



Building Better Water Rates for an Uncertain World:

Balancing Revenue Management, Resource Efficiency, and Fiscal Sustainability

**FINANCING
SUSTAINABLE
WATER**
Rates. Revenue. Resources.





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Balancing Revenue Management, Resource Efficiency, and Fiscal Sustainability

AUGUST 2014

Developed by the Alliance for Water Efficiency, in partnership with the California Urban Water Conservation Council



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** Available at www.FinancingSustainableWater.org*

Preface and Acknowledgements



The Alliance for Water Efficiency took on the challenge of producing this Handbook and rate model because of the alarming perception by utility managers throughout North America that conserving water and maintaining stable revenues are not compatible objectives. We wanted to prove this perception wrong, and to develop tools for all those involved in utility rate setting to foster a better understanding of how to successfully create water efficient communities with financially stable utilities.

The Handbook was produced under the direction of Thomas W. Chesnutt, Ph.D., CAP®, A&N Technical Services, Inc, with editing by Kenneth Mirvis, Ed.D., Principal of The Writing Company.

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Lastly, we wish to recognize the California Urban Water Conservation Council for its seminal work on conservation rates since 1994, and particularly for its comprehensive examination of efficiency-oriented rate setting in its 1997 publication *Designing, Evaluating and Implementing Conservation Rate Structures*, also authored by Dr. Thomas Chesnutt. Our new work is meant to build on that important groundbreaking effort and would not have been possible without this foundational material, which is gratefully referenced throughout this Handbook.

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Introduction



Across North America, water use has declined dramatically over the past several decades, and per capita consumption has dropped to a level equal to that of the mid-1950s. With demands and strains on freshwater supplies continuing to grow, this recognition of water's value and stewardship of this precious resource is a great accomplishment.

Success, however, has created new challenges. Using traditional economic models, declining sales translate to declining revenues. With this decline, water utilities face the difficult task of continuing to encourage much-needed efficiency and conservation programs while covering the costs of water treatment and delivery as well as infrastructure repair and replacement.

Addressing this challenge is crucial. Our ability to provide sufficient resources to sustain human life, fuel economies, and protect fragile ecosystems is at stake.

This daunting phenomenon — often called the “conservation conundrum” — provided the backdrop for the *Declining Water Sales and Utility Revenues Summit* in August 2012. The Alliance for Water Efficiency (AWE) convened 30 experts, including rate setters, economists, regulators, utility executives, and advocates to discuss the various drivers of declining utility revenues across the country. A White Paper presented a framework for defining the problem and pursuing solutions. A Summit Summary presented the major discussion threads, conclusions, and recommendations.

A primary outcome of the Summit was the recognition that utilities need new solutions to changing circumstances. The emerging trends of revenue instability, the achievements of efficiency efforts (such as the 1992 Energy Policy Act changes that revolutionized plumbing standards), and extended droughts and capacity shortfalls now necessitate a reexamination of the ability of traditional water ratemaking practices to account for economic, social, and environmental changes. These ratemaking concepts unbundle the costs of specific services, recognize the true costs of developing future capacity, and place a measurable value on the consequences of wasteful use.

These innovative approaches to rate setting require active analyses of local context and are not amenable to the “averaging” strategies embedded in traditional cookbook approaches.¹ Changing regulatory frameworks of states also affect how rate structures can and should be modified and implemented at a local level. California's requirements, for example, merit careful

1 Savage, Sam L., (2012) *The Flaw of Averages*, Hoboken, NJ John Wiley and Sons. (www.flawofaverages.com)

assessment: the California Urban Water Conservation Council Best Management Practice on Rates, and Proposition 218, passed by the voters in 1996, outline the need for water utilities to establish a strong link between volume-related system costs and rates when implementing water conserving retail water rate structures.

This Handbook builds on a solid foundation of traditional and industry standard methods on ratemaking to provide practical guidance to water managers, helping them understand, design, and implement rate structures that incentivize efficiency, contribute to revenue stability, and support long-term financial health.

It provides background and tools for designing better rate structures and tools for quantifying and evaluating the impact of those rates to promote better decision-making. It identifies forward-looking ratemaking alternatives and explains vetted rate models that can be adapted with confidence by water managers. It provides concepts, tools, and illustrated examples of solutions for the water utility manager who needs help to understand and manage these changes and uncertainties. In addition, it goes hand-in-hand with the Alliance for Water Efficiency's new Excel-based *Sales Forecasting and Rate Model*, an innovative new tool that can help rate analysts better identify and incorporate the risks of a changing world into their rate setting and analyses.

This Handbook is designed for non-technical and technical utility employees, utility leadership, elected officials, board and council members, interested citizens, and other stakeholders, such as media and community members. It is designed to serve diverse purposes, including equipping utility employees who are creating change within their organizations with the third party verification and support for their efforts that they need.

How different utility employees may benefit from this handbook:

Finance Managers and Rate Analysts may use it to understand the components of a strong financial planning process, devise rate cases that better achieve utility objectives, and communicate rate cases in a compelling way to internal stakeholders.

Conservation and Resource Managers may use it to better communicate with finance teams and with external groups about the role of efficiency-oriented rates and the value of efficiency as a long-term resource management strategy.

Public Affairs and Communications Professionals may use it to devise a public engagement plan around a rate increase or craft key messages for elected officials, community groups, or internal departments about utility financial and resource management objectives.

Utility Managers may benefit from the contents to better understand how efficiency supports short-term and long-term financial and resource management goals, and how transforming financial and governance policies can benefit utilities.

Interested Board Members and Elected Officials may benefit from this material as an in-depth introduction to their new responsibilities and the challenges of rate setting.

Overview of Each Chapter

CHAPTER ONE: *Financing Sustainable Water* acknowledges the multiple, diverse objectives utilities must achieve to fulfill their mission of providing a reliable, affordable supply of drinking water to customers today and in the future.

CHAPTER TWO: *The Role of Ratemaking* provides a primer on the role of water ratemaking as a means to achieve those objectives. It introduces the topic of how water rates affect water efficiency, utility revenue, and fiscal sustainability. It outlines the Handbook's approach to rate setting, asserting that in the absence of a single universal rate solution that works everywhere, water utilities and stakeholders must take steps to evaluate their own rate alternatives and gather information that can inform better tradeoffs among rate criteria.

CHAPTER THREE: *Building a Better (Efficiency Oriented) Rate Structure* reviews water ratemaking concepts and principles. It guides the reader step-by-step through the rate design and evaluation process, noting critical improvements and activities that can help improve the effectiveness of an efficiency-oriented rate structure.

CHAPTER FOUR: *Financial Policies and Planning for Improved Fiscal Health* addresses the need for strong financial planning policies and practices to support fiscal sustainability. It outlines several types of policies that utilities may consider to improve effectiveness of efficiency-oriented rate structures and cope with revenue volatility.

CHAPTER FIVE: *Implementing an Efficiency Oriented Rate Structure* gives an overview of strategies and tools to ensure smooth implementation of efficiency-oriented rate structures. It provides communication guidance for different internal and external audiences, including management within the utility, the general public, and boards.

APPENDIX A: *Costing Methods* provides technical background on water costing methods, including costing concepts, a comparison of average embedded cost of service to marginal/incremental cost of service, simple applications of marginal/incremental cost of service methods to water service, and an overview of two avoided cost models that rigorously estimate the forward looking incremental costs around the expansion paths of water and waste water service, respectively.

APPENDIX B: *Demand Forecasting and Revenue Modeling* provides technical background on water demand modeling and water sales modeling, including various approaches, examples, and illustrations.

APPENDIX C: *User Guide to the AWE Sales Forecasting and Rate Model* is the user guide that explains how the methods of probability management apply to the task of setting water rates given predictable and still uncertain water demand. It facilitates rate setting for drought stages and graphically depicts customer bill impacts and the "shape of uncertainty" in future water sales and revenue.

In short, this Handbook offers a conceptual overview of ways in which a fundamental transformation of utility management and a model centered on sustainability and efficiency can support a more holistic and sustainable view of water service. Additional resources on related issues can also be found at www.FinancingSustainableWater.org.

HOW TO USE THIS HANDBOOK AND THE AWE SALES FORECASTING AND RATE MODEL

Water ratemaking is a complex analytical endeavor composed of many building blocks, each of which needs to be addressed before a utility can model and select a successful rate structure.

Such critical steps as demand forecasting, carrying out a cost of service analysis, determining revenue requirements, and identifying objectives cannot be undervalued. Only after completing them can rate setters undertake the exercise — or art — of designing a rate structure and evaluating it against multiple scenarios to determine its effectiveness.

This Handbook provides the background and concepts needed to develop an effective rate structure. It precedes and accompanies the new *AWE Sales Forecasting and Rate Model*, which is a complete rate design tool that applies the concepts in this Handbook. The model is just one component of sound rate-setting practice; other elements, like good financial management, must remain an integral part of the effort.

Chapter 1



Financing Sustainable Water: Today's Imperative for Utility Financial Management

Water utilities are entrusted with the most vital of missions: providing a reliable supply of high-quality water to sustain communities, business, and industries. For many utilities, that responsibility is even expanding to wastewater, storm water, and watershed management. As providers of a vital resource that is often in limited supply and that can either help a community thrive or wither, water providers are becoming both economic actors and environmental stewards within their communities.

What Do Utilities Have to Achieve?

Utilities must balance a variety of often conflicting financial and resource management objectives that are necessary to fulfill this critical societal mission.

Revenue Stability and Cost Recovery

Like any business, water utilities must be as concerned about revenue flows as they are about water flows. Without financial viability, a water utility cannot meet its mission of delivering safe and reliable potable water cost-effectively. In the short term, utilities must generate sufficient revenue to provide safe and affordable water services to customers while also covering the costs of providing that water service through a variety of income-generating tools. In the long term, utilities must provide those services at the lowest possible cost to their ratepayers. Water rates charged to customers rest at the heart of this imperative.

Resource Efficiency

While water is one of the most plentiful elements on the planet, the portion we have available access to for human health and for economy-sustaining activities such as agriculture, industry, and power generation is rapidly dwindling.

Water efficiency remains the most cost-effective, environmentally beneficial, and immediate way to stretch water supplies in the short term and protect them for the long term. Improved long-term water use efficiency is a viable complement to — and sometimes a substitute for — alternative investments in long-term water supplies and infrastructure. Efficiency paves a way to reduce long-term costs, and it is often the most cost-effective option available for securing “new” supply. When efficiency activities deliver benefits that exceed costs, the activity can be considered to be cost-beneficial or cost-effective compared with other supply alternatives. A water use efficiency program that works to reduce the permanent level of customer water demand requirements will reduce the utility revenue requirements,² if it is cheaper than the alternative required water supply/infrastructure investment. In addition, viewing cost-effective efficiency programs as just a component of least-cost resource planning does not include potential indirect benefits for utilities, such as improved utility responsiveness to customers, providing customer options for retaining water use benefits in a world of higher costs, and improved resource management.

2 Long-term water use efficiency is distinguished from the need to better manage shortages associated with droughts or other short-term emergencies. Referred to as “drought management” or “shortage management,” this short-term water use efficiency has as its objective the reduction of customer shortage costs induced by a water supply shortage by means of improving water use efficiency and reduction of water waste

WESTMINSTER, COLO.: CONSERVATION LIMITS RATE INCREASES FOR CUSTOMERS



The City of Westminster, Colorado, which services more than 106,000 people, has long invested in efficiency as part of their strategy to manage resources and keep costs down for the utility and ratepayers. When customers began to question why rates continued to rise as they increasingly conserved water, the City set out to develop a more compelling response by examining the effect conservation measures have had on water rates and fees.

Westminster examined water use patterns and water demand, as well as avoided capital costs, additional treatment costs and operational costs over a 30 year period dating from 1980 — before conservation programs were implemented and efficiency standards and codes went into effect — to 2010.

The results were startling. Reductions in water use in Westminster since 1980 have resulted in significant savings in both water resource and infrastructure costs, saving residents and businesses 80% in tap fees and 91% in rates compared to what they would have been without conservation. While water rates and tap fees have increased over 30 years due to rising costs for operating and maintaining water systems, they have not increased as much as they would have without conservation.

The City of Westminster conducted this analysis with these basic steps:

1. Examine change in water demand pre- and post-conservation investments.
2. Determine additional supply needed to meet today's demand in a no-conservation scenario and costs to secure this supply.
3. Determine additional treatment requirements needed, as well as changes in peak demands.
4. Determine costs of expanding treatment capacity to meet new demand and new peak demands.
5. Determine additional wastewater treatment capacity needed and the cost of this capacity.
6. Determine additional operational costs presented by new demand (labor, energy, chemicals).
6. Determine how to fund new supply, treatment capacity, and wastewater needs.
8. Allocate new costs to water and wastewater rates and tap fees to determine the impact on today's rates.

Westminster determined that over that time period, daily per capita water demand was reduced by 21%, from 180 GPCD in 1980 to 149 GPCD in 2010. This was accomplished through conservation programs, rate structures, and plumbing code improvements. If the City had not reduced its per capita demand, it would have needed to secure an additional 7,295 acre-feet (AF) of water supply to meet current demand. The City would also have needed an additional 52 MGD of treatment capacity and an additional 4 MGD of wastewater treatment capacity with associated capital costs. The estimated total capital costs associated with increased demand came to \$591,850,000 with an additional \$1,238,000 per year in increased operating costs. Without conservation these costs would have been passed on to the customer, who would be paying much higher rates today.

Fiscal Sustainability

Water utilities must not only manage resources responsibly and recover the costs of their services, they also need to work from a secure and sustainable financial foundation.

The General Accounting Standards Board's proposed definition of "Fiscal Sustainability" reads:

Fiscal sustainability is a government's ability and willingness to generate inflows of resources necessary to honor current service commitments and to meet financial obligations as they come due, without transferring financial obligations to future periods that do not result in commensurate benefits.³

While utilities must maintain a high level of financial stability, they must also continually redefine the changing levels of "water service" their customers demand. Water efficiency and careful ratemaking are tools that help utilities meet these levels of service and improve prospects for a financially sustainable future. They must be supported by financial policies and planning practices that strengthen the organization's financial position and enable it to weather unexpected needs and challenges.

Indeed the puzzle is complex and will become even more so in coming decades: water supplies and demand, new infrastructure, delivery efficiency, customer fairness, increased transparency, system maintenance, and so much more must be considered. Effective rate making rests at this foundation, and the entire full and dynamic puzzle is key to building an effective rate structure and to supporting financial sustainability while encouraging the efficient use of water.

Why is Utility Financial Management Harder than Ever?

Historically, utility financial management rested on a tradition of steady growth, slowly changing water service requirements, and fairly stable costs and revenues. Water utilities viewed their role as one of supporting economic development and assuring reliability of service and unrestrained consumption even under emergency conditions. Traditional water utility financing focused on generating sufficient revenue to enable construction of the required water infrastructure and to fund operations and maintenance expenses under forecasts of steadily increasing water demand and known and stable costs.

The basic assumptions that grounded this traditional approach to utility financial management are no longer valid, and for water utilities across North America, the context in which they operate is clearly changing. This shift in the way utilities do business is not only required, but it must be accelerated to ensure long-term viability. It is being driven by two major forces: new challenges and constraints, and increased uncertainty related to major drivers of water use.

³ Preliminary Views of the Governmental Accounting Standards Board on major issues to Economic Condition Reporting: Financial Projections. No 13-3, Nov 29, 2011

New Challenges and Constraints

Systemic changes within the supply chain and the external environment, along with the ability to manage demand, have been causing the overall playing field to shift for some time. Some of these changes include:

- Water supply uncertainty resulting from pervasive overdrafting of groundwater basins;
- Threats to water quantity or quality in surface waters and watersheds;
- Uncertain regulation affecting water quality or quantity;
- Changing environmental compliance standards;
- Competition for source water; and
- Higher customer expectations for communication, service, and involvement.

As a result of these forces, most water utilities may be characterized as being in an “increasing-cost” industry where future water costs will be greater than historical costs. Forthcoming regulations may require higher water treatment standards and change the costs of inputs such as energy and chemicals. Not only will the development of new water supply sources be more costly, often in unknown ways, the cost of maintaining the quality and quantity of existing sources may also require new financial outlays. Augmented competitive pressure to maintain and secure raw water sources may also present surprises and additional costs.

The Consumer Price Index (CPI) is used to measure the average change over time in prices paid by urban consumers in the United States for a market basket of consumer goods and services. An examination of public utility services and how they compare over time with each other and with other major household expenditures reveals that prices for water and sewer maintenance continue to rise at a rate much higher than the overall rate of inflation (CPI).⁴

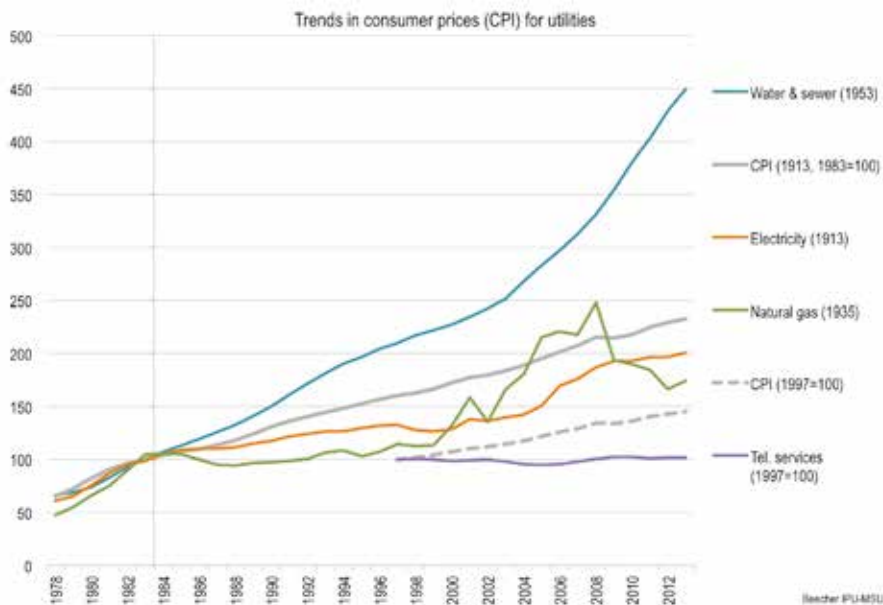


Figure 1 — Trends in Consumer Prices (CPI) for Utilities

4 J. Beecher, Trends in Consumer Prices (CPI) for Utilities Through 2013, Michigan State University, January 2014

Increased Uncertainty

Utilities must also grapple with increased uncertainty. Traditional approaches to water rate design assume that future sales are known with certainty and do not respond to price, weather, the economy, or supply shortages — that is to say, not the world we live in.

Water demand and water sales are declining across the nation, as water-using fixtures become more efficient, utilities take steps to manage supplies, and customers become more aware of the value of this precious resource and make more water-wise decisions. AWE's 2012 Summit identified several highly variable areas that are adding challenges to and increasing the need for good demand forecasting in order to make sound financial decisions.

Weather patterns are becoming increasingly unpredictable. Wide swings in temperature and precipitation are causing dramatic results for utilities. Extremely wet or dry seasons can have a significant effect on supplies and customer demand, and multi-year dry or wet periods can have disastrous effects on utility financial positions. Furthermore, accurately measuring and predicting the effects of climate change presents a daunting challenge.

Economic conditions are cyclic and not easily predicted. Even the slightest economic downturn can influence water use significantly. The recent recession affected many regions that had made financial planning decisions based on anticipated growth. Those regions now face challenges in meeting debt payments for investments made for extra supplies or treatment capacity.

Customer bases are becoming increasingly dynamic. A traditionally residential customer base may gradually incorporate more commercial and industrial customers with different uses for water, or a shrinking industrial base may cause large drops in sales. Commercial and industrial customers are also taking steps to use water more efficiently.

Water sales are declining not for one reason, but for all of these reasons in shifting proportions, none of which are easily predicted.

The time has come for the water industry to shift from a paradigm of growth to a paradigm of sustainability. There is not a single solution that applies to all water utilities. However, water utilities must begin to embrace efficiency as a way to better serve customers by minimizing costs in the long-term and maximizing benefits from smarter water services.

Building sustainable utilities that can continue to supply reliable, affordable water supplies to diverse customers well into the future means not just addressing revenue losses and adopting better financial policies, but also looking at the larger question of water service. Addressing this new, larger question entails examining the political environment in which utilities operate, the way they are structured, the role of public engagement, and how water services are planned, financed, and delivered.

Chapter 2



The Role of Ratemaking

Introduction to Rate Structures

Water ratemaking defines where the rubber meets the road between water supply and water demand. A utility's water rates provide a price signal to customers about the cost consequences of their usage decisions. The Alliance for Water Efficiency's goal is to help utilities continue to incentivize water efficiency while supporting short-term revenue stability and long-term fiscal sustainability. Improved water ratemaking that encourages investments in water efficiency will help utilities manage costs and preserve benefits to customers, communities, and the environment.

By directly addressing the technical problems of efficient water ratemaking with technical solutions, water utilities will be a better position to meet short-term and long-term financial objectives while incorporating the water use efficiency programs that improve service.

Traditionally, public utility ratemaking rests on practice and precedent. Water, energy, and telecommunication services, whether publicly or privately owned, share ratemaking principles recognized and reinforced by public policy. Legislatures and courts have deemed that public utilities must charge "just and reasonable prices" for services rendered (Phillips, 1993), and they must do so in an equitable and nondiscriminatory fashion. In 1961, James Bonbright identified ten fundamental principles of rate design. They provide a useful starting point for examining rate designs of the 21st Century:

BONBRIGHT PRINCIPLES OF RATE DESIGN



1. **Revenue adequacy** — Effectively yield the revenue requirements in a fair and reasonable manner without undue capital spending while meeting service and quality objectives.
2. **Revenue stability** — Provide revenue stability and predictability with a minimum of unexpected changes.
3. **Rate continuity** — Provide stable and predictable rates with a minimum of unexpected changes that have adverse effect on customers.
4. **Static efficiency** — Establish rate structures that discourage the wasteful use of the service provided while promoting all justified uses and amounts.
5. **Full cost pricing** — Reflect of all present and future private and social costs and benefits of service provision.
6. **Fair and equitable** — Apportion costs of service among the different customer classes that are not arbitrary and capricious, and achieve horizontal and vertical equity.
7. **Avoid undue discrimination** — Not requiring subsidies across customer groups.
8. **Dynamic efficiency** — Set rate structures that are dynamic and promote innovation and that respond to changing demand and supply patterns.
9. **Simple, understandable and acceptable** — Set rate structures that are simple to use, convenient, understandable, economic to implement and maintain, and are publicly acceptable.
10. **Freedom from controversy** — As to proper interpretation of the rate structure.

Bonbright (1961, 1988) set forth principles for Rate Design

Water utilities are organized as monopolies for good reason. They provide an essential service that requires substantial fixed capital and demonstrates declining costs of production (economies of scale). Duplication of water facilities, such as pipelines and treatment plants, to allow for competition would be highly inefficient. As a result, utilities receive an exclusive franchise to serve a given territory. Monopolies, while reasonable and practical, also enjoy an economic power over customers who cannot easily give up the service or shop around for an alternative provider.

Traditional ratemaking recognizes the value to society of the monopoly organization and the importance of protecting customers from excessive or discriminatory rates. Privately-owned monopolies must not earn excessive returns or unduly reward stockholders, and publicly-owned monopolies must not generate inappropriate levels of revenues to subsidize other governmental functions.

Traditionally, the pricing design of utility services ensured that revenues were adequate to sustain operations and finance system expansions and upgrades, as well as to distribute costs equitably. Traditionally, however, resource scarcity and environmental consequences of overuse were rarely of grave concern. Bonbright's principles, for example, simply do not take these realities of today into consideration.

While the Bonbright principles still form the basis of sound rate design, balancing potentially competing objectives is becoming increasingly challenging as the role of water utilities evolves and they become major economic actors and environmental stewards within their communities. Water utility performance metrics now often include Triple Bottom Line⁵ considerations, reflecting a utility's financial, environmental and social responsibilities. While this traditional paradigm no longer exists, certain components are as important as ever, including determining revenue requirements, allocating cost, and designing rates — in this case, rates that support and encourage efficiency.

Ratemaking as a Tool for Financing Sustainable Water

The setting of water rates is embedded within the requirements for effective financial management of the water utility. Water rates are an important tool that utilities can use to achieve various objectives, including:

- **Revenue Generation** — to generate sufficient revenue to pay prudent costs
- **Fiscal Sustainability** — to support sustainable water service delivery
- **Resource Efficiency** — to avoid consumptive or productive waste

Revenue sufficiency is a utility's primary and most straightforward objective. They must recover the costs incurred to provide reliable water, pay for daily operations, and fund needed system improvements. Rate structures should be designed to cover these costs and provide sufficient revenue at a level determined by the utility.

Rate setting should also be firmly embedded within overall utility financial management to contribute to long-term fiscal sustainability. Water rate setting can be guided by financial policies and mechanisms that can help create a more fiscally sound organization that is fully able to meet its service requirements.

Finally, rates are a powerful tool to help ensure the efficient use of finite water resources. Prices that reflect costs help ensure this prudent use of resources. Rates should signal the additional costs of extra production, treatment, and delivery, thus providing the basis for matching consumptive decisions with production costs.

5 S. Kenway, C Howe, and S Maheepala, *Triple Bottom Line Reporting of Sustainable Water Utility Performance*, AWWA Research Foundation 91179, 15 Jan 2008

Figure 2 illustrates how water rate setting ties into financial planning and fiscal sustainability policies.

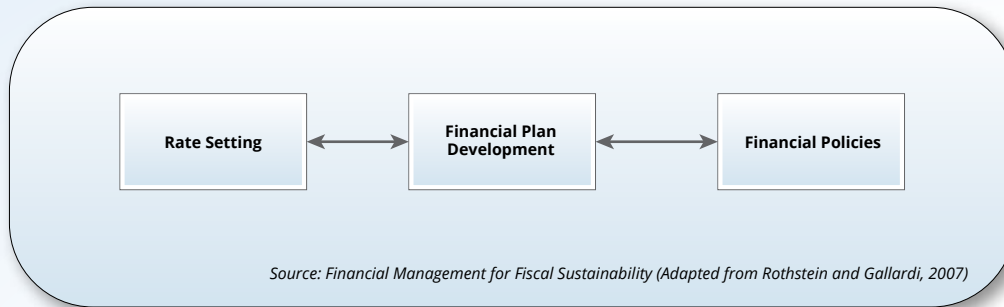


Figure 2 — Financial Management for Fiscal Sustainability

Figure 3 below provides a more detailed depiction of the components of Rate Setting, Financial Plan Development, and Financial Policies.

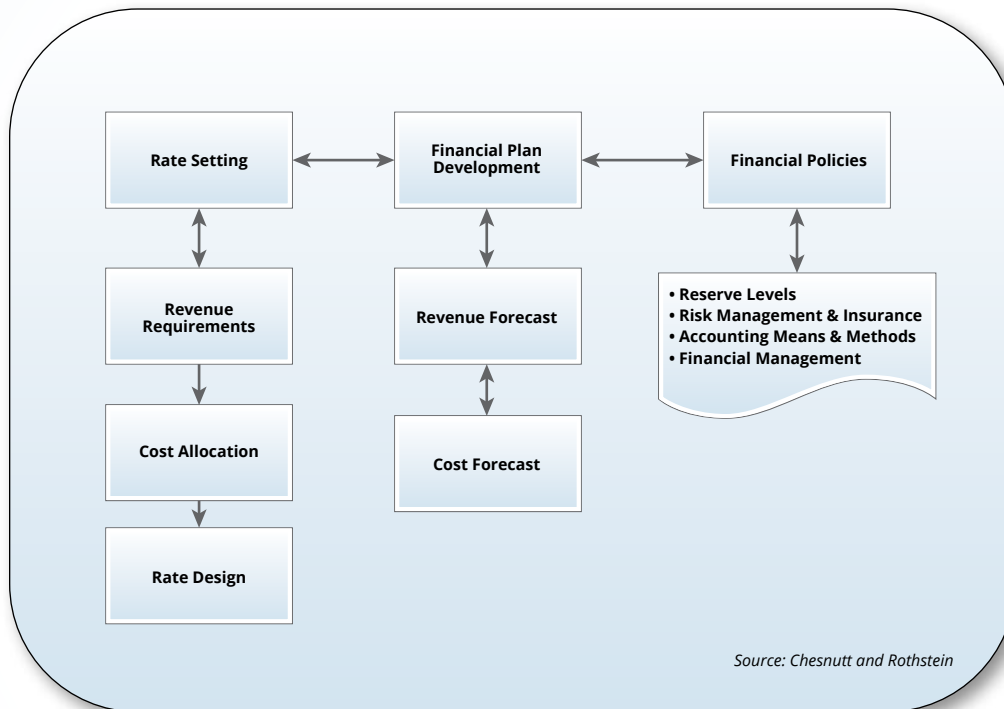


Figure 3 — Components of Financial Management for Fiscal Sustainability

Additionally, utilities must often achieve secondary objectives through rate setting, including affordability of basic services for customers and supporting economic development. In setting rates, these objectives become a balancing act for utilities.

To further complicate the landscape, water utility management and decision-makers cannot isolate rate design from system planning, cost analyses, and implementation issues. Since rate changes can change water demand, an integrated approach to pricing and other conservation strategies

is essential. For example, analysts must consider the joint effect of water supply and wastewater treatment pricing since many customers are billed simultaneously for water and wastewater services. Rate designers now need to consider such issues as the combined elasticity effect of rate increases, the joint effects of conservation on operations and revenues, and long-term planning.

These evolving shifts will require substantial efforts to increase customers' understanding of the relevant factors. While water use efficiency programs, such as fixture retrofit or rebate programs, can increase customers' ability to respond to rate changes, water utilities must monitor customer responses to price changes as they develop and implement conservation programs. Effective outreach and education can enhance the value of price signals conveyed by rate levels.

Rate design also needs to be integrated into the utility's drought management plan since customers will be using less water. This integration might entail:

- Penalties or surcharges tied to drought levels;
- Linkage of drought surcharge revenues to funding of drought response and water efficiency programs; and
- Strategies for revenue management during rationing episodes.

PRICE, PROGRAMS, AND PERSUASION: EFFICIENT SYNERGIES



Water demand, like energy demand, is changing. Despite the fact that reductions in water use have economic, social, and environmental benefits and costs, water utilities must nevertheless engage in focused water conservation efforts to help contain infrastructure costs and manage growth-related demand. Three drivers of water conservation programs are pricing, programs, and persuasion:

Pricing — charging water rates that reflect resource costs induce customers to align consumptive choices with those costs;

Programs — typical water efficiency programs can include rebate programs, device replacement, plumbing codes, or efficiency standard changes; and

Persuasion — public-information campaigns, and social marketing, and general appeals.

The goal of water efficiency-based pricing is to move usage along an economic demand curve. Non-price efficiency programs (including changes to code and retrofits) and persuasion (including public-information campaigns, social marketing, and general appeals) are aimed at shifting the entire curve. Efficient rates can provide a powerful incentive to change water-using practices and reduce water bills, just as efficiency programs can provide a route to that end. As a rule, utility-sponsored efficiency programs accelerate the pace of adopting efficiency practices and technologies in comparison to market forces alone.

The synergy between price and non-price conservation strategies extends beyond the objective of demand management. Water conservation initiatives can also be an important part of a utility's customer service program since customers in all service classes can benefit from assistance in reducing water use, which will help keep water bills down in the long-term. The public outreach accomplished through efficiency programs can make for more solid public support for the water utility and a better understanding of the utility's pricing policies.

Why Adopt an Efficiency-Oriented Rate Structure?

As highlighted in this Handbook, the principles of water rate design can support resource efficiency objectives and embrace holistic water resource management.⁶ Serving efficiency objectives does not require compromising other objectives; rather, there are numerous opportunities for coalescence and synergy. Water rate designs that send price signals reflecting the full cost of sustainable water services will promote water resource use efficiency, and water efficiency rates will promote sustainable economic development by avoiding the historic underpricing that has contributed to the depletion of our precious water resources.

In short, water rates can not only be a means of meeting utility revenue requirements, they can also be a valuable public policy tool and a tool for informing consumers of the private and social costs related to water development and delivery. With that information, users can base their consumption decisions on a more realistic accounting of the benefits and costs of using more or less water.

When done correctly, the pricing of water can be a powerful means of signaling the cost and scarcity of the resource to water users, most of whom experience very little connection between their water usage and their total bill. In an era where overall water demands are increasing due to population growth and industrialization while water supplies are constant or diminishing, economic tools can help communicate the true value of fresh water.

Furthermore, this price signal supports two-way communications. The customer's consumption decisions based on price provide a signal to utilities about their willingness to pay for water. Utilities need this information to make production decisions. Historically, utilities have often underestimated customers' willingness to pay for reliable water service and/or water quality.

The law of demand states that consumers buy less of a good when its price increases and more of a good when its price decreases. Economists use the concept of "price elasticity" to measure the extent to which the demand for a good or service is sensitive to changes in its price. Price elasticity tells the percentage change in demand for a one percent change in price. For example, if a good has an elasticity of magnitude 1.0, then a 10% increase in its price will produce a 10% decrease in its demand.⁷ If a good has an elasticity of magnitude 0.5, then the same 10% increase in price would produce only a 5% decrease in demand. Economists describe a good or service as "inelastic" when its price elasticity is of magnitude less than 1.0,⁸ which means the percentage change in demand will be less than the percentage change in price. Conversely, an "elastic" demand is one with a price elasticity magnitude greater than 1.0, so the percentage change in demand is greater than the percentage change in price.

6 Specifically, to be most effective, water rate design should also be considered in the context of wastewater, stormwater, and water reuse rates in support of holistic water resource management.

7 Price elasticity actually has a negative sign because price and quantity demanded move in opposite directions. To keep the discussion simple, we are presenting elasticity as a positive parameter. Technically, what we actually are presenting is the absolute value of the elasticity parameter.

8 Note that many often read the label of "inelasticity" to mean "no elasticity." The authors are unaware how the label of "inelasticity" was chosen to mean "limited elasticity." Economists refer to a complete lack of demand responsiveness to price as "perfectly inelastic." This subtlety has been a longstanding and unfortunate source for misunderstanding between economists studying water demand and non-economists.

Over the historic range of prices and consumption, urban residential demand for water has been relatively inelastic: the percentage change in customer water demand has generally been smaller than the percentage increase in water price.⁹ While the residential demand for water in urban settings is inelastic, however, its elasticity is not zero. This distinction is important: if demand for water exhibited zero elasticity (what economists call “perfect inelasticity”) water rates would have no relevance to consumer decisions about water use, and rate structures would prove to be an ineffective instrument for encouraging water conservation. Since customer demand tends to be relatively inelastic but not perfectly inelastic, rates can be used strategically used to influence the level of demand.¹⁰ The long-run response is greater than the short-run response.

■ Thus, the issue is not whether prices affect use, but rather how much prices affect use.

Key Considerations for Adopting an Efficiency-Oriented Rate Structure

Adopting an efficiency-oriented rate structure can help a utility promote water conservation without sacrificing the bottom line and support better financial planning for the future. However, a “one-size-fits-all” approach will not work when constructing efficiency-oriented rate structures. Following some general principles and considerations will help when considering adopting an efficiency-oriented rate structure, or making efficiency-related improvements to rate design.

Embracing Uncertainty Can Enable Better Decision-Making: Traditional water industry ratemaking and financial planning tools have generally been predicated on certainty. These models make a few now-outdated assumptions: that next year’s water sales volume is known; that sales will not respond to changes in water rates (the “price signal”); that rates remain disconnected from drought/shortage management plans; and that multiple-year revenue forecasts are predicated on steady certain growth. This traditional model must become more responsive to efficiency and sustainability imperatives by acknowledging and incorporating the idea of uncertainty. Short-term variability in consumption, sales, weather, and growth can be better quantified and managed through principles of probability management than through the use of historical data alone. Analysis of rate design must represent the future as a distribution of possibilities rather than a point so it informs decision makers about probabilities and consequences of risk.

Understand Efficiency Objectives Before You Start: It is important to be clear about utility objectives when designing and communicating rates, and especially important to make a distinction between the long term and the short term. Short-term management might involve better financial planning to handle drought and minimize the costs of a shortage. An investment in cost-effective conservation lowers the revenue requirement over time and affects long-term resource efficiency while users face cost consequences related to their consumptive behavior.

9 Renzetti, Steven (2002). *The Economics of Water Demands*, Kluwer Academic Publishers, Boston.

10 Epsey, M., J. Epsey, and W. Shaw (1997). *Price Elasticity of Residential Demand for Water: A Meta-Analysis*. *Water Resources Research* 33 (June) 1369-1374. Also see Dalhuisen, J., et. al. (2003). *Price and Income Elasticities of Residential Demand: A Meta-Analysis*. *Land Economics* 79 (May): 292-308.

Customer Empowerment and Understanding is Key: The success of efficiency-oriented rates hinges on incentives and a customer's ability to make changes in usage. Rate design must be focused on giving customers enough control to make decisions that benefit them while simultaneously achieving utility objectives. It is also important to communicate the price signal effectively and accurately, or rate revisions will risk being viewed as punitive by customers. Frequent billing, for example, will send signals to customers in a time frame that will allow them to make changes in consumption patterns quickly.

One Size Does Not Fit All: A single rate structure may not work for all utilities or even all classes of service. A high uniform rate may provide the same desired price signal as an increasing tiered rate that varies across customer classes. It is important to consider a variety of factors when selecting a rate structure, including priority objectives, service area characteristics, and customer values and demographics.

Revenue Instability is a Feature of all Rates: Better analysis can allow utility managers to know more about the consequences of different rate decisions and make better choices about tradeoffs from competing objectives. Understanding the risk of revenue instability can also help guide development of financial policies that will promote stability. The *AWE Sales Forecasting and Rate Model* is designed to help water managers better understand how variations in sales might affect revenues and allow better quantitative analysis of this revenue risk.

Better Rate Analysis Requires Good Data: Both the cost of conducting an analysis and the relative benefits obtained from the effort are closely tied to the type and quality of data available. Simplistic demand modeling approaches predicated on population growth and average water use may be easy to execute, but they miss major drivers of demand and focus too heavily on producing a single point. The consequences of poor demand forecasting are significant: building too much capacity can result in capacity that is never used, while building too little results in poor reliability and customer shortage costs. Demand/Sales forecasting can be improved in simple ways that produce more useful and accurate data to inform decision makers about the impact of rate options. (See Appendix B for more detailed information on demand forecasting.)

AWE's Sales Forecasting and Rate Model

The *AWE Sales Forecasting and Rate Model* helps water managers address many of the challenges and correct many of the flaws in traditional rate setting. It allows water managers to review, analyze and model the potential impacts of various rate structures, specifically including the following features and capabilities:

Customer Consumption Variability, demonstrating variability driven by weather, drought/shortage, or external shock.

Demand Response, predicting future block sales (volume and revenue) with empirical price elasticities. The *AWE Sales Forecasting and Rate Model* bases rate design on an empirical understanding of customer demand: when the price of water goes up, customers use less.

Drought Pricing, enabling contingency planning for revenue neutrality. The *AWE Sales Forecasting and Rate Model* addresses rate shifts that occur during droughts and shortage to yield net revenue neutrality at each drought/shortage level.

Probability Management, conducting a simulation of revenue risks. Traditional rate making relies on the use of averages as a basis for decision-making. The field of probability management demonstrates that planning for the future is rife with uncertainties, and that plans based on average assumptions are, on average, wrong. Sales forecasts avoid the “Flaw of Averages”¹¹ by incorporating the standards and principles of “Probability Management”¹² to reveal the likelihood of attaining financial viability for the water utility.

Fiscal Sustainability, allowing for sales forecasting over a 5-year time horizon to facilitate better planning for financial health in the short-to-medium term.

The model is just one component of sound rate-setting practice; other elements, like good financial management, must remain an integral part of the effort. Such critical steps as demand forecasting, carrying out a cost of service analysis, determining revenue requirements, and identifying objectives cannot be undervalued. Only after completing them can rate setters undertake the exercise — or art — of designing a rate structure and evaluating it against multiple scenarios to determine its effectiveness.

TYPES OF QUESTIONS THE AWE SALES FORECASTING AND RATE MODEL CAN ANSWER:

- What effect would increasing the rate in our top tier by 15% have on water demand?
- Will shifting to seasonal rates cause overall water use to increase or decrease?
- What block rate design could allow us to preserve our current level of revenue while reducing overall demand?
- How should we adjust our rates to support our water demand management objectives during water shortages?
- What proportion of customer bills will increase (or decrease) under our proposed rates when compared to our current rates?

11 Savage, Sam L., (2012) *The Flaw of Averages*, Hoboken, NJ John Wiley and Sons.(www.flawofaverages.com)

12 Savage, Sam L and Shayne Kavanagh , (2014) “*Probability Management in Financial Planning*,” Government Finance Review Magazine, February 2014. (www.probabilitymanagement.org is a non-profit that promotes the communication and calculation of uncertainties.) As described by Dr. D. Ralph, Director of the Centre for Risk Studies, at Cambridge University: “The discipline of probability management provides a transformation of proven risk modeling techniques into simple business steps. Its open standard advances the field by representing uncertainties as unambiguous data, which may be shared across platforms.” Middle school students appear to quickly grasp the concepts of probability management: investment contest at Horace Mann School in Beverly Hills; see <http://youtu.be/vR0BFJFEvCM>.

Chapter 3



Building a Better (Efficiency-Oriented) Rate Structure

Despite changes in the utility finance paradigm, certain foundational components of financial management are as important as ever, including determining revenue requirements, allocating cost, and designing rates — in this case, rates that support and encourage efficiency.

Traditional ratemaking involves three discrete steps:¹³

- Step 1** — Identify costs and the utility's revenue requirements.
- Step 2** — Allocate costs to customer classes.
- Step 3** — Design rates and charges to recover costs from customers.

Figure 4 shows the step framework of traditional ratemaking.

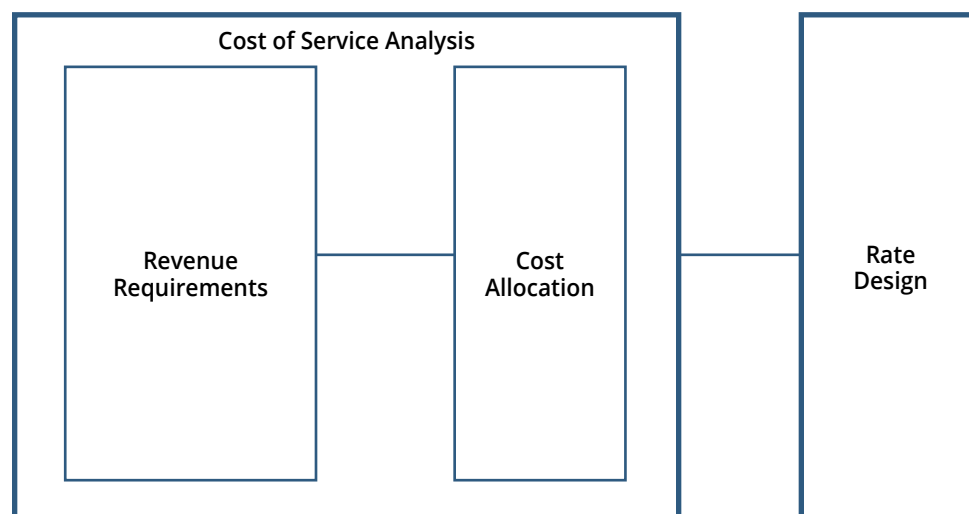
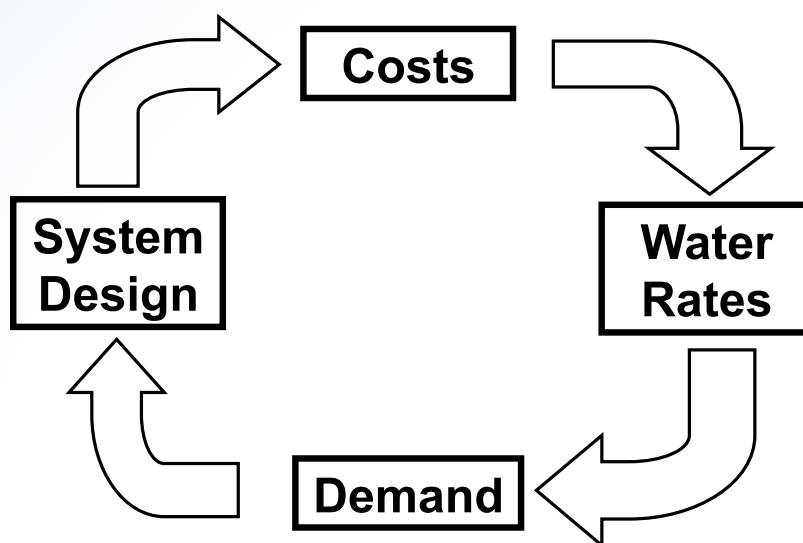


Figure 4 — Cost of Service Analysis

13 American Water Works Association (AWWA) *Manual of Water Supply Practices, M1, Principles of Water Rates, Fees and Charges, 6th Edition*, (2012), p. 112.

A more robust ratemaking process is required today to ensure rate structures achieve their objectives. Managers must invest sufficient time in discussing utility objectives at the outset, and conduct appropriate analysis to evaluate the proposed rate structure's performance against those objectives. Finally, the very act of deciding on a rate structure must be a thoughtful process.

These steps support a circular flow of economic logic in which costs to provide water service are recovered through water rates charged to customers. Based on these water prices, customers make consumptive decisions about their demand for water. Utilities can then use the demand information provided by customers to make decisions about how to design and operate their systems, thus changing the costs involved. **Figure 5** illustrates the circular flow of this economic logic.



Source: Beecher IPU/MSU

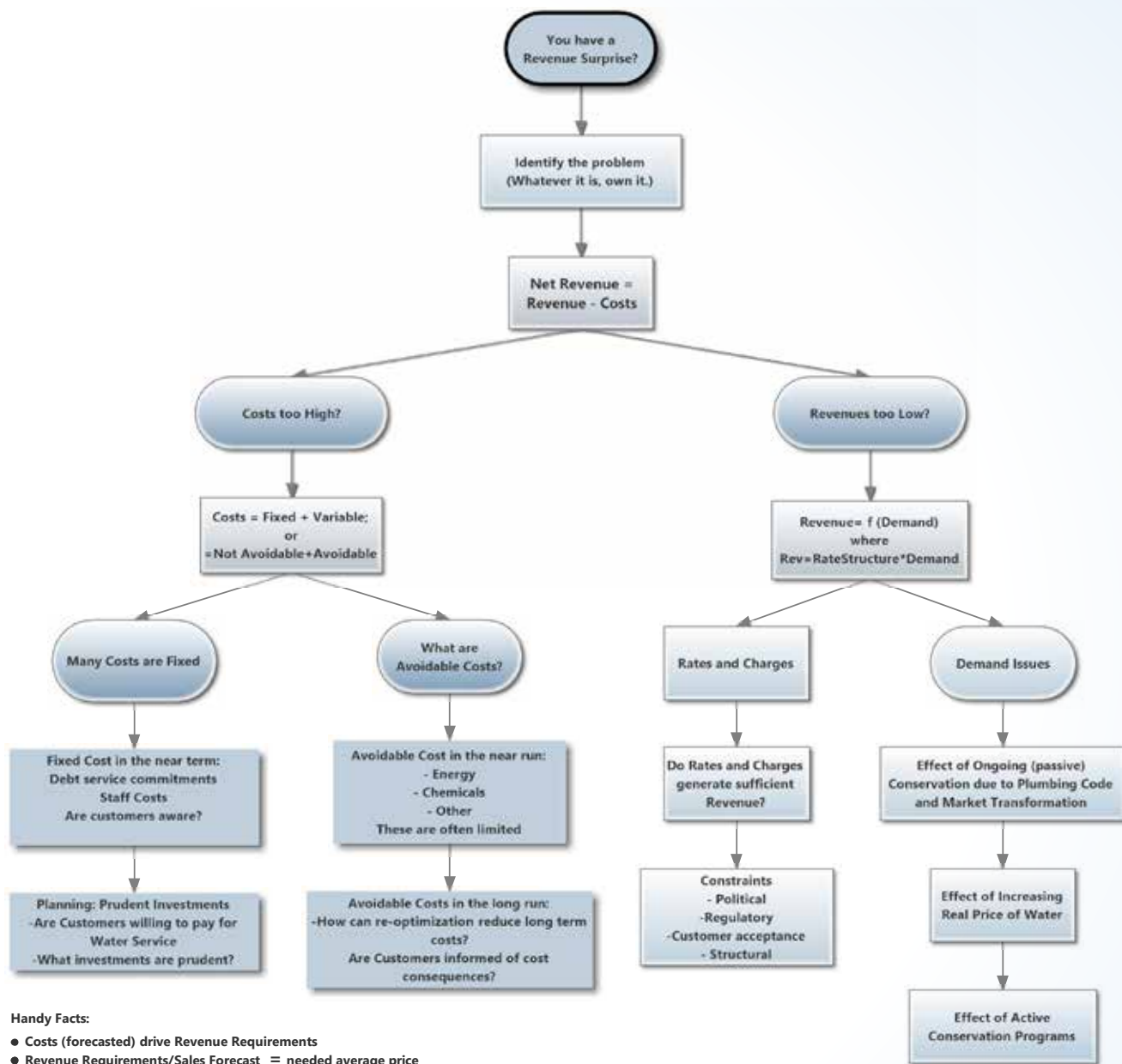
Figure 5 — Flow of Economic Logic

The challenge the industry faces today is that water rates have traditionally been focused solely on historical cost recovery. However, when system costs change quickly and perhaps unpredictably, historical rates do not reflect today's cost consequences, and the rates do not give customers correct information to make consumptive decisions.

Utility managers can also help set themselves up for success by taking stock of their financial position prior to reviewing or developing a rate structure. The AWE Self-Assessment Flowchart can help water utility managers who have financial responsibilities assess their utility and its external environment, which in turn will help them develop an equitable rate structure that will recover the full cost of service. Identifying the nature of the problem (Is a revenue shortfall due to revenues too low or costs too high?) is key to defining the nature of any solution. This Flowchart will help identify the right approach to balancing cost recovery with efficiency and fiscal sustainability. Utilities should examine costs closely, as cost-effective investments in efficiency will reduce long-term required expenditures.

As a matter of note, the AWE Self-Assessment Flowchart adds resource scarcity as a factor, thus complementing, but not replacing, the more complete Self-Assessment processes that have come out of the “Effective Utility Management” movement, as well as additional performance metrics and benchmarking tools that are available in North America and internationally.¹⁴

How to Avoid Revenue Surprises: Defining the Problem



Source: Chesnutt

Figure 6 — AWE Self-Assessment Flowchart

14 Performance Benchmarking for Effectively Managed Water Utilities (Project 4313) User Guide for the Self-Assessment Tool, January 2014, Performance Assessment of Urban Infrastructure Services, Cabrera and Pardo, IWA, 2008, and the IWA Aquearing System <http://www.aquearing.org>.

Identify and Prioritize Ratemaking Objectives

The art of ratemaking involves designing rates that balance inherently conflicting objectives in a manner that reflects community values. At a minimum, rates should be sufficient to generate revenue to support operations, maintain and develop capital infrastructure, and preserve (or enhance) the financial integrity of the utility system. In addition, there are other technical and policy objectives for utility services that utilities may want the rate structure to achieve, such as rate stability, equity, simplicity, and public understanding. Utilities may further seek to support or promote economic development through their rate design, or ensure the affordability of minimal levels of service for low-income ratepayers. Water resource efficiency is among the most common policy objectives, particularly with the cloud of water resource scarcity hovering over many regions.

COMMON RATEMAKING OBJECTIVES FOR WATER PROVIDERS

- Revenue Sufficiency
- Revenue Stability
- Rate Continuity
- Resource Efficiency
- Affordability for Customers
- Full Cost Pricing
- Fair and Equitable
- Economic Development
- Public Understanding

As a rule, water utilities are enterprises that must generate enough revenue to fund their operations and maintenance expenses and to finance their capital investments. Revenue adequacy is a threshold condition of effective rate setting, since it alone assures the long-term financial viability of the utility.

Utilities devise rates to achieve revenue adequacy by determining rate revenue requirements. These revenue requirements reflect the annual revenue needs required to meet all of the financial commitments that are not funded through other sources. These other revenue sources may include system development charges, impact fee revenues, miscellaneous charges for administrative or customer account services, or interest earnings. Typically, however, most of a utility's revenues are derived from rates imposed for the water services it delivers.

A more expansive view of revenue requirements would help utilities more easily pursue objectives such as resource efficiency and financial resiliency through their rates. Traditional utility practices have defined revenue requirements in terms of current and known costs involved in delivering water service. With a small number of notable exceptions, water use efficiency investments have not been capitalized, though arguably their primary benefit is to avoid or defer capital expenditures. Revenue requirements are based on a narrow definition of accounting costs that tend to ignore externalities, efficiency of usage, and valid social considerations such as low income affordability. Additionally, similar to revenue forecasting, determining revenue requirements often assumes constancy of future water demand.

A more expansive view of revenue requirements could internalize some costs that have historically been treated as externalities, or it could shift some discretionary costs to true costs. By establishing funds to diversify supply sources and advance preparedness for drought, for example, utilities may better prepare for the implications of climate change. By recognizing asset management and water loss control as primary water use efficiency measures, they may be able to increase investments in infrastructure. Water use efficiency programs that are demonstrated to be cost-effective and that yield high returns may be funded as a component of a water resource service offering rather than a nicety to customers. Rate structures that support conservation, efficiency, and resilience services will have a significant impact on the financial integrity of water utilities in the future. Creating rates that address the future, keep the utility whole, promote resilience, and satisfy the community is assuredly something of an “art.”

There is not one single objective of rate making, and water managers must achieve a balancing act in their rate design. AWE’s goal is to help water managers conduct better analyses of the tradeoffs from competing objectives resulting from different rate structures to inform decision-making.

Determine Revenue Requirements: Cost of Service

Selecting a Test Year

Determining revenue requirements inevitably entails reference to historical costs and some evaluation of how those costs may change in the future. The first step in this determination involves selecting a representative test year. The selection of the test year and the methods by which it incorporates projected costs can have significant implications. In addition, the test year must meet a “known and measureable” standard. This standard, which is generally required in regulated rate setting contexts, sets a high hurdle in anticipating costs, thus sometimes imposing a “regulatory lag” in cost recovery. Future test year approaches, while based on historical cost data, involve projections of future requirements that not only are uncertain, but that become increasingly uncertain the longer the projection period is extended. These complexities are further compounded by the reality that water utility costs and revenues vary as a consequence of variations in weather and the uncertainties of customer responses to water conservation programs and pricing structures.

Traditionally, the test year has been an actual historical year, typically a recent 12-month period for which cost accounting data are available. It also can be a future year, such as the next immediate year, based on forecast data. Or it can be a hybrid year that combines historical data and cost forecasts. Regardless of the test year, this first step must determine revenue requirements — the total costs that must be recovered through water rates and charges.

For regulated utilities, the choice of a test year is subject to state law and approval by state public utility commissions. Utilities with the option to choose a test year often choose the future year option because it can have some beneficial effects. It reduces the lag between incurring and recovering costs; it produces forecasts of future costs from which estimates of avoided costs can be derived; and it allows utilities to plan for the effects of rate changes on future water use and revenues.

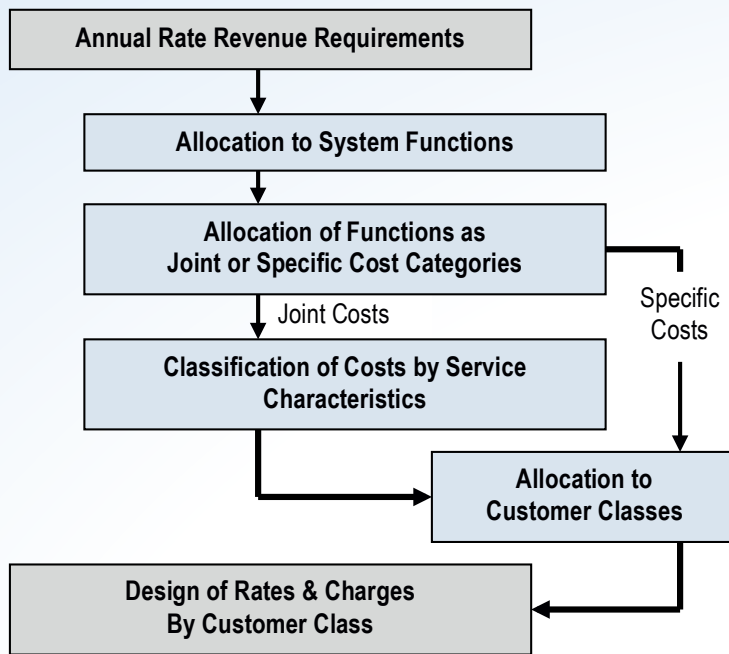


Figure 7 - Revenue Requirements

Publicly-owned utilities typically choose a future test year approach to facilitate alignment with their budgeting processes: the test year is actually the forthcoming budgeted fiscal year. These utilities, which typically operate using a cash-basis approach, may more easily accommodate variances from future projections through management of their fund balance levels. In contrast, investor-owned utilities often are required to adhere to the established policies of the state utility commission that has jurisdiction over their rate-setting practices.¹⁵ For these utilities, actual variances from test year revenue requirements have earned return implications as well as impacting fund balance levels. In terms of promoting water resource efficiency, it has been argued that use of a future test year period is preferable insofar as it enables some consideration of future demand and facility capacity needs, and may advance intergenerational equity by more fully reflecting the long-term costs of resource use and capacity development¹⁶.

The major shortcoming of ratemaking based solely on historical costs (rather than future costs) is the risk of underpricing the water, which can lead to overconsumption and further increase stresses on system capacity. From a practical perspective, using historical data to forecast the future encourages utilities to overinvest in capacity while providing little incentive to deploy existing resources more efficiently through rate design and other load management techniques.

¹⁵ See Beecher, Chapter 3 "Institutions, Incentives, and Water Efficiency—Effects of Utility Structure on Conservation" in *A Balanced Approach to Water Conservation in Utility Planning*, 1P-1.25C-4175-02/12-FP, Water Research Foundation (March 2012).

¹⁶ J. Michael Harrison, "Forecasting Revenue Requirements," *Public Utilities Fortnightly* Vol. 103, March 1979, pp. 11-15.

HOW HISTORICAL DATA CAN LEAD TO AN UNEXPECTED OUTCOME



Imagine a utility with a single water source that has a safe yield of 100 million gallons per day (MGD), costs that can be covered by charging customers \$1 for each billing unit, and growing demand. Demand forecasts showed that this utility would soon exceed its 100-MGD capacity, so it made a seemingly obvious capital improvement decision: to develop a new water source, this one with a 50-MGD capacity. As a result of this costly endeavor, the utility had to double rates, to \$2 per billing unit.

This doubling of water bills caught the attention of the utility's customers who lowered their water use on the basis of the new higher price. The next year, water sales dropped by 20%, to 80 MGD.

Because the utility priced water based upon historical costs, it added new capacity sooner than needed. Customers saw their rates double for the sake of a supply project that could have been delayed several more years...if it ever needed to be built at all.

Determining Revenue Requirements of the Test Year

The second step involves the utility's determination of the revenue requirements for the test year. They may use one of two common accounting alternatives to estimate the financial obligations of the utility to its bondholders, employees, and its customers: the cash-needs approach or the utility approach.

The cash basis approach defines utility revenue requirements as the cash needs of the utility for the year(s) during which calculated rates will be in effect. Under this approach, system revenue requirements are the sum of:

- Operations and Maintenance (O&M) expenses
- Cash-funded capital expenses
- Debt service obligations (principal, interest, reserve funding)
- Payments in Lieu of Taxes and/or franchise fees (if applicable)

The utility basis approach differs from the cash basis approach in its treatment of capital-related costs, such as depreciation and allowed returns. Capital-related revenue requirements are derived based on a rate of return applied to the utility's rate base, and the rate base reflects the book value of system capital investments made by the utility enterprise. It excludes the value of assets contributed to the utility by governmental agencies or developers, (or assets not prudently acquired), including:

- Operations and Maintenance (O&M) expenses
- Depreciation expenses
- Taxes
- Return on rate base

Determining a utility's revenue requirement involves estimating annual costs, including operating expenses and capital costs. Operating expenses include salaries and wages of utility employees, electricity and chemicals for plant operations, and customer metering and billing. Capital expenses include expenditures for plant expansions and upgrades, as well as system renewal and rehabilitation, regardless of whether they are financed through current revenues or debt issuances.

Most publicly-owned utilities use the cash basis approach to determine revenue requirements because it aligns with the municipal budgeting process and is relatively easily understood and administered. On the minus side, however, it does not recognize the decline in the useful life of capital assets — unless annual renewal and rehabilitation costs are included in budgeted capital spending plans — and it is subject to understatement because of all-too-frequent political pressures to limit rate increases.

The utility basis approach is mandated for investor-owned water utilities and publicly-owned utilities under state commission jurisdiction. In addition, public utilities not regulated by a state utility commission may employ the utility basis for determining revenue requirements for service to customers outside their jurisdictional municipal boundaries. The utility basis approach may provide several advantages, such as basing capital costs on invested asset value and explicitly including depreciation expenses. In addition, some argue that the paradigm of rate of return regulation incentivizes efficiency. On the flip side, however, this paradigm may be viewed as complex, difficult to understand and administer, and often arbitrary. Certainly, determining appropriate rates of return has been controversial.

Cost of Service

Designing rates is an inexact science, and the cost allocations that provide the basis for rate design are estimates at best. Cost studies involve the judgments of analysts based on theories and assumptions about the forces that drive system costs. Though average embedded cost studies are used to set overall revenue requirements, marginal/incremental cost analyses define what constitutes an appropriate price signal—a needed benchmark for designing rates.

GLOSSARY OF COST JARGON



Financial versus Management Cost Accounting: Financial accounting for external reporting deals with after-the-fact values, while management accounting for internal purposes takes a proactive view of value. Management accounting—by relating measured costs to cost causation—serves the ends of improving water utility efficiency improvements.¹⁷

Attributable versus Joint Costs: If all costs could be easily, accurately, and cheaply attributed to individual customers, cost-causation would be relatively straightforward. Such is not the case.¹⁸ Attributable cost is based on causality, while “joint” costs reflect joint functions. Providing capacity for peak periods, for example, also provides capacity for nonpeak periods, and providing flow capacity sufficient for fire protection also provides capacity that may be used for other high-flow needs. Joint costs complicate the task of cost allocation.

Fixed versus Variable Costs: Fixed costs remain unchanged throughout the year regardless of the volume of water produced. Variable costs, or commodity costs, vary directly with the volume of water produced or consumed. Variable costs include purchased water, electricity, and chemicals. In light of the up-front capital costs needed to build new capacity, some traditional costing methods classify system expansion costs as fixed, referring to them as “demand” costs. Marginal or incremental costing methods recognize that the dividing line between fixed and variable depends on the period of time used for the analysis: in the long run, fixed capital expenditures change, thus becoming variable.¹⁹

Triple Bottom Line: An accounting of costs and benefits that includes finances, societal impacts, and the environment. John Elkington coined the term in 1994.²⁰

Full Cost Pricing: Full cost pricing promotes efficient water use by fully recovering the cost of water or wastewater services in an economically efficient, environmentally sound, and socially acceptable manner.²¹

17 IMA “Conceptual Framework for Managerial Costing,” March 2013. Capstone, 1997.

18 Shillinglaw 1963, “The Concept of Attributable Cost.”

19 IFAC Professional Accountants in Business Committee, “Evaluating and improving costing in organizations,” International Good Practice Guide, July 2009

20 Elkington, J., “Cannibals with Forks: the Triple Bottom Line of 21st Century Business”.

21 USEPA Expert Workshop on Full Cost Pricing of Water and Wastewater Service, IPU-MSU, USEPA Office of Water 2006.

Allocate Costs

Water utilities (and regulators) often use cost-of-service studies to allocate costs, which include capital and operating expenses. The goal is to reflect the cost of service associated with different patterns of water use, such as variations in seasonal and daily peak demands.

Cost of Service Principles/Full Cost Recovery

Rate design emphasizes the principle of cost causation: revenues should be recovered from those who cause costs to be incurred. Further, utilities design rates according to revenue requirements for classes of customers based on account and meter population distributions along with patterns of water use for that class.

To illustrate why costs may be calculated differently for different customers — an allocation of costs based on cost causation — consider a customer group with high peak demands. Additional costs might be associated with that class for the need to have additional storage facilities and pipeline capacities.

Cost-of-service-based rates aim at equal treatment for users with similar costs of service, and rate differentials for users with unequal costs of service. Thus, utilities set rates so revenues from each user class approximate the cost of serving that user class. This practice helps utilities avoid undue price discrimination. When developing rates to encourage efficiency, utilities should retain a focus on the costs — or avoided costs — that are caused by customers using — or not using — water.

Critics argue that some efficiency-oriented rate structures cannot be reconciled with the cost-of-service principle. On the other hand, managers in water utilities that have successfully used efficient rates argue that their rates more accurately reflect the full, long-term cost of providing water service, potentially inclusive of externalities. Indeed, cost-of-service principles have evolved over time and will continue to evolve in ways that help rates more accurately reflect the costs associated with alternative resource choices.

Shifting toward more efficiency-oriented rate structures does not mean that utilities should abandon cost-of-service ratemaking principles. These rate structures must reflect costs, regardless of their specific form. Rates based on correctly measured costs enable utilities and their customers to make efficient supply and demand choices.

Cost of Service Analyses

A cost of service analysis (COSA) helps set the stage for calculating of specific rates and charges.

The COSA process is a multi-step process designed to distribute revenue responsibilities to customer classes in proportion to the demands that those customer classes place on the water system. For example, if residential customers represent 80 percent of the number of accounts and they impose 50 percent of average day demands and 70 percent of peak-day demands, the residential class is allocated 80 percent of customer related costs, 50 percent of average-day demand related costs, and 70 percent of peak-day demand related costs.

Once total costs are determined (budgeted) and offsetting non-rate revenues projected, determining the shares of rate revenue requires three steps:

- **Functionalize costs (supply, treatment, storage, etc.):** This step separates costs into functional categories such as source development, treatment, transmission, and distribution. The accounting system may calculate the costs directly by functional category, or the costs may be estimated indirectly using accounting information.
- **Allocate costs to functions (such as base, maximum day, etc.):** This step assigns functional costs to usage categories using either the base-extra-capacity method or the demand-commodity method. The base-extra-capacity method assigns functional costs to an average day, a maximum day, and maximum hourly usage categories, as well as meter equivalent and customer categories. The demand-commodity method allocates functional costs to demand and commodity usage categories, as well as meter equivalent and customer categories.
- **Distribute the functionalized costs to customer classes:** This step assigns fixed and variable (commodity) costs to customer classes. Fixed costs, such as administrative costs associated with billing and metering, are typically allocated according to the number of service connections. Variable costs are allocated according to water use. Capacity costs are allocated differently under the base-extra-capacity and commodity-demand methods. Interest in advancing economic efficiency has led some utilities to use marginal/incremental cost methods to allocate costs and determine cost of service. Appendix A defines and explicates costing methods and how they apply to water efficiency.

Some of these costs may be specifically assigned to or excluded from individual customer classes. Wholesale customers, for example, are typically excluded from sharing in distribution-related costs since they maintain their own distribution system.

COSA differs from accounting-based distinctions between fixed and variable costs. Although from an accounting perspective, most water utility costs are fixed, under COSA, most of these costs are typically associated with volume-related functions and recovered through volumetric rates. For example, the cost to repair and replace pipeline assets would typically be allocated to average and peak-day demand related service characteristics though they do not vary with levels of water production.²²

Within the construct of COSA-based allocations, there are important mechanisms to advance water resource efficiency objectives and provide a foundation for efficiency-oriented water rate design; however, COSA also has inherent limitations that constrain the extent to which it may advance resource efficiency. For example, COSA derives unit cost calculations that reflect average embedded test year costs to apportion revenue responsibilities in proportion to customer class demands. To the extent that test year costs do not include prospective water supply development costs or internalize environmental externalities, the resulting price signals will fail to reflect the full, long-term costs of service.

22 Rates based on accounting definitions, where the preponderance of costs are viewed as fixed and as such are the basis for fixed charges, are relatively uncommon and at variance with industry-standard COSA approaches based on cost causation.

This limitation lies at the heart of the quandary of setting rates that promote economic efficiency and assure no more than full cost recovery. Economic theory posits that the pricing of goods and services at their marginal costs in a competitive market will clear markets and promote resource efficiency. Emulating this outcome in a non-competitive market, where water utilities face atypical long-term cost structures, has, however, proven complicated. If a utility defines marginal costs as the cost of the next unit of service (short-term marginal costs), it would fail to recover the embedded costs of service, which are dominated by fixed capital investment costs. On the other hand, if rates were set equal to long-term marginal costs — those that contemplate future supply development — utilities would accrue net revenues that exceed their average embedded costs.

Here are a few strategies help to address this quandary:

- Redefining revenue requirements to more fully reflect true costs of service.
- Redefining water system functions, such as water supply development and environmental mitigation, to more fully reflect the scope of the utilities' long-term responsibilities.
- Revising rate structures to blend marginal cost and average embedded cost pricing (as discussed in the section on Rate Design).

Even after implementing these strategies, managing the tension between the appeal of leveraging economies of scale so whole customer populations benefit from affordable embedded costs-of-service, and pricing services to reflect long-term, often non-monetized, resource costs remains a challenge. This challenge is further exacerbated by the complexities of estimating the value of future, often non-monetary impacts, of resource utilization.²³

In this context, it should be further noted that while COSA is an industry standard analytical method, it is not generally required in many jurisdictions, and there are a number of policy reasons why individual communities may choose to deviate from cost-of-service-based rate setting. Some communities, for example, subsidize a specific customer class to advance economic development or low-income affordability policy objectives. These deviations define where the “art” of rate setting complements the mechanics of COSA.

More detail on costing methods can be found in Appendix A.

Customer Classification

In the past, utilities, especially smaller ones, typically adopted a single rate structure for all classes of customers, except possibly for fire protection. Today, utilities are more apt to design class-specific rate structures for different customer groups, such as single family residential, multiple family residential, commercial, industrial, institutional, irrigation-only, and wholesale.

23 Beyond the uncertainties associated with projections of future demand levels, water supply development costs (including environmental mitigation costs) must be projected in an environment of increasing scarcity, climate change, and economic volatility

COSA's focus on cost causation as the basis for equitable distribution of revenue responsibilities depends on effective customer classifications. Effective classifications enable utilities to impose differential rates based on differences in costs to serve different types of customers. Without them, COSA is largely limited to defining appropriate levels of fixed charges and volumetric rates on a system-wide basis.

Effective classification involves grouping customers with different usage characteristics into different classes. The traditional classifications of residential, commercial, industrial, and wholesale reflect these distinctions. In addition, some utilities also classify customers according to types of commercial operations or government sectors.

Classification helps address the principles cited by Bonbright, namely horizontal and vertical equity — horizontal equity meaning that similar customers are treated similarly, and vertical equity being that different customers are treated differently.²⁴

Perhaps most importantly for this Handbook, classification is also a powerful mechanism for enabling water use efficiency-oriented rate setting. Utilities may segregate customers with similar consumption patterns and tailor price signals to the attributes of those customers and their consumption patterns. To the extent that residential customers exhibit similar usage patterns and peak-demand characteristics, carefully designed inclining block rate structures can provide price signals that reflect higher per unit costs of serving peak demands. On the other hand, imposing that same type of rate structure on customers that exhibit diverse consumption patterns, as is typical among general commercial classes — which is a heterogeneous class — may penalize larger customers for their relatively higher levels of consumption, irrespective of the relative efficiency of their water usage.

Advances in metering and billing technologies are creating a new platform for creating more discrete and precisely drawn classifications. These technologies even hold the promise of tailoring price signals at the individual customer level. Modern billing software systems, for example, can reference individual users' consumption histories to define the usage thresholds at which inclining block rate tiers should be imposed on that particular customer. This ability provides the basis for water budget-based rate structures mentioned below.

Design a Rate Structure

Building a better water rate structure requires an improved understanding of how different alternatives perform with respect to the desired objectives. Sadly, there are no simple, one-size-fits-all answers to the question "How should water rates be set?" Furthermore, establishing a one-size-fits-all approach would be impractical because rate objectives and rate performance relative to objectives differ so widely among utilities. As a result, this Handbook emphasizes the key principles and analytic tools needed to build better rate structures for individual utilities. When uncertainty is high and the stakes compelling — as is increasingly the case with emerging resource scarcities — the payoff of more active evaluation of rate alternatives can be profound.

24 H. Peyton Young (1994). *Equity: In Theory and Practice*. Princeton University Press.

Rate Structure vs. Rate Level

A foundational step in rate making is drawing the distinction between a rate structure and the rate level:

- **Rate Structure** — The form of the rates: differing combinations of fixed charges and volumetric rates that together form a shape, such as block rates, seasonal rates, or rates that differ by customer class.
- **Rate Level** — The magnitude or height of each specific component of the rate structure.

This distinction can help clarify controversy. The primary concerns address the *rate level*: what should be included in the set of water services offered by a water utility? What is an appropriate expenditure to secure that level of water service? What is the total level of rate revenue required to pay for those expenditures? The second-tier concerns address the *rate structure*: how to generate that level of revenue in a way that satisfies the multiple objectives of the utility and its customers?

Fixed vs. Variable Charges (Service Fees, Drought Surcharges, etc.)

When designing rates, utilities must determine whether to recover costs through commodity charges, which vary with usage, or fixed charges, which do not vary with usage. Revenue collected through commodity charges varies with the amount of water used by customers. Revenues from fixed charges, such as service charges and readiness-to-use charges, are not sensitive to use. Commodity charges send a message that consumers should conserve, while fixed charges provide no incentive to reduce water use. A common practice in rate design provides for recovery of costs that are sensitive to usage (such as pumping costs) from commodity charges, while recovering costs that are not caused by usage (such as connection costs) from the fixed charges.

Fixed charges have often been viewed as working in opposition to water conservation objectives by limiting the extent to which customers may reduce their bills through usage reductions. Nevertheless, when water utilities are facing revenue shortfalls, they sometimes turn to rate designs that recover a large share of their revenues through fixed charges. For an opposing point of view, see LaFrance (2011) “What to Do with Less.” LaFrance argues that improved implementation of existing rate setting practices can correct many problems. He cites practices such as “truing up” revenues and costs with current water sales levels, developing more accurate sales revenue forecasts over a 3-5 year period, and empirically checking that reserves are sufficient to absorb risks. LaFrance concludes by stating “...raising fixed fees is not the only way to manage revenue risks—and perhaps is not the best way.”²⁵

Three commonly used fixed charges are: service or customer charges, meter charges, and fixed charges with a quantity allowance. In occasional cases, fixed charges may be used to recover all of the utility’s rate requirements.

1. Service or Customer Charges

Service or customer charges recover costs associated with such activities as meter reading, billing costs, and other costs that the utility incurs equally per customer or per account. They are generally assessed uniformly to each account per billing period.

25 LaFrance (2011) “What to do with Less,” Journal AWWA, Nov. 2011, p. 6.

2. Meter Charges

A meter charge is a fixed fee that generally increases with meter size. It typically recovers the customer-related costs that are a function of meter size, such as meter repairs. Meter charges and service charges may be combined in a utility rate schedule.

3. Fixed Charge with Quantity Allowance

Fixed charges sometimes include a quantity allowance to recover the cost of a minimum amount of billable volume in each billing period in addition to the customer and meter costs. The usage allowance may be set at a level necessary for basic health and sanitary needs, typical indoor water use, or some other basis.

4. Flat Rates

Flat rates recover annual revenue requirements without a volumetric component. They may be assessed uniformly system-wide, or they may vary by customer class.

Utilities can also create special charges for services, such as hook-up fees or system-development charges. These special charges can discourage system expansion in capacity-constrained water systems or encourage expansion in water systems with excess capacity.

The water demand of each individual utility – preferably broken down by well-defined customer classes – goes into determining the appropriate shares of total revenue recovery from fixed and volumetric charges. Utilities with seasonal demand may be able to advance load management objectives while also making revenue recovery more certain through higher fixed charges and strong volumetric price signals related to peak use. Utilities that face supply constraints and experience limited demand peaking may not reduce their revenue uncertainty by shifting shares of cost recovery between fixed and variable charges; rather, they should set price signals that reflect year-round supply scarcities.

Types of Efficiency-Oriented Rate Structures

There are a number of efficiency-oriented rate structures, each designed to incentivize more efficient water use by the customer. Choosing among the various rate structure options depends on the specific objectives to be achieved, and this directly relates to the attributes of water resource use found in the utility system. For example, inefficiencies may be the result of requirements to provide capacity to meet peak demands, which in turn might suggest an increasing block rate structure. To quote from the AWWA M1 *Manual of Water Supply Practices*:

“Because a system must be constructed to meet peak-day and peak-month water demands, system capacity is underutilized during non-irrigation seasons. Moreover, if the system were sized to meet the average demand or winter demand only, the resource and infrastructure demands could be much smaller. Consequently, an increasing block rate structure may be designed to recover the cost of constructing and maintaining extra capacity for the peak demands. Because this capacity is underutilized, the per unit cost of water is higher than for base capacity, which is used year round. In short, a block structure can remain consistent with, if not enhance, the relationship of rates to costs of service²⁶.”

26 American Water Works Association (AWWA) *Manual of Water Supply Practices, M1, Principles of Water Rates, Fees and Charges, 6th Edition*, (2012), p. 112.

However, just implementing an increasing block rate may not be enough to incentivize water use efficiency. Poorly designed increasing block rates — those that do not consider exhibited water use characteristics — can frustrate water use efficiency objectives. By the same token, uniform volume rates for specific customer classes may send price signals that effectively convey the value of water.

Incentivizing water use efficiency through rate design involves three fundamental considerations:

1. The water demand patterns of concern.
2. The water usage characteristics of the ratepayers who are subject to the rate design.
3. The rate structure options available.

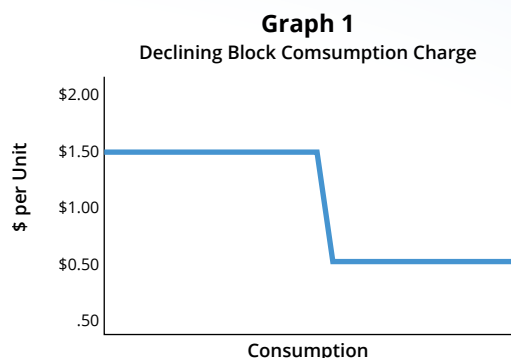
Depending on their demand patterns, there are significant differences in the strategies individual utilities may employ to stimulate water use efficiency under different supply and demand circumstances. If a utility with adequate water supplies faces acute peak demands, for example, the increasing block rate structure highlighted in the AWWA quote above may be compelling. It may not be compelling, however, for a utility with adequate peaking capacity but general supply challenges; instead, that utility might adopt uniform volume rates that reflect water supply development costs. Though one can make the case that promoting efficient water use is inherently beneficial since it supports stewardship of an environmental resource, the relative weight of this objective and the importance of ratemaking as a tool to achieve efficiency is likely to vary based on the level of water scarcity or other threats to water quantity.

Similarly, the importance of conveying water use efficiency price signals may increase in circumstances where water use patterns impose significant costs and delivery challenges. In this instance, there are important linkages between COSA and water use efficiency pricing. As a consequence, rate analysts should examine customer class water usage characteristics carefully, especially if certain levels of usage receive differential treatment. Where high volume residential users exhibit higher peaking factors than other residential users, for example, increasing block rates may convey the relatively higher unit costs of delivering water during peak demand patterns. However, if higher volume residential users do not exhibit higher peak period demands, they may be no more expensive to serve than lower volume residential users.

These complexities make it exceptionally important that the range of rate structure options and their relative advantages and disadvantages be known for advancing given policy objectives. Accordingly, provided below is a brief review of both traditional and emerging rate design options along with limited commentary on their merit for advancing the objectives of equity, water use efficiency, and financial resiliency.

Declining Block

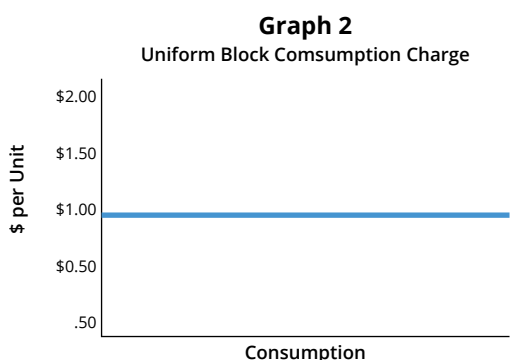
In any examination of rate design options, it is also important to note the historic use of declining block structures, which still exist today in certain parts of the country.



As displayed in **Graph 1**, declining block rates divide a customer's consumption into volume ranges or "blocks" and charge more for the initial units of consumption and less for later units of consumption. There is no standard limit to the number or size of blocks used in a declining block structure. Also, there is no standard for how steeply the blocks decline.

Declining block rates have often been regarded as anathema to water efficiency since they send a positive price signal for higher volumes of use. Interestingly, declining block rate structures had their origin in efficiency, as they presented an efficient rate for a declining cost industry. Economies of scale would reduce the average price if additional consumption could be encouraged. When there are no limiting factors, encouraging growth will encourage a lower average cost/price for all customers. Today, in what is recognized as an increasing cost industry, they provide an incorrect price signal to customers. As with any rate structure, the applicability of declining block rates must be assessed against the local conditions.

Uniform

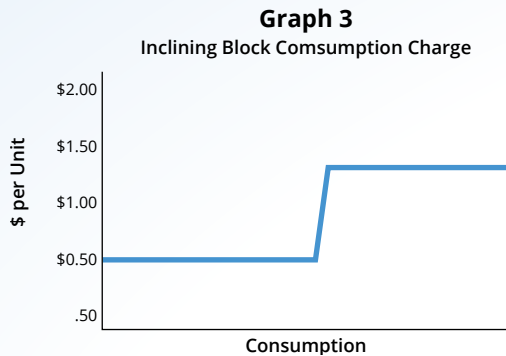


As displayed in **Graph 2**, a uniform rate is a single charge per unit of consumption. The charge remains constant for all metered consumption of water on a year-round basis. A customer's utility bill increases by a uniform amount for each additional unit of water consumed. Uniform volume rates can be an efficient water rate structure if the applicable rate conveys the full costs of water. Uniform

rates are particularly appropriate when applied to customer classes composed of customers with relatively similar demand loads. Customer class-specific uniform rate designs that differ across classes based on cost-causative principles can have the effect of rendering more accurate, better tailored price signals that can promote water efficiency as opposed to system-wide inclining/declining block rates that ignore cost-causation.

Inclining Block

As displayed in **Graph 3**, increasing block rates also divide a customer's consumption into blocks but charge less for initial units of consumption and more for later units of consumption. As with the declining block rate structure, there is no standard number or size of the blocks, nor is there a standard for how steeply the blocks increase.

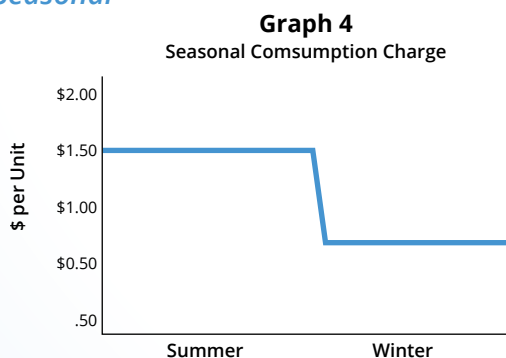


Inclining block rates have traditionally — and somewhat simplistically — been viewed as promoting efficiency because of the price signal that conveys higher costs for higher volumes of use. As noted in the AWWA M1 Manual, for utilities facing peak demand management, inclining block rates may indeed be appropriate, particularly for customer classes exhibiting relatively homogeneous demand patterns, such as residential users.²⁷

However, in part because of the extent to which efficiency-oriented or conservation rates have been misinterpreted to equate to inclining block rates, it is important to recognize the limitations and appropriate applicability of this rate form. Poorly designed inclining block rates can be less effective in promoting efficiency than well-conceived declining or uniform volume rates, and they can impose profound inequities.

The crux of the matter lies in careful evaluation of the utility's exhibited demand patterns, most preferably by well-defined customer classes. Inclining block rates that provide meaningful incentives to alter usage levels within relevant ranges of use for the targeted customer group can be powerful for efficiency-oriented water rates. For example, inclining block residential rates that significantly increase the per unit cost of water that is associated with high irrigation demands can strongly incentivize customers to moderate their lawn watering practices. On the other hand, system-wide inclining block rates often have the effect of penalizing often relatively efficient large users simply for being large.

Seasonal



As displayed in **Graph 4**, seasonal rates impose different charges per unit of service based on the time of year. Generally, a utility will charge more per unit of consumption during the peak water demand season and less during the low demand season. Typically, utilities employ rates for summer and winter, but it is also possible to have more seasonal divisions.²⁸

²⁷ American Water Works Association (AWWA) *Manual of Water Supply Practices, M1, Principles of Water Rates, Fees and Charges, 6th Edition*, (2012)

²⁸ Seasonal rates are generally not used for sewer service since billable wastewater flow contributions are generally invariant with changes in weather patterns.

Seasonal rates may be particularly appropriate, and they may promote efficiency in circumstances where the utility's sources of supply have differential availability on a seasonal basis and/or when exhibited demand patterns exhibit profound, cost-inducing, seasonal variations. For utilities seeking to extend efficiency signals to commercial and institutional users, seasonal rates are often more equitable than inclining block rate forms insofar as they reflect higher costs of seasonal use without imposing penalties simply on the basis of customer size.

All of these rate structures can be modeled and analyzed using the *AWE Sales Forecasting and Rate Model*.

Innovative Rate Structures

In addition to the traditional volumetric rate structure options, some communities are implementing rate structures — or components of rate structures — to send precise price signals to individual users and/or to reflect the economics of water services delivery. These rate structures or concepts include surcharges, water budget-based rates, marginal or incremental cost pricing, and value of service pricing.

1. Surcharges

Surcharges may be added to fixed charges or to the base volumetric rates (\$/hundred cubic feet) for some or all of a utility's customers for two general purposes. Surcharges may be assessed to collect a targeted amount of revenue for a specific purpose, or they may be designed to send a price signal to customers during a specified period of time, such as during a drought, to support water use efficiency programs, or to fund special water supply development initiatives. The effectiveness of surcharges in sending efficiency-related price signals depends on the clarity of the need.

2. Water Budget-Based Rates.²⁹

Water budget-based rates, which are also sometimes called goal billing, allocation-based rates, or customer-specific rates, establish rate blocks based on specific characteristics of each customer, such as persons per household, lot size, or evapotranspiration requirements of landscaping. Rates rise as usage exceeds the pre-established budget goal. The distinguishing characteristic of water budget-based rates is the way in which the rate block is defined rather than the pricing. These examples of water-budget-based rates offer an illustration:

- **Evapotranspiration-based water budgets for separately metered irrigation-only customers:** The utility defines a goal for each irrigation-only account by combining a customer-specific estimate of landscaped area with an estimate of evapotranspiration requirements. The utility may visit the site or use commercially available real estate data to establish the area. Local weather data can provide the information needed to estimate evapotranspiration.

²⁹ "Water Budgets and Rate Structures — Innovative Management Tools," American Water Works Association Research Foundation, (Project 3094), 2007.

- **Water budget-based rates for single-family residential customers:** Single-family residential account water-use goals require consideration of both indoor and outdoor uses. Outdoor water use allotments may factor in irrigable area, house footprint area, driveways, and pools. Indoor water allotments may either be based on an amount per person or household.
- **Budget-based rates for nonresidential customers:** Commercial, Industrial, and Institutional (CII) users may have customer-specific rates established by analyzing their historical water use and their industrial processes. This analysis may require a relatively intensive information-gathering effort of surveys with follow-up. Historically, water budget-based rates have been difficult to enact for commercial customers.

Budget-based water rates were pioneered in communities facing limited water supplies or shortages. They require public education and communication efforts, ongoing customer service to address questions, complaints, and appeals, and they may put a demand on billing system capabilities.

That said, the concept of water budget-based rates has considerable appeal as a mechanism to encourage efficient water use practices and to distribute revenue responsibilities equitably within customer classes. In communities that have historically encouraged water conservation, budget-based rate structures may become successful aids to conserving water. These water budget rate structures are often more expensive to administer,³⁰ but for many utilities, the benefits they produce may outweigh their costs over time. They may have particular appeal because they convey precisely focused efficiency price signals, and they have been perceived by customers as being fairer than other rate structures.³¹ When collected revenue exceeds goals, water budget-based rates have also been used to help fund dedicated water use efficiency or watershed programs.

30 With advances in water metering and billing technology, both the administrative cost and accuracy of water-budgeting is likely to make this form of rate more viable in future.

31 As noted in the WRF Report (op cit.) budget-based rates have been criticized as less than perfectly efficiency-oriented because they primarily aim to improve water use efficiency of current landscape (short-run efficiency). Budget-based rates may provide insufficient incentive to change to a more efficient landscape mix (long-run efficiency). Other critics have cited this and potentially more fundamental flaws. (Beecher, 2011) These rates represent a tradeoff that communities have made between administrative costs, equity of water shortage allocations, and short- and long-run water efficiencies.

WESTERN MUNICIPAL WATER DISTRICT ADOPTS BUDGET BASED RATES TO REDUCE WATER USE AND ACHIEVE REVENUE STABILITY



Western Municipal Water District, a wholesale and retail water provider, serves about 23,000 retail customers in Southern California. Operating in a semi-arid region, Western relies on expensive and increasingly unreliable imported sources that make up 75 percent of its supplies. In 2008, Western adopted a Water Efficiency Plan encompassing programs, education and outreach, as well as a new rate structure to support its goals. In 2011, Western rolled out budget-based rates to customers in service areas previously facing uniform or increasing block rates. Western's primary objectives for a new rate structure included:

- **Financial Stability:** Western had been raising rates over time while asking customers to conserve. They wanted a rate structure to deliver the message that rates would only increase when absolutely necessary, and ensure efficient use would result in the lowest possible cost.
- **Customer Equity:** Western sought a structure that placed equal responsibility on customers to efficiently manage the region's supplies, and did not require some to pay for the wasteful use of others.
- **Water Use Efficiency:** Western had long invested in efficiency to stretch local supplies and avoid rising supply costs, and new state regulations required further cuts.

Western developed a five-tier budget-based rate structure. Every customer receives a personalized water budget designed to meet their specific indoor and outdoor water needs. Residential budgets are calculated based on each customer's landscaping, real-time localized weather data and the number of residents, among other factors. Most customers' water use regularly remains within their water budget (Tiers 1-2), and they are billed at the lowest available rates. The only customers who are billed in the higher tiers (Tiers 3-5) are those whose use exceeds their water budget. The naming of tiers also clearly communicates whether use is efficient, inefficient or unsustainable.

Residential Budgets in Detail:

Water Budget:

- **Tier 1** – Efficient Indoor Use: based on the efficient indoor water needs of your household
- **Tier 2** – Efficient Outdoor Use: based on the efficient outdoor water needs of your property

Water Waste:

- **Tier 3** – Inefficient Use: Based on exceeding your total water budget by up to 25%
- **Tier 4** – Excessive Use: Based on exceeding your total water budget by between 25% and 50%
- **Tier 5** – Unsustainable Use: Based on exceeding your total water budget by more than 50%

Western's management believes the rate structure has achieved their objectives:

- Western customers are becoming more efficient. Customers collectively lowered their 'over-budget' water use by 34 percent in 2013 when compared to 2012. Western's efficiency programs are funded with revenue from upper tiers, meaning that inefficient customers pay for efficiency programs.

Continued on next page

Western Municipal Water District Adopts Budget Based Rates to Reduce Water Use; Achieve Revenue Stability, Continued

- All revenue to cover O&M costs is collected from the first and second tiers, creating revenue stability for Western. While customers will become more efficient over time and use only their water budget, Western will not need to raise water rates to recover lost revenue resulting from reductions in water usage in the higher tiers.

Western recommends several successful practices for utilities considering budget-based rate structures:

- **Create Open Dialogue:** Finance and Water Resources teams collaborated to understand conflicting objectives and design rates to increase efficiency without compromising financial integrity.
- **Learn from Peers:** Western met with neighboring agencies with budget-based rates to understand their challenges and successes.
- **Cover O&M Costs in Lower Tiers:** Thoughtful tier design has helped guarantee revenue stability.
- **Adopt Financial Policies:** Maintaining an operating reserve helps buffer unanticipated operating costs.
- **Empower and Educate Customers:** Western sent a letter to every customer to explain their personalized budget, and provided a form and prepaid return postage to request adjustments – an immediate opportunity to address discrepancies. In the first eight weeks, 6,000 forms were sent in. Western sent assistance letters to larger users, continues to help customers lower their usage and has invested in thorough training of customer service staff.
- **Ensure Administrative Oversight:** Investing in a rate consultant and legal specialist helped ensure all regulatory requirements and statutes were met, including thorough documentation of the cost of service study.

For the full case study and sample utility resources, visit www.FinancingSustainableWater.org.

3. Marginal/Incremental Cost Pricing

The basic premise of marginal cost pricing is that since rates affect future usage, the future costs of water are those most relevant for setting rates. Rates based on the marginal cost of water provide signals to consumers about the cost consequences of their usage decisions. Conversely, they also reflect the future cost consequences of consumption decisions.

Theoretically, marginal cost pricing may send accurate price signals to customers and help optimize resource allocations. Practically, however, widespread implementation has not occurred because of limitations such as mismatching revenues with actual costs, unavailability of data necessary to develop accurate marginal costs, and significant divergences from the theoretical market conditions required to ensure optimal resource allocation.

Though marginal cost pricing may have limitations, marginal cost theory and average cost approaches have been successfully blended in water rate design through inclining block rate structures where the last block is set according to the unit cost of the next increment of water supply. This “next increment of supply” reflects the opportunity cost of not conserving; it is the avoided cost achieved by having conserved.

ALTERNATIVE THEORETICAL RATE STRUCTURES



A 2014 report entitled *Defining a Resilient Business Model for Water Utilities* was written by the Environmental Finance Center at UNC and Raftelis Financial Consultants and funded by the Water Research Foundation and the U.S. EPA. It explored three alternative pricing models that focus on generating more reliable and predictable revenue streams over a budget period without sacrificing pricing signals to customers to be more efficient. These models hold the potential to better align the goals of revenue stability, sufficiency, and customer conservation. Ultimately, each of these models would allow the utility to recover more revenue from the fixed portion of a customer's bill, while still financially incentivizing conservation and efficiency. The report contains explanations of these structures using real utility data, although none have been fully implemented and studied. Further exploration is needed on implementation feasibility, customer understanding, and demand response, but the report advances these models as innovative strategies for overcoming the inherent challenges of the utility business model.

A. PeakSet Base Rate Model

Inspired by demand ratchet charges used by power utilities, the PeakSet Base Rate model would charge individualized base charges calculated using a customer's historical maximum month of consumption. A customer's base charge would be individually set based on a three-year rolling average of that customer's peak month of demand. The utility would continue to send a smaller variable price signal every month to send immediate feedback on water use. This model would allow a utility to build more of their cost recovery into the base charge while still promoting customer conservation by using a customer's historical demand to establish that base charge. It would encourage consistent customer water use (because one month of high usage would be costly), reduce financial risk for the utility, and increase financial predictability for customers.

B. CustomerSelect Model

The CustomerSelect model gives customers the choice to select an allotment of use that meets their needs and charges a fixed amount for that allotment for all use under it. Water use exceeding the allotment is charged at a punitive rate. This model is similar to a budget-based rate structure, but rather than the utility establishing the budget for customers, it enables customers to choose their own fixed budget. Potential benefits include increased revenue and stability because customers commit to plans. It would promote water use efficiency, especially around the plan's "break points." It is a relatively simple model to understand, and it advances the utility as a provider of a service. Customers would have an incentive to consume within their plan and to move down to a lower plan the next year. However, providing customers with frequent usage updates may increase customer awareness, but could also signal a license to waste water at the end of the month because they may be able to do so at no extra cost. There may be challenges in the planning process, such as questions related to how to predict what plans customers will choose. Smart meters may also be required as customers will want to track their consumption against their plan.

Continued on next page

C. WaterWise Dividend Model

Some cooperative retail organizations return profit to their “owners” once financial obligations are met. Many times these cooperatives return larger “dividends” to the “owners” that bought more of their product over time. Under the WaterWise Dividend model, utilities seeking revenue stability and efficient customers would adopt an adapted model. Rather than rewarding customers that used more, they would return conservation dividends to customers that used less or used water in a way that minimized costs. The definition of “less” could be established against a customer’s budget or relative to an individual customer’s historic use. The utility could calculate a dividend according to any number of policies it wants to promote, such as “peak shaving.” This model has the benefit of communicating that the utility is a not-for-profit entity, as “profits” are returned to customers. It provides a positive way for utilities to interact with customers, and it helps ensure that financial goals are met. Returning money to citizens is not unprecedented. In January 2013, DC Water announced that it would refund a one-time credit to customer bills because it finished Fiscal Year 2012 with a surplus.

4. Value of Service Pricing

A departure from conventional ratemaking methods that focus on cost recovery involves consideration of factors that reflect customer perceptions about the value of utility service, as well as their “willingness to pay” for different levels or types service. Value-of-service pricing considers customer preferences beyond those traditionally represented in cost-based pricing. In recent years, concepts related to value-of-service pricing have received considerable attention in the water and wastewater industry as concerns have been elevated about the general underpricing of water and sewer services relative to its value, and the disparity between existing funding levels and forecasted infrastructure investment needs.

There are several approaches, with attendant limitations, to estimating the value of water service. Customer preferences can be assessed through surveys and related contingent valuation methods that evaluate users’ “willingness-to-pay” for services under various circumstances. Customers might be surveyed, for example, about how much they would be willing to pay for a higher degree of reliability or for additional treatment for a taste or odor issue. Additionally, customer demand patterns under prior pricing regimes may be used to impute value of service. For example, the effect of seasonal rates on consumption may indicate the value customers place on seasonal usage.

There are several specific examples of value-of-service-based pricing in use in the industry. For example, some utilities have developed customer-specific rates to establish reliability pricing, or fire-protection pricing where special service levels are extended to these customers. Additional concepts include:

- **Demand-based (Ramsey) pricing:** One value-of-service approach to pricing is to base prices for different customers on their relative responsiveness to price. Users with relatively price-inelastic demand (not sensitive to price changes) would be charged more than users who are more responsive to changes in price. Ramsey pricing will generally suggest lower prices for large-volume wholesale and industrial customers who may have

alternative supply or service options while higher prices for residential customers (who are captive of the utility monopoly). To the extent that the significant water conservation potential is reflected in relatively higher price elasticity, price elasticity based pricing will encourage efficient water use. On the other hand, perceptions of rate fairness may be challenged when pricing for services is based on demand elasticity, especially when water and sewer services are essential to human health and sanitary needs.

- **Property-value pricing:** In Great Britain, charges to unmetered customers are based on “rateable” property values. Customers with more expensive properties, and typically more extensive landscaping requirements, pay more for service than customers with lower valued properties.
- **Negotiated rates:** Some water utilities have had occasion to negotiate rates with large-volume users, including wholesale customers. Negotiated revenue requirements may be based on the cost of service, but the negotiation process can introduce other values and preferences including requirements for implementation of conservation programs, employment programs, or other community-valued programs.

Implementing value-of-service pricing can be complex and may raise a variety of concerns about equity, efficiency, and effectiveness — and it has not been generally accepted by regulatory agencies with jurisdiction over water ratemaking. However, the concepts of value may be incorporated into some elements of water pricing, and there is growing interest in doing so to address chronic sector pricing issues. Prices that are fundamentally cost-based prices, while also incorporating customer preferences, may further service and water resource efficiency goals.

There are also a number of communities that have implemented rate designs generally targeted to specific ratepayer sub-populations that are designed rather explicitly to advance community policy objectives. In general, these rate designs involve the extension of subsidies to one sub-population at the expense of the remaining ratepayer population; therefore, they do not reflect costs-of-service. Perhaps the two most common forms of policy-based rate options: (a) extend subsidies to low-income populations and (b) promote economic development.

a. Low-Income Rates

As water and wastewater rates have continued to increase at well above inflation or income growth rates over the last decade or more, many communities have become increasingly concerned about the affordability of services necessary for basic human health and sanitary needs. Accordingly, some communities have established low-income affordability rates and programs whereby qualifying ratepayers receive discounted rates. These subsidies may come in a variety of different formats ranging from a simple percentage discount on the ratepayers’ total bills to rates that are discounted for a limited volume of usage. In general, the concept is to ensure the affordability of minimal usage levels required for human health and sanitary needs, which are often accompanied by targeted low-income assistance programs.

b. Economic Development Rates

Similarly, some utilities have provided rate discounts as a component of a community's economic development program. Economic development rates (EDR) have become of increasing interest among utilities that have excess system capacity. In these circumstances, economic development rates may enable utilities to leverage capacity that would otherwise remain stranded, and in so doing benefit all parties. Existing ratepayers are benefited by virtue of the fact that the largely fixed revenue requirements will be distributed over a larger customer base, and new customers that are eligible for the EDR are recipients of subsidized service. Even without excess system capacity, a community may elect to offer an EDR to help stimulate local job growth and economic expansion.

Ensuring Affordability

Utilities have a responsibility to provide necessary water services for basic human health and sanitary needs. As a result, rate design must involve considerations of affordability for low-income households, which may face challenges if rates are raised.

Any evaluation of a rate structure should involve an in-depth and informed understanding of affordability. The U.S. EPA has provided affordability criteria to help guide utilities — specifically that a water bill is affordable if it costs less than 2.5% of small community's median household income.

However, it has been noted that the reliance on median household incomes means that average bills less than some fraction of median income do not guarantee affordability, and this approach may underestimate the impact on low-income households. A 2013 brief from the U.S. Conference of Mayors (USCM), the American Water Works Association (AWWA) and the Water Environment Federation (WEF) suggested several alternative methods, including assessing the impact on customer water bills across entire income distributions, especially at the lower end; as a percentage of income for potentially vulnerable populations; across neighborhoods known to be economically at risk; and through a variety of other indicators such as the unemployment rate or the percentage of households receiving public assistance.³²

The *AWE Sales Forecasting and Rate Model* provides an Affordability Index to help gauge the impact of a proposed rate structure by customer class. Users should note that additional precision may be required, depending on the community.

Drought Pricing

Drought pricing incorporates rates into drought/shortage planning. Water utilities in California currently develop drought management plans that call for coordinated response to water shortages, including planning for water rates.³³ When a water utility declares a shortage emergency and requests voluntary or mandatory curtailment of water use, a corresponding change in water rates for the duration of the drought emergency accomplishes several goals:

32 AWWA, USCM, WEF Brief, 2013 (<http://www.awwa.org/Portals/0/files/resources/water%20utility%20management/affordability/Affordability-IssueBrief.pdf>)

33 USBR Drought Management Planning Guidelines, the CA DWR Urban Drought Guide, the CA Urban Water Management Planning Act, and the AWWA M1 Manual of Rates' section on Drought Pricing

- Customers receive a higher price signal that indicates the scarcity value of water.
- Water utilities avoid the inevitable “unexpected” revenue shortfall that follows a successful citizen response to calls for curtailed water use.
- Water utilities can avoid the political backlash that may occur if water rates rise after customers have heeded the call to perform a civic duty by curtailing use.

LOS ANGELES DEPARTMENT OF WATER AND POWER ACHIEVES DEMAND MANAGEMENT GOALS WITH UNIQUE VOLUMETRIC RATE STRUCTURE AND LONG-TERM PLANNING



The Los Angeles Department of Water and Power (LADWP) is one of the largest municipal utilities in the nation, serving a population of almost 4,000,000. In 1993, largely in response to the California drought of the late 1980s and early 1990s, LADWP adopted an increasing block rate structure that was developed by the Mayor’s Citizen Blue Ribbon Committee. The rate structure had several notable innovative features such as a seasonal increasing block rate structure based on marginal cost pricing principles, elimination of fixed charges (resulting in a 100 percent commodity-based revenue generation), an intensive home survey program that accompanied the roll out of rates, rate adjustment mechanisms to balance revenue, and an ongoing public involvement and outreach program.^{34, 35}

Due to the high level of public participation, LADWP received feedback that led to the advancement of its relatively standard increasing block rate structure (in which each block is defined by a fixed amount of water) to one based on water budgets. In 1995 the City adopted its current water budget-based rate structure that uses information on lot size, weather zone, and household size to define each customer’s block size.

The LADWP water budget-based rate structure has been widely seen as a success that, mixed with a portfolio of innovative conservation measures, helped flatten water demand in spite of a growing population and economy.

The most significant barriers to the program’s success cited by staff were the complexity of the reprogramming required by the water budget, reconfiguring billing system reports, and data task of matching addresses to obtain accurate lot size information. These barriers were largely overcome in a six to eight month time frame through the concentrated efforts of existing employees. In general, customers responded very well to the revised 1995 water rate structure that incorporated lot size (5 categories), household size, and temperature zone (3 zones). Of these three factors, staff cited the lot size adjustment as the most important. The lot size adjustment is well understood by customers and contributed the most in terms of gaining acceptance. The household size adjustment and temperature zone adjustments, while acknowledged, were less cited by customers.

Continued on next page

34 Darwin C Hall and W. Michael Hanemann, 1996, “Urban Water Rate Design based on Marginal Cost,” in , *Advances in the Economics of Environmental Resources: Marginal Cost Rate Design and Wholesale Water Markets*, Volume 1, JAI Press, Inc., Greenwich, Connecticut, pp. 95-122.

35 Chesnutt, T.W., C.N. McSpadden, and D.M. Pikelney, *An Impact Evaluation of Home Water Surveys in Los Angeles, A report for the Metropolitan Water District of Southern California*, October 1996.

LA DWP staff provided recommendations to utilities considering implementing a water budget-based rate structure. These include:

- Public acceptance is critical. Public workshops permitted LADWP to elicit customer feedback on the 1993 increasing block rate structure, construct adjustments to the rate structure and, with augmented customer outreach, win over more of its customer base.
- It is imperative that a water budget have a rational basis that can be clearly communicated to customers. By providing a rational basis for defining the width of tiers, water budget-based rate structures can be perceived by customers as being intrinsically fairer.

The LADWP water budget-based rate structure has now been in place for more than two decades and continues to be an effective billing methodology. It has maintained required utility revenues, reinforced incentives to use water efficiently, and has achieved broad customer acceptance within a major metropolitan area having a diverse customer base.

For the full case study and sample utility resources, visit www.FinancingSustainableWater.org.

The *AWE Sales Forecasting and Rate Model* facilitates planning for drought rates and probabilistic revenue management where water shortages might occur, even if they are unlikely.

A Framework for Building a Rate Structure

As summarized in **Table 1**, a sequential decision structure may help utilities as they build rates designed to encourage efficient use.³⁶ For many rate managers, some of the decisions may not constitute feasible choices, but the decision structure attempts to include the range of all potentially relevant decisions.

1. Should all costs be recovered through rates and charges? Some water utilities have other sources of revenue or financial support, which can affect the willingness of rate managers to implement innovative rates.
2. Should the rate structure be applied to all customers and if not, how should rates vary across customer classes?
3. How will the rate structure address fixed charges?
4. Should the rate structure incorporate seasonal variations, and if so, how should the peak period be defined and what should be the specific rate periods and seasonal rate levels?
5. If the structure will include block rates, how many blocks, what will the break points be between blocks, and what rates will be attached to each block?
6. How will the rates be integrated into the utility's drought management plans?

³⁶ Chesnutt, T. W., J. A. Beecher, P. C. Mann, D. M. Clark, W. M. Hanemann, G. A. Raftelis, C. N. McSpadden, D. M. Pekelney, J. Christianson, and R. Krop. (1997) *Designing, Evaluating, and Implementing Conservation Rate Structures*, A handbook for the California Urban Water Conservation Council, Sacramento California, <http://www.cuwcc.org>.

Table 1 — A Decision Framework for Efficiency-Oriented Rate Design

PRIMARY CHOICE:	OPTIONS	IMPLICATIONS
1. Recover all costs through rates and charges	External tax support	Some revenue sources from outside the water rate structure.
	No external tax support	Recovers all costs through rates and charges attached to water service.
2. Differentiate rates and charges by customer class	Same rates for all customers	Recovers revenues under a single rate structure for all customers
	Class-based rates	Recovers revenues through different rate structures for different groups of customers (such as residential, commercial, and industrial).
3. Design the fixed component of the customer bill	No fixed charges	Recover all revenues through variable charges.
	Same fixed charge for customers	Recovers metering, billing, and other charges. Reflects no cost variations based on customer-class distinctions.
	Different fixed charge for customers	Reflects cost variations in metering, demand, billing, and other factors based on meter size or other customer-class distinctions.
4. Vary rates by season (Peak Pricing)	Year-round rates	No variation in rates by season of use.
	Seasonal rates	Rates that vary for two or more time periods within a year, reflecting seasonal variation in costs.
5. Vary rates by block of water usage (Block Rates)	Uniform rate	The rate does not vary with usage for all customers or all customers within a class (uniform rates by class).
	Block rates	Requires a determination of: (1) the number of blocks, (2) unit rates for each block. (3) block switchpoints by usage
	Water Budget-based Block Rates	Define block width by a technical definition of efficient water use: a water budget conditional on customer characteristics.
6. Vary rates during drought emergencies (Drought Pricing)	No Drought Pricing	Rates are not integrated into drought management plan.
	Drought Pricing	Rates increase during shortage events to reflect scarcity value.

Adapted from Designing, Evaluating, and Implementing Conservation Rate Structures³⁷

³⁷ *Designing, Evaluating, and Implementing Conservation Rate Structures*, A handbook for the California Urban Water Conservation Council, Sacramento California, 1997, (<http://www.cuwcc.org>)

PERFORMANCE METRICS



Performance Metrics (PMs) can help rate setters determine the effectiveness of certain rate structures in promoting efficiency. One approach is to use a customer-weighted performance approach: what is the proportion of customers whose last unit of consumption is priced at the long-term marginal cost of water? A second approach builds on the first by determining a quantity-weighted average: what proportion of a utility's total sales face a marginal price that is set to the long-term marginal cost of water?

Regardless of the approach, efforts to assess the efficiency-orientation of a rate structure should include the following considerations:

- The estimated short-run and long-run marginal/incremental cost of water over time
- Estimates of performance metrics in peak and peak periods
- The average system water price (total sales quantity divided by total system revenue from rates)
- The proportion of system revenues generated from non-volumetric sources (fees and charges)
- The estimated system loss (total production quantity minus total sales quantity).

Evaluate the Rate Structure against Objectives

A good rate decision process begins by formalizing the criteria that will be used to judge alternatives. Public involvement efforts should begin with an attempt to develop a consensus on appropriate criteria for judging alternatives.

With appropriate criteria in place, analysts can evaluate rate alternatives and make tradeoffs explicit. Some criteria for evaluating rate structures emphasize measurable outcomes, such as the effects of a rate structure on utility revenues, customer bills, and resource efficiency. Others emphasize less easily measured issues, such as understandability to customers, acceptability to decision makers, or effect on the conservation ethic of the community.

Evaluating a rate structure can help reveal the consequences of rate structure choices. The depth of analysis depends on the costs and benefits. Water utilities with stable system costs and demands may need to invest less in evaluation. Water utilities facing rapidly changing system costs, demands, or other uncertainties may need to invest more.

Benefits of Rate Evaluation

- **Improved Decision Making** — An improved understanding of rate consequences can lead to a more informed basis for choosing among rate alternatives.
- **Avoided Surprises** — Designing rates is not error-free and some of the efficiency-oriented rate structures (block rates) require more work to design correctly. A better rate evaluation can avoid the surprise of unanticipated outcomes.
- **Reduced Uncertainty** — A standard strategy for coping with uncertainty is to invest in better and more certain information.

- **Improved Likelihood of Public Acceptance** — Changing rates in accordance with changed conditions can affect some customers more than others. Identifying the impact of rates on different groups of customers permits utility officials to address political considerations early in the ratemaking process.

Costs of Rate Evaluation

- **Direct Utility Costs** — The cost of labor and materials.
- **Indirect Utility Costs** — Overhead or administrative costs.
- **Direct Contract Costs** — The cost of any analyses contracted out.
- **Cost of Communication** — Complicated analyses can be more difficult to explain to decision makers and the public.

Two broad criteria govern the complex choices related to rate setting alternatives: effectiveness in meeting the utility's goals and the feasibility of implementation. "Feasibility" addresses political possibilities while "effectiveness" addresses economic or water use efficiency effects. Not infrequently, these two criteria are at odds with each other: options that are highly effective may not be feasible, while more feasible options may not be effective. This tension between efficiency and equity is an ongoing concern of policymaking and ratemaking for utility services.

Rate evaluation can take on many different forms, spanning a continuum from quantitative to qualitative.

Types of empirical analyses often used in rate evaluation:

- **Modeling Water Demand Variability** — Evaluating the effect of rate alternatives on water demand.
- **Modeling Water Revenue Variability** — Evaluating the effect of rate alternatives on utility revenue and finances.
- **Customer Bill Analysis** — Evaluating the effect of rate alternatives on customers.

Rate evaluation provides better information about the consequences of rate alternatives to water utility managers, regulators, and the community-at-large.

Figure 8 shows some of the inputs and outputs needed for rate evaluation. Once evaluated, the results should help lead to a rate structure decision.

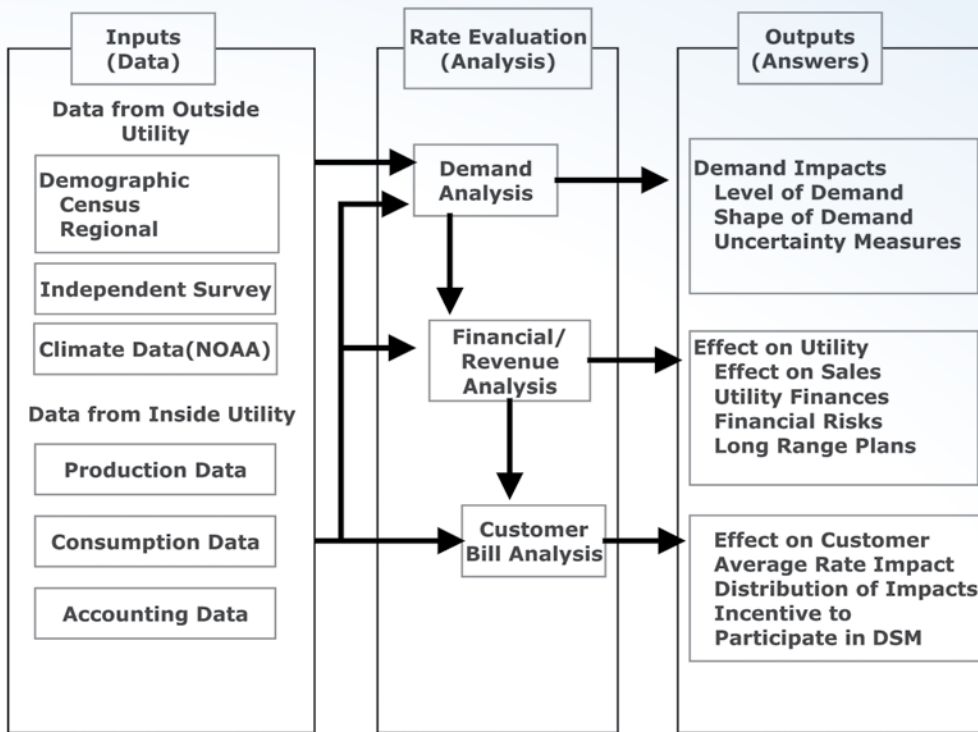


Figure 8 — Rate Evaluation

Adapted from Designing, Evaluating, and Implementing Conservation Rate Structures³⁸

At best, technical rate evaluations provide informational inputs. Decision-makers, however, must not just evaluate how each rate alternative stacks up against the established design criteria, they must also engage the political debate of “values” versus “facts.”

Good evaluations help focus the debate on how different parties value outcomes. They also help estimate the measurable consequences of a rate structure and clarify the magnitude of tradeoffs among alternatives. Since some of the criteria can be quantified and others cannot, no rate evaluation provides all of the answers to all of the questions, and no spreadsheet can make a decision, much less take responsibility for the consequences of that decision.

38 *Designing, Evaluating, and Implementing Conservation Rate Structures*, A handbook for the California Urban Water Conservation Council, Sacramento California, 1997, (<http://www.cuwcc.org>)

Effectiveness in Achieving Objectives

The quantifiable effects of an efficient rate structure include:

- Revenue
- Consumption
- Costs and Resource Efficiency

Of course, the effectiveness of an efficiency-oriented rate structure depends on the perspective of the viewer. Each of the stakeholders — utilities, customers, and society — might have a different perspective. From the utility's perspective, an effective efficiency-oriented rate structure generates sufficient revenues to pay for the cost of service and maintain financial viability. From the customer's perspective, a rate structure is effective if it sends signals to customers about the true worth of water and enables better consumption decisions, which in turn enhances the utility's ability to manage its load. In addition, customers' decisions about when and how much to consume send the utility signals about the worth of additional or improved water service. In this way, an effective efficient rate structure can improve the balance between water consumption and production and thus encourage resource efficiency.

Rate setters should always bear in mind, however, that many of the problems surrounding the implementation success of new rate structures result from unintended and unexpected consequences.

Revenue Effects: Rates that limit the difference between revenue received and cash expended are desirable as long as the rates balance the twin objectives of achieving revenue sufficiency and avoiding undue earnings. Cash flow instability can increase the need for costly short-term financing. In extreme cases, revenue shortfalls may require emergency rate increases, which are unpopular, difficult to implement, and politically costly. If not addressed quickly, revenue shortfalls can result in bond rating downgrades for a water utility, a very expensive penalty. Lastly, an uncertain future can make system planning more difficult and expensive.

Consumption Effects: Rate structures can be a tool of demand management in two ways:

- **“Load management”:** the short run problems caused by the “shape” of demand.
- **“Capacity planning”:** the long run problems of meeting demand.

That rate changes have predictable effects on both the level and shape of demand should be recognized and incorporated into long-term utility planning. With sensitivity to the effect of rates on demand, rate structures can be designed to target either total or peak water demands (Hasson, 1993). For example, water utilities confronting system peaking problems might benefit from considering seasonal pricing, while utilities confronting a general shortage of water will benefit from conserving water year-round. Since design criteria for capacity expansion often are driven by peaking requirements, even these simple examples are not as straightforward as they appear. Rate structures should be compatible with, and preferably advance, both short-term load management and long-term capacity planning.

Modeling Water Demand Variability

Demand forecasting serves many purposes, and is a critical step in the planning, design and evaluation of a rate structure. In order to ensure that revenue collected will cover costs, water utilities need to anticipate how much water they expect to sell. As water rates are typically reviewed and revised every few years, it is also important that water utilities forecast future demand several years in advance to ensure that sufficient funds are collected.

In the past, demand forecasts have tended to overestimate demand as they have relied on historical consumption patterns and simple assumptions. Methods have improved over time to capture the trend of declining water demand and incorporate variables that impact demand, such as weather and climate change, new legislation, penetration of more efficient technology, efficiency programs, and demographic changes.

UNDERSTANDING WATER DEMAND

Lessons Learned from Setting Urban Rates that Encourage Efficiency and Conservation

- **Lesson 1:** Rates influence demand.
- **Lesson 2:** “Price elasticity” is the percentage change in demand induced by a one percent change in price, all other factors being constant.
- **Lesson 3:** Demand can be thought of as the sum of demands for different end uses of water.
- **Lesson 4:** Demand for outdoor uses is more price-elastic than demand for indoor uses.
- **Lesson 5:** Demand for water during peak (summer) periods is greater than demand during off-peak (winter) periods.
- **Lesson 6:** Residential water demand is inelastic, meaning that the response of residential demand to rate changes, though not zero, is small.
- **Lesson 7:** Demand is more elastic in the long run than in the short run.
- **Lesson 8:** Demand is influenced by forces other than price, such as population growth, the economic cycle, weather fluctuations, income growth, and technological change.
- **Lesson 9:** Demand responses are more difficult to predict when there are large changes in price.

Source: Mitchell, D.M. and W.M. Hanemann³⁹

The simplest approach to analyzing demand would be to use a single important determinant to create a forecast. Population, for example, might be the single-most important force driving urban water demand. As population grows, water demand also tends to grow. As a result, water managers often think in terms of per capita water use (total water use divided by total population). As simple as this sounds, however, there are exceptions, especially in the short term. If the weather is particularly wet and cool, for example, water use might decrease due to reduced lawn watering.

39 Mitchell, D.M. and W.M. Hanemann (1994), *Setting Urban Water Rates for Efficiency and Conservation*, A report for the California Urban Water Conservation Council Sacramento California, <http://www.cuwcc.org>.

In the long run, however, more people usually does mean more total water use. The utility may also add total water requirements to the forecast by multiplying a population forecast by a per capita water requirement.

The simplicity of this approach no doubt helps to explain its popularity. The main weakness of the approach is that it omits other forces that influence demand, so it does not go far enough.

WATER DEMAND AS A WATER REQUIREMENT

Future Water Demand = Population X Per Capita Water Requirement

Strengths:	Inexpensive, easy to do, and easy to explain Accounts for population growth
Weaknesses:	Implicitly assumes that rates do not affect water demand Does not account for how other forces affect water demand Provides no measure of the pattern of demand (load shape) Provides no measure of the uncertainty surrounding demand

To develop a more complete and explicit understanding of water demand, analysts must incorporate more than population growth into a model of water demand, such as climate, economic forces, and price. In-depth demand modeling can yield cost-effective returns to the water utility.

Other than population, what are the important forces that drive future water demand and uncertainty about future water demand? In a given year, weather conditions can cause demand to increase or decrease. Strong regional economic activity can increase water demand through additional commercial or industrial water use. In addition, a rising economic tide can broadly increase personal income levels and encourage additional population in-migration. Changes in water rates, as emphasized throughout this report, will change the relative attractiveness of water conservation and induce changes in water consumption. For this Handbook, the driver variable of a water requirements model—per capita water use—serves as the dependent variable. After accounting for population, why might per capita water use change over time?

Weather: Per capita water use can go up or down in any given year due to weather fluctuations. Per capita water use in hot and dry years generally is higher than water use in cool and wet years. Other things being equal, increases in rainfall or decreases in temperature tend to decrease per capita water use due to decreased demand for outdoor water uses. The reverse, of course, also holds true. Decreases in rainfall and increases in temperature tend to increase per capita water use due to increased outdoor water use.

Composition of Users: Changes in the composition of water users can also change per capita water use. The total water use of a city derives from several different types of water users—residential, commercial, industrial, and institutional. If, for example, a city loses a water-intensive industrial customer, per capita use will initially decline. (Population is constant and total water use is reduced.) Likewise, increased economic activity can result in an immediate increase in commercial and industrial water use.

Income: Over the long-term, per capita income can increase as a result of economic prosperity. Real income growth—that is, income growth above the rate of inflation—is consistent with increased per capita water use. Higher income households tend to have larger yards, lush landscapes, dishwashers, clothes washers, spas, and pools. Not all high income households use more water than low income households but, in general, increases in real personal income over time tend to increase household water use.

Price: Changes in the price of water can also affect decisions over the use of water. It has been documented that water rates have been increasing nationwide for a number of reasons.⁴⁰ Competing water users, increased water quality standards, infrastructure replacements, and the expense of developing new sources of water have all translated into higher water costs. When customers are charged more for water, they can choose to use less water. In the short-term, water users may be limited in how much they can reduce water use through changes in their water-using habits. Over the long-term, water users can choose to change both their water-using habits and their water-using equipment. Thus, the long-term response to increases in water rates is greater than the short-term response.

How can these determinants be formally incorporated into an understanding of water demand?

There are several methods in use for estimating future demand with varying levels of complexity depending on the number of variables. Models can also be classified as aggregate (total water demand for an entire service area or customer class) or disaggregate (demand by individual customer or individual end uses). In principle, disaggregate models can answer a wider range of questions; they also require more detailed data, more data manipulation, and more data validation.

The *AWE Sales Forecasting and Rate Model* helps water managers incorporate several variables through a simulation technique called “indexed sequential simulation”:

Weather Variability: Given historical data on precipitation and average maximum daily air temperature, the model randomly draws five-year sequences of these data for use in each simulation trial. For each weather sequence, the model adjusts average water use for each rate class based on how much the sequence deviates from long-term normal weather.

Account Growth: The model requests the expected growth rate over the next five years for each rate class, as well as the lower and upper bounds for this growth. You then select from one of three probability distributions constructed from these values to represent the uncertainty of future account growth.

Water Use Curtailment: This component allows simulation of the effect of water use curtailments as specified via drought/shortage curtailment levels by the water manager. It presents multiple options for simulating water use curtailment.

Further guidance on choosing among these probability distributions is given in the User Guide in Appendix C. More technical guidance for building more sophisticated multivariate water demand forecasting models can also be found in Appendix B.

40 Alliance for Water Efficiency. (2012), *Declining Water Sales and Utility Revenues: A Framework for Understanding and Adapting*.

IRWD'S LAND USE-BASED APPROACH TO DEMAND FORECASTING



Irvine Ranch Water District's (IRWD) water supply and resource planning is driven by land use plans proposed by the major land developers in its service area. IRWD uses an advanced geographic information system (GIS)-based utility demand forecasting tool to estimate water/wastewater demands in response to changes in the land use. Water supply planners are able to track growth and estimate the supply and demand requirements in their service area, and they can identify system capacity requirements by conducting a "what-if" analysis while dynamically forecasting the demand on the distribution system. The model is periodically re-calibrated by comparing projections to actual demands. This analysis allows IRWD to overcome supply and demand planning challenges using the wealth of GIS data in its service area.

Modeling Water Revenue Variability

Robust evaluation of efficiency-oriented rate structures requires an additional layer of forecasting impacts. Since variations in demand tend to create revenue volatility, forecasting models must consider the impact of block rate structures on sales and revenue. Accurately forecasting long-term sales volume lies at the heart of establishing a correct rate level. Analysts must consider water supply availability, future water demand, and the effect of different types of rates on revenue.

Many financial analyses rely on an overly simple model of future sales. Some of these simple approaches include: sales next year will be like sales last year; or, the growth in sales this year will equal the growth in sales last year; or, the trend in sales will equal the trend in the preceding ten years. These methods do not account for the effects of climate on demand in a given year, the potential effect of swings in the business cycle, and the effect of rates on demand. Weather normalization helps balance some of this oversimplification.

Revenue prediction for rate design requires a short-term price elasticity estimate that reflects the demand response that might occur in a one- or two-year period. If an estimate of elasticity in a rate design is too low, it can be adjusted in the next rate redesign. Utilities concerned about uncertainty surrounding price elasticity should conduct sensitivity analyses to see how much predicted revenue will change with different price elasticity assumptions.

The estimates in **Table 2** provide a good starting point for incorporating residential demand response, but the demand response of commercial and industrial customers would be more variable. In general, nonresidential demand response is thought to be greater than residential demand response.

Table 2 — Recommended Short Run Elasticity Estimates for Short Run Rate Design

SINGLE FAMILY RESIDENTIAL CUSTOMERS	RANGE OF ESTIMATES	POTENTIAL SHORT RUN REDUCTION IN DEMAND FOR A 10% REAL PRICE INCREASE
Winter season	-.00 to -.10	0.0% to 1.0%
Summer season	-.10 to -.20	1.0% to 2.0%
Multiple Family Residential Customers		
Winter season	-.00 to -.05	0.0% to .5%
Summer season	-.05 to -.10	0.5% to 1.0%
Irrigation Only Customers	-.20 to -.30	2.0% to 3.0%
Commercial/Industrial	-.15 to -.25	1.5% to 2.5%

Source: Chesnutt and Mitchell

Most empirical studies have found the long-term residential price elasticity to range between 0.2 and 0.6. Griffin (2006) concluded that price elasticity for annual residential water use is likely to lie in the range of 0.35 to 0.45, meaning that a 10% rate increase may produce a 3.5% to 4.5% reduction in demand over time.⁴¹

Indoor residential water demand is more inelastic than outdoor residential demand. On a percentage basis, residential water users have displayed a willingness to reduce outdoor consumption more readily than indoor consumption. The corollary of this finding is that summer demand tends to be more elastic than winter demand, because most outdoor use occurs during the summer. One study that estimated residential price elasticities separately found that outdoor water use has a higher magnitude of price response. Households having no outdoor irrigated area had a price elasticity of about 4.6%.⁴² **Figure 9** shows how single-family residential price response varied as a function of irrigated area.

41 Griffin, Ronald C. (2006). *Water Resource Economics: The Analysis of Scarcity, Policies, and Projects*. The MIT Press, Cambridge, MA.

42 Chesnutt, T.W., C.N. McSpadden, and A. Bamezai, *Ultra Low Flush Toilet Programs: Evaluation of Program Outcomes and Water Savings*, A report for the Metropolitan Water District of Southern California, July 1995. The time-series cross-sectional panel data of 2944 single family households in Los Angeles and Santa Monica controlled for household meter-specific variability, season of the year, a seasonally-varying response to weather variations, and participation in ongoing ULF toilet, LF showerhead, and meter replacement programs.

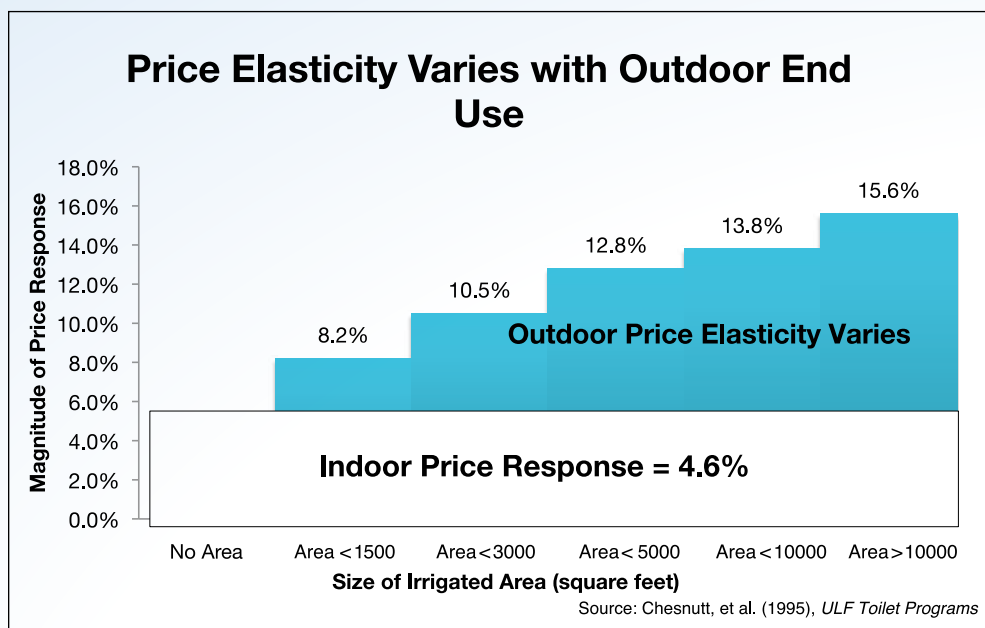


Figure 9 — Residential Price Elasticity Varies with Outdoor Water Use⁴³

Additionally, residential customer demand for water is more responsive to price over the long-term than over the short-term. Another way of stating this is that it takes time for price changes to fully influence the demand for water. Right after a price increase, consumers are mostly locked into their water using appliances and landscaping. While they can modify their water using behavior in response to the price increase or change in rate structure, they may not be able to adjust their stock of water-using equipment (appliances, plumbing fixtures, etc.), at least not right away. Over time, as this stock of capital wears out and is replaced, improvements in the efficiency of the capital can be realized. Thus, long-run demand tends to be less inelastic than short-run demand. These are broad generalizations, however. Demand responses are often specific to the time and circumstances in which the price adjustment occurs, and therefore can significantly vary by region and time period.

Technical guidance to construct models of system demand and revenue for specific block rate structures can be found in Appendix B.

The propensity of a rate structure to generate revenues that exactly match the revenue requirements of a water utility is subject to a variety of risks involving both supply and demand. These risks can produce revenue instability in the form of both revenue surpluses and revenue shortfalls, and they are associated with changes in the number of customers, changes in customer mix, changes in usage patterns, changes in weather, changes in conservation ethic, changes in the price elasticity of water demands, and changes in rate structure.⁴⁴ An important additional source of risk comes from supply or drought-driven curtailments. Finally, another important driver of short-term revenue uncertainty is climatic uncertainty.

43 Chesnutt, T.W., C.N. McSpadden, and A. Bamezai, *Ultra Low Flush Toilet Programs: Evaluation of Program Outcomes and Water Savings*, A report for the Metropolitan Water District of Southern California, July 1995. P.A-18

44 Beecher, J.A. and P.C. Mann (1991), *Cost Allocation and Rate Design for Water Utilities*, Denver, Colorado: The American Water Works Association Research Foundation, March.

These sources of risk need to be assessed in the process of determining revenue requirements and mechanisms such as contingency funds and automatic rate adjustments put in place for coping with the unanticipated revenue changes.⁴⁵

In an ideal world, rate analysts would calculate revenue risks for each rate alternative. The *AWE Sales Forecasting and Rate Model* provides modules to help water managers predict future block sales (volume and revenue) by using empirical price elasticities and conducting a risk theoretic simulation of revenue risks and fiscal sustainability over a five-year time horizon. This kind of information can help water managers make more informed decisions about the tradeoffs involved in developing an efficiency-oriented rate structure.

Customer Bill Impacts

Some attempts at rate innovation have been undermined by an insufficient understanding of who bears the brunt of rate changes. Large changes in rate structure can greatly change exactly who pays what, so an analysis should (1) calculate the change in customer bills that would result from a change in rates, (2) identify subgroups that have relatively larger bill impacts, (3) inform the ratemaking process about those impacts, and (4) investigate measures to mitigate adverse impacts on specific customer groups. Good rate evaluation will help utilities avoid unintentional rate shock.⁴⁶

Figure 10 shows a comparison of the relative bill impacts related to moving from a uniform rate structure to an increasing block rate structure for single-family customers, referring to rate scenarios found in the *AWE Sales Forecasting and Rate Model*. A Board of Directors may want to see additional analyses of bill impacts. Examples of relevant bill impact categories include:

- the annual change in bill impact per customer;
- the average change in summer bills;
- the average change in bills among customers with different seasonal water use patterns;
- the change in bills among small, medium, and large customers in each customer class;
- the average impact by voting district; and
- the change in bills among customer groups that have been vocal in previous rate setting processes.

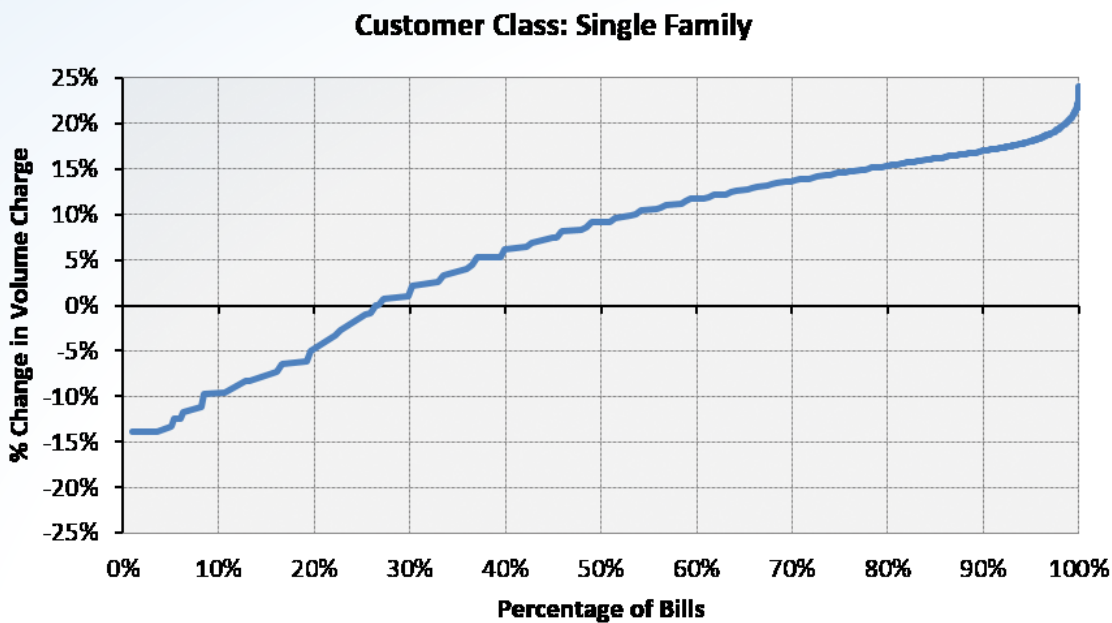
Conducting a careful and thorough analysis of the impact of the rate structure on the customers' bills will help prevent surprises and secure successful acceptance.

45 Chesnutt, Thomas W., Casey McSpadden, and John Christianson. (1996) "Revenue instability induced by conservation rates." *Journal of the American Water Works Association* 88, No. 1 (1996): 52-63.

46 AWWA Water Utility Council, 2004. *Avoiding Rate Shock: Making the Case for Water Rates*. American Water Works Association

Bill Impacts of Proposed Rates Relative to Current Rates

The chart below shows the cumulative distribution of bill impacts by Customer Class under the Proposed service charges and volumetric rates. The x-axis shows the percentage of bills while the y-axis shows the percentage change in the volume charge.



Source: AWE Sales Forecasting and Rate Model

Figure 10 — Customer Bill Impact Relative to a Uniform Rate



Probability Management—A SIP and SLURP of Water

The fundamental equation used to determine the average required water rate in traditional methods is as follows:

$$\begin{aligned} \text{Required Rate} &= \frac{\text{Total Revenue Requirement} - \text{Fixed Revenue}}{\text{Sales Volume}} \\ &= \frac{\text{Rate Revenue Requirement}}{\text{Sales Volume}} \end{aligned}$$

Note that all numbers that appear above are treated as certain. Yet it is easy to see how future values of none of these are not known with certainty. Thus the traditional approach is subject to the “Flaw of Averages.”

Flaw of Averages

Fact 1 — Planning for the future is rife with uncertainties.

Fact 2 — Most people are not happy with Fact 1 and prefer to think of the future in terms of average outcomes.

Fact 3 — The “flaw of averages” states that plans based on average assumptions are, on average, wrong. The book by Sam Savage, *The Flaw of Averages*, documents numerous ways that this can occur.

The methods of Probability Management were originated to address the “Flaw of Averages” and are embedded in the *AWE Sales Forecasting and Rate Model*.

Traditional water industry rate models assume that future sales are certain, known with certainty, and do not respond to price, weather, the economy, or supply shortages—that is to say, not the world we live in.

The AWE Sales Forecasting and Rate Model addresses this shortcoming through several features:

- Customer Consumption Variability - weather SLURP and drought/shortage conditions
- Demand Response - Predicting future block sales (volume and revenue) with empirical price elasticities
- Drought Pricing - Contingency planning for net revenue neutrality
- Probability Management - probabilistic simulation of revenue risks
- Fiscal Sustainability - Sales forecasting over a 5 Year Time Horizon

PROBABILITY MANAGEMENT AND UNCERTAINTY



ProbabilityManagement.org is a non-profit that promotes the communication and calculation of uncertainties through education, best practices, and the open SIPmath™ standard, which represents probability distributions as auditable data.

Uncertainties can be calculated by storing potential outcomes in data arrays called SIPs (Stochastic Information Packets). For example, the SIP of a die would consist of a column of integers randomly chosen between 1 and 6. Calculations using SIPs are referred to as SIPmath™. SIPmath™ can be performed in almost any computer environment, including a commonly used spreadsheet format with the native data table function. A collection of SIPs is encapsulated in a Stochastic Library. A Stochastic Library that preserves coherence is referred to as a Stochastic Library Unit with Relationships Preserved (SLURP). Examples of these concepts applied to water can be found on the ProbabilityManagement.org website.

Feasibility of Implementation

In addition to evaluating the effectiveness of a rate structure in achieving diverse objectives, a water manager should also evaluate feasibility. The feasibility of a rate structure depends on several factors:

- Consistency with cost-of-service principles
- Administrative cost
- Institutional legitimacy and legality
- Public acceptance

Consistency with Cost-of-Service Principles: A prime consideration for utility managers, this factor raises the issue of institutional legitimacy: will the rate structure receive external approval from oversight bodies?

Administrative Cost: Is the cost of implementing a new rate structure administratively prohibitive? Will it entail major changes in billing or metering practices? Seasonal rates, for example, generally require monthly or bimonthly billing so customers receive a price signal in time to change their consumption behavior within a given seasonal period. The initial cost of converting to a more frequent billing cycle can be high. In some states, in fact, regulators have disallowed expenses related to metering and billing changes because the regulators believed that the benefits would not exceed the costs of the conversion. Additionally, changing the rate structure may require utilities to step up efforts to educate customers and resolve complaints.

Institutional Legitimacy and Legality: Is the new rate structure acceptable to federal, state, and local governments? Might it violate legislative, regulatory, or judicial standards? To complicate this matter, laws and regulations may be different for publicly-owned utilities than for investor-owned utilities, particularly when the former are not under the jurisdiction of a state utility commission. Existing legislation can also influence rate structures. In Massachusetts, for example, publicly-owned utilities cannot use a decreasing-block rate. In Florida, water rates outside a city cannot exceed a 50% differential over rates inside the city. Public utility laws in general call for minimizing price discrimination and avoiding undue discrimination.⁴⁷

It may be wise to work with governing bodies to show that rate setting might serve a larger public purpose and help them enact laws and policies that encourage new approaches to ratemaking.

Public Acceptance: Is the rate structure simple and understandable enough for customers to accept and use to make efficient consumptive choices? Is the rate structure “fair”? Of course, reaching consensus about the concept of “fairness” can be a challenge. For example, higher rates for large-volume users can be controversial if some perceive them as discouraging local and regional economic development.

Public acceptance depends in part on affordability, and regardless of efficient pricing, the cost of water is rising. Affordability and efficiency goals may appear to be at odds: higher prices may encourage efficiency, but some customers may then find water service too expensive. Lifeline rates — charging a lower price for the first block of water consumption — ensure that every customer has affordable access to the minimal usage required for public health and sanitary needs. In addition, water utilities can tailor efficiency programs, such as plumbing retrofits and customer outreach, to the needs of the low-income population.

Another fundamental fairness concern is equity. Might there be concerns about one group subsidizing another and paying more or less of one’s “fair share” of costs? In short, today’s customers should not be served at the expense of future customers, either in terms of utility costs or resource availability. Economists tend to view efficient solutions as “equitable” when subsidies are minimized. Others, of course, might define equity in quite different terms, such as affordability.

Decide on a Rate Structure

Multiple legitimate perspectives turn water ratemaking into an ongoing balancing act. Rates perceived to be affordable by the customer might not generate enough revenue for the utility. Rates perceived to be equitable might not be efficient. Rates that serve societal needs might require unrealistic changes in a utility’s administrative practices. Rate modifications aimed at minimizing revenue volatility might distort the price signals communicated by the rate structure. A lifeline rate motivated by affordability concerns might send a poor signal about the worth of water to users within the lifeline block. Rate structures that try to address multiple equity concerns can become overly complex and difficult to understand. Responsible ratemaking involves inevitable tradeoffs among potentially conflicting objectives.

47 Bonbright, J.C., A.L. Danielson, D.R. Kamershen (1988) *Principles of Public Utility Rates*. Public Utilities Report Arlington VA.

There are no magic methods for selecting the best rate structure. No analytic method or evaluation technique can make choices. However, evaluating and understanding those tradeoffs can enable water managers to select a rate structure that best helps them meet their objectives.

By evaluating both the effectiveness of the proposed rate design — through demand forecasting, revenue modeling, and assessing impacts to customer bills — against the feasibility of the rate design, water managers can determine how well the proposed rate structure achieves the objectives identified at the outset of the rate setting process.

No rate design option can fully satisfy all of the evaluation criteria. In fact, efficiency goals can intensify the conflict over other ratemaking objectives. Selecting a rate structure is an exercise in judgment, with the explicit presumption that some objectives will be sacrificed in the effort to achieve the most important ones.⁴⁸ Setting reasonable ratemaking objectives may be the most important part of the implementation process.

Over the years, experts have put forth numerous ideas for making decisions about multiple-criteria problems, such as goal programming, multi-objective programming, and coin tossing. This Handbook does not offer a review of formal decision-making approaches. However, we do recommend creating a scorecard: a device for evaluating multiple alternatives with multiple objectives. To complicate the strategy, scores need not be strictly quantitative. Rather, they may fall along a quantitative-qualitative continuum as appropriate.

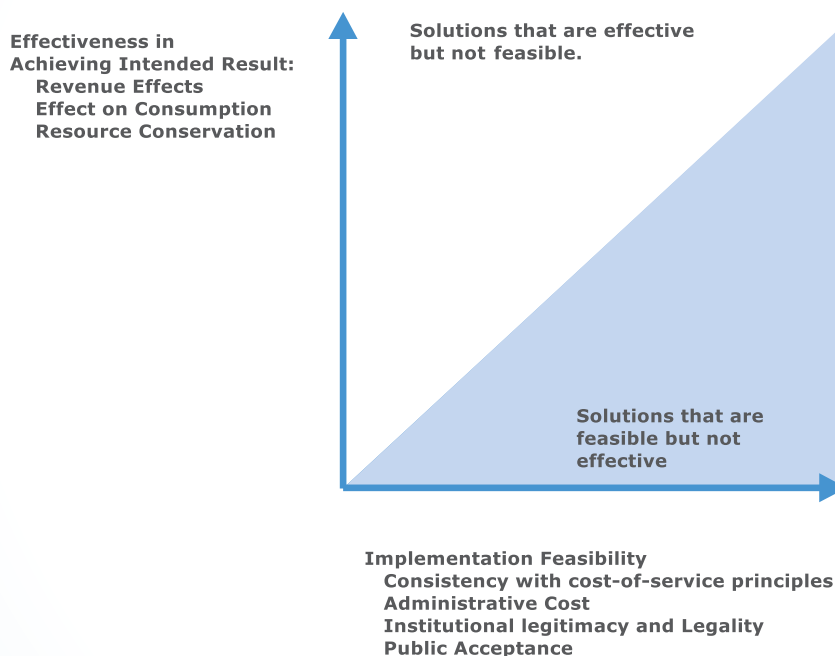


Figure 11 — Balancing Effectiveness vs Feasibility Criteria: Making Better Tradeoffs

48 Beecher, J.A. and P.C. Mann (1991), *Cost Allocation and Rate Design for Water Utilities*, Denver, Colorado: The American Water Works Association Research Foundation, March.

Chapter 4



Financial Policies and Planning for Improved Fiscal Health

Research on efficiency-oriented rates and revenue volatility provides several lessons (Chesnutt, et al., 1996). Revenue instability is a feature of all rate structures; the difference is only a question of degree. To the extent that moving to an efficiency-oriented rate structure entails a shift from fixed charges to variable charges, revenue instability can increase. Regardless of the change in revenue volatility brought about by a rate change, managers need to develop coping strategies to hedge against revenue risk.

These strategies may include:

- maintaining a contingency fund;
- including a risk margin in the determination of revenue requirements;
- developing an automatic rate adjustment mechanism; and
- adjusting rates more frequently.

Revenue instability should not be an obstacle to pursuing the benefits of implementing water rates that encourage conservation and efficiency. In fact, as utility costs continue to increase and evolve, new rates for efficient water service become even more necessary and beneficial, both to bring revenues in line with costs and to give customers the correct message about the value of the water. Water managers facing problems in providing reliable water service have a real incentive to be committed to the benefits of careful rate design.

With policies that embrace and reflect a commitment to water use efficiency, managers can navigate market dynamics and uncertainties with good planning, performance monitoring and evaluation, and adaptive measures. Traditional approaches have not always recognized or supported the potential for purposeful changes to water use practices. However, the future will require tools that enable utilities to leverage water use efficiency so they deliver water services cost-effectively well into the future.

In light of the risks faced by water utility managers, they must develop strategies to manage the dynamic relationship between revenue and expenses, particularly the revenue effects of encouraging efficiency and developing and complying with policies that ensure long-term fiscal sustainability.

Policy Options to Promote Revenue Stability

Financial policies should articulate a utility's position on a variety of financial issues and enhance understanding and compliance by employees, vendors, customers, and stakeholders. Policies, which are typically approved by a utility's governing board, are an important component of the framework for effective utility financial management. These financial policies establish parameters for developing financial plans and providing guidance for decision makers. Developing a clear financial policy can benefit a utility in a number of ways, such as providing a tool to benchmark performance and enabling accountability throughout the organization.

A clear policy also presents other benefits related to credit ratings. As was evident in the post-2008 credit crisis period, maintaining a utility's credit rating is a key to success. A Fitch publication that summarized the results of a 1999 study of municipal debt defaults describes this need and the connection to financial management practices well:

Fitch came to the conclusion that management practices were more important in predicting favorable credit performance than had been appreciated in the past. Fitch's public finance group identified several preferred management practices and said on record that issuers who incorporate several of these best practices could see a difference of one to three rating notches above the ratings of similar issuers that do not incorporate such practices.⁴⁹

As a result of this study, Fitch reviewed its entire portfolio in 2000 and changed half of its water and sewer ratings. Many of the preferred management practices identified by Fitch relate to financial policies. Fitch has not been the only rating utility that recognized the importance of financial policy development. A 2005 presentation by Standard and Poor's noted that:

Credit analysis has moved beyond a simple current rate comparison...ratings increasingly reflect the extent of a utility's ability to implement strategies and policies that address its unique characteristics and allow it to finance needed improvements.⁵⁰

49 "The 12 Habits of Highly Successful Finance Officers; Management's and Disclosure's Impact on Municipal Credit Rates," Fitch Ratings, November 21, 2002

50 Weimken, Jim, "The Growing Importance of Rate Structure and Rate Setting for Water-Sewer Utility Ratings," Standard and Poor's, March 17, 2004.

More recently, in 2008, this overarching focus led the major ratings agencies to revise their credit ratings criteria for water and sewer credits.⁵¹ This revision focused on strategies, policies that promote achievement of strong financial metrics, and managerial aptitude, particularly in the face of increasingly stringent regulations related to major capital spending. While it has been assumed that financial policies can contribute favorably to a utility's long-term operational and financial integrity, the value to the utility of adopting a formal policy framework through improved credit ratings and lower cost of capital has become apparent.

In developing a policy framework, the difference between financial policies and procedures also becomes important, as described in a 2004 article published in the *Government Finance Review*:

*[F]inancial policies are guidelines for financial management decisions; administrative procedures cover the detailed steps needed to accomplish business processes. Administrative procedures are an important complement to financial policies because they ensure that day-to-day activities are in line with financial policies.*⁵²

In this article, the author describes three types of financial policies:

1. **Actionable:** policies linked to specific performance measures and that dictate actions based on the status of those indicators.
2. **Performance measures:** performance measures alone, without a prescribed course of action.
3. **Philosophical:** general policy goals.

The mix of general and specific financial policies should be tailored to individual utilities' circumstances and governing board preferences.

While the composition of financial policies may vary across utilities, promulgating specific policies beyond informal "rules of thumb" is becoming standard practice. For example, the American Water Works Association has identified the development of financial policies in the business practice standards it has promulgated for its member agencies. These standards address Policies and Performance, Functions and Practices, and Organizational Capacity and Technology, and they are applicable to:

- Financial Planning
- Financial Accounting
- Debt Management
- Ratemaking
- Financial Budgeting
- Financial Reporting
- Reserves Management

51 Standard & Poor's Revises Criteria For Rating Water, Sewer, And Drainage Utility Revenue Bonds, RatingsDirect, Standard & Poor's September 15, 2008.

52 Kavanagh, Shayne, "Developing Financial Policies that Work" in *Government Finance Review*, April 2004, Volume 20 No. 2

Issued in 2008, these standards⁵³ focus on requirements to assure effective financial management, and they now span all water resource utilities, including water, wastewater, and stormwater. They emerged in part from the challenges many utilities are facing as a result of declining water demands, lower sewer flows, and the associated revenue shortfalls. Those dynamic realities demonstrate the need for new approaches to financial resiliency. Utilities that establish and comply with financial planning policies and that consider approaches to risk management will be better positioned to withstand pressures associated with water use reductions, economic decline, regulatory pressures, and capital market volatility.

Recent collaborative efforts of major U.S. water and wastewater industry organizations have also helped define attributes of effectively managed utilities. “Strategic business planning” is key to management success, and “financial viability” is one of the ten attributes of effectively managed utilities. Financial viability may be defined as:

Understands the full life-cycle cost of the utility and establishes and maintains an effective balance between long-term debt, asset values, operations and maintenance expenditures, and operating revenues. Establishes predictable rates—consistent with community expectations and acceptability—adequate to recover costs, provide for reserves, maintain support from bond rating agencies, and plan and invest for future needs.⁵⁴

This understanding should help drive a utility organization through periods of volatility due to external factors and across changes in leadership of governing board and utility management. It provides a level of clarity and transparency that assures key stakeholders of the utility’s financial integrity and management approaches.

Eight general categories help define the spectrum of financial policies that are not only applicable to most water utilities, but that also clarify their commitment to water use efficiency.

Financial Planning

Financial planning includes policies related to the annual operation and maintenance budget process, capital program development and approval, and the development and updating of strategic financial plans. It should facilitate preparedness for variability in water use, including the variability influenced by efficiency-oriented rates and programs, and it should help define utility responses to planned and unplanned variability in water use practices.⁵⁵

53 American Water Works Association, “Standard for Business Practices for Operation and Management,” ANSI/AWWA G410-09, (2008)

54 *Effective Utility Management: A Primer for Water and Wastewater Utilities*, June 2008, USEPA, AMWA, APWA, NACWA, NAWC, WEF, P. 5.

55 Sam Savage and Shayne Kavanagh, *Probability Management in Financial Planning*, Government Finance Review Magazine, February 2014.

Financial reporting includes policies related to the structuring of the utility's chart of accounts, methods of cost accounting, and formats of financial reports. These policies may prescribe the frequency of reports — monthly, quarterly, annual — audiences for different types of reports, and requirements for financial audits. Increasingly, reporting policies have delineated performance measurement and benchmarking requirements. In the context of resource scarcity and concerns related to sustainability, these performance measurement and benchmarking efforts are increasingly including measures of water use efficiency.⁵⁶

Capital Financing

Capital financing includes policies related to targeted capital structure — debt vs. equity — in annual financing of capital improvements and as reflected in balance sheet accounts, as well as in protocols for selecting debt instruments. When utilities have substantial outstanding debt, capital financing policies will address covenanted and targeted debt service coverage levels — senior and junior lien obligations — and uses of various forms of debt security, including sureties, insurance, and reserves. With respect to water use efficiency, changing perceptions regarding the malleability of long-term water demands may affect decisions related to capital structure. Similarly, as utilities become more engaged in demand management, capital financing policies related to offering assurance to bond holders of credit quality — such as target coverage or reserve levels — may warrant modifications to reflect better understanding and management of revenue variability.

Ratemaking Policies

Rates and charges include policies related to the basis for calculation of user rates, often calling for cost-of-service ratemaking and outlining specific metering and billing procedures. Policies may address the frequency of updating cost allocation calculations and protocols for setting and updating miscellaneous fees and charges. Utilities focusing on water use efficiency may further establish policies that call for developing and evaluating efficiency-oriented rate design alternatives and evaluations of the effectiveness of conservation pricing — and these practices may be aligned with State and regional efficiency initiatives.

Ratemaking is a tool for ensuring that utilities generate sufficient revenues to perform their service function. Adaptive rate design methods can help stabilize revenues and ensure revenue adequacy. For example, some water utilities have established a formal rate adjustment that can move the rate level up or down based on departure from the revenue target of the previous period. These mechanisms can be used in conjunction with various rate structures, but each approach involves tradeoffs among competing objectives. For example, many of the methods involve a potential conflict between rapid cost recovery and adequate incentives for cost control. Some cost pass-throughs and adjustment mechanisms may not be acceptable to utility regulators, especially in the case of investor-owned utilities. In addition, some of the methods applicable to regulated utilities may not be compatible with the needs of publicly-owned water utilities.

56 S. Kenway, C Howe, and S Maheepala, *Triple Bottom Line Reporting of Sustainable Water Utility Performance*, AWWA Research Foundation 91179, 15 Jan 2008.

Reserves and Rate Stabilization Funds

Strategic financial planning provides a long-term perspective of the challenges presented by potential changes in such areas as water demand and supply, system development needs, and regulatory requirements. By looking beyond annual budgets and management requirements, utilities can establish gradual rate increase plans and contingency provisions that may insulate them from adverse consequences. In some cases, utilities may determine that volatility in future revenues or expenses warrant the establishment of a rate stabilization fund to help mitigate rate variability. In some circumstances, especially for utilities with significant debt, such funds may be used to change the timing of revenue recognition such that revenues are recognized in the year of application rather than collection for purposes of debt service coverage calculations.

Reserves, including operating reserves and working capital, ensure that the utility has adequate liquidity to meet daily operational requirements and respond to emergency situations. Other reserves and associated policies may also be established to provide funding for other purposes, such as equipment replacement, rate stabilization, and to secure bonded indebtedness. As utilities advance water use efficiency, levels of appropriate reserves will require re-examination and tailoring to reflect a changing understanding of potential revenue variability.⁵⁷

Revenue/Cost Recovery Mechanisms

Revenue-stabilizing mechanisms offset the effect of fluctuating demand and supply in the context of pricing, conservation programs, and other factors that influence levels and patterns of water demand. For example, a drought surcharge imposed when a regional or state utility declares a drought emergency can mitigate revenue losses associated water use restrictions. Additionally, various forms of cost pass-through may be triggered by unanticipated escalation in key operating costs. More static measures — those that do not trigger an event — may include use of higher base or customer charges so a greater share of revenue recovery is not subject to water use volatility. Though deviating from traditional practice, these revenue recovery mechanisms can help achieve a balance between enabling customers to control their water service bills through efficient practices while ensuring revenue resiliency from the volatility that results from demand, climatic variability, and the economy.

Similarly, cost-recovery mechanisms can also offset the effect of fluctuating costs in the context of an otherwise prudent and efficient water utility operation. As a general rule, they should be applied only to costs that are difficult to predict and are highly volatile.⁵⁸ These mechanisms allow utilities to pass cost increases or decreases through to ratepayers more or less automatically. In other words, adjustments to customer bills do not require a formal rate approval process, thus reducing regulatory lag, the lag between incurring costs and increasing revenues.⁵⁹

57 For an application of Probability Management to the appropriate level of reserves, see Sam Savage and Shayne Kavanaugh, *The Sequestron*, Analytics Magazine, November/December 2013

58 Beecher, J. A., P.C. Mann, and J.D. Stanford. (1993) *Meeting Water Utility Revenue Requirements: Financing and Ratemaking Alternatives*, Columbus, Ohio: The National Regulatory Research Institute, Chapters 3, 5, 6, & 8, November.

59 Although cost-recovery mechanisms sound “automatic,” costs and revenues must be reviewed and reconciled in subsequent rate reviews. In the regulatory context, reconciliation proceedings involving “automatic-adjustment” mechanisms can be as contentious as regular rate hearings, as utilities must defend the prudence and efficiency of their operations.

For water utilities, cost-recovery mechanisms have been widely used for purchased water and energy. Purchased water cost estimates assume a unit cost for estimated water purchase for the test year. Most purchased water agreements involve variable pricing in the form of a wholesale water rate. If the level of purchases or the unit price varies from the forecast levels, deviations from forecasted water expenses result. The level of purchases may be affected by the use and availability of other supplies, or the purchase price may vary because the purchased water contract period may not be compatible with the effective period of retail rates. If wholesale price increases cannot be passed along to ratepayers immediately, a revenue shortfall will probably occur.⁶⁰

Market-Based Tools and Asset Management

Asset management is an emerging area of financial policy development related to the implementation of programs designed to minimize the life cycle cost of system assets at acceptable levels of risk. These policies may identify criteria for defining asset replacement schedules, address procurement procedures to garner life-cycle cost data, and establish reporting requirements for asset management. These policies, like related operations policies, are intertwined with a utility's commitment to water use efficiency, particularly with respect to water loss control.

The idea of exploring risk-sharing mechanisms and financial instruments to mitigate risk has recently emerged as a potential solution for utilities. The weather risk management market in particular may present a promising opportunity for water utilities. Extremely wet or dry seasons, or persistent weather patterns spanning several years, can have a significant impact on a utility's sales, net revenue, debt service coverage ratios and overall financial position. A number of weather-related financial instruments currently exist and are utilized successfully in industries such as energy and agriculture to help water utilities better manage weather-related revenue losses.

Operations

Operations policies may be relatively detailed prescriptions that impose critical internal controls, such as those that govern transaction authorities, segregations of duties, and purchasing procedures. Additionally, these policies may address aspects of financial operations including management of investments, criteria for capitalization of expenses, and approaches to risk management, such as criteria for self vs. purchased insurance. For most water utilities, operations policies that address water loss control activities and limit potential deferral may help utilities demonstrate their commitment to water use efficiency.

Service Extension Funding

Service extension funding policies typically address how responsibilities for funding capital investments will be assigned to development interests, how dedicated funds for this purpose will be created and managed, and how system development charges — impact fees — will be used to recover costs related to growth-related improvements. Since system development may lead to more claims on limited water resources, service extension policies may be structured to provide incentives for water efficient development, and related charges may reflect impending resource scarcities.

⁶⁰ Electricity and natural gas utilities face a similar problem in coping with fluctuating fuel costs. For energy utilities, fuel costs present a substantial operating expense over which the utilities have little control; deviations from forecast levels can lead to significant revenue shortfalls or surpluses. With the consent of regulators in many states, fuel adjustment clauses (FACs) and purchased gas adjustments (PGAs) have been used to pass along to ratepayers both costs and savings associated with changes in energy prices. Customer energy bills often reflect this information by identifying the portion of the bill attributable to fuel costs.

Financing Efficiency: Debt Financing vs. Operating Budget

On the expense forecasting side, efficiency program costs have typically been treated as an operating cost, similar to customer service costs, rather than being forecast in alignment with water demand forecasts.⁶¹ Efficiency investments are no longer typically capitalized, thus providing a negative incentive to instituting water efficiency programs that have long-term benefit similar to other capitalized water resource investments. Further, potential changes in water use patterns are often not incorporated or discounted in utility system development and master planning. More generally, traditional utility practices define revenue requirements solely by the direct, accounting costs of providing water service, and they tend to ignore externalities, efficiency of usage, and valid social considerations such as low income affordability. This poor planning can result in unplanned-for costs to address supply shortages, and unanticipated expenses always result in adverse consequences, especially in the absence of adequate reserves to fund such expenditures.

Advancing resource use efficiency involves shifting this construct to one where efficiency program development and implementation is subject to the same analytical rigor as built infrastructure investments. Water efficiency programs that are projected to provide benefits that exceed costs have only met one necessary condition for funding. Utilities may develop a portfolio management approach to program selection and funding in which combinations of candidate programs that yield the greatest returns receive funding.⁶² Often, the most cost effective efficiency program entails reducing water losses, and in this case, the relationship between asset management and resource efficiency is profound.

Planning for Efficiency and Revenue Effects

Utilities must plan based on projected revenues and expenses. Meeting revenue projections requires projections of water use and water use changes that result from rates changes.⁶³ Developing reliable forecasts of utility revenue patterns is extremely difficult and often frustrated by prevailing economic and behavioral uncertainties.⁶⁴ Such forecasts must rely on assumptions related to weather effects, population, business expansion or contraction, and evolving user consumption patterns. This forecasting has typically defaulted to vague assumptions of modest economic growth, “normal” weather patterns, and stable per capita consumption, none of which are really valid. More advanced forecasts offer limited scenario analyses, such as variations in assumed economic growth rates or per capita consumption values. In this context, water efficient pricing can have various revenue

61 Drought management expenses have not, in general, been incorporated into revenue requirement forecasts.

62 “Conservation in the Portfolio of Water Supply Options for Regional Reservoir Planning,” Eric Rothstein, E. Allison Keefer, and Mary A. Elfner, Proceedings of the 2003 Georgia Water Resources Conference, April 2003; and “Benefit/Cost Evaluation of Water Conservation Programs,” Eric Rothstein, Proceedings of the American Water Works Association CONSERV’96 Conference, January 1996, pp. 395-399.

63 The issues of demand and revenue forecasting are addressed in Chapter 8. A recent AWWA Research foundation report addresses a more specific form of the revenue management issue—Managing the Revenue and Cash-Flow Effects of Conservation, (Amatetti, E.J., 1996).

64 Billings, R.B. and C. Vaughan Jones, (2008) Forecasting Urban Water Demand 2nd Ed., and Chesnutt, Bamezai, McSpadden, Christianson, and Hanemann (1995) Revenue Instability and Conservation Rate Structures.

effects.⁶⁵ Some rate design changes can be made “revenue neutral” while others may have different impacts in terms of both revenue generation and the distribution of cost responsibilities across customers. Inadequate attention to rate design, however, can result in avoidable revenue shortfalls or surpluses.

Demand and revenue forecasts are generally used for system master planning, long-range financial planning, and as a reference for short-term budgeting and rate setting exercises. Historically, most water utilities have not considered or developed explicit plans for instances of severe drought that could disrupt long-term availability of supplies, nor have they evaluated the extent of their options to manage both peak and average demands, especially in the context of supply shortages.⁶⁶

Revenue generation forecast scenarios have not traditionally been established based on the value of service pricing or marginal resource costs, but rather they tend to be restricted to options that focus on the recovery of near-term expenses required to deliver reliable services. As resource scarcities become more pronounced and concerns for long-term water use sustainability become more profound, rate setting and associated revenue forecasting designed to reflect resource values are gaining importance. Utilities committed to water use efficiency will increasingly be called upon to reconcile short-term flows or fund management challenges with the need to convey price signals that reflect long-term resource scarcities.

These complexities in revenue and expense forecasting underscore the risks that characterize the financial management environment for water utilities. These risks include:

- **Risks of Obtaining Water Rate Increases:** Over the last two decades the cost of providing water has increased at a rate greater than the rate of general inflation. The result has been substantial upward pressure on water rates that must be justified before governing boards or public utilities commissions. Justifying rate increases can be a politically risky and practically daunting task regardless of the cause, and rate increases are often reduced in scope or even denied outright by elected officials worried about angry consumers.
- **Risks of Rising Costs:** Water utilities must contend with rising capital costs associated with maintaining, improving, and expanding water supply infrastructure and with rising operating costs, such as water, chemical, and energy costs. Population growth and regional economic development contribute to the growing demand for water, but developing new sources of supply has become extremely expensive. In addition to developing reliable supplies, water utilities also must comply with more stringent federal and state drinking water standards, maintain the water distribution infrastructure, address deferred water infrastructure replacement, and cope with customer demands for better watershed stewardship. Addressing these challenges imposes very real and substantial costs.

65 Beecher, J.A., P.C. Mann, Youssef Hegazy, and John D. Stanford. (1994) *Revenue Effects of Water Conservation and Conservation Pricing: Issues and Practices*. Columbus, Ohio: The National Regulatory Research Institute, Appendix A, Chapter 4,

66 The Water Research Foundation *Drought Response Model* (Chapter 5, Chapter 7, and attached CD-ROM) for one such approach.

- **Risks of Revenue Shortfall:** The risk of a revenue shortfall rises with unplanned cost escalation and uncertain water supply reliability. Prudent financial management suggests that water utility managers should find ways to offset revenue shortfalls and maintain financial solvency. Without adequate revenues, infrastructure repairs and replacements might get deferred, resulting in more costly operations in the long term. Better financial planning can reduce cost and revenue uncertainty; better rate design can minimize the damage of the cost and revenue uncertainties that remain.⁶⁷
- **Risks of Public Unacceptability:** As water service costs claim an increasing share of incomes, consumers will have an increasingly difficult time accepting the seeming inevitability of increasing water costs. Water utilities are likely to face more pressures related to achieving efficiencies in both operations and capital project delivery and in the mitigation of water service cost escalation.

Transforming Utility Management for a Sustainable Future

Given the uncertainties that prevail for water utilities and available revenue management strategies, ensuring a fiscally sustainable future⁶⁸ may require fundamental and transformational changes to how water services are planned, delivered, and financed.⁶⁹ These changes may come in the form of:

- Technical Innovation
- Public Engagement
- Financial Incentives
- Institutional Structures

Technical Innovation

Some water sustainability issues can be solved through technical innovation. Many water use efficiency programs therefore appropriately focus on implementing innovative technical solutions to achieve improved performance of water end-use fixtures. Similarly, supply-side efficiency has seen rapid technological advances that can yield substantial efficiency improvements and cost savings. Rapid developments in new technologies have led to new options for non-potable and potable recycling of wastewater. Stormwater capture and reuse has broken historical roles for wastewater institutions. Advanced metering systems have broken barriers for conveying information rapidly and bi-directionally between water utilities and water customers. As the water utility industry embraces sustainability and seeks to advance water efficiency, its financial obligations are likely to require more expansive funding for these technological innovations.

67 Meeting revenue requirements in an increasing-cost industry requires a dynamic design for rate structures. Otherwise, revenue flows will poorly match even prudently incurred costs. Water utility managers can learn lessons from ratemaking methods used in other utility sectors. Several cost adjustment and revenue-adjustment methods can and have been modified for use by water agencies. Adoption of these methods, however, requires understanding and acceptance by utility managers, regulators, and consumers

68 Mitchell, D.L., T.W. Chesnutt, J.A. Beecher, D.M. Pekelney, M. Dickenson, *Transforming Water: Water Efficiency as Stimulus and Long-Term Investment*, A White Paper for the Alliance for Water Efficiency, December 2008.

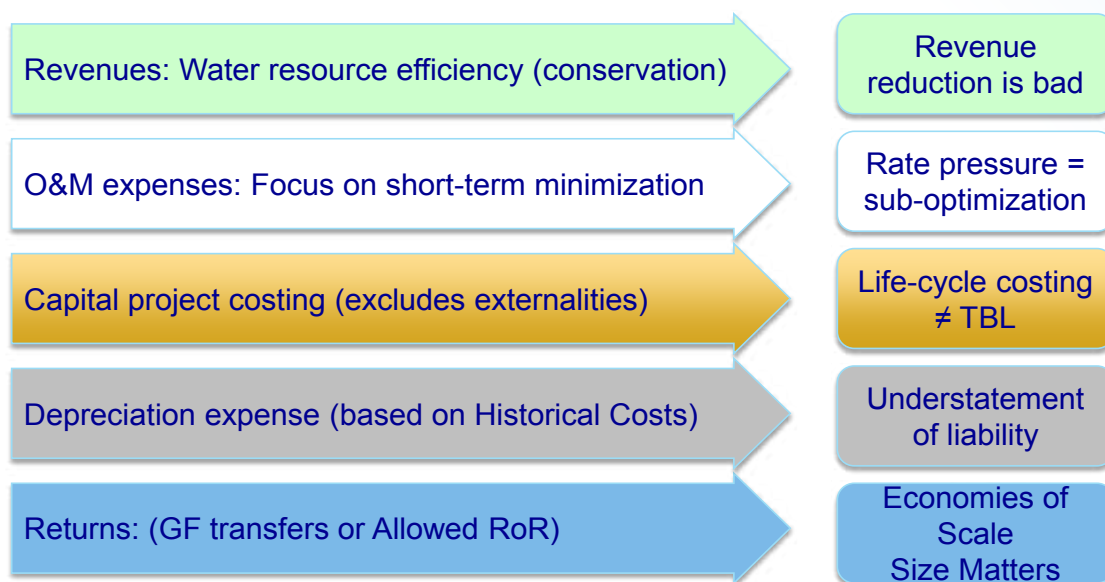
69 Rothstein and Galardi, (2012) *Financing Water Utilities' Sustainability Initiatives: Challenging Institutionalized Governance and Market Failures*, AWWA Sustainable Water Management Conference.

Public Engagement

Public engagement is often a necessary ingredient in creating support for innovative sustainable solutions and adoption of non-traditional approaches to financial and resource management. For water utilities to gain support for future water rate increases and funding of technological innovation, they must communicate effectively to build understanding. Utilities may find value in improved public engagement that focuses on transparency, trust and open exchanges to create understanding and consensus.

Financial Incentives

The financial incentives facing a water utility do not always align with the goals of water efficiency and sustainability. **Figure 14** summarizes five dimensions where traditional approaches to financial management impose effective financial disincentives to water use efficiency or effectively compromise long-term, financial sustainability.



Source: Rothstein and Galardi, 2012

Figure 14 — Financial Disincentives for Sustainability

ONE STATE'S EXAMPLE

**Policy Changes in Rhode Island Address Infrastructure Funding Needs Unmet by the Existing Rate Structure**

Rhode Island's approach to defining statewide norms for water infrastructure replacement shows how a state can lead an effort to change incentives. The state adopted a program more than a decade ago in response to trouble experienced by water utilities in financing needed water infrastructure. Its infrastructure replacement act required all of the state's water utilities to establish a replacement account and update it every 5 years. The utilities must evaluate value of assets in terms of replacement cost and fund an amount equal to that value through rates passed on to customers. These funds can only be used for infrastructure replacement, not extensions or upgrades. The initiative is widely considered to be successful. Utilities have money for replacement without having the funds diverted for unauthorized purposes.

Institutional Structures

Alternative institutional structures and responsibilities can also produce efficient solutions to new and changing definitions of water service requirements. **Table 3** shows five primary structural dimensions for water systems. Any given water system will exhibit a combination of often-interrelated characteristics that can change over time. For example, many small water systems are privately owned and subject to economic regulation, while many larger systems are publicly owned and subject to oversight by municipal departments or governing boards. Understanding structure, institutional context, and associated incentives helps in the design and implementation of water efficiency policies, even in the context of complementary or conflicting factors.

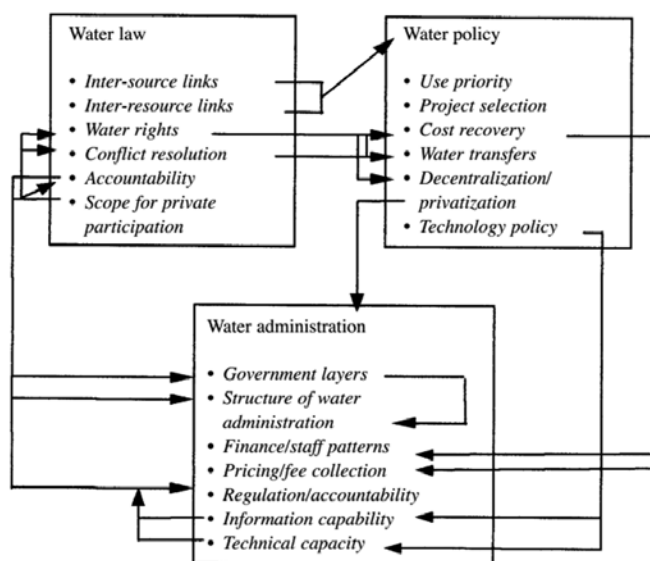
Table 3 - Water System Structural Dimensions

	PRIMARY CATEGORIES	SECONDARY CATEGORIES
Scale	Very small	
	Small	
	Medium	
	Large	
	Very large	
Scope	Retail utility	Purchased water distribution system
		Water supply and distribution
		Water and wastewater utility
	Wholesale utility	
Ownership	Privately owned utility	Single owner company
		Multi-system utility
		Multi-utility holding company
	Nonprofit utility	Nonprofit corporation
		Homeowners association
		Cooperative
	Publicly owned utility	Public authorities and districts
		State and county systems
		Municipal and other governmental systems
	Publicly owned and privately managed	
Oversight	Local economic regulation	Nonprofit boards
		Municipal department
		Independent local governing board
	State economic regulation	Regulated privately system
		Regulated nonprofit system
		Regulated privately owned system
Rights	Riparian	
	Permitting	
	Prior allocation	

Source: Beecher (2012), Chapter 3 of *A Balanced Approach to Water Conservation in Utility Planning WRF 4395*

Institutional structures reflect broader social constructs. As a result, it is important to examine the institutional context in which water systems operate. In addition to organizational governance, for example, policies and laws also shape the water industry. Further, in light of the large number of water utilities in North America, it is clearly uneconomic for them all to promote water use efficiency and environmental sustainability. To advance these water efficiency and sustainability goals, therefore, it will be important to establish incentives for organizational consolidation and building institutional foundations that serve the end of establishing more holistic approaches to water resource management, including watershed-based planning. Similarly, in an effort to make a shift from traditional approaches to financial management that incentivizes water resource efficiency, utilities may need to consider revising their charters and organizing principles to address the valuation of non-monetary impacts of resource use, such as Triple Bottom Line assessments of capital projects, to provide better assurance of long-term fiscal sustainability in an uncertain and dynamic environment.

Figure 15 summarizes a structure for understanding water governance that was put forth by Saleth and Dinar in 2004.⁷⁰ The structure shows the interplay of water law, water policy, and water organizations. Bringing about more efficient and sustainable solutions to water problems often requires reconfiguring these boxes and their inter-connections.



Source: Saleth and Dinar (2004)

Figure 15 — Water Governance Structure

70 Beecher (2013) "Beyond Public v. Private: The Relevance of Institutions to Utility Performance," working paper submitted to *International Review of Applied Economics* (Special Issue on Public Enterprise, Privatization, and the Quality of Institutions).

Chapter 5



Implementing an Efficiency-Oriented Rate Structure

Designing a rate structure that will help achieve a utility's objectives for resource efficiency and fiscal sustainability will be of little use if it cannot be implemented successfully and does not achieve the desired response from customers. The strategy for implementation plays a vital role in determining how successfully rates achieve their objectives. Indeed, implementation is at least as important as efforts to design and evaluate rates. Since rate changes must be approved by internal and external stakeholder groups, effective public engagement will help build support for the effort. Even a multi-year effort to create a new rate structure can be undone overnight if it is not administered and communicated effectively to customers, elected officials, community groups, and civic leaders.

While strategies for “getting to yes” on a new rate structure have long been considered, the relationship between utilities and customers is evolving, especially as water systems face new challenges related to weather volatility, economic drivers, and changes in customer use, each of which affect long-term supply sustainability and fiscal health.

This challenge is compounded by the reality that customers and the broader community rarely appreciate or fully understand the services that water utilities provide and the many costs and investments required to deliver that service. Tap water in the United States has a long history of being readily available and inexpensive, especially compared to other services. Few Americans grasp the true cost of water and its value to society. Likewise, most Americans do not know where their water comes from: a 2011 Nature Conservancy survey revealed that 77% of Americans surveyed could not accurately identify the natural source of the water used in their homes.⁷¹ Utilities have also struggled to effectively communicate the critical need for a reliable supply of safe, affordable drinking water for today and for generations to come. With pipes buried underground and treatment plants far from view, water infrastructure and resource challenges have largely been “out of sight, out of mind,” from the consumer’s perspective.

71 The Nature Conservancy, 2011 (<http://www.nature.org/newsfeatures/pressreleases/more-than-three-quarters-of-americans-dont-know-where-their-water-comes-from.xml>)

As the cost of water continues to rise and rates need more frequent reviews to adapt to changing environments, this relationship between water providers and customers is evolving. Utilities must work to establish a more open, clear and collaborative dialogue with customers and to build trust and clarity where there has long been confusion and silence.

Regardless of the particular rate structure adopted, successful implementation relies on a deliberate and thoughtful effort that should begin well before a rate structure appears before decision-makers for approval. A successful implementation strategy typically includes the following components:

1. A United Front: Internal Support and Collaboration

Building a united front involves fostering internal support for the rate structure among utility managers with diverse and sometimes competing interests, such as financial managers and resource managers. Various utility departments, such as Customer Service, IT, Billing, Finance, and Conservation, should be involved in the rate development and implementation process, and they should each have enough stake in the game to be invested in the effort.

2. Getting to “Yes”: Institutional Approval

Oversight agencies, including boards of directors, utility regulators, and the courts, all need to approve a rate structure. These groups all need special attention.

3. The Public as Partners: External Participation and Support

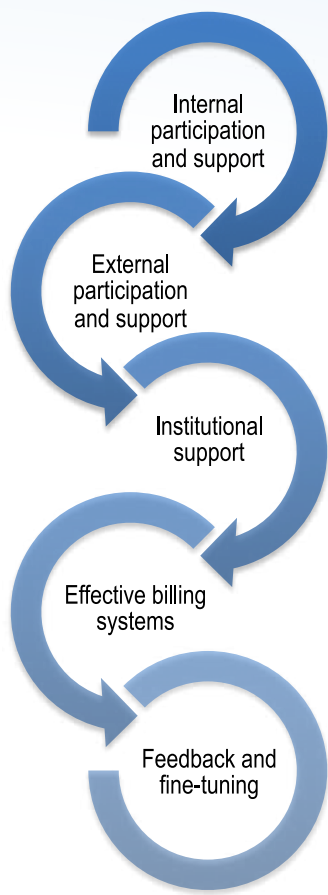
It is essential to build external support for the rate structure among a diverse group of customer stakeholders — residential, industrial and commercial — elected officials, and community groups, such as ratepayer advocacy groups and environmental groups. As water challenges evolve, utilities should consider a participatory role for the public in rate setting and implementation.

4. Clear Signals and Empowered Customers: Effective Billing Systems

Effective billing practices, knowledge, and a sense of empowerment convey important signals to customers and help them make informed decisions about water use.

5. Maintaining Dialogue: Feedback and Fine-tuning

Implementation will be a dynamic process. Utilities should be prepared to monitor responses to the rate structure and to incorporate this information into the evaluation and communications efforts.



The process is largely iterative and sequential, although the steps are also interactive. Challenges in one step may reset the process. Although implementation strategies are critical for any change in rates or rate design, some unique challenges arise when efficiency and conservation goals are attached to the ratemaking process. In particular, many managers today must navigate the complex convergence of rising rate levels and falling water usage. In effect, they must ask customers to pay more for water while using less. As a result, it is essential for managers to communicate the potential value of efficiency in terms of avoiding operating costs, such as energy and chemicals, in the short run, and capital cost, such as infrastructure, in the long run.

Designing and implementing an efficiency-oriented rate is challenging and complex. Utility staff may not have the necessary expertise or resources. Fortunately, new tools such as the AWE Sales Forecasting and Rate Model can help utilities apply more sophisticated techniques, not only for establishing effective rates, but also for developing data and strategies to better engage the public.

Some utilities may find it cost-effective to seek professional assistance for help in certain areas, such as financial analysis, risk evaluation, legal assessment, survey research and public relations, or stakeholder engagement. Utilities should take care to specify clear performance requirements and oversight processes.

Figure 12 — An Iterative Process for Implementing a Change in Rates or Rate Design

A United Front: Internal Participation and Support

Successfully implementing an efficiency-oriented rate structure requires agreement and collaboration among utility managers from across the organization. These managers must first reach a common understanding of pricing objectives and guiding principles; agreement on a specific rate structure comes later. In the implementation phase, a new rate structure may face unnecessary obstacles if utility staff do not fully support the effort or are not adequately prepared to defend it.

Many utilities have a fragmented division of authority and responsibility, which must be overcome for successful rate structure implementation. For example, the effort could become derailed if the billing department is unprepared or unwilling to make improvements to the billing process or a customer service staff does not fully understand the objectives and importance of a new rate structure, and cannot respond effectively to customer concerns.

Likewise, internal support for the new rate structure itself may be mixed. Advocates of efficiency-oriented rates may face resistance from managers and departments who are primarily concerned with revenue stability. A negative response from a single utility manager can undermine an effort to implement a rate change.

Integrated Planning

Integrated resource planning emphasizes the need to integrate water utility planning functions. Integrated planning will improve information sharing and help build a common understanding of utility goals and needs. Many of the analytical tools associated with integrated resource planning, such as scenario analyses, will prove useful in the processes of designing and implementing rates.

The rate design team should consider all of the departments that could be involved with implementing a new rate structure and engage them early in the process. Even staff members who are not typically involved in rate setting can provide important input on potential pitfalls and opportunities for improvement. Engaging teams and departments in a collaborative way will help them to be more invested in the success and create a sense of shared purpose.

Utility functions that might be involved include:

- Conservation and Resource Planning
- Information Technology
- Customer Service
- Billing
- Communications/Marketing
- Public Affairs

Wastewater managers represent another stakeholder group who should be engaged early in the process. After all, efficiency-oriented rates and efficiency programs are implemented to achieve goals related to benefit of reduced water usage, and reduced indoor water usage also results in reduced flows to wastewater treatment facilities. These reductions may or may not be beneficial to the wastewater operations. In areas where wastewater treatment capacity is constrained, reductions in wastewater flows may be one reason to pursue water use efficiency (even though the concentration of the waste will increase). In addition, reductions in water use can also affect wastewater revenues and finances depending on the design of wastewater prices. By working together, managers from water and wastewater utilities can plan jointly for optimal service levels and prepare for adjustments in prices and usage. After all, it is in the best interest of both service providers to price these services efficiently, optimize capacities, and avoid costly capital investments.

Securing Manager Approval

Presenting an efficiency-oriented rate design to senior managers and securing their approval is a vital step in building internal support for successful implementation. Solid backing from leadership can help facilitate engagement with critical external stakeholders, such as elected officials, and is necessary to address utility-wide concerns and build internal consensus for the pricing structure. Making the internal case for a new pricing strategy involves three basic components:

1. **Anticipate the concerns of various managers.** Ideally, managers will be surveyed at the outset of a rate setting process so their thoughts have been articulated and considered. Revenue stability and impacts on capital investment planning tend to be their paramount concerns.

2. **Present the rate revision in an open, clear and digestible manner.** In executive briefings to senior managers, include visual elements to explain key messages, such as summary tables and graphs. Emphasize critical issues and findings, and provide supporting data and analysis as needed.
3. **Inform modifications to the rate and plans for its implementation with the help of senior management.** Present managers with alternatives and provide ample opportunity for them to explore the rate options in depth.

The information presented to managers must be comprehensive, including both advantages and disadvantages of the proposed change, as well as expected outcomes for diverse scenarios. Managers must be comfortable with the risks and uncertainties associated with pricing changes. Communicate information to the managers on variables that will be affected by a change in rates, as well as the embedded uncertainties in those changes. Include worst-case and best-case scenarios, as well as the probability of their occurrence.

Fortunately, there are increasingly more tools and strategies available to help quantify and analyze the uncertainties that could affect the success of a rate structure. The goal is to help managers agree on realistic goals and devise adaptive strategies.

Revenue sufficiency and stability are key areas of concern to many utility managers and oversight boards. Financial integrity and sustainability are necessary to providing ongoing service. Rising infrastructure and resource costs put considerable pressure on utility revenue requirements, while water usage is generally falling. Public water supply and distribution is a capital-intensive industry, meaning that it requires a high level of infrastructure investment to provide service. The system's fixed costs must be covered regardless of fluctuations in water use and sales.

Revenue shortfalls will also be a concern because of the need to maintain market competitiveness when issuing debt. Utilities that issue revenue bonds are subject to certain coverage requirements to ensure against default. From a financing perspective, higher rates to customers may be needed to ensure credit quality and thus lower debt costs. From an operational perspective, revenue shortfalls can delay system maintenance and repair necessary for economic asset management. Inadequate revenues can degrade a utility's organizational capacity for providing service, which can also add to the long-term cost of service. The AWE Sales Forecasting and Rate Model provides opportunities to simulate the effects of various rate structures in diverse circumstances and understand the potential impact on revenue.

As a result of these concerns, effective communications about the value of efficiency-oriented rates is critical. Communications to managers and the public should explain the relationship between rates, revenues and service quality, as well as the mechanisms proposed for reducing revenue instability. Particular emphasis should be placed on how efficiency can help water systems and their customers avoid variable costs in the short term and both variable and fixed costs in the long term. And as economists say, in the long run all costs are variable (and thus potentially avoidable).

Utility managers with different interests will ask tough questions. These questions provide essential checks and balances that ensure a rate structure will achieve its objectives and that it can be successfully implemented. In some instances, the rate design team may have to “go back to the drawing board” to address managerial concerns. The additional time devoted to resolving these issues will be time well spent because it will strengthen the utility’s ability to respond to the concerns of various audiences. A unified management will provide for a smoother approval process as well as a more effective implementation process.

A CHECKLIST FOR PRESENTING A RATE PLAN TO EXECUTIVES

Managers should consider including the following in their internal briefing package:

- A statement of objectives associated with efficiency-oriented pricing.
- A discussion of how pricing fits within resource and asset management strategies.
- Detailed demand forecasts by major customer classes.
- Estimates of price elasticity of demand by customer class.
- Revenue forecasts under alternative water-use scenarios.
- An assessment of impacts on water and wastewater finances and operations.
- An analysis of risks and uncertainties and proposed mitigation methods.
- An assessment of related public policy, regulatory, and legal issues.
- An overview of proposed changes to metering and billing practices.
- An implementation plan including timetables.

TOUGH QUESTIONS EXECUTIVES ASK

Good water utility executives will ask tough questions, such as:

- Why is the rate change needed — and why now?
- Is resource conservation really a social issue rather than a water utility issue?
- Does promoting efficiency undermine our fundamental business model?
- How will our utility’s revenues and financial health be affected?
- How will our asset management and improvement programs be affected?
- Will the savings justify the administrative expense associated with changing rates?
- How will customers react to the change in rates or rate structure?
- Should large-volume customers with favorable load factors get favorable rates?
- Will reductions in usage simply lead to further rate increases?
- What will happen if projected savings are not realized?

Getting to Yes: Institutional Support

Water utilities and their managers are typically accountable to at least one oversight body, such as a Board of Directors, a city council, a county commission, or a state public utility commission. These bodies legitimize the utility's planning, financial, and ratemaking choices in the eyes of the public. Approval from these bodies marks the first step towards successful implementation of a change in rates or rate structure.

Elected officials may be reluctant to approve rate increases, primarily due to potential opposition from their constituents. They will have specific priorities and concerns that utility managers should consider, including the impact on customers' bills, the affordability of a new rate structure, and how a rate structure will be administered. Utilities should be sure to address these specific issues throughout the engagement with officials.

Engaging the Decision Makers

Engaging the Board at the outset of the rate setting process is recommended whenever possible. Participatory models for developing rates establish a shared understanding, as well as a degree of consensus for the plan going forward. Understanding their priorities and concerns upfront will also help utility managers address these issues in both rate design and presentation.

Securing approval of rates may require public hearings. Utilities must be prepared to justify their recommendations to policymakers with a thorough analysis of the alternatives considered. Technical information must be reduced to an amount that those with limited knowledge of the industry can easily absorb.

Public hearings may be more or less formal. Town hall meetings and public workshops might be permitted in advance of more formal processes. In some jurisdictions, utility representatives might be allowed to meet privately with two or three board members at a time to answer questions.

Bringing Officials on Board

Utility managers must convince Boards and other regulatory entities that the proposed rate plan is necessary and appropriate. Understanding specific concerns before presentation for approval is ideal, but below are a few topics for managers to emphasize and prepare for to increase likelihood of a smooth approval.

- Demonstrate a real need for change to achieve utility objectives, such as increased revenue stability, more efficient use of resources, or others.
- Articulate the value of pricing as an option to meet that need, and pricing's role within the utility's overall resource and asset management strategy.
- Provide context through comparison and precedence. Communicate how the system compares with neighbors in the region in terms of policies, practices, and perception. Be prepared to compare and contrast the proposed rate structure with other efficiency-oriented rate structures and to demonstrate how it embodies prevailing principles and practices.
- Be clear, concise, and visual. Most policymakers have limited technical understanding of utility finances. Simple messages and visuals such as graphs can help them more quickly understand the issue and the solution.

- Clearly explain the impacts on customers. Clearly address administrative issues, such as metering and billing changes. Policymakers may want assurances about how the utility plans to mitigate adverse effects on operations or customers.
- Emphasize the investment in efficiency. A rate structure should be frequently reviewed, evaluated, and updated to be effective and to produce long-term savings. A long-term monitoring and reporting plan will assure policymakers that the utility will evaluate the effectiveness of the rate in meeting goals and address unintended consequences.

Defending the Rate

The risk of litigation should not be overstated or understated, but utilities should understand the risk of litigation and be prepared to defend the proposed rate structure in a court of law. Affected parties are entitled to express their grievances regarding a rate structure through appropriate legal channels. When the need for rate change is well supported, utilities should not use the possibility of litigation as an excuse to avoid rate reform. At the same time, the utility should not design a rate that poses unnecessary legal risks. Rate structures that conflict with other policies or depart substantially from accepted principles and practices will be more vulnerable to legal challenge.

Litigation is costly, both directly and in terms of the opportunity costs associated with postponing implementation of proposed rate. Should a dispute arise, utilities may want to explore alternative dispute resolution processes to resolve the dispute more efficiently than through a protracted legal proceeding. For some utilities, regulatory agencies provide a quasi-judicial means of review and approval as well as dispute resolution.

CITY OF DAVIS, CALIFORNIA ADOPTS INNOVATIVE CONSUMPTION-BASED FIXED CHARGE RATE STRUCTURE; RATE STRUCTURE REPEALED BY VOTERS



On March 29, 2013 the City of Davis City Council in California adopted Ordinance No. 2405 which authorized water rate increases over a five year period, and changed the way rates were to be calculated. The new rates were intended to cover the costs of the Davis Woodland Water Supply Project, which is expected to provide 12 MGD to meet future needs.⁷²

The City of Davis consumption-based rate structure would have been the first of its kind. It was designed to bill customers proportionally for their “share” of the utility infrastructure, and to provide an incentive for efficiency.⁷³ The structure uses customer peak season demand data to determine a percentage share of the utility’s total fixed costs for each account, which was termed a “supply charge.” Customers are billed in the subsequent year based on this percentage. A bill would also include a uniform variable charge and a distribution charge. These components were calculated as follows:

- **Distribution Charge:** Based on size of water meter, was expected to be ~13% of an average monthly water bill.
- **Variable Charge:** Uniform rate for all classes, was expected to be ~20% of an average monthly water bill.

Continued on next page

⁷² City of Davis. (Accessed July 2014). The Davis Woodland Water Supply Project.

⁷³ Loge, Frank. (July 2013). UC Davis Center for Water-Energy Efficiency Policy Brief: Consumption-based fixed water rates: a novel conservation-oriented rate structure.

- **Supply Charge:** “The supply charge fee is calculated by using the projected annual revenue requirement related to water supply and treatment and dividing it by the total projected 6-month peak period (May through October) water use of the Water Utility to produce a per ccf rate. The individual fee per customer is then calculated by taking the per ccf rate and multiplying it by the individual customer’s prior year’s 6-month peak period water use. Each year, this CBF amount is recalculated based on an individual’s actual water use during the prior 6-month May through October peak consumption period.” Was expected to be ~67% of an average monthly water bill.

Ultimately the new rates were repealed by voters during a general municipal and special election in June 2014. Citizens voted 7,058 (yes) to 6,771 (no) to the question, “Shall an initiative ordinance repealing Ordinance No. 2405, which adopted increased water rates, and putting water rates in effect prior to May 1, 2013 back into effect, be adopted?”⁷⁴. Passage effectively reinstated the water rates established by 2010’s Ordinance No. 2364.

Those opposed to the new water rates argued that they were unfair to single-family home owners.

“With CBF, the cost per gallon of water is largely determined by summer water use. This shifts the costs to single-family residents who must irrigate to keep trees healthy and keep Davis green. Maintaining a healthy tree canopy and other urban greenery also removes large amounts of carbon dioxide from the atmosphere.”⁷⁵

Those in favor of the new rates argued that the innovative rate structure promoted fairness.

“Everyone pays their fair share, both for the water they use, and for the system that brings it to them. The new system promotes fairness for those who don’t use much water—often seniors, low-income residents, and those in apartments or with small lots. In Davis, approximately two-thirds of residential ratepayers will pay less under the new rate structure than they would have under a rate structure like the one we used to have. The approved rates create strong incentives for conservation, without penalizing you with rate hikes when you conserve.”⁷⁶

Helping Officials Hold the Line

Board engagement does not end once the rate structure is approved. Elected officials have a critical role to play once implementation begins and customers are presented with a higher bill or are confused by new billing structures. If caught off guard by an onslaught of unhappy voters, they may question their decision and even push to repeal it to keep voters satisfied.

Boards must be equipped to respond to customer concerns, questions, and complaints, help the utility hold the line, and support continued education of customers. Utility managers should arm policymakers and officials with the same messages and materials provided to utility customer service staff, and they should provide a specific utility representative to escalate constituent complaints to if needed. Utilities may also want to invest time in preparing Board members for an influx of inquiries and briefing them on how to address a diverse set of questions.

74 City of Davis, California. (June 24, 2014). Resolution of the City Council of the City of Davis Declaring the Results of and Such Other Matters as Provided by Law for the General Municipal and Special Election Held on June 3, 2014

75 City of Davis, California. (Accessed July 2014). Measure P — Argument in Favor.

76 City of Davis, California. (Accessed July 2014). Measure P - Argument Against. <http://city-managers-office.cityofdavis.org/Media/Default/Documents/PDF/CMO/City-Clerk/Election/2014jun/Measure-P---Argument-Against.pdf>

TOUGH QUESTIONS POLICYMAKERS ASK**Members of Boards, Councils, and Regulatory Commissions can ask especially tough questions:**

- Will the new rate cover the utility's revenue requirements?
- Will the new rate structure cause revenue instability or raise financing costs?
- What will the utility do with excess revenues if requirements are exceeded?
- Will conserving water customers be punished or rewarded?
- How will low-income and fixed-income customers be affected by the rate?
- What pricing or other changes would be needed during an emergency or drought?
- How were stakeholders involved in the development of the rate and are they supportive?
- Is the rate structure consistent with prevailing principles and practices?
- How does the rate fit within the utility's overall efficiency strategy?
- What alternatives for promoting efficiency were considered?

The Public as Partners: External Participation and Support

However sound the technical analysis behind a proposed change in rates, successful implementation will depend on external support. Utility managers must agree on when and how to involve the public in the development, implementation, and evaluation of the rate structure. An open and participatory process can serve an educational purpose while also providing customers with opportunities to express their preferences.

Managers will find that maintaining open channels of communication will be a very useful part of the ongoing implementation process and beneficial to future changes and decisions that must be made. A community that feels responsible for the stewardship of its water resources and has an opportunity to shape the management of those resources is more likely to be receptive to and supportive of difficult decisions.

Involving the Public

The value of public participation in formulating policies has become increasingly important. Involving customers and other stakeholders in the initial stages of rate revisions conveys the message that customer concerns will be taken seriously and builds customer support for ratemaking goals and initiatives that benefit the community. Involving the public on a continuing basis can facilitate conflict resolution and may reduce the likelihood of vocal opposition, including litigation. Perhaps most importantly, involving customers in ratemaking can help assure that effective price signals will be sent and received from the customers' point of view.

Throughout the process of public engagement, building good relationships with stakeholders should be an ongoing priority for the water utility. Good and open relationships will provide a foundation for a productive discussion among stakeholders about shared responsibility for efficient water use and the role of rates toward that end.

The utility will need to host an appropriate number of forums to allow for meaningful stakeholder involvement. In any type of forum, it is important to understand and respect all parties and their various interests. It is equally important not to underestimate their constituency and their level of interest and engagement. A well-engaged group of stakeholders can be beneficial to the process both procedurally and substantively. If the utility forms an advisory committee or task force, members should be invited to play a prominent role in making presentations to and engaging with the public at large.

Knowing the Audience

Expanding public involvement requires managers to decide who will participate and how participation will be accomplished. Although utilities may be tempted to include only familiar and supportive faces, a legitimate public involvement process requires inclusion of diverse interests. Utilities should expand engagement beyond just customers to community groups and leaders that can help build support for a rate change by championing the utility, or that could present a challenge to implementation if they misunderstand utility objectives. Where appropriate, the following parties should be represented:

- Residential customers
- Commercial customers
- Industrial customers
- Wholesale customers
- Consumer advocates
- Community leaders
- Chambers of commerce
- Environmental groups
- Local planning and economic development agencies
- Local legislative representatives
- Media outlets
- Other local stakeholders

Because each group represents diverse interests and priorities, the engagement of each group requires a tailored approach and messaging that communicates the information in a way that resonates.

In cataloging and defining strategies to engage each audience, utilities may also want to pay special attention to two key customer groups in both the participatory process and communications efforts:

1. **Large volume users**
2. **Low-income users**

Large-volume customers can be particularly sensitive to changes in utility prices. Changes in prices will induce bigger changes in industrial water use than typically are seen in the residential sector. Because water costs are a direct cost of production, industrial managers have strong incentives to control, reduce, or avoid these costs.

Although relatively rare, rising rates may lead large users to bypass the utility through self-supply (particularly if they do not require treated water). Industrial water users may even relocate to another service area with more favorable conditions. Most water providers do not want to lose valued large-volume customers who exhibit favorable load factors and contribute substantially to revenues. The impact on the utility and its remaining customers may or may not be detrimental depending on resource needs, capacity, and costs. In some cases, the loss of industrial load can burden remaining customers who must cover the utility's fixed costs.

Therefore, partnerships between water utilities and large-volume users can be mutually beneficial while also serving broader community goals. Working closely with large-volume customers will ensure that water managers will be better able to incorporate this response into planning. Utilities should discuss proposed rate changes and potential consequences in a timely fashion with the appropriate stakeholders and offer support as needed. Here are several strategies for engaging this group:

- If possible, work directly with customers on a one-on-one basis to help them prepare for rate increases.
- For larger groups, consider workshops to explain the rate changes and offer support.
- Offer water audits and technical assistance to help them implement efficiency measures and mitigate the effects of a rate increase.

The increased efficiency achieved in the residential sector over the last several decades has not been fully realized in the commercial and industrial sectors. Efficiency has typically had limited uptake by these groups because the return on investment for efficiency measures is generally insufficient given that the low cost of water compared to other expenses means the payback period is too long to make the savings worthwhile. Combined with the lack of high quality marketing and sustained assistance, these opportunities fall to the bottom of the list when compared to other initiatives customers are considering.

A rate change or increase is a prime opportunity to engage these users around the benefits of efficiency — including not only water savings that impact their bottom line, but also the opportunity to demonstrate their commitment to sustainability to customers, partners and utilities, and the community at large. According to the 2012 Edelman goodpurpose® study, 87% of global consumers believe that businesses need to place at least equal weight on society's interests as they do on business interests, and 53% assert that when quality and price are equal, social purpose ranks as most important when selecting a brand, a 26% percent increase since 2010.⁷⁷

In the long term, all customers, including large-volume customers, benefit from efficiency gains and more reliable supplies in the communities in which they operate. A rate increase is a timely opportunity to educate large-volume customers and help them embrace their role as citizens of the community who are responsible for contributing to resource protection.

77 Edelman goodpurpose Study, 2012 (<http://www.scribd.com/doc/90411623/Executive-Summary-2012-Edelman-goodpurpose%C2%AE-Study>)

Low-income customers are adversely affected by rising rates because household utility costs are regressive, meaning that they take a proportionally greater amount from those with lower incomes. The movement toward more efficiency-oriented rate levels and structures may add to the upward pressure on utility bills for low-income and some fixed-income customers, causing concern among consumer advocates. In both the rate design and implementation stages, utilities must be aware of the demographic characteristics of the community they serve and anticipate the consequences of a change in rates for various groups.

The affordability of water service and the challenge of providing universal service are legitimate public policy concerns that must be addressed by rate makers. There are several strategies available that can help utilities meet the needs of these groups and gain critical support for rate changes:

- **Rate Structure Design:** The rate for a basic first block of water service can be designed to meet the needs of many customers. “Lifeline rates” that provide a lower rate for the first block of water have parallels to efficiency-oriented rates. However, some lifeline rates price the first block below the marginal cost of service, which can run contrary to efficiency goals. When water is underpriced (or free), the consumer has far less incentive to conserve. However, most of the efficiency gains from pricing come from the price signals associated with more discretionary usage found in the higher “tail” blocks.
- **Non-Pricing Mechanisms:** Because of potential distortion of price signals and the social nature of the problem, many utilities prefer to address affordability through other subsidy and assistance programs rather than through rate structures. In addition to governmental programs that may be available, some utilities have established voluntary programs to help low-income customers. Utility efficiency programs might also be targeted to the needs of low-income customers. Retrofit, rebate, and plumbing assistance programs can be especially effective in helping low-income customers replace old and inefficient water-use fixtures and repair costly leaks.

Addressing the needs of low-income customers from the outset and through proactive communications will help keep customers connected to a vital service and help address some of their concerns. Moreover, a clear commitment from the utility to ensure affordable service and adopt targeted water use efficiency programs can help promote customers’ bill-payment behavior and foster good will toward the utility.

Choosing a Model

The following models — presented in an increasing order of formality — provide approaches for public involvement that reflect various styles of participation. Their suitability depends on the community.

- **Direct Dialogue Forums** (or Town Meetings) provide a very open, informal, and participatory venue for expressing values and preferences. Town meetings are used in governmental decision-making (such as in New England). They are also used in political campaigns, which in many ways are similar to the process of winning political support for a change in rates. These venues can be useful in building customer relationships as well as support for water resource and infrastructure management strategies.

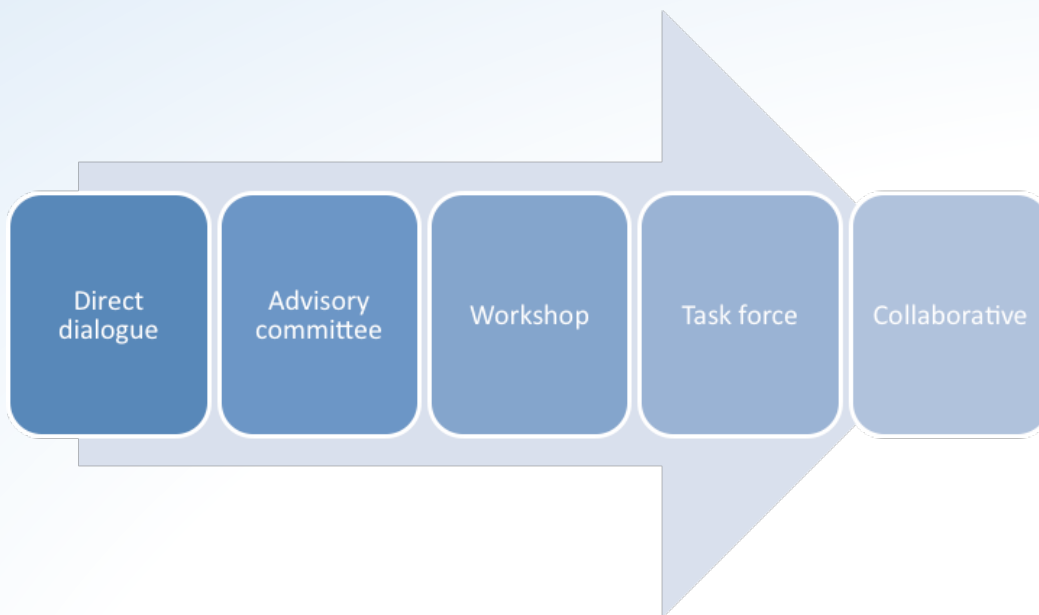


Figure 13 — Public Involvement Models

- **Advisory Committees** allow representatives of a wide range of community stakeholders to provide recommendations to the utility and provide a more structured format for public involvement than Town Meetings. An advisory committee that is representative of the community can be a useful channel for listening and understanding for both the utility and its customers. Utilities in various sectors have found this model useful to collect input and build credibility among customers and stakeholders. Utilities might consider letting citizens volunteer for the committee, perhaps even recruiting potential opponents of the rate change.
- **Workshops** provide an open, participatory, and informal yet structured process for generating and exchanging ideas and information. The format can be general or highly focused on specific issues and concerns related to the rate changes. Workshops can include an educational focus if built around specific topics while also providing an opportunity to gather input.
- **Task Forces** are more formalized and exclusive. Members recommend strategies for addressing specific goals or problems. Task forces should represent a valid cross section of affected interests. The water utility or an outside entity can serve as the organizing and integrating agent for the group. A process must be established for reaching consensus and processing recommendations.
- **Collaboratives** are formalized advisory groups charged with a specific purpose related to policy or oversight, sometimes with a mandate from a regulatory utility. Collaboratives have been used in the energy sector to promote specific means of demand-side management. Much consideration must be given to the membership of collaboratives, as well as the rules of engagement and strategies for implementing recommendations.

Involving the community in the development and implementation of rate structures is in itself a public engagement endeavor, and it must be treated as such. Beginning a formal dialogue with the public is not without costs, risks, and a significant investment of time and resources. Identifying interested and affected parties who also are willing to participate actively can be challenging. A good

deal of time is required of key staff to support and coordinate group activities. If the process itself becomes too complex or tedious to administer, its fundamental purpose may be lost. Stakeholders may have various levels of understanding of water resources planning and may require different types of educational information to help them contribute most effectively to the process. Reaching consensus among conflicting perspectives can be difficult, and even one individual can hold up progress toward an agreement. A failed participatory process can affect the utility's public image and force managers to engage in damage control even before a rate structure is introduced and implemented.

Fortunately, there are a number of strategies, methods and models available to water utility managers, and there are increasingly examples of successful efforts and best practices for soliciting meaningful public and stakeholder input in a way that builds trust between the utility and its customers. In most instances, the time and energy spent getting in touch with community concerns about ratemaking will be time and energy well spent.

Presenting the Rate Structure to the Public

Regardless of the model chosen, presenting a proposed rate to the public and stakeholders and receiving their input requires different preparation and a different approach than management briefings. Utility managers must be well prepared to communicate clearly with customers about utility ratemaking goals as well as respond to a wide array of questions and concerns that will surface during public forums.

- 1. Prepare for Tough Questions** — Utility managers should never underestimate the capacity of the public to ask tough questions. Inadequate preparation, insufficient analysis, or a poorly designed rate plan will be quickly identified and can create doubt about the utility's ability to be good stewards of community resources.
- 2. Keep it Simple** — The rate proposal should be presented in a straightforward manner with an appropriate level of detail. As a general rule, graphical presentations will facilitate understanding and dialogue more effectively than a set of detailed and complex schedules or calculations. The utility may also want to prepare a press release in advance of the public event to ensure media start with the correct information.
- 3. Bring Back-up** — Additional supportive material should be available, including handouts that concisely communicate the most essential information. Copies of presentation materials should be distributed to the group and made available on the utility's website.
- 4. Honesty Builds Trust** — Managers should be forthcoming about uncertainties in planning and ratemaking, and be honest about what is known and not known. The proposed rate change should not be undersold or oversold in terms of what it might accomplish. It is important to be sensitive about and ready to address questions about rate impacts on particular groups, including large-volume and low-income customers.

Managers also should be prepared to follow-up with members of the public who have special concerns. Perhaps most importantly, managers should be genuinely open to modifying their proposal based on stakeholder input to improve the plan as well as the implementation process.

CHECKLIST FOR PRESENTING A RATE PLAN TO STAKEHOLDERS

Managers should consider including the following in their external briefing package:

- Purpose of the proposed rate level and structure and anticipated benefits.
- Water supply and demand outlook under current conditions.
- The role of rates in meeting efficiency goals while preserving customer choice.
- An overview of current water system costs and revenues.
- The benefits of cost-based ratemaking to water systems and resources.
- The relationship of water rates to usage, system design, and revenue requirements.
- An overview of the cost analysis and rate development processes.
- A summary of present and proposed rates by customer class.
- The overall plan and key steps for implementing the change in rates.
- Sample water bills for customers with various usage profiles.
- Comparisons with what water rates would have been without conservation.

Communicating Effectively

Whether rolling out a new rate structure to an entire service area or bringing a rate proposal to an elected Board, being able to effectively getting the message across is just as important as undertaking the communications effort itself. Utility managers who know their target audience and adapt the message they deliver will be more successful. A few basic principles will help strengthen messaging and communications.

1. **Be Relevant** — Utilities should tailor communications and messages to the specific audience targeted. For example, customers are often concerned about affordability, efficient resource management, reliability of long-term service, and the impacts of rate increases on bills. Board members may be specifically interested in impacts on their constituents and comparison to other providers. Utilities should proactively identify and address these issues through tailored messaging. A message map that clearly identifies the relevant points and data for an audience can help keep communication on point and ensure it resonates.
2. **Be Authentic** — Transparency is critical to building trust among customers. A reputation for honesty, integrity, and service will help build positive relationships and loyalties on which the utility can draw as it navigates the challenges of ratemaking. It is also important to be open and comprehensive in communications and willing to discuss the details of challenges, options, and consequences. Although the topic matter may be complex, utilities should seek ways to offer clear explanations rather than assuming an issue is too complex for the customer or other stakeholders to grasp.
3. **Be Succinct** — In today's world of constant noise and information flows, a focused, concise and effective message is the only kind that resonates. Make messages count by distilling content to the key points and delivering in sound bites or short sentences that capture the essence of the idea.

4. **Be Responsive** — All water utilities benefit from maintaining a strong commitment of service toward their community and customers. The utility must be responsive to customer concerns in all aspects of the service relationship. Utilities should ensure multiple channels — from social media to email — are available for the customer to make contact and that customer service teams and other frontline staff are equipped to handle every inquiry.
5. **Be Consistent** — The majority of people need to hear a message three to five times before they absorb it.⁷⁸ Furthermore, customers tend to have a general distrust of water utilities, perhaps due to a historical lack of communication on the part of the utilities and a poor understanding of the service they provide. To help overcome this barrier, utilities must be prepared to deliver messages to customers repeatedly and to be consistent in their communications. Customer service representatives should be equipped to deliver consistent information, and upper management and elected officials should be delivering the same coordinated messages.
6. **Be Findable** — The public is bombarded daily with news from millions of brands and through every medium — from print to mobile. It is no longer enough to send a notice with the bill; utilities need to be present where customers are actively taking in content. Engaging customers through multiple channels will make information more accessible and increase the likelihood that customers encounter the message multiple times. Utility websites are prime locations to provide more detail on rate impacts and supply challenges through fact sheets, videos, FAQs, blogs, and more. Social media communities such as Facebook and Twitter allow utilities to both share information with customers and create a two-way dialogue that can build trust. The media can also be a key asset in reaching customers through digital media partnerships and editorial opportunities.

78 Edelman Trust Barometer, 2013 (<http://www.slideshare.net/EdelmanInsights/global-deck-2013-edelman-trust-barometer-16086761>)

WATER RESEARCH FOUNDATION PROJECT #4455: RATE APPROVAL PROCESS COMMUNICATION STRATEGY AND TOOLKIT



A forthcoming project from the Water Research Foundation aims to identify and develop communication strategies and specific messages that utilities can use to gain support during their rate approval process, and complement these communication strategies and messages with a set of scalable and ready-to-use products to support utilities and governing boards throughout this process. The Project will develop a messaging strategy and communication framework that builds trust and supports effective communications during the budget and rate approval process, including specific guidelines, processes, innovative products and ready-to-use communication tools that support the budget and rate approval process.

Utilities' leaders must effectively communicate with each other in order to coordinate and implement revenue enhancing strategies. There may be barriers that inhibit effective communication between utilities' decision makers stemming from differences in knowledge and perception; disparate political influences or differences in organizational responsibilities. During a rate setting proceeding, effective communication between a utility's operational staff and governing board is of vital importance. The goal of the Project is to develop a set of tools that will allow a water utility manager to effectively communicate with their governing bodies during the budget and rate approval process.

Project deliverables are targeted for completion in Spring 2015. Interested utilities should visit www.WaterRF.org for updates.

TOUGH QUESTIONS CUSTOMERS ASK

Utility customers will ask tough questions, such as:

- Why are water and sewer costs and prices going up and how will I be affected?
- Why should households use less water if rates keep going up anyhow?
- What is the purpose of conserving water when there is no drought?
- What is the utility doing to lower the cost of water and sewer service?
- Why are there different rates for different amounts of water use?
- How is the water utility paying for the extension of service to new customers?
- How can a large family or fixed income household afford water?
- Are local businesses being charged fairly for water service?
- Have the utility's costs or proposed rates been independently reviewed?
- Does the utility have the authority to raise the rates or change the structure?

Preparing the Utility's Front Line

The dialogue between utility customer service and the public is one of the most important communication efforts that happen during the initial implementation of a rate structure, and it extends indefinitely.

Utilities may overlook internal communications in planning for a rate structure, which can have disastrous results. Customer service representatives and others, such as engineers in the field who read meters, are the utility's front line of interaction with customers. The information they deliver to customers must be on-message, accurate, and above all, consistent to avoid confusion among customers.

Utilities should strategically plan for educating and training front line staff to explain the rate structure to customers, preparing the staff to assist customers with understanding the impact to the bill and to respond to a diverse set of inquiries. Invest ample time to ensure that customer service representatives understand the need for the rate change and support its implementation. Utilities might arm customer service with responses for anticipated questions, a fact sheet of bill impacts for different customer classes, and other resources to handle highly agitated customers. It may even be necessary to retool the customer service and public relations functions to ensure that efficiency and pricing goals are well understood and communicated by all utility representatives.

Customer service activity also provides a wealth of information to help evaluate the effectiveness of a rate structure over time. Utilities should consider conducting formal check-ins with customer service staff to gauge what topics are most misunderstood by customers and to understand where staff is inadequately prepared. That input can be incorporated into materials provided to staff, and used to evaluate where additional customer education might be needed.

COBB COUNTY, GEORGIA IMPLEMENTS EFFICIENCY-ORIENTED RATE STRUCTURE AND EDUCATES CUSTOMERS THROUGH STRATEGIC PUBLIC ENGAGEMENT EFFORT



In 2006, Cobb County Water System in Metro Atlanta received a directive from the Metropolitan North Georgia Water Planning District to implement conservation rates as part of a statewide water management plan. Up until that time, Cobb County's rate structure consisted of a flat volumetric water rate that did not escalate based on use, and a sewer credit, which entailed capping the sewer charges at 125% of average metered winter use and which was determined to be a disincentive to conservation. In response to the Planning District's directive, Cobb County proposed a three-tier increasing-block rate structure and wastewater billing equal to metered use.

This proposed rate change would result in a 300% increase in water bills for heavy irrigation customers. Anticipating strong opposition from its 175,000 customers, Cobb County assembled a core Rate Setting Team to develop and execute a robust public engagement effort that would support rollout and implementation. Cobb County's effort proved to be highly successful and has produced long-lasting benefits for the utility. The rollout strategy combined five tactics:

Consistent Messaging: Cobb County developed comprehensive, clear messaging for all audiences and kept the message consistent across all mediums, thus eliminating confusion and helping drive understanding through repetition.

Board Engagement and Reinforcement: The Rate Setting Team proactively engaged Board members and equipped them to respond to citizen complaints. The team also provided ongoing support after the rollout as complaints escalated.

Customer Service Strategy and Internal Collaboration: The water system engaged its entire organization to rally around the shift. Customer service and field staff were thoroughly trained and provided with resources such as FAQs and bill comparisons to help them respond to questions confidently, accurately and consistently. Throughout the rollout, the organization regularly solicited input on how to enhance the effort from these engaged staff members.

Working with the Media and Civic Groups: Cobb County proactively reached out to customers through civic groups and targeted influential community members who could direct public opinion. The county also adopted a collaborative approach to working with the media, which helped influence public debate and communicate the system's needs and perspective.

A Customer Response SWAT team: Two designated individuals handled escalated calls, where customers received a more nuanced but consistent message supported by a clear process for timely response.

This investment in communication continues to pay off nearly eight years later. Although customers continue to call inquiring about rates, the frequency of those calls is decreasing over time. As an added benefit, the Cobb County Water System's management believes that the effort changed the environment within the utility by creating a more collaborative relationship between staff and management. The issue of rates — the organization's source of funds now and for the future — touches all employees and provides an opportunity for the organization to come together around a common goal. For additional detail on this case study and sample resources, visit www.FinancingSustainableWater.org.

Clear Signals and Empowered Customers: Effective Billing Systems

As emphasized throughout this Handbook, water prices must be communicated clearly and effectively to customers to achieve utility goals. Price signals can be muffled or amplified by methods and content of communications. Customers need a clear signal to make informed choices about water consumption. The principal vehicle of communication is typically the customer's bill. Bills convey prices and amounts due, but they also can be used creatively to provide customers with information and tools for understanding their water usage, how they compare with their neighbors, and methods to reduce their consumption. For many water utilities, these improved billing practices can play a role in promoting efficiency.

Additional creative tools have recently been explored as a means to modify customer behavior, such as home water reports and digital dashboards.

Billing and Metering Cycles and Methods

Metering and billing practices will influence a utility's ability to achieve the desired benefits from pricing. An efficiency-oriented rate structure is most effective when customers are billed monthly because it provides early feedback about the impact of their usage on their water bill. Early and frequent feedback provides an opportunity for customers to make adjustments in consumption behavior. A seasonal rate, for example, may be less effective if the customer receives a quarterly bill after a three-month period of substantial water use.

More frequent billing typically requires more frequent meter reading, which presents administrative costs. Estimated billing is generally discouraged because it sends inaccurate signals to customers and undermines efficiency goals. More frequent billing is enabled by automatic and advanced metering systems that do not require manual reading. Furthermore, automatic meter reading presents numerous benefits that support and enhance efficiency objectives.

A "smart" water meter is a measuring device that has the ability to store and transmit consumption data frequently. Smart meters may also be referred to as "time-of-use" meters because in addition to measuring the volume consumed, they also record the date and time the consumption occurs. Smart meters can be read remotely and more frequently, providing instant access to water consumption information for both customers and water utilities.

The potential benefits of smart meters can be expanded through advanced metering infrastructure (AMI). AMI systems using "smart" water meters are capable of measuring, collecting, and analyzing water use information and then communicating this information back to the customer via the Internet. The information that is communicated might include real-time usage and pricing, leak and abnormal usage detection, targeted water efficiency messaging, changes in water use, and even remote service disconnects. More timely and clear information provided to the customer gives them greater responsibility for their water use and enables more individual control of efficiency improvements.

Separate versus Combined Billing

In some communities, customers receive a single bill combining charges for diverse services that might include energy, water, wastewater, stormwater management, and refuse collection. The combination of water and wastewater services on a single bill is common, even when they are provided by separate entities.

To some extent, combined bills may have the effect of magnifying price signals. Wastewater charges are typically a flat rate rather than a volumetric rate based on metered water, although wastewater charges may be applied to off-peak water-use levels to account for outdoor use that does not actually place demands on the wastewater system.

The price signal for water may be lost if water costs are not separated from other utility costs. Separate billing may provide a better price signal for individual services, but it can be administratively costly and an annoyance to customers who prefer the simplification of a consolidated bill. A less costly approach might be to redesign the bill to ensure that customers can interpret its separate components. Billing inserts also can help provide customers with tools for understanding their bill and its various parts. In reality, many customers do not read bill inserts, especially because of automatic payment processing, but an increasing number are finding information through utility websites and social media. Improved billing strategies may require improved coordination among the entities billing for different community services. Ideally, these unique entities will share the common goals of improved pricing and understandability.

Designing the Water Bill

A water bill must be able to deliver key information to a water customer, including:

- How much water did they use over a certain period of time?
- What is the rate charged per gallon or cubic foot?
- What is the total bill?

While it is important to avoid providing too much data that may overwhelm customers, the information provided must be comprehensive enough for customers to understand their usage and how their bill is determined. Ideally, the bill will include historical usage data so customers can track their usage and efficiency efforts over time.

There are many variations of the customer bill format to choose from today. Many water providers have traditionally used postcard billing, which saves administrative costs. Despite limited space, a well-designed postcard bill can effectively communicate vital information to customers. With envelope billing, inserts can provide additional information.

Electronic billing and bill payment are becoming more common as customers increasingly prefer to manage monthly expenses online or via mobile devices. Electronic billing offers an opportunity to include detailed information about the customer's billing history as well as a variety of links to educational resources. The water bill presents an obvious opportunity to provide customers with educational information, such as how they might obtain a water-use audit or efficiency rebate.

More accurate and timely information, combined with digital communications, provide further opportunities to engage customers in new ways. Many utilities are blending individual water use data with education and a bit of competitive spirit to drive consumer behavior changes. For example, utilities are providing personalized reports including a customer's water use, how it compares with neighbors, and water-saving tips. A year-long pilot of such a program in Northern California indicated that with this information participants reduced their water use by an average of 5%.⁷⁹

"CITY SERVICES BILL" EMPHASIZES MUNICIPAL SERVICES IN CITY OF WEST LINN



City Councilor Mike Jones of West Linn, Oregon had a bone to pick with the "utility bill" that arrived in his mailbox each month from the city. After years of serving the city on the Planning Commission, Library Foundation, and City Council, Councilor Jones realized that the City of West Linn provided far more services from the revenue generated from that bill than the title inferred.

Typically called a "utility bill" or "water bill," Councilor Jones knew that the City of West Linn depended on fee-based revenue for a wide variety of services, including water, storm water, sewer, streets, parks, and trails. He also knew that the rising water prices in other parts of the country could mistakenly lead some residents to think that their water bill was unfairly high.

Councilor Jones began an effort to rename that monthly bill as the "City Services Bill." Councilor Jones knew that a critical component of explaining West Linn's very low water prices, as well as the city's efficient use of all other fee revenue, relied on the proper naming of this city bill. City staff began using various communications tools to rebrand the bill as a "City Services Bill." From emails from the Finance Director to all staff reminding them to use the new name on telephone calls, to updates from the City Manager at Department Director meetings — at every level, the West Linn organization mobilized to make the switch and ensure the terms "utility bill" or "water bill" were never used again.

Phasing-In

Sudden and significant changes in rates and rate structures have economic and political consequences. Many managers may be more comfortable with a phased approach to implementing new rates that involves multiple, smaller rate adjustments. This may be particularly important for utilities making a major rate structure change, such as shifting from a rate perceived as "consumption-oriented" or encouraging consumption (such as a decreasing-block rate) to a rate perceived as "efficiency-oriented" (such as an increasing-block rate). Gradual implementation may be useful and provide a longer runway to educate the general public and build support.

The principal objective of phase-in plans is to avoid "rate shock" — a substantial reaction to a rate increase manifested economically in terms of reduced water usage (based on the price elasticity of the water demand) and politically in terms of consumer outcry. Phase-in plans do not eliminate the need for rate hikes; rather they help cushion the impact of escalating costs and prices on ratepayers. In fact, phase-in plans are not revenue neutral because they will increase total costs (or revenue requirements) because of additional financing costs.

79 Mitchell, David M. and Thomas W. Chesnutt, California Water Foundation, Evaluation of East Bay Municipal Utility District's Pilot of WaterSmart Home Water Reports, 2013

A phase-in strategy may be accomplished by limiting the percentage change in bills to some “acceptable” amount for a specified length of time. What is deemed acceptable is a largely a judgment shaped by customer attitudes but also institutional considerations, including oversight or regulatory approvals. Phase-in plans for rate design purposes sacrifice a degree of economic efficiency in return for improved acceptance, which may prove worthwhile over the long term in terms of effectiveness in achieving system goals.

Maintaining Dialogue: Feedback and Fine-Tuning

All efficiency efforts should be considered long-term investments for utilities, and pricing is no different. Effective efficiency-oriented rate structures will require some patience on the part of managers and customers alike. Efficiency will save variable costs in the short term but even more significant savings in capital costs in the long term.

Water customers may not respond immediately or consistently to a change in prices. They may seem to ignore important communications, and may even become annoyed with messages about efficiency. They may appear to be tacitly supportive of initial rate increases, but then become more vocal when peak seasons come around and the impact on their bills becomes more visible. Managers should be prepared for rebound effects after initial water-use reductions.

Ratemaking and other strategies that work in one community may not work in another due to unique cultural and other considerations. New circumstances may call for adjustments. Feedback from customers is essential for water agencies to fine-tune their programs and communications strategies. Utilities should continue to engage with stakeholders and provide regular reports on progress in achieving efficiency goals.

Understanding Customer Attitudes

An assessment of customer attitudes at both the outset of a rate change and at various moments throughout the implementation process can produce a variety of benefits. Water utility managers will benefit from gaining early insight about the acceptability of a proposed rate plan. This insight can help focus or enhance customer education programs, provide insights into how much customers are prepared to pay for increased reliability, or other benefits. An assessment can also help gauge how thoroughly consumers understand the service they receive.

One way to take the pulse of customers is by measuring attitudes about water service, efficiency, price changes, drought management, and other issues. Water providers have employed a variety of consumer attitude surveys for this purpose, and many options exist at various price points. The survey instrument itself tends to have educational value because it raises awareness of water supply and demand issues. In designing a survey, it is important to adhere to accepted sampling and design techniques. A poorly designed or biased survey will endanger the credibility of the findings and misinform decision-makers.

Improving Customer Response through Steady Communications

Ongoing public education efforts can be used not only to inform customers about water supply and demand conditions but also to clarify and reinforce price signals. Utilities might consider collaborating with other providers that share a water source to develop materials. Below are a few links to utility websites that were developed specifically to engage customers and educate them on resource challenges.

- www.DryFolsomLake.com
- www.watersmartsd.org/
- www.edwardsaquifer.org

Periodic reminders about the importance and value of water efficiency may also be needed, as well as intermittent public celebrations of accomplishments in terms of reduced water demand and system impacts. Utilities must assure customers that their efficiency efforts are appreciated and that these efforts are making a difference in achieving long-term system and community goals.



Bibliography



- Abrams, Barry, Santharajah Kumaradevan, Vasilis Sarafidis, and Frank Spaninks. (2011) "An Econometric Assessment of Pricing Sydney's Residential Water Use." *Economic Record* 88, no. 280 (2012): 89-105.
- Agthe, E., R.B. Billings, J.M. Dworkin. (1988) Effects of Rate Structure Knowledge on Household Water Use. *Water Resources Bulletin*.
- Albouy. (1997) *Marginal Cost Analysis and Pricing of Water and Electric Power: Methodology Notes*, John Hopkins University Press, Baltimore Maryland.
- Alliance for Water Efficiency. (2012), *Declining Water Sales and Utility Revenues: A Framework for Understanding and Adapting*.
- Altmann, David. (2007) *Marginal Cost Water Pricing: Welfare Effects and Policy Implications using Minimum Cost and Benchmarking Models, with Case Studies from Australia and Asia*. University of Adelaide.
- AWWA Rates and Charges Committee. (2000) *Principles of Water Rates, Fees, and Charges, Manual M-1*, 5th Edition, American Water Works Association, Denver Colorado, <http://www.awwa.org>.
- AWWA. (2010) *Water Rates. M1*, Sixth Edition, American Water Works Association, Denver Colorado, <http://www.awwa.org>.
- AWWA. (2004) *Avoiding Rate Shock: Making the Case for Water Rates*. American Water Works Association, Denver Colorado, <http://www.awwa.org>.
- Averich, H., and L.L. Johnson. (1962) "Behavior of the Firm under Regulatory Constraints," *American Economic Review*, Vol. 52, pp. 1053-1069, December.
- Baerenklau, Kenneth A., Kurt A. Schwabe, Ariel Dinar. (2013) "*Do Increasing Block Rate Water Budgets Reduce Residential Water Demand? A Case Study in Southern California*" Water Science and Policy Center, UC Riverside.
- Barberán, Ramón, Fernando Arbués. (2009) "Equity in domestic water rates design." *Water resources management* 23, no. 10 (2009): 2101-2118.
- Baumann, D. D., J. Boland, and J.H. Sims (1984), "Water Conservation: The Struggle Over Definition," *Water Resources Research*, Vol. 20, No. 4, pp. 428-434.
- Beato, Paulina, and Antonio Vives. (2013) "A primer on water economics." *Investing in Water for a Green Economy: Services, Infrastructure, Policies and Management*.
- Beecher, J.A. and A.P. Laubach. (1989) *Compendium on Water Supply, Drought, and Conservation*, Columbus, OH: The National Regulatory Research Institute.
- Beecher, J.A. and P.C. Mann (1991), *Cost Allocation and Rate Design for Water Utilities*, Denver, Colorado: The American Water Works Association Research Foundation, March.

- Beecher, J. A., P.C. Mann, and J.D. Stanford. (1993) Meeting Water Utility Revenue Requirements: Financing and Ratemaking Alternatives, Columbus, Ohio: The National Regulatory Research Institute, Chapters 3, 5, 6, & 8, November.
- Beecher, J.A., P.C. Mann, Youssef Hegazy, and John D. Stanford. (1994) *Revenue Effects of Water Conservation and Conservation Pricing: Issues and Practices*. Columbus, Ohio: The National Regulatory Research Institute, Appendix A, Chapter 4,
- Beecher, Janice A., and Peter E. Shanaghan. (1999) "Sustainable water pricing." *Water Resources Update* 114 (1999): 26-33. Beecher, Janice A, Peter E. Shanaghan. (2011) Sustainable Water Pricing. *Journal of Contemporary Water Research and Education*, 114(1), 4.
- Beecher, Janice. (2007) Full-Cost Pricing. MSU.
- Beecher, Janice. (2008) "PRACTICAL ETHICS FOR PRUDENT REGULATORS".
- Beecher, Janice A. (2011) "Avoided cost: An Essential Concept For Integrated Resource Planning." *Journal of Contemporary Water Research and Education* 104, no. 1 (2011): 8.
- Beecher, Janice A. (2011) "Primer on Water Pricing." Institute of Public Utilities Regulatory Research and Education, Michigan State University, East Lansing, MI.
- Berk, R.A., C.J LaCivita, K. Sredl, T.F. Cooley. (1981) *Water Shortages: Lessons in Conservation from the Great California Drought 1976-1977*. Abt Books, Cambridge Mass.
- Billing, R.B., C.V. Jones. (1996) *Forecasting Urban Water Demand*. AWWA Publications, Denver.
- Bishop, D.B., J.A. Weber. (1996) *Impacts of Demand Reduction on Water Utilities*. AWWARF and AWWA by Montgomery Watson Americas.
- Black, P.E. (1982) *Conservation of Water and Related Land Resources*, New York: Praeger Publishers.
- Boiteux, M. (1949) La tarification des demandes en point. *Journal of Business* Vol 33, pp 157-179.
- Boland, J.J. (2011) Pricing Urban Water: Principles and Compromises. *Water Resources Update* pp. 7-10.
- Bonbright, J.C., A.L. Danielson, D.R. Kamershen (1988) *Principles of Public Utility Rates*. Public Utilities Report Arlington VA.
- Borisova, Tatiana, Burcin Unel, Colin Rawls. (2008) *Conservation Pricing for Residential Water Supply*. Florida Cooperative Extension Service.
- Boyer, Christopher N., Damian C. Adams, Tatiana Borisova, and Christopher D. Clark. (2012) Factors Driving Water Utility Rate Structure Choice: Evidence from Four Southern US States. *Water resources management* 26, No. 10 (2012): 2747-2760.
- Brady, Michael, and Jonathan Yoder. (2013) "Understanding the Relationship between Water Price, Value, and Cost." WSU.
- Brandes, Oliver M, Steven Renzetti, Kirk Stinchcombe. (2010) *Worth Every Penny: A Primer on Conservation-Oriented Water Pricing*. POLIS Project.
- Cabrera, E., and M. A. Pardo -Ed. (2008) *Performance Assessment of Urban Infrastructure Services*. IWA Publishing, London UK.
- Cabrera, E., M. A. Pardo, E. Cabrera Jr, and F. J. Arregui. (2013) Tap Water Costs and Service Sustainability, a Close Relationship. *Water Resources Management* 27, No. 1 (2013): 239-253.
- Carter, David W. and J. Walter Milon. (1999) Marginal Opportunity Cost vs. Average Cost Pricing of Water Service Timing Issues for Pricing Reform. University of Florida Staff Paper.
- Carver, P.H. and J.J. Boland. (1980) "Short-run and Long-run Effects of Price on Municipal Water Use." *Water Resources Research*, Vol. 16, August.
- Chen, H. and Z.F. Yang. (2009) Residential water demand model under block rate pricing: A case study of Beijing. *Communications in Nonlinear Science and Numerical Simulation*, Volume 14, Issue 5.

- Chesnutt, T. W., A. Bamezai, C.N. McSpadden, J. Christianson, and W. M. Hanemann. (1995) Revenue Instability and Conservation Rate Structures, American Water Works Association Research Foundation and AWWA, 1P-5C-90681-9/95-CM.
- Chesnutt, T.W., C.N. McSpadden, and A. Bamezai. (1995) Ultra Low Flush Toilet Programs: Evaluation of Program Outcomes and Water Savings. Metropolitan Water District of Southern California.
- Chesnutt, Thomas W., Casey McSpadden, and John Christianson. (1996) "Revenue instability induced by conservation rates." *Journal of the American Water Works Association* 88, No. 1 (1996): 52-63.
- Chesnutt, T. W., J. A. Beecher, P. C. Mann, D. M. Clark, W. M. Hanemann, G. A. Raftelis, C. N. McSpadden, D. M. Pekelney, J. Christianson, and R. Krop. (1997) *Designing, Evaluating, and Implementing Conservation Rate Structures*, A handbook for the California Urban Water Conservation Council, Sacramento California, <http://www.cuwcc.org>.
- Chesnutt, Thomas. W. (2011) Volumetric Pricing for Sanitary Sewer Service in the State of California. A & N Technical Services, Inc.
- Clark, R.M. and Richard. G. Stevie. (1981) A Water Supply Cost Model Incorporating Spatial Variables. *Land Economics*, Vol. 57, No. 1.
- Collinge, R.A. (1992) Revenue-Neutral Water Conservation: Marginal Cost Pricing with Discount Coupons. *Water Resources Research*, Vol. 28, No. 3, pp. 617-622.
- Collinge, R. A. (1996) "Optimal Conservation by Municipal Water Customers: A Revenue-Neutral `Feebate' System," in *Journal American Water Works Association*, pp. 70-78, January.
- Correia, Ricardo, and Catarina Roseta-Palma. (2012) "Behavioral Economics in Water Management."
- Cuthbert, Richard W., Pamela R. Lemoine. (1996) Conservation - Oriented Water Rates. *Journal of AWWA*.
- Dandy, G.C., E.A. McBean, and B.G. Hutchinson. (1984) A Model for Constrained Optimum Water Pricing and Capacity Expansion. *Water Resources Research*, Vol. 20, No. 5, pp.511-520.
- Deloitte. (2004) *Regulated Utilities Manual*, A service for Regulated Utilities.
- Donnelly, Kristina and Dr. Juliet Christian-Smith. (2013) *An Overview of the "New Normal" and Water Rate Basics*. Pacific Institute.
- EPA, (2005) *Case Studies of Sustainable Water and Wastewater Pricing*.
- Flack, Ernest J., George J. Roussos. (1978) Water Consumption Under Peak-Responsibility Pricing. *Journal of AWWA*.
- Flores, Nicholas E. (2013) *The Value of Water in the US Economy: Problems of Basic Inference*. University of Colorado.
- Foster, Holly. (2011) *A Case Study Analysis On Residential Water Demand Management: An Evaluation Of Current Demand And Pricing Strategies With Implications For Future Water Policy*. La Trobe University.
- Frone, Simona. (2012) *Issues on the Role of Efficient Water Pricing for Sustainable Water Management*. Institute of Nation Economy.
- Garcia, Serge, and Arnaud Reynaud. (2003) Estimating the benefits of efficient water pricing in France. *Resource and Energy Economics*.
- Goldstein, J. (1986) "Full-Cost Water Pricing." *American Water Works Association Journal* 78 no. 2, pp. 52-61, February 1986.
- Griffin, R.E. and C. Chang. (1990) Pretest Analysis of Water Demand in Thirty Communities. *Water Resources Research*, Vol. 26, pp. 2251-2255.
- Hanke, Steve H. and Robert K. Davis. (1971) Demand Management through Responsive Pricing. *Journal of AWWA*.

- Hanke, S.H. (1978) "A Method for Integrating Engineering and Economic Planning." *Journal American Water Works Association*, Vol. 71, pp. 487-491, September 1978.
- Hanke, S.H. (1978) *Pricing as a Conservation Tool: An Economist's Dream Come True*. Municipal Water Systems University Press.
- Hanke, S.H. and R.W. Wentworth (1981) On the Marginal Cost of Wastewater Services. *Land Economics*, Vol. 57, No. 4.
- Hanke, S.H. (1981) "On the Marginal Cost of Water Supply." *Water Engineering and Management*, Vol. 120, pp. 60-63, 69, February 1981.
- Hanemann, W. Michael. (2011) "Designing new water rates for Los Angeles." *Journal of Contemporary Water Research and Education* 92, no. 1: 3.
- Harrison, M.J. (1979) Forecasting Revenue Requirements. *Public Utilities Fortnightly*, Vol. 103, pp. 11-15.
- Haywar, Keith (2011) The need for a new model of water pricing: lessons from the financial crisis. *IWA Water Utility Management International* 6.1.
- Hentschke, Daniel S. (2013) *Conservation Through Water Pricing Reconciling Constitutional Mandates*. Berkeley School of Law.
- Hill, T., and G. Symmonds. (2012) "Sustained water conservation by combining incentives, data and rates to effect consumer behavioral change." *Water and Society* 153 (2012): 409.
- Hirshleifer, J. (1958) Peak Loads and Efficient Pricing: Comment. *Quarterly Journal of Economics*, Vol. 72
- Hufschmidt, M.M. and M. B. Fiering, 1966. *Simulation Techniques for Design of Water Resource Systems*, Cambridge Mass.
- Hughes, Jeff, Mary Tiger, Adam Lang, and Scott Haskins. (2011) *Water Utility Challenges in Meeting Revenue Gaps*.
- Iglesias, E., M. Blanco. (2008) New directions in water resources management: The role of water pricing policies. *Water Resources. Res.*, 44
- James, G.W. (1917) *Reclaiming the Arid West*, New York, McGraw Hill.
- Jordan, Jeffrey L. (2011) "Pricing to Encourage Conservation: Which Price? Which Rate Structure?." *Journal of Contemporary Water Research and Education* 114, no. 1 (2011): 5.
- Katko, T.S., P.S. Juuti and K. Schwartz — Ed. (2013) *Water services Management and Governance*. IWA Publishing, London UK.
- Kiefer, Jack. (1999) *The Search for Acceptable Water Rates: Research Needs and Possibilities*. Open SIUC.
- Krutilla, J. V. and O. Eckstein, 1985. *Multiple Purpose River Development*, Baltimore: Johns Hopkins Press.
- LaFrance (2011) "What to do with Less," *Journal AWWA*, Nov. 2011, p. 6. LaFrance
- Lehmann, Paul. (2011) *Making water affordable to all: A typology and evaluation of options for urban water pricing*. No. 10/2011. UFZ-Diskussionspapiere.
- Li, Cuimei, Tao TAO, and Suiqing LIU. (2010) A Study on Prediction of Urban Water Prices Based on the Marginal Cost Methodology. *Resources Science* 7 (2010): 020. Mann, P.C., R. J. Saunders, and Jeremy J. Warford. (1980) "A Note on Capital Indivisibility and the Definition of Marginal Cost," *Water Resources Research*, Vol. 16, pp. 602-604, June 1980.
- London Economics. (1997) *Water Pricing: The Importance of Long Run Marginal Costs?* London Economics/ London Office of Water Service. Mann, Patrick C., Donald L. Schlenger. (1982) *Marginal Cost and Seasonal Pricing of Water Service*. *Journal of AWWA*.

- Maddaus, L., W Maddaus, and M. Maddaus. (2014) *Preparing Urban Water Use Efficiency Plans*. IWA Publishing, London UK.
- Mann, P. C. and P. R. LeFrançois. (1983) "Trends in the Real Price of Water", *Journal American Water Works Association*, 75, 441-443.
- Mann, Patrick C., Don M. Clark. (1993) *Marginal-Cost Pricing: Its Role in Conservation*. Journal of AWWA.
- Marcellino, Dominic and Max Grünig. (2011) *The German Experience with Full Cost Recovery in the Water Sector: Practice and Problems*. L'Acqua, No. 2.
- Marino, A. M. (1979) "Capacity Choice under Regulation in a Variable Load Pricing Model with Diverse Technology," *Southern Economic Journal*, vol. 45, pp. 858-866, January 1979.
- Marsden, John, Peter Jacob, and Jasper Mikkelsen. (2004) *Estimation of Long Run Marginal Cost*. Marsden Jacob Associates for Queensland Competition Authority.
- Martín-Hurtado, Roberto. (2012) *Pricing water resources to finance their sustainable management*. EU Water Initiative — Finance Working Group.
- Mass, A. and others, eds. 1962. *Design of Water Resource Systems*, Cambridge Mass. Harvard University Press.
- Massarutto, Antonio. (2007) "Water pricing and full cost recovery of water services: economic incentive or instrument of public finance?." *Water Policy* 9, No. 6: 591-613.
- Mayer, Peter, William DeOreo, Thomas Chesnutt, and Lyle Summers. (2008) "Conservation-Water budgets and rate structures: Innovative management tools" *Journal of the American Water Works Association* 100, no. 5 (2008): 117.
- Mercer, L.J. and W.D. Morgan (1986) "The Efficiency of Water Pricing: A Rate of Return Analysis for Municipal Water Departments," *Water Resources Bulletin*, American Water Resources Association, April 1986.
- Mitchell, D.M. and W.M. Hanemann (1994), *Setting Urban Water Rates for Efficiency and Conservation*," A report for the California Urban Water Conservation Council Sacramento California, <http://www.cuwcc.org>.
- Moncur, J. E. T. And Y. Fok, (1995) "Water Pricing and Cost Data: Getting the Right Numbers." *Water Resources Update*.
- Monteiro, Henrique Pedro Currais. (2005) *Water Pricing Models: a survey*. DINÂMIA - Research Centre for Socioeconomic Change Working Paper.
- Nataraj, Shanthy. (2007) *Do Residential Water Consumers React to Price Increases? Evidence from a Natural Experiment in Santa Cruz*. Foundation of Agricultural Economics.
- Nieswiadomy, Michael L. (1992) "Estimating urban residential water demand: Effects of price structure, conservation, and education." *Water Resources Research* 28, No. 3: 609-615.
- OECD. (2010) *Pricing Water Resources and Water and Sanitation Services*. OECD Publishing.
- Olewiler, Nancy. (2012) "Smart Environmental Policy with Full-Cost Pricing." University of Calgary. SPP Research Paper 12-6 (2012).
- Pethig, Rüdiger Klaus Fiedler. (1991) *Efficient Pricing of Drinking Water*. FinanzArchiv / Public Finance Analysis.
- Pint, Ellen M. (1999) *Household Responses to Increased Water Rates during the California Drought*. *Land Economics* Vol. 75, No. 2 (May, 1999), pp. 246-266.
- Reisner, M., (1986) *Cadillac Desert: The American West and Its Disappearing Water*, New York: Penguin Books.
- Renzetti, Steven. (2003) *Full Cost Accounting for Water Supply and Sewage Treatment: A Case Study of the Niagara Region, Canada*. Brock University, Catherines, Ontario.

- Rinaudo, Jean-Daniel, Noémie Neverre, Marielle Montginoul. (2012) Simulating the Impact of Pricing Policies on Residential Water Demand: A Southern France Case Study. *Water Resources Management*, Volume 26, Issue 7, pp 2057-206
- Rogers, Peter, Radhika de Silva, and Ramesh Bhatia. (2002) "Water is an economic good: How to use prices to promote equity, efficiency, and sustainability." *Water Policy* 4, no. 1 (2002): 1-17.
- Rucker, R.R., and P. Fishback, (1987) "The Federal Reclamation Program," in *Water Rights*, ed. by T.L. Anderson.
- Rouse, Michael. (2007) *Institutional Governance and Regulation of Water Services. The Essential Elements*. IWA Publishing, London, UK.
- Ruijsa, A., A. Zimmermann, M. Van Den Bergb. (2008) Demand and distributional effects of water pricing policies. *Ecological Economics*, Volume 66, Issues 2-3, 15.
- Sanza, María Pascual, Marco Schoutenb, Michael Hantke-Domas. (2011) Consumer-inclusive economic regulation: water pricing under different regulatory regimes. *IWA Water Policy Vol 13 No 4* pp 459-470.
- Schneemann, Margaret. (2012) *Full-Cost Water Pricing Guidebook for Sustainable Community Water Systems*. Chicago Metropolitan Agency for Planning (CMAP).
- Shirley, M., ed. (2002) *Thirsting for Efficiency: The Economics and Politics of Urban Water System Reform*, World Bank and Pergamon, published by Elsevier Science Ltd.
- Sibly, Hugh. (2006) "Efficient urban water pricing." *Australian Economic Review* 39, no. 2 (2006): 227-237.
- Sridhar, Kala Seetharam and Om Prakash Mathur. (2011) *Pricing Urban Water A Marginal Cost Approach*. India Infrastructure Report.
- Spulber, D. F. (1992) "Capacity-Contingent Nonlinear Pricing by Regulated Firms," *Journal of Regulatory Economics*, Vol. 4, pp. 299-319, 1992.
- Turvey, R. (1976) "Analyzing the Marginal Cost of Water Supply," *Land Economics*, Vol. 52, pp. 158-168, May 1976.
- UNC EFC. (2008) *The State of Full Cost Pricing: Full cost pricing among public water & sewer utilities in the Southeast*.
- Walton, Brett. (2013) *The Price of Water 2013: Up Nearly 7 Percent in Last Year in 30 Major U.S. Cities; 25 Percent Rise Since 2010*.
- Water Environment Federation. (2013) *User-Fee-Funded Stormwater Programs. Second Edition*.
- Ward, Michael, Chris White. (2011) *Welfare impacts of urban water pricing versus water*. Global Water Forum.
- Yanmin, Feng, and Feng Jie. (2009) *Research on Full-Cost Pricing Model of Water Resource in Market Economy*. *Water Power* 8 (2009): 86-87.
- Yu, S. I., and L. I. Yu-ping. (2010) "Pricing Method of Urban Water Based on Ramsey Model." *Journal of Harbin University of Commerce (Social Science Edition)* 4 (2010): 027.
- Zeft, Harrison B., Gregory W. Characklis. (2013) *Managing Water Utility Financial Risks Through Third-Party Insurance Contracts*. American Geophysical Union.

Appendix A

Costing Methods



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Introduction

A thorough examination of utility costs is an integral component of sound utility financial management and ratemaking, serving several purposes.

Because water utilities are natural monopolies, historic regulation has required some form of cost of service analysis to ensure that rates are “just and reasonable” and that rates are not derived on an “arbitrary or capricious” basis. Good efficiency-oriented rate design relies on full cost pricing, which fully recovers the cost of providing water service and which promotes efficient water use by customers. It also emphasizes the principles of cost causation: revenues should be recovered from those who cause costs to be incurred. Understanding these costs associated with different patterns and classes of customer use is a critical step in developing full-cost pricing.

Additionally, marginal/incremental costs reflected in rates can provide more accurate price signals to customers of the cost-causative consequences of consumptive decisions and more effectively encourage conservation. The use of marginal cost of service principles and marginal cost rate design (pricing) to establish utility rates is well documented within the utility industry.

This appendix provides definitions of various cost concepts, an overview of cost allocation methods, and an explanation of the connection of marginal cost pricing to cost-of-service principles. It focuses primarily on production costs.¹

Cost Concepts

Understanding the costing methods required to estimate a utility’s costs involves several basic issues. First, the distinction between **fixed and variable costs**, which is key to many costing methods, depends entirely on the time period under consideration. Second, assigning cost responsibility requires a distinction between **attributable and joint costs**. Third, **data** quality and availability will limit cost analysis. This section defines these basic cost concepts and explains their relevance to costing methods.

Fixed versus Variable Costs: Many costing methods identify costs of water service as either **fixed** or **variable** based on accounting expenditures. **Fixed** costs are expenditures that remain the same, regardless of the volume of water produced. Because large up-front capital costs are required to build capacity for meeting demand, some traditional costing methods classify all system expansion costs as fixed and refer to these costs as “demand” costs. **Variable** costs, also called “commodity costs,” are expenditures that vary directly with the volume of water produced or consumed; variable costs include, for example, purchased water, electrical, and chemical costs. Marginal costing methods recognize that the dividing line between fixed and variable depends on the period of time used for the analysis. In the long run, fixed capital expenditures can and do change, thus becoming “avoidable.”

¹ Parts of this appendix were adapted from “*Designing, Evaluating, and Implementing Conservation Rate Structures*”, July, 1997, California Urban Water Conservation Council.

Attributable versus Joint Costs: If all costs could be easily, accurately, and cheaply attributed to specific utility functions, cost-causation would be straightforward. (See Shillinglaw 1963, “The Concept of Attributable Cost.”) Attributable cost is directly based on causality. Some costs of water supply are considered “joint” costs because they reflect joint functions. As an example, providing flow capacity sufficient for fire protection simultaneously (or jointly) provides capacity that can be used for any other instantaneous high-flow use. Similarly, providing capacity for peak periods will necessarily provide capacity for nonpeak periods. Joint costs complicate the task of cost analysis.

Data Issues: Costing methods use, and are limited by, accounting and other data generated in the day-to-day operations of the water utility. The quality and availability of these data also affect the accuracy and applicability of avoided-cost methods. Much of the water supplier cost accounting data, for example, is not allocated by utility function—supply, storage, treatment, and conveyance. By improving the process of defining and collecting accounting-cost measures, better decisions can be made using even simple methods. The need for accurate flow data is another data issue. Costs are allocated through this data and many utilities do not have data by class of service beyond monthly data.

Definition and History of Marginal/Incremental Cost Pricing

An important starting point in the discussion of utilizing marginal cost pricing to establish water rates is simply understanding the proper definition of marginal costs. “Marginal” production costs refer to the cost of producing (or not producing) another unit of water supply. Marginal costs taken for an increment of supply are often referred to as “incremental” costs. Marginal or incremental cost pricing refers to setting prices to equal marginal costs.

Marginal cost pricing has a long history of development in the economic literature and has been successfully applied to problems of public utility pricing.² The historical evolution of traditional costing in the water industry drew heavily from methods developed for other public utility industries. In the energy and telecommunications industries, where most utilities are subject to economic regulation, average-cost pricing prevailed until roughly the 1980s. Marginal-cost methods have gained some acceptance in the realm of public utility regulation. In fact, the Public Utility Regulatory Policies Act (PURPA) of 1979 required the larger electric and gas utilities to consider these pricing methods.

² In fact, some of the early work on marginal cost pricing for public utilities was focused specifically on hydroelectric reservoirs. See Massé, P. 1944, *Application des probabilités en chaîne à l'hydrologie statistique et au jeu des réservoirs*. Paris. or Boiteux, M., 1949, “La tarification des demandes en pointe,” *Revue Générale de l'Electricité*, 58, 321-40.

Economic Theory and Marginal Cost of Service

Economic theory provides the logic for marginal costs serving as the basis for the marginal cost of service. There is extensive economic background for marginal cost applications in electric cost of service and rate setting as well as other type of utilities.³ This section provides a summary of the economic theory of using marginal cost as a basis for rate making and cost of service.

One of the main tenants of economics at the individual firm and individual consumer level is that society is better off when the price of a good or service is equal to its marginal cost. The welfare of society is the highest when marginal price equals its marginal cost. Where there is a free market with open competition, this occurs naturally. In the public utility arena where utilities are granted monopolies of service, economic theory would recommend that pricing be based on marginal cost with certain caveats. The analysis behind this finding will be explored in a limited way here, but there is substantial economic literature on the topic.⁴⁵

Marginal cost is the cost of producing an additional unit of a good or service at a level of production. The following example is for a firm producing widgets which seeks to maximize profit. Figure B.1 depicts a simple example of a cost of production function for a generic good, "widget", that relates total cost for producing the widgets by the amount of widgets produced. As more widgets are produced the cost per widget increases, an increasing marginal cost example.

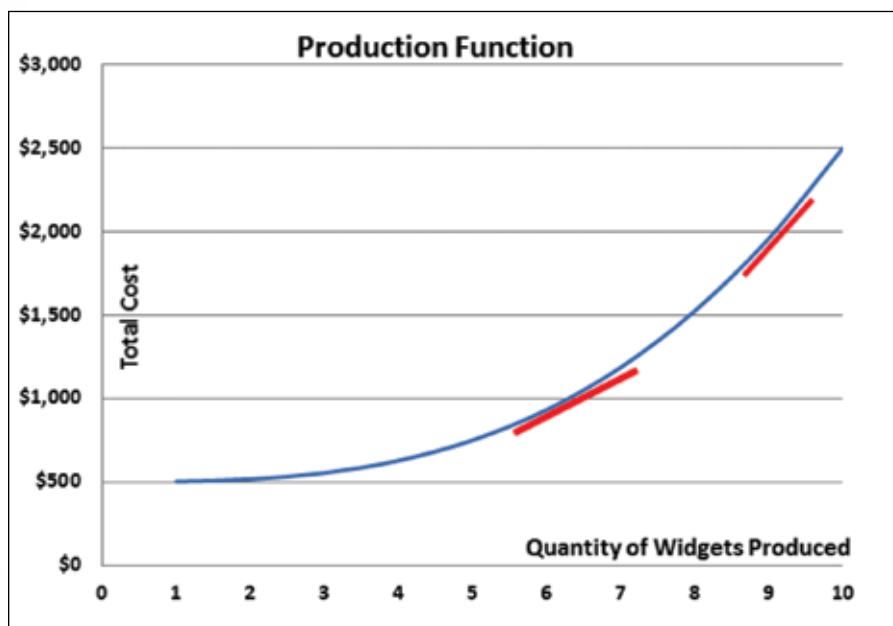


Figure A.1 Total Cost of Production

- 3 Kahn, Alfred, *The Economics of Regulation: Principles and Institutions*: 1970, Wiley & Sons.
- 4 Bonbright, James & Danielson, Albert & Kamershen, *Principles of Public Utility Rates*: 1988, Public Utility Reports, Inc.; Mass, A. and others, eds. *Design of Water Resource Systems*, Cambridge Mass, Harvard University press, 1962. Hufschmidt, M.M. and M. B. Fiering, *Simulation Techniques for Design of Water Resource Systems*, Cambridge Mass, Harvard University Press, 1966. Krutilla, J. V. and O. Eckstein, *Multiple Purpose River Development*, Baltimore: Johns Hopkins Press, 1985. These are seminal works on the role of marginal cost for utility rates and cost of service.
- 5 Freidman, Milton, *Price Theory*: 1976, Aldine Publishing Company and Varian, Hal, *Microeconomic Analysis*, 1978, Norton & Company

The increasing marginal cost in this example is reflected by the two red lines at 6 and 8 widgets. The marginal cost at any point on the production function is the slope of the function/line at that point. For the mathematically inclined the marginal cost is the calculus derivative at the production level of concern. This is represented by the red lines tangent in the above example. Clearly the slope of production at widget 9 is higher than the slope at widget 6. Figure B.2 shows the average cost per unit, the marginal cost per unit and an illustrative demand curve for the above production function. All are a function of cost/price per unit by quantity. Average cost is total cost divided by amount of production.

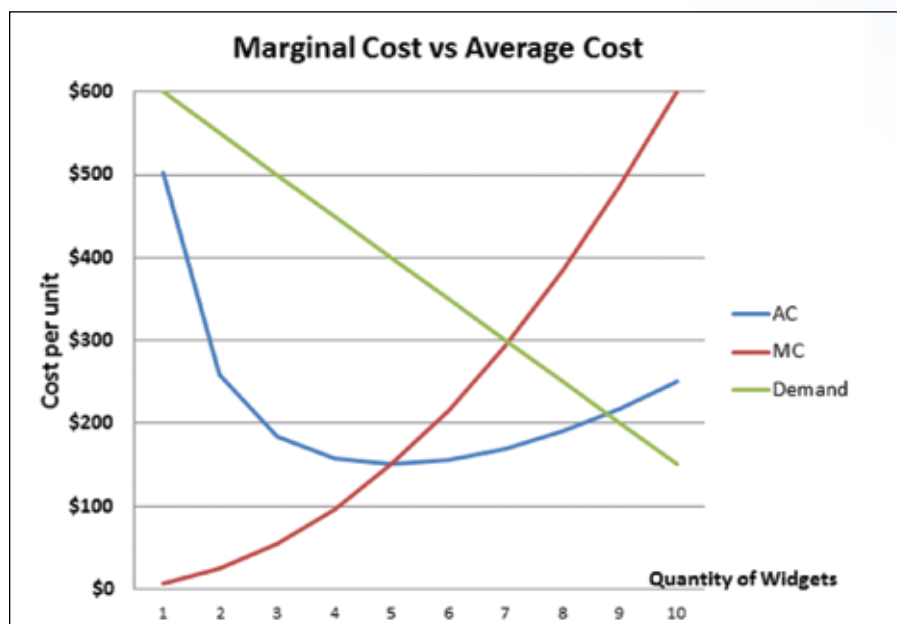


Figure A.2 Marginal Cost vs Average Cost

At 7 units of production, the marginal cost and the price for a demand of 7 widgets is \$300 per widget. The average cost is \$150 per unit at 7 units of production. At 9 units, the MC = \$500 and the price of demand and AC are equal at \$200. The profit and overall revenue to the firm is higher at 7 units than at 9 widgets. This is a simple demonstration of how marginal cost equaling demand price results in higher value than at average cost at demand price.

In practice for utility pricing, there are many issues that overlay this simple example such as long term versus short term costs, monopoly pricing and marginal cost revenues are not equal to actual revenue requirements that must be addressed. However, the simple example provides some insight into the economic theory of marginal cost pricing.

The concept of “cost of service” is central to utility rate setting. Federal, state and local regulators, and the courts, generally require rates to adhere to a cost-of-service justification; that is, rates should be designed so that users pay water rates that bear a direct relationship to the costs they impose on the water system. Marginal-cost pricing provides the link between today’s consumptive behavior and the means of satisfying tomorrow’s demand. As such, it can be understood as an expression of cost-of-service methods that brings a closer relationship between costs imposed and cost responsibility.

The concept of marginal cost pricing has also been extended beyond direct production costs. They should be thought of as inclusive of all marginal opportunity costs, including marginal distribution costs, marginal connection costs and marginal environmental costs.⁶ By intention, this appendix focuses on marginal production costs.

Two Traditional Cost Allocation Methods: Commodity-Demand and Base-Extra Capacity

Marginal cost methods can be better understood in contrast to the more traditional methods based on embedded average cost. Two traditional methods for allocating embedded costs by demand characteristics have been widely applied by water utilities: the Commodity-Demand method and the Base-Extra Capacity method. Both approaches are extensively discussed and illustrated in the American Water Works Association (AWWA) Manual **M1**, Water Rates.

The **Commodity-Demand method** separates costs into the cost components associated with commodity, demand, customer and direct fire protection. In California, water utilities regulated by the PUC prepare a Fixed Cost and Commodity Cost analysis that is a variation of the Commodity-Demand method. The Commodity-Demand method uses the peak (maximum) demand of each customer class to allocate capacity costs, but does not consider how that peak is related to the overall system peak. In the language of the trade, this approach is termed a “non-coincident” peak responsibility cost allocation. Non-coincident approaches evaluate the maximum day and maximum hour peaking characteristics of customer classes, no matter when the peak occurs. A “coincidental” approach evaluates these peaking factors when the system is peaking. Thus, the Commodity-Demand method could allocate a large proportion of system costs to a customer class with a substantial peak demand at a time other than that of the system peak. By not tying rates to the time of highest system peak, the Commodity-Demand allocation method can miss an opportunity to send an appropriate price signals.

The **Base-Extra Capacity method** is the cost-of-service procedure used by the majority of larger public water utilities, as well as many regulatory utilities. The Base-Extra Capacity method first examines the costs for “Base” or average annual water use. “Extra Capacity” addresses responsibility for the additional costs incurred to meet maximum-day and maximum-hour demands. The base costs of the Base-Extra Capacity method capture all of the commodity costs identified in the Commodity-Demand method plus the portion of demand-related costs necessary to provide capacity for meeting the average-day demands. Extra-capacity costs, then, cover the rest.

Customer related costs under both methods reflect the cost of meters and services, meter reading, customer billing and collection expenditures. These costs are often allocated to customers uniformly by connection or by meter size.

6 See for example, R.C. Griffin, 2001, “Effective Water Pricing,” Journal of the American Water Resources Association.

PEAK AND LOAD FACTORS



Peak demand is defined as the maximal demand during a specified period of time. Thus, peak/maximum day demand would be the maximum demand observed on any day. Peak/maximum hour demand would be the maximum demand observed in any hour. Peak ratio is the ratio of peak demand to average demand.

A load or capacity factor is defined as the ratio of average demand to peak demand. Thus if a facility is designed to meet some maximal demand, the capacity factor has the interpretation of the percent of total capacity allocated to average demands.

Seasonal Base-Extra Capacity

The Base-Extra Capacity method can be modified to incorporate seasonal time-of-use into the cost assignment. For many systems, water usage (or system “load”) will have a seasonal pattern—higher during the warmer months and lower during the cooler months. These seasonal patterns also are reflected in maximum-day and maximum-hour demands. Thus, after developing the average cost per unit of water associated with base and extra capacity requirements, seasonality can be introduced. Under this approach, base and extra capacity costs are allocated to time of year before being assigned to customer classes.

For readers familiar with traditional cost allocation, Table A.1 illustrates a Seasonal Base-Extra Capacity method. First, costs are allocated between base and extra-capacity components. Approximately two thirds of the total cost of service of \$22,510,348 is deemed necessary to provide capacity for average day demand. (If this allocation applied to a single facility, it would imply that maximal peak demand is about 50 percent greater than average demand) The remaining costs are allocated to extra capacity. (The amounts allocated to maximum day and maximum hour would come from a facility by facility allocation based on the capacity factors.)

The principal departure from the traditional method is the allocation of maximum-day and maximum-hour costs between seasonal and non-seasonal consumption. In this example, a four-month summer period has been defined as the peak season. As in the traditional method, the annual “base” cost of service is divided by total annual consumption, to yield a base cost of \$1.60 per CCF. This base amount applies throughout the year. The extra capacity costs, in turn, are further divided by season. The allocation factors for maximum day costs would suggest that 50 percent of the days that exceed average day demand would occur in the eight month off-peak season and 50 percent would occur in the four month peak summer season. Similarly, allocation factors have been developed for maximum hour costs. This procedure results in a non-seasonal rate of \$2.22/CCF and a summer rate of \$2.72/CCF.

The Seasonal Base-Extra Capacity method results in unit costs and seasonal differential factors that can be applied in the rate design to yield a seasonal rate structure. Seasonal prices signal to consumers the additional cost of the extra capacity needed to provide peak seasons service. **This method alone, however, does not consider the potential for changes in the future costs** of supply alternatives, which would require a forward-looking marginal-cost analysis.

The Seasonal Base-Extra Capacity example shows one limited way that embedded cost methods can be improved for conservation purposes—by incorporating **the time** dimensions of usage patterns into the costing. Seasonal differences in cost responsibility (as defined by traditional methods) provide the basis for seasonal peak pricing. Because future system capacity costs also are driven by peak load, the higher rates during periods of peak load is a step in the right direction.

Table A.1 Analysis of Seasonal Costs - Base/Extra Capacity Method

DESCRIPTION	COST OF SERVICE	PERCENT SHARE	AMOUNT
I. Allocation Between Base and Extra Capacity			
Base	\$22,510,348	66.0%	\$14,859,250
Max Hour	\$22,510,348	15.8%	\$3,547,127
Max Day	\$22,510,348	18.2%	\$4,103,971
II. Base Cost of Service			
Base	\$14,859,250	100.0%	\$14,859,250
Total Consumption			9,288,311
Base Cost per CCF			\$1.600
III. Non-Seasonal Extra Capacity Cost of Service			
Max Hour	\$3,547,127	50.0%	\$1,773,564
Max Day	4,103,971	40.0%	\$1,641,588
Non-Seasonal Extra Capacity Cost of Service			\$3,415,152
Non-Seasonal Consumption (8 off-peak months)			5,504,381
Extra Capacity (Non-Seasonal) Cost per CCF			\$0.620
Base Cost per CCF			\$1.600
Non-Seasonal Extra Capacity Cost per CCF			\$2.220
IV. Summer Cost of Service			
Max Hour	\$3,547,127	50.0%	\$1,773,564
Max Day	4,103,971	60.0%	\$2,462,383
Total Summer Cost of Service			\$4,235,946
Summer Consumption (4 peak months)			3,783,930
Seasonal Extra Capacity Cost per CCF			\$1.119
Plus: Base Cost per CCF			\$1.600
Summer Cost per CCF			\$2.719

Marginal/Incremental Cost Pricing for Water

Two important components of marginal cost are the change in operating costs caused by a change in the use of existing capacity (short-run marginal operating cost), and the cost of expanding capacity (long-run marginal capacity cost).

- **Short-run marginal operating costs** reflect the cost consequences during time periods in which some inputs are fixed. Short-run marginal costs are comprised mostly of variable operating costs, and are relatively straightforward to estimate.
- **Long-run marginal capacity costs** extend to time periods far enough into the future to be changed by system and resources planning. Long-run marginal costing methods can identify costs that can be avoided through more efficient use or non-use (conservation). Because the long-run concept of marginal costs (1) extends into the future, and (2) reflect all future alternatives, estimation methods must deal with more uncertainty.

Total long run marginal costs include both the short-run operating costs and the long-run capacity expansion/contraction costs.

Marginal costs are computed with respect to two different time periods:

- **Short-run marginal operating costs** constitute a floor for water rates—volumetric rates should never be set below short-run marginal costs.
- **Long-run marginal costs** represent the definition of an efficient price signal—to convey information about the long-run cost consequences, rates should reflect long-run marginal costs.

Applying Marginal Cost Analysis to Water Service

In estimating marginal costs, a central issue is where the next increment of supply will come from and what it will cost. A variety of supply options with different capacity and cost consequences may be available. The identification and quantification of future resource alternatives lies at the heart of water utility planning. Existing water supply/management plans are a good place to start to determine the current set of resource alternatives to which a utility is committed.

The Appropriate Time Horizon: Calculating marginal cost involves projecting capacity costs, operating costs, and water demand over a specified time horizon. These projections require data on the price elasticity of demand, anticipated changes in technology, and the prices of inputs required to provide water service.

Selecting the time horizon directly affects the estimation of marginal capacity cost (long-run marginal cost) and the marginal operating cost (short-run marginal cost). The length of the time horizon or planning period affects both the cost numerator and the output denominator in calculating marginal cost.

Sometimes a shorter time period has been chosen out of a misplaced desire for precision in estimating marginal costs. Though it is often true that shorter time horizons lend themselves to more precise cost and demand forecasts, precision should not be confused with accuracy. Forecasts

over long time horizons may contain fewer known and more estimated quantities. These longer term forecasts can be more accurate, because they contain a broader set of alternatives, while necessarily being less precise. The choice of the time horizon also must take into account the span of time required to implement cost-effective changes in the mix, capacity or availability of resources. Most water utilities define a “time horizon” for planning purposes.

Time also matters because forward-looking marginal/incremental costs must necessarily grapple with the economic principles of the time value of money, ongoing inflation, and escalation of future costs in ways that can differ from the general rate of price inflation.

Time Value of Money: It is assumed that most readers are familiar with the concept of the time value of money—most people would prefer to have one dollar today than one dollar a year from today (or ten years from today) because productive things can be done with the dollar within that time. This is the opportunity cost of money. A stream of costs occurring through time can be re-expressed in terms of the present value by using a discount rate that adjusts for the opportunity cost of money.

$$PresentValueCosts = \sum_{t=0}^n \frac{Cost_t}{(1 + DiscountRate)^t}$$

In equation A.1, $Cost_t$ are costs in year t ; n is years in the period of analysis, and “year” refers to a calendar year.⁷ The question of an appropriate discount rate depends on the perspective of analysis (utility direct financial perspective, narrowly defined societal perspective [GDP], and broadly defined societal perspective [inclusive of future generation, for example]) and what constitutes the relevant opportunity costs. For water utilities having to borrow money to build water infrastructure, the cost of borrowing money constitutes a good benchmark of this opportunity cost—that is the “cost of capital”.

The discount rate to be applied depends on whether the stream of costs are measured in real (adjusted for inflation) or nominal (not adjusted for inflation) terms. Costs and benefits should be valued in either real or nominal terms—not a combination of the two. If costs are expressed in nominal terms, say a stream of financial payments over time, a nominal discount rate should be used. If costs are expressed in real terms, a real discount should be used.⁸

Marginal Operating Cost

Several techniques can be used to estimate marginal operating cost (MOC) for a water utility. The simplest techniques calculate an average operating cost and thus can deviate from theoretical marginal cost. Additional analysis, using very similar data, can arrive at estimates closer to marginal cost. Both techniques are relatively uncomplicated and involve minimal data requirements.

7 For example, costs that occur immediately at the outset of the program accrue in “year zero” ($t=0$). Costs that occur during the first year of the program accrue in “year one” ($t=1$), etc.

8 Real and nominal discount rates, if certain, can be converted as follows: $d = (r - i) \div (1 + i)$ where d is the real discount rate, r is the nominal discount rate, and i is the expected inflation rate. If these rates are uncertain, the “Flaw of Averages” provides several ways that inserting the expected real discount and interest rates would not yield the correct expected nominal discount rates. “Risk-adjusted” discount rates constitute an algebraic “solution” to a problem that is better handled through “probability management” (Savage, 2012).

A Short Method: One technique used to calculate MOC is to forecast the annual operating expenses for the first year that a capacity increment is anticipated to become operational, and then divide that annual cost estimate by the forecast revenue-producing output for the same year (Hanke, 1981) and accounting for the time value of money. When operating costs can be predictably forecast, this technique can be extended over multiple years. The forecast annual operating expenses over the entire planning period in which the capacity increment is anticipated to become operational are divided by the forecast revenue-producing output for the same time period (Hanke, 1978). Water systems exhibiting significant seasonal operating cost differences—due to purchased water prices or electrical power expenses—can adapt this technique to a seasonal basis.

Illustration: Table A.2 illustrates the two calculations of average operating cost. The example assumes that a new treatment plant is operational in Year 1. The projected annual operating expenses and revenue-producing output of a new facility are provided in the table. The first method, using data only from Year 1, generates an average operating cost of \$0.47 per CCF. The second method, using data from Years 1 through 5, generates an annual estimate of average operating cost that increases to \$0.50 per CCF.

Table A.2 Calculation of Average Operating Cost - Hanke Method

DESCRIPTION	YEAR 1	YEAR 2	YEAR 3	YEAR 4
Operating Expense (millions of dollars)	\$4.343	\$4.3760	\$4.4370	\$4.7150
Revenue-Producing Water (CCF)	9,288,311	9,330,170	9,372,302	9,414,711
Average Operating Cost (\$/CCF)	\$0.468	\$0.469	\$0.473	\$0.501

The primary advantage of this technique is that it has minimal data requirements. The primary disadvantage is that, strictly speaking, this technique produces an estimate of average, not marginal operating cost. Producing an estimate of marginal operating cost can be performed using little additional data and readily available statistical methods.⁹

9 Bishop and Weber (1996) provide comparisons of regression-based estimates of marginal operating costs versus average operating costs. Since a regression model can be specified to estimate an “average” operating cost, it is wrong to attribute the difference between the two estimates solely to method. The regression-based method yielded a lower estimate because the model was able to control for the other influences upon operating costs. A simple average, by contrast, forces all variation in operating costs to be explained (caused) by output. Consider the model:

$$\text{Monthly Operating Cost} = a + b \cdot \text{Revenue Producing Quantity}$$

Where a and b are the coefficients to be estimated. If the coefficient a is constrained to be zero, the above regression equation will produce an estimate of b equivalent to an average operating cost. If the fixed cost coefficient a is not constrained and takes on a positive value, the estimated coefficient b will be the estimate of marginal operating cost and will necessarily be less than the average operating cost if a is positive.

Marginal Capacity Cost

Most of the marginal capacity cost (MCC) estimation techniques used in water system cost analysis are variations of two basic MCC approaches: (1) the avoided cost approach, and (2) the Average Incremental Cost (AIC) approach.¹⁰ A brief description and discussion of each of these techniques is provided below.

Marginal Capacity Cost as an Avoided Cost:¹¹ As explicated by Turvey, this approach expresses MCC as either the cost incurred by an acceleration in growth of demand, or as the cost avoided by a deceleration of demand. A plan for system expansion is taken as a given, and only the timing of that expansion is varied; plans for system expansion are not re-optimized, only rescheduled. The original Turvey method examined the savings associated with slowing down system expansion through conservation. The cost numerator was formed by the change in the present value of capacity expenditures by moving the capacity increment forward into the future. The usage denominator was the annual change in demand that allowed the postponement of the capital facility. The original method focused on the change in cost associated with a postponement or acceleration of the construction period.

Clearly, the avoided capital cost calculated by the Turvey method applies directly to valuing the worth of water use efficiency programs. WUE programs directly attempt to affect the growth of expected water demand. This change to water demand, if quantified, constitutes the quantity denominator of the marginal capital costs estimate. The more difficult part of the task would then be calculating what capital costs could then be postponed or avoided.

ILLUSTRATION OF TURVEY MCC METHOD



The following example illustrates the calculation of MCC under the Turvey method. Assume that the utility planned to construct a treatment facility in three years (Year 3). As a result of demand management and conservation programs, annual demand decreases by 1,000 CCF per day (838 acre-feet per year). This decrease in demand allows the construction of a treatment facility to be postponed for one year (from Year 3 to Year 4.) The treatment facility costs \$17.0 million. Taking the utility's planning discount rate of four percent (at a real or inflation-adjusted level), the \$17.0 million spent three years from today would have a present value of $(PV = \$17.0 \text{ million} \div (1+.04)^3 =)$ \$15.113 million. By comparison, an additional year's delay would yield a present value of $(PV = \$17.0 \text{ million} \div (1+.04)^4 =)$ \$14.532 million. The cost numerator is the difference in the present value of capital expenditures by delaying the capital project from year three to year four ($\$15.113 \text{ million} - \$14.53 \text{ million} =)$ \$0.581 million. (Methodical analysts might also include a small adjustment for the residual difference in scrap value, due to a finite facility project life.) Dividing the change in cost of \$0.581 million by the change in annual demand produces a MCC of 1.59 \$/CCF. This estimate added to the MOC for the new facility produces the estimated total long-run marginal cost estimate.

Several notable characteristics of the original Turvey method (1976) are:

10 Both approaches were summarized in Chapter 15 of the AWWA Manual M-1 Principles of Water Rates, Fees, and Charges, 5th Edition, 2000. (The reader should beware the error in equation 15-1.) The more recent 6th Edition of the Manual M-1 provides an entirely less coherent summary of Marginal Cost Pricing—caveat lector.

11 Turvey, R. (1976) "Analyzing the Marginal Cost of Water Supply," Land Economics, 52, 158-168, May 1976.

1. The method produces an annual (not seasonal), estimate of MCC that changes each year. (Marginal costs are the same in the peak and off peak season.)
2. The size of the planned system expansion only enters into the cost numerator. The quantity denominator is strictly determined by the change in annual demand that allows the deferral. Both of these quantities are empirically difficult to estimate and are associated with considerable uncertainty. If the postponement period, in the above example, were expressed as a range from 0 to 2 years, then the MCC would vary between zero and 3.12 \$/CCF.
3. The Turvey MCC gets larger as the system gets closer to its capacity limitations and is zero otherwise. Since water projects involve large discrete changes in system capacity, the resulting Turvey marginal cost estimates could be volatile. The Turvey MCC focuses only on the next capacity increment, ignoring the cost consequences of subsequent increments.

Different variants of the Turvey approach have been proposed:

1. To produce a seasonal estimate of MCC, Hanke (1975) suggested categorizing cost data into facility costs designed to meet peak demands and system costs designed to meet average demands. Hanke (1981) implemented a seasonal variant of a Turvey avoided capital cost by disaggregating cost and consumption data into peak and off-peak periods.
2. Several applications have stressed quantifying the demand expected in the future and linking changes in this expected demand to the corresponding sizes of the deferrable facilities. (For an illustration, see Hanke, 1981). These variants of the Turvey approach will use the same numerator (the difference in the present value costs of two differently timed but otherwise identical system expansions) while substituting the planned usable facility capacity (that matches the avoided demand) into the denominator. The denominator is also adjusted downward to account for the effect of system loss; due to distribution leaks, more than one gallon must be produced to deliver one gallon of water.
3. Several variants of the Turvey method use an averaging of the marginal cost over several years for different rationales:
 - as the long run consistent strategy that results when an administrative feasibility constraint is included in an optimal planning framework (Dandy, 1984),
 - to produce a consistent price signal for long-term decision making (Boiteux, 1959), and
 - as a more appropriate tradeoff between short-run allocative efficiency (efficient use of existing capacity) and long-run resource efficiency (efficient capacity-sizing decisions) (Mann et al., 1980).

The original Turvey method (1976) is direct, relatively straightforward, and requires only data available in the existing water system plan. As such, it is easily interpretable as the direct cost of additional (or avoided) water use. Though directly appropriate for assigning value to conservation (demand-side management), strict implementation of the original Turvey method has several shortcomings: it does not reflect the higher cost of using water during peak periods (without an additional seasonal allocation step), it becomes erratic when capacity increments are lumpy, and it does not look beyond the next capacity increment. The reader should note that CUWCC and the U.S. EPA developed avoided costing models that avoid the above deficiencies. Though models will be discussed later, they should be understood as building on these simple methods while applying more realism and rigor.

Marginal Capacity Cost as an Average Incremental Cost: The Average Incremental Cost (AIC) approach for estimating MCC involves the annualization of incremental cost. Sometimes also referred to as a “Levelized Cost,” the AIC approach first involves calculating annualized capacity cost (K), which is defined as the annual payment, over the useful service life of the new capacity (n), required to recover both financing costs and the additional capacity costs:

$$K \equiv \frac{C \cdot i \cdot [1 + i]^n}{[1 + i]^n - 1}$$

where: K = total annualized incremental capacity costs,

C = total capital expenditure required,

N = useful service life of the capacity increment, and

i = appropriate financing (interest) rate.

“ K ” must be calculated for each system function (that is, source development, transmission, treatment, distribution, etc.) in which a capacity increment is planned, since service lives will vary across these functions. “ K ” can be disaggregated into peak/off-peak components. The output (quantity) denominator is based on the expected annual delivery capacity, adjusted for system losses.¹²

The output (quantity) denominator is based on the designed annual capacity (annual firm yield). The planned capacity, however, should be adjusted to account for losses due to leakage in the system. System losses mean that more than one gallon must be produced to deliver one gallon to the customer. For example, a system loss of 10 percent implies that 1.11 gallons must be produced for each gallon delivered. The output denominator can be expressed as revenue-producing annual capacity (annual planned delivery capacity averaged over the life of the plant).¹³

12 Incremental costing for each service element required for production are more common with other utility services that use “unbundled” ratemaking, such as Telcom. The FCC refers to this approach as TELRIC: Total Element Long Run Incremental Cost.

13 Some AIC calculations take the accounting an additional step, separately accounting for the capacity that is used and the capacity that is held in reserve. Analysts should avoid using “expected capacity utilization” as the output denominator; this sends the exact wrong short run signal. (Since the expected utilization is low immediately after construction of a capacity increment and is high as the maximum capacity is approached, AIC with expected utilization in the denominator would send a high/low price signal when capacity is plentiful/scarc.) This handbook therefore recommends use of expected capacity utilization averaged over the life of the project, adjusted for system loss.

ILLUSTRATION OF AVERAGE INCREMENTAL COST (AIC) MCC METHOD



Continuing the previous example, the AIC method can be used to estimate the marginal capital cost of the same new treatment facility. Assuming that the treatment plant has a useful service life of 25 years ($n=25$), and that the real annual interest rate is 4 percent (7 percent nominal financing rate and a 3 percent rate of inflation), the AIC method produces an annualized capacity cost (K) of \$1,088,203. Dividing by the planned capacity of 10,000 CCF per day, the AIC method estimates the MCC of the treatment plant to be:

$$\$1,088,203 \div 10,000 \text{ CCF/day} \times 365 \text{ days} = 0.298 \text{ \$/CCF}$$

This AIC is then added to the MOC to yield the total marginal cost. Because the AIC method involves averaging, its results are less sensitive to changes in the assumptions than other methods. A service life of 20 years produces an estimated AIC of 0.343 \$/CCF and a real interest rate of 5.0 percent changes the estimated AIC to 0.330 \$/CCF.

The example is simplistic because not all components of a treatment plant will have the same service life. More importantly, a treatment plant is of little use if a utility does not have a corresponding raw water source, pumping and transmission capacity to move the water, and storage facilities to handle fluctuations in system load.

A more realistic example of the AIC method for a major system expansion is illustrated in Table B.3. Supply, treatment, pumping and storage capital improvements all are required for a major system expansion. Any costs related to expansion of the distribution system are considered customer costs and are not included in the AIC calculation. An analysis of each function determines the capital cost, useful physical life, and annual capacity cost. Annual capacity costs are summed by function and totaled. To derive the AIC estimate, the total annual capacity costs are divided by the output measure to arrive at a AIC per CCF. The summary at the bottom of **Table A.3** shows the effect of accounting for a 12 percent system loss by comparing marginal capital costs using the planned firm yield of the system expansion and the deliverable water (88 percent of the firm yield.) The AIC method produces an estimate of \$ 1.91 per CCF for the system expansion.

Table A.3 Illustration of AIC Method for calculating the MCC of System Expansion

DESCRIPTION	TOTAL CAPITAL EXPENDITURE (C)	LIFE (N)	ANNUALIZED INCREMENTAL CAPACITY COST (K)	
Supply				
Wells	\$15,000,000	40	\$757,852	
Reservoirs	\$30,000,000	40	\$1,515,705	
Transmission Mains to Dist. System	\$5,000,000	100	\$204,040	
Land	\$18,500,000		\$740,000	
Total Supply Capacity Cost	\$68,500,000		\$3,217,597	
Treatment				
Facilities	\$10,000,000	25	\$640,120	
Equipment	\$5,000,000	20	\$367,909	
Land	\$2,000,000	-	\$80,000	
Total Treatment Capacity Cost	\$17,000,000		\$1,088,028	
Pumping				
Structures	\$18,000,000	50	\$837,904	
Equipment	\$5,750,000	20	\$423,095	
Total Pumping Capacity Cost	\$23,750,000		\$1,260,999	
Storage				
Facilities	\$10,000,000	50	\$465,502	
Land	\$2,500,000	-	\$100,000	
Total Storage Capacity Cost	\$12,500,000		\$565,502	
Summary	Annualized Capacity Costs (K) \$		Marginal Capacity Costs (K / Yield) \$ per CCF	Marginal Capacity Costs (K / Delivery) \$ per CCF
Supply Capacity Costs	\$3,217,597		\$0.882	\$1.002
Treatment Capacity Costs	\$1,088,028		\$0.298	\$0.339
Pumping Capacity Costs	\$1,260,999		\$0.345	\$0.393
Storage Capacity Costs	\$565,502		\$0.155	\$0.176
Total Capacity Costs	\$6,132,126		\$1.680	\$1.909
Increment to Supply (CCF/year), Planned Yield = 10,000 CCF/day * 365 days/year Delivery Capacity = Yield* (1-SystemLoss(12percent))			3,650,000	3,212,000

The average costs for additional capacity increments can be used to calculate a downsizing avoided cost attributable to reduced demand. This relatively straight forward process involves comparing two average incremental capacity costs—the AIC designed without the effect of conservation programs and the AIC of a system designed with conservation. Though the calculation of avoided capacity costs due to downsizing is less common, it is mentioned here for several reasons. First, it is a valid method that has found use in the water industry. Second, these costing methods also provide the basis for the determination of a “good” price signal to be provided by water rates. Last, calculation of average incremental costs by function can serve as a useful benchmark for other costing methods.

CUWCC Avoided Cost Models – Water and Wastewater

CUWCC — with the Water Research Foundation and the US EPA as partners — historically developed two companion models to estimate costs that are avoided on the water supply and wastewater systems as a result of water use efficiency (WUE)-induced demand reductions.

A complete picture of the costs and benefits of WUE include the costs avoided by the water supply utility, avoided environmental degradation from water not supplied, wastewater system costs avoided due to more efficient water use, and avoided stormwater management costs. The primary use of these models is to assist in valuing the economic benefits of WUE (conservation) programs; The typical users of the model are water and wastewater system staff, managers and decision makers.

Model Characteristics. Both avoided cost models are characterized by a two period time step (peak/off peak), a long planning horizon (over fifty years), and an annual summary of both short and long run avoided costs over the entire planning horizon. A set of common assumptions are imposed for a consistent economic logic—projected interest rate, projected inflation rate, a consistent planning time horizon, and user-selectable units of measure for inputting flow and volume.

Both of these avoided cost components are differentiated by season, so that the avoided costs in the peak-demand season may differ from those in the off-peak season. They also may change over time, as cost components escalate and as system configurations change. Thus, avoided costs are expressed annually—in tabular form or as a chart.

Figure A.3 is the flow chart of the US EPA/CUWCC Wastewater Avoided Cost Model where clicking on a flow object takes the user to the model input or output sheet.

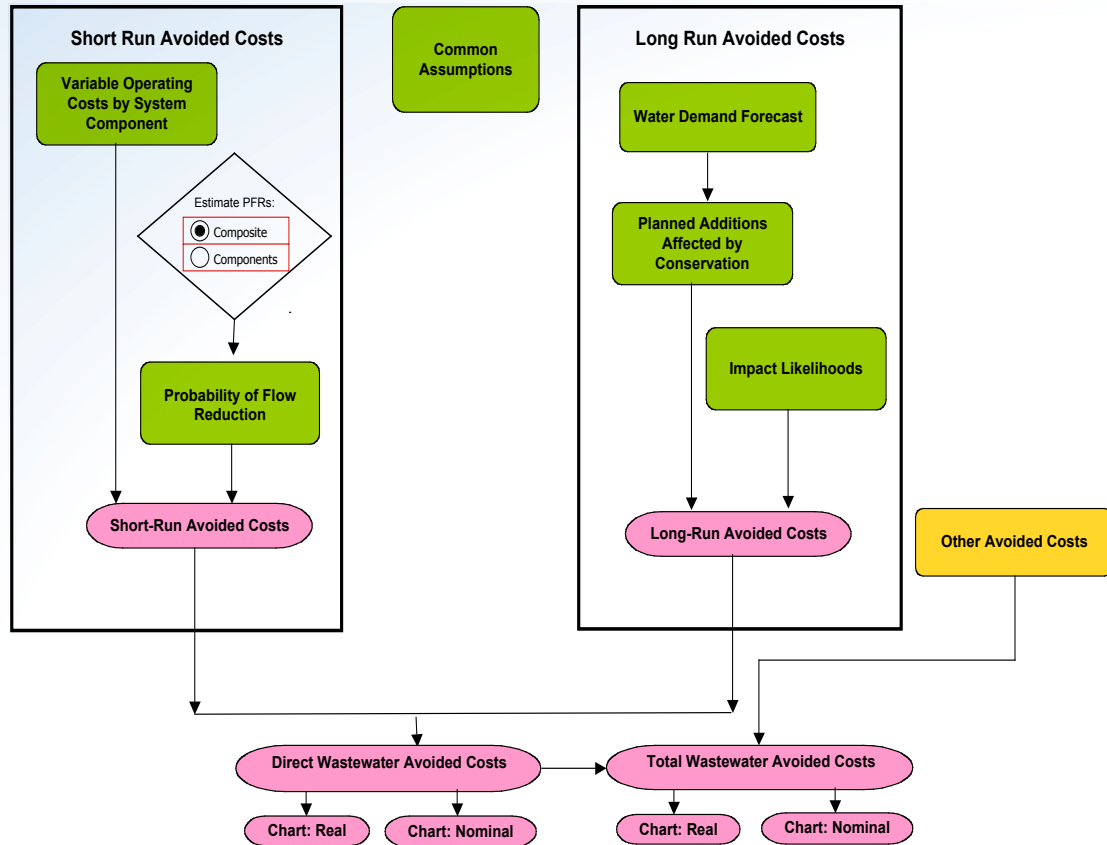


Figure A.3 USEPA/CUWCC Wastewater Avoided Cost Model Flow Chart

Table A.4 and Figure A.4 show typical tabular and graphical outputs of the *WaterRF/CUWCC Direct Utility Avoided Cost Model*. This model and the instructions for use can be found on the CUWCC website.

Table A.4 WaterRF/CUWCC Direct Utility Avoided Cost Model: Sample Water Supply Avoided Cost

Total Direct Utility Avoided Costs: Nominal Dollars						
(\$/mg)						
Year	Peak Season			Off-Peak Season		
	Short-Run	Long-Run	Total	Short-Run	Long-Run	Total
2007	\$228	\$0	\$228	\$225	\$0	\$225
2008	\$234	\$0	\$234	\$232	\$0	\$232
2009	\$241	\$0	\$241	\$238	\$0	\$238
2010	\$247	\$0	\$247	\$245	\$0	\$245
2011	\$254	\$0	\$254	\$251	\$0	\$251
2012	\$274	\$923	\$1,197	\$267	\$0	\$267
2013	\$281	\$924	\$1,205	\$274	\$0	\$274
2014	\$289	\$924	\$1,213	\$282	\$0	\$282
2015	\$297	\$1,469	\$1,766	\$289	\$0	\$289
2016	\$305	\$1,469	\$1,775	\$297	\$0	\$297
2017	\$361	\$1,470	\$1,831	\$321	\$0	\$321
2018	\$372	\$1,470	\$1,842	\$330	\$0	\$330
2019	\$382	\$1,470	\$1,852	\$339	\$0	\$339
2020	\$393	\$1,471	\$1,863	\$349	\$0	\$349
2021	\$404	\$1,471	\$1,875	\$359	\$0	\$359
2022	\$409	\$1,472	\$1,881	\$369	\$352	\$721
2023	\$421	\$1,472	\$1,893	\$379	\$352	\$731
2024	\$433	\$4,645	\$5,078	\$389	\$353	\$742
2025	\$445	\$4,654	\$5,098	\$400	\$353	\$753
2026	\$457	\$4,662	\$5,119	\$411	\$353	\$764
2027	\$497	\$4,671	\$5,167	\$420	\$353	\$773
2028	\$511	\$4,679	\$5,190	\$431	\$353	\$785
2029	\$525	\$4,689	\$5,214	\$443	\$354	\$797
2030	\$540	\$3,898	\$4,437	\$456	\$7	\$463
2031	\$555	\$3,794	\$4,349	\$468	\$7	\$476
2032	\$573	\$3,804	\$4,377	\$478	\$9	\$487
2033	\$589	\$3,815	\$4,404	\$491	\$9	\$500
2034	\$606	\$3,825	\$4,431	\$505	\$9	\$515
2035	\$623	\$3,291	\$3,914	\$519	\$10	\$529
2036	\$641	\$3,302	\$3,943	\$534	\$10	\$544
2037	\$659	\$3,314	\$3,973	\$549	\$10	\$559
2038	\$678	\$3,326	\$4,004	\$564	\$11	\$575
2039	\$697	\$3,338	\$4,035	\$580	\$11	\$591
2040	\$717	\$3,351	\$4,068	\$596	\$11	\$608

Total Direct Avoided Costs: Nominal Dollars

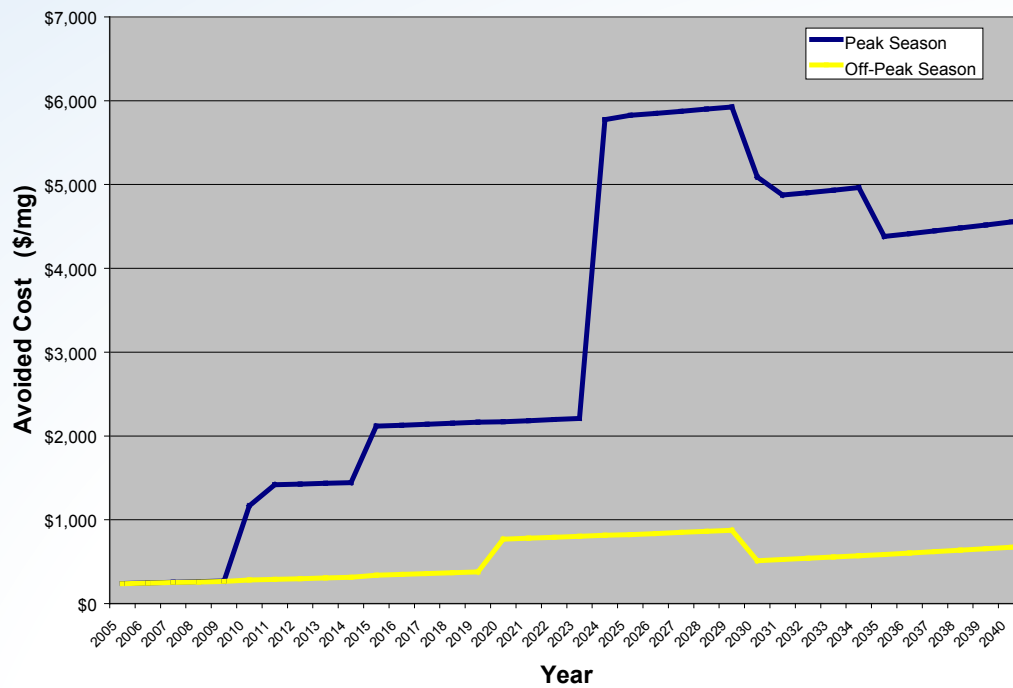


Figure A.4 WaterRF/CUWCC Direct Utility Avoided Cost Model Sample Water Supply Avoided Cost Chart

Table A.5 and Figure A.5 show typical tabular and graphical wastewater avoided cost results by year and season. As with the Water Avoided Cost Model, the results are generated as a vector over time, rather than as a scalar. Avoided costs outputs are summarized in both nominal dollars (as used in financial plans) and real dollars (as used for economic decision making).

Table A.5 USEPA/CUWCC Wastewater Avoided Costs

Direct Wastewater Avoided Costs (\$/mg)									
Nominal Dollars					2008 Dollars				
Year	Peak-Demand Season		Off-Peak Demand Season		Year	Peak-Demand Season		Off-Peak Demand Season	
	Indoor	Outdoor	Indoor	Outdoor		Indoor	Outdoor	Indoor	Outdoor
2008	\$157	\$49	\$237	\$98	2008	\$157	\$49	\$237	\$98
2009	\$161	\$50	\$244	\$101	2009	\$158	\$49	\$239	\$99
2010	\$182	\$55	\$517	\$235	2010	\$175	\$53	\$497	\$226
2011	\$187	\$57	\$525	\$239	2011	\$176	\$53	\$495	\$225
2012	\$192	\$58	\$533	\$242	2012	\$177	\$54	\$492	\$223
2013	\$197	\$60	\$540	\$245	2013	\$178	\$54	\$490	\$222
2014	\$203	\$61	\$549	\$249	2014	\$180	\$55	\$487	\$221
2015	\$208	\$63	\$603	\$275	2015	\$181	\$55	\$525	\$240
2016	\$214	\$65	\$612	\$279	2016	\$183	\$55	\$523	\$238
2017	\$220	\$67	\$621	\$283	2017	\$184	\$56	\$520	\$237
2018	\$210	\$64	\$1,010	\$501	2018	\$172	\$53	\$835	\$476
2019	\$216	\$66	\$1,028	\$584	2019	\$174	\$53	\$827	\$470
2020	\$230	\$70	\$1,426	\$1,354	2020	\$181	\$55	\$1,125	\$1,068
2021	\$236	\$72	\$1,436	\$1,358	2021	\$183	\$55	\$1,110	\$1,050
2022	\$243	\$74	\$1,447	\$1,363	2022	\$184	\$56	\$1,097	\$1,033
2023	\$246	\$75	\$1,517	\$1,493	2023	\$183	\$56	\$1,127	\$1,109
2024	\$253	\$77	\$1,528	\$1,497	2024	\$184	\$56	\$1,113	\$1,091
2025	\$260	\$80	\$1,540	\$1,502	2025	\$186	\$57	\$1,100	\$1,073
2026	\$268	\$82	\$1,551	\$1,507	2026	\$187	\$57	\$1,086	\$1,055
2027	\$275	\$84	\$1,564	\$1,512	2027	\$189	\$58	\$1,073	\$1,038
2028	\$283	\$87	\$1,640	\$1,644	2028	\$191	\$58	\$1,103	\$1,107
2029	\$291	\$89	\$1,652	\$1,650	2029	\$192	\$59	\$1,090	\$1,080
2030	\$300	\$92	\$1,666	\$1,655	2030	\$194	\$59	\$1,077	\$1,071
2031	\$308	\$94	\$1,679	\$1,661	2031	\$196	\$60	\$1,065	\$1,053
2032	\$317	\$97	\$1,694	\$1,667	2032	\$197	\$60	\$1,053	\$1,036
2033	\$321	\$99	\$1,703	\$1,670	2033	\$196	\$60	\$1,038	\$1,018
2034	\$330	\$102	\$1,718	\$1,676	2034	\$197	\$61	\$1,026	\$1,002
2035	\$340	\$105	\$1,488	\$1,560	2035	\$199	\$61	\$877	\$914
2036	\$350	\$108	\$1,504	\$1,567	2036	\$201	\$62	\$864	\$900
2037	\$360	\$111	\$1,520	\$1,574	2037	\$203	\$62	\$856	\$886
2038	\$366	\$112	\$1,533	\$1,576	2038	\$202	\$62	\$846	\$870
2039	\$377	\$115	\$1,550	\$1,583	2039	\$204	\$62	\$839	\$857
2040	\$388	\$118	\$1,522	\$1,567	2040	\$206	\$63	\$808	\$832

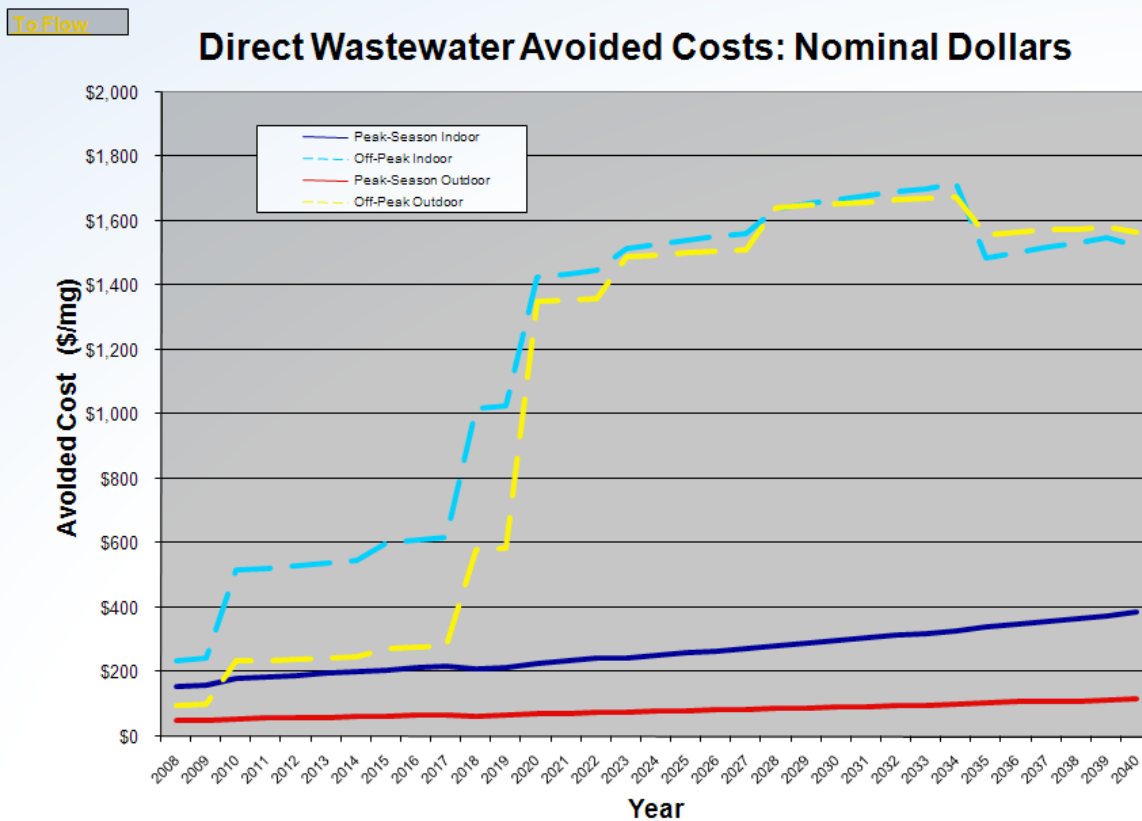


Figure A.5 USEPA/CUWCC Wastewater Avoided Cost Chart Output

These two models constitute an approach that incorporates the requisite analytical rigor in fashion that is usable by and adaptable to the needs of different water utilities. The avoided cost models provide a motion picture of the real economic cost consequences of consumption over time. The pat answer to the question as to which price signal—short-run or long run—should be used is: “In the short-run, prices should reflect short run marginal costs and in the long run, prices should reflect the long run marginal costs.” This principle may not provide the necessary guidance. If the long term expansion path of the water utility displays increasing avoided costs, then current customers need to be provided this information for efficient decision to be made. Utilities managers can decide how to shape the avoidable costs into feasible price signals in water rates over time.

Comparing Cost of Service Analyses: Average/Embedded vs. Marginal/Incremental

Cost of Service Analysis (COSA) can be conducted on a traditional average/embedded approach or on a marginal/incremental approach. The alternative methods are not substitutes for one another and are often combined. This section outlines the alternative approaches and suggests how they might be combined.

- Cost Functionalization
- Cost Classification
- Cost Allocation

Figure A.6 shows the “top down” steps of an Average/Embedded Cost of Service Analysis, beginning with the total costs (total revenue requirements) being separated into smaller bins: 1) the total costs are placed into functionalized cost bins—supply, transmission, distribution, and customer costs; classified into cost types—either commodity/demand or base/extra capacity; allocated to customer classes by an allocation factor.

Figure A.6 Average/Embedded Cost of Service Approach

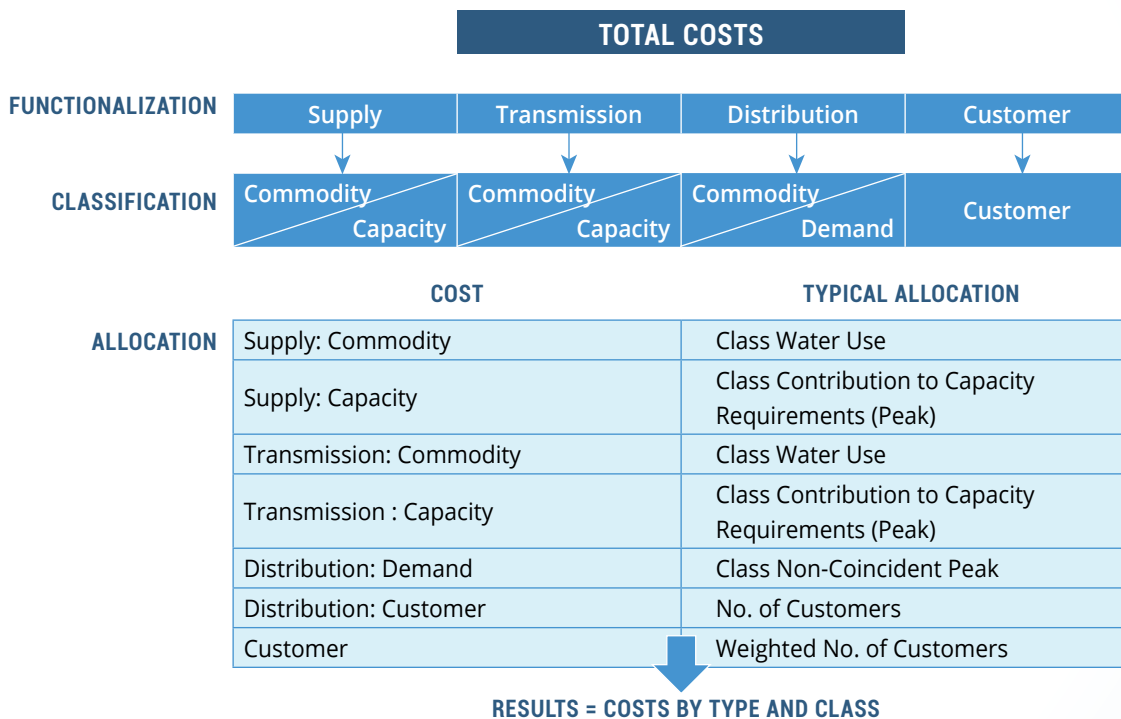


Figure A.7 shows the “bottom up” steps of a Marginal/Incremental Cost of Service Analysis that begins with identification of the marginal/incremental unit costs per function and allocates cost responsibility to individual customer classes. Class specific cost responsibility determines the class share of the total costs (total revenue requirements):

- Cost Functionalization
 - Assign costs (revenue requirements) to major functional categories based on cost drivers:
 - Supply, Distribution, Transmission, Customer, or A&G.
- MC Unit Cost Definition & Development
 - Determine the choice of units to allocate costs within functional categories (e.g., average usage, peak usage (capacity), number of customers).
 - Develop marginal unit costs by function.
- Customer Class Cost Allocation
 - Develop marginal costs by customer class by allocating functional costs to stable customer classes based on applying the marginal cost to the classification units for each class.
 - Compare the marginal costs to the current revenues.

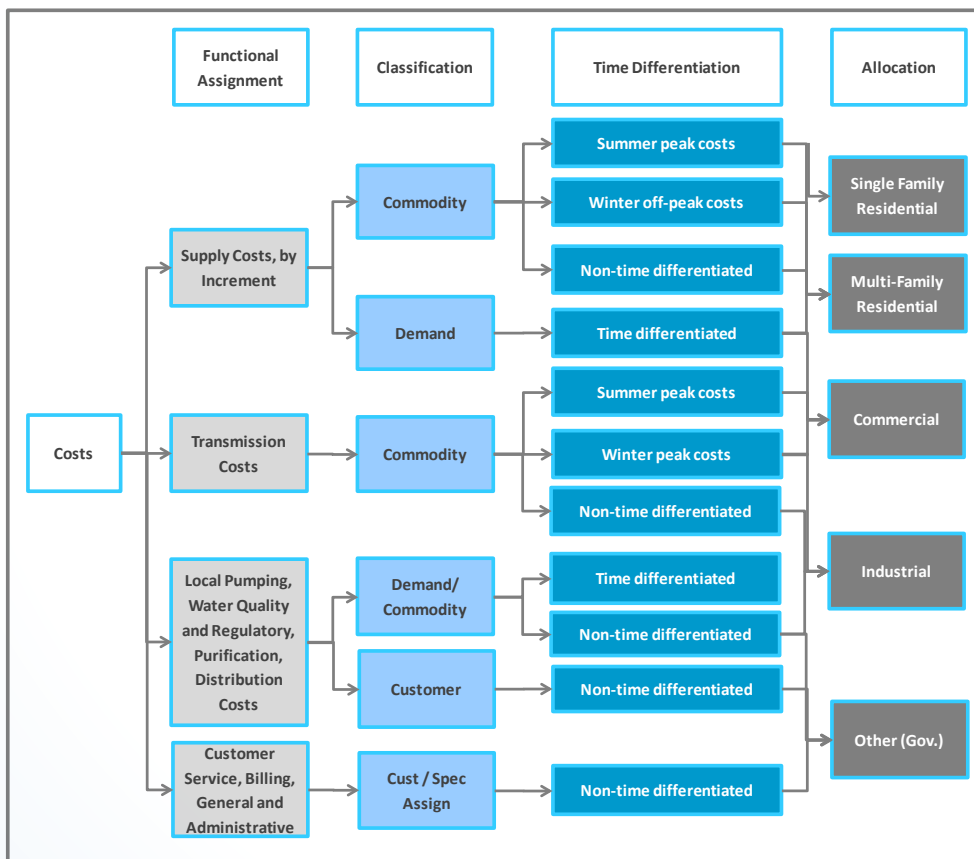


Figure A.7 Steps of a Marginal/Incremental Cost of Service Analysis

Table A.6 sets forth the different dimensions along which these two methods can be contrasted.

Table A.6 Cost Methods Contrasted

AVERAGE/EMBEDDED	MARGINAL/INCREMENTAL
Allocation of total revenue requirements to smaller and smaller “buckets” (top-down)	Identification of unit costs (bottom-up)
Cost allocated to classes using some measure of cost causation	Costs by demand load level
Based on history	Forward-looking
Rarely time-differentiated (Non-Coincident Peak)	Detailed time-differentiation
Capital costs often treated as completely capacity/demand-related	Not all capital costs are capacity/demand-related
Allocated costs total to overall revenue requirement (more or less)	“Revenue gap” is likely

It should be noted that a Marginal/Incremental COSA does not provide the total revenue requirement for the test period. Thus, a Marginal/Incremental COSA does not replace the traditional definition of the revenue requirement. It does provide information for rate design on the cost consequences for the water utility of customer consumption in different time periods.

Conclusion

All of the foregoing approaches shed light on the issues that must be addressed in estimating utility costs for ratemaking. Traditional costing methods are still required to generate the utility revenue requirement and avoid monopoly rents. Marginal/Incremental costs provide more accurate price signals to customers of the cost-causative consequences of consumptive decisions.



Appendix B

Demand Forecasting and Revenue Modeling



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Introduction

Demand forecasting serves as a critical step in the planning, design and evaluation of a rate structure. In order to ensure that revenue collected will cover costs, water suppliers need to anticipate how much water they expect to sell. As water rates are typically reviewed and revised every few years, it is also important that water suppliers forecast future demand several years in advance to ensure that sufficient funds are collected.

Robust evaluation of efficiency-oriented rate structures requires an additional layer of forecasting impacts. Since variations in demand tend to create revenue volatility, forecasting models must consider the impact of block rate structures not just on demand, but also on sales revenue. Accurately forecasting long-term sales volume lies at the heart of establishing a correct rate level. Analysts must consider water supply availability, future water demand, and the effect of different types of rates on revenue.

This appendix covers approaches, concepts and methods for water demand and water sales/revenue modeling.¹

Demand Modeling

Different types of models can be used to incorporate the various forces driving water demand. Models can be classified as aggregate (total water demand for an entire service area or customer class) or disaggregate (demand by individual customer or individual end uses). In principle, disaggregate models can answer a wider range of questions; they also require more detailed data, more data manipulation, and more data validation effort. For readers interested in pursuing a modeling effort using disaggregated data, an example of disaggregate models applied to the prediction of revenue uncertainty can be found in Chesnutt, et al. (1995b). For the heuristic purposes of this handbook, aggregate data are used to illustrate models of water demand.

Most methods used to predict the effect of rate changes on demand response look at average water demand. Customer billing records provide a good tool for seeing these demand distributions, which tend to be very skewed. Figure B.1 depicts the parametric demand distribution from a random sample of single family customers using recent year data—with values for the mean and standard deviation (logarithm of bimonthly use) of 3.4 and 0.7 respectively. The distribution is notably skewed to the right; relatively few customers use a large amount of water.

¹ Parts of this appendix were adapted from “*Designing, Evaluating, and Implementing Conservation Rate Structures*”, July, 1997, California Urban Water Conservation Council.

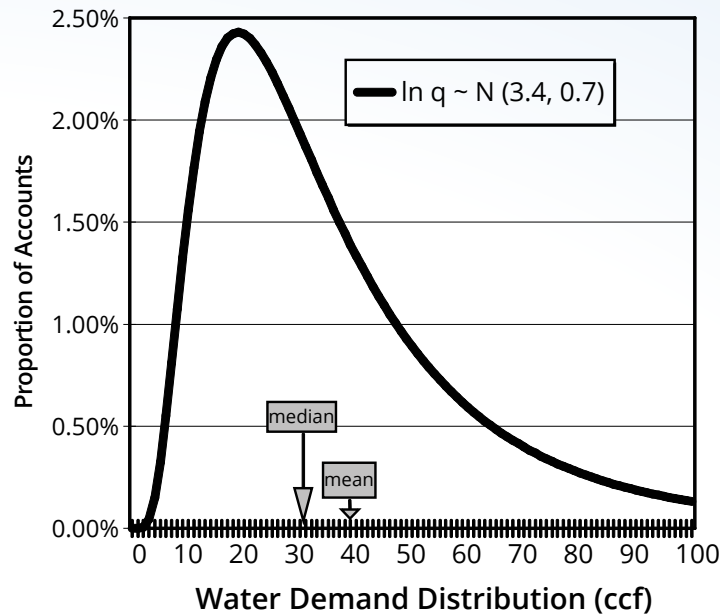


Figure B.1 Distribution of Single Family Water Demand

A right-skewed distribution complicates the design of block rate structures. Revenue prediction for block rate structures requires a more nuanced model than average water demand alone; it requires a model of the entire demand distribution (Chesnutt, et al. 1995b). The rate analyst might want to know how many customers and how much water would be affected by a second block. To estimate revenue, the analyst must know how much water is affected by the higher price in the second block. The next complication in estimating revenue from blocks is accounting for the fact that not all of the water used by customers in the second block is priced at the higher second price.

Model Zero: Water Requirements Model

The date is July 14, 2010. The location is West Anywhere. The water manager of the West Anywhere Water Authority (WAWA) has asked the in-house expert to forecast water sales for next year. The rate analyst hit the recalculate button on the computer and results were produced: water sales in the next year will be about 35 thousand acre feet. The manager inquired as to the model behind this prediction. "Well, the city planning department has projected next year's population of around 170 thousand people and water requirements for the last twenty years have averaged about 183 gallons per capita per day. The rest is algebra (170,000 people x 183 gallons per capita per day x 365 days per year / 325900 gallons per AF = 34,842 AF)".

The astute manager, worried that recent trends might change the result, asked the analyst to repeat the calculation using water requirements only from the last three years. The rate analyst hit the recalculate button on the computer, the lights dimmed, and results were produced: water sales in 2011 will be 35,600 thousand acre feet. "Are you sure," demanded the manager? "Yes, I hit the recalculate button three times before the lights blew. I got the same answer each time."

Confident in this sensitivity analysis, the water manager adopted 35 thousand acre feet as the 2011 sales forecast. The water sales in the next year ended up being less than 27 thousand acre feet. Later the manager and the analyst compared notes in the unemployment line: “Where did we go wrong?” They decided to think more formally about their mistaken analysis. They began with a formal statement of the water requirements model:

$$\begin{aligned} \text{Sales Quantity} &= f(\text{Population}), \text{ or} \\ Q &= \text{Pop} \cdot \mu, \text{ where} \\ \mu &\equiv \text{mean use per person} \end{aligned}$$

They decided that this explanatory model should be expanded to account for more determinants of water demand. They decided that to conduct their retrospective analysis in a spreadsheet (demand.xls) using a monthly data set compiled by the previous year’s summer intern.

Model 1: A Very Simple Water Use Model

The first step to improving the water requirements model requires adding additional explanation to the sales model. A simple possibility would be to add measures of weather— temperature and precipitation—to the model. In functional notation, the model would be described as:

$$\text{Sales Quantity} = f(\text{Population}, \text{Temperature}, \text{Rainfall})$$

To make the model explicit, one must specify exactly how these determinants relate to sales, that is, the form of the function f . A simple possibility would be a linear equation for monthly water sales:

$$Q_t = \beta_0 + \beta_1 \cdot \text{Pop}_t + \beta_2 \cdot \text{Temp}_t + \beta_3 \cdot \text{Rain}_t$$

Through the miracles of modern statistical technology, the four coefficients (β_0 - β_3) can be estimated to “fit” this surface to observed data. Each of the β parameters also has an interpretation— β_0 is the “intercept” that represents a constant level of sales each month and the other β ’s are the “slope” coefficients of the determinants. These slope coefficients represent how water sales would change if one determinant changes by a small amount while all other determinants remained unchanged. For example, we expect use to decrease if rainfall increases in a given month; therefore β_3 should be a negative quantity. The reverse holds for temperature and population, so β_1 and β_2 should be positive values.

If life were simple, the systematic determinants in the model described by the equation above would fit the data perfectly: all water sales on record would lie on the plane defined by f . Clearly, this will not be a problem that many analysts need lose sleep over. The vertical distance from any point to this plane defines the nonsystematic error in the model. Defining this quantity by ϵ , the very simple model of water use (Model 1 in the spreadsheet) can be described as

$$Q_t = \beta_0 + \beta_1 \cdot \text{Pop}_t + \beta_2 \cdot \text{Temp}_t + \beta_3 \cdot \text{Rain}_t + \epsilon_t$$

In general, modelers are happier when they can minimize the unexplained random error of a model while maximizing a model’s explanatory power. The most popular regression method, Least Squares, derives its coefficient estimates so as to minimize the (squared) error around the equation.

Current generation spreadsheets implement Least Squares regression as an analysis option. The reader may visit the accompanying spreadsheet (demand.xlw) to produce estimates of the four coefficients in the model described by equation above.

These estimates imply the following water use equation:

$$Q_t = -84.7 + 0.31 \cdot Pop_t + 1.61 \cdot Temp_t - 53.4 \cdot Rain_t + \varepsilon_t$$

The coefficients may be interpreted as the effect, with everything else constant, of a one unit change in the determinant upon the dependent variable, water sales. Thus, a one unit increase in Anywhere population (one thousand people) would result in a .31 acre foot per day increase in monthly water sales. Similarly, a one unit increase in precipitation (inches per day) would result in a 53.4 acre foot per day decrease in monthly water sales and a one unit increase in monthly average maximum daily air temperature (degrees Fahrenheit) would result in a 1.6 acre foot per day increase in monthly water sales. Note that our unemployed research team was careful to standardize all measures for the number of days in the month to ensure comparability.

Critique: The main strength of this model is ease of explanation. Technically, the model has more than a few shortcomings. The “fit” of the model is not terrific for a trending dependent variable. The R^2 statistic ($R^2=.77$) refers to the proportion of the variation in water sales explained by the model; Model 1 explains about 77 percent of the variation in water sales. The estimated error, implied by the estimated coefficients, is far from random. (This can be verified by plotting the estimated error, or a 12 month moving average, over time.) The functional form of the model asserts that the estimated effects remains the same in each month throughout the year; one inch of rain in January, for instance, would produce the same drop in sales as an inch in July. The rainfall and temperature measures are also highly (negatively) correlated; when rainfall increases, air temperature tends to decrease. This makes it difficult for any amount of statistical magic to discern the independent effect of each. The functional form of the model only allows for seasonal movement in sales through seasonal movements in temperature. Last, this model implies that changes in the price of water have no effect upon the level of water sales. None. Zero.

Model 2: A Simple Water Demand Model

To improve upon Model 1, several changes are adopted. First, a different functional form is specified—a logarithmic transformation—for the dependent variable and the independent variables. A different functional form illustrates a different connection between water demand and its determinants, a set of coefficients having different statistical properties, and a different set of coefficient interpretations. Second, Model 2 permits a separate intercept term for each month to better capture a constant seasonal pattern. Third, the climatic measures are expressed somewhat differently. Instead of the absolute amount of rainfall that fell in a month, the model uses the amount of rain minus the average rainfall for the month. Similarly, temperature is expressed as its deviation from monthly mean temperature. Logarithmically transformed population is expressed as its deviation from sample mean. Last, a measure of real (inflation-adjusted) marginal price is added to the model. Because all measures are logarithmically transformed, the estimated coefficients can be interpreted as elasticities: the percentage effect that a one percent change in the determinant will have on water sales. (Because the mean monthly amount of daily rainfall is fractional, a scaling factor of one is added prior to logarithmic transformation.)

Re-expressed, the second attempt at model improvement results in the following model specification:

$$\begin{aligned} \ln Q_t = & \beta_1 \cdot (\ln Pop_t - \mu_{\ln Pop_t}) + \beta_2 \cdot (\ln Price_t - \mu_{\ln Price_t}) + \beta_3 \cdot (\ln Temp_t - \mu_{\ln Temp_t}) \\ & + \beta_4 \cdot ((\ln Rain + 1)_t - \mu_{\ln Rain+1_t}) \\ & + \beta_5 \cdot (mo1 \equiv Jan. = 1) + \beta_6 \cdot (mo2 \equiv Feb. = 1) + \dots + \beta_{16} \cdot (mo12 \equiv Dec = 1) + \varepsilon_t \end{aligned}$$

Table B.1 provides the regression estimates of the Model 2 coefficients that imply the following monthly water demand equation.

$$\begin{aligned} \ln Q_t = & \beta_1 \cdot (\ln Pop_t - \mu_{\ln Pop_t}) + \beta_2 \cdot (\ln Price_t - \mu_{\ln Price_t}) + \beta_3 \cdot (\ln Temp_t - \mu_{\ln Temp_t}) \\ & + \beta_4 \cdot ((\ln Rain + 1)_t - \mu_{\ln Rain+1_t}) \\ & + \beta_5 \cdot (mo1 \equiv Jan. = 1) + \beta_6 \cdot (mo2 \equiv Feb. = 1) + \dots + \beta_{16} \cdot (mo12 \equiv Dec = 1) + \varepsilon_t \end{aligned}$$

Table B.1 A simple Model of Water Demand

SUMMARY OUTPUT, MODEL 2				
<i>Regression Statistics</i>				
Multiple R	0.919			
R Square	0.844			
Adjusted R Square	0.834			
Standard Error	0.081			
Observations	264			
<i>ANOVA</i>				
	<i>df</i>	<i>SS</i>	<i>MS</i>	<i>F</i>
Regression	16	8.897	0.556	83.765
Residual	248	1.646	0.007	
Total	264	10.543		
	<i>Coefficients</i>	<i>Standard Error</i>	<i>t Stat</i>	<i>P-value</i>
ln_pop (demeaned)	0.988	0.174	5.695	0.000
ln_price (demeaned)	-0.090	0.048	-1.887	0.060
dir_mean	-0.805	0.111	-7.251	0.000
dir_mean	0.914	0.127	7.173	0.000
mo1	4.160	0.017	239.247	0.000
mo2	4.170	0.017	239.923	0.000
mo3	4.183	0.017	240.467	0.000
mo4	4.317	0.017	248.343	0.000
mo5	4.422	0.017	254.440	0.000
mo6	4.529	0.017	260.709	0.000
mo7	4.601	0.017	264.786	0.000
mo8	4.614	0.017	264.996	0.000
mo9	4.496	0.017	258.401	0.000
mo10	4.389	0.017	252.493	0.000
mo11	4.285	0.017	246.666	0.000
mo12	4.196	0.017	241.501	0.000

The coefficients can be interpreted as the percentage effect on water demand associated with a one percent change in the determinant, with everything else constant. Thus, a one percent increase in Anywhere population results in almost one percent increase in monthly water demand. A one percent increase in the real price of water results in less than a tenth of one percent decline in water demand. A one percent increase in precipitation (over its monthly mean) results in a .8 percent increase in monthly water demand and a one percent increase in monthly average maximum daily air temperature (over its monthly mean) results in a .9 percent increase in monthly water demand. The intercept term has been given a seasonal dimension; each month has its own intercept. This monthly intercept

represents an estimate of the normal water use pattern over the historical period.

Critique: The strength of Model 2 is that it carefully separates a constant seasonal pattern from the climatic measures. Because any constant seasonal pattern has been removed from the climatic measures (the monthly averages of climate are estimated via “interim” regressions in the spreadsheet), the “departure-from-mean” form of rainfall and temperature are independent of the seasonal effect (the 12 monthly indicator or dummy variables). The logarithmic transformation of water use results in a less skewed dependent variable and a better fitting equation. The improved fit implies that the model is leaving less unexplained; the random error that remains is 1) smaller in magnitude, 2) more normally distributed, and 3) has less “structure” in it. The model, though straightforward and parsimonious, is still far from perfect:

- The effect of a drought in earlier historical periods has been ignored.
- The effects of WUE (conservation) programs have been ignored.
- The effect of climate is constant through the year (a one percent increase in temperature above normal has the same percentage effect in July and January.)
- The effect of climate has no memory (last month's or year's climate does not effect the current month.)
- The equation error still contains information that could be used to improve the (efficiency of) statistical estimation of the structural coefficients.

Further caveats are in order for the statistical estimate of the response of water demand to price. Even the single (mean) price elasticity produced by aggregate demand models tends to be very sensitive to model specification and the period of time over which the model is estimated. The fact that aggregate time-series models tend to produce unstable estimates of price response can be attributed to several factors: 1) insufficient variation in historical water rates, 2) measurement error in the price measure (any single price measure used—modal, median, or some melded average—does not reflect the true marginal price faced by each customer), and 3) omitted long-run determinants due to lack of measures or an insufficiently long time period. Empirical investigators interested in estimating the determinants of demand tend to favor customer-specific models to bring the weight of more data to bear on these difficult questions.

Model 2 does illustrate, however, that careful data construction can produce a simple model with plausible estimates of short and long-run determinants of demand. Other useful ingredients for rate evaluation also can be derived from this model. One construct that will prove very handy in the next section is a measure of the percentage effect of climate on aggregate demand. Since climatic uncertainty is a very important driver of demand uncertainty in the short-run, quantifying the magnitude of this uncertainty allows the analyst to construct a measure of revenue risk. Similarly, an estimate of the demand pattern under normal weather conditions—a constant seasonal pattern—can be derived. Estimating an average seasonal pattern permits empirical testing for changes to the pattern of seasonal peaking. Last, the model provides an explicit method for addressing how changes in rates can affect water demand.

Revenue and Sales Modeling

Most methods used to predict the effect of rate changes on demand response look at average water demand. Block rate structures, however, require a more nuanced model than average water demand alone; they require a model of the entire demand distribution (Chesnutt, et al. 1995b). Customer billing records provide a good tool for seeing these demand distributions. The distribution of customer use tends to be very skewed. To illustrate, a random sample of single family customers was taken from the WAWA billing system, with data including meter read date, meter read amount (in one hundred cubic feet, CCF), and the number of days in the billing system. For the purposes of illustration, Figure B.2 depicts the parametric demand distribution using the recent year data—with values for the mean and standard deviation (logarithm of bimonthly use) of 3.4 and 0.7 respectively. The distribution is notably skewed to the right; relatively few customers use a large amount of water.

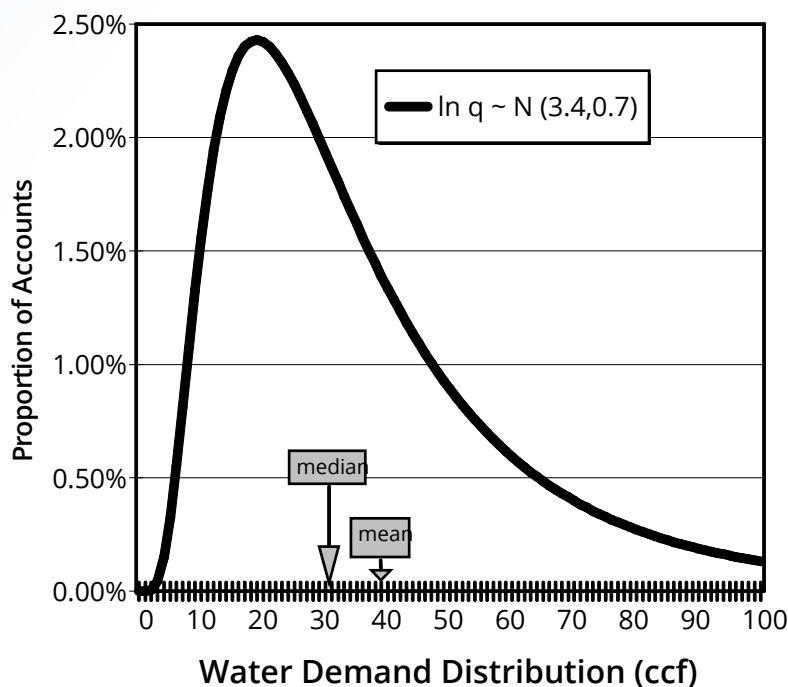


Figure B.2 Distribution of Single Family Water Demand

A right-skewed distribution characterizes water use in most water utilities and complicates the design of block rate structures. Suppose the WAWA rate analyst wants to design an increasing-block rate structure with two blocks. It directly follows from Figure B.2 that if the switch point—where the first block ends and the second begins—were set to median water use (about 31 CCF per bimonthly), then half of the customers would see the lower price in block 1 and half of the customers would face the higher price in block 2. Does this mean half of all water consumption is facing price 1 and the other half faces price 2? No. The mean of the distribution in Figure B.2 (about 40 CCF) would be the switch point where water consumption is split in half.

Customer Accounts versus Water Use in an Upper Block

The WAWA rate analyst might want to know how many customers and how much water would be affected by a second block. Figure B.3 plots the proportion of customer accounts falling into the second block as the block switch point changes. To estimate revenue, the analyst must know how much water is affected by the higher price in the second block. Figure 8.3 also illustrates that the proportion of water use falling into the upper block is greater than the proportion of accounts. This fact is directly implied by the right skewed distribution of water consumption.

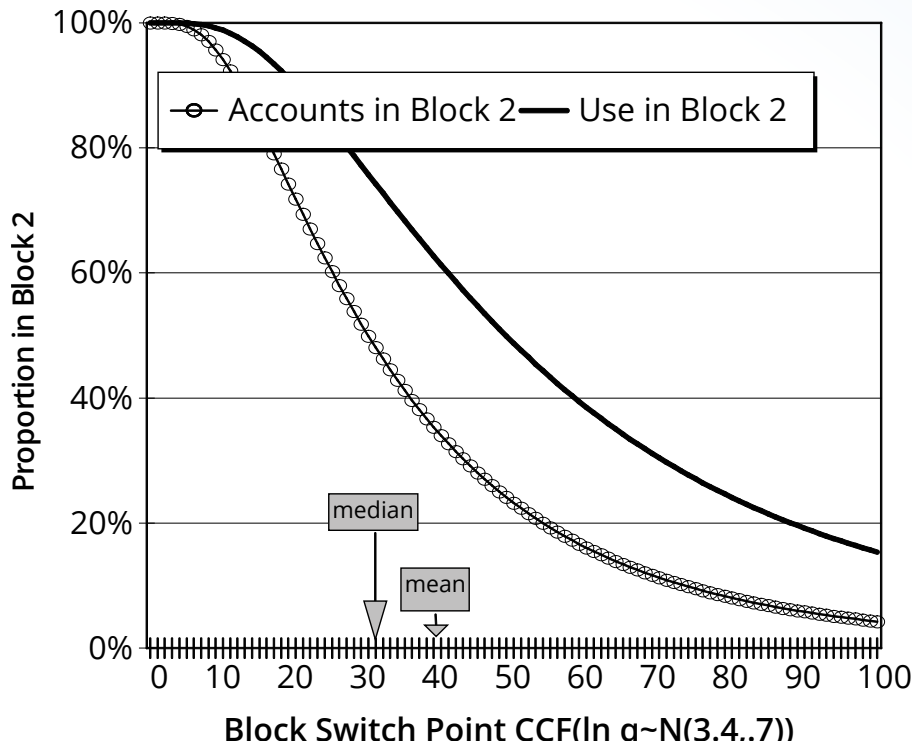


Figure B.3 Customer Accounts versus Water Use in an Upper Block

The next complication in estimating revenue from blocks is accounting for the fact that not all of the water used by customers in the second block is priced at the higher second price. The first k units (where k is the number of units in the first block) are priced at the lower first price. Figure B.4 removes the first k units for each customer in the second block to arrive at the line (with the crosses) that depicts, for any switch point, the proportion of total water use priced at the higher, block 2 price.

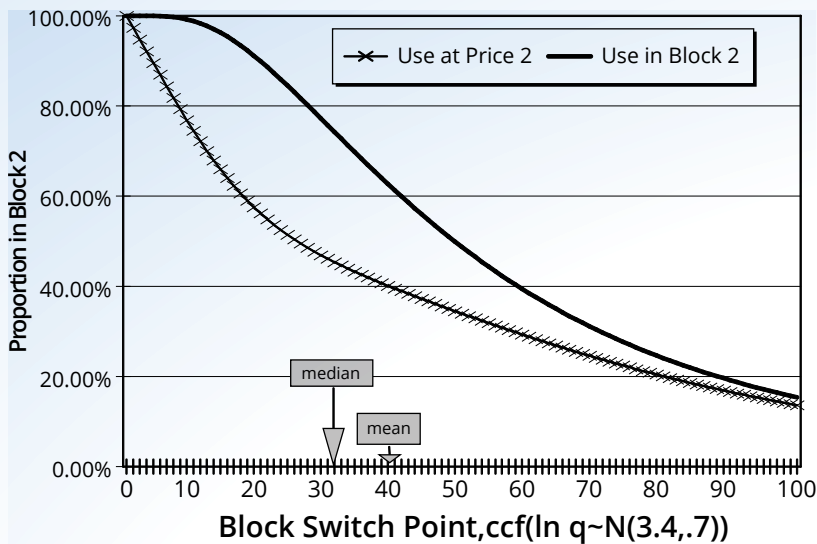


Figure B.4 Proportion of Total Water Use Priced at Price 2

Revenue prediction for block rates requires a deeper understanding of demand distributions. Household demand models can generate the expected (mean) demand in a given time period, $E[Qt]$, and a measure of the dispersion about that mean, the variance $V[Qt]$. These two parameters are sufficient, for any given rate structure, to determine system revenue. For a uniform rate structure, a model of system revenue requires only expected demand:

$$SystemRevenue = E\left[\sum_{i=1}^N Bill_i\right] = N \cdot E[Bill] = N \cdot (\alpha + P \cdot E[Q])$$

where N is the number of accounts in this customer class and α is a fixed charge.

Alternatively, system revenue can be expressed as the combination of fixed revenue and variable revenue:

$$SystemRevenue = FixedRevenue + VariableRevenue = N \cdot (\alpha + N \cdot P \cdot E[Q])$$

A seasonal rate structure requires the addition of a time index to this equation. Block-rate structures require knowledge of both the mean and the dispersion. The model of system revenue from block rate structures uses the demand models to predict the proportion of accounts (n/N) and the proportion of water use (ρ) that fall within a consumption block. For example, the variable revenue from accounts falling entirely within the first block (from 0 consumption units to q_1 consumption units) is:

$$VariableRevenue_1 = P_1 \cdot E[WaterUseinBlock1] = P_1 \cdot \rho_1 \cdot E[Q] \cdot N$$

Variable revenue from accounts in the second block will be broken into two parts: (1) revenue from the first block (the quantity of water in the first block times the first block price), and (2) the additional revenue from the second block (the amount of water in the second block times the second block price):

$$\begin{aligned}
\text{Variable Revenue}_2 &= P_1 \cdot E[\text{WaterUseinBlock1}] + P_2 \cdot E[\text{AdditionalWaterUseinBlock2}] \\
&= P_1 \cdot q_1 \cdot n_2 + P_2 \cdot (E[\text{WaterUseinBlock2}] - q_1 \cdot n_2) \\
&= P_1 \cdot q_1 \cdot n_2 + P_2 \cdot (\rho_2 \cdot E[\text{TotalWaterUse}] - q_1 \cdot n_2)
\end{aligned}$$

The key to carrying out this kind of calculation is arriving at (1) the proportion of accounts that fall within each block ρ ($= n/N$), and (2) the proportion of total use falling within a block (ρ_i).

Simulation Methods – A Monte Carlo Example of Revenue Volatility

The propensity of a rate structure to generate revenues that exactly match the revenue requirements of a water utility is subject to risks involving both supply and demand. These risks can produce revenue instability in the form of both revenue surpluses and revenue shortfalls. These risks are associated with changes in the number of customers, changes in customer mix [e.g., the loss of a large user], changes in usage patterns, changes in weather, changes in conservation ethic, changes in the price elasticity of water demands, and changes in rate structure [Beecher and Mann, 1991].

An important additional source of risk comes from supply or drought-driven curtailments. These sources of risk need to be assessed in the process of determining revenue requirements and mechanisms such as contingency funds and automatic rate adjustments put in place for coping with the unanticipated revenue changes [Chesnutt, et al, 1995b]. One of the other important drivers of short-term revenue uncertainty is climatic uncertainty. This exercise uses the estimated historical effect of climate from the aggregate model of demand.

Analysts are encouraged to aggregate the swings in revenue over multiple months or even multiple years. The estimated risk of revenue surplus (or deficit) will be greater over a multiple year period due to streaks of hot and dry (or cool and wet) weather. The magnitude of the increase in multiple year risk depends directly on the ability of utilities to adjust their rates over time to cope with revenue swings. Chapter 4 of *Building Better Rates for an Uncertain World on Financial Policies* discusses some of dynamic rate adjustment strategies to cope with revenue risks. In an ideal world, rate analysts would calculate revenue risks for each rate alternative. For an impression of how different rate structures can vary in terms of revenue risk, readers are referred to Chesnutt, et, al. 1996.



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