# National Regulatory Research Institute

# Reducing Electricity Used for Water Production:

## Questions State Commissions Should Ask Regulated Utilities

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# Executive Summary


Utilities consume large quantities of electricity to produce safe drinking water for their customers. About 4 percent of electricity use in the United States is attributable to the supply, conveyance and treatment of water and wastewater. Pumping accounts for between 90% and 99% of electricity use at water utilities for extracting water from its source of supply, treating it and distributing it to customers. Typical water utilities use between 1.4 and 1.8 kilowatt-hours of electricity to produce and deliver 1,000 gallons of drinking water.

Water utilities can reduce electricity use by increasing pumping efficiency. This can be accomplished by replacing inefficient motors on pumps, installing variable-speed drives on pumps and implementing operational controls, such as those provided through Supervisory Control and Data Acquisition (SCADA) systems.

Pumping less water is even more effective in reducing electricity use than increasing pump efficiency. One way for utilities to pump less water is to reduce water loss in the production process. Conducting leak detection surveys and fixing leaks in the system are labor intensive activities, but effective in reducing electricity use. Replacing old pipes also reduces leaks and decreases water flow resistance caused by corrosion and mineral build-up on pipe walls, thus lowering electricity use for pumping.

Studies show that increasing economies of scale at water utilities also reduces the electricity needed to produce a given quantity of drinking water. Consolidating small utilities into larger ones, where treatment and other facilities can be shared, saves electricity.

To better manage electricity use, water utilities should conduct comprehensive energy audits of their facilities and systems. They should establish electricity reduction targets in terms of electricity use, electric demand, electricity costs, and greenhouse gas emissions. They should establish specific performance measures to evaluate their progress toward goals over time and have a process for monitoring those measures and adjusting their targets as appropriate. They should prepare an electricity reduction plan of prioritized projects and initiatives based on the targets they have established.

Commissions can induce water utilities to take electricity-saving actions by (1) establishing electricity use standards and expectations, (2) evaluating the effects of energy adjustment clauses, (3) promoting electricity-saving projects and programs, (4) increasing utility economies of scale, and (5) requiring energy audits and electricity reduction plans.

Only about 15% of water utilities in the U.S. are under the jurisdiction of state regulatory commissions. Commissions can influence electricity use at non-jurisdictional water utilities through the regulation of jurisdictional electric utilities that serve them. These electric utilities could implement rate designs for water utility electric service that reflect long-run marginal costs and encourage electric utilities to offer energy efficiency programs directed specifically to water utilities.

This paper also suggests specific questions state commissions can ask regulated water and electric utilities to determine energy savings potential at water utilities and develop regulatory policies to realize that potential. This paper is available electronically at: http://nrri.org/pubs/water/reducing_electricity_used_for_water_08-06.pdf.

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## I. Introduction

Utilities consume large quantities of electricity to produce safe drinking water for their customers. This report will assist regulators wishing to develop policies to reduce electricity use by water utilities in that production process. It will provide regulatory commissions with information about the electricity requirements for producing and delivering drinking water to customers. It will discuss how water utilities and the electric utilities that serve them can adopt practices that reduce power use. It will summarize effective practices water utilities should use to manage use of electricity. While only about 15% of water utilities are regulated by state commissions, it is possible for state commissions to affect the practices of the non-jurisdictional water utilities through commission regulation of the electric utilities that serve those water utilities. Finally, the report will suggest questions commissions should ask of water and electric utilities to evaluate the effectiveness of electricity use by water utilities. Better understanding of the use of electricity for water production will lead to better regulatory decision making affecting both the water and electric utility sectors.

## II. How is electricity used for water production?

About 4 percent of electricity use in the United States, or 75 billion kilowatt-hours (kWh) annually, is attributable to the supply, conveyance and treatment of water and wastewater.[1] Moving water from place to place accounts for about 80% of that electric use. Water weighs over eight pounds per gallon. Moving water with electric powered pumps consumes large quantities of electricity. The amount of electricity used by water utilities varies depending on the design of the water system and the elevations and distances needed to pump water. Supplying water from groundwater sources, for example, requires about 30% more electricity than from surface water sources, due to the energy needed to pump (lift) raw water out of groundwater aquifers.[2, 3] In California, about 20% of all electricity use in the state is for the treatment and

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[1] Electric Power Research Institute, *Water and Sustainability (Volume 4): U.S. Water Consumption for Water Supply & Treatment—The Next Half Century*, Topical Report, March 2002.

[2] Ibid.

distribution of water.[4] The California State Water Project, which pumps water over 400 miles from Northern California to Southern California and raises it 2,000 feet over the Tehachapi Mountains, alone uses 2 to 3 percent of all electricity consumed in California.[5] Surface water utilities typically use 1.4 kWh to produce 1,000 gallons of drinking water, and ground water utilities typically use 1.8 kWh per 1,000 gallons produced.[6] This part (Part II) discusses how electricity is used in the process of extracting water from its source, treating it and distributing it to customers.

### A. Extraction

Water utilities produce drinking water from one of two supply sources: surface water (taken from a lake, reservoir, river or other surface water body) or ground water (drawn from an underground aquifer). A surface water utility typically draws water from its supply source and conveys it to a treatment plant. Depending on the relative elevation of the water source to the treatment facility, water may flow into the system by gravity or may be pumped into the system. The need to pump water from its supply source into the water system increases the utility's need for electricity. About 8% of the total electricity requirements of a typical surface water utility are for pumping water from its source to a treatment facility.[7]

Ground water utilities must use well pumps to lift water to the surface where it can be treated and delivered to consumers. Pumping water from an aquifer consumes more electricity

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[3] An *aquifer* is an underground layer or body of water-bearing, permeable rock or unconsolidated material (e.g., gravel, sand or silt) from which ground water can be extracted using a water well.

[4] Foran, Paul, G., American Water, *Interdependencies, Security, and Growing Resource Constraints*, presentation at NARUC Winter Meetings, Committee on Critical Infrastructure, Washington, D.C., February 17, 2008.

[5] National Resources Defense Council, *Energy Down the Drain: The Hidden Costs of California's Water Supply*, August 2004.

[6] Electric Power Research Institute, *Water and Sustainability (Volume 4): U.S. Water Consumption for Water Supply & Treatment—The Next Half Century*, Topical Report, March 2002.

[7] Electric Power Research Institute (EPRI), *Water and Wastewater Industries: Characteristics and Energy Management Opportunities,* CR-106941, 1996.

per gallon produced than any other water utility function. A Wisconsin study[8] found that water utilities with the highest electricity use per gallon produced were in counties where the water tables[9] were deepest (i.e., water was being pumped from the greatest depth). The study found that the median electricity use for all ground water utilities in Wisconsin was about 1.8 kWh/1,000 gallons. Utilities in counties with deep aquifers, however, were using in excess of 3.4 kWh/1,000 gallons. In comparison, the study found that the median electricity use for surface water utilities in Wisconsin was between 1.4 and 1.5 kWh/1,000 gallons. About one-third of the total electricity requirements of a typical ground water utility is for well pumping.[10]

### B. Treatment

Since surface water is exposed to many contaminants (both man-made and naturally occurring), extensive treatment is needed to produce safe drinking water from these water supplies.[11] Contaminants may, for example, consist of naturally occurring and ubiquitous bacteria and viruses in the environment. Man-made contaminants, such as agricultural chemicals and industrial or household waste, can also enter water supplies through runoff or improper disposal techniques. Different types of water treatment systems use different amounts of electricity. For a typical surface water system that uses 1.4 kWh per 1,000 gallons of water produced, between 0.2 and 0.3 kWh (15% - 20%) is used for water treatment.[12] Between 15% and 40% of electricity used in the treatment system is to power pumps in the treatment process.[13]

Drinking water quality standards promulgated by the U.S. Environmental Protection Agency (EPA) dictate the level of water treatment required of water utilities. Treatment

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[8] T. Elliott, et. al., *Energy Use at Wisconsin's Drinking Water Facilities*, Energy Center of Wisconsin Report 222-1, July 2003.

[9] *Water table* is defined as the top of a ground water aquifer.

[10] Electric Power Research Institute, *Water and Wastewater Industries: Characteristics and Energy Management Opportunities,* CR-106941, 1996.

[11] For a more detailed description of a typical water treatment system, see *The Water Industry at a Glance* at http://nrri.org/pubs/water/Water_industry_at_a_glance.pdf on the NRRI website.

[12] Electric Power Research Institute, *Water and Sustainability (Volume 4): U.S. Water Consumption for Water Supply & Treatment—The Next Half Century*, Topical Report, March 2002.

[13] Electric Power Research Institute, *Water and Wastewater Industries: Characteristics and Energy Management Opportunities,* CR-106941, 1996.

requirements for surface water utilities have increased in recent years and all indications point to a continuation of that trend. Requirements for increased and more rigorous water treatment raise electricity needs in two ways: (1) new treatment technologies are generally more energy intensive and (2) an increase in treatment processes results in increased pumping needs, regardless of the type of enhanced treatment employed.[14] The Wisconsin study[15] evaluated two new treatment technologies: ozone disinfection and microfiltration. It estimated increases in electricity use up to 0.55 kWh per 1,000 gallons of water treated with ozone systems and up to 0.70 kWh per 1,000 gallons treated with microfiltration systems.

Ground water aquifers, by virtue of their location below layers of unconsolidated material (e.g., soils, sand, silt, clay) or impermeable rock, are better protected from contamination sources than surface water bodies. Thus, ground water systems generally require less water treatment than surface water systems. The extent of water quality treatment for a typical ground water utility consists of adding chlorine to the water as a disinfectant. A typical ground water utility that uses 1.8 kWh of electricity to produce 1,000 gallons of drinking water uses less than .009 kWh (0.5%) for chlorination.[16]

Like surface water utilities, however, there is a trend toward increased water treatment for ground water utilities. Many ground water utilities that do not currently chlorinate their water will be required to do so by December 2009 under new regulations promulgated by EPA.[17] There is also an increase in the number of ground water utilities treating water for aesthetic reasons (e.g., removing iron and manganese to address color, taste and odor issues) and to remove other contaminants (e.g., arsenic, radionuclides, volatile organic compounds).[18] Electricity use for such treatment of ground water is comparable to that for surface water treatment processes. In general, though, electricity use for pumping at ground water utilities far overshadows electricity use for water treatment.

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[14] Ibid.

[15] T. Elliott, et. al., *Energy Use at Wisconsin's Drinking Water Facilities*, Energy Center of Wisconsin Report 222-1, July 2003.

[16] Electric Power Research Institute, *Water and Sustainability (Volume 4): U.S. Water Consumption for Water Supply & Treatment—The Next Half Century*, Topical Report, March 2002.

[17] National Primary Drinking Water Regulations: Ground Water Rule, 40 CFR Parts 9, 141 and 142.

[18] For a more detailed description of potential contaminants, see *The Water Industry at a Glance* at http://nrri.org/pubs/water/Water_industry_at_a_glance.pdf on the NRRI website.

### C. Distribution

Following extraction and treatment of water in either a surface water or ground water system, drinking water is conveyed to customers through a system of water mains and service lines[19] referred to as a distribution system. Pumping is needed to maintain pressure and move water through the distribution system. Pumping is also required to put water into storage reservoirs within a distribution system so it is available during periods of high demand and to meet fire-flow requirements. Overall, including extraction, treatment and distribution, 90% to 95% of *all* electricity use for a typical surface water utility is for pumping,[20] with 80% to 85% of the total attributable to *distribution system* pumping. Over 99% of *all* electricity use for a typical ground water utility goes toward pumping (extraction and distribution), with 66% of the total used for *distribution system* pumping[21] and the remainder for well pumping.

## III. What actions can water utilities take to save electricity?

Water utilities can implement specific projects and programs aimed at reducing electricity use, and can establish long-term energy management initiatives. This part discusses (1) project- and program-specific opportunities for saving electricity (Part III.A); and (2) opportunities for long-term energy management (Part III.B).

### A. Opportunities for savings

#### 1. Increase pumping efficiency

We have seen that pumps account for, by far, the greatest amount of electricity use by water utilities. Increasing pumping efficiency, therefore, can save large amounts of electricity. Precise savings potential depends on the specific equipment involved and the design of the water system. Pumping efficiency may be increased in a number of ways:

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[19] *Water mains* are large-diameter (usually 6-inch to 24-inch) pipes, buried in rights-of-way and beneath streets, through which water is distributed from supply and treatment facilities to utility customers. *Service lines* or *laterals* are smaller-diameter (⅝-inch to 1-inch) pipes tapped into a water main, running perpendicular to the water main, that carry water from the main to individual customers.

[20] Electric Power Research Institute, *Water and Wastewater Industries: Characteristics and Energy Management Opportunities,* CR-106941, 1996.

[21] Ibid.

### a. Replace inefficient motors

Water system pumps are generally powered by electric motors. Older, standard-efficiency motors are less efficient than modern high-efficiency or premium-efficiency ones. Motors also operate inefficiently if they are oversized for their application and thus do not run fully loaded. Water utilities can save electricity by sizing pumps and motors to their load and installing high-efficiency motors on pumps.

### b. Use variable speed drives

Drive mechanisms transfer energy from a motor to a pump by converting the electrical energy to mechanical energy. Drives may operate at a constant, fixed speed or at variable speeds. Variable-speed drives (also known as variable-frequency drives) control the pump speed and water flow electronically and match the speed and flow to the demand for water. As demand increases, the pump speeds up and increases water flow. Variable-speed drive pumps are more efficient than fixed-speed drive pumps.

### c. Implement operational controls

Water utilities can control their pumping operations either manually or automatically. Many large utilities have invested in automated, computerized Supervisory Control and Data Acquisition (SCADA) systems for this purpose. Other utilities, particularly small systems, depend on manual control by operators. The effectiveness of either option depends on knowledgeable operators. One advantage of SCADA systems is, once properly programmed, they react instantaneously to a predetermined set of criteria and eliminate human error.

Operational controls can improve efficiency in the following ways:

#### (1) Optimize electric demand management

Electricity cannot be stored easily and economically in large quantity. An electric utility must size its generating, transmission and distribution facilities to meet peak demands. Water, however, can be stored. Even though electricity and drinking water have similar seasonal and daily demand curves, water utilities can treat water and pump it to storage during periods of low electric demand, and hold it in storage until customers need it. The ability to control time-of-day treatment and pumping of drinking water can thus reduce electric peak demands. Electric demand charges create economic incentives for water utilities to use storage facilities to control electric use during peak periods. Realizing this efficiency opportunity requires coordinating the electric utility's rate structure for the water utility with the water utility's operational practices.

#### (2) Optimize use of pumps

Control systems can optimize pump operation. The control system can be programmed to select the most appropriate available pump for a given need, to ensure pump motors are fully loaded and operating at highest efficiency. When switching pumps, something as simple as making sure one pump is turned off before starting another can save electricity without affecting service.

### 2. Reduce water loss

While increasing pumping efficiency can save electricity, reducing pump operation saves even more. To accomplish this, utilities must pump less water. Utilities can reduce water waste in its production process (supply side) and take action to encourage more efficient water use by its customers (demand side). This report focuses on reducing electricity use in water production. We will address how reducing water loss in the production process affects electricity use. We will not address in this report, however, the many and varied demand-side initiatives that water utilities and their customers could implement to reduce water use. To the extent that demand-side efficiency efforts reduce water use (and the need to produce safe drinking water), they obviously save electricity.

Water loss (sometimes referred to as “unaccounted for water”) is the difference between the amount of water a utility extracts from its source of supply and the amount the utility delivers for consumptive use. Utilities generally calculate the amount of water lost in the production process by comparing metered measurements of water extracted to metered and estimated amounts of water delivered to customers or used by the utility. All water delivered for consumptive use may not be metered. Some water utilities do not meter all customers (they may bill unmetered customers on the basis of estimated use). Some consumptive use (e.g., fire hydrant use) is not usually metered. Thus, water loss calculations are only as good as the existence and accuracy of meters and estimates from which they are derived.

The industry’s generally accepted standard for system water loss is 10% to 15%.[22] Water loss for all water utilities in Wisconsin is 11%.[23]

The primary cause of water loss in a water system is leaking pipes. Water mains and service lines are interconnected with joints and valves. Damage and deterioration over time can cause the pipes, joints and valves to leak water. In extreme cases (e.g., a water main break), leaking water will likely find its way to the surface and can be easily detected and fixed. In most cases, however, leaks are small and slow, water does not reach the surface, and leaks may go undetected indefinitely.

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[22] American Water Works Association, *Opflow*, July 1994.

[23] T. Elliott, et. al., *Energy Use at Wisconsin’s Drinking Water Facilities*, Energy Center of Wisconsin Report 222-1, July 2003.

The only effective way for a utility to detect leaks that do not force water to the surface is to conduct a leak detection survey. Such surveys require a worker to walk around the distribution system with specialized equipment that records the sound of underground leaks. Even though leak detection equipment has improved in recent years, providing more accurate location of leaks, it is still a time-consuming, labor intensive process. Once a leak is detected, it is also an expensive, labor-intensive process to expose the pipe and fix the leak. Finding and fixing leaks in a water system has a direct effect on electricity use. Every gallon of water that does not leak from the system is a gallon of water that does not need to be extracted, treated and pumped through the system.

### 3. Reduce water flow resistance in pipes

Over years of use, water pipes corrode and minerals build up on the inner surface of pipe walls. These pipe impairments create resistance to water flow. This resistance requires the utility to use more pumping power, and electricity, to move water through the distribution system. Proper maintenance of water mains helps control build-up in pipes and reduces flow resistance. Water utilities can maintain pipes by conducting a regular unidirectional flushing or pigging program.[24] Replacing old, corroded pipes also lowers electricity use for pumping as well as reduces leaks and improves reliability.[25]

### 4. Increase economies of scale

Larger utilities generally operate more efficiently than smaller ones. The efficiencies inherent in economies of scale translate into reduction in electricity for water production.[26] In Wisconsin, the median electricity use for water utilities serving 1,000 to 4,000 customers (1.85 kWh/1,000 gallons) is 22.5% higher than the median electricity use for utilities serving more than 4,000 customers (1.51 kWh/1,000 gallons).[27] For utilities serving fewer than 1,000

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[24] *Unidirectional flushing* is a system of manipulating valves and opening hydrants in a manner that maximizes water velocity in isolated segments of pipe. While this operation optimizes distribution system cleaning, it is much more labor intensive and expensive than traditional flushing systems. *Pigging* forces foam and plastic bullet-shaped plugs through the distribution system to scour and clean the insides of pipes.

[25] Electric Power Research Institute, *Water and Sustainability (Volume 4): U.S. Water Consumption for Water Supply & Treatment—The Next Half Century*, Topical Report, March 2002.

[26]Ibid., p. 1-3.

[27] T. Elliott, et. al., *Energy Use at Wisconsin's Drinking Water Facilities*, Energy Center of Wisconsin Report 222-1, July 2003.

customers, the median electricity use (1.89 kWh/1,000 gallons) is 25% higher than for utilities serving more than 4,000 customers. Consolidating small utilities into larger ones, where treatment and other electricity-using facilities can be shared, increases economies of scale and reduces electricity use for water production.

## B. How water utilities should manage electricity use

### 1. Determine baseline electricity use

Water utilities should conduct comprehensive energy use audits to gather full data on their electricity use. There are many good sources to guide a utility in conducting such audits.[28] Effective energy audits may also be conducted by a utility's electricity provider or by experienced energy consultants. The goal of any good energy audit is to identify in as much detail as possible the electricity use of each component of the water production process. This effort requires a thorough review of electricity use and expense records over a number of years as well as field inspections of facilities and equipment. To the extent possible, water utilities should separately submeter high-electric-load facilities and equipment (e.g., pumping stations) for both electricity use and electric demand. SCADA systems are an excellent way to automatically track electricity use and demand throughout a water system.

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[28] The following are four examples:

1. U.S. Environmental Protection Agency, *Ensuring a Sustainable Future: An Energy Management Guidebook for Wastewater and Water Utilities*, January 2008.

2. Jack Jacobs, *Best Practices for Energy Management*, AWWA Research Foundation, Proj. No. 2621B, 2003.

3. Electric Power Research Institute, *Energy Audit Manual for Water/Wastewater Facilities: A Guide for Electric Utilities to Understand Specific Unit Processes and Their Energy/Demand Relationships at Water and Wastewater Plants*, EPRI Technical Report CR-104300, 1994.

4. U.S. Environmental Protection Agency and U.S. Department of Energy, *Energy Star*, Buildings and Plants, Guidelines for Energy Management, www.energystar.gov.

### 2. Establish targets and measures

It is important for a utility to establish electricity reduction targets in terms of electricity use, electric demand, electricity costs and greenhouse gas (GHG) emissions.[29] Prioritizing electricity reduction options depends on the weighting given to these various criteria. For example, a utility may be able to lower peak demand and reduce electricity purchase costs (avoid demand charges) by installing a diesel backup generator, but this would not be a good choice if the goal is to reduce GHG emissions. The utility should also establish specific performance measures to evaluate its progress toward targets and goals over time.

### 3. Prioritize opportunities for improvement

A utility should prepare an electricity reduction plan based on a prioritized list of potential improvements. The plan should reflect an economic analysis of options based on costs and benefits reflecting the criteria and targets previously established. The plan should also provide a timeline for improvements based on current and projected budgets.

It is important that a utility evaluate electricity savings for each project in its capital improvement plan. Many of those projects, obviously, are not designed to specifically reduce electricity use, but most will affect electricity use. Many water utilities, for example, are planning replacement of aging water mains over the next decade. Water main replacement projects can reduce electricity use by (1) reducing leaks and water loss, and (2) decreasing flow resistance in pipe, which in turn reduces pumping needs. New regulations will require some utilities to install new water treatment processes. While these new treatment systems are likely to be more energy intensive, utilities may be able to select among several alternative systems. Electricity use should be one criterion they look at when making that selection. A higher initial cost for some treatment alternatives, for example, may be offset in whole or in part by lowered electricity expenses.

### 4. Monitor measures and adjust targets

Finally, a utility should continually monitor its performance measures and review its energy management programs. Lack of expected progress toward performance targets should be investigated and resolved. If targets are not realistic, they should be adjusted. If they are realistic, appropriate action should be taken to ensure that they are met.

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[29] For more information on the implications of greenhouse gases and global climate change for state utility regulations, see Keeler, Dr. Andrew G., *State Commission Electricity Regulation Under a Federal Greenhouse Gas Cap-and-Trade Policy,* National Regulatory Research Institute, Pub. No. 08-01, January 2008. Available on the NRRI website at: http://nrri.org/pubs/electricity/08-01.pdf.

## IV. What policies can commissions establish to induce water utilities to take electricity-saving actions?

Commissions may be limited by jurisdictional authority in their ability to directly induce water utilities to implement energy-saving measures. As of 1995, forty-six state regulatory commissions regulated some water utilities.[30] All 46 regulated privately owned utilities. Only eleven regulated any water utilities owned by municipalities. Many do not regulate water utilities below a specified size. Thus, only about 15% of water utilities in the U.S. are under the jurisdiction of state regulatory commissions. Small water utilities are disproportionately represented in that 15%. Most large municipal systems are not regulated by state commissions. Consequently, the percentage of drinking water produced from utilities regulated by state commissions is even smaller than 15%.

While only a small percentage of water utilities are regulated by state commissions, this paper's discussion of electricity-saving potential applies to all water utilities. The 85% of water utilities that are not under the jurisdiction of a state regulatory commission are very likely to purchase power from an electric utility that is regulated by a state commission. So there is potential for a state commission to influence, directly or indirectly, the practices of most water utilities. A state would need to analyze its own jurisdictional reach to determine this potential. This part provides theoretical options, with the expectation that not every state will have the jurisdictional ability or statutory authority to implement them for all utilities.

### A. Commission actions directed at jurisdictional water utilities

#### 1. Establish electricity use standards and expectations

Commissions could establish reasonable electricity use expectations for water utilities, based on normative standards for the state or region and for the design of the water system. The standards might be based on electricity use per 1,000 gallons of water produced (or some other similar base to make comparisons useful), electric demand per 1,000 gallons of production capacity, electricity costs or GHG emissions per 1,000 gallons of water produced, depending on the priorities of the commission. Commissions might induce compliance with such standards by (1) allowing accelerated rate recovery for projects designed to meet the standards, (2) refusing certification of new systems that do not meet the standards, and (3) disallowing rate recovery for electricity expenses exceeding the standards. It may be necessary to establish different standards

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[30] Beecher, Janice A., *1995 Inventory of Commission-Regulated Water and Wastewater Utilities,* Indiana University, School of Public and Environmental Affairs, Pub. No. 95-E18, November 1995. Dr. Beecher (now with the Institute of Public Utilities at Michigan State University) is currently working on a project to update this data.

based on the size of the system, to recognize the limits on efficiency improvements experienced by systems of different sizes.

### 2. Evaluate energy adjustment clauses

Water utilities may seek protection against rising or volatile electricity prices by asking for authority to track electricity prices or costs they experience, and adjust water rates to reflect such changes without filing for a rate case. Commissions can evaluate these requests to determine the proposed tariff's likely effect on the water utility's electricity use.

Energy *cost* adjustment clauses, even when accompanied by frequent prudence review based on state-of-the-art knowledge of energy savings potential, reduce a water utility's incentive to invest in electricity-saving projects.

Energy *price* adjustment clauses shift price risk from utilities to consumers. Since they allow passthroughs of cost increases related only to price rather than quantity, they do not weaken a utility's incentive to invest in electricity-saving projects. But neither do they encourage such investments.

### 3. Promote electricity-saving projects and programs

Commissions should encourage and provide timely, certain rate recovery for cost-effective projects and programs designed to reduce electricity use by water utilities. Such projects might include metering and submetering, implementing leak detection programs, installing or upgrading SCADA systems, replacing standard-efficiency pump motors, or installing variable-speed drives on pumps. A commission could require a utility to submit to the commission a proposed plan for these investments, along with a proposed rate path for cost recovery. Commissions should also encourage water utilities to participate in cost-effective energy efficiency programs offered by their electricity provider.

### 4. Increase economies of scale

Commissions should promote or prescribe increased economies of scale for water utilities. They might do this by (1) establishing certification requirements that discourage small, stand-alone water systems; and (2) encouraging mergers and acquisitions of struggling small systems. Tools that could be used to encourage mergers and acquisitions include (1) rate recovery of a share of the acquisition premiums (provided such share is offset with cost reductions or other benefits arising from the acquisition)[31], and (2) single-tariff pricing, which allows a uniform rate structure or consolidated rates for systems owned by the same entity.

### 5. Require energy audits and electricity reduction plans

Commissions with authority to do so should require all water utilities under their jurisdiction to conduct energy audits of their systems. They should ask for the utility's electricity use targets and the performance measures the utility will use to track progress toward those targets. Commissions should also request a monitoring plan that the utility will use to review its performance measures and energy management programs over time for the purpose of making adjustments and modifications to its electricity-saving projects and programs. Finally, commissions should request from water utilities electricity reduction plans with descriptions and schedules of projects and programs the utility intends to implement.

## B. Commission actions directed at jurisdictional electric utilities

### 1. Implement rate designs for water utility electric service that reflect long-run marginal costs

Commissions could implement rate designs for water utility electric service (or "pumping rates" for all industries) that reflect long-run marginal costs, including costs associated with GHG emissions. When long-run marginal costs exceed the traditional embedded average cost rates, they provide customers a greater financial incentive to save electricity. Time of use pricing, such as demand charges, can shift pumping schedules (when water storage is available) thus reducing the electric utility's peak demand, but does not necessarily reduce electricity use.

For ratemaking purposes, anticipated revenues from marginal cost pricing can be reconciled to embedded revenues in a variety of ways. If reducing or eliminating a customer charge would produce revenue neutrality, this device is the best choice from the perspective of promoting efficiency. A commission may also use a form of inverted block rates, lowering the cost for electricity use up to a specified level, to make higher price signals on the margin revenue-neutral in the context of the overall rate design.[32]

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[31] Regulators have used varied approaches to the rate treatment of acquisition premium, from full recovery to no recovery. It is not this paper's purpose to recommend a particular rate treatment but instead to identify the option and indicate that some evaluation of the benefits flowing from the acquisition premium is necessary.

[32] For more information on marginal cost pricing, see: Khan, Alfred E., *The Economics of Regulation: Principals and Institutions*, Vol. I, Part II, chapters 3-4, pp. 63-122, The MIT Press, 1988. As with the previous discussion of acquisition premium, there are multiple approaches to

### 2. Encourage electric utilities to offer energy efficiency programs directed at water utilities

Commissions should address the appropriate role for electric utilities in providing efficiency programs that address the needs of water utilities of various sizes. Efficiency programs should be designed to overcome the market barriers that make it difficult for customers (in this case water utilities) to take advantage of cost-effective electricity efficiency opportunities. The key is to identify the market barriers that impede water utility up-take of cost-effective electricity efficiency for their systems. Following are some common market barriers to energy efficiency measures that apply to many industries and should be considered as potential barriers for water utilities:

1. A water utility may lack the up-front cash (or willingness or ability to borrow)[33] to fund efficiency investments, while efficiency measures may have higher up-front costs than less efficient equipment and applications that will meet the utility's needs.

2. A water utility may seek a high return on investment and may not implement efficiency measures unless they show a high return.

3. A water utility may want a short payback period on its investments that an energy efficient application may not provide.

4. A water utility may lack the information and expertise needed to identify and understand opportunities to save electricity.

5. A water utility may be wary and risk-averse to new or innovative solutions.

6. A water utility may lack the internal communication and coordination needed to implement efficiency measures effectively. A maintenance worker or purchasing agent, for example, may decide what model of pump motor to buy strictly on the

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rate design, and long-running debates about the economic efficiency and practicality of those approaches. Our purpose is not to recommend any particular approach, but to identify rate design as one of several subjects to investigate on the way toward developing effective regulatory policies aimed at reducing water's consumption of electricity.

[33] The most important barrier for many water utilities is the ability to raise capital. Municipal water utilities may need to get governmental approval of any bonding or other fund raising mechanisms that commits the utility to long-term debt. Many small water utilities do not have the expertise or the credit to obtain longer-term financing.

basis of purchase price without the input of operations, engineering or financial staff on the efficiency and operating cost of the motor.

Traditional energy efficiency programs have attempted to address market barriers by lowering the relatively high “first cost” of energy-saving devices and measures. Thus, electric utilities may offer cash rebates to customers who purchase more efficient motors, equal to some or all the difference in cost between the standard motor and the more efficient model. The cost of a rebate program or any other program offered (e.g. technical assistance) is borne by all electric utility customers or by certain classes of customers in their electric utility rates.

To the extent that such rebates are insufficient to overcome market barriers, electric utilities should pursue other innovative programs. Regulators entertaining proposals for such programs targeted to water utilities are likely to face a variety of issues, such as: (1) how to raise funds for the program (e.g., surcharge on electric bills, reflection of costs in the electric utility’s base of rates, different charges for various classes or the same charge for all classes), (2) how to overcome the disincentive to the electric utility caused by reduced earnings from reduced sales, and (3) how to give the electric utility an incentive to maximize all cost-effective efficiency programming.

We have in this paper just touched on electric utility energy efficiency programs and issues. Many other references are available on this topic, which an interested reader can pursue.[34]

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[34] The following are six examples:

1. Paul A. Cillo & Harlan Lachman, Pay-As-You-Save Energy Efficiency Products: Restructuring Energy Efficiency, A report by the Energy Efficiency Institute for the National Association of Regulatory Commissioners. December 1, 1999.

2. Cheryl Harrington, Catherine Murray, and Liz Baldwin. *Energy Efficiency Policy Toolkit,* Regulatory Assistance Project, Gardiner, ME. January, 2007.

3. Cheryl Harrington and Catherine Murray. *Who Should Deliver Ratepayer Funded Energy Efficiency? A Survey and Discussion Paper.* Gardiner, ME. The Regulatory Assistance Project. May 2003.

4. Eric Hirst, “Electric Utilities and Energy Efficiency.” Oak Ridge National Laboratory Review. Available at http://www.ornl.gov/info/ornlreview/rev28_2/text/uti.htm

5. Martin Kushler and Patti Witte**,** *Can We Just “Rely on the Market” to Provide Energy Efficiency? An Examination of the Role of Private Market Actors in an Era of Electric Utility*

# V. What questions should commissions ask of regulated utilities to (1) determine energy savings potential and (2) fashion regulatory policies to realize that potential?

## A. For water utilities:

### 1. Questions on managing electricity use

1. Do you have a written plan or procedure in place for managing electricity use?
2. Have you had a comprehensive energy audit of your facilities and operations?
3. Have you established targets or goals for reducing electricity use, electric demand, power purchase costs, and greenhouse gas emissions?
4. Have you identified specific performance measures to evaluate your progress toward those targets and goals over time?
5. Do you have a written procedure for monitoring your progress and making adjustments to your plan if you find you are not making the progress you expected?

### 2. Questions on electricity reduction planning

1. Do you have a prioritized list of projects and initiatives for reducing electric use, based on economic analyses and the goals you have established?

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*Restructuring.* American Council for an Energy-Efficient Economy, ACEEE Report Number U011, Washington, D.C., September 2001, available at http://aceee.org/pubs/u011full.pdf.

6. Mark Levine, Howard Geller, Jonathan Koomey, Steven Nadel, and Lynn Price, *Electricity End-Use Efficiency: Experience with Technologies, Markets and Policies Throughout the World,* Report No. I921, American Council for an Energy-Efficient Economy, Washington, D.C., 1992, available at: http://www.aceee.org/store/proddetail.cfm?CFID=1313&CFTOKEN=76068687&ItemID=182&CategoryID=7

2. Are electricity use and cost criteria employed in the prioritization and economic analyses of projects in your capital improvements plan?

3. Has electricity use been a criterion in analyzing alternatives for any new treatment systems under consideration?

4. Do you have a plan (e.g., an asset management plan) for replacing aging water mains and other utility infrastructure?

### 3. Questions on utility operations

1. Do you have a SCADA system?

    a. If so, is it used to manage electricity use and demand and to record data on use and demand?

    b. If not, do you have experienced, trained operators and written procedures for managing and recording electricity use and demand?

2. Do your operating procedures call for treating and pumping water to storage during periods of low electric demand? Do your procedures address optimization of pump operation?

3. Do you have high- or premium-efficiency motors on all pumps? Do you have variable-speed drives on pumps where it would improve efficiency?

4. Are all your customers metered?

5. Have you had a leak-detection survey conducted on your distribution system?

6. Do you conduct a regular unidirectional flushing or pigging program?

### 4. Questions on normative standards and economies of scale

1. What is your total electric use (in kWh) to deliver 1,000 gallons (or some other appropriate standard) of drinking water?

2. Is there an opportunity for you to improve efficiency through consolidation with another utility?

## B. For electric utilities:

1. How does your rate structure affect water utilities' behavior? Does it send price signals consistent with efficient use of resources? For example, does it reflect long-

run marginal costs, including costs associated with greenhouse gas emissions? Should it?

2. What energy efficiency programs do you have in place that are specifically targeted toward water utilities? What data have you collected concerning the effectiveness of these programs? Has the response been sufficient?

3. What aspects of these programs help overcome the market barriers that impede water utilities from implementing cost-effective electricity efficiency measures?

4. Have you worked directly with water utilities to ensure that the programs you offer address the specific market barriers the water utilities are facing?

5. Does your (the electric utility's) present rate treatment encourage or discourage you from achieving full potential for water utilities to save on electricity consumption?