fixed (i.e. do not change over time period of days, months, or even years due to fluctuations in customer consumption), over time, all costs are variable or dynamic (Beecher, 2010). For actual implementation purposes of CBFR, agencies can provide an online calculator that could give customers a range or “ballpark estimate” of charges to expect under CBFR.

Another point of potential customer confusion under CBFR is viewing conservation in terms of the community when users are accustomed to seeing their water bills directly tied to individual consumption. The fixed–volumetric charge in CBFR instead views actual water use in terms of the system as a whole. On water bills, then, users should clearly know what their share of the system is and how their water use compares to that of others in the community.

Finally, under CBFR water rates will still increase with reduced water demand, even without accounting for increasing costs faced by water utilities today due to replacing or maintaining deteriorating infrastructure, complying with increasingly strict environmental regulations, and ensuring existing facilities can survive in a changing climate (Donnelly & Christian-Smith, 2013). To prevent customer surprise at rate increases even after implementing a new rate structure, Figure 5 takes a theoretical look at how quickly water rates increase in the face of a continuing 5% annual shortfall in projected water demand (as a result of conservation,
economic downturn, or some other reason). The theoretical water unit prices are calculated by dividing the total revenue required for the year by the total water consumed.

For the conventional rate structure (assuming 80% fixed with 20% variable costs and 30% fixed with 70% variable revenue), to keep calculations simpler, the revenue is assumed to “keep pace” with the costs, which in a real utility would mean restructuring in real time as unanticipated conservation occurred in order to be able to recoup both lost revenue (i.e. shortfall due to the mismatch between costs and revenue) and utility costs. Therefore, the unit prices calculated are what the utility would charge if there were enough time to recalculate the revenue requirement between conservation causing revenue shortfall and customers being charged.

Because CBFR keeps costs and revenue matched, no assumptions need to be made about restructuring except to assume that fixed–volumetric charges are calculated in real time over the course of the year.

In general, water unit prices increase as annual water consumption decreases. As seen in Figure 5, the conventional rate structure increases at a faster rate than CBFR, given a 5% continuing shortfall in projected demand. To quantify this, it is useful to discuss these unit prices in terms of a rate threshold, which in reality could be a set constraint or cap, often legally dictated, that puts a limit on prices or frequency of rate increases (Olmstead & Stavins, 2009). A rate of $1.20 per ccf was arbitrarily chosen to compare the two structures; the conventional rate structure passes this threshold at approximately 2.5 years, while CBFR passes it after about 4.5 years. Under CBFR, then, even though 5% annual shortfall in water demand still drives rate increases, rates rise at a pace much slower than for a conventional rate structure. Any rate increase, though, could alarm customers who may have agreed to a new rate structure with a notion of rates not rising. Utilities must make it clear in the adoption of CBFR that rates, by
necessity, will still increase, but will do so at a slower pace than if other rate structures were in place.

Overall, all of these implementation issues or clarifications should be settled in the rate development and adoption process so customers are more likely to accept the new charges after implementation. Potential tools to engage the public in the rate-making process include bill inserts or newsletters, community presentations and meetings, and maintaining a website with all materials generated or used during a rate study to determine which structure is best for the community to implement (AWWA, 2012). CBFR can be proposed to customers as a structure that allows customers to pay their fair share of utility costs while stabilizing the utility’s revenue stream.

**Best management practices compliance.** Currently, CBFR satisfies the CUWCC’s Best Management Practices (BMPS’s) to promote a conservation signal by having at least 70% of annual revenue linked to volumetric charges (CUWCC, 2008). CUWCC is currently reviewing its retail conservation pricing BMP to differentiate more effectively the efficacies of different rate structures and other efforts by utilities to promote conservation. A new points-based option for determining the strength of a utility’s current conservation signal is proposed in a draft report on this new BMP. Based on the current framework released, CBFR is predicted to perform very well on the new point matrix and is mentioned explicitly in the matrix as “an innovative rate structure to promote efficiency” (CUWCC, 2014).

While CBFR presents challenges in implementation, it presents a potential solution to an inherent structural problem in current conservation-based rate design. Utilities can lay the groundwork for CBFR implementation by opening a dialogue with customers about utility
financial instability in the face of reduced water demand, potentially prompting a rate study to
determine whether CBFR is a good fit for the utility and the community.

CONCLUSION

Consumption-Based Fixed Rates (CBFR) presents a viable solution to the “new normal,”
or balancing utilities’ objectives of conservation promotion and revenue stability.

For a conventional rate structure, the mismatch between the fixed and variable portions of
a utility’s operating expenses and corresponding revenue requirement is the fundamental reason
behind a utility’s financial instability. This mismatch leads to revenue loss when an unanticipated
reduction in water demand is experienced. In other words, the disharmony between costs and
revenue amplifies any potential revenue-decreasing situation (e.g. consumer water conservation)
to the detriment of the utility’s finances.

CBFR was proposed as a solution to this problem due to its theoretical ability to
maximize conservation while protecting utility solvency. CBFR achieves this by reapportioning
the utility’s costs into fixed–fixed, fixed–volumetric, and variable components, allocated to
customers in the form of water bill charges determined using a calculation. This new rate
structure is theoretically proven to maintain stable revenue directly aligned with costs, send a
conservation signal, and require slower rate increases than existing conventional conservation-
based structures if unanticipated conservation occurs. CBFR can lead utilities out of the “new
normal” into a new era of financial solvency even when promoting conservation.
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