
# 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, and third-party certification programs. In some areas, per capita reductions are enough to offset water needs for economic and population growth such that total water use has remained relatively constant or even declined over recent decades.

Federal and state regulations also impact water use. The Energy Policy Act of 1992 restricted water use in common household fixtures and appliances to save energy. The recent drought in California resulted in Senate Bill 606 and Assembly Bill 1668, which limit indoor water use to 55 gallons per person per day until 2025.

Water efficiency is an important way to 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 for their service area.

## THE RESEARCH

Over the last 20 years, WRF has published more than 50 projects on water use and efficiency. Because of the importance of sustaining reliable water supplies into the future, 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, Arizona State University, and California Urban Water Agencies (CUWA).

From 2012 to 2017, WRF maintained a Research Priority Area dedicated to this issue, Water Demand: Improving the Effectiveness of Forecasts and Management. This research helps utilities accurately calculate water use estimates, adopt demand management strategies, forecast future water demand, and effectively 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, and contributes to planning,

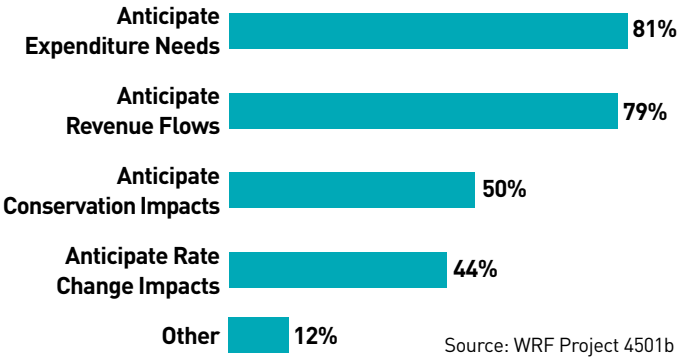
demand forecasting, metering, efficiency and demand management programs, water loss control, plumbing product development, and many other core water industry purposes. In 2016, WRF published *Residential End Uses of Water, Version 2* (4309) as an update to a 1999 study. One of the main results was that 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 40% in 2016). Thus, water providers should consider water efficiency when forecasting long-term demands.

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, and 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.

**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). Choosing a forecast approach is critical because it mathematically represents how factors influence demand and must match the forecasting goals (such as time horizon, inclusion of appropriate factors, etc.). While often overlooked, evaluating near-term forecast accuracy is important for providing feedback on model performance. Proactive utilities acknowledge forecast uncertainties and use adaptive techniques to allow for flexible planning. Two WRF reports cover these topics, *Short-Term Water Demand Forecasting: Survey, Manual, and Research Report* (4501) and *Uncertainty in Long-Term Water Demand Forecasting* (4558).

## TOP UTILITY REASONS FOR CONDUCTING SHORT-TERM DEMAND FORECASTING




Source: WRF Project 4501b

Accurate demand forecasts also need to account for factors such as economic data and cycles, as well as water efficiency. The 2016 WRF study *Isolating the Effects of the Great Recession* (4458) provides a better understanding of the impacts of economic cycles, such as recessions, on water demand. In four case studies, recessionary forces contributed to a reduction of between 5% and 15% in water use, and findings suggest macroeconomic data (such as national composite indices) is highly correlated with regional water consumption patterns. Another report, *Integrating High-Efficiency Standards, Building Codes, and Technology into 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 supply 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 various 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 increasingly turning toward short-term demand management to minimize the impacts. Droughts can affect water quality, operation and treatment costs, fire suppression capabilities, energy expenses, and interruptions in power. 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.

**Water Loss Control**

While the media often focuses on leaking pipes, leading water utilities focus on the actual efficiency of distribution systems, which means fully capturing sales and reducing leakages. Utilities can use *Real Loss Component Analysis: A Tool for Economic Water Loss Control* (4372a) to analyze their real losses in more detail. This requires data collection about leaks from mains, service connections, appurtenances, and storage tanks and may be aided by using the companion *Leak Repair Data Collection Guide*. A complimentary tool, the Leakage Component Analysis model, estimates reported, un-reported, or background losses so utilities can match the type of loss to an effective intervention strategy.

An initial step for improving distribution system efficiency is conducting a water audit, as described by AWWA M36 Water Audits and Loss Control Program. In 2015, WRF released *Water Audits in the United States: A Review of Water Losses and Data Validity* (4372b), one of the first analyses of a large batch of water audits. The report analyzes more than 4,500 water audits, providing a snapshot of water loss reporting. The findings also underscore the importance of education, training, and data validation on improving the quality of a water audit. As a follow on, WRF published *Level 1 Water Audit Validation* (4639) to provide North American water utilities and regulatory entities with clear guidance and a standard method to validate water audit data.

Published in 2019, *Guidance on Implementing an Effective Water Loss Control Plan* (4695) provides advice on how to analyze more than three years of water audits to set performance targets, offering material that compliments AWWA M36. This project created a guidance manual and

## SOLUTIONS IN THE FIELD:
## California Water Audit Validator Training

**After facing its worst drought on record, in 2017, the State of California began requiring urban retail water suppliers to submit validated distribution system water audits each year—a first step in understanding and preventing water loss. To help utility personnel prepare for and comply with this development, the California-Nevada Section of the AWWA sponsored a training series, conducted by Water Systems Optimization, Inc., and Cavanaugh & Associates. The Water Audit Validator course is a two-day program designed to qualify individuals to perform Level 1 water audit validations in California. Water audit validators examine water loss audit inputs to consider the water audit's accuracy and document sources of uncertainty. Individuals who successfully complete this course and exam receive a Water Audit Validator certificate, which is valid for three years.**

**The training materials for this course drew heavily on WRF's 2016 manual, *Level 1 Water Audit Validation* (4639). The manual was developed to help water utilities and regulatory entities understand key components of an accurate and reliable water audit and follows AWWA methodology for water audits. The use of this research in the training materials furthered the project goals—getting clear guidance and standard methods for water audit validation into the hands of water utilities and regulatory entities.**

decision framework to help North American water utilities develop actionable, cost-effective, and defensible water loss reduction and control plans.

**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, existing water infrastructure was built with higher flows in mind, and changes in water efficiency are also impacting infrastructure. Initially, many utilities were not aware that water use was becoming more efficient 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 the challenges of revenue gaps and lays the groundwork for a shift in thinking by utilities to modernize financial and management practices by strengthening linkages among systems, processes, and decision-making 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 about the negative impacts during recent drought and mandatory water restrictions in California. Results indicate 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 California's current and future water challenges.

## WHAT'S NEXT?

WRF has several ongoing efforts to further enrich the water sector's understanding of water use and efficiency. *Developing Water Use Metrics for the Commercial and Institutional Sectors* (4619) is exploring factors affecting water demand in the non-residential sector. The research will evaluate commercial and institutional customer water use, develop rate-of-use metrics, set water use benchmarks for select commercial and institutional customer categories, and provide guidance for water utilities on how to use and implement commercial and institutional water use benchmarks.

WRF will also address oversized water meters, a common problem for utilities across North America, especially considering increased water conservation and more efficient plumbing fixtures. *Assessing Water Demand Patterns to Improve Sizing of Water Meters and Service Lines* (4689) is working to improve understanding of correct meter sizing and performance, which will help prevent inaccurate meter registration at low flow regimes and underreporting of delivered water. More accurately sized meters will ultimately help increase recurring utility revenue.

As a growing number of water utilities implement advanced metering infrastructure (AMI) to capture detailed information from customer meters, WRF research will also help realize the full potential of this data. With this new information, utilities can better respond to customer billing questions, enforce policies for water usage, and better quantify and ultimately reduce the level of non-revenue water in their distribution systems. *AMI Meter Data Analytics* (4741) will improve understanding of the benefits of correct meter sizing and meter performance. The research will identify strategies for AMI data analyses and use case studies to demonstrate the value of using AMI data. The research will result in a meter performance index, which will allow utilities with AMI data to define their meter maintenance and replacement strategies based on actual meter performance.

*Utilizing Smart Water Networks to Manage Pressure and Flow for Reduction of Water Loss and Pipe Breaks* (4917) will use network solutions to help water utilities better manage pressures and flows in their water distribution networks to extend the life of pipes and reduce water loss. The research will develop case studies from utilities using data-driven technologies as well as a guidance manual of best practices for implementing smart water network technology, including a step-by-step approach to planning, budgeting, technology selection, and operations and maintenance.