THE Water Research FOUNDATION

Water Use & Efficiency

THE CHALLENGE

In the United States, per capita water use has been declining since the 1980s, largely due to efficiency improvements from product standards, codes, third-party certification programs, and federal and state regulations. The Energy Policy Act of 1992 restricted water use in household fixtures and appliances to save energy. More recently, California legislation reduced wasteful water use and limited indoor water use to 55 gallons per person per day. In some areas, these per capita reductions are enough to offset the increase in water needs due to economic and population growth such that water use has remained constant or even declined over recent decades.

Water efficiency helps increase a utility's water supply reliability and decrease the capital costs of building a new supply, ultimately reducing treatment and distribution costs. Because water use trends will continue to change, utilities should be aware of and track the drivers of water use so they can plan appropriately.

THE RESEARCH

Over the last 20 years, WRF has published more than 50 projects on water use and efficiency. Because of the importance of this topic, WRF completed many of these projects with partners like the U.S. Environmental Protection Agency (EPA), the U.S. Bureau of Reclamation, the National Oceanic and Atmospheric Association (NOAA), UK Water Industry Research, American Water Works Association (AWWA), the Alliance for Water Efficiency, and California Urban Water Agencies (CUWA).

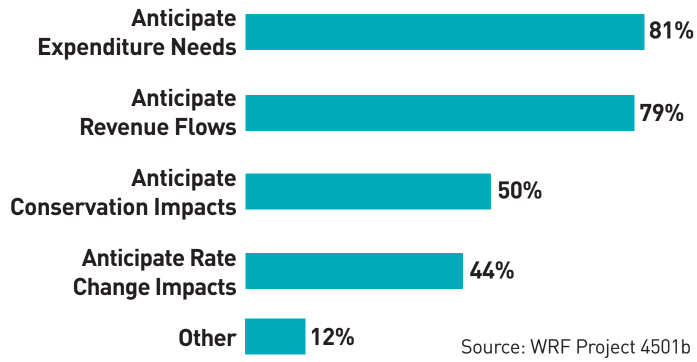
From 2012 to 2017, WRF maintained a Research Priority Area on this issue, entitled Water Demand: Improving the Effectiveness of Forecasts and Management. This research helps utilities accurately estimate water use, adopt demand management strategies, forecast future water demand, and incorporate these forecasts and their uncertainty into financial, infrastructure, and water resource plans. The Research Priority Area funded eight projects with a total value of $1.8M.

Water Use Estimates

Utilities need a comprehensive understanding of water use to meet current and future water demands. Water sales are based on periodic readings of customer meters, helping to predict demand. Water meter data, however, has limitations because utilities do not use uniform customer categories, meter readings may not occur frequently enough to be useful, and not all customers have meters.

Compared to commercial and industrial customers, single-family water sales are typically larger, both by volume and dollars. Understanding how water is used in single-family homes is essential for utilities. In 2016, WRF published *Residential End Uses of Water, Version 2* (4309) as an update to a 1999 study. A main finding was that indoor water use decreased while household water use behaviors stayed consistent. Average daily indoor water use declined 22% per household (or 15% per capita) since 1999, which coincides with an increased occurrence of water-efficient toilets and clothes washers (up from about 5% in 1999 to

TOP UTILITY REASONS FOR CONDUCTING SHORT-TERM DEMAND FORECASTING



Source: WRF Project 4501b

40% in 2016). Deliverables included a database of the end use water events recorded during the study, along with survey response data, historic billing data, and other data obtained for each study site. The database also contains summary results from other end use studies. Because of how expensive and labor intensive it is to collect such data, over 80 researchers and utilities have used the database as a jumping off point for further research.

Multi-family water use tends to be lower and less seasonally variable than water use in the single-family sector; however, the gap between these customer classes narrows when accounting for household size and seasonality. *Water Use in the Multi-Family Housing Sector* (4554) demonstrates how a utility can analyze data for this growing customer demographic, accounting for factors such as development density. Analyzing water use in this sector is challenging due to inconsistent categorization. More uniformity in the criteria for classifying multi-family water users would allow for better metrics and more robust comparisons. The report features data from water utilities and other key sources to provide foundational information on multi-family consumption and to demonstrate data management and analytical techniques, which can be applied to improve planning and forecasting efforts.

WRF has also published several projects on water use and efficiency in the commercial, industrial, and institutional (CII) sectors. *Developing Water Use Metrics for the Commercial and Institutional Sectors* (4619) represents the most sweeping analysis to date of CII water use metrics. The three customer categories that consistently showed high rates of use per square foot included eating/drinking establishments, retirement/nursing homes, and lodging. The three categories that consistently showed low rates of use per square foot included religious buildings, retail outlets, and warehouses. Although the rate-of-use metric results were compared for each customer category across participating utilities, the results varied significantly enough that national benchmarks could not be recommended. Rather, each utility will be better served using its own results to establish local benchmarks that account for the unique characteristics of the service area, including climate, billing rates, pricing structures, economic conditions, regulations, metering infrastructure, and other factors.

Demand Forecasting

Demand forecasting can occur weekly (for distribution system operations), a few years out (for budgeting and revenue projections), or long term, such as 20 to 40 years into the future (for capital improvement, supply, and master planning). It is critical to choose an appropriate forecast approach that matches the forecasting goals (such as time horizon, inclusion of appropriate factors, etc.) and data and resource availability. *Improving the Accuracy of Short-Term Water Demand Forecasts* (4501) found that there is no one-size-fits-all approach—planning context determines which forecasting method is optimal. Replicating previous demand patterns is sometimes adequate, but adding in additional variables can add explanatory power; however, more complex models are not always better. Regression models incorporating weather indicators appear well-suited for operational planning purposes, while for revenue planning, econometric models with price variables are promising. Using high-quality, up-to-date time series data and cross-checking assumptions regarding future trends can improve accuracy. Evaluating multiple dimensions of accuracy using quantitative techniques helps inform future planning efforts. Accuracy comparisons conducted with historical data can help in selecting between alternative methodologies.

Accurate demand forecasts must also account for economic data and cycles, as well as water efficiency. The 2016 WRF study *Isolating the Effects of the Great Recession* (4458) investigated the impacts of economic cycles, such as recessions, on water demand. In four case studies, recessionary forces led to a 5-15% reduction in water use, and findings suggest macroeconomic data (e.g., national composite indices) correlates with regional water consumption patterns.

Long-term water demand forecasts are critical to utility planning efforts and decision making. Over-building of supply and water treatment capacity can lead to stranded capital assets, higher water rates than might otherwise be necessary, and additional stress on watersheds. On the other hand, under-investment could result in water shortage restrictions, economic damages from water shortages, and harm to a utility's credibility. *Uncertainty* *in Long-Term Water Demand Forecasting* (4558) found that the best forecasting approach for any utility depends on its specific situation. Key uncertainties include future growth in customers, future climate, economic conditions, and water efficiency. In addition, utilities tend to accept the risks of over-predicting long-term demands rather than under-predicting long-term demands. Another important consideration in long-term demand forecasting is an analysis of water efficiency in your service region. The report, *Integrating Water Efficiency into Long-Term Demand Forecasting* (4495) explores ways to include efficiency in long-term demand forecasts, including common approaches like end-use models, a lognormal distribution for device failure in a stock model, and appropriate use of multi-city datasets.

Water Demand Management

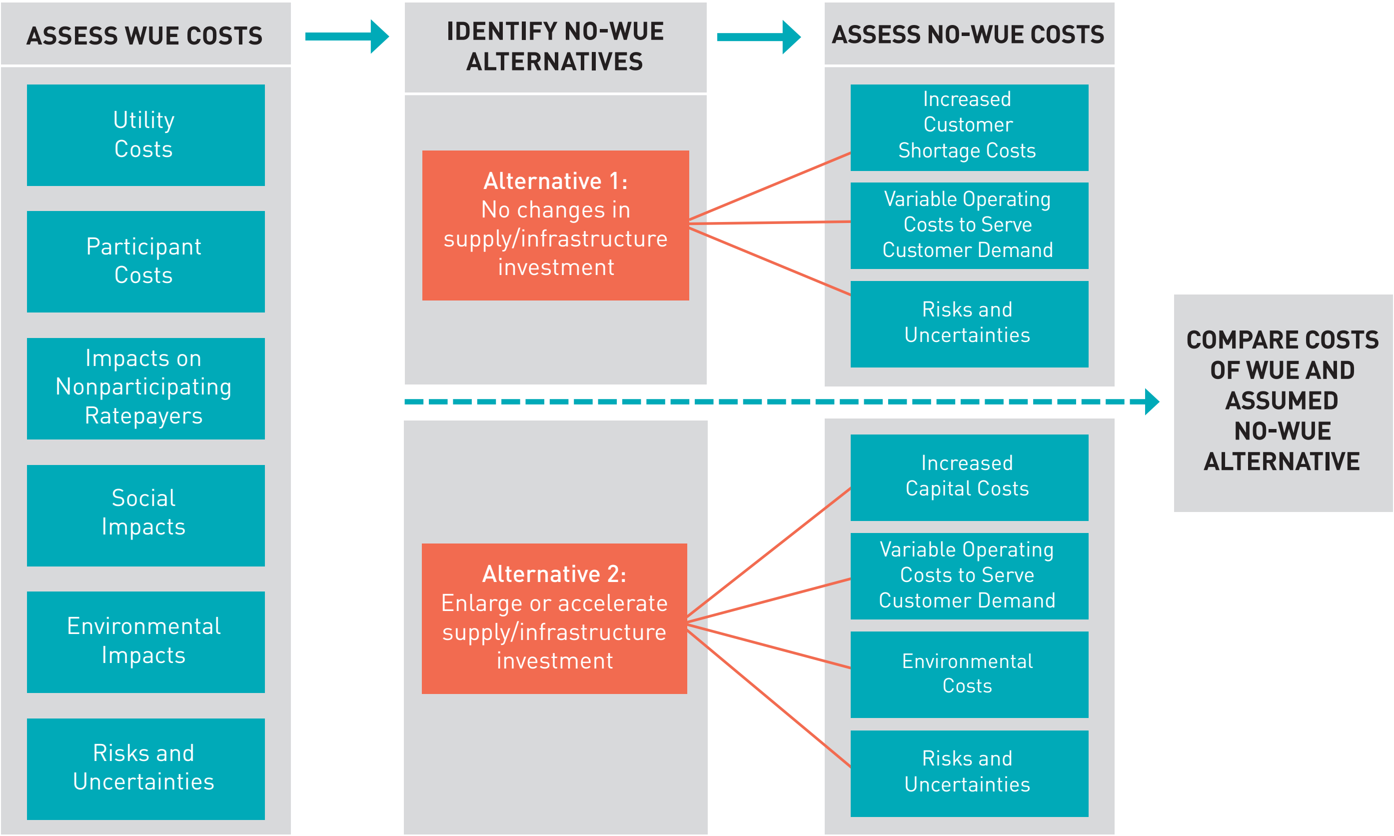
Water demand management programs are utility-sponsored and focus on active conservation—encouraging customers to use water more efficiently or temporarily restricting use during shortages. Short-term demand management activities are associated with drought or other time-limited events, while long-term demand management focuses on reducing prolonged water use and includes a conservation program as part of an integrated water resources portfolio.

WRF's 2012 report, *A Balanced Approach to Water Conservation in Utility Planning* (4175) discusses conservation program design considerations, with a focus on utility characteristics and goals. The project includes a Drought Response Tool to assist in rate and revenue management under varying drought and non-drought conditions. Two corresponding models allow users to estimate avoided costs of future water supply and wastewater treatment and weigh the costs and benefits of conservation programs.

As droughts occur more frequently, utilities are turning toward short-term demand management to minimize the impacts. Released in 2015, *Drought Management in a Changing Climate: Using Cost-Benefit Analysis to Assist Drinking Water Utilities* (4546), explores the costs and benefits of leading practices in drought management and risk mitigation. The report helps water customers, boards of governance, and other stakeholders better understand the total possible costs of drought and improve acceptance of drought planning and mitigation measures to minimize these costs.

Published in 2016, *Drought Management Strategy – Learning from Australia* (4640) investigated the decade-long Australian Millennium Drought to compile lessons learned. Urban water efficiency was the quiet achiever,

PLANNING FOR WATER USE EFFICIENCY (WUE) AS A WATER RESOURCE INVESTMENT OPTION



Source: Adapted from WRF Project 4175

saving more water at lower cost and greater speed than supply options. Clear, credible communication about the drought and response is paramount to public participation and support. Good data and robust monitoring are also critical. Innovative water pricing mechanisms are required to balance water savings, revenue, and equity goals.

Unintended Consequences of Water Efficiency

As water use trends have evolved over the last 20 years, utilities are seeing the impacts in their rate and revenue projections. In addition, increased water efficiency also impacts existing infrastructure, much of which was built with higher flows in mind. Initially, many utilities were not aware that water use was declining, and they experienced revenue shortfalls. In 2014, WRF published a key report on this issue, *Defining a Resilient Business Model for Water Utilities* (4366). The research helps utilities address revenue gaps and shift their thinking to modernize financial and management practices.

The interconnectedness of our water systems also means that improved drinking water efficiencies can impact downstream wastewater providers. Sponsored by CUWA, *Adapting to Change: Utility Systems and Declining Flows* (4736) surveyed water utilities in California and found that lower drinking water flows resulted in lower wastewater flows, which led to sewer odors and wastewater with a higher concentration of contaminants—making treatment more challenging. In addition, lower wastewater flows mean less water available for reuse applications. These observations offer a preview into the potential impact of establishing permanent indoor water use targets. Understanding the system-wide impacts of increased conservation will help decision makers address the current and future challenges in California as well as those in other states.

Outdoor Water Use

In addition to understanding indoor water use trends, utilities are increasingly recognizing the need to keep tabs on outdoor water use. As in most of Florida, Orange County Utilities relies on groundwater from the Floridan Aquifer to meet urban, agricultural, and industrial needs. Faced with a future shortfall in its groundwater supply, Orange County Utilities participated in the project, *Smart Irrigation Controller Demonstration and Evaluation in Orange County, Florida* (4227). Orange County Utilities found that on average, the evapotranspiration irrigation controllers reduced irrigation between 18% and 32%, while the soil moisture sensor technology reduced irrigation between 30% and 42%.

As the balance between urban water supplies and water demand becomes more critical, the search for additional residential conservation gains has shifted to landscape water use. *Urban Landscape Water Use Research Evaluation* (4633) found that urban landscape water demand is driven by highly complex human and physical systems that vary by customer and region. Results for urban landscape water reduction strategies in different locations vary widely, and some strategies may even result in increased water use for some customer classes. The final report includes an overview of landscape water use research specific to climate regions with high landscape water use and a prioritized list of research needs. A companion literature review database is available on the Arizona State University Global Sustainability website.

WHAT'S NEXT?

Trends in Long-Term Demand Forecasting (4667) will provide an overview of currently used long-term demand forecasting models in support of water resources and infrastructure planning and management. The research will also identify the extent to which forecasting models, practices, and communications influence utility plans and actions. This information will lead to the development of recommendations to improve the effectiveness of demand forecasting practices and communication strategies on water resource and infrastructure planning and decision-making.

Despite efforts to set realistic goals for water reuse, there remain uncertainties on what level of water reuse is feasible and how to maximize the potential for recycled water. *Identifying the Amount of Wastewater That Is Available and Feasible to Recycle in California* (4962) will help California utilities estimate the amount of wastewater that might be available for water reuse purposes. This project will develop a spreadsheet and GIS databases to estimate current and future volumes of municipal wastewater available to recycle under applicable constraints. These deliverables will be used by the California State Water Resources Control Board to set realistic recycled water targets, develop mandates, and identify funding needs and strategies to optimize recycled water in California.

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