Water and Energy Efficient Showers: Project Report

Executive Summary

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EXECUTIVE SUMMARY

Purpose

This report describes an interdisciplinary research study of factors affecting water use in domestic showering. The study was sponsored by United Utilities (UU) and undertaken by Liverpool John Moores University (LJMU). The study has investigated showers in terms of both key physical performance criteria and customer satisfaction. The findings have been used to identify and reinforce potential strategies to encourage efficient use of water and energy by showers in homes.

The study has confirmed the major challenge for the UK to implement actions that will influence water use in showers in order to minimise the potential for major increases in water and energy use in the future. The current trend is for a rapidly increasing number of customers to own showers that provide high flow-rate, which together with high frequency of use, results in water and energy use by showers often being greater than for baths. Water use for showers is currently projected to double over the next 20 years.

Shower types

Water use by showers and the appropriate strategies to influence water use vary according to the type of shower.

Electric showers (46% of installed showers) have typical flow-rates of 3 to 8 l/min. The flows are inherently low and any modification to the showerhead or flow characteristics could damage the heating unit.

Mixer showers without pumps (38% of installed showers) have typical flow-rates of 5 to 15 l/min. Pumped showers (16% of installed showers) have typical flow-rates of 10 to over 20 l/min. The fitting of a flow restrictor or regulator, or change of showerhead can be used to reduce the flow of a mixer or pumped shower.

Customer and stakeholder views

Focus groups organised by LJMU found that customers want showers to provide good water flow, at the right temperature, in order to wash and also enjoy the experience of showering. It is perceived as important to have enough water running over the body in order to keep warm in the shower. There is a growing trend toward daily or twice daily showering because of the ease of taking a shower.

There is increasing recognition in the Water Industry and amongst environmental groups of the need to conserve water, including reducing water used by showers, to help protect the environment.

Physical performance characteristics

LJMU carried out laboratory work to investigate the physical performance of over 20 showerheads or flow restrictors. The characteristics investigated included flow-rate, spray pattern, temperature and skin pressure, as these have been identified by the

Market Transformation Programme as the key physical parameters that affect customer satisfaction.

The majority of the showerheads tested obeyed a simple pressure-flow relationship. In each case the flow-rate was proportional to the square-root of the internal pressure at the showerhead in the form $Q = k.P_{int}^{0.5}$ (where Q = flow, P_{int} = internal pressure in the showerhead, and k is a constant which varies between different showerheads).

As an alternative showerheads can be classified on the basis of equivalent diameter, D_e (the diameter of a single orifice producing the same pressure flow relationship). Low volume showerheads that produce a maximum flow-rate of 8 l/min could be defined as having an equivalent diameter of less than 4 mm. It is therefore suggested that D_e could be a useful parameter in evaluating the comparative flow performance of different showerheads.

Attempts were made to predict the pressure flow relationship from the physical appearance of the showerhead (i.e. to test whether D_e = number x diameter of holes/nozzles) but without success.

The radial distribution of spray from the showerheads varied widely, both between different showerheads and between different settings of the same head. Showerheads vary considerably in their ability to maintain a spray pattern over a range of flows. Some heads were designed to give a more centrally concentrated or jet like spray. Where more diffuse spray patterns were adopted it was generally found that spray dispersion increased with flow-rate.

Quite large temperature differences (up to 10^{o}C) were measured between water just leaving the shower and arriving at the shower floor. The temperature drop varied widely – in general larger temperature drops were found at lower flow-rates. Although the correlation between flow-rate and temperature drop was weak, it could have implications for shower comfort if the flow-rate is deliberately restricted.

"Skin pressure" P_{skin} was measured as an average over an area, rather than for each droplet. As expected P_{skin} varied with flow and the internal press in the showerhead (P_{int}). However the ratio P_{skin} / P_{int}, defined here as the head-factor H_f, was effectively constant for a single showerhead, though it varied between heads. A useful experiment for the future would be to try to relate H_f to some measure of user satisfaction, to see if the head-factor might be a useful simple predictor of satisfaction.

Taken overall, the behaviour of each showerhead is regular. The effect of changes of flow-rate on temperature profile and skin pressure can readily be predicted from relatively few measurements. However, changes in spray dispersion are more difficult to rationalize or predict.

Although flow-rate can be reduced by introducing a simple restriction in the flow path this is likely to have unwanted consequences because of the way that flow and related properties are linked. Consequently, it seems likely that the most effective means of water saving will be via specially designed showerheads that achieve high customer satisfaction with the "shower experience".

The data derived from these experiments has been used to validate a computational fluid dynamic model of the shower. The verification of this model is important as it provides a potentially important method of predicting performance.

Customer performance requirements

Water saving devices were tested by LJMU in 18 homes in order to investigate the extent to which customers are willing to accept a shower water saving device. Flow regulators were fitted in 9 homes and aerated showerheads were fitted in 9 homes. The key findings were:-

- 8 of the 9 households where an aerated showerhead was fitted requested that it be kept. Only 3 out of the 9 households where a flow regulator was fitted requested that it be kept although the flow reductions were similar to those achieved by the showerhead.
- The fitting of an aerated showerhead was effective in reducing flow-rate by 28% (3.2 l/min) on average, whilst improving or only marginally reducing customer satisfaction with the shower performance.
- The fitting of a flow regulator is effective in reducing flow-rate but adversely impacts on customer satisfaction with the shower performance. At the 6 households that requested removal of the flow restrictor the average water saving was 3.3 l/min.
- Some customers (5 out of the 18 households tested) requested retention of the water saving flow restrictor or showerhead even though there was a reduction in the satisfaction score.

Water and energy use

The water and energy use of showers was evaluated and compared with washing using a bath. The estimated average usage rates per washing event are tabulated as follows:-

	Flow-rate	Duration	Volume per event	Energy per event	Cost to customer
Electric shower	3.9 l/min	5.8 min	22.6 litres	0.95 kWh	20 p
Mixer shower (short duration)	8 l/min	5.8 min	46.4 litres	2.8 kWh	26 p
Mixer shower (long duration)	8 l/min	9 min	72 litres	4.3 kWh	40 p
Pumped shower	12 l/min	9 min	108 litres	6.5 kWh	60 p
Bath	n/a	n/a	73 litres	4.9 kWh	43 p

Note: Short and long duration alternatives are presented for mixer showers to represent the range of average values reported.

The study has identified that customers with a mixer or pumped shower operating at over 8 l/min can enjoy a financial payback within a few months from installing a water saving showerhead that does not impair customer satisfaction.

It is difficult to accurately determine the relative use of baths and showers for personal washing. The available data has been used to estimate average annual water, energy and carbon use in the home for each method of personal washing, as follows:-

Method of washing	Water use per event	Energy use per event	Water use per household per year	Energy use per household per year	Total carbon use per household per year
Electric shower	22.6 litres	0.95 kWh	14,000 litres	580 kWh	249 kg
Mixer shower (short duration)	46.4 litres	2.8 kWh	28,000 litres	1720 kWh	327 kg
Mixer shower (long duration)	72 litres	4.3 kWh	44,000 litres	2650 kWh	503 kg
Pumped shower	108 litres	6.5 kWh	66,000 litres	3980 kWh	756 kg
Bath	73 litres	4.9 kWh	35,000 litres	2330 kWh	443 kg

The findings from this study therefore suggest that many mixer and pumped showers may consume more water, electricity and carbon than washing by bath. This is due to a combination of factors: water flow-rates of mixer and pumped showers can be significant, and the frequency and duration of showering are much greater than for bathing, particularly due to the ease of having a shower.

A further finding is that the energy use in homes to heat (and pump) water for personal washing is about 70 times that used by a water company to supply the water and dispose of the wastewater. Therefore actions to reduce water use, and associated energy consumption, by showers do not only reduce water abstraction from the environment but also, very importantly, will have a significant effect on the energy and carbon consumption in the home.

Strategies for water efficiency

Strategies for encouraging more water efficient use of water by showers have been identified based on the findings of the UU/LJMU study. It is recommended that:-

- The purchase/installation of electric showers should be strongly encouraged in preference to mixer or pumped showers due to the inherent low water and energy use.

- Shower manufacturers should produce and promote water saving showerheads that limit flow without impairing customer acceptance. They should be fixed head not giving the user the opportunity to select a higher flow setting.

- Water companies and others should encourage customers to retro-fit water saving showerheads to existing mixer or pumped showers that have high flow-rates.

- The Water Industry (companies and regulators) and others need to maintain education /awareness programmes and do further work to understand how best to influence customers to not opt for pumped showers.

- The Water Industry (companies and regulators) should examine the feasibility of targeted pressure regulation in homes in areas where high mains pressures are unavoidable.

- Data presented in this report, and the supporting technical reports, can assist the Market Transformation Programme, Waterwise and others to inform water product information schemes to assist the selection of water efficient products. The study has shown that showerheads are available that restrict flow-rate of mixer or pumped showers to below 8 l/min but give acceptable shower performance.

- WRc is using the results from the study, on behalf of the Market Transformation Programme, to develop performance standard tests for "spray pattern", "spray force" and "soap removal" in order to more specifically define water efficient showers.

- Unilever are investigating the development of hair shampoos that are easier to rinse out, thereby potentially reducing the length of time required under the shower. This work should be encouraged by the Water Industry.

- Data presented in this report can assist water companies in understanding current and potential future water use for showers, and the potential benefits of water efficiency programmes.

- Further work is required to evaluate a wider range of water saving showerhead types in homes. More detailed customer surveys are required to determine the best means of providing customers with information and practical help to encourage them to reduce water use in showering.

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