Tapping into Conservation:

Emerging Demand Side Management Practices to Augment Residential Water Prices

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LOS ANGELES SUSTAINABILITY COLLABORATIVE

About the Los Angeles Sustainability Collaborative (LASC)

The Los Angeles Sustainability Collaborative (LASC) is dedicated to creating a more sustainable Los Angeles by facilitating research, informing stakeholders and providing solutions to emerging environmental challenges. LASC seeks to achieve this mission by 1) promoting collaboration with other non-profit organizations and academic institutions to identify research needs on key environmental issues, 2) funding research projects conducted by emerging environmental leaders at the university level, and 3) sharing research findings at community events that bring together and foster collaboration among environmental, policy, community, and business stakeholders.

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Executive Summary

The Los Angeles region is already a leader in water conservation, Los Angeles city has the lowest per capital water usage of any U.S. city with a population over one million and is part of the Southern California region which has grown by five million people since 1985 without an increase in net water demand.[1] Yet, as California faces an unprecedented drought, Los Angeles region water utilities are compelled to expand their demand-side management portfolios and explore novel approaches to further reduce water consumption. Home to almost 10 million residents, Los Angeles County exhibits diversity of climate zones, building types, income, and demographics. The area's water retailers have consequently employed a diverse array of price-based and non-price based measures to curb regional water demands. In fact, the larger South Coast region which is home to LA County leads the nation in tiered water rate budgets, expenditures on conservation rebates, and recycles a higher percentage of wastewater than any other place on the globe except for Israel. However, LA county retailers must pursue further improvement to decrease their reliance on imported water.

This paper has several goals. We aim to provide water retailers, policymakers and other stakeholders with practical information about best practices in price-based and non-price-based demand side management, explore how different populations respond to different approaches, and recommend policies that can increase conservation effectively and equitably.

Demand side management programs ultimately aim to encourage two types of actions. The first is conservation or curtailment. Examples of conservation include actions like taking shorter showers or watering the lawn less frequently. The second is investment in efficiency improvements that enable consumers to use less water to accomplish the same tasks, for instance by investing in water efficient appliances like dishwashers or low-flow toilets.

The two main challenges are:

- **Inconsistent Responses to Increasing Block Tariffs**: Experiments suggest that consumers do not always react to price-based demand side management measures as economists would expect. In some instances, consumers' responses to increasing block tariffs (IBT), where consumers pay more per unit of water as they use more, were not meaningfully different than if they faced a fixed volumetric rate, implying that in some instances the rate fails to create a high perceived incentive for high users to conserve.
- **Consumer Heterogeneity and Equity**: Consumers of different income classes have been shown to respond differently to demand side management measures. Most importantly, higher-income consumers have been shown to be less sensitive to price changes despite the fact that, on average, they consume more water and are more likely to have a lawn giving them more potential to conserve. Preliminary evidence also suggests that there are differences in the responsiveness of different groups to non-price policies.

Understanding these challenges can help policymakers and water retailers craft practices that can further reduce water usage and prevent a disproportionate impact on low-income

[1] "Southern California Water Use Trends, Developments and Local Supplies." Southern California Water Committee, September 30, 2014.

consumers in their service territories. This paper makes these general recommendations, many of which have been already been adopted by leading water retailers in the Los Angeles region:

Price-based measures

- **Increasing the cost of non-essential use**: Several strategies can be used to increase the incentives for high-income consumers to reduce usage while protecting low-income consumers. These strategies include using household specific budgets to determine rate tiers and sub-metering of outdoor and indoor uses.
- **Use education to improve price efficacy**: Utilities can inform consumers of rate structure by providing on-bill information about rate structure, delivering web-based information on customer's specific water usage, and alerting consumers when they enter the higher rate tier.
- **Drought pricing**: Utilities can increase the rate for non-essential usage during droughts to reduce water consumption.

Non-price-based measures

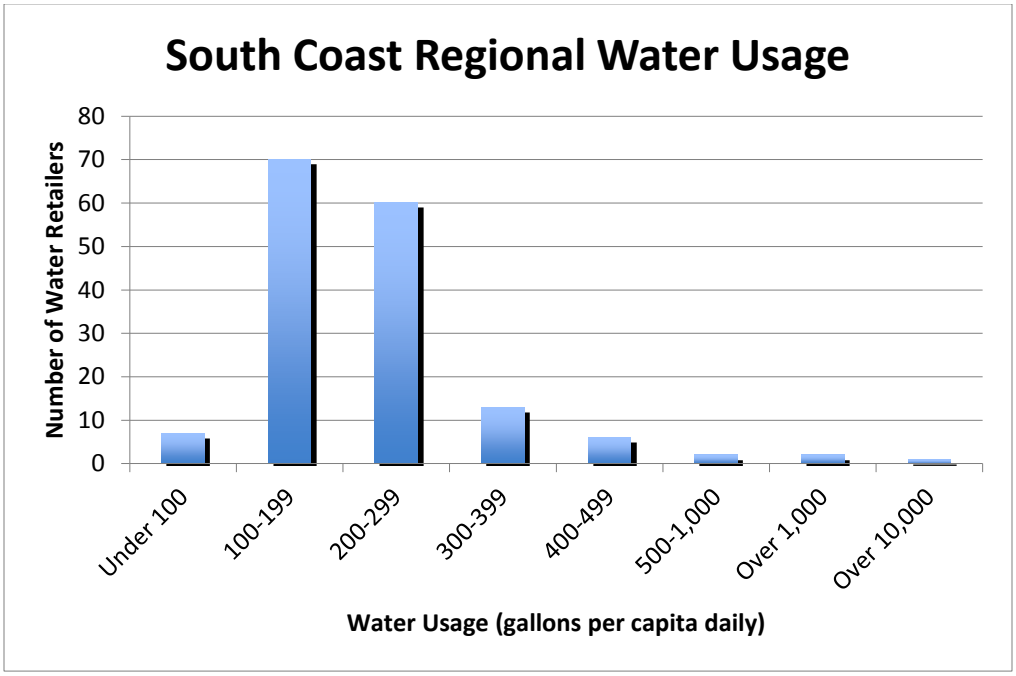
- **Social comparisons**: Comparing water usage with the consumers' neighbors and stating the social and environmental impact of the usage may entice high-volume users to reduce their consumption. These consumers are otherwise difficult to influence due to their insensitivity to incremental rate increases.
- **Further research to refine social normative comparison**: While electric utilities have expanded their use of "behavioral" strategies like social comparisons to encourage conservation, this practice is still fairly new and has not yet been widely studied in the context of water. Further studies and partnerships can identify effective messaging and information delivery methods that can maximiz impact.
- **Employ mandatory but flexible restrictions during periods of critical scarcity**: Placing restrictions on non-essential water use can result in large reduction in water usage, particularly in higher-income neighborhoods, yet rigid constraints on behaviors (for example enforced watering days) can, in some cases, lead to increased usage.

Introduction

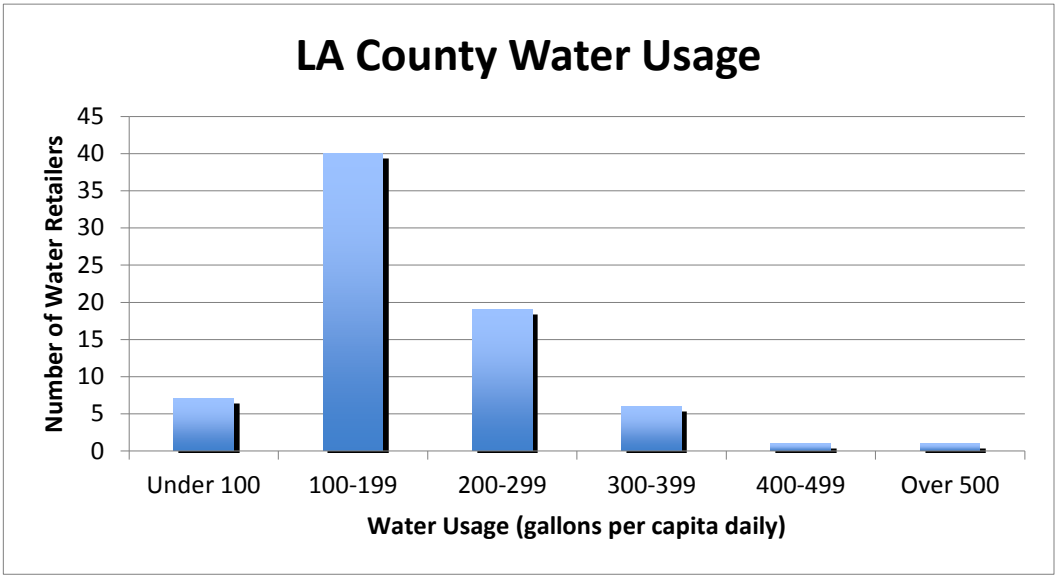
Governor Brown declared a state of emergency in January 2014, in response to a drought that endangers California's ability to meet the water needs of its ecosystems, agriculture, and citizens. Looking back at California's history, it is clear that this drought is not exceptional, but part of an ongoing trend in a state with the largest population in the U.S., a large agricultural sector, and unpredictable precipitation. Unfortunately, water shortages will only become more critical and more frequent in a warming climate as Sierra snowpack diminishes and precipitation becomes less predictable

While developing new sources of water will undoubtedly be a part of the state's long-term strategy, demand-side management, which describes a variety of price-based and non-price-based approaches to alter ratepayers' consumption behaviors, also represents relatively affordable and reliable source. For this reason, the legislature passed SBX7-7 in 2009, which mandates water retailers to reduce their per capita water use by 20% by 2020 and develop Urban Water Management Plans to meet that goal.

The Los Angeles region has been a leader in water conservation, but still has significant opportunities to improve water conservation by employing efficiency or conservation measures. Daily per capita water consumption in the Southern coastal area of the state is in the range of 190 gallons per capita daily (gpcd) while per capita consumption in Los Angeles County averages around 163 gpcd. [2]Water consumption in most cities' range between 100 to 299 gpcd. Huntington Park holds the lowest consumption in the County at 77 gpcd. The County's average is lower than the South Coast regional average. The charts below compares water usage of the entire South Coast region with the County of LA.



[2] Calculation based on San Jose Mercury News' Data Center: Average Water Usage by Supplier in California, where the City of Los Angeles has a gpcd of 152. http://www.mercurynews.com/data/ci_25059942/water-usage



A recent analysis by the NRDC and the Pacific Institute[3] reveals that a home taking advantage of available and cost effective efficiency technologies, such as low-flushing toilets and high-efficiency washing machines, and practices should only consume 50-90 gpcd, demonstrating that the LA County can still do more to conserve.

While demand side management is a problem that California energy and water suppliers have grappled with for decades, there has been a proliferation of more recent studies with new insights into which approaches may be the most effective, especially for residential consumers who consume 70% of the county's water budget. [4] We have both surveyed that literature and consolidated it in order to make it more accessible to Los Angeles water retailers, policymakers and other stakeholders who wish to increase the region's drought resilience.

Temporal dynamics of conservation actions

Any retailer's demand side management plan likely includes strategies to encourage both conservation and efficiency. Efficiency improvements are critical because they lead to durable changes in water demand, but the widespread adoption of efficient technologies tends to be slow since consumers may only replace equipment when it breaks or when building ownership turns over.

Conservation, especially dramatic conservation that has been observed in response to past droughts, can lead to rapid changes in aggregate demand, but may be difficult to sustain over time if it requires consumers to make significant sacrifices.

Most consumer retailers' strategies will likely rely upon continued emphasis on efficiency to manage long-term demand and campaigns to induce pronounced conservation in response to periods of water scarcity. However, as homes become more efficient, the amount of water that they can reduce through conservation declines, a phenomenon often referred to as demand

[3] Pacific Institute and National Resources Defense Council 2014 "Urban Water Conservation and Efficiency Potential in California" *Issue Brief 14-05-D*
[4] CUWCC Water Use Billed 2010

hardening. Due to Metropolitan Water District leadership in providing rebates for efficient technologies to LA County households and businesses, consumers may not be able to cut use as dramatically as consumers in less efficient communities. For this reason, the effect of policy interventions designed to induce conservation could be somewhat muted in the region unless those policies persuade consumers to make large changes to the way that they use water, for instance by changing their landscaping practices.

Understanding Water Use in Los Angeles

In order to evaluate the conservation potential for a given community and its ideal conservation strategy, it is important to assess both the adoption rates of efficiency technologies and end-use composition, specifically the ratio of indoor to outdoor water use. For example, some communities may be disproportionately made up of multi-family buildings, or dense single-family developments with minimal outdoor landscaping. It would make sense to prioritize efficiency in that jurisdiction since households do not have large discretionary water budgets that they could cut. On the other hand, another community may have little potential for improvements in efficiency due to high rates of efficient technology adoption but may have the potential to realize large reductions by foregoing lawn watering during droughts.

It is important to remember that the relative efficiency and curtailment potential of different communities may exhibit strong overlap with income. For example, individuals in higher income communities may use more water per household, in part, because they are more likely to live in a single-family dwelling with a lawn. A study of residential consumption in the City of Los Angeles conducted by UCLA's Center for Sustainable Communities found a strong correlation between higher incomes and water consumption and the link was particularly strong between income and outside water use.[5] This has important implications for policy since research indicates that high-income consumers are less likely to conserve in response to marginal price increases.[6789]

The relationships between income, consumption, and price sensitivity raise important equity concerns when designing demand-side management policy, especially for retailers that serve economically diverse communities. For example, imagine a utility serves both low-income consumers living in apartments consuming little discretionary water and high-income consumers living in single-family homes with large lawns. If they simply raised prices in order to incentivize conservation, the price change may not be dramatic enough to convince high-income consumers to cut-back on their watering. At the same time, the higher prices may create a burden for low-income consumers who are forced to either bear the cost or cut back on essential water uses. In a worst-case scenario, the price change would not result in appreciable demand reduction, and may create economic hardship for low-income families.

For this reason, it is critical that individual utilities assess the make-up of their communities and target demand side management policies to advance both the adoption of efficiency and conservation during periods of drought. Demand side management policies can generally be divided into two categories, price-based and non-price-based.

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[5] "Residential Water Consumption in Los Angeles: What are the drivers and are conservation measures working?" A policy summary written by Céline Kuklowsky, based on the Ph.D. dissertation of Caroline Mini at UCLA, and overseen by Terri Hogue and Stephanie Pincetl, California Center for Sustainable Communities at UCLA. Part of a National Science Foundation funded project.

[66] Wichman, C. Taylor, L. von Haefen, R. 2014 "Conservation Policies: Who Responds to Price and Who Responds to Prescription" *National Bureau of Economic Research Working Paper Series*

[7] Mansur, E. Olmstead, S. 2012 "The Value of Scarce Water: Measuring the Inefficiency of Municipal Regulations." *Journal of Urban Economics*

[8] Renwick, M. Archibald, S. 1998 "Demand side management policies for residential water use: Who bears the conservation burden?" *Land Economics*

[9] Ito, K. Ida, T. Tanaka, M. Draft "The Persistence of Intrinsic and Extrinsic Motivation: Experimental Evidence from Energy Demand"

Price-Based Demand Side Management

The simplest way to efficiently allocate a scarce resource is to make it more expensive, consequently increasing consumers' incentive to use less of it. While the price responsiveness of residential consumers is often debated, a survey of the literature reveals that a 10% increase in price generally produces a 3-4% reduction in urban residential consumption[10]. However, there are several reasons why utilities may choose alternative policies to manage demand. For example, california water utilities' ability to raise rates is significantly constrained by the legal requirements of Propositions 218, 13, and 26[11]. As a result, utilities often cannot increase water rates as part of a demand side management strategy and they may potentially face limits to the types of tariff structures that they can adopt.

Independent of political concerns, raising rates can also create equity concerns if low-income families cannot meet their basic water needs affordably. More complicated rate structures can potentially address that issue, but other rate structures may exacerbate equity concerns. The most commonly encountered rate structures that residential water consumers face are listed below.

- **Flat Fee**- though uncommon, there are properties in California that pay a set fee for water regardless of the amount that they consume. Properties facing this pricing system have no incentive to curb their use, and unsurprisingly have been found to use more water than similar properties that face a volumetric charge.[12]
- **Constant Volumetric Fee**- Many water consumers pay a uniform volumetric fee per gallon they consume. It is important to note that most consumers facing this type of fee pay both a fee for service as well as a per-gallon charge. The ratio between the volumetric and the fixed fee determines the monetary incentives to conserve.
- **Decreasing Block Tariff**- There are some instances in which consumers pay a volumetric fee that declines once they have exceeded certain usage thresholds, analogous to a bulk discount. This type of structure reduces the incentives for heavy consumers to conserve.
- **Increasing Block Tariff (IBT)-** It is more common for retailers, at this point in time in the Los Angeles region, to employ a rate structure under which prices *increase* with usage. IBT is a form of tiered rates, which is indicated as one of the rate structures that can incentivize conservation in California Urban Water Conservation Council's best management practices.[13] These types of tariffs generally take two forms. ***IBT rates*** establish set usage tiers based upon the volume of water consumed. The first set amount of water is charged at a relatively low per gallon price and then once they cross a predetermined threshold that per gallon price increases. Tariffs range from two-block

[10] Olmstead, S. Stavins, R. 2007 "Managing Water Demand: Price vs Non-Price Conservation Programs" *Pioneer Institute White Paper* No. 39

[11] For a more in depth discussion of the legal limitations for California water retailers to raise rates see Hanak, E. et al. 2014 "Paying for Water in California" Public Policy Institute of California

[12] Kim, Mina and Molly Samuel. "California Communities that Pay a Flat Rate for Water Use More of It." KQED Science. March 10, 2014. http://blogs.kqed.org/science/2014/03/10/california-communities-that-pay-a-flat-rate-for-water-use-more-of-it/

[13] "Utility Operations Programs." California Urban Water Conservation Council. http://www.cuwcc.org/Resources/Memorandum-of-Understanding/Exhibit-1-BMP-Definitions-Schedules-and-Requirements/BMP-1-Utility-Operations-Programs

systems to those with multiple blocks that create greater and greater incentives for heavy users to conserve. With ***IBT budgets,*** those price tiers are determined by housing level characteristics like household size or irrigation needs. These budgets aim to establish a set budget of "essential use" for each household so that utilities can ensure that households can purchase affordable water to meet basic needs, while providing a strong incentive to reduce discretionary water consumption.

- **Seasonal Rates**-The marginal cost to the retailer of providing water varies over time, and often increases during warmer months. To reflect the greater costs, some utilities may vary their rate schedules seasonally.
- **Drought Rates**- Increasing consumer water rates during droughts is the easiest way for the retailer to communicate the higher cost of water scarcity to consumers and to recover revenue outlays when sales decline due to higher rates. This provides a clear incentive for consumers to conserve when those actions are the most critical.

It is important to note that regardless of whether a pricing schedule is flat, volumetric, or a "block" tariff, those rates may still vary across seasons or be subject to drought rates.

The water management community has generally come to the consensus that the increasing block tariff (IBT) is a demand-side management best practice since it promises to keep essential water use rates low without eroding the conservation incentive of high users. [14][15] This type of pricing system has been very popular in the electricity sector; California's three investor-owned utilities adopted five tier IBT rates in the wake of the deregulation crisis in 2001. While not as widespread as in the electricity sector, IBT has also been growing in popularity among water retailers. As of 2005, 50% of California's water utilities were utilizing IBT pricing[16] though the use of IBT budgets remained limited[17].

In theory, IBT should be effective in promoting conservation equitably, but it rests on two main assumptions. First, in order to be effective, consumers must be informed about and attentive to the rate structure, so that they realize that water is becoming progressively more expensive as they use more. Second, if utilities wish to protect low-income consumers from high rates, those consumers must either have relatively low usage or the ability to reduce usage while meeting their basic needs.

Rate structures in Los Angeles County

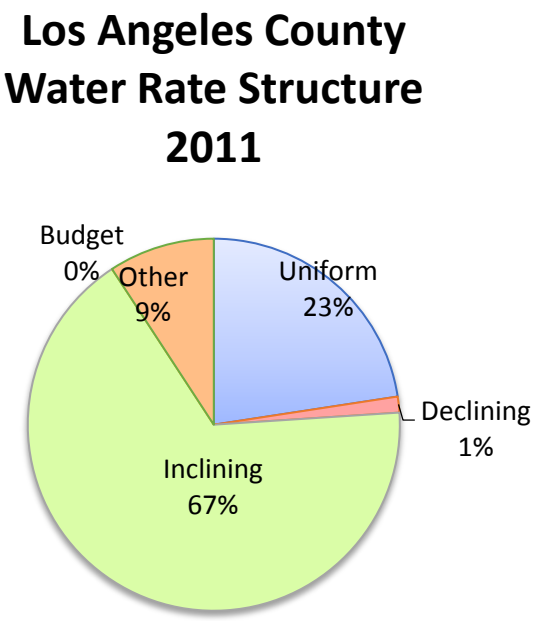
Data obtained from the American Water Works Association (AWWA) showed that most water retailers in Los Angeles County have adopted increasing tiered rates for residential users. Some have also adopted seasonal rates—Long Beach Water Department has seasonal increasing block tariffs, where block rates are higher during the summer season. Some retailers adopted uniform rate structure, and those may apply to mostly multi-family residential units.

[14] Cooley, H. Donnelly, K. Ajami, N. 2013 "Energizing Water Efficiency in California: Applying Energy Efficiency Strategies to Water" Pacific Institute

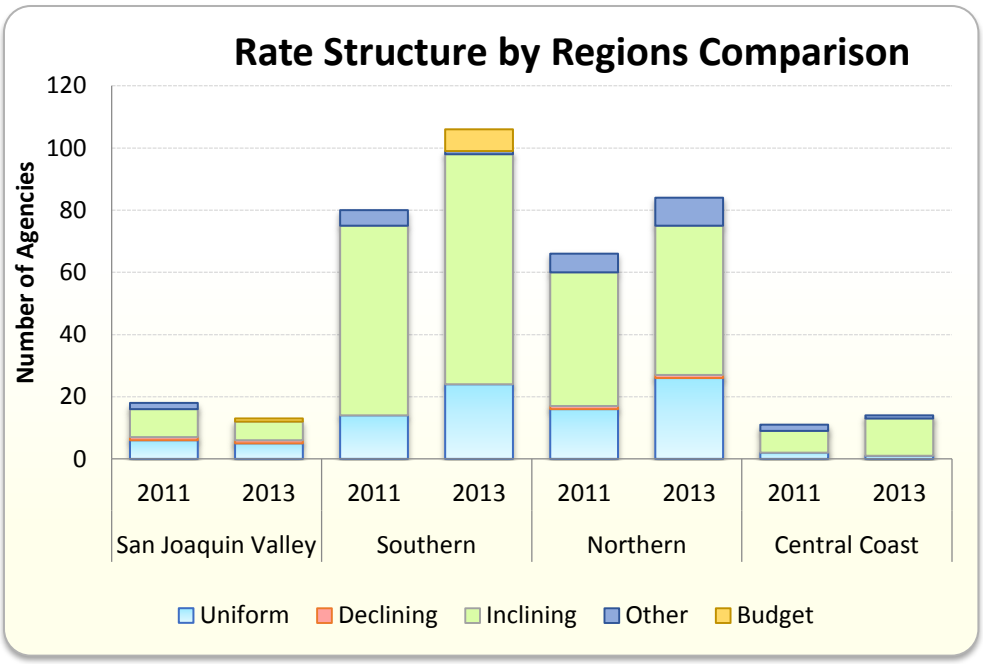
[15] Veverka, J. 2010 "Keeping Water Conservation Afloat" Sustainable outdoor water conservation through progressive,ely tiered pricing" Report for Los Angeles Sustainability Collaborative

[16] Hanak, E. 2005 "Water for Growth: California's new frontier" *Public Policy Institute of California*

[17] Mayer, P. DeOreo, W. Chesnutt, T. Summers, L. 2008 "Water budgets and rate structures: Innovative management tools" *Journal of the American Water Works Association* 100(5)



Source: AWWA CA/NV Survey 2013



Source: AWWA CA/NV Survey 2013

The survey results also revealed that in the larger Southern California region some retailers have adopted budget or allocation-based rate structure, which could signal more urgency in water conservation as the drought persists. Budget rate structure in general disincentivize non-essential use, since using more water than budgeted will be significantly more costly for ratepayers.

Do consumers respond to increasing block tariffs?

Consumers facing increasing water rates under IBT should feel more pressure to conserve water as they use more, yet many households may not even realize that water is becoming progressively more expensive. Surveys have revealed that only a small fraction of consumers are aware of the per-unit cost that they pay for water[18] and research across domains shows that inattentive consumers tend to imperfectly interpret complicated price schedules. Specifically, they "smooth" increasing block rates and behave as though they face a constant rate equal to the average unit cost.[19]

The literature on the response of water consumers to IBT is mixed. One Santa Cruz study showed that consumers did measurably reduce use in response to the addition of a third price tier and the reduction was most marked among consumers with consumption in that tier.[20] Similarly a study of Eastern Municipal Water District's IBT water budget prices found that the pricing system resulted in an 18% reduction in consumption compared to a constant volumetric fee generating the same amount of revenue.[21]

However, two other recent studies of typical IBT tariffs found that consumers responded to the average price rather than the marginal, increasing cost of water.[2223] In addition, an analysis of the determinants of water conservation for the Los Angeles Department of Water and Power (LADWP) showed that consumers were actually more responsive to changes in Tier 1 (lower usage tier) rather than Tier 2 prices. This trend was particularly pronounced among higher users and higher-income groups while low-income consumers were more sensitive to changes in Tier 2 rates.[24] These results indicate that, at least within LADWP's service territory, the IBT is failing to incentivize conservation among higher-volume users while disproportionately affecting low-income households.

Improving increasing block tariffs

The failure of many consumers to respond to the granular incentive signals of an IBT does not diminish the fact that it provides an opportunity to insulate those who are low users from significant increases in price. It also ensures better paybacks for those investing in efficiency, or even on-site grey-water systems.

It may be possible, through complementary policies, to enhance the efficacy of price signals. Researchers at UCLA and Stanford found that after teaching California electricity consumers about how the IBT rate structure impacted their bill, consumers became more price-sensitive,

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[18] Carter, D.W. Milon, J. W. 2005 "Price Knowledge in Household Demand for Utility Services" *Land Economics*

[19] Liebman, Jeffrey and Richard Zeckhauser. 2004 "Schmeduling"

[20] Nataraj, S. Hanemann, M. 2011 "Does Marginal Price Matter? A regression discontinuity approach to estimating water demand" *Journal of Environmental Economics and Management* 61

[21] Baerenklau, K. Schwabe, K. 2012 "Do Increasing Block Rate Water Budgets Reduce Residential Water Demand? A Case Study in Southern California" *Water Science and Policy Center Working Paper*

[22] Ito, K. 2013 "How do Consumers Respond to Nonlinear Pricing? Evidence from Household Water Demand"

[23] Wichman, C. 2014 "Perceived Price in Residential Water Demand: Evidence from a Natural Experiment" *Journal of Economic Behavior and Organization*

[24] "Residential Water Consumption in Los Angeles: What are the drivers and are conservation measures working?" A policy summary written by Céline Kuklowsky, based on the Ph.D. dissertation of Caroline Mini at UCLA, and overseen by Terri Hogue and Stephanie Pincetl, California Center for Sustainable Communities at UCLA. Part of a National Science Foundation funded project.

with low users actually increasing usage while heavy users reduced their use by about 5%.[25] The web-based treatment could easily be used to exclusively target high users in order to maximize net program savings. This treatment's use of a web-based tool is especially exciting because it could be scaled economically. There may also be other effective ways to improve consumer knowledge of and sensitivity to IBT including delivering reminders to consumers who are on track to exceed their essential use budget.

Conservation rebates

While not purely a price intervention, many utilities may consider providing an incentive like a bill rebate for ratepayers who cut their usage during a critical time. This approach may appeal to utilities since it rewards households that conserve without raising prices. However, research into electricity conservation rebate programs suggests that these programs are not particularly effective, especially considering the program cost. A study of utility rebates for California electricity consumers who reduced summer usage relative to their summer usage over the past year showed that the rebate had no effect for homes in coastal geographies and only a small effect in inland areas, making the rebate a very expensive intervention relative to its benefit.[26]

Reaching higher-income consumers

As described above, a range of studies[27],[28],[29],[30] both in Los Angeles and across the U.S. demonstrate that higher-income consumers are less responsive to price, which means that conservation tends to predominately occur among lower-income consumers. This is problematic since higher-income consumers use more water[31], largely due to greater landscaping demands, a trend that was documented in the Center for Sustainable Community's study of residential users in LADWP, which found that households in wealthy neighborhoods consumed three times as much water compared to homes in less wealthy neighborhoods. [32] This same study found no evidence that consumers were motivated to conserve due to the higher rate that they face under LADWP's IBT.

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[25] Kahn, M. and Wolak, F. 2013 "Using Information to Improve the Effectiveness of Nonlinear Pricing: Evidence from a Field Experiment"

[26] Ito, K. Forthcoming "Asymmetric Incentives in Subsidies: Evidence from a Large-Scale Electricity Rebate Program" *American Economic Journal: Economic Policy*

[27] Wichman, C. Taylor, L. von Haefen, R. 2014 "Conservation Policies: Who Responds to Price and Who Responds to Prescription" *National Bureau of Economic Research Working Paper Series*

[28] Mansur, E. Olmstead, S. 2012 "The Value of Scarce Water: Measuring the Inefficiency of Municipal Regulations." *Journal of Urban Economics*

[29] Renwick, M. Archibald, S. 1998 "Demand side management policies for residential water use: Who bears the conservation burden?" *Land Economics*

[30] Ito, K. Ida, T. Tanaka, M. Draft "The Persistence of Intrinsic and Extrinsic Motivation: Experimental Evidence from Energy Demand"

[31] In their study of a group of California water retailers, Renwick and Green found that a 10% increase in income was associated with a 2.5% in water consumption. Renwick, M. Green R. 2000 "Do Residential Water Demand Side Management Policies Measure Up? An Analysis of Eight California Water Agencies" *Journal of Environmental Economics and Management*

[32] "Residential Water Consumption in Los Angeles: What are the drivers and are conservation measures working?" A policy summary written by Céline Kuklowsky, based on the Ph.D. dissertation of Caroline Mini at UCLA, and overseen by Terri Hogue and Stephanie Pincetl, California Center for Sustainable Communities at UCLA. Part of a National Science Foundation funded project.

Similarly, a study of residential water consumption in North Carolina found that on average, households with incomes over $75,000 a year were one third as price responsive as households with incomes under $75,000 a year.[33] The same study also found that households with automated sprinkler systems were similarly unresponsive to marginal increases in price. The implication of these findings is that higher-income consumers, especially those with automated irrigation, are not, on average, moved to reset their watering schedules due to marginal rate increases.

This dynamic has consequences for equity as well as for ultimate efficacy. In order to reach deep levels of efficiency, Los Angeles water retailers must identify and deploy demand side management policies that move affluent households to cut their landscaping water budget. Luckily, several non-price demand side management policies have been demonstrated to be just as effective, or even more effective at inducing conservation among higher-income consumers.[3435]

[33] Wichman, C. Taylor, L. von Haefen, R. 2014 "Conservation Policies: Who Responds to Price and Who Responds to Prescription" *National Bureau of Economic Research Working Paper Series*

[34] Wichman, C. Taylor, L. von Haefen, R. 2014 "Conservation Policies: Who Responds to Price and Who Responds to Prescription" *National Bureau of Economic Research Working Paper Series*

[35] Ferraro, P. Miranda, J. 2013 "Heterogeneous treatment effects and causal mechanisms in non-pecuniary, information-based environmental policies: evidence from a large-scale field experiment" *Resource and Energy Economics*

Policy Recommendations:
Price-based Demand Side Management Policy

Increasing block tariffs have the potential to curb the consumption of heavy users while protecting low-income consumers, but research indicates that they may not be having the intended effect. Utilities possess several tools to try to induce high-income high-volume users to conserve that can be adopted individually or in concert for the greatest effect. It is worth noting that many water retailers in Los Angeles County have already adopted some of these approaches. These tools include:

- **Increase the cost of non-essential use**: Because high-income consumers tend to be both the largest water consumers and less price-responsive, the price differential between tiers must be quite high to induce them to cut back on their consumption. The right of low-income consumers to inexpensive water can be protected in several ways under this scenario. First, IBT water budgets that calculate essential use based upon household size and other characteristics can protect low income homes. Second, IBT systems with multiple price tiers provide a buffer zone between the low rates for essential uses and the very high rates needed to influence the higher-income users. However, more tiers may increase complexity and confusion. Third, sub-metering of outdoor and indoor use would allow utilities to charge significantly higher rates for water used for irrigation, while keeping indoor water, which is predominately used for consumption, cleaning, and bathing, affordable. However, the installation of sub-metering infrastructure would be expensive and utilities must carefully weigh those costs against potential benefits.

- **Education**: Initiatives to educate high users about the rate structure have been shown to induce savings among high energy consumers facing IBT. Utilities could potentially increase consumer awareness via several strategies: providing simple, easy to understand information about the rate structure on bills, delivering web-based customer specific information, or alerting consumers when they are crossing into a higher usage tier.

- **Drought Pricing**: Utilities should continue to increase the price of water in non-essential usage thresholds during droughts to provide a stronger conservation incentive.

While utilities should focus on deploying high prices for non-essential uses rather than conservation rebates to encourage conservation, they should also look past price-based strategies in efforts to influence higher-income consumer behavior.

Non-Price Demand Side Management

As discussed above, while high-income consumers may be relatively price insensitive, they may be somewhat more responsive to non-price demand side management. By employing certain proven strategies in concert with smart pricing, utilities may be able to both manage normal demand and drought-related scarcity without significantly increasing the cost to meet basic household water needs.

Traditional conservation campaigns

There is significant debate over whether information, education, and exhortation can significantly affect consumer demand.[36] It is difficult to definitively assess the potential of these programs, especially in comparison to price signals, since program approaches vary significantly, and the simultaneous introduction of multiple price and non-price interventions confound discrete effect identification. The range of savings estimates varies wildly. While the residents of Fredericksberg, Virginia voluntarily reduced usage by 60% in response to a 1966 drought, many other campaigns have resulted in negligible savings. In a survey of U.S. conservation campaigns, researchers found that most utilities could expect to produce a 15%-30% short-term reduction in use of response to drought.[37] However many of these effects cannot be definitively attributed to the treatment and researchers have failed to establish a clear link between information and conservation through carefully designed experiments. [38] Furthermore, research employing several methodologies has yet to reveal a significant effect of information campaigns on water consumption in the long-term.[39] Utilities planning to use conservation appeals may choose to work with researchers to identify and test different messages and strategies to encourage conservation.

Voluntary and mandatory use restrictions

The study of conservation drivers conducted by researchers from UCLA's California Center for Sustainable Communities found that voluntary use restrictions, in which the utility "prohibits" specific water end-uses in an attempt to ration and limit non-essential water uses like lawn watering and washing of sidewalks, did not significantly reduce consumption, while mandatory use restrictions resulted in large savings. The mandatory restrictions specifically had the largest impact on hard to influence high income communities, with Pacific Palisades reducing usage by about 17% between 2008 and 2010. Interestingly, the study also found that landscape "greenness" did not suffer as a result of the policy, implying that policy reduced overwatering without reducing landscape aesthetics.[40]

These results were similar to those observed in other parts of the country. A study in North Carolina that compared the efficacy of prices to prescriptive restrictions found that high-income

[36] Syme, G. Nancarrow, B. and Seligman, C. 2000 "The Evaluation of Information Campaigns to Promote Voluntary Household Water Conservation" *Evaluation Review* 24 (539)
[37] Century Research Corporation 1972
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[40] Residential Water Consumption in Los Angeles: What are the drivers and are conservation measures working?" A policy summary based on the Ph.D. dissertation of Caroline Mini at UCLA

consumers with automatic irrigation, who were unresponsive to price (and voluntary restrictions), were the most responsive to watering restrictions, cutting use over 20%.[41]

Unsurprisingly, voluntary restrictions tend to be less effective than mandatory restrictions. A survey of studies showed that the range of savings from voluntary residential water restrictions was 0-7% while the range of savings from mandatory restrictions was 4-22%.[42]

However, researchers have also documented instances in which water use restrictions may backfire. For example, when one water retailer in a high dessert district restricted the days on which residences could water their lawns, consumers actually increased consumption due to a lack of flexibility.[43] This study suggests that utilities may be more successful if they set consumption limits and allow consumers to determine the best ways to meet them, which also has the benefit of reducing the regulatory cost of ensuring compliance.

Combined with price-based approaches, restrictions have the potential to achieve deep savings. A study of eight California water agency demand side management policies from 1989-1996 (many of these policies were designed to address the 1985-1992 statewide drought) found that while moderate price increases, and voluntary restrictions were capable of generating conservation within the 5-15% range, mandatory restrictions and significant price increases were necessary to induce dramatic conservation exceeding 15%.[44]

Emerging behavioral approaches to demand side management

Over the last several years, energy utilities have dramatically expanded their use of non-price behavioral "nudges" to promote conservation. Among novel behavioral interventions, the most successful in terms of both effect[45] and persistence[46], is the use of social comparisons presented through a home energy report or on the utility bill. In these programs, consumer energy bills are explicitly compared to either a neighborhood average or an otherwise comparable property. The average savings for these programs can be up to 5% (but are generally in the 2-3% range) and are persistent over time.[47]

While most of the studies of these neighbor comparisons have focused on residential energy use, preliminary evidence suggests that the method works equally well in curbing water consumption. In January of 2014, the East Bay Municipal Utility District (EBMUD) validated the results of a one-year, 10,000 customer pilot that they conducted in partnership with WaterSmart Software and the California Water Foundation. Those three entities employed a social comparison billing program for water consumption that included personalized water saving suggestions. The pilot participants saved 5% more, on average, than customers who did not

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receive the WaterSmart bills.[48] The pilot also suggests that social comparison interventions may amplify the impact of other demand-side management policies. Participants receiving WaterSmart bills were twice as likely to enroll in other EBMUD conservation programs.

Even one-time interventions employing social comparisons can result in significant water savings. One study conducted in Georgia, compared the effect of an appeal to conserve water over the course of the summer, mailed from the water utility, to an otherwise identical appeal that compared a household's use to that of the average residential consumption in the county. The treatment with the social comparison resulted in a nearly 5% reduction in water use, nearly twice as much as the appeal without the social comparison. [49] Importantly, the savings were most pronounced among the more difficult to treat high-users and higher income consumers[50]. The one-time intervention's effect was still significant after two years (those receiving the social comparison saved 2.6% the following summer compared to the control group's 1.3% the summer after that) while the social appeal without the comparison had no effect after the first summer.[51]

Studies of social comparison in the energy field have demonstrated that savings may vary significantly depending upon the population and the design of the intervention. For example, one California study showed that liberals and environmentalists exhibited greater savings after receiving home energy reports featuring social comparisons,[52] though a study of social comparisons and water consumption found no difference in treatment effects based on political affiliation.[53] Another study, conducted with residents of UCLA's graduate student housing found that the comparisons were far more effective when they emphasized the negative health impacts of energy consumption than when they stressed the financial cost of that consumption.[54] For this reason, it is imperative that both water and energy utilities that are exploring these approaches work with researchers and other experts to further explore which messages and intervention designs maximize savings.

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Policy Recommendations:
Non-price Demand Side Management

The research suggests that both conservation appeals featuring social comparisons and mandatory water use restrictions can have a large impact on water consumption, especially among high-users who are otherwise difficult to influence due to relatively lower price sensitivity. Specific recommendations include the following.

- **Employ Mandatory Restrictions During Drought**: During periods of drought, utilities should quickly move to deploy mandatory restrictions rather than relatively ineffective voluntary restrictions. Utilities may also work with researchers to develop strategic messages that employ norms or other strategies to potentially enhance the impact of restrictions. Mandatory restrictions should also be structured in ways that preserve flexibility, to avoid rebounds.

- **Deliver Social Comparisons of Water Consumptions:** Utilities should also work with researchers or third parties to deliver conservation appeals featuring a comparison of household use to similar homes. These normative comparisons can also be included with bills. These types of messages should potentially be delivered regularly to sustain conservation over time.

Conclusion

While prices are a theoretically efficient way to manage demand and increasing block tariffs provide a way to help insulate low-users from high prices, the burden of price-based management appears to be falling on lower-income consumers while failing to induce conservation among high-income consumers who use large quantities of water. This problem can be addressed through improvements to the rate structure, including the establishment of well-crafted water use budgets with very high rates for those that exceed that budget, or setting much higher prices for outdoor water use. Education may also improve consumer responsiveness to current increasing block tariff (IBT) rates.

It is also critical to augment price-based management with other policies including mandatory use restrictions during periods of drought, and novel behavioral strategies to induce conservation over time. Irvine Ranch Water District, situated in Orange County, which shares a similar climate as Los Angeles and has demographics similar to some of the more affluent areas of Los Angeles, have employed a multi-pronged approach to reduce customers' water consumption. They have achieved greater conservation by using tiered water rate budgets with an effective public education program using WaterSmart billing software. While there are limitations to raising water rates, utilities should also be sensitive to different approaches that can realize a wide range of savings and learn from various best practices.