INNOVATIVE CONSERVATION PROGRAM
Metropolitan Water District of Southern California

DISCLAIMER

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SoCalGas
A Sempra Energy utility

Big Data Analytics with Smart Shower System in Hotel Buildings

MWD ICP Final Report
Agreement Number: 214272

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SHOWER STREAM

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Executive Summary

This report summarizes the findings from the development and refinement of Shower Stream's big data analytics platform in hotels. Shower Stream is a high quality motion activated smart shower head that saves water and energy in hotels. The IoT sensor tech embedded in Shower Stream also collects real time shower-water statistics that enables smart data insights into shower water and energy usage and savings. The shower data collected is deployed to Shower Stream's cloud analytics platform.

Following a successful 12-month pilot, Shower Stream's big data analytics platform has revolutionized how hotels manage shower water and energy usage. This initiative began with the goal to develop a comprehensive big data solution, resulting in tangible insights through the analysis of live shower data from over 3,200 events, tested for the first time on Shower Stream's cloud-based dashboard.

The pilot project kicked off with a series of user interviews - hotel executives, to establish robust software specifications tailored to the demands of this industry. These insights guided the development of product features focusing on scalable WiFi solutions, shower alert system for long running showers and scalding shower water risks; and seamless self-service customer interaction with the platform.

During the 12-month pilot, 20+ smart shower units were deployed at an Extended Stay hotel location in Austin, Texas. The live data collected in Shower Stream's big data analytics platform proved an average savings of 26% per shower or $6.36 per room per month in utility cost reduction. The monthly savings total for a full building with 120 rooms is estimated to be $763.20 in utility costs, 1,141.2 gallons of water, and 13.56 therms. The deployment not only demonstrated significant reductions in operational costs and resource conservation but also highlighted the impactful role of data-driven insights in optimizing hotel operations.

Considering the broader potential impact across the Extended Stay America franchise of 65,000 rooms, deploying this system with big data analytics across all rooms would lead to estimated annual savings of utility use worth 7.43 million gallons of water and 88,236 therms. Further extending these benefits to the broader market of 15 million rooms in branded economy hotels, the potential annual savings could be approximately $1.5 billion in utility costs, over 1.7 billion gallons of water, and 20 million therms of energy. These projections underscore the substantial economic and environmental benefits achievable through the large-scale adoption of advanced data analytics in smart technologies across the hospitality sector.

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1. Project Background

1.1. Problem

Lawrence Berkeley Lab has found that 70% of bathers leave their showers on and unattended even after the water has warmed up (Lutz 2004, 2011). This hot water waste generated from this habit is called ‘behavioral waste’ or ‘shower warm-up waste’. Behavioral waste is the most expensive part of the shower and accounts for over 20% of shower utility costs (Lutz 2004). Across all showers in the U.S., this problem wastes 2T gals of water, 1T kWh of energy & $50Bn annually.

Customer interviews with hoteliers unanimously cite utility costs, maintenance costs and maintenance staffing as their primary pain points (STR 2023). For a typical economy hotel, 85% of their operating costs come from utilities and showers are their 2nd highest utility cost after HVAC. Shower behavioral waste adds an additional $1.5 billion in utility costs to the branded franchise economy hotel industry in the US every year.

1.2. Solution

To eliminate behavioral waste in hotels and commercial facilities, our team at Abstract Engineering built Shower Stream. Shower Stream is a high quality IoT motion activated smart shower head that saves hotels from warm up waste, proves the savings via WiFi-connected analytics and is completely unobtrusive to the user. The patented sensor tech embedded in Shower Stream devices collects real-time data on shower time, water temperature, pressure, when the motion activation feature gets triggered and other shower statistics at 2-second time intervals. This incoming data is gathered and organized within our cloud analytics platform.

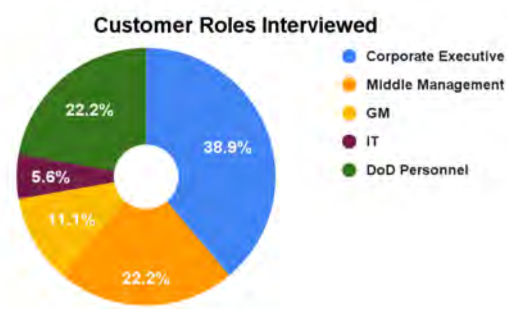
This project focused on deploying this technology at a customer location and creating a functional analytics platform prototype. This report summarizes the development outcomes and insights from testing these features with data from a hotel pilot study.

1.3. Market and Customers

Our beachhead market segment is franchise hotels, totalling 15M rooms. Our existing customers shown in the table below represent a 3% sample of this market, and they all share the same unmet need: *reducing hotel Operating Expenses (OPEX)*.

Name	Hotel Brand	Job Title	Rooms
Tom Lusk	Motel6 & Studio6	VP of Procurement	45K
Mark Hoplamazian	Hyatt	CEO	350K
David Crider	Extended Stay America (ESA)	Dir. Energy and Sustainability	65K
Amman Dosani	La Quinta Inns & Suites	Property Owner	90K

To obtain sufficient customer feedback for this project, we reached out to multiple points of contacts from all the listed hotel corporations. This report contains feedback gathered from these points of contact that also serve as survey participants. Letters of support available upon request.



1.4. Pilot Demonstration

We have completed a 12 month pilot with Shower Stream at an Extended Stay of America (ESA) location. This pilot facilitated technical development of our product, enhanced WiFi compatibility and extended active time for sensors. The pilot data is deployed real-time to Shower Stream's updated cloud dashboard. The improved product saved ESA 26% of shower utility cost exceeding the promised 20% savings while maintaining high guest satisfaction.

The pilot findings, savings and results from the incorporated big data analytics features were presented and reviewed by one of our largest customers: David Crider - Dir. of Energy and Sustainability at ESA. We subsequently obtained a signed Letter of Intent (LOI) indicating that ESA is willing to approve a 720 room expansion of Shower Stream at their hotels.

We also secured a $750K commercial contract with the US Department of Defense to install and pilot our latest smart shower head across 3 military bases. We are currently conducting internal pilots and testing on the latest version of our smart shower technology before transitioning to install and pilot 300 units at US military bases. Two other customers, Mark Hoplamazian and Rob Palleschi, CEOs of Motel6 and Hyatt respectively, have greenlit Shower Stream trials. Both customers are currently waitlisted as we increase manufacturing of our devices to meet this demand.

2. Planned Project Objectives & Deadlines

Objectives	Tasks	Deadline
Market Requirements for Big Data Analytics based on customer feedback	Collect objective data/feedback after initial tech introduction	5/31/2023
	Post demonstration data collection	
	Pre-pilot update interviews	
	Present post pilot findings to customers	
	Post pilot customer feedback	
	Customer feedback summary	
	Narrow scope and market requirements for big data analytics	
Design and develop MVP prototype for Big Data Analytics	Design a mock-up of the platform.	8/31/2023
	Create a prototype that resembles the mock-up.	
	Test the prototype with data.	
	Deploy to actual customers. (Adjustment Feature).	
Refine prototype based on customer feedback	Customer feedback on prototype	12/31/2023
	Refine prototype based on customer feedback	
	Identify potential bugs in refined prototype	
	Integrate field data with prototype dashboard	
Deploy an updated dashboard with advanced features to a full-building pilot.	Integrate field data into MVP dashboard	3/31/2024
	Find and fix potential bugs	
	Present updated dashboard to customers	
	Summarize customer feedback	
Final Project Report	Summarize full project work	5/29/2024

3. Pilot Review

3.1. Literature on Behavioral Waste

LBNL researcher Jim Lutz studied this problem extensively and found that bathers waste 20% of the average shower as warm-up waste in the residential sector. He conducted a follow-up study using field data from 3 California residential properties that confirmed this result (Lutz 2011).

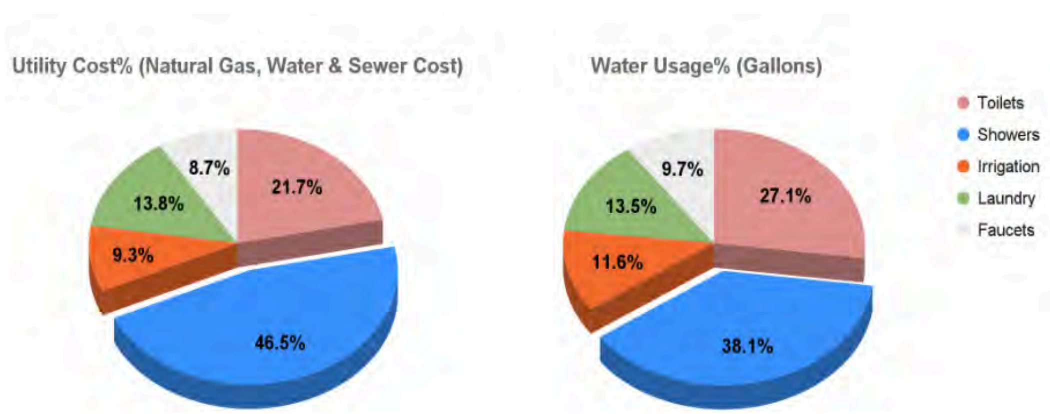
3.2. Pilot Findings

We expanded on Lutz's research by building smart shower units with occupancy sensors and piloting them in hotels. A live 12-month pilot was conducted at an Extended Stay of America. (Pictured right is an image of Shower Stream installed at one of the pilot rooms.)

Data was collected from 20 smart shower units installed at the pilot site. These devices accounted for 20% of the rooms in the hotel, serving as an adequate sample for the treatment group, with the rest functioning as a control baseline. New insights derived from over 3,200 shower events are summarized as follows:

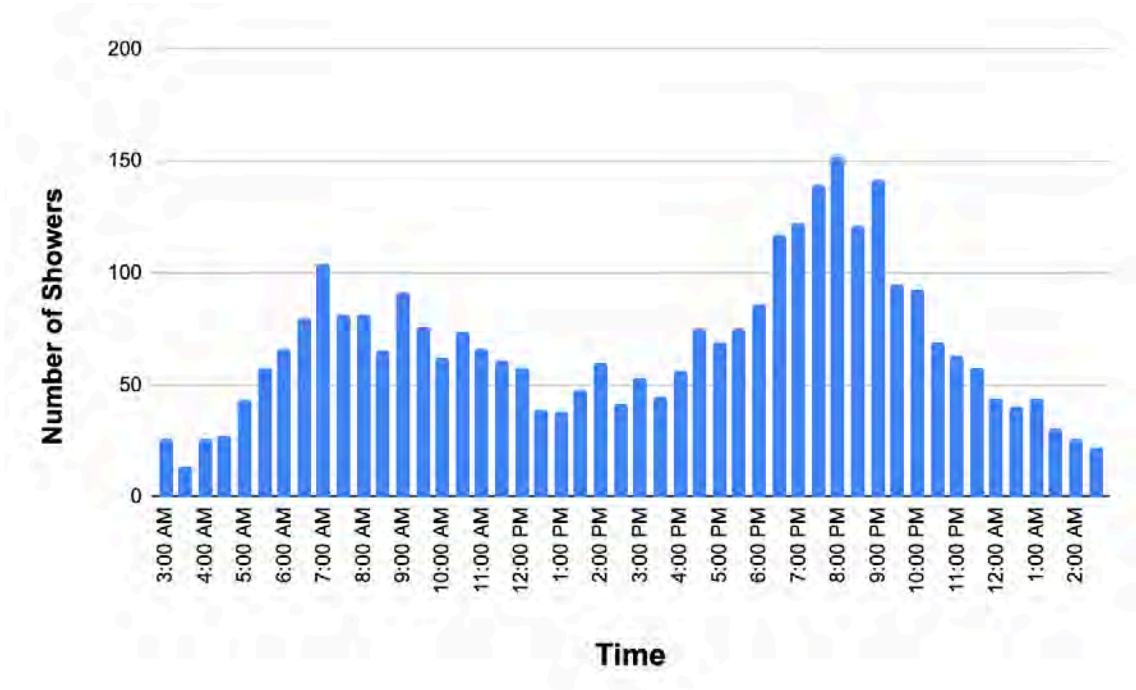
- The average warmup waste recovered from hotel showers is 26%; which is 6% higher than previous literature found in residential showers.
- Discovered an additional 10% savings from excessively long shower events in hotels, these excessive waste events were not found prior in residential shower studies.

3.3. Shower Usage in Hotels



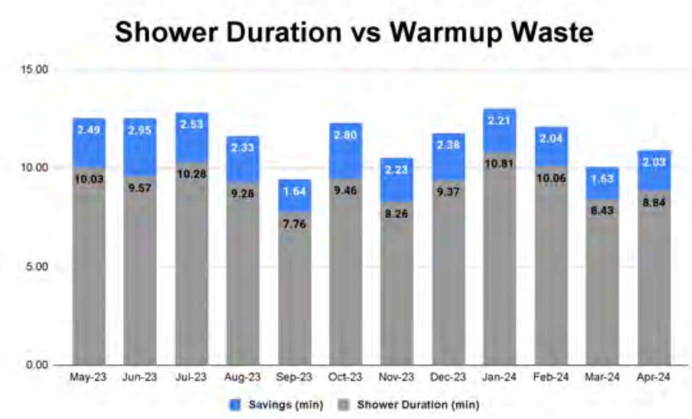
The influence of showers on the total utility expenses is significantly disproportionate, since it affects water cost, sewer costs and natural gas cost. As depicted in the charts above, showers are responsible for a significant 46.5% of utility cost when considering natural gas, water and sewer combined. Also, showers account for 38.1% of water consumption, marking them as the largest water use case in hotels.

Pilot data from 3200 shower events revealed a bimodal distribution (graph below) in peak shower times with an average shower time of 12 minutes, which is 30% longer than Lutz's findings.



Pictured right is the average shower duration (min) over average warm up waste savings (min) for showers under 60 minutes in the collected pilot data.

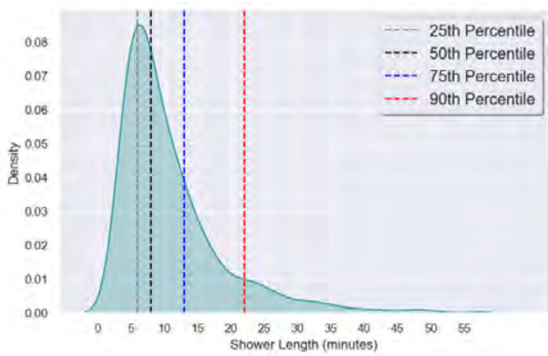
Our devices measured warm-up waste in hotels to be 141 seconds per shower on average, while Lutz found that warm up waste in residentials was between 56 and 95 seconds per shower.

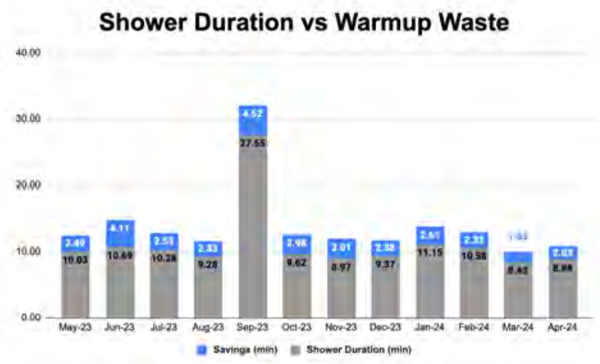


3.4. Excessive Waste Discovery

Further examination of our pilot data led to the discovery of excessive shower waste events, defined as showers longer than 60 minutes. Shower duration distributions reveal that most showers last between 8 and 15 minutes, but many showers have durations far longer than the average. The distribution graph is truncated to 60 minutes because including longer showers extends the tail so much that it obscures the visibility of the common range of shower durations.

This indicates the high waste that these extremely long showers can generate. These long showers occur rarely (1% showers) but waste a lot of water (4+ hours/shower).
By comparison, the hot water wasted in one excessive shower event is equivalent to the warm-up waste from 86 typical showers. Adding these excessive showers to the average shower duration vs warm-up waste savings graph results in a far higher average duration and waste amount.



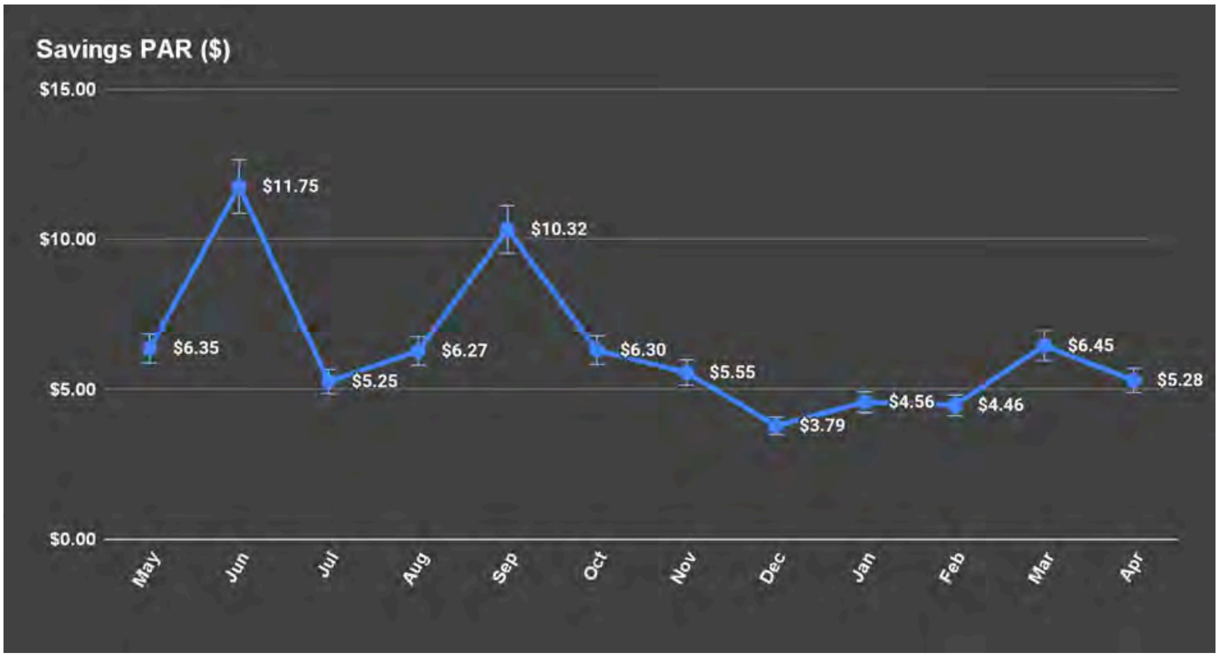


List of Use Cases for Extremely Long Hotel Guest Shower Events	
Steaming Wrinkles out of Clothes	Steam from showers smooths clothing wrinkles, useful for delicate fabrics.
Room Humidity Control	Guests use hot showers to increase room humidity, countering dry air effects like dry skin.
Guest Emergency	Showers running for a long time could be as a result of a guest accident/emergency like heart attacks or slips and falls.
Therapeutic Use	Showers offer relaxation, easing muscle pain or acting as hydrotherapy for conditions like arthritis.
Mental Health Relief	Extended showers help manage stress, anxiety, or depression, offering a mental escape.
Accidental Neglect	Guests may forget the shower on, leading to prolonged use, such as falling asleep with it running.
Personal Care Rituals	Long showers can be part of extensive routines, such as shaving, deep conditioning hair or other multi-step skincare.
Cleaning Personal Items	Using showers to clean items like muddy boots or saltwater soaked swimwear.
Cultural Practices	Showers facilitate rituals like pre-wedding purification baths or spiritual cleansing.
Technical or Maintenance Issues	Faulty showers that require longer adjustment times or stuck temperature controls.
Sound Detonation	Utilizing shower noise for privacy, such as discussing confidential information.
Pet Washing	Bathing pets in showers, especially challenging for larger breeds or multiple animals.

3.5. Savings Per Available Room (SavingsPAR)

Over the course of 12 months, Shower Stream saved an average of $6.36 of savings per available room (PAR) at the pilot hotel location.

The graph below shows a monthly trend in savings PAR across the year. Also, preliminary analysis reveals a notable correlation between the months with the highest number of showers and the peaks observed in the Savings PAR graph. This correspondence suggests that the presence of excessive shower usage significantly influences savings outcomes.

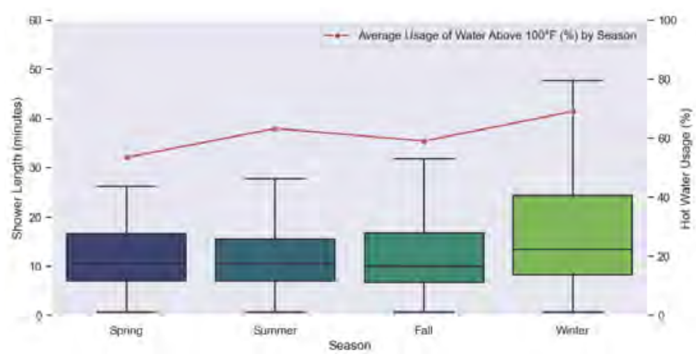


Shower Stream's motion activation feature is triggered when the *water is hot* and if the shower stall is *unoccupied*. Upon activation, this feature closes the valve, shutting the shower's water flow to a trickle. The device measures the duration the valve remains closed (VCT, as illustrated in the graph below) and calculates the water saved by multiplying this time by the water's flow rate and the cost of water. Additionally, using calculations approved by the Texas Public Utility Commission (PUC), the device estimates the energy saved in heating the water (Texas PUC).

The table below offers a synopsis of the shower usage and savings data from Shower Stream at the pilot location. Extrapolating the 23-room hotel pilot to the entire establishment, which consists of 120 rooms, yields an average savings of approximately $6.36 per available room. In terms of resource usage, there's a recorded monthly average duration of shower use of over 45 hours, correlating with a consumption of approximately 122,895 gallons of water and 117.14 MMBtu of energy. This translates to a monthly saving of $763.40 for the building, showcasing the potential for significant cost reductions and resource efficiency on a larger scale.

Pilot Property	Usage	Savings
Directly Measured in 20% of Installed rooms [23 rooms]		
Duration (monthly) [dd:hh:mm]	10:21:33	2:11:27
Water (monthly) [gals]	23,555.16	5,354.10
Energy (monthly) [mmbtu]	22.45	5.1
Dollars (monthly) [$]	$643.72	$146.32
Extrapolated to 100% of rooms - full building [120 rooms]		
Duration (monthly) [dd:hh:mm]	45:09:24	10:07:37
Water (monthly) [gals]	122,895.70	27,934.35
Energy (monthly) [mmbtu]	117.14	26.63
Dollars (monthly) [$]	$3,358.52	$763.40
Metered [mm:ss] per shower	11:45	2:40
Dollars (monthly) per room [$]	$27.99	$6.36

We also find seasonal patterns in shower duration and percent of hot water usage above 100 F temperatures in hotels (graph below-right). We see noticeable variations throughout the year. Although the shower length (the line inside the box) is fairly consistent across seasons the variability of this length is very different.



- In winter, not only does the hot water usage percent increase but the variability in shower lengths also seems to increase.
- Summers have the shortest showers with the smallest variability, suggesting more consistency in shower duration among hotel guests during this season.
- Spring and fall have similar distributions in terms of length, but there is a noticeable increase in the percent of hot water usage from spring to fall.

In summary, shower usage behaviors in hotels can be categorized into three groups: '0 Wasters,' comprising 35.13% of the sample, with an average shower time of 8 minutes and negligible waste; 'Warm-up Wasters,' the majority at 64.87%, taking showers averaging 12 minutes with about 21% of water wasted; and 'excessive Shower Event Users,' a small fraction at 1.11%, whose showers last an average 4 hours, resulting in a projected 85% waste of water.

4. Savings Adjustments

External factors such as hotel room availability, internet connectivity, shower water flow rate and hardware device limitations create a gap between modeled savings and actual savings realized from Shower Stream's motion activated smart shower system. To accurately estimate the shower warmup waste savings, we developed a feature set known as 'Savings Adjustments" as part of our big data analytics roadmap.

We apply these adjustments as ***'offline percentage'*** to the shower water savings model that is derived from the [Texas Public Utility Commision Reference Manual](#) (page. 329). The formula for shower water savings is as follows:

$$\text{Monthly Shower Water Savings} = (BW \times n_S \times SHFR \times 30.5 \times \frac{OCC}{n_{SH}}) \times n_R$$

Where:

BW	=	Behavioral waste, minutes per shower
n_S	=	Number of showers per occupied room per day
SHFR	=	Showerhead flow rate, gallons per minute
30.5	=	Number of days per month
OCC	=	Occupancy rate
n_{SH}	=	Number of showerheads per room
n_R	=	Number of rooms

The following adjustments are applied to the above savings model in the form of an ***'offline percentage'*** to accurately estimate hotel savings.

9829 Pilot Savings	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	Average
Rooms	9	8	10	10	11	15	19	22	23	23	21	21	16.00
Offline%	42.90%	52.29%	34.57%	31.73%	69.84%	51.18%	54.62%	47.73%	52.98%	43.36%	43.16%	26.22%	45.88%
Valve closed duration (per occupied room per day) [mm:ss]	04:52	09:17	04:34	05:27	08:28	05:16	04:51	04:23	04:27	04:02	05:07	04:27	05:26
Water saved (per occupied room per day) (gals)	8.51	16.26	7.99	9.55	14.82	9.21	8.50	7.68	7.80	7.07	8.96	7.78	9.51
Energy saved (per occupied room per day) (mmbtu)	0.0101	0.0194	0.0095	0.0114	0.0177	0.0110	0.0101	0.0091	0.0093	0.0084	0.0107	0.0093	0.0113
Savings (per occupied room per month) ($)	$7.65	$14.15	$7.19	$8.59	$12.90	$8.28	$7.40	$6.89	$7.02	$5.95	$8.06	$6.77	$8.40
Assumed occupancy rate	83%	83%	73%	73%	80%	76%	75%	55%	65%	75%	80%	78%	75%
Savings PAR	$6.35	$11.75	$5.25	$6.27	$10.32	$6.30	$5.55	$3.79	$4.56	$4.46	$6.45	$5.28	$6.36

<u>(i) Waste Capture Limit</u>

Shower warmup waste is typically the first 2 minutes of the shower (Lutz 2011). For this reason, Shower Stream was initially designed to collect data every 2-seconds up to the first 8.5 minutes to capture warm-up waste and the last data point to capture total shower time. However, pilot findings have recorded showers remaining on and unoccupied for much longer. In response, we increased the waste capture limit beyond the initial 8.5 minutes.

Table: Distribution of shower duration in the pilot data collected from May to September 2023

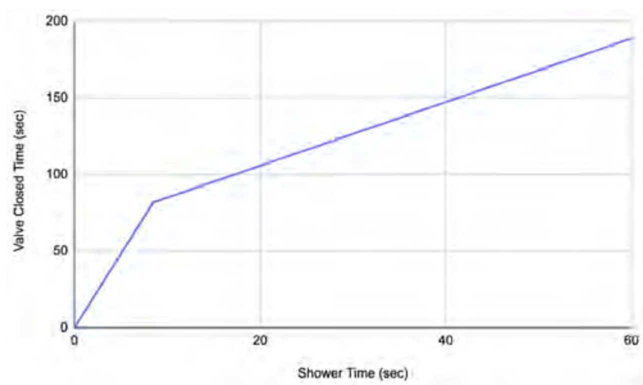
Number of showers	***May***	***June***	***July***	***Aug***	***Sep***
	156	**154**	**112**	**109**	**207**
Showers with duration > 15 min	22.44%	21.43%	18.75%	19.27%	14.49%
Showers with duration > 30 min	2.56%	5.19%	5.36%	5.50%	4.35%
Showers with duration > 60 min	0.00%	1.30%	0.00%	0.00%	2.42%

Select showers during this pilot period (2 showers in June were longer than 1 hour and 5 showers in September were longer than 5 hours) had a savings potential that exceeded much beyond 8.5 minutes. To estimate the potential savings with an extended capture limit, we implemented a small increase in savings captured from 8.5 minutes to 17 minutes for the month of October and extrapolated the findings to obtain expected savings.

$$Adjusted\ savings : \frac{Measured\ Savings\ with\ increased\ cap}{Total\ showers\ with\ increased\ cap} \times Slope \times Total\ showers$$

Where:

- Adjusted savings - the positive or negative change in savings due to an adjustment
- Measured savings with increased cap - the metered savings when capture limit was increased from 8.5 minutes to 17 minutes.
- Total showers with increased cap - number of showers with savings between 8.5 minutes to 17 minutes.
- Slope - (pictured right) represents the rise (increase) in savings or the extended duration of valve closure as the shower time is increased.



- Total showers - total number of showers exceeding 17 minutes in the pilot data that had uncaptured savings.

Applying the adjusted waste capture limit to the savings model increased our savings (refer to Table below) by an additional average of **27 seconds per shower**.

Months	**May**	**June**	**July**	**Aug**	**Sep**
Unrealized savings (sec) > 8.5 min to 17 min	4,205	4,551	3,104	2,605	5,836
Unrealized savings (secs per shower)	26.96	29.55	27.71	23.90	28.20

We increased the waste capture limit from 8.5 minutes to 17 minutes in Oct' 23; to 25.5 minutes in Nov' 23 and Dec' 23 and then to 34 minutes in Jan '24 and Feb' 24.

Table below shows the additional savings realized as we move from 8.5 to 34 minutes.

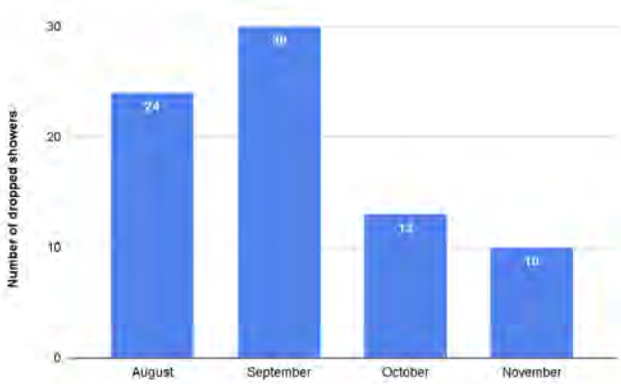
Waste capture limit	**17 min**	**25.5 min**		**34 min**	
Months	Oct '23	Nov '23	Dec '23	Jan '24	Feb '24
Additional savings captured (%)	29.56%	39.90%	31.82%	30.56%	32.49%

Future work on a self-powered turbine will allow us to increase this limit much further. See section 7 for more details.

<u>(ii) Dropped Showers/Downtime Adjustment</u>
Hotels can occasionally have spotty and unreliable internet connections. To capture all shower events and record accurate savings in our cloud dashboard, the Shower Stream device must be connected to WiFi. However, the previous product version that we piloted from May to July does not support 5G Wi-Fi networks but is compatible with 2G Wi-Fi. This resulted in several showers (and savings) dropped.

The latest product version is now compatible with both 2G and 5G however, as a temporary measure a "**shower drop counter**" was implemented where the cloud dashboard would receive the total number of showers dropped due to internet connection. This counter counts the number of WiFi connection failure attempts when a user starts a new shower and stores this drop count on the local device. Once the device re-connects to wifi successfully, we model the average shower for that month in place of the dropped shower event data.

Pilot findings after incorporating product WiFi compatibility is evident in the decrease in dropped shower count or increase in Uptime percentage (see below).



<u>(iii) Occupancy Rate</u>
The occupancy rate significantly influences the potential savings that can be achieved with Shower Stream in hotels. The occupancy rate for an average ESA hotel location is 75%. However, our limited-unit pilot install was only in select rooms that had drastically different occupancy rates compared to that of an entire building. .

A proxy for hotel occupancy rate is to use rooms with at least 1 recorded shower in our cloud dashboard as a ‘room sold’ (equation pictured right).

Standard Hotel Occupancy Rate:

$$\frac{\text{Rooms Sold per Day}}{\text{Rooms Available per Day}}$$

Occupancy Rate from Showers:

$$\frac{\text{Rooms with at least 1 Shower per Day}}{\text{Rooms Available per Day}}$$

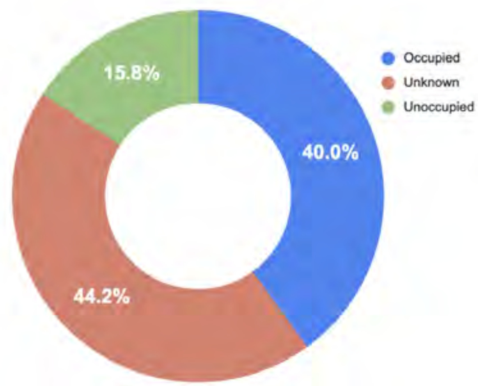
To test the validity of Occupancy Rate from Showers, we collected daily vacancy sheets (pictured below-left) from the pilot location to validate any discrepancies between Shower Stream recorded occupancy and hotel occupancy rate.
A total of 16 vacancy sheets were collected for the month of October. Analyzing the vacancy sheets, we categorized days into ‘Occupied days’, ‘Unoccupied days’ and ‘Unknown’ in the piloted rooms (pictured below-right).


STAY AMERICA ESA Suites - Austin - Northwest -
Hotel ID : 9829

Date : Oct 10, 2023
Run Date : Oct 10, 2023
Run Time : 9:06:18 AM
Username : Denise Ratcliff
Room Status : ALL VACANT ROOMS

Vacant Room List

Room Number	Room Type	Date Last Occupancy	Days w/o Occupancy	Status
104	STD1QB	Oct 07, 2023	3	Available and Clean
109	STE1KN	Oct 07, 2023	3	Available and Clean
112	STE1KN	Oct 07, 2023	3	Available and Clean
114	STE1KN	Oct 08, 2023	2	Available and Clean
116	STE1KN	Oct 07, 2023	3	Available and Clean
118	DLX1QN	Aug 08, 2023	63	Out of Order and Clean
122	DLX1KB	Jun 19, 2023	113	Out of Order and Clean
129	DLX1QN	Oct 08, 2023	2	Available and Dirty
[illegible]	STE1KN	Jul 11, 2023	91	Out of Order and Clean



We then proceeded to compare Shower Stream recorded occupancy and hotel occupancy rate. The table below shows a 10 room occupancy rate comparison between the pilot hotel record and Shower Stream record. The estimates conclude an **average error margin of 5%.**

Pilot Hotel Occupancy Rate	Shower Stream Occupancy Rate	Error %
63.63%	64.52%	0.89%
67.77%	67.74%	0.03%
46.58%	51.61%	5.03%
53.95%	54.84%	0.89%
35.04%	35.48%	0.44%
43.33%	29.03%	14.30%
45.19%	41.94%	3.25%
50.25%	45.16%	5.09%
67.32%	77.42%	10.10%
55.34%	70.97%	15.63%

The following challenges/bugs have been identified with this adjustment method:

- Collecting vacancy sheets from the location is tedious and not scalable as a repeatable process. Despite collecting vacancy sheets every alternative day, the days with unconfirmed occupancy accounts for **44.19% of uncertainty**.
- An interesting finding from our pilot data and vacancy sheets are showers recorded in confirmed Unoccupied Days. **15.8% of showers** in October occurred on vacant days. We anticipate these showers per unoccupied days to be 'pre-checkout shower events', 'shower maintenance (cleaning, temperature check) events' and other 'hotel staff shower events'.

The occupancy rate adjustment is applied to obtain Shower Stream savings at scale. This adjustment will become redundant in a full building pilot and therefore <u>will not be included as part of **'offline percentage'**.</u>

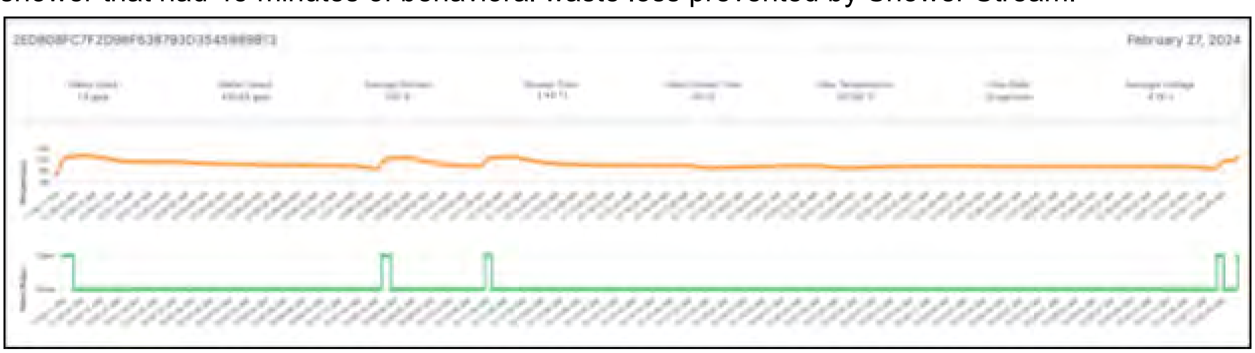
4.1. Pilot Data

<u>(i) Waste Capture Limit</u>

The data from longer showers with each waste capture limit increase are automatically recorded in our updated cloud dashboard cloud.

Shower sample #1 - The image below is a screenshot from our cloud dashboard of a long shower that had 6 minutes of behavioral waste loss prevented by Shower Stream.

Shower sample #2 - The image below is a screenshot from our cloud dashboard of a long shower that had 45 minutes of behavioral waste loss prevented by Shower Stream.

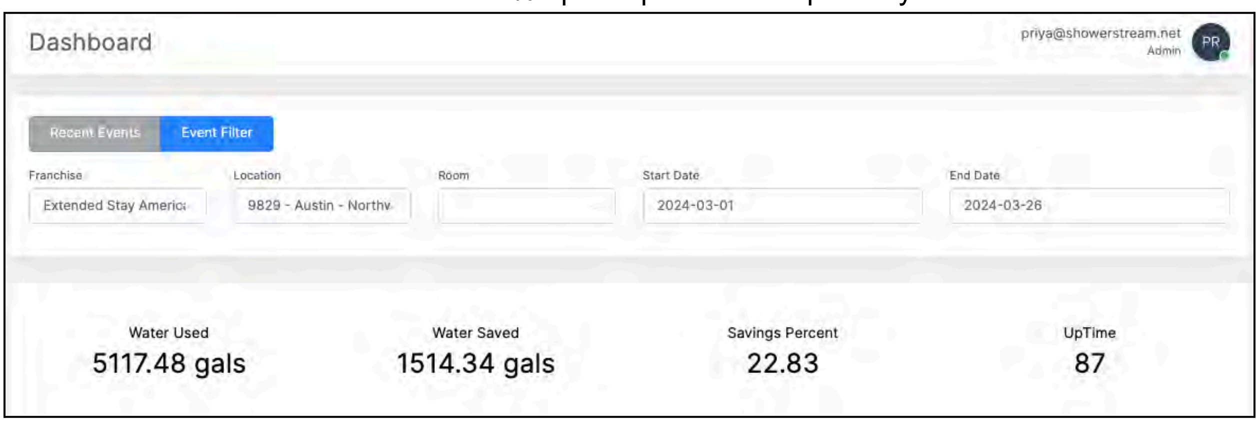


(ii) Dropped Showers/Downtime Adjustment

To counter data loss from spotty hotel internet connection Shower Stream's latest product version is now compatible with both 2G and 5G. The 'drop counter' (see section 4) shows significant reduction in showers dropped as represented in the cloud dashboard screenshots below.

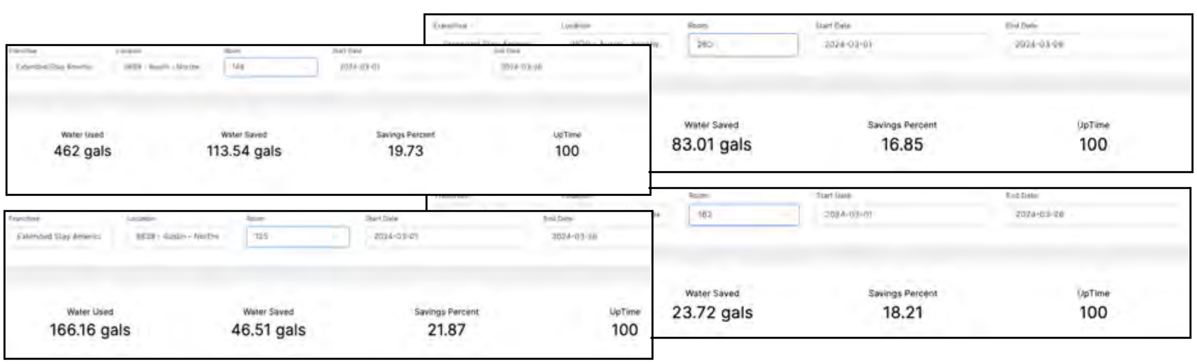
Screenshot of cloud dashboard with 58% uptime prior to 5G compatibility.

Screenshot of cloud dashboard with 87% uptime post 5G compatibility.

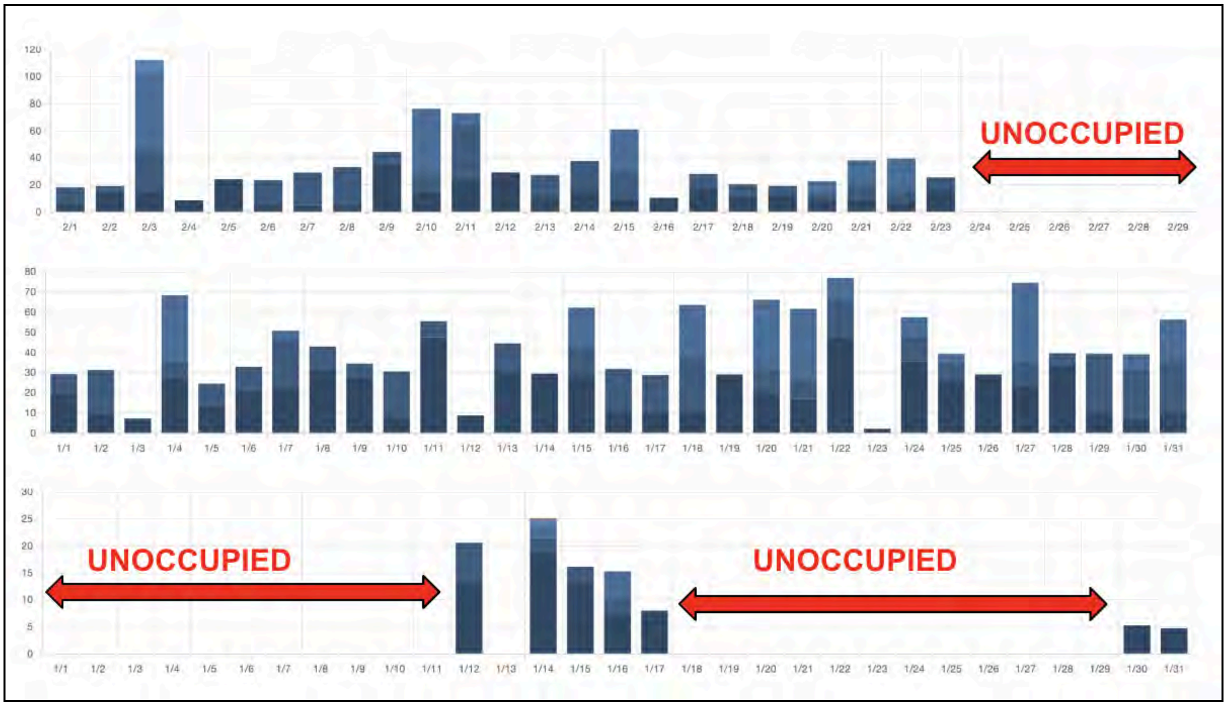


The 'Uptime' percentage depicted in the right of the cloud dashboard screenshot above, indicates that the combined total rooms installed at the pilot location have been connected to the internet 87 percent of the time.

Moreover, majority installed rooms with the latest product version show a 100% uptime.



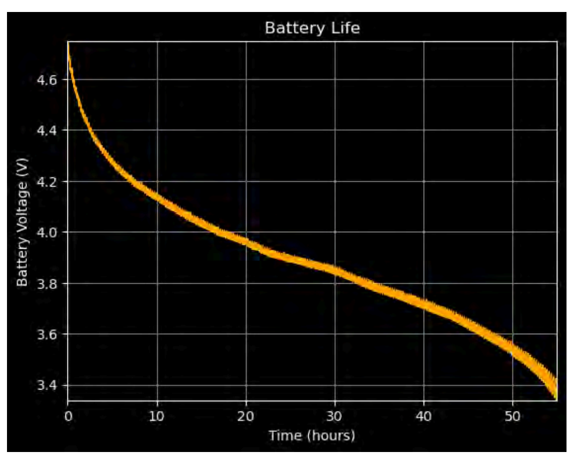
(iii) Occupancy Rate
The gaps in showers in a room during a month is clearly visible in the updated cloud dashboard. For instance, three rooms are showcased in the dashboard screenshot below. A rectangular block indicates a shower event and gaps in showers during a month is very indicative of a vacant hotel room.



4.2. Limitations

(i) Waste Capture Limit
The biggest trade off when increasing the waste capture limit from 8.5 minutes to 25.5 minutes was the battery life of the device. Multiple battery life tests were conducted at 8.5, 17 and 25.5 minute capture limits.

- The battery life tests for 8.5 minute capture limit records 257 to 269, 10-minute showers.
- The battery life tests for 17 minutes capture limit records 142 to 186, 30-minute showers.
- The battery life tests for 25.5 minutes capture limit records 157 to 78, 30-minute showers.



Although the total shower time impact is negligible, the length of the shower would affect battery life significantly. An alternative approach we are exploring is the incorporation of a mini turbine to act as a power generator that sustains the device. See section 7 for more details on this feature.

<u>(ii) Dropped Showers/Downtime Adjustment</u>

Transitioning to dual band 5G antenna has significantly improved device uptime percentage. This improvement is noted in the decreasing number of dropped showers. Using dropped showers as a downtime adjustment factor has the following limitations:

- Battery reset - The dropped shower counter is reset to 0 once the shower head battery is replaced. Since current battery life is 2 years, this limitation does not affect the downtime adjustment factor calculated during pilot period.
- Device out-of-service - The shower drop count is incremented whenever the internet connection fails. This count is only recorded in our cloud dashboard once the device connects to WiFi. If the device never connects to WiFi, the drop counter is never updated. To counter this problem, our dashboard records the 'last shower event date time' and the 'last heartbeat data time' (see below). All devices automatically send a signal once every 72 hours to confirm WiFi connection. The 'last heartbeat' is the last date time in which the device sent data (or signal) via WiFi to the cloud. If the last heartbeat exceeds the 72 hour WiFi check, the device is tagged 'red' notifying Shower Stream personnel to uninstall and repair.

FRANCHISE	LOCATION	ROOM NUMBER	VALVE TOGGLE	LAST EVENT DATE TIME	LAST HEARTBEAT DATE TIME
Extended Stay America	9829 - Austin - Northw...	260	Off	2023/11/08 09:12:33 PM	2023/12/17 09:16:45 PM
Extended Stay America	9829 - Austin - Northw...	149	Off	2023/12/17 09:11:57 AM	2023/12/20 09:12:02 AM
Extended Stay America	9829 - Austin - Northw...	249	Off	2023/11/12 03:23:20 AM	2023/12/19 05:28:52 PM
Extended Stay America	9829 - Austin - Northw...	148	Off	2023/12/19 09:54:45 PM	2023/12/19 09:54:44 PM
Extended Stay America	9829 - Austin - Northw...	228	Off	2023/12/17 09:55:58 AM	2023/12/20 09:56:12 AM
Extended Stay America	9829 - Austin - Northw...	226	Off	2023/12/03 11:02:50 AM	2023/12/20 09:18:41 AM
Extended Stay America	9829 - Austin - Northw...	116	Off	2023/12/10 10:28:44 AM	2023/12/10 10:28:43 AM
Extended Stay America	9829 - Austin - Northw...	125	Off	2023/12/18 09:42:34 PM	2023/12/18 09:42:33 PM

<u>(iii) Occupancy Rate</u>

Below are the potential discrepancies between hotel occupancy rate and occupancy rate from showers:

1. Guests not using/showering in the rooms they booked.
2. Pre-check out showers recorded in otherwise 'vacant rooms'.
3. Non-guest showers recorded due to routine shower cleaning and maintenance.
4. Inaccurate hotel logistics reported by local GM.
5. Inconsistency in the metric 'Room Available per Day' which is used as a denominator in both hotel occupancy rate and Shower Stream occupancy rate.

4.3. Customer Feedback

(i) Waste Capture Limit - We presented the savings potential with unlimited waste capture limit to our customer, ESA point of contact. The customer, although very satisfied with 26% shower savings, is looking forward to the additional pilot savings from a turbine integrated shower head (see section 7 for more details).

(ii) Dropped Showers/Downtime Adjustment - We presented the case of potential hotel internet data loss to our ESA point of contact Dir. of Sustainability, David Crider. The customer is very happy with our transition to account for both 2G and 5G and one of his responses was “In the long term ESA will be switching from 2G to 5G in all locations”.

(iii) Occupancy Rate - Pilot findings and the case of occupancy rate was presented to our customer and he confirmed and shared that full building data for daily occupancy is readily available. The hotel occupancy rate is not necessary for billing since we directly meter our savings.

5. Maintenance Alerts Feature

Feedback from customer demos and pilots indicate a high demand for solutions to shower related issues such as prolonged showers, scalding shower water temperature and clogged shower detection, among others. Our novel sensor technology is able to ascertain when a shower maintenance issue emerges real-time. This system enables our platform to automate real-time alerts via text or email to optimize maintenance & housekeeping staffs’ performance. Below is a list of our most requested alert notification features to be automated based on customer feedback.

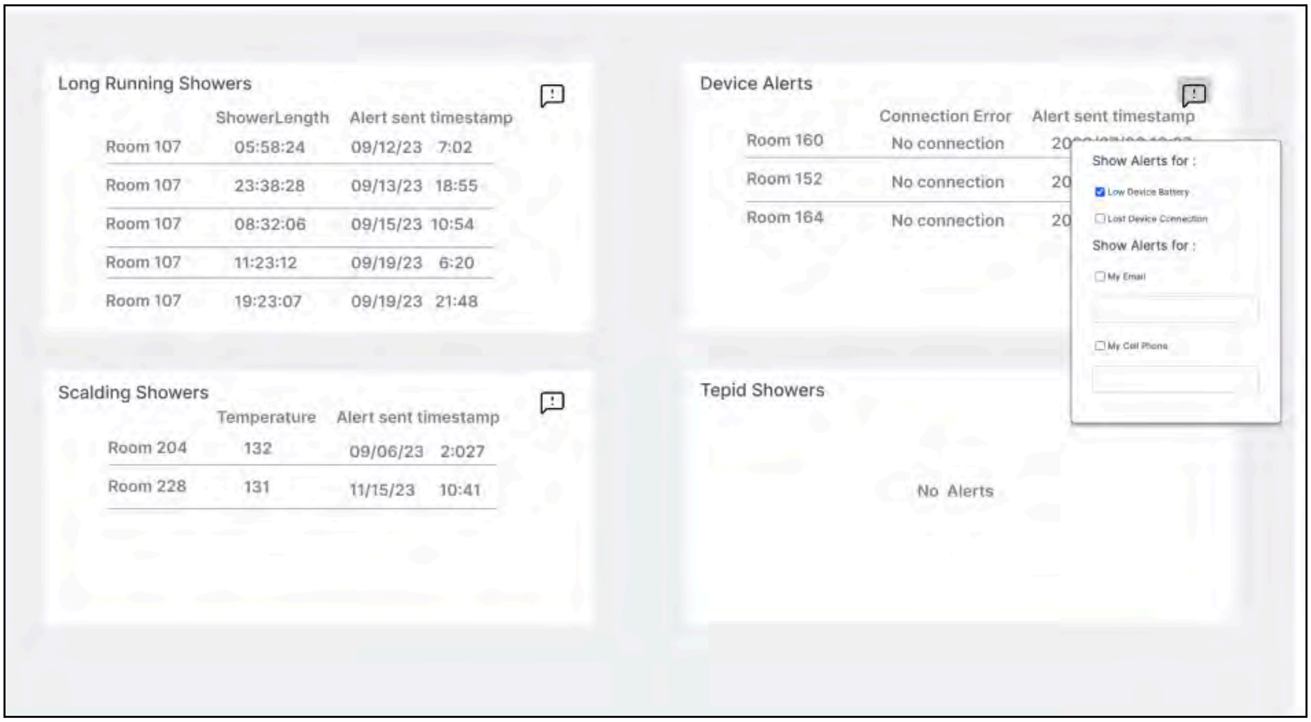
Below are the commonly cited shower alert notification system from customer interviews:

i. Long running showers
ii. Scalding showers
iii. Clogged showers
iv. Device alerts
v. Tepid showers
vi. Shower cleaning reminder to prevent Listeria
vii. Shower repair call

The first version of this “Maintenance Alert” functionality is currently undergoing beta testing with the ESA pilot program. We have beta tested alerts from 3200+ shower events and have shared the results with the ESA executive team.

5.1. Pilot Data

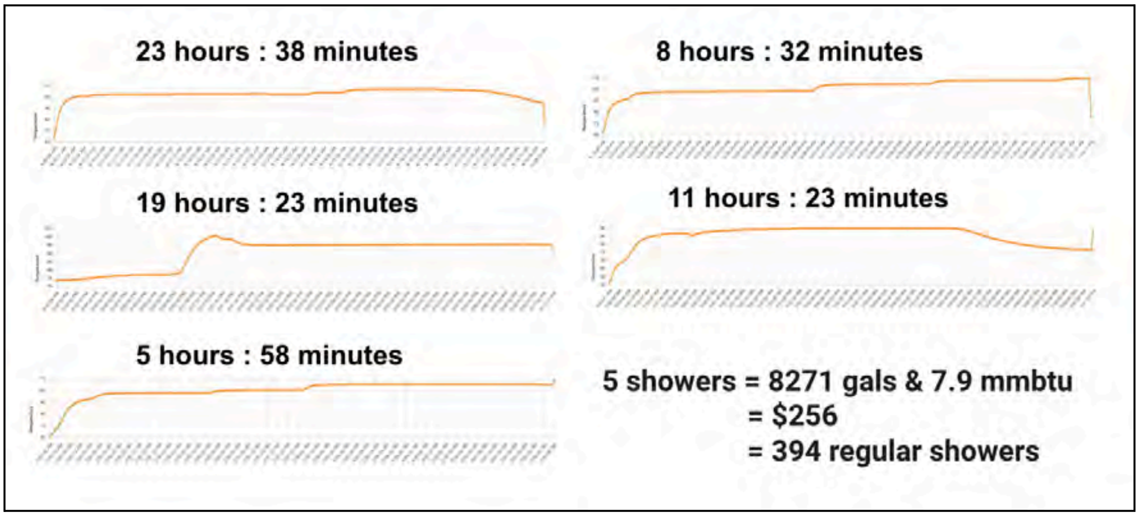
Several shower related maintenance alerts were identified during the 12-month pilot period. The shower maintenance alert list corresponding to our pilot data is included in the alert dashboard mockup below:

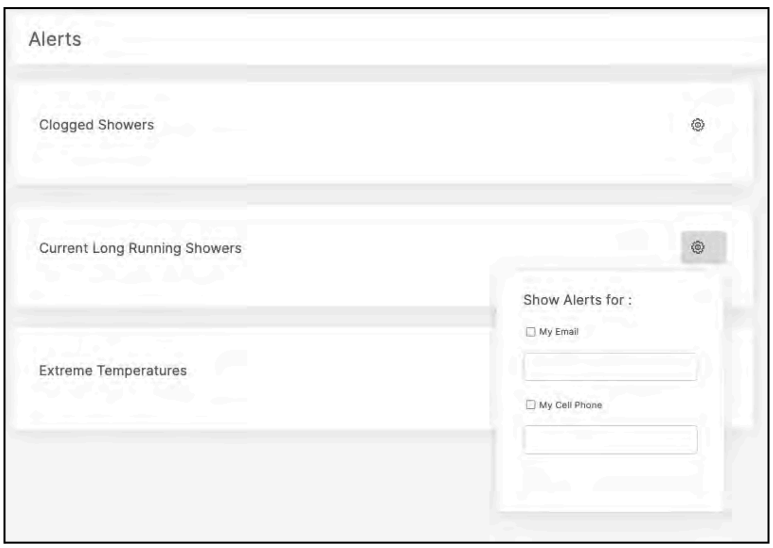


(i) Long running showers - 1% of shower events had shower lengths exceeding one hour. We call such events ‘extended showers’ or ‘long running showers’.

Time stamp	hh:mm:ss	Water used (gals)	Energy used (therms)
2/27/2024 23:59:12	3:46:13	452.45	1.19
1/16/2024 2:09:39	1:41:14	202.47	2.46
9/12/2023 6:10:00	5:58:24	716.82	6.83
9/13/2023 5:53:39	23:38:28	2836.93	27.04
9/15/2023 5:23:06	8:32:06	1024.19	9.76
9/19/2023 5:58:41	11:23:12	1366.40	13.02
9/19/2023 21:48:41	19:23:07	2326.22	22.17
6/3/2023 9:38:35	1:02:39	125.30	1.22
6/24/2023 15:45:17	2:09:11	258.37	1.59

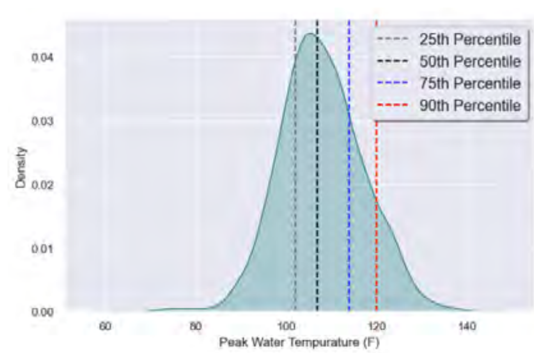
Using our cloud dashboard data we presented the showers greater than 4 hours or more as well as the alert notification system to our customers (pictures below).





(ii) Scalding showers

We record a normal distribution (graph to the right - probability distribution graph of maximum shower water temperatures recorded in every shower), with a slight skew to the right indicating occasional instances of very high water temperatures. Both the median and the mean of the water temperatures are in the range of 105 to 106 degrees Fahrenheit. Notably, a significant portion of the data—specifically, the upper quartile—reveals that roughly 25% of recorded showers reach scalding temperatures between 115 to 140 degrees Fahrenheit, posing a risk of scalding.



Such extreme temperatures are not utilized for the act of showering itself; rather, they reflect a common practice where individuals initially set the shower to its maximum temperature to expedite the warming process. Subsequently, after a brief interval, the temperature is adjusted to a more tolerable level before one commences showering.

The shower water temperature's upper limit is determined by the adjustment of the heating set point temperature in the water heater. The hotel executive believed that the set point was set at 120°F, but our data indicates 59 showers exceed this limit at the outlet and few over 130°F.

Time stamp	Room#	Max Shower Water Temperature (F)
2023-09-06 2:26:41	204	132
2023-11-15 10:40:23	228	131

5.2. Limitations

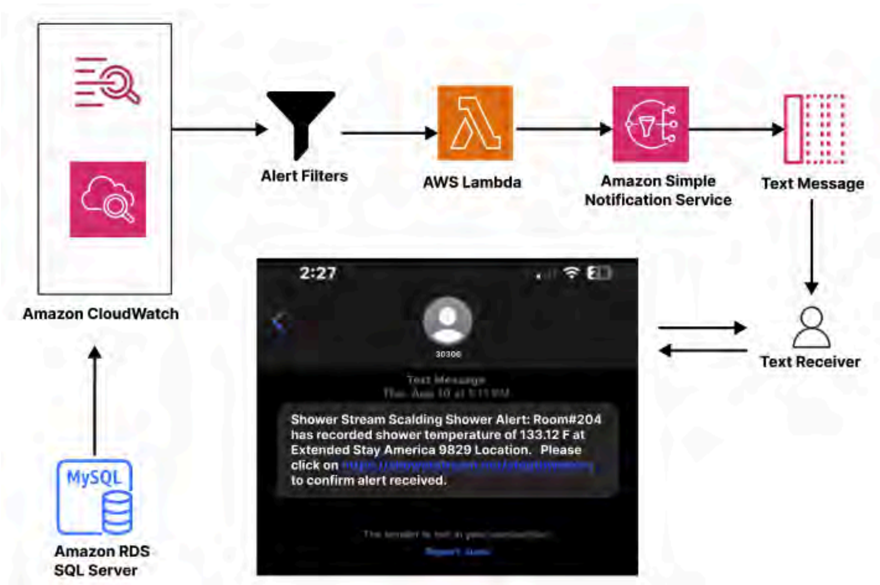
The primary challenge we have encountered deploying the maintenance alerts feature is figuring out an ‘endpoint’ for the customer to use and onboarding the customer’s staff.

Technically, the feature has been a success - it has correctly detected alerts in the field with high reliability at the customer location.

Preliminary Prototype: We use Amazon Simple Notification Service to send notifications directly to the hotel staff registered to receive the alerts.

- Step 1: We set up Amazon's database service (RDS for SQL Server) to send error reports to Amazon CloudWatch.
- Step 2: Then, we add a filter which includes the alert list specified in section 4.1
- Step 3: Next through Amazon Simple Notification Service the alert messages are generated where the message content (sample shown above) is specified in the AWS Lambda function.
- Step 4: The final message is received by the number/email registered as maintenance staff at the specific pilot location.

The architecture diagram behind setting up an alert notification system is shown below:

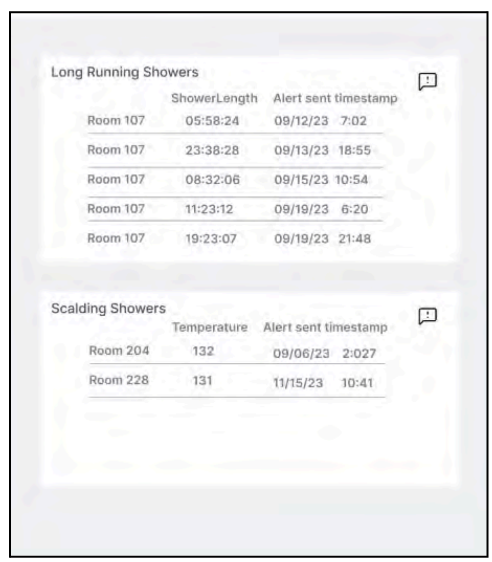


Logistically, the feature has faced more resistance to adoption than we initially anticipated. Our customers are very interested in the feature in the long term. However, for now they are focused on our MVP of directly metered shower savings. As we grow a larger install base, the maintenance alerts feature will become more useful and on-site customer onboarding will have less friction.

5.3. Customer Feedback

(i) Long running showers - ESA pilot hotel point of contact, David Crider, is very interested in a turbine powered shower head to capture the waste from extended long showers.

(ii) Scalding showers - ESA pilot hotel point of contact, David Crider, was very surprised with the high water temperatures recorded at the use point. This information enables hotel staff to immediately adjust down water heater temperature levels to ensure hotel guest safety and satisfaction.



Long Running Showers

	ShowerLength	Alert sent timestamp
Room 107	05:58:24	09/12/23 7:02
Room 107	23:38:28	09/13/23 18:55
Room 107	08:32:06	09/15/23 10:54
Room 107	11:23:12	09/19/23 6:20
Room 107	19:23:07	09/19/23 21:48

Scalding Showers

	Temperature	Alert sent timestamp
Room 204	132	09/06/23 2:027
Room 228	131	11/15/23 10:41

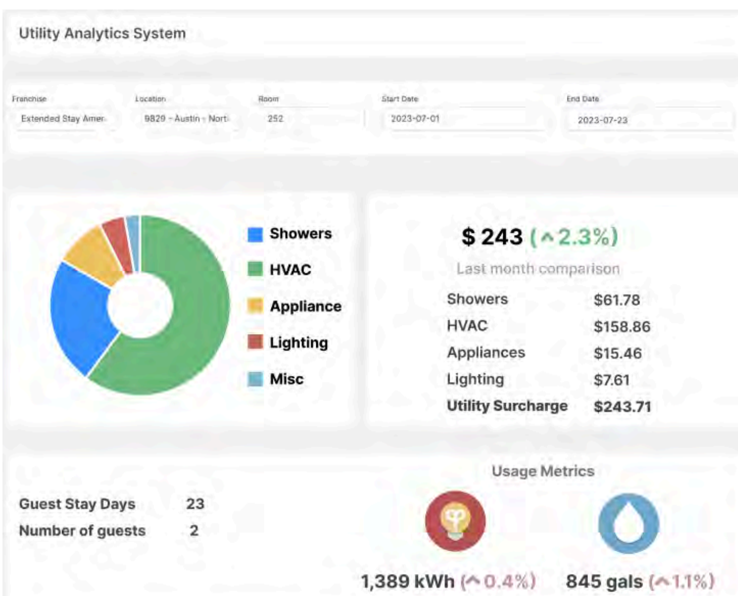
In summary, the pilot hotel point of contact, David Crider - Dir. Energy & Sustainability of ESA have signed a letter of support (pictured below right) to install and deploy Shower Stream in 5 buildings (720 rooms) at $5/room/month.

6. Utility Surcharge Feature

One of the top concerns for our pilot customers is the unmitigated guest utility expenses that are a recurring and increasing charge for hotels. Ways to reduce utility usage is a long-standing issue and makes it infeasible for hotels to charge their guests without accruing negative guest satisfaction risk. One solution to overcome this hurdle is to add an additional feature to our big-data analytics platform: *a per room per guest stay utility usage surcharge generation feature*.

6.1. Early Stage in New Prototype

The utility surcharge feature set will enable our analytics platform to generate a surcharge which hotel operators can add to their guests' bill. This will shift up to 75 to 100 % of in-room utility costs to the end-user who is directly responsible for that room's utility use. Using the data from a sample use-case, we designed a preliminary Surcharge Generation mockup:



Monthly Surcharge Generated per Building	
# of Rooms	1.00
Guest Stay Duration per month	23.00
Shower utility use per day	
Showerhead flow rate (gals/min)	1.75
Shower length (min)	10.50
Number of showers per occ.room per day	2.00
Water used (gals)	36.75
Energy used (kWh)	10.14
HVAC utility use per day	
Room Size (sq ft)	300.00
Operating hours	20.00
HVAC Efficiency factor	0.80
Energy Load per sq feet	20.00
Energy used (kWh)	43.96
Misc utility use per day	
Energy used - Appliances & Lighting(kWh)	6.30
Utility Surcharge Creation	
Water (gals)	845.25
Energy (kWh)	1389.20
GHG (metric tonnes of CO2)	0.60
US Avg - Dollar Savings @ 75% offset	**$182.79**
US Avg - Dollar Savings @ 100% offset	**$243.71**

We applied a proof of concept (POC) utility surcharge model to a sample guest stay at our Extended Stay America pilot location:

- The average length of guest stay for extended stays are 23 nights. So in our use-case sample - we have 2 guests staying in one room for 23 days. Assuming one shower per guest per day we use the standard Extended Stay America room layout of 300 square feet to estimate total water and energy use to be 845 gals and 1389 kWh respectively.
- We estimate the utility surcharge for this use-case of a typical ESA hotel room guest stay to be $243. Off setting even 75% of the utility cost can generate $182 per room utility surcharge.

This feature set will de-incentive environmentally wasteful hotel guest behavior & offset up to 75 to 100 % of hotel's in-room utility costs.

6.2. Customer Feedback

The utility surcharge feature is currently in its proof-of-concept stage. Our ESA point of contact is interested in the concept of a utility surcharge however, he did not sign a letter of support when we solicited his feedback since it is a new concept in the hotel industry.

We have, however, successfully obtained 3 signed letters of support for our innovative technology, which offers detailed tracking of utility usage and savings on a per-room basis, along with an optional surcharge feature for guests.

Based on preliminary research and customer feedback, we have enhanced our prototype with new, market-driven features to better align with customer needs and preferences.

7. Self-powered Shower Head

The current Shower Stream saves 20% of shower utility usage by eliminating warm-waste. By eliminating both warm-up waste and excessive waste, Shower Stream will save over 30% of shower utility usage. With 5.3 million rooms in the US branded hotel market (Hotel Tech Report), this novel innovation can save $2.7B in U.S. hot water utility costs annually.

7.1. Early Stage in New Prototype

Shower Stream currently runs on 3 disposable AA batteries because hotels have plenty on-hand at any given time. However, after installing our smart shower head product at customer sites, we discovered limitations with this approach (see section 3.4) that necessitate the replacement of the batteries with a self-powering turbine system.

Annual Savings from Behavioral Waste	
Hotel Shower Metrics	
Total rooms in US hotels	5,300,000
Shower water used (Gals)	88,631,052,000
Shower energy used (kWh)	67,582,443
Annual Savings	
Behavioral water saved (Gals)	30,049,735,342.51
Behavioral energy saved (MMBtu)	28,641,690.60
GHG emission reduction (MT of CO2)	1,519,728.10
Utility cost savings across US hotels	**$955,871,092**
Utility cost savings across SAM (15M Rooms)	**$2,705,295,542**

Based on the pilot data collected,self-powered Shower Stream can save at least $180 per year per shower head once we are able to capture extended shower waste (see table below).

Row	Hotel Shower Metrics	Value	Metric	Formula	Source
A	Total US Hotel Rooms	5,300,000	Num		[1]
B	Avg Annual Hotel Occupancy	66%	%		STR 2024 proj.
C	Avg Num Rooms Occupied per Day	3,519,200	Num	A * B	calculated
E	Avg Hotel Showers per Day in US	8,094,160	Num	C * 2	calculated
F	**Avg Hotel Showers per Year in US**	**2,954,368,400**	**Num**	**F * 365**	calculated
Row	**Shower Water Use**	**Value**	**Metric**	**Formula**	**Source**

G	Avg Shower Water Use	12	Min		Estimated
H	Avg Shower Flow Rate	2.5	GPM		EPA
I	**Annual Shower Water Use in All US Hotels**	**88,631,052,000**	**Gals**	**G * H * I**	calculated
Row	**Behavioural Water Waste**	**Value**	**Metric**	**Formula**	**Source**
J	Avg Warm-up Waste per Shower	22.83%	%		Estimated
K	Avg excessive Waste normalized to per Shower	11.07%	**%**		Projected
L	Annual Behavioral Water Waste in All US Hotels	30,049,735,343	Gals	I * (J + K)	calculated
M	**Annual Behavioral Water Waste per Room**	**5,670**	**Gals**	**L / A**	calculated
Row	**Behavioral Energy Waste**	**Value**	**Metric**	**Formula**	**Source**
N	Energy to Heat 1 Gal Water from 60 to 140F	0.0006672	MMBTU		[8]
O	Water Heater Recovery Efficiency	70%	%		[8]
P	Annual Behavioral Energy Waste in All US Hotels	28,641,691	MMBTU	L * N / O	calculated
Q	**Annual Behavioral Energy Waste per Room**	**5.40**	**MMBTU**	**P / A**	calculated
Row	**Annual Savings per Hotel Room**	**Value**	**Metric**	**Formula**	**Source**
R	Avg Water & Sewer Cost	$17.97	$/KGal		ESA provided
S	Avg Energy Cost	$14.52	$/MMBTU		BLS
T	Annual Water Cost Savings in All US Hotels	$539,993,744	USD	L * R/1000	calculated
U	Annual Energy Cost Savings in All US Hotels	$415,877,348	USD	P * S	calculated
V	Annual Behavioral Waste Cost Savings in All US Hotels	$955,871,092	USD	T + U	calculated
W	**Annual Savings per Room from Behavioural Waste**	**$180.35**	**USD**	**V / A**	**calculated**

Initial R&D have identified the following action items when replacing batteries with a rechargeable battery and a turbine that gathers energy from the flowing water:

1. The turbine must generate 500 mW of energy from 40-80 psi water so that our battery never fully runs out (pictured right - power usage summary table)
2. The turbine must not make noise that is louder than a running shower (50 dB) since this noise disturbs the bather.
3. The turbine must communicate effectively with the shower head CPU to enable accurate battery management.

Component	Average Power Use
Micro-controller[1]	200 mW
Ultrasonic sensors	150 mW
Temperature sensor	2 mW
Solenoid valve	2 mW
Wi-Fi Adapter[2]	50 mW
Total average power	**403 mW**

Currently the self-powered shower head is in its proof-of-concept stage and we submitted an NSF SBIR Phase I proposal to develop this novel tech for our customers. Hoteliers and investors have expressed interest (Letters of support available upon request) and as a result we have conducted preliminary product feasibility tests.

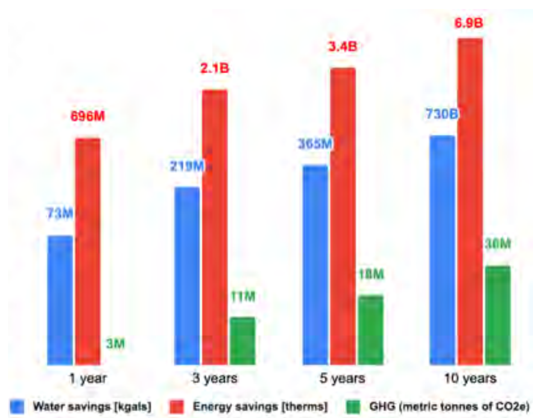
7.2. Customer Feedback

(i) The U.S. DoD P.O. includes an explicit, written request for a power harvester to eliminate battery replacement. This is an explicit requirement for Shower Stream to scale commercially within DoD.

(ii) Extended Stay America has provided a written approval to deploy Shower Stream in 5 ESA hotels. The decision was largely influenced by the data collected and reviewed on extended shower events (see section 5.1).

8. Conclusion and Path Forward

The US hotel industry annually generates $8.3M in wages, $211B in tax revenue, $1.5T of business sales and $760B in GDP (AHLA). A self-powered Shower Stream can save over 30% of shower utility usage. Adoption of smart showers across this industry can save 73M kgals of hot water and GHG reduction of 3M metric tonnes of CO2e each year.



Moreover, hotel guests have expressed a keen interest in supporting climate-friendly and socially responsible companies. 80% of global travelers demand green accommodations (Statista). In response to this demand, hotels have set ambitious sustainability goals. Our novel solution helps hotels achieve their ESG goals without compromising their guest and staff experience.

To conclude, the successful 12-month pilot deployment of the smart shower system with integrated big data analytics at an Extended Stay hotel location has proven the substantial savings in utility costs and resource usage, while demonstrating the revolutionary impact of data-driven solutions in the hospitality sector. The significant operational improvements observed in a single hotel, along with the projected savings for the Extended Stay America franchise and the broader market of economy hotels, illustrate the impressive scalability and potential of this technology.

Moving forward, the achievements of this pilot provide a solid groundwork for further expansion, indicating a promising direction for integrating advanced analytics into resource management practices. The continuous application of big data insights promises to foster significant advancements in sustainability and cost efficiency, offering considerable benefits to the industry, its customers, and the environment.

We thank the MWD-ICP team for their continued support! ICP funding was critical to successfully complete Shower Stream's 1 year pilot and secure launch of our novel product.

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