

1 *Review*

# 2 **Energy Management in the Water Sector: A Major** 3 **Sustainability Opportunity**

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7 **Abstract:** Reliable, high-quality water services are a substantial component of a state's or country's  
8 energy consumption profile. Although the water–energy nexus has received much attention in the  
9 past few years, relatively little work has addressed water systems' energy use, their potential for  
10 energy savings, or their empirical results of energy management. This paper surveys the literature  
11 on theoretical energy savings in water systems and compares the estimates with the outcomes of  
12 numerous case studies where water systems undertook energy efficiency projects and/or  
13 programs. The results in practice confirm that the theoretical estimates are indeed achievable;  
14 annual energy savings of 10 to 30 percent are typical among water utilities that pursue energy  
15 management. These savings come by capital projects, operational changes, and interagency  
16 coordination to deliver water by the most energy-efficient path. Such solutions often help improve  
17 hydraulic performance and water quality, showing that energy management is cost effective,  
18 prompt, and synergistic, a critical step in advancing sustainable water supply.

19 **Keywords:** energy, water distribution, hydraulic modeling, efficiency  
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## 21 **1. Introduction**

22 The water–energy nexus has received considerable attention in the past 10 years. Much of the  
23 work has focused on the water intensity of energy generation, local studies of energy intensity for  
24 water services, and the research needs in this emerging field. Less work has addressed energy  
25 efficiency in the water sector.

26 Water services are a substantial component of a state's or country's energy consumption. Public  
27 water and wastewater utilities consume 2% of all U.S. energy, or about 2 quadrillion BTU annually  
28 [1]. Utah, the country's second-driest state, expends about 7% of its energy on water supply [2, 3]. In  
29 California, water consumes 19% of the state's electricity and 30% of its natural gas, underscoring the  
30 significance of the water sector's role in energy consumption, especially amid California's current  
31 multiyear drought [4, 5].

32 Water is a significant energy demand. As the challenge of managing water and energy  
33 resources continues to grow, energy efficiency in the water sector is a ripe sustainability  
34 opportunity.

## 35 **2. Background**

36 Historically, water suppliers have focused on providing reliable, high-quality water without  
37 necessarily considering energy requirements. Many have viewed a water system's energy footprint  
38 as fixed; several technical, financial, social, and political obstacles have dissuaded water utilities  
39 from pursuing energy efficiency [6]. Now, with increasing population, stricter water-quality  
40 standards, and rising energy costs, energy efficiency in the water sector is emerging as an optimal  
41 solution.

42 Indeed, “planning by drinking and wastewater utilities is increasingly considering issues of  
43 energy use,” mostly for financial reasons [7]. According to the U.S. Environmental Protection

44 Agency (EPA), energy for water and wastewater services is the largest single cost for municipal  
45 governments and private utilities, accounting for over 40% of operating expenses; for small cities,  
46 the cost can exceed 80% [8]. The World Bank likewise acknowledged that “improving energy  
47 efficiency is at the core of measures to reduce operational cost at water and wastewater utilities” [9].

48 Looking beyond cost savings, the Department of Energy identified the optimization of water  
49 management, treatment, and distribution systems as one of its six strategic pillars in the  
50 water–energy nexus [10]. Water in the West concluded that “the energy deployed in water treatment  
51 and distribution is a principal target for reducing the embedded energy in the nation’s water  
52 supplies” [11]. The EPA realized that “improved energy efficiency ... will help ensure the long-term  
53 sustainability of our nation’s water and wastewater infrastructure” [8].

## 54 **2. Energy Management as a Solution**

55 Efficiency is the most immediate, affordable, and environmentally beneficial solution to  
56 resource shortages [12]. For power providers, energy management is a least-cost resource; its  
57 levelized cost is two to three times less than conventional energy generation [13, 14]. Though power  
58 providers are aware of this difference and have targeted residential and commercial energy  
59 efficiency, potential savings in the water sector have been largely overlooked until recently. For  
60 water utilities, energy efficiency offers reduces their operation costs, shrinks their energy footprints,  
61 and improves public acceptance.

## 62 **3. Theoretical Savings**

63 Potential and theoretical energy efficiency savings for water utilities have been studied  
64 extensively, and most estimates indicate that savings of 10%–30% are possible through combinations  
65 of operational (no-cost) and capital measures. An EPA Region 9 pilot study found an average of 17%  
66 energy savings potential and 26% cost savings potential, regardless of a utility’s size [15]; a  
67 Massachusetts pilot study identified an average 33% potential savings at 14 water facilities [16].  
68 According to the EPA, water facilities can achieve up to 30% percent reduction in energy use  
69 through energy efficiency upgrades and operational measures [17]. The Alliance to Save Energy  
70 claimed that 25% savings are possible in most water systems worldwide [18]. The World Bank found  
71 that 10%–30% energy savings are common, with relatively short payback periods of one to five years  
72 [9]. The U.S. Department of Energy (DOE) observed that “energy usage in delivering water services  
73 represents a non-trivial portion of U.S. electricity consumption and may present significant  
74 opportunities for both efficiency and renewable generation” [10].

## 75 **4. Actual Savings**

76 Beyond theory, significant energy savings have been achieved throughout the United States as  
77 water utilities and engineers translate theory into action. See Table 1.

78 In Utah, Jordan Valley Water saved 3.9 million kilowatt-hours (kWh) with operational changes  
79 [19]. North Salt Lake’s water system saved 32% through no-cost operational changes and Spanish  
80 Fork’s water system saved 29% after a capital project [20]. Logan, Utah, reduced its water system’s  
81 energy use by 32% and also observed a 17% decrease in water use and a 40% decrease in mainline  
82 breaks, demonstrating that energy efficiency has a synergistic effect that can support rather than  
83 oppose improvements in other areas [21]. A large pump station of Nashville’s Metro Water Services  
84 used 30% less energy after an efficiency upgrade [22]. Equipment upgrades and operational changes  
85 saved significant energy at several Arizona water utilities [23]. Energy efficiency in wastewater  
86 treatment, though not discussed here, is likewise effective. These cases show that energy savings are  
87 not only possible but also catalyze other improvements. Several best practices and resources to help  
88 water utilities save energy are available [8, 10, 24–30].  
89  
90

91 **Table 1.** Water System Energy Efficiency Results

Water Utility	Location	Annual Energy Savings	Source
City of Yuma	Yuma, Ariz., USA	6,500,000 kWh	[23]
City of Flagstaff	Flagstaff, Ariz., USA	5,800,000 kWh	[23]
Jordan Valley Water Conservancy District	West Jordan, Utah, USA	3,900,000 kWh (10%)	[19]
Dublin San Ramon Services District	San Francisco, Calif., USA	2,232,000 kWh	[17]
City of North Salt Lake	North Salt Lake, Utah, USA	1,800,000 kWh (32%)	[20]
City of Holbrook	Holbrook, Ariz., USA	1,750,000 kWh	[23]
Spanish Fork City	Spanish Fork, Utah, USA	1,100,000 kWh (29%)	[20]
Logan City Water	Logan, Utah, USA	900,000 kWh (32%)	[21]
Carefree Water Company	Carefree, Ariz., USA	425,000 kWh	[23]
Metro Water Services	Nashville, Tenn., USA	30% (facility)	[22]

92 **5. Discussion**

93 To date, most of the literature and practice has focused on equipment energy efficiency at water  
 94 facilities. While those advances are welcome, there many opportunities beyond the facility. A typical  
 95 water system is a collection of water sources, treatment plants, pump stations, storage tanks, and  
 96 other facilities that function not as discrete elements but as an interdependent system. Many  
 97 potential water delivery paths exist, each with different energy requirements. The underlying  
 98 assumption in the value of facility-specific equipment upgrades is that the facility lies along the most  
 99 energy-efficient water delivery path. This is not always true, since in many cases there is a better  
 100 way to deliver water by thinking “outside the box”—that is, thinking outside the facility—on a  
 101 system level. For example, Jordan Valley Water saved energy by prioritizing its most efficient water  
 102 sources, and North Salt Lake saved energy by adjusting pressure-reducing valves to keep water in  
 103 the intended pressure zone without excessive pumping. Rather than undertake capital projects to  
 104 upgrade certain facilities, both water utilities found a more efficient water delivery path that  
 105 leverages their existing efficient facilities and avoids inefficient ones. The practice of water system  
 106 optimization considers such system-wide possibilities and aligns energy efficiency with water  
 107 quality and level of service, the three main constrains of public water supply [26].

108 The next level of optimization is thinking outside the system—forging mutually beneficial  
 109 partnerships among neighboring water suppliers to give and take water in ways that lower the  
 110 overall energy requirements. Several water utilities in the Salt Lake Valley area are negotiating such  
 111 agreements, which may be the first of their kind.

112 **6. Conclusions**

113 Energy efficiency in the water sector is an untapped sustainability opportunity. Research and  
 114 case studies demonstrate that energy reductions of 10% to 30% are typical for water utilities that  
 115 pursue efficiency. Such solutions are cost-effective, prompt, and synergistic.

116 **References**

- 117 1. Sanders, K.T.; Webber, M.E. Evaluating the Energy Consumed for Water Use in the United States. *Env. Res. Letters* **2012**,  
 118 7 034034.
- 119 2. Larsen, S.G.; Burian, S.J. Energy Requirements for Water Supply in Utah. In *The Water–Energy Nexus in the American*  
 120 *West*, Kenney, D.S., Wilkinson, R., Eds.; Edward Elgar Pub., 2012.
- 121 3. Utah Division of Water Resources. *The Water–Energy Nexus in Utah: Meeting the Water and Energy Challenge*. Salt Lake  
 122 City: Utah Dept. of Natural Resources, 2012.
- 123 4. Klein, G. *California’s Water–Energy Relationship*. Final Staff Report CEC-700-2005-011-SF. California Energy Commission.  
 124 2005.

- 125 5. Navigant Consulting. *Refining Estimates of Water-Related Energy Use in California*. CEC-500-2006-118. Public Interest  
126 Energy Research (PIER) Program. 2006.
- 127 6. Barry, J.A. *Watergy: Energy and Water Efficiency in Municipal Water Supply and Wastewater Treatment*. Washington, D.C.:  
128 Alliance to Save Energy, 2007.
- 129 7. Tidwell, V.C.; Moreland, B.; Zemlick, K. Geographic Footprint of Electricity Use for Water Services in the Western U.S.  
130 *Env. Sci. & Tech.* **2014**, *48*, 8897–8904.
- 131 8. U.S. Environmental Protection Agency. *Ensuring a Sustainable Future: An Energy Management Guidebook for Wastewater  
132 and Water Utilities*. 2008.
- 133 9. World Bank. *A Primer on Energy Efficiency for Municipal Water and Wastewater Utilities*. Energy Sector Management  
134 Assistance Program (ESMAP) Technical Report 001/12. Washington, D.C.: World Bank, 2012.
- 135 10. U.S. Dept. of Energy. *The Water–Energy Nexus: Challenges and Opportunities*. DOE/EP-002. 2014.
- 136 11. Water in the West. *Water and Energy Nexus: A Literature Review*. Stanford, Calif.: Stanford University, 2013.
- 137 12. Dickinson, M.A.; Chesnutt, T.W.; Chery, M. Aligning Water Rates, Revenues, and Resources: Strategies for Today’s  
138 Utility Managers. *J. Am. Water Works Assoc.* **2015**, *2*, 52–59.
- 139 13. Hoffman, I.M.; Rybka, G.; Leventis, G.; Goldman, C.A.; Schwartz, L.; Billingsley, M.; Schiller, S. The Total Cost of Saving  
140 Electricity through Utility Customer-Funded Energy Efficiency Programs: Estimates at the National, State, Sector and  
141 Program Level. Technical Brief, Lawrence Berkeley National Laboratory. 2015.
- 142 14. Molina, M. The Best Value for America’s Energy Dollar: A National Review of the Cost of Utility Energy Efficiency  
143 Programs. Report Number U1402. Washington, D.C.: American Council for an Energy-Efficient Economy, 2014.
- 144 15. Horne, J.; Turgeon, J.; Boyus, E. Energy Self-Assessment Tools and Energy Audits for Water and Wastewater Utilities.  
145 Webinar, 31 July 2014.
- 146 16. Massachusetts Dept. of Environmental Protection. Massachusetts Drinking Water & Wastewater Facilities Energy  
147 Management Pilot. Massachusetts Energy Management Pilot. Available online:  
148 <http://www.mass.gov/eea/agencies/massdep/climate-energy/energy/water-utilities/massachusetts-energy-managemen>  
149 [t-pilot.html](http://www.mass.gov/eea/agencies/massdep/climate-energy/energy/water-utilities/massachusetts-energy-managemen) (accessed on 6 June 2016).
- 150 17. U.S. Environmental Protection Agency. *Energy Efficiency in Water and Wastewater Facilities*. EPA-430-R-09-038. Local  
151 Government Climate and Energy Strategy Guides. Washington, D.C.: U.S. Environmental Protection Agency, 2013.
- 152 18. Alliance to Save Energy. Watergy. Available online: <https://www.ase.org/projects/watergy> (accessed on 8 January  
153 2016).
- 154 19. Utah Dept. of Environmental Quality. Energy Efficiency Profile: Jordan Valley Water Conservancy District. Case study.  
155 2015.
- 156 20. Hansen, Allen & Luce, Inc., unpublished data.
- 157 21. Jones, S.C.; Lindhardt, P.W.; Sowby, R.B. Logan, Utah: A Case Study in Water and Energy Efficiency. *J. Am. Water Works  
158 Assoc.* **2015**, *8*, 72–75.
- 159 22. Yarosz, D.P.; Ashford, W. From Planning to Powerful Pumping. *Water Env. & Tech.* **2015**, *8*, 58–63.
- 160 23. Mundt, N.; Dodenhoff, J. Water System Optimization: An Energy Efficiency View. ACEEE Summer Study on Energy  
161 Efficiency in Industry, 2015.
- 162 24. Martin, B.; Ries, T. Managing Energy Helps Optimize a Distribution System.” *Opflow* **2014**, *12*, 8–9.
- 163 25. Utah Division of Drinking Water. *Drinking Water Energy (Cost) Savings Handbook*. Salt Lake City: Utah Dept. of  
164 Environmental Quality, 2014.
- 165 26. Jones, S.C.; Sowby, R.B. Water System Optimization: Aligning Energy Efficiency, System Performance, and Water  
166 Quality. *J. Am. Water Works Assoc.* **2014**, *6*, 66–71.
- 167 27. New York State Energy Research & Development Authority. *Water & Wastewater Energy Management Best Practices  
168 Handbook*. 2010.
- 169 28. Moran, D.; Barron, C. Low-Cost Strategies Optimize Energy Use. *Opflow* **2009**, *12*, 10–14.
- 170 29. Arora, H.; LeChevallier, M.W. Energy Management Opportunities. *J. Am. Water Works Assoc.* **1998**, *2*, 40–51.
- 171 30. New York State Dept. of Environmental Conservation. How to Boost Energy Efficiency in Municipal  
172 Facilities/Operations. Available online: <http://www.dec.ny.gov/energy/64322.html> (accessed on 28 January 2016).

