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Understanding utility disincentives to water conservation as a means of adapting to climate change pressures

Proponents of water conservation typically emphasize the environmental benefits of minimizing river development and streamflow depletions—but the case in favor of conservation is actually much broader and stronger. A primary consideration is financial; meeting demands through conservation is often dramatically cheaper (and less politically sensitive) than developing new supplies or reallocating water from agriculture to the municipal sector (Kenney et al, 2011). Additional environmental and financial savings can accrue from the resulting energy savings because the water sector is a major energy consumer (Kenney & Wilkinson, 2011). In fact, water conservation has become a core strategy in California's energy conservation efforts, which are not only motivated by environmental and financial concerns, but also by the state's efforts to reduce greenhouse gas emissions (Spivy-Webber, 2011). In this case, the link between water conservation and climate change mitigation is explicit.

A MANAGEMENT MODEL THAT SYSTEMATICALLY PROVIDES INCENTIVES FOR CONSUMPTION MORE SO THAN CONSERVATION MAY NO LONGER PROMISE THE GREATEST SOCIAL BENEFITS.

The link between water conservation and climate change adaptation, however, is more complex. In an era of increasing water scarcity and climatic uncertainty, there are obvious benefits to a management philosophy that seeks to keep demands well below natural limits, especially in regions where river yields are expected to decline under climate change. But although this risk management argument may be intuitive, the reality is that "for public utilities, including water suppliers, the incentives to add capacity have always been stronger than the incentives to control demand" (Chesnutt & Beecher, 1998). For example, under western US water law, the first party to develop and use a water resource obtains the right to use that water in perpetuity, an immensely valuable asset in water-short regions. To the extent that obtaining and keeping these water rights requires financing expensive infrastructure and encouraging its full utilization, law and economics conspire to encourage the race to develop—i.e., to get the last remaining sliver of water before someone else can (Cody, 2011). Because of this incentive structure, water conservation is often viewed as a strategy to be "reserved" for the time when new development is impossible. But given water engineers' ability to move water hundreds of miles and capital markets' willingness to finance these efforts (because they are backed by reliable revenue streams from water sales or by a broad taxing base), this era of demand management is delayed further (Leurig, 2010).

UTILITIES FACE TWO MAJOR DISINCENTIVES TO CONSERVATION

Equally as problematic as the incentives to consume are the disincentives to conserve, which are the focus of this article. Water conservation creates two serious problems for water providers. First is "demand hardening," which is the concern that policies that encourage consumers to use less water can effectively reduce the "slack" in the system and thereby undermine the ability of those consumers to further reduce consumption during droughts or other supply emergencies. On Colorado's Front Range, for example, many water utilities during the 2002 drought were able to significantly reduce demand—in the city of Lafayette, by 56% from what would have been normally expected given temperature and precipitation conditions—through temporary programs focused mainly on mandatory lawn watering restrictions (Kenney et al, 2004). If lawn watering and other "nonessential" water uses had been scaled back before the drought (as part of an ongoing demand management program), would emergency reductions have been possible? To some water managers, the prudent risk management strategy is to not find out—i.e., to not aggressively pursue reductions in water consumption, especially in lawn watering, on an ongoing basis—and to enact temporary watering restrictions when necessary to deal with droughts.

The second type of conservation disincentive facing water providers is fiscal. The activities of water providers are financed, in whole or in part, by selling water. If less water is sold, then revenues drop. Because many of a utility's costs are fixed (e.g., the capital costs of existing infrastructure), conservation can drop revenue (income) faster than costs, leading to budgetary shortfalls that necessitate rate increases unpopular with customers, utilities, and political leaders. This link between the volume of sales and a utility's financial health is known as the "throughput incentive" and is a powerful conservation disincentive seen in several utility sectors (Erickson & Leventis, 2011). Unlike in other sectors, however, the throughput incentive for water utilities has rarely been addressed by revenue model reforms, although interest in the subject is growing.

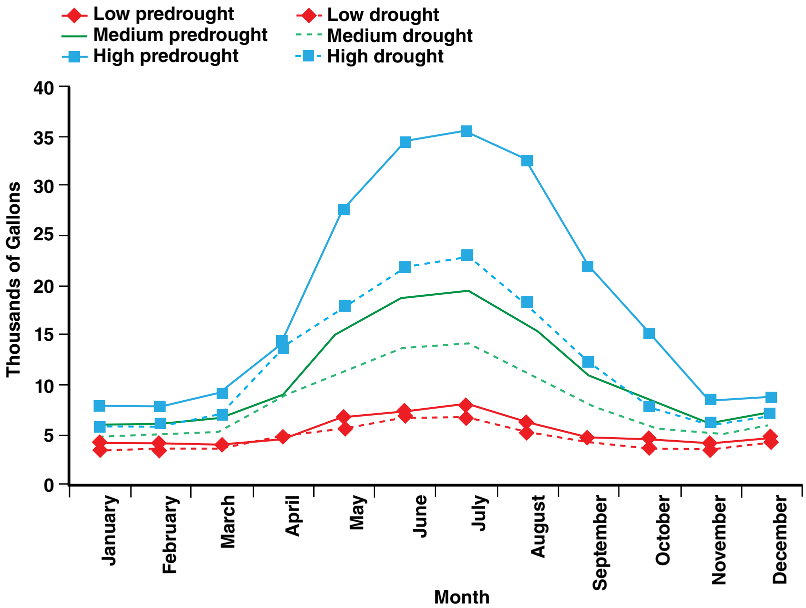
These two conservation disincentives—the service reliability (demand-hardening) concern and the desire to protect revenue streams—are explored in this article. These are disincentives strictly affecting water providers; customers (end-users) often have different incentives. This point is central to the discussion of revenue models, in that rate structures which provide conservation incentives for customers can provide a conservation disincentive for utilities. The words incentive and disincentive are used extensively, especially in reference to the way that institutional arrangements (e.g., laws, policies, management frameworks) reward or punish behavior. The intent is not to criticize utilities for not aggressively pursuing conservation at some theoretically optimal level; on the contrary, given the disincentives under which water utilities operate, the existing breadth and success of many conservation programs are remarkable. It is not normally the responsibility or authority of the water provider to create the institutional structure within which it operates. To the extent that reform opportunities exist, that is a message primarily directed at higher levels of government.

Although the challenge of adapting to climate change was the impetus for this investigation, the issues investigated are relevant with or without a changing climate. Even if the disincentives to conservation are removed or addressed, it is still debatable how prominent a role water conservation should play as a climate adaptation tool. The answer undoubtedly varies significantly from case to case, and the details matter. Similarly, the value of conservation in achieving environmental and economic goals is also highly variable. The intent therefore is not necessarily to argue for more water conservation across the board but to better understand the institutional disincentives that hinder the application of this strategy in those situations in which it could likely be beneficial.

SERVICE RELIABILITY AND DEMAND HARDENING

Service reliability. Arguments in favor of greater water conservation are occasionally countered by water managers based on a concern over how conservation affects service reliability, a concern often summarized by the term demand hardening. Demand-hardening terminology is usually raised by individuals arguing

FIGURE 1 Average consumption per billing period by user type and drought condition



The figure is for residential water use in Aurora, Colo., and shows water use predrought (Jan. 1, 2000, to April 30, 2002) to drought (May 1, 2002, to April 30, 2005), for three populations of water users: high, medium, and low. These categories are based on average household summer consumption between 1997 and 1999 (a relatively normal period climatologically). Half of water users were classified as medium; the top and bottom quartiles comprise the high and low groups, respectively.

that existing inefficient or nonessential water uses by customers should be viewed as an asset to be maintained rather than a weakness to be eliminated, in that this is water that can be easily "conserved" on a temporary basis as needed to respond to any unforeseen shortage—such as a drought crisis. Remove this slack from the system through a comprehensive conservation program, it is argued, and the ability to quickly reduce demands during a crisis is also reduced. When viewed through this lens, long-term demand management programs can be viewed as undermining short-term conservation efforts. Although many reports make mention of this phenomenon, there is almost no literature that explores this thinking in any systematic or sophisticated way.

The lack of scholarly writings on demand hardening is perhaps best explained by the observation that it undoubtedly occurs. Because long-term conservation programs eliminate the most water-wasting activities and technologies—and presumably those with the lowest economic value to customers—then further reductions are inherently more difficult to achieve. An inefficient use, once eliminated, cannot be eliminated a second time for additional savings. Further, the ability to quickly suspend nonessential water uses in a crisis is a remarkably useful management tool that water managers can, understandably, be hesitant to discard.

These viewpoints are easy to appreciate when reviewing the drought-coping activities of Colorado's Front Range cities during drought conditions in the early 2000s. In that region and period, summertime lawn watering accounted for half (or more) of total annual residential water use, but much of that urban irrigation was beyond what was essential for plant survival, and temporary cutbacks were tolerated by both the plants and the community. In one study, Kenney et al (2004) found that voluntary lawn watering restrictions yielded summertime water demand reductions ranging from 4 to 12% of expected use; savings from modest mandatory reductions ranged from 18 to 56%. Not only are these quantities significant, they also were achieved with virtually no need for advance planning or investment by the utility. But digging deeper, it was illustrated (Kenney et al, 2008) that the majority of these savings came from those customers who were predrought the highest volume water users. Those customers who were using the least water predrought—i.e., presumably, those with the fewest inefficient and nonessential uses—were unable (or unwilling) to cut back at a level commensurate with the more profligate users (Figure 1). Given this observation, long-term conservation programs that systematically shift households from the "high-water-using" to "low-water-using" categories raise concerns about the magnitude of short-term reductions capable from coping strategies such as lawn-watering restrictions.

But confirming that demand hardening can be a real phenomenon adds little to the discussion about whether it is a compelling argument against aggressively pursuing water conservation programs. That determination should be based on at least two threads of analysis: one that explores the extent to which conservation actually endangers service reliability and one that explores the net societal costs and benefits associated with the program.

The idea that conservation can threaten service reliability is often attributed to Flory and Panella (1994), but is generally not backed up in the literature by case studies or simulations. To the contrary, a simulation by DeOreo (2006) suggests good reasons to expect the opposite can be true.

Consider that the probability of any given year being a "shortage" is a function of both supply and demand. If a long-term conservation program decreases demand, for example, from 1,000 to 800 acre-ft, then a year featuring only 850 acre-ft of supply is no longer a shortage. Without the long-term conservation program, a reduction of 150 acre-ft of demand would be needed. Undoubtedly, this level of savings would be easier to achieve from a population that had previously been exempted from conservation requirements than from a population already subject to such a program. But it is erroneous to suggest that the long-term conservation program decreased the ability of the utility to respond to the shortage: It eliminated the shortage before it happened.

The situation would change significantly if the water savings from long-term conservation were used to facilitate new growth. If, in the previous example, the 200 acre-ft freed up from the program were used to facilitate 200 acre-ft of new demands (e.g., new housing stock), then the year of 850 acre-ft yield would create a need for 150 acre-ft of emergency reductions among of population of customers that are already efficient water users. This would certainly pose a larger challenge than if the long-term conservation program had never occurred and the 1,000 acre-ft demand was largely "unhardened" and distributed across a smaller population. On the other hand, if the 200 acre-ft freed up from the long-term conservation program were saved as reservoir storage, then the system's vulnerability to shortage would be greatly reduced by a combination of reduced demands and enhanced emergency supplies. Most systems would be unlikely to fall at either extreme because a combination of legal, political, and infrastructure concerns could determine how much water could be directed to growth and how much to storage.

Demand hardening. The other thread relevant to assessing this relationship between system reliability and demand hardening is economic: At what point are the long-term societal benefits of reducing baseline demands overtaken by the short-term costs associated with an increasingly hardened system challenged by drought or other supply emergency? Evaluating this sort of tradeoff is routine in economics literature; Howe and Goemans (2007) applied it to demand management. In their example, they envisioned a system in which ongoing conservation programs imposed costs of \$50,000 (\$20,000 for the measures themselves and \$30,000 in lost consumer satisfaction associated with the eliminated consumption), but returning capacity and operating cost savings of \$100,000, for a net annual benefit to society of \$50,000 (plus nonquantified environmental benefits) in nonshortage years. However, during shortages, this system now features an additional \$60,000/year in costs (borne by the utility and the customers) as a result of the now-hardened demand. Whether this is good economic policy is a function of the probability of any year being one featuring a shortage. If three years in 10 were shortage years, then the benefits from the seven normal years (7 × \$50,000 = \$350,000) exceeds the added costs from the three shortage years (3 × \$50,000 = \$150,000) by \$200,000, so the long-term conservation program is justified. However, if five years of 10 are shortage years, then the benefits (\$250,000) are exceeded by the added costs (\$300,000), and the long-term conservation program is not justified.

Although such a framework calls for the calculation of net societal costs and benefits to determine if demand hardening is a legitimate argument against conservation, it does not address the reality that utilities' behavior will not always be consistent with that economic calculation. One consideration is that a calculation of net costs and benefits hides the issue of how they are allocated between the utility and the customer. As discussed later in this article, conservation programs have significant financial implications for utilities because many programs have upfront capital costs, and reductions in water deliveries can stress revenue models tied to the volume of water consumed. What is good (economically) for society as a whole—in terms of minimizing public expenditures for water service—may not be good for the financial health of the utility. Perhaps of more fundamental importance is that some of the most important costs and benefits of concern to the utility are not economic, but rather are political and cultural. (Similarly, many of the benefits to society are not necessarily economic, including environmental benefits.) For many water managers, a successful management approach is one that minimizes situations in which the utility must ask customers to cut back on water consumption, regardless of whether that approach is economically justified at the societal scale.

> One of the most effective ways to shape customer behavior is through the design of water rates.

Potential solutions to a potential problem. Whether water conservation is a benefit or threat to service reliability is largely a function of two factors. First is the question of whether conserved water will be used primarily to support new growth, a practice that can unquestionably harden demand. To prevent this from occurring would likely entail strengthening the ties between water agencies and the planning and land-use agencies that shape growth. Determining exactly what form this integration should take, however, is a difficult question and is beyond the scope of this analysis (Kenney & Klein, 2009). Expecting water agencies to bear the responsibility for tempering the pro-growth attitudes of city-planning entities in water-short regions is unrealistic and is a function that water agencies generally do not want to—or be expected to—perform. A much more politically comfortable arrangement is to somehow condition new growth on the expansion of water supplies.

A second important factor is that maintaining nonessential water uses, including many outdoor uses, is only one type of coping mechanism used to deal with a service reliability concern. A nearly infinite variety of market (e.g., pricing) or regulatory (e.g., rationing) approaches could potentially be applied if managers were inspired to question cultural and political norms about what constitutes good water management. One particularly promising approach takes advantage of water use in many regions being a mix of municipal and industrial (M&I) and agricultural, and that a temporary shift of agricultural supplies to urban users can be a financial win–win for water users in both communities. Dry-year options and leaseback arrangements—which shift agricultural water supplies to urban users only in drought conditions—are examples (National Research Council, 1992).

If it can be shown that conserved water will primarily be used to serve new growth and that maintaining nonessential water uses (such as lawn watering) is the most practical coping mechanism for addressing any resulting water service reliability problems—and furthermore that neither of these conditions can be modified by reforms emerging either within or outside of the water utilities—then the so-called demand-hardening argument against long-term water conservation is established. But in many regions, this may not be the case.

Under western US water law, the first party to develop and use a water resource obtains the right to use that water in perpetuity.

FISCAL INCENTIVES

The incentives (and disincentives) of conservation facing water utilities and their water customers (end-users) are not identical. Why would they be? They are subject to different institutional frameworks. The more salient observation is that these two parties have incentives that are not always fully compatible; in some cases, this limits the degree to which water conservation can be used for climate adaptation or other objectives. In this section, the focus is solely on the financial incentives—for customers, these are the monetary costs paid for water service; for utilities, these are the mechanisms used to ensure that revenues cover costs. This relationship is primarily manifest in debates about rates and rate structures.

Salience of end-user water rates. There are many ways for customers (end-users) to conserve water, including using water-efficient technologies and responding to behavioral incentives discouraging excessive use and encouraging more efficient behavior (Vickers, 2010). One of the most effective ways to shape customer behavior is through the design of water rates. For most M&I customers, water bills comprise both fixed and variable components, with the latter featuring water priced in blocks or tiers, often in 1,000-gallon increments. Until recently, the tradition in most water agencies was to offer customers either a flat or declining rate structure—i.e., one in which the per-unit cost of water declines as consumption levels increase. However, decreasing block rates largely fell out of favor because of their ineffectiveness at discouraging excessive consumption and because "declining block rates cannot be justified unless the system tends to experience decreasing unit costs with increased usage." Although this was the case at one time, "it appears that many water systems have exhausted such economies of scale" (Phillips, 1993). The cost of providing additional water now often involves a significant jump in per-unit cost because it entails bringing new projects online that can lack the advantages in location, water quality, or reliability of systems constructed earlier.

An obvious solution has been to shift to increasing block rate structures in which the per-unit cost of water increases as consumption levels increase. This shifts behavior in two ways. First, the increasing block rate structure conveys to a customer that excessive water use is considered an undesirable behavior (Kenney et al, 2008; Olmstead et al, 2003); second, it imposes a financial penalty to those customers who persist with high-water-using behaviors.

Several studies document significant systemwide water savings attributable to establishing one or more high-priced billing tiers for high volumetric users, and the approach has widespread support among water conservation advocates (Western Resource Advocates, 2003). Water utilities often share in this enthusiasm because water use is generally price-inelastic (Brookshire et al, 2002), meaning that when prices are raised by a given percentage, consumption drops at a rate smaller than that percentage—for example, a 10% price increase may net an 8% drop in consumption. When this is the case, overall revenues do not decline (but actually increase slightly), and the cost-of-service requirement is satisfied. (The cost-of-service requirement states that, systemwide, total revenues received by the water agency need to cover the total costs of providing water service.) In an increasing block rate structure, high-tier water is priced above cost of service and low-tier water is priced below, so that the average of all water sold is at cost of service (i.e., total revenues match total expenditures). Thus, water is conserved; only profligate water users see major water bill increases (whereas low water users are rewarded with low water bills), and utilities achieve their revenue targets. Further refinements can still be pursued (e.g., tiers based on individualized water budgets), and to many observers, this is the right model. But it may not be so simple.

Despite the benefits of an increasing block rate structure, the behavioral incentives are incomplete. For example, although the high-tier prices discourage some of the most wasteful practices by the biggest water users, they do little to encourage conservation among other users. On the contrary, water at the lowest tiers is highly subsidized (by those using water at the highest tiers). This perhaps is a desirable public policy goal, because offering a modest level of water service at very low cost can be viewed as a basic human right. The bigger issue is that the water sold at the high-tier prices becomes an increasingly critical and sensitive portion of the utility's revenue stream. Research into this issue by Chesnutt et al (1996) found that "increasing the slope of an increasing block-rate structure always increased revenue uncertainty" because "steeply sloped rate structures generate more revenue from the upper tiers." For utilities with this characteristic, even a modest decline in consumption by these highest volumetric users can undermine the revenue picture—a problem that appeared only recently in many cities because of the combined onset of metering (which facilitates the transition to revenue models emphasizing variable charges over fixed charges) and the transition from declining to increasing block rate structures.

With this incentive structure, it can be financially problematic for utilities to aggressively clamp down on the most excessive water users and uses—particularly outdoor landscape uses, which are notable not only for their high volume (on Colorado's Front Range, for example, outdoor water use is generally assumed to compose at least half of total M&I water deliveries), but also for their very low return flows—stifling further conservation gains. This fiscal disincentive is further reinforced by the previously mentioned demand-hardening rationale because maintenance of high-volume users can be viewed as enhancing service reliability.

A further limitation of this pricing model is that it is designed so that in total the revenues generated exactly equal the cost of providing the water service (as cost-of-service mandates require). This is a form of average-cost pricing. An alternative approach advocated by many economists and in economic theory is to price water at its incremental or marginal cost to "ensure economic efficiency and promote conservation" (Phillips, 1993). The idea of marginal cost-pricing became popular among economists as early as the 1930s, led by proponents such as Emory Troxel and Harold Hotelling, but did not see application until the 1970s when Wisconsin and New York first implemented the practice in the electricity sector (Makholm, 2008). (Detailed information on how to implement marginal cost principles into rate structures is provided by the California Urban Water Conservation Council; Chesnutt et al, 1997). This argument for marginal-cost pricing is based on the observation that most water systems, as they expand, typically take on new elements that are increasingly cost-inefficient because the water provider must often look to increasingly distant and lower-quality sources for new water (Chesnutt & Beecher, 1998; Chesnutt, 1997). By averaging the expensive new projects in with the pre-existing and less expensive projects, the costs of expanding consumption are hidden, resulting in a premature growth in demand. In contrast, in marginal-cost pricing, all water is priced at the cost associated with the development of the last unit.

In an average cost regime featuring an increasing block rate structure, customers purchasing water in the highest tier may actually be paying a rate that is similar to the marginal rate, but that would be largely coincidental, and the economic benefits are mostly lost because water sold in the lower tiers is well below even the average cost. If an increasing block rate structure is to be used in a way that sends accurate signals about scarcity and the costs of providing water service, the high- and low-priced tiers should bracket the marginal cost, not the average cost. This is not a typical practice because it would result in revenues in excess of costs and would thus violate the cost-of-service standard under which most water utilities operate. Rather, the typical approach is to assess new users a separate charge (normally a tap fee) to convey that their new use is particularly expensive. In many ways, this is fair because it does not ask existing users to subsidize new users. But the result is that it allows water rates (on existing supplies) to remain artificially low and, more important, can make the utility financially sensitive to and dependent on new users (and their tap fees) in a way analogous to how the increasing block rate structure ties the financial health of the utility to the highest volume users. This was recently illustrated by the Southern Nevada Water Authority, which relies heavily on new connection charges. Since 1997, roughly 55% of Southern Nevada Water Authority's total revenues had come from connection fees. By 2006, before the real estate collapse, those measures annually generated $188.5 million in revenues. By 2010, those annual revenues had plummeted to $3.2 million and have rebounded only modestly to $11.1 million as of 2012 (SNWA, 2012). This creates a difficult environment in which to pursue conservation programs.

In addition to marginal-cost pricing, many economists believe that water rates should reflect the embedded value of the water system infrastructure. In addition to revenues that cover operating costs, many utilities—in sectors other than water—charge customers a rate reflecting the so-called "rate base"—the net value of the asset, which is a measure of either its initial cost, market value, or replacement cost minus any accrued depreciation (Phillips, 1993). It is easier to envision the application of this principle when focusing on a private enterprise in which investors expect a rate of return that reflects the magnitude of their investments and value of the assets tied up in the enterprise; in a public water system, the issue is more complex. But the overriding principle is that water systems are assets that in some cases are worth billions; to charge customers a rate that only reflects operating costs fails to capture the opportunity costs associated with tying up so much valuable capital. Again, the differences between economic analysis and financial analysis largely explain the tradition of largely ignoring the value of the water system assets in establishing pricing regimes.

Ultimately, any approach such as marginal-cost rate setting, which results in higher water rates for end-users, promotes conservation—even though water consumption is typically price inelastic (i.e., an *X*% increase in price results in something less than an *X*% reduction in consumption) (Brookshire et al, 2002). However, there is little reason for water utilities to support such changes because it would require politically unpopular rate increases, and under cost-of-service pricing, any "excess revenue" would need to be returned to the customer. If it is returned in the form of rate reductions, it simply brings the rate structure back to average-cost pricing. Revenue surpluses could potentially be refunded in other ways (e.g., through reduced property taxes, allowing money to accrue in an operation and maintenance or system expansion account). These approaches ensure that the customer gets something for the increased economic efficiency. But, again, it offers little to the utility. Neither solution imposes a reason for the utility to discourage high consumption among end-users (in fact, high consumption might be encouraged if surplus revenues fed an operation and maintenance and expansion account); similarly, neither approach provides the utility with an incentive to encourage reduced end-user consumption.

In summary, although increasing block rate structures has proven effective in providing customers a signal and an incentive for supporting water conservation, and although this has been done to date in a way that has not imposed fiscal burdens on water utilities, achieving further conservation gains may require addressing a utility's fiscal disincentives to conservation (Beecher, 2010; Chesnutt & Beecher, 1998). Specifically, the challenge is to identify models that provide customers (end-users) and water utilities with fiscal incentives for water conservation.

The institutional environment of utilities. Any attempt to devise new approaches that provide conservation incentives to both end-users and utilities must acknowledge that we do not have the luxury of a blank slate on which to innovate. Between the rate structures that guide end-user behavior and the revenue models that shape how utilities can and must behave to fund their operations are a host of institutional arrangements designed especially to meet the needs of "public utilities"—i.e., those enterprises focused on providing public needs for energy, water, public transportation, telecommunications, and other shared services. A common characteristic of such undertakings is that service is most efficiently provided by firms acting as monopolies because this avoids wasteful expenditures on repetitive infrastructure. From a structural standpoint, the variety in public utilities is best captured by three closely related key distinctions: (1) how they are structured, (2) how they are regulated, and (3) how much revenue they are allowed to collect and keep (Phillips, 1993). These elements are briefly described in the following paragraphs, in part to illustrate that US water utilities are not only different from most other public utilities, but also that they are different from water utilities in most other developed countries.

Utilities typically take two possible structures: private investor-owned utilities (IOUs) subject to governmental regulation through various public utility commissions (PUCs) or entities established by government to provide these services. In most industrialized countries, the tradition is for government to establish entities to provide public services, with privatized water service being a common exception. The opposite pattern exists in the United States—here, IOUs dominate the landscape in fields such as energy and telecommunications—whereas the water sector is almost entirely reliant on government-established utilities. This is particularly true for large M&I water systems. These US water utilities have a variety of structures, with most falling on a continuum from an agency of local government to an independent agency.

In most states, the jurisdiction of the PUCs is limited to the IOUs, which effectively excludes water utilities from their oversight. Instead, water utilities that are agencies of local government are typically overseen by city councils (with capital needs often financed by general obligation bonds), whereas independent agencies are overseen by elected or appointed commissions (with capital needs often financed by revenue bonds). Perhaps because of this relationship, most of the leading theories and practices regarding the regulation of public utilities are not seen in the water sector. As Phillips (1993) observed two decades ago: "[C]ompared with other utility industries, the water industry has been neglected." And it still is.

As noted, a typical US water utility operates under a cost-of-service framework, also known as a revenue-requirement or a cost-recovery model, that limits it to keeping only those revenues sufficient to cover its cost of service. Although this is done to shelter citizens from price-gouging, it essentially means that agencies have no compelling economic incentives, so decisions are based on other criteria. Because agencies do not get to accrue profits, they have no economic incentive to maximize revenue through rate increases or to limit costs by pursuing the most cost-effective strategies to meet demand. But in many cases that is exactly what conservation requires—raising end-user water rates and meeting demands through avoided consumption.

A much more politically preferable outcome for the agency is to keep rates low (as long as revenues can cover costs). Low rates, however, encourage premature growth in demands, accelerating the pursuit of new and often expensive projects. Unless these new costs are completely offset by tap fees, system expansions ultimately translate to rate increases—although they are softened by using average-cost pricing—but this lags rather than proceeds the decision to expand, forgoing the opportunity for price signals to inform any public consideration of the merits of expansion. Additionally, such an expansion may occur in a crisis mode in which the new project can be defended as essential and the public can equate the higher rates with a tangible asset—the newly constructed project—making the politics manageable. The cost-of-service mentality ensures that rate increases to deal with emerging (and perhaps self-created) scarcity problems are seen as reasonable and politically viable; rate increases designed to avoid future scarcity problems are not. In this way, a policy intended to limit customer costs actually discourages conservation and encourages construction of new (and inherently more expensive) sources of water that the public must ultimately pay for—and ensures that the pattern will repeat.

Alternative models. That utilities often face a financial disincentive to conservation is not a new observation, nor is the realization that pursuing aggressive conservation-oriented rate reforms for end-users can be politically sensitive. These are longstanding and well-understood problems in other utilities, especially in the energy sector. A variety of strategies can be used to deal with existing conservation disincentives (Malecek, 1992). At one extreme is the traditional command-and-control regulation—i.e., a mandate from an oversight body requiring the utility to implement conservation programs. This approach does not remove the disincentive per se, but simply removes the ability of the utility to let the disincentive dictate behavior. This approach is likely to gain much higher utility support if it is tied to a commitment from the oversight body to "reimburse" the utility for any resulting lost revenues. This can be done by ensuring prompt consideration and approval of rate increases (as revenues fall) or by developing net lost-revenue adjustment mechanisms to steer other sources of public funds to the utility facing the shortfall (Baxter, 1995).

A different approach is to sever completely the responsibilities for conservation from the utility with the responsibility for providing service. One example of this model is the Energy Trust of Oregon, an independent nonprofit organization established in 2002 to offer services and cash incentives to customers to pursue energy conservation (http://energytrust.org). A small portion (3%) of electricity and natural gas bills finance efforts that the trust estimates have saved customers more than $1 billion on energy bills and, more important, have eliminated the need for $1.57 billion in expansion investments by the utilities—costs that would have been passed on to ratepayers. The trust estimates that electricity conservation is usually one fourth the cost of system expansion.

Decoupling. Approaches that remove the financial pain that utilities associate with conservation, although a major step forward, still do not necessarily provide incentives for conservation. One approach for a utility is known as decoupling (Erickson & Leventis, 2011; Hirst et al, 1994; Cross, 1993), a term used to describe mechanisms that sever the link between utility revenues and the amount of a good sold. Instead, utility revenues are "recoupled" to some other value, such as the number of customers served and/or the reliability or quality of that service. In most cases, customers are still assessed charges (at rates established by regulators) based on quantities consumed—thereby preserving the conservation incentive for end-users—but the allowed revenue the utility is awarded is based on the newly established criteria. The allowed revenue is a determination made by the oversight body based on a consideration of various factors, undoubtedly including some consideration of the utility's fixed costs and revenues, often calibrated to metrics such as the

Consumer Price Index or other variable costs (e.g., fuel costs, weather).

Decoupling can take various forms (Hirst et al, 1994). The most basic form is revenue-per-customer decoupling, in which allowed revenues are the product of the number of customers served multiplied by a fixed value ($*X*/customer). As an illustration, consider a community in which customers have historically on average paid about $1,000/connection for annual water service that the utility can provide at $1,000/connection. The system is at equilibrium, just as the cost-of-service model dictates. Now consider a newly established decoupling program in which the utility has an annual budget of $975/connection to provide reliable water service in the service area. This money will be paid from an account managed by the regulator and fed by customer water bill payments. Given this situation, the utility realizes that the status quo will result in a net loss (of $25/connection) and further that a growth in customer demands will magnify losses as the cost of providing service will increase further, whereas the revenue retained by the utility will not.

For the utility, the throughput incentive is broken because more sales equal greater losses, not greater revenues. The better management strategy in this situation is to aggressively pursue conservation programs that result in less demand (and thus a reduced cost to serve each customer, say $950/connection), which when matched to the guaranteed return of $975/connection, nets a profit to the utility (of $25/connection). In short, any efficiencies the utility can implement that lower the costs of providing service generate additional utility profit; likewise, failure to control costs or to avoid growth in customer consumption will reduce profits and could trigger losses. Rates and allowed revenues are periodically adjusted to keep the arrangement financially solvent, but always with the intent of rewarding the most cost-effective means of providing service, which in most cases is conservation.

During the past three decades, the majority of experimentation with alternative utility business models focused on the electricity and natural gas sectors; the water sector has been largely absent. In part, this is due to the presence of active PUCs in the energy sector, which in turn, is largely reflective of the prevalence of IOUs (Totten et al, 2010). Some models, such as decoupling, rely on the profit motive of the regulated industry. Decoupling does not seek to remove profits but rather to change the way utilities earn those profits; in a decoupled system, profits do not arise from increasing sales but by strategies that help customers conserve or that provide services at lower per-unit costs.

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As noted previously, very few US water utilities are IOUs, which has discouraged experimentation with water utility decoupling. One exception is California, where approximately 20% of its residents are served by IOUs, and, since 2008, several have been subject to decoupling programs administered by the California PUC (Erikson & Leventis, 2011). A water revenue adjustment mechanism keeps track of each utility's actual revenues and allowed revenues; similarly, a modified cost-balancing account tracks actual and adopted costs. Any accrued balances are periodically amortized into future rates, with overcollections refunded to customers and undercollections leading to surcharges.

The experience with decoupling in California is too brief to support many conclusions (Beecher, 2010), although Ernst & Young (2013) suggest the effort, although "not perfect," is nonetheless a "success and thus can provide a case study for other regions." Consumption levels have dropped as intended, but municipal water demand has been dropping for many years, a trend accelerated by the recent economic downturn. This trend highlights the complex relationship between revenue models and the risks assumed by utilities and customers. Before decoupling, these below-expected demand levels would have resulted in a sharp revenue decline for the utility and an immediate savings (i.e., lower bills) for customers—at least until rates were adjusted. Similarly, before decoupling, when external forces would have promoted higher-than-expected consumption, utilities would have expected a revenue increase, and customers would have seen higher bills initially, perhaps dropping over time. Without decoupling, these fluctuations, for both utilities and customers, presumably balance out, but the year-to-year fluctuations can be significant. With decoupling, these swings in utility revenues and customer bills are moderated because the decoupling arrangement ensures stable utility revenues, and for customers amortizing utility revenue imbalances into bills as credits and surcharges over long periods can potentially moderate short-term fluctuations associated with rapid pricing changes.

SUMMARY AND CONCLUSION

Expanded water development and consumption have facilitated economic development in many regions, including the western United States. However, in areas where supplies are no longer abundant, a continued expansion in water consumption can entail unacceptable economic and environmental costs and can undermine service reliability—especially under climatic regimes threatening reduced streamflows. In such situations, reducing water consumption is the management approach promising the greatest societal benefits. This is a fundamental shift in the industry and suggests that the behavioral incentives that guide utility decision-making may require reexamination—especially of those elements most directly tied to the previous era of abundance and expansion. Incentives for continued expansion of water consumption are an obvious concern, as are the disincentives for conservation.

At first glance, the two issues highlighted in this article—the ways in which long-term conservation can negatively affect both service reliability and revenue stability—seem to be different, but they are actually closely linked. From the water utilities' standpoint, maintaining high levels of inefficient and interruptible consumption (primarily landscape watering) does an admirable job of achieving present-day service reliability and revenue stability—the primary goals of most utilities. But what is good for any given utility is often not good for the entire industry, because high consumption levels breed conflict and escalating costs. Although society certainly shares the utility's goals of service reliability and revenue stability, a full articulation of societal objectives would also prominently feature cost-effectiveness, environmental protection, conflict avoidance, and social equity over the long term; in other words, sustainability. Going forward, it is difficult to imagine that this full suite of objectives can be achieved by a management model that systematically provides more incentives for consumption than for conservation. But changing behavioral incentives is a formidable challenge.

Two overarching problems are particularly salient. First is the observation that from the standpoint of some utilities, the most proven way to "reserve" water for future needs is to promote and maintain current consumption in inefficient and interruptible uses. Not tapping a water supply today no longer means it will be there for use tomorrow; rather, it means someone else will take it. Even water stored in your own reservoir may not really be reserved for you because it may get redirected to a new use or user. This, in a nutshell, is the demand-hardening argument. Second, the traditional approach for utilities to meet existing financial commitments is to promote full utilization of existing supplies. Water projects are normally financed by bonds, and the revenue to pay those bonds typically comes from selling water. This is the throughput incentive. Combined, these two realities encourage projects to come online and be used at full capacity much earlier than would otherwise occur, which in turn, accelerates the race for future development and consumption.

Given these observations, it is fair to conclude that protecting service reliability by perpetuating high levels of nonessential or inefficient water uses that can be curtailed during shortages is clearly inefficient and nonoptimal. However, it is a still common strategy that is a logical and predictable outcome of the incentive structure within which many utility decisions are made. To the extent that different outcomes are sought, then different incentives will be necessary. For that to happen, oversight bodies—more so than the water utilities themselves—will need to show more leadership. This has been seen in the energy sector, primarily driven by the presence of PUCs. Given the lack of profit-driven (i.e., IOU) water agencies, PUCs are largely absent from the decision space. It is ironic that PUCs are presumed unnecessary in the water sector given the cost-of-service model, which is intended to shelter citizens from price-gouging but instead ensures that decisions are made by utilities that lack economic incentives. Because public water agencies do not get to keep accrued "profits" or suffer "losses," they have no economic incentive to maximize revenue through rate increases or to limit costs by pursuing the most cost-effective strategies to meet demand. But those are core tools for achieving big conservation gains and are an essential part of the formula for increasing long-term societal benefits.

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