Calculating Savings For:

Auto-Diverting Tub Spout System with ShowerStart TSV

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This paper presents considerations and calculations for the water savings potential of the Evolve Technologies' Auto-Diverting Tub Spout System with ShowerStart TSV (ADTS). Please note that the calculations contained herein are modeled for the California and Southwestern US markets. Adjustments should be made, primarily to the behavioral waste variable and the other variables on which it is dependent, when making computations for regions outside of those markets.

ADTS Background

There are two methods for drawing hot water to a shower in a tub/shower combination bathroom. The first method is called a showerhead warm-up. This type of warm-up occurs when bathers activate the water flow and immediately divert water from the tub spout to the showerhead while it is still cold - thereby drawing hot water via the showerhead. After the water exiting the showerhead becomes hot, bathers begin showering. Showerhead warm-ups occur in a tub/shower combo bathroom 60% of the time (Sherman 2014 Appendix B – Question 8).

The second method is called a tub spout warm-up. This type of warm-up occurs when bathers draw hot water by having cold water exit the tub spout until hot water arrives. After the water becomes hot, bathers use the tub spout diverter to send water to the showerhead and begin showering. Tub spout warm-ups occur in a tub/shower combo bathroom 40% of the time (Sherman 2014 Appendix B – Question 8).

It is important to consider the significant difference in flow rates for showerhead warm-ups and tub spout warm ups. The average showerhead flows at 2.2 gpm (REUWS 1999) and the average tub spout flows at approximately 5 gpm (assumption). Thermal losses while hot water is traveling through pipes vary significantly depending on the water's velocity.

At showerhead flow rates (2.2 gpm per REUWS 1999) hot water travels at "long bullet" flow and the volume of water that must be purged prior to hot water arriving is 10% to 50% more that the volume of water being held in the pipe (Koeller 2007 – Page 44-45).

At tub spout flow rates (5 gpm) hot water travels at "plug flow" and the volume of water that must be purged prior to hot water arriving is nearly equal to the volume of water being held in the pipe (Koeller 2007 – Page 44-45).

As a result of these dynamics it is reasonable to conclude that showerhead warm-ups have, approximately, a 30% greater volume of water to purge before hot water arrives.

(10% higher flow rate + 50% higher flow rate)/2 = 30% higher flow rate on average

A considerable volume of water is wasted while users are waiting for hot water to arrive. This waste is called warm-up waste and consists of two distinct components; structural waste and behavioral waste.

Structural waste is the volume of water that is wasted while purging the previously heated, but now cold, water from the hot water line before hot water arrives at the point of use. Behavioral waste is the volume of hot water that is wasted before bathers actually begin showering.

Behavioral waste occurs when bathers use their time comfortably and efficiently while waiting for hot water to reach the shower. As a result, they turn on the water and leave to do something else while waiting. When they return the water is hot, but a meaningful volume of hot water is inadvertently wasted while they are away.

By analyzing papers and data from Lawrence Berkley National Lab, (Sherman 2014 – Page 11) determines that behavioral waste occurs for 47 seconds and is 59% of the warm-up waste. Considering this conclusion, structural waste would comprise 41% of the warm-up waste and occurs for 33 seconds.

[(47 seconds of behavioral waste / 59% behavioral waste) – 47 seconds of behavioral waste] = 33 seconds of structural waste

The total warm-up waste lasts for 80 seconds.

33 seconds structural waste + 47 seconds behavioral waste = 80 seconds of total warm-up waste.

Data from Sherman 2014 (Page 10) also indicates that getting hot water more quickly to the point of use does not reduce behavioral waste. As such, it is reasonable to conclude that the duration of time spent away from the shower for both showerhead warm-ups and tub spout warm-ups is consistent at 80 seconds.

Finally it is important to acknowledge the common presence of leaks emanating from tub spout diverters while bathers are showering in tub/shower combination bathrooms. Leaking diverters allow water to flow out of the tub spout while water is being diverted to the showerhead. The leaking water runs down the drain with no benefit to the bather and is wasted.

Field research of 120 tub/shower combination bathrooms by Taitem Engineering in 2011 revealed that 34% of tub spouts have significant leaks and the average of those leaks is .8 gallons per minute (Taitem 2011 – Page 2).

ADTS Theory Of Operation

Evolve Technologies' Auto-Diverting Tub Spout System with ShowerStart TSV (ADTS) functions by making every shower warm-up a tub spout warm-up. This has the dual benefit of delivering hot water more quickly to the point of use (5 gallons per minute vs. 2.2 gallons per minute) and reducing structural waste.

ShowerStart TSV technology is incorporated into the tub spout portion of the product. As result, cold water exits the tub spout until hot water arrives. Once the water becomes hot the integrated ShowerStart TSV shuts off the tub spout's flow and the hot water is automatically diverted to a specialized showerhead. Incorporating the ShowerStart TSV into the tub spout has the added benefit of positively shutting off the flow thereby eliminating the potential for a leaking tub spout.

The specialized showerhead to which the hot water is automatically diverted is a WaterSense 1.5 gpm model with an integrated NC (normally closed) valve. The NC valve causes the specialized showerhead to trickle by default – thereby eliminating behavioral waste. Pulling the specialized showerhead's integrated lanyard allows the bather to bypass the NC valve to begin normal showerhead flow.

Once the bather is finished showering and water flow has been terminated, the ShowerStart TSV integrated into the tub spout and the NC valve integrated into the specialized showerhead automatically reset for their next use.

The default operation for ADTS assumes a shower will be taken. This default operation can be bypassed to allow for baths and cold showers. If by passed the unit returns to its default mode after the bath or cold shower is taken.

A core functionality diagram is available on the following page.

A thermal imaging video of ADTS functionality can be seen by clicking here.

1. Turn water on.

2. Cold water exits tub spout.

3. Tub spout automatically closes once hot water arrives.

4. Hot water is automatically diverted to specialized showerhead (integrated normally closed valve).

5. Specialized showerhead trickles by default so hot water is not flowing until user is ready to shower.

6. User pulls cord to activate specialized showerhead's normal flow and begins showering.

ADTS Savings Calculations

Please note that the calculations contained herein are modeled for the California and Southwestern US markets. Adjustments should be made, primarily to the behavioral waste variable and the other variables on which it is dependent, when making computations for regions outside of those markets.

Evolve Technologies' Auto-Diverting Tub Spout System with ShowerStart TSV (ADTS) is a showering system that saves water by:

- **REDUCING STRUCTURAL WASTE**
  This is the previously heated, but now cold, water that must be purged before hot water arrives.
- **ELIMINATING BEHAVIORAL WASTE**
  This is the hot water that's inadvertently wasted before the user begins showering.
- **PREVENTING TUB SPOUT DIVERTER LEAKS**
  This is the hot water leaking from tub spout while the user is showering.
- **PROVIDING EFFICIENT SHOWERING**
  It uses a specialized 1.5 gpm WaterSense certified showerhead.

To properly calculate the efficiency of ADTS each element should be examined individually by first determining the water savings. Although this paper does not attempt to determine energy savings, they can easily be derived from the water savings based on regional factors including, but not limited to showers per day, occupancy, water inlet temperatures, heating source types, heating source fuels.

Below are considerations and corresponding calculations for determining the average water savings associated with each unique savings element. Various savings scenarios are explored based on qualifications/feasibility for ADTS installation.

Citations have been made in the prior background information to support the calculations. Additionally, as appropriate, notes regarding the water's energy content are included.

Savings are calculated on a per shower basis. Appropriate multipliers should be used to determine household savings based on factors such as average occupancy and showering days per year.

STRUCTURAL WASTE SAVINGS CALCULATIONS

- Calculate the volume of structural waste for showerhead warm-ups

  (33 sec of structural waste/60 sec. per min.) x 2.2 gpm showerhead flow rate = 1.21 gallons

- Determine structural waste savings achieved by warming up through the tub spout due to reduced thermal loss (Koeller 2007 – Page 44-45)

  1.21 gal structural waste through tub spout x 30% savings vs. showerhead warm-up = .363 gallons saved by warming up through tub spout

- The additional .363 gallons saved by warming up through the tub spout should only be added to showerhead warm-ups. This amount will be called the "structural waste reduction benefit".

BEHAVIORAL WASTE SAVINGS CALCULATIONS

New Condition Approach –
This method should be used if savings projections for behavioral waste have been traditionally calculated using the flow rate of the new measure. An example of this approach would be using a 1.5 gpm flow rate to calculate the behavioral waste savings of a 1.5 gpm showerhead with ShowerStart TSV. Because ADTS automatically converts all shower warm-ups to a tub spout warm-up, savings under the New Condition Approach are calculated using 100% tub spout warm-ups.

- Calculate behavioral waste savings for tub spout warm-ups

  [(80 seconds total warm-up waste/60 seconds) x 5 gallons per minute] – 1.21 gallons of structural waste = 5.46 gallons

Weighted Average Approach –
This method might be used if savings projections for behavioral waste have not been traditionally calculated by using the flow rate of the new measure. It considers a weighted average of tub spout to showerhead warm-ups based on pre-installation behavior.

- Calculate behavioral waste savings for showerhead warm-ups

  [(80 seconds of total warm-up waste/60 seconds per minute) x 2.2 gpm flow] – (1.21 gallons of structural waste + .363 gallons structural waste reduction benefit) = 2.09 gallons of behavioral waste savings for showerhead warm-up

- Calculate behavioral waste savings for tub spout warm-ups

  [(80 seconds total warm-up waste/60 seconds) x 5 gallons per minute] – 1.21 gallons of structural waste = 5.46 gallons

- Calculate the weighted average of behavioral waste savings (this is avg. quantity saved)

  (2.09 gallons of behavioral waste from showerhead warm-up x 60% frequency) + (5.46 gallons of behavioral waste from tub spout warm-up x 40% frequency) = 3.5 gallons saved by eliminating behavioral waste

behavioral waste energy content note: *Behavioral waste is the most energy intensive waste because it occurs when the mixing valve is turned to full hot (Lutz 2004 – Page 2). As a result approximately 80% - 85% of the water exiting the showerhead or tub spout is hot water during the behavioral waste event (estimation based on pressure balanced mixing valve functionality).*

ANTI- LEAK TUB SPOUT SAVINGS CALCULATIONS

Replace Leaking Tub Spout Approach -
This method should be used if ADTS is replacing a leaking tub spout.

- 34% of tub spouts leak an average of .8 gpm during the shower (Taitem 2011 – Page 2)

- Determine the amount of time water is leaking from the tub spout during a shower by subtracting the previously calculated warm-up waste numbers (structural waste + behavioral waste) from the REUWS 1999 total average shower volume and then divide by the REUWS 1999 showerhead flow rate volume of 2.2 gpm.

  [(17.2 total shower gallons) - (1.21 gallons of structural waste + 3.5 gallons of behavioral waste)] /2.2 gallons per minute = 5.68 minutes of actual showering time

- Multiply the actual showering time by the leak rate to determined gallons saved

  (5.68 minutes of actual showering time x .8 gallons per minute) = 4.54 gallons saved

Replace All Tub Spouts Approach -
This method should be used if ADTS is replacing a tub spout without pre-qualifying for the presence of a leak.

- 34% of tub spouts leak an average of .8 gpm during the shower (Taitem 2011 – Page 2)

- Determine the amount of time water is leaking from the tub spout during a shower by subtracting the previously calculated warm-up waste numbers (structural waste + behavioral waste) from the REUWS 1999 total average shower volume and then divide by the REUWS 1999 showerhead flow rate volume of 2.2 gpm.

  [(17.2 total shower gallons) - (1.21 gallons of structural waste + 3.5 gallons of behavioral waste)] /2.2 gallons per minute = 5.68 minutes of actual showering time

- Determine the average tub spout leak volume per shower by multiplying actual showering time by the leak rate and then multiplying by the incidence of tub spout leaks.

  (.8 gallons per minute leaking from tub x 5.68 minutes of actual showering time) x 34% incident of leaking tub spouts = 1.54 gallons saved

EFFICIENT SHOWERHEAD SAVINGS CALCULATIONS

1.5 gpm showerhead savings are likely well defined within existing efficiency program databases or technical resource manuals. However a calculation is made below using data from REUWS 1999 and WaterSense testing for Evolve Technologies' most recently certified 1.5 gpm showerhead product.

- Determine the per minute savings for the evolve 1.5 gpm showerhead by taking the average showerhead flow rate from REUWS 1999 and subtracting the average flow rate from WaterSense testing for the evolve showerhead.

  [(2.2 gallons per minute – (1.3 gallons per minute average flow)] = .9 gallons savings per minute

- Determine the per shower savings by multiplying the per minute savings by the showering duration.

  .9 gallons saved per minute x 5.68 minutes of actual showering time = 5.11 gallons saved per shower

ADTS Savings Scenarios

Please note that the calculations contained herein are modeled for the California and Southwestern US markets. Adjustments should be made, primarily to the behavioral waste variable and the other variables on which it is dependent, when making computations for regions outside of those markets.

The following summation compiles savings for the Evolve Technologies Auto-Diverting Tub Spout with ShowertStart TSV (ADTS) based on two savings scenarios.

1. ADTS is installed without verifying the existence of a tub spout leak or the flow rate of the showerhead being replaced.

5.46 gallons	by eliminating behavioral waste using New Condition Approach
1.54 gallons	by eliminating leaking tub spout using Replace All Tub Spouts Approach
5.11 gallons	by providing efficient showering
12.11 gallons	**total saved per shower by ADTS**

2. ADTS is installed in bathrooms that exhibit a tub spout leak, but the flow rate of the showerhead being replaced is not verified.

5.46 gallons	by eliminating behavioral waste using New Condition Approach
4.54 gallons	by eliminating leaking tub spout using Replace Leaking Tub Spout Approach
5.11 gallons	by providing efficient showering
15.11 gallons	**total saved per shower by ADTS**

Auto-Diverting Tub Spout Pricing Estimate

The Auto-Diverting Tub Spout System will be made to available to utilities, implementers and their installation contractors in various configurations. Please contact Evolve Technologies for the most current information.

References – In Order Of Citation

(Sherman 2014) **Disaggregating Residential Shower Warm-Up Waste**

(REUWS 1999) **Residential End Uses of Water Study**

(Koeller 2007) **Evaluation of Potential Best Management Practices – Residential Hot Water Distribution**

(Taitem 2011) **Taitem Tech Tip – Leaking Shower Diverters**

(Lutz 2004) **Feasibility Study and Roadmap to Improve Residential Hot Water Distribution Systems**

(Lutz 2011) **Water and Energy Wasted During Residential Shower Events**

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