Water Conservation = Energy Conservation
A Report for the CWCB

Western Resource Advocates
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June 30, 2009

WESTERN RESOURCE
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Executive Summary

Energy and water are inextricably linked: Colorado's water utilities use energy to pump, treat, and distribute potable water; customers use energy to heat, cool, and/or pressurize water; and wastewater utilities use energy to treat and discharge wastewater. By conserving water, water utilities and customers can save energy. Equally important, energy and water savings translate into direct savings on customers' energy and water bills. Water conservation represents an important – and as of yet, underutilized – opportunity to attain substantial energy savings. Water conservation is consistent with the overarching goals of the New Energy Economy, and is an important component of moving Colorado towards a more sustainable future.

The "energy intensity" of water – the energy embedded in every gallon of water – varies considerably throughout the State. Utilities like Denver Water, for example, use very little energy to treat and distribute potable water supplies. The energy intensity of Denver's water – including supplying water and treating wastewater – is 821 kWh/AF. Parker Water and Sanitation, in contrast, uses a substantial amount of energy to pump groundwater from the Denver Basin aquifers. The energy intensity of water in Parker averages 4,494 kWh/AF – groundwater pumped from deeper portions of the aquifer is even *more* energy intensive.

Importantly, new water supplies that Front Range cities hope to develop will be more energy intensive than existing supplies. Groundwater pumped from greater depths, surface water conveyed over longer distances, and water treated to higher standards (i.e. using UV radiation) will all require more energy than today's water supplies.

Water conservation, in contrast, can provide significant energy savings, while saving customers money and reducing the State's greenhouse gas emissions. For example, we estimate that retrofitting half of Denver's households with water-efficient faucets, showerheads, dishwashers, and clothes washers would avoid the emissions of 274,000 metric tons of CO_2 ***each year***. Over the lifetime of the water-efficient appliances, the cumulative water, energy, and greenhouse gas savings would be extensive.

Two of Colorado's state agencies – the Governor's Energy Office (GEO) and the Colorado Water Conservation Board (CWCB) – have substantial experience in energy efficiency and water efficiency programs, respectively. Merging efforts could provide important economic and environmental benefits throughout the State. Specifically, GEO has several programs that could include broader water conservation measures. The federal Weatherization Assistance Program and the State's Energy $aving Partners program provide perhaps the biggest opportunities for greater water/energy conservation. These programs offer a long-term opportunity for GEO and the CWCB to collaborate on water/energy conservation and help Colorado's communities reap valuable energy, water, and financial savings. Other residential and commercial energy efficiency programs, like the K-12 School Energy Program, could also include water conservation measures.

Many of the energy efficiency programs have also received supplemental funding through the American Recovery and Reinvestment Act; this represents an immediate opportunity to attain important energy and water savings. In addition to the State's energy efficiency programs, Colorado’s counties have directly received funding through the ARRA. GEO and CWCB’s expertise could effectively help direct local funds toward water/energy efficiency initiatives.

We encourage GEO and the CWCB to collaborate on water conservation programs that save energy, and to give “weighted” consideration to efficiency programs that save both energy and water. Working together, the expertise of GEO and the CWCB could provide invaluable financial and environmental benefits to Colorado’s communities.

Introduction

Water utilities use energy to pump, treat, and distribute potable water supplies; customers use energy to heat, cool, or pressurize water; and wastewater utilities use energy to treat and discharge wastewater. Water conservation—through reducing the need for *all* of the above—can provide direct energy savings. In many cases, water conservation represents the "low hanging fruit" for meeting energy efficiency and greenhouse gas reduction goals.

Water conservation can provide immediate, direct energy savings. Equally important, it delays or eliminates the need for utilities to develop new water supplies, which are, in most cases, more energy intensive than existing supplies. Water conservation represents a "win" on four fronts: it saves water, saves energy, saves consumers' money on their energy, water, and wastewater bills, and helps avoid new, potentially damaging water supply projects.

In the following sections, we outline how Colorado's utilities and customers use energy for water. We do not present a comprehensive analysis of how much energy is embedded in all of Colorado's water supplies; rather, we provide a series of representative examples, including several of Colorado's major water utilities. Second, we profile several water conservation measures and the energy savings (and greenhouse gas emissions) each measure could provide. Finally, we examine federal and state programs – focusing on energy efficiency programs managed by the Governor's Energy Office – that could promote water conservation.

Background: Energy Use for Water

Energy is embedded in water. Water utilities use energy to pump groundwater, move surface water supplies, treat raw water to potable standards, and distribute it to their customers. Customers use energy to heat, cool, and pressurize water; and wastewater treatment plants use energy to treat wastewater before discharging it (Figure 1). The amount of energy embedded in water – its "energy intensity" – varies substantially, depending on the source of the raw water, the end use, and water quality requirements for discharge. *New* water supplies will almost certainly be more energy intensive than existing supplies: Groundwater pumped from greater depths, water conveyed over longer distances, and lower quality water (requiring more advanced treatment) will all demand more energy than existing supplies. The following sections present the energy used for water at each stage of the water supply process.

Figure 1. Energy is used to pump, treat, distribute, and use potable water, and to treat wastewater. Graphic: Cohen, R., B. Nelson, and G. Wolff, 2004. *Energy Down the Drain: The Hidden Costs of California's Water Supply.* Natural Resources Defense Council and Pacific Institute.

1. Water Supplies and Treatment

In Colorado, the amount of energy used by water utilities varies dramatically. Front Range water utilities like Denver Water or Fort Collins Water Utility, which rely on gravity-fed surface supplies, use minor amounts of energy to treat and distribute water to their customers. Utilities in the South Metro area, in contrast, use substantial amounts of energy to pump groundwater from the Denver Basin aquifers.

In 2007, Denver Water used just over 20,000,000 kWh to treat raw water to potable standards, and over 31,000,000 kWh to distribute this water to their customers. Denver Water supplied 222,187 AF of water to its customers; accordingly, the energy intensity of Denver's water supplies is 232 kWh/AF.[1] In 2005, the City of Fort Collins used slightly more than 4,000,000 kWh of electricity to treat and distribute potable water; the energy intensity of its water supply is 154 kWh/AF. Many of Colorado's cities have gravity-fed systems and high-quality water supplies that do not require energy for extensive treatment; the energy-intensity of water supplies in cities with systems similar to Denver or Fort Collins likely will be comparable.

Water utilities that rely on groundwater, in contrast, use substantially more energy on their water supplies. The energy used to pump groundwater depends on the depth of the aquifer and whether the aquifer is under artesian pressure. The South Metro area, for example, relies heavily on groundwater from the Denver Basin aquifers. Groundwater pumping in the Denver Basin aquifers exceeds recharge rates, and aquifer levels have fallen substantially in recent years. As the aquifer levels decline, the artesian pressure also falls. The energy required to pump water from these aquifers is expected to increase precipitously over the next 10 – 20 years as the aquifer level (and artesian pressure) drops.

The City of Parker, in the South Metro area, relies exclusively on groundwater from Denver Basin and alluvial aquifers. In 2008, Parker pumped 8,754 AF of water, and used 24,749,000 kWh of electricity. The energy intensity of the groundwater is substantial: the average energy intensity of Parker's water is 2,827 kWh/AF.[2] Water from deeper aquifers has higher energy intensity; pumping water from the Arapahoe Aquifer, for example, required between 3,700 and 3,950 kWh/AF.[3] The Arapahoe aquifer is not the deepest of the Denver Basin Aquifers – it overlies the Laramie and Fox Hills Aquifers.[4]

Pumping groundwater from shallower, alluvial aquifers requires less energy – in 2008, Parker's alluvial wells used 303 kWh/AF of water. In addition to groundwater pumping, Parker used 189,000 kWh of electricity at booster stations to distribute water throughout the city. Parker is not the only city that relies on groundwater from the Denver Basin Aquifers; many of the cities in the South Metro region – which have experienced some of the highest rates of growth in recent years – also rely on groundwater, and likely have similar energy demands.

Table 1 summarizes the energy intensity of each of these utilities' water supplies.

[1] Personal communication, Bob Peters, Denver Water, on July 28, 2008
[2] All data from James Roche, Operations Manager at Parker Water & Sanitation; emailed in May, 2009.
[3] Energy data varied slightly between different groundwater wells.
[4] As of May 2009, Parker did not have energy data for water pumped from these aquifers.

Table 1. The energy intensity of delivering potable water varies substantially, depending on the source of water.

Utility/City	Energy Intensity (kWh/AF)		
	Raw Water Pumping	Raw Water Treatment	Distribution
Denver Water	0	232	
Fort Collins Utilities		154	
Parker Water and Sanitation *	2,827 (303 – 4,679)	0	22 (0 – 7,692)

* For Parker Water and Sanitation, the energy intensity of pumping groundwater and distributing potable water spans a wide range (shown in parentheses).

2. Consumers' End Use

Customers use energy to heat, cool, pressurize, or further treat water.[5] Of these processes, ***heating*** represents, by far, the biggest water-related energy use in residences and many commercial applications.

The energy used to heat water – and the resulting greenhouse gas emissions – depends on whether a gas or electric water heater is employed. In the Rocky Mountain West, 68% of residential households rely on gas water heaters, 27% use electric heaters, and the remainder use alternative methods of water heating.[6] Heating 1 AF of water to 106ºF, a typical temperature for a shower, requires just over 42,000 kWh of electricity or 1,440 therms of natural gas (Table 2). These figures incorporate a host of assumptions, including the efficiency of the water heater.

Table 2. Estimated energy required to heat water for different uses.[7,8]

Appliance	Water Temperature	Electricity Required (kWh/AF)	Gas Required (therms/AF)
Faucet	80ºF	18,574	631
Shower	106ºF	42,361	1,440
Dishwasher	140ºF*	67,419	2,292

* A residential water heater is typically set at 125ºF; dishwashers use additional energy to heat water to temperatures as high as 140ºF.

3. Wastewater Treatment

Wastewater treatment plants' energy use can also vary substantially, depending on the size of the plant and the treatment requirements (i.e. secondary or tertiary standards).

The Metro Wastewater Reclamation District treats wastewater generated in the Denver region at its Robert W. Hite treatment facility. In 2008, the facility treated 145,000 AF of wastewater,

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[5] Some industrial users treat water to higher standards; households may employ water softeners that also use additional, if minor amounts of energy.

[6] EIA, Residential End User Survey, 2005. We do not have data for Colorado or specific water utilities' service areas.

[7] Vickers, A., 2001. *Handbook of Water Use and Conservation*. WaterPlow Press: Amherst, MA.

[8] Lenntech, Energy and Cost Calculator for Heating Water, last viewed June 1, 2009. Available at http://www.lenntech.com/calculators/energy-cost-water.htm.

using 85,439,000 kWh of electricity. The energy intensity of the wastewater is approximately 589 kWh/AF. Fort Collins' wastewater treatment process has a similar energy intensity. Fort Collins' Drake Plant used 12,866,080 kWh of electricity to treat 17,658 AF of water in 2008; the energy intensity of the wastewater treatment was 729 kWh/AF.[9] Both the Hite and Drake facilities treat wastewater to secondary standards before discharging it. Other utilities – including Parker Water and Sanitation District – are required to treat water to tertiary standards, a much more energy-intensive process. Parker's South Water Reclamation Plant, for example, used 1,645 kWh/AF in 2008.[10]

4. New Supplies

In Colorado – like much of the West – cities already have tapped the easiest, least energy-intensive water supplies. *New* supplies will likely require pumping water from greater depths, moving water over longer distances (sometimes through or over mountain ranges), and more extensive water treatment. Several recent or proposed water supply projects provide apt examples:

- Colorado Springs' Southern Delivery System
- The Northern Integrated Supply Project
- Agricultural transfers

Below are estimates of the energy embedded in each of these new proposed supplies.

Colorado Springs' **Southern Delivery System** (SDS) would pump 52,900 AF/year from Pueblo Reservoir to the City of Colorado Springs – lifting the water 2,100 feet over a distance of 62 miles. Annually, the pipeline would use 245,000,000 kWh of electricity,[11] enough energy to meet the annual needs of approximately 24,500 Coloradans. The energy intensity of water provided by the SDS would be 4,630 kWh/AF.

The **Northern Integrated Supply Project** (NISP), as planned, would provide water to 13 cities or water providers in Northern Water Conservancy District's service area. The project would use energy to lift water from the Poudre River and pump it into Glade and Galeton Reservoirs. Ultimately, NISP would have an annual energy demand between 34,000,000 and 58,000,000 kWh, and the energy intensity of the water would range from 850 to 1,450 kWh/AF.[12]

Some other proposed supply projects in Colorado would have much smaller energy demands. The Windy Gap Firming Project, for example, would use a very small amount of energy to pump water into the delivery pipelines (on the Western Slope), but would generate hydropower as the water flows downhill to cities along the Front Range. The project would, in total, generate more

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[9] Data provided by Ray Kemp, Process Control Supervisor, City of Fort Collins. May 14, 2009 (by phone).

[10] Parker's North Water Reclamation Facility used substantially more energy: 2,759 kWh/AF. This figure, however, includes electricity use by offices and laboratories, which we cannot separate from the energy used for treatment (Parker's office and laboratory facilities are on the same electrical meter as the treatment plant.)

[11] Bureau of Reclamation, 2008. Southern Delivery System Final Environmental Impact Statement.

[12] Army Corps of Engineers, 2008. Northern Integrated Supply Project Draft Environmental Impact Statement. Range reflects two possible configurations of the project, which depend on whether the project has a contract with the Bureau of Reclamation.

energy than it consumes.[13] Although data is not yet publicly available on the energy demands of Denver's proposed Moffat Expansion, we expect it will follow a similar pattern. Other recently proposed projects such as the Regional Water Supply Project (aka "Million pipeline") and Yampa Pumpback Project would have considerable energy demands; the energy intensity of the Yampa Pumpback Project, for example, would be 2,000 kWh/AF.

Agricultural Transfers

In recent years, some cities have purchased and transferred water from the agricultural sector. The energy used for these transfers could vary substantially, depending on the local infrastructure. We profile two possible scenarios: transfers from agricultural users in the Arkansas River basin and transfers along the South Platte.

In the Arkansas River basin, the "Super Ditch" provides an institutional framework for transferring agricultural water to growing cities like Colorado Springs and Aurora. In this system, agricultural water supplies would most likely be stored in Pueblo Reservoir, and pumped to Colorado Springs or Aurora.[14] If built, Colorado Springs potentially could use the SDS to move stored agricultural water from Pueblo Reservoir to the city.[15] Even assuming that no pumping would be needed to get water to Pueblo Reservoir from farms lower in the basin, the energy intensity of the water would be very high – 4,630 kWh/AF.

In contrast, certain agricultural water transfers in the South Platte Basin would use very little energy. In the South Platte, agricultural water supplies might be stored in existing reservoirs (where space is physically – and legally – available) or in gravel pits along the banks of the South Platte River. Where exchange of water rights would allow storage in existing reservoirs that are gravity-fed, little or no additional energy would be required. Where *new* storage is necessary to "firm up" agricultural water rights, some cities have constructed gravel pits. Storing water in gravel pits typically requires a small amount of energy to pump water from the river, over a berm or levee, and into the gravel pit. The energy used would depend on the height of the berm or levee; we estimate it would require 30 – 50 kWh/AF. If agricultural transfers require pumping water from the lower stretches of the river to cities or reservoirs along the Front Range, energy use could be more substantial.

5. Summary

Energy is embedded in every step of the water supply process. Colorado's water utilities use energy to provide water to customers *today*, and many of the proposed new supplies will have even greater energy requirements. Table 3 provides a summary of energy intensity of water supplies for three of the systems described in prior sections. Importantly, these totals reflect utility savings only, and do *not* include the energy used by the customer to heat, cool, pressurize, or further treat water, which depends on the final end use (described in greater detail in the following section).

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[13] Bureau of Reclamation, 2008. Windy Gap Firming Project Draft Environmental Impact Statement.

[14] HDR Engineering, 2007. *Rotational Land Fallowing-Water Leasing Program, Engineering and Economic Feasibility Analysis.* Prepared for Lower Arkansas valley Water Conservancy District.

[15] In informal conversations, Colorado Springs water utility representatives indicated that storing and conveying transferred agricultural water was a potential benefit of building the SDS.

Of the three case studies presented, Parker Water and Sanitation District has the most energy-intensive existing water supplies. Pumping and treating **just one gallon** of water/wastewater requires 14 Watt-hours of electricity, or the equivalent of running a 60 Watt light bulb for 15 minutes [for the energy embedded in 1 AF of water, see Table 3]. In Parker, the average person has a water-related energy "footprint" of 880 kWh/year – this estimate includes only energy used by the groundwater pumps and treatment plants, and ***does not*** include energy used by the customer to heat, cool, or treat water.[16] For reference, the average Coloradan uses 10,000 kWh/yr (including all residential, commercial, and industrial use).[17]

Table 3. The energy intensity of water and wastewater processes for three of Colorado's water utilities' existing systems, and Colorado Springs' proposed SDS.

Utility/City	Energy Intensity (kWh/AF)				
	Raw Water Pumping	**Raw Water Treatment**	**Distribution**	**Wastewater Treatment**	**Total**
Denver Water	0	232		589	821
Fort Collins Utilities		154		729	883
Parker Water and Sanitation *	2,827 (303 – 4,679)	0	22 (0 – 7,692)	1,645	4,494
Colorado Springs – proposed SDS	4,631	**	**	**	4,631**

* For Parker Water and Sanitation, the energy intensity of pumping groundwater and distributing potable water spans a wide range (shown in parentheses).
** Colorado Springs' energy use for treatment, distribution, and wastewater treatment was not available. The total energy embedded in water from the SDS would be *at least* 4,631 kWh/AF.

Water conservation offers important energy savings; reducing per capita water use results in dramatic energy savings for water utilities. In the next section, we profile several water conservation measures and assess their energy savings and greenhouse gas reductions. Accelerating implementation of these water conservation measures would provide even greater energy and carbon savings.

[16] Calculation reflects Parker's system-wide, per capita water use in 2007, 165 gpcd. Integra Engineering, 2009. *Water Conservation Plan*. Prepared for Parker Water and Sanitation District.
[17] Northwest Power and Conservation Council, 2005. *The Fifth Northwest Power and Conservation Plan*. Appendix A, p. 34.

Water and Energy Conservation

By reducing the need to pump, treat, and distribute water and wastewater, water conservation measures can offer real energy savings for the utilities. Saving *hot* water, however, offers the biggest potential energy savings. Measures that save customers electricity and/or natural gas can provide significant financial savings on customers' energy bills.

Water conservation measures have varying levels of energy savings. ***All*** water conservation measures reduce the volume of water pumped (from groundwater or surface water sources), treated, and distributed to customers, saving energy at each of those steps. Indoor water conservation measures also reduce the amount of water flowing to a wastewater treatment plant, saving energy at the treatment plant. Indoor measures that save *hot* water – the single greatest element of the energy intensity of each gallon – save energy used by the customer. Table 4 provides a matrix of the steps where energy is saved for several sample water conservation measures.

Table 4. Matrix of the steps where energy is saved for several sample water conservation measures.

	Energy Savings				
Conservation Measure	**Raw Water Pumping**	**Treatment**	**Distribution**	**Heating**	**Wastewater Treatment**
Leak Detection	**Yes**	**Yes**	**Yes**	No	No
Outdoor conservation	**Yes**	**Yes**	**Yes**	No	No
Water-efficient toilets	**Yes**	**Yes**	**Yes**	No	**Yes**
Water-efficient showerheads, faucets, or clothes washers	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**

Leak detection programs and outdoor conservation (i.e. installing a xeric landscape or watering lawns efficiently) would save the energy used to treat and distribute potable water to customers. In Denver Water's service area, for example, every AF of water saved by leak detection programs or outdoor conservation would save 232 kWh of electricity. Water conservation that saves *cold* water, like toilet replacement programs, would also save energy used by the wastewater treatment plant – in Denver, saving one AF of cold water used indoors saves 821 kWh/AF.

Saving hot water saves tremendous amounts of electricity, natural gas, and greenhouse gas emissions. Every AF of hot water conserved saves 18,600 – 67,400 kWh of electricity (depending on the temperature of the hot water). Water conservation measures that save hot water also provide direct financial savings to the customer. Not all indoor fixtures use energy in the household, however. Figure 2 illustrates how residents use water indoors[18]; Figure 3 illustrates the *water-related energy use* in the household, and underscores the importance of certain measures like water-efficient showerheads.[19]

[18] Vickers, 2001.
[19] Estimates in Figure 3 generated by WRA.

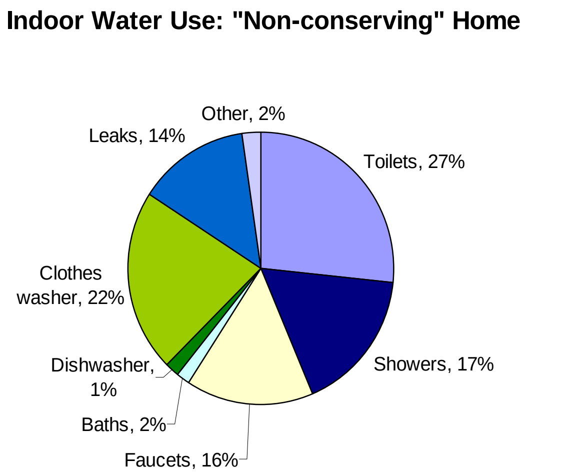

Figure 2. Breakdown of indoor residential water use.

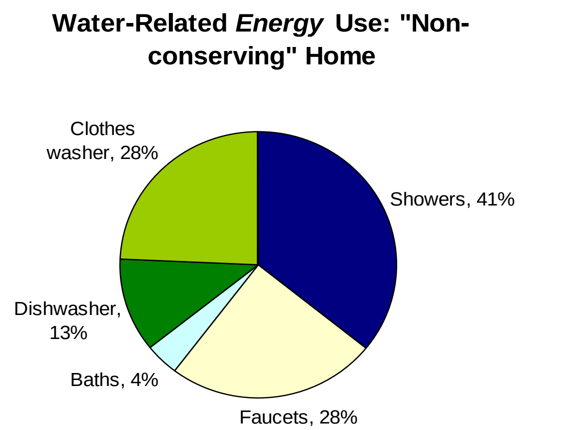

Figure 3. Consumers' water-related energy use, by appliance.

Table 5 lists several water conservation measures, estimates of the in-home electricity or gas savings, and associated cost savings. The average customer would save *either* electricity *or* gas, depending on their water heater. The estimates provided are on a per capita basis – in homes where two people share a shower or clothes washer, the annual water, energy, and cost savings will be double. Additionally, this analysis focuses on residential appliances. Water and energy efficient commercial appliances like clothes washers, dishwashers, restaurant faucets and spray nozzles could potentially provide even greater savings.

Table 5. Annual savings (per capita, per year) for a Denver Water customer with either an electric or gas water heater.

Measure	Water Savings (gal)	Electric Water Heater		Gas Water Heater	
		Energy Savings (kWh)	Cost Savings ($)	Energy Savings (therms)	Cost Savings ($)
Showerhead	1,129	147	$12	5	$4
Faucet aerator	3,696	211	$17	7	$6
Faucet	2,711	155	$12	5	$4
Clothes washer	1,880	213	$17	7	$6
Dishwasher	155	32	$27	12	$9

On a utility-wide basis, the potential energy savings are tremendous. In 2008, Denver Water distributed 9,561 rebates for high efficiency clothes washers, saving 110 AF of water.[20] This measure alone saved an estimated 642,000 kWh of electricity and 47,000 therms of natural gas.[21] Although the energy and water savings depend on a host of factors, Table 6 and Table 7 present two different estimates of the potential benefits. Table 6 illustrates the potential water and energy

[20] Denver Water, 2009. *Solutions: Saving Water for the Future.* Available at http://www.denverwater.org/cons_xeriscape/conservation/pdfs/solutions.pdf.

[21] Calculation assumes that the average water temperature in a washing machine is 80ºF, 27% of rebate recipients have electric water heaters, and 68% have gas water heaters. Clothes washed in high efficiency washing machines also have shorter drying times; therefore, additional energy savings would be gained in the drying process. These additional savings are not included in the estimates presented here.

savings if half of Denver Water's residential customers replaced older showerheads, faucets, clothes washers, and dishwashers with water efficient models.[22] The estimates reflect the region-wide mix of electric and gas water heaters (27% and 68%, respectively).[23] Table 7 presents the greenhouse gas emissions avoided by reducing per capita water use by 20%, 30%, and 40% in the three case study regions; these estimates reflect the regional mix of gas and water heaters.

Table 6. System-wide ***annual*** savings for Denver Water (assuming half of all residents replace older appliances with new, water efficient appliances).

Measure	Water Savings (AF)	Electric Savings (MWh)	Gas Savings (therms)	GHG Reductions (metric tons CO_2)
Showerhead	2,250	27,600	2,205,300	37,600
Faucet aerator	7,370	43,000	3,163,200	57,200
Faucet	5,410	31,600	2,320,400	42,000
Clothes washer	3,750	39,800	3,213,600	54,300
Dishwasher	310	59,800	5,101,300	83,000
Total	**19,100**	**201,700**	**16,003,600**	**274,000**

1. Gas and electric savings include all energy saved in water treatment/distribution, in the household, and at the wastewater treatment plants.
2. The energy savings are system-wide, including hot water savings. To calculate in-home savings, we assume 68% of residents have gas water heaters, and 27% have electric water heaters.
3. Estimates do not reflect the implementation of conservation measures that Denver Water may have already employed (calculations are based on data from Vickers, 2001). We do not incorporate data on the average age/replacement rate of appliances; the water and energy savings depend on the age (and efficiency) of replaced appliances.

Table 7. Colorado could reduce its greenhouse gas emissions substantially if per capita residential water use fell by 20%, 30%, or 40%.

	Denver Water	Fort Collins Utilities	Parker Water & Sanitation
SFR Per Capita Water Use (gpcd)	137	135	116
20% Water Conservation – Avoided Emissions (metric tons CO_2/yr)	76,600	8,700	5,300
30% Water Conservation – Avoided Emissions (metric tons CO_2/yr)	114,900	13,000	7,900
40% Water Conservation – Avoided Emissions (metric tons CO_2/yr)	153,200	17,300	10,500

1. The commercial, industrial, and institutional sectors would likely provide additional savings.
2. These calculations assume that half of the water savings are outdoors, and half indoors (and reflect both cold and hot water savings)
3. The ghg emissions are calculated based on the portion of residents that use electric and gas water heaters.
4. Calculation assumes electricity used by a water heater has the ghg intensity of electricity from Colorado's grid.

[22] Replacing half of the appliances in Denver's service area would likely occur over a period of years. The energy and greenhouse gas savings would last for many years, however, depending on the lifetime of different appliances.
[23] EIA, Residential End User Survey, 2005. We do not have data for Colorado or specific water utilities' service areas.

The *cost* of a program depends on a host of factors. For example, how many showerheads or bathroom faucets would need replacing in each house? How many are actually used on a regular basis? Does an effective conservation program demand that program staff install water efficient appliances? We do not provide cost estimates here, but note that many water conservation programs are cost effective on their own. And some programs that are not cost effective based solely on the water savings may become cost-effective when energy savings are included.

Service Area Issues

Water, wastewater, and energy utilities often have very different service areas. For example, the Southern Delivery System will provide water to Colorado Springs residents, but will have pumping stations (and energy demands) in three different energy utilities' service areas: Mountain View Rural Electric Cooperative, Black Hills Electric, and Colorado Springs Utilities. Saving water in Colorado Springs, therefore, saves energy in three different service areas. Developing a co-funded water/energy efficiency program between four utilities (Mountain View, BHE, and Colorado Springs' energy and water utilities) has inherent institutional challenges.

Similarly, water conservation in the Denver area benefits Denver Water, but may *increase* energy demands slightly for the Metro Wastewater Reclamation Authority. According to Metro Wastewater, water conservation measures have reduced total inflows into the treatment plant, increasing concentrations of pollutants and the energy intensity of treating wastewater on a *per gallon* basis: In 2001, Metro Wastewater treated 173,000 AF of water and used 466 kWh/AF; in 2008, Metro treated only 145,000 AF of water, but used 589 kWh/AF. The *total* energy used by the wastewater plant remained essentially flat, while Denver Water and the end user likely saw energy savings.

Federal and State Opportunities

State and federal agencies clearly recognize the energy embedded in hot water. The Colorado Governor's Energy Office estimates that "water heating can account for 14 – 25% of a home's energy use."[24] Residents can reduce their water-related energy use by either (1) improving the efficiency of their water heater, or (2) reducing the hot water use in indoor appliances. Importantly, reducing hot water use has the added benefit of reducing energy use offsite, along with delaying or eliminating the need to develop new water supplies.

Water conservation measures, particularly those that save energy, may be eligible for funding from numerous Federal and State programs. Relevant programs in the State of Colorado include the Weatherization Assistance Program and Energy $aving Partners program. These programs present long-term opportunities to integrate water efficiency into energy efficiency measures. Several other residential and commercial energy efficiency programs may also present opportunities to improve water use efficiency.

The American Recovery and Reinvestment Act (ARRA) may offer a near-term opportunity to pursue major energy and water efficiency savings. The Weatherization Assistance Program, State Energy Program, and Energy Efficiency and Conservation Block Grants Program all received additional funding through the ARRA. Additionally, Colorado's counties received funding directly from the ARRA; the expertise at GEO and the CWCB could help channel a portion of the counties' funding toward energy/water conservation measures, providing both environmental and economic savings to Colorado's communities.

1. Weatherization Assistance Program

The DOE's Weatherization Assistance Program was designed to "reduce energy costs for low-income households by increasing the energy efficiency."[25] Historically, the Weatherization program has included several water-related measures: replacing showerheads, replacing water heaters, and wrapping water heaters and pipes with insulating blankets. The measures chosen for any given household depend on which provide the biggest energy savings. Replacing a water heater – an expensive measure – has not been common; replacing showerheads has been much more common (and cost competitive).

The measures that are cost competitive in the Weatherization Program vary from region to region, and depend on the number of heating (or cooling) days, the typical fuel used to heat (and cool) houses, and the fuel used to heat water. Measures that reduce baseload electricity use, like replacing refrigerators with energy-efficient models, tend to be the most cost-effective, because of the high cost of electricity (per Btu). In households relying on electricity to heat water, energy-efficient clothes washers and dishwashers would also fall into this category. In a 2002 report, Schweizer and Eisenberg assessed which measures were cost effective under a $2,500 expenditure cap and under an expanded program. Clothes washers were *almost* cost-effective in

[24] Governor's Energy Office, 2009. Water Heating and Water Conservation, http://www.colorado.gov/energy/index.php?/residential/water-heating-water-conservation viewed May 22, 2009.
[25] U.S. Department of Energy, 2009. Weatherization Assistance Program for Low-Income Persons: Final Rule, p. 5. Available at: http://apps1.eere.energy.gov/weatherization/pdfs/wap_2009_federal_register_notice_for_territories.pdf.

the Southeastern U.S. (where most water heaters use electricity) at the $2,500 cap, and the authors note that

> "In the future, any increase in fuel prices, decrease in product costs, or technological improvements to appliance efficiency could make these measures more widely cost-effective and could also add other measures (e.g., energy-efficient dishwashers) to the list of appropriate options."[26]

Although this comment refers specifically to Southern households, the same conditions – higher fuel prices, lower product costs, and improved product efficiency – also make the measures cost competitive in Western states.

The American Recovery and Reinvestment Act (ARRA) increased the minimum average expenditure per dwelling unit from $2,500 to $6,500.[27] With this increase, more water-efficiency measures may also become cost-competitive.

2. Residential Energy Efficiency Programs

The State of Colorado promotes energy efficiency through several programs. Of those, two programs could potentially promote water conservation: the Energy $aving Partners (E$P) Program, and the Insulate Colorado Program. Additionally, the Energy Star New Homes Program potentially could improve water efficiency in new homes.

The **Energy $aving Partners** (E$P) program improves energy efficiency in low income households. The State of Colorado has applied federal Weatherization funds to its Energy $aving Partners (E$P) program, which has also received funds through HB 06-1200, Xcel energy, and other partners. In 2007, E$P delivered or installed over 12,000 energy saving kits, which include both showerheads and light bulbs.[28] In state fiscal year (sfy) 2006-07, the E$P's first year of operation, the E$P program distributed or installed over 20,000 showerheads, with estimated lifetime gas savings of almost 1,000,000 therms.[29,30] The cost-benefit ratio of the energy efficiency measures in the E$P program (including compact fluorescent light bulbs, showerheads, and other measures) was an impressive 1 to 2.79.

The **Insulate Colorado** program provides incentives to homeowners to improve or replace home insulation, furnaces, lighting, and ***appliances***. We encourage GEO to include water efficient devices on the menu of appliances it will consider replacing. As part of its consideration of water-efficient appliances, GEO should recognize both the onsite, in home energy (and cost) savings, as well as the offsite energy savings by the water utility.

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[26] *Id*, at p. 11.
[27] *Id*, at p. 11.
[28] Governor's Energy Office, 2009. Annual Report of the Governor's Energy Office Fiscal Year 2008. p. 11.
[29] Governor's Energy Office, 2001. State Funded Energy Efficiency Services for Colorado's Low-Income Households: First Annual Report to the Colorado General Assembly. Executive Summary. Accessed at http://www.colorado.gov/energy/in/uploaded_pdf/AnnualReport_sfy0607_HB061200_002.pdf.
[30] This analysis appears to assume that all households have gas water heaters.

Historically, the **Energy Star New Homes** has not focused on water efficiency measures. However, with Colorado's population projected to grow by over two million residents between now and 2030, it will be important to improve both water efficiency and energy efficiency in new homes. Through its Water Sense program, the EPA has also developed draft specifications for water-efficient new homes.[31] We recommend the Energy Star New Homes program include, at a minimum, the specifications outlined in the Water Sense new homes program for indoor fixtures, and consider integrating the Water Sense specifications for outdoor landscaping. At present, the Water Sense program (a very new program) has only approved a few indoor devices, but the program will likely approve more appliances in coming years.

In terms of water efficiency, not all homes are created equal. Homes constructed before 1994 will likely have older, less water efficient fixtures. A program to retrofit residential water appliances, therefore, should focus on counties or cities with older dwellings. Although the ***Background*** section of this report highlighted the energy intensity of water supplies in Parker, CO, most of the homes in Douglas County are relatively new, and likely have water efficient fixtures. El Paso County, in contrast, has a substantial number of older houses, rapidly growing water demands, and a proposed new energy intensive water supply. A water/energy efficiency retrofit program should focus on places like El Paso County. Figure 4 illustrates the age of homes in select Colorado counties.

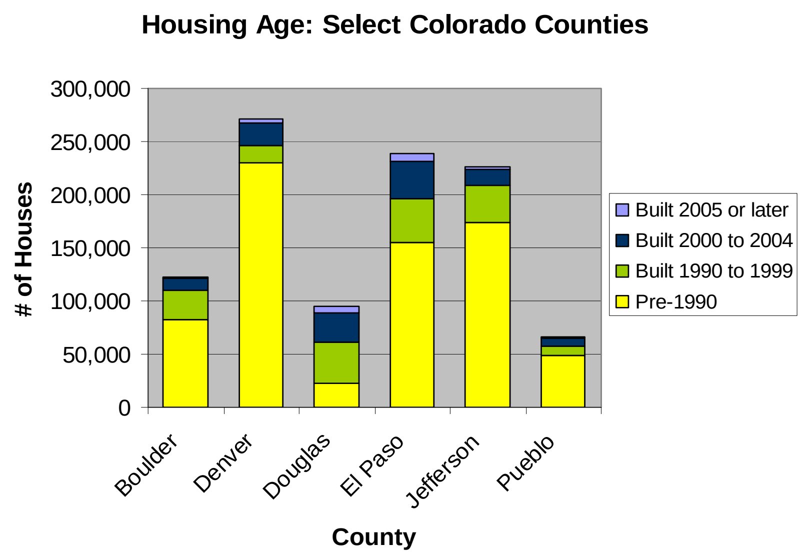

Figure 4. Houses built after 1994 will have more water efficient fixtures than houses built before 1994. Residential retrofit programs should focus in counties with older dwellings. Data source: U.S. Census Bureau, 2005 – 2007 American Community Survey.

3. Commercial Energy Efficiency Programs

Opportunities for improving water use efficiency in the commercial, industrial, and institutional sector are just as ripe as in the residential sector. Potential water savings in the commercial and industrial sector are estimated at 15% to 50%, with savings of 15% to 35% typical.[32] As in the

[31] EPA, 2009. *Revised Draft Water-Efficient Single-Family New Home Specification.* Accessed at: http://www.epa.gov/watersense/specs/homes.htm.

[32] AWWA Research Foundation, *Commercial and Institutional End Uses of Water* (Denver, CO: AWWA Research Foundation, 2000), 145.

residential sector, the energy savings generated by water conservation in the commercial sector depend on the conservation measure: installing water-efficient clothes washers in laundromats, bathroom fixtures in hotels or schools, and faucets in restaurants, for example, all save hot water and would save more significant amounts of energy. GEO has three commercial programs that could incorporate water conservation measures.

GEO's **Performance Contracting** program helps owners of existing buildings improve the energy efficiency of those buildings. Although GEO has primarily aided in feasibility analyses, the agency can provide oversight to its third party contractors (i.e. Trident Energy Services in fiscal year 2008) and support the inclusion of water conservation measures in its "menu" of energy efficiency options. Similarly, GEO should ensure that its **High Performance Design** program, which applies to public buildings, includes water-efficiency measures.

The **K-12 School Energy Program** represents the third main opportunity for integrating water conservation measures into commercial buildings. The K-12 School Energy Program promotes energy efficiency projects, providing energy *and* cost savings for public schools.[33] If these programs broadened their scope to include water efficiency measures, they could provide important water, energy, and cost savings. For example, in 2009, Denver Water expects to save 217 AF/yr by installing water efficient toilets, urinals, and faucets in 84 schools in the Jeffco School District.[34] The water saved by these measures will save approximately 178,000 kWh/yr in energy used at Denver Water's and Metro Wastewater's treatment plants. The water-efficient faucets, which save hot water, are projected to save 41 AF/yr,[35] with estimated *onsite* energy savings of over 760,000 kWh/yr and energy bill savings of $61,000/yr.[36] In addition to Jeffco Schools, Denver Water is working with Denver Public Schools, Cherry Creek Schools, and others to reduce schools' water use, and has already reaped important water savings.

The K-12 School Energy Program represents a prime opportunity for collaboration between the Governor's Energy Office, CWCB, and local water districts. The following two examples, based on Denver Water's programs, illustrate the benefits of a statewide approach:

- Denver Water only retrofit the Jeffco schools within its service area, but the potential for energy and water savings in the other Jeffco schools is likely comparable. Throughout the state, many water utilities do not have the resources or capacity to pursue similar retrofit programs; a statewide effort to improve water and energy efficiency in schools could provide valuable savings.
- Denver Public Schools requested water-efficient clothes washers and dishwashers in its buildings, but Denver Water has not yet committed to providing the devices, in part because the cost-competitiveness of the devices – in terms of water savings alone – is not evident. The *energy* savings associated with water efficient clothes and dishwashers,

[33] Governor's Energy Office, 2009. Governor's Energy Office Strategic Goals and Objectives for the American Recovery and Reinvestment Act funding of the State Energy Program. Available at: http://www.colorado.gov/energy/images/uploads/pdfs/GEO_ARRA_Program_Goals_and_Objectives.pdf
[34] Denver Water, 2009. *Solutions.* Available at http://www.denverwater.org/docs/assets/DD81F7B9-BCDF-1B42-DBDA3139A0A3D32D/solutions1.pdf.
[35] Personal communication with Cindy Moe, Industrial Water Conservation Engineer, Denver Water.
[36] Calculation assumes that water in faucets is 80 ºF, schools have electric water heaters, and electricity costs $0.08/kWh. If schools have gas heaters, the energy and cost savings would be less – approximately 26,000 therms of natural gas/year, and $20,000/yr.

however, are substantial. Co-investment from GEO could make the water efficient machines cost effective for Denver Water.

Other opportunities to enhance water and energy efficiency in schools may also arise. In 2009, Colorado's State Legislature passed HB 09-1312, the Renewable Energy and Energy Efficiency for School Loans Program Act. This act could be amended to include water efficiency, enabling schools to receive loans from the State for water efficiency upgrades.

4. American Recovery and Reinvestment Act

Water conservation measures are consistent with the American Recovery and Reinvestment Act (ARRA), which states the following overarching purposes:

(1) To preserve and create jobs and promote economic recovery.
(2) To assist those most impacted by the recession.
(3) To provide investments needed to increase economic efficiency by spurring technological advances in science and health.
(4) To invest in transportation, environmental protection, and other infrastructure that will provide long-term economic benefits.
(5) To stabilize State and local government budgets, in order to minimize and avoid reductions in essential services and counterproductive state and local tax increases. (Section 3(a), accessed at http://frwebgate.access.gpo.gov/cgi-bin/getdoc.cgi?dbname=111_cong_bills&docid=f:h1enr.pdf)

As described in earlier sections, water conservation measures can provide immediate energy and financial savings, reducing customers' energy and water bills (consistent with goal (2)) and water utility budgets (consistent with goal (5)). All water conservation measures reduce the need to develop new and costly water supplies or expand existing supplies, providing long-term economic and environmental benefits (consistent with goal (4)).

The Governor's Energy Office will allocate a portion of its ARRA funding – through the State Energy Program – to residential energy efficiency programs, commercial energy efficiency programs, and the **Energy Efficiency and Conservation Block Grants** program. Water conservation measures are consistent with the existing Energy Efficiency and Conservation Block Grants program, which allows funds to be used for "energy efficiency retrofits" or to "develop and implement energy efficiency and conservation programs for buildings and facilities within the jurisdiction of the entity", among other goals.[37,38] By focusing on programs that save both energy and water and collaborating with other state agencies, the block grants could be effectively leveraged to provide even greater environmental benefits.

In allocating the Energy Efficiency and Conservation Block Grants, we encourage the GEO to provide "weighted" consideration to programs that will save both energy *and* water.

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[37] Governor's Energy Office, 2009. Energy Efficiency and Conservation Block Grants, Available at: http://www.colorado.gov/energy/index.php?/policy/energy-efficiency-and-conservation-block-grants-eecbg/.
[38] Of the $42.8 million the State of Colorado received for its Energy Efficiency and Conservation, GEO has $9.6 million to distribute state-wide.

The ARRA represents a short-term funding mechanism. However, to the extent that the State Energy Program initiatives and Energy Efficiency and Conservation Block Grants continue promoting energy efficiency in future years, we recommend they include water conservation measures.

Conclusion

Water conservation offers many benefits – among those, but seldom recognized, are the potential energy savings and avoided greenhouse gas emissions. Indeed, water conservation represents “low hanging fruit” in terms of both energy conservation and greenhouse gas savings. Equally important, water conservation measures that save *hot* water can save customers money on gas and electric bills. In all regards, the water, energy, and financial savings – and the avoided greenhouse gas emissions – meet the overarching goals of the Governor’s Energy Office and the American Recovery and Reinvestment Act. Water conservation falls under the purview of several existing State and Federal programs, each of which will receive additional funding through the ARRA.

Investing in water conservation reduces strains on freshwater resources, provides energy and greenhouse gas emissions reductions, and delays or eliminates the need to invest in new, energy-intensive water supplies. The nexus between water conservation and energy efficiency provides an important opportunity for collaboration between the CWCB, GEO, and local water districts. Specifically, we recommend the following initial programs:

1. **Residential Water Efficiency Retrofit Program:** State agencies should partner with local water utilities to expand residential retrofit programs. We recommend focusing on places like Colorado Springs, which has older residential dwellings, growing water demands, and a proposed new energy intensive water supply.

2. **Commercial Water Efficiency Retrofit Program:** State agencies should partner with local water authorities to install water-efficient fixtures, particularly those that save hot water, in government buildings. Specifically, the K – 12 School Energy Program should include water efficiency measures along with energy efficiency measures.

3. **Legislative Changes:** Where necessary, consider amending legislation that promotes energy efficiency to include water efficiency. Specific examples from 2008 and 2009 include, but are not limited to Senate Bill 08-184, House Bill 08-1350, House Bill 08-1335, House Bill 09-1312, and Senate Bill 09-039.

In sum, we recommend the GEO incorporate water conservation measures in its existing energy efficiency programs and as it allocates ARRA funding. The Colorado Water Conservation Board has established relationships with local water utilities, and can provide important guidance on which conservation programs also provide energy savings. Working with the CWCB on energy/water conservation programs would enhance the environmental and economic benefits of the State’s energy efficiency programs.