Do automatic water faucets actually save water?

A comparative test of manual and automatic water faucets at California State University, Sacramento.

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Abstract

Due to the lack of research and consensus on the water efficiency of automatic water faucets, we designed a study to comparatively evaluate the water usage of manual faucets and automatic faucets in a public setting. We implemented three phases across a four month period of time to compare a manual faucet, an automatic faucet with a 0.5 gpm aerator, and an automatic faucet with a 0.35 gpm aerator in both the men's and women's restroom at California State University, Sacramento. We found that the automatic faucets with a 0.5 and 0.35 gpm aerator resulted in an average water reduction of 32% and 54% respectively in comparison to the manual faucet. Additionally, we were able to evaluate the ROI of a single faucet based on the water savings. From this study, we determined that the most sustainable faucet is the automatic water faucet with a 0.35 gpm aerator.

Introduction

Automatic water faucets have become a staple in public restrooms. They are convenient, energy efficient, hygienic and, according to manufactures, water efficient. Some manufactures report a water savings of up to 70% depending on the size of the aerator used. However, whether or not these automatic faucets save water when compared to manual faucets is a point of contention among water efficiency professionals. A study by Koeller and Gauley (2010) in Hillsborough County, Florida, found a significant (30%) increase in water demands when manually-operated faucets were converted to automatic faucets. Hills et al. (2002) published a report in the UK and found that manual faucets used less water than automatic and push-top faucets. The study noted that users typically do not turn a conventional faucet on all the way leading to a reduction in the gallons per minute (gpm) of water used. The Hills et al. (2002) report found that the optimal flow rate for a single hand wash is between 0.25 and 0.50 gpm. Dougherty et al. (2002) tested a photovoltaic water heater and inadvertently found that 0.5 gpm aerators yielded significantly lower water consumptions, but larger aerators yielded higher water consumption. Finally, The American Society of Civil Engineers (Abdallah et al. 2013) published a report on the performance of sustainable measures in public buildings; they found that users were satisfied with the performance and maintenance of automatic faucets, but noted that the water conserving faucets only translated to a 1% water savings. These studies show a varying array of results and

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are uninformative for a consumer attempting to make the decision of whether converting manual faucets to automatic faucets is worth the time and cost.

Throughout these studies, there are two factors that appear to make a significant difference in whether automatic water faucets confer a water savings; these factors include the size of the aerator and human behavior. In the Koeller and Gauley (2010) study, the sensor faucets tested had a flow rate of 1.2 gpm which is 140% bigger than the faucet aerators required in commercial buildings today. In an interview with the Sacramento Bee, Koeller noted that the new maximum (0.5 gpm) flow rate of aerators may abate the problem of automatic water faucets wasting water. In regards to the human behavior aspect, the Hill et al. (2002) study found a striking difference between male and female bathroom behavior. They found that 6% of females use the restroom for preening in comparison to 2% of males. Additionally, females washed their hands more frequently after using the restroom (83% of females washed their hands in comparison to 73% of males); this translated to women's restrooms consuming more water overall.

Due to the lack of consensus on the water savings of automatic water faucets, the Facilities Management Department at California State University, Sacramento designed a study to determine if 1. Automatic water faucets conserve water; 2. It is cost effective to replace the manual faucets on the Sacramento State campus with automatic faucets.

Methods

Study location

The men's and women's restrooms on the second floor of the Academic Information Resource Center (AIRC) at California State University, Sacramento were chosen as the sites for the experiment. These restrooms receive a high volume of use and are within the jurisdiction of the Facilities Management Department.

Faucet Specification

The manual faucets used in the study were the Delta 510 model (0.5 gpm, Figure 1). Two electronic faucets were obtained on loan from Chicago Faucets (0.5 gpm, 0.35 gpm, model # 116.606.AB.1, Figure 2). The automatic faucets were placed on the right hand side of the counter

in both the men's and women's restroom. To record water usage, a digital water flow meter from Savant Electronics (DigiFlow 6700M) was installed on both faucets (Figure 3).

Figure 1. Manual Faucet.

Figure 2. Automatic Faucet

Figure 3. Water flow meter

Phases

To accurately assess the water usage of the manual faucets and automatic faucets, three phases were implemented beginning in December of 2015 and ending in March 2016; the phases were as follows:

Phase 1: Manual faucet, 0.5 gpm aerator, 14 day trial.
Phase 2: Automatic faucet, 0.5 gpm aerator, 14 day trial.
Phase 3: Automatic faucet, 0.35 gpm aerator, 14 day trial.

To ensure that the usage volume was consistent between the three phases, people were manually counted entering the restrooms using a stratified random sampling method during peak times, which were noted as the hours between 9:00 am and 5:00 pm, Monday through Friday. Additionally, an electronic reader device from Chicago Faucets was used to assess the number of activations of the electronic faucets; this data was used to affirm the consistency of faucet usage across the three phases (Figure 4, Table 2).

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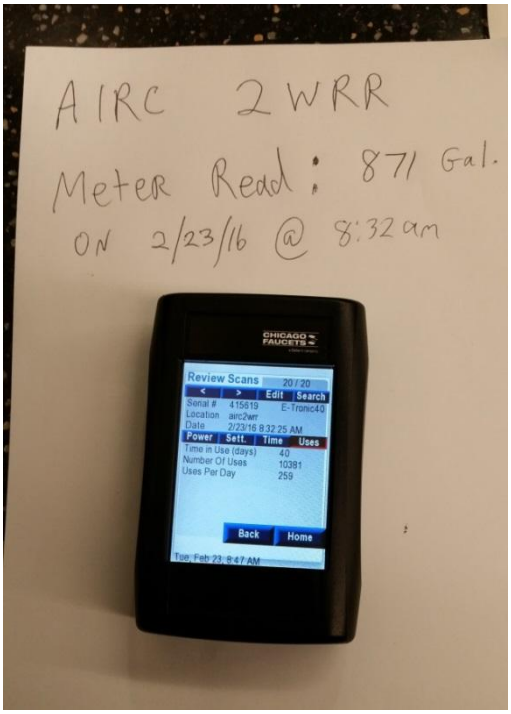

Figure 4: Electronic meter reader

Results

Table 1. Gallons of water used in each of the three phases in the men's and women's restroom.

	Gallons used Men's	Gallons used Women's
Phase 1 (Manual Faucet 0.5 gpm)	132	240
Phase 2 (Automatic Faucet 0.5 gpm)	84	172
Phase 3 (Automatic Faucet 0.35 gpm)	58	111

Table 2. Number of electronic faucet activations in the men's and women's restrooms.

	Activations Men's	Activations Women's
Phase 2 (Automatic Faucet 0.5 gpm)	3145	4892
Phase 3 (Automatic Faucet 0.35 gpm)	2971	5034

Table 3. Average number of men and women entering the restrooms per hour during peak times.

	Average Men's	Average Women's
Phase 1 (Manual Faucet 0.5 gpm)	60	61
Phase 2 (Automatic Faucet 0.5 gpm)	58	60
Phase 3 (Automatic Faucet 0.35 gpm)	57	59

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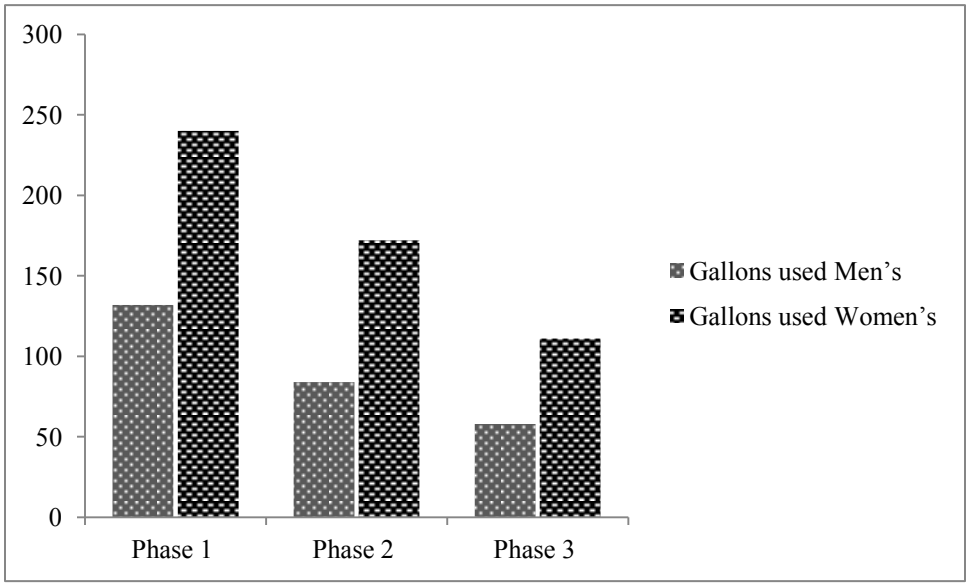

Figure 5. Gallons of water used in the men's and women's restroom per phase.

Discussion

To adequately consider the two factors that influence whether automatic faucets confer a water savings, we compared different sized aerators and calculated the water usage between the men's and women's restrooms separately. Overall, women used more water than men in each of the phases; this is consistent with the findings of Hill et al. (2002). The automatic water faucet with the 0.5 gpm aerator used in phase 2 resulted in a 36% reduction in water use for the men's and a 28% reduction for the women's. The automatic water faucet with the 0.35 gpm aerator used in phase 3 resulted in a 56% reduction in water use for the men's and a 53% reduction for the women's. The average number of men and women entering the restrooms obtained from stratified random sampling was ~ 60 men and women per hour during peak times; this average was consistent throughout the three study phases. Additionally, the number of electronic faucet activations was not significantly different between phase 2 and phase 3 of the study which aids to confirm that the volume of use was relatively consistent between the three phases.

From our study, it appears that automatic water faucets do present a significant water savings and these savings are further amplified when a smaller aerator is used; this finding answers the first question of our study. To address our second question, in regards to the cost of converting the manual water faucets on the campus to automatic faucets, we outlined a cost-benefit analysis and return on investment for a single faucet.

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Cost-Benefit Analysis

To determine the approximate return on investment, we considered the cost of the faucet, installation, maintenance, water/sewer and the savings provided by the reduction in water use. The automatic faucet with a 0.5 gpm aerator has an initial cost of $311.00 per faucet and confers an average water savings of ~32%. With this model, the battery must be replaced every 5 years. The cost of the battery and the in-house maintenance to replace this battery is $54.45 every 5 years. The automatic faucet with a 0.35 gpm aerator has the same price guidelines as the automatic faucet with the 0.5 gpm aerator, but confers a greater average water savings (~54%). For price comparison, we also included an SPSS automatic faucet in our analysis. This faucet has a 0.5 gpm aerator which we estimated will result in a 32% reduction in water use. The SPSS model was not used in the study, but was included in the cost-benefit analysis for price comparison; it is a self-power generating faucet that has a battery life of approximately 12 years and only needs to be recharged once every 4 years (Table 4, Table 8).

To calculate the cost of installation, we obtained the plumbing rates for California State University, Sacramento's in-house plumbers as well as the rates for an outside contractor. Because the rates of the in-house plumbers change depending on the building, we broke down the cost for state buildings and non-state buildings (Table 5, Table 6, Table 7).

To consider the cost of water and sewer we used the average number of gallons of water used in our study to convert the cost into the total cost of water/sewage per faucet per day (Table 9). For the time component, we used the academic calendar year (including academic work days) which is 170 days. With this data, we were then able to estimate the return on investment (in academic years) for a single faucet. For in-house plumbing installation (state building), the 0.5 gpm automatic faucet ROI is 74 academic years, the 0.5 gpm SPSS faucet ROI is 91 academic years, and the 0.35 gpm automatic faucet ROI is 44 years. For in-house plumbing installation (non-state building), the 0.5 gpm automatic faucet ROI is 80 academic years, the 0.5 gpm SPSS faucet ROI is 98 academic years, and the 0.35 gpm automatic faucet ROI is 48 years. For outside contractor installation, the 0.5 gpm automatic faucet ROI is 86 academic years, the 0.5 gpm SPSS faucet ROI is 107 academic years, and the 0.35 gpm automatic faucet ROI is 52 years (Table 10). These ROI estimates do not take into consideration the maintenance and battery costs which would be an additional $54.45 every 5 years for the 0.5 and 0.35 gpm automatic faucets and $60.68 every 4 years for recharging the SPSS model.

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Table 4: Faucet model, cost (USD), and average water savings.

Faucet	Aerator (gpm)	Total Cost per Faucet	Battery Life (years)	Battery Cost	Water Savings
Automatic Faucet Model #116606	0.5	311.00	5	14.00	~ 32%
Automatic Faucet Model #116606	0.35	311.00	5	14.00	~ 54%
SSPS Automatic Faucet	0.5	375.00	~ 12	N/A	~ 32%

Table 5: Initial installation cost (USD) for state buildings.

Faucet	Cost per Faucet	Installation Time (hours)	Hourly Rate	Total Cost per Faucet
Automatic Faucet (0.5 gpm)	311.00	1.5	44.94	378.41
Automatic Faucet (0.35 gpm)	311.00	1.5	44.94	378.41
SSPS Faucet (0.5 gpm)	375.00	2.0	44.94	464.88

Table 6: Initial installation cost (USD) for non-state buildings:

Faucet	Cost per Faucet	Installation Time (hours)	Hourly Rate	Total Cost per Faucet
Automatic Faucet (0.5 gpm)	311.00	1.5	63.36	406.04
Automatic Faucet (0.35 gpm)	311.00	1.5	63.36	406.04
SSPS Faucet (0.5 gpm)	375.00	2.0	63.36	501.72

Table 7: Initial installation cost (USD), outside contractor:

Faucet	Cost per Faucet	Installation Time (hours)	Hourly Rate	Total Cost per Faucet
Automatic Faucet (0.5 gpm)	311.00	1.5	85.00	438.50
Automatic Faucet (0.35 gpm)	311.00	1.5	85.00	438.50
SSPS Faucet (0.5 gpm)	375.00	2.0	85.00	545.00

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Table 8: Maintenance cost (USD) per faucet.

Faucet	Maintenance Time (Hours)	Hourly Rate	Total Cost Maintenance
Automatic Faucet (0.5 gpm)	1	40.45	40.45
Automatic Faucet (0.35 gpm)	1	40.45	40.45
SSPS Faucet (0.5 gpm)	1.5	40.45	60.68

Table 9: Water and sewer cost in USD.

Faucet	Average Gallons Used in Study	Cost of Water/Gallon	Cost of Sewer/Gallon	Total Cost of Water/Sewage per Gallon for Study	Total Cost Water/Sewage per Faucet per Day
Manual Faucet (0.5 gpm)	186	0.0018	0.0051	1.28	0.09
Automatic Faucet (0.5 gpm)	128	0.0018	0.0051	0.88	0.06
Automatic Faucet (0.35 gpm)	84	0.0018	0.0051	0.58	0.04
SSPS Faucet (0.5 gpm)	128	0.0018	0.0051	0.88	0.06

Table 10: Return on investment.

Faucet	Days in Academic Year	Cost Water/Sewage per Academic Year (USD)	Savings (USD)	Cost-State Building	ROI	Cost-Non-State Building	ROI	Cost-Outside Contractor	ROI
Manual (0.5 gpm)	170	15.30	0	0	0	0	0	0	0
Automatic (0.5 gpm)	170	10.20	5.10	378.41	74	406.04	80	438.50	86
Automatic (0.35 gpm)	170	6.80	8.50	378.41	44	406.04	48	438.50	52
SSPS (0.5 gpm)	170	10.20	5.10	464.88	91	501.72	98	545.00	107

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Conclusion

Based on the water reduction and return on investment, the most economic and *sustainable* water faucet is the automatic water faucet with the 0.35 gpm aerator (Chicago Faucets model # 116.606.AB.1). Although the ROI for this faucet ranges from 44 to 52 years, this is based on the 170 day academic year and the building used in this study (the AIRC) is open year round, 24 hours a day, thus the estimated ROI is conservative and this faucet may actually result in a much greater savings. Additionally, water is a precious resource and this is becoming more apparent as California faces a drought and the world recognizes the effects of climate change; this is also becoming more apparent economically as the cost of water has risen and will most likely continue to rise in the future. Therefore, the 54% reduction in water use that this faucet provides will not only save a limited resource, but will also show that California State University, Sacramento has a commitment to sustainability.

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