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A Review

The Water and Energy Implications of Bathing and Showering Behaviours and Technologies

April 2009

Supported by

Acknowledgments

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Authorship

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About us

Waterwise is an independent, not-for-profit, nongovernmental organisation focused on decreasing water consumption in the UK, and on building the evidence base for large-scale water efficiency. In England, we sat on the Environment Minister's Water Saving Group, which came to a close in autumn 2008. We co-convene the Saving Water in Scotland Roundtable.

Our aim is to reverse the upward trend in how much water we all use at home and at work. We are developing a framework supported by a robust social, economic and environmental evidence base to demonstrate the benefits of water efficiency.

To achieve our aims we work with water companies, governments, manufacturers, retailers, non-governmental organisations, regulators, academics, agricultural groups, businesses, domestic consumers, the media and other stakeholders.

We conduct our own research and also undertake work as consultants.

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Recommendations

Knowledge of the drivers of showering and bathing behaviour must be developed
A review of evidence on showering and bathing patterns inside the home revealed an extremely high variance in basic factors such as frequency of use for showers and baths, and duration of use for showers. Research exploring the interaction between shower and bath use is limited, as is research which seeks to identify and describe the factors which control how frequently a bath or shower is used, and the volume of hot and cold water used in each event. Research which focuses on user attitudes and perceptions, their relation to behavioural patterns in the home, and the interaction between different users and different appliances should be carried out in order to underpin any behavioural or technological change campaigns.

Performance indicators and baselines for acceptance must be further developed in showers
Past research has identified variables which can be used to describe shower performance, such as spray pattern, skin pressure, temperature consistency etc. What have yet to be investigated fully are the relative weightings of these variables according to user preferences. To successfully transform the showering market towards water efficiency, good performance must be guaranteed in order to address current public concerns over the quality of water efficient appliances and to avoid customers rejecting new technologies. Research should trial various designs of low flow shower systems and identify where the risk of underperformance rests. In turn, an enforceable, recognised, minimum standard for performance in showers would help to encourage public confidence in efficient showers and would compliment any planned water efficiency labelling scheme.

Product development and marketing must not rely on environmental messaging
Marketing an appliance as water efficient may significantly limit its market without additional messaging. Research into current factors which affect bathroom fitting purchases emphasise price, appearance, and performance over water consumption. Shower systems which employ all of these messages in conjunction are more likely to see success. A showerhead which has been designed according to customer specifications of performance and marketed as “advanced” or “optimised” will fare better than one labelled as “water efficient”, which is still associated with poor performance in many people’s perceptions. When water efficient showers can be elevated in terms of social status and performance to the level power showers currently enjoy, water efficient showering will become an aspiration rather than a compromise.

An upgrade in plumbing and shower technology may lead to the need/opportunity to replace electric showers
Evidence suggests that around 40-50 % of showers installed in the UK are electric showers, most likely due to their being relatively self-contained in terms of water pressure and hot water supply, and so well suited to retrofits and bath replacement. Electric showers present a difficult trade-off between water, energy, and carbon consumption. Flow rates and therefore hot water and energy consumption tend to be lower, and there may be an additional advantage to heating at point of use due to cutting storage losses for hot water. However, the carbon weighting of electricity per unit of energy is significantly higher than gas, meaning that electric showers tend to out-perform in terms of water and energy, but might not in term of carbon. There is perhaps less room for product development in electric showers, with significant savings attributed more to behavioural change. Holding the carbon weighting of gas and electricity constant, replacing electric showers with efficient mixer showers of comparable flow rates may prove to be a valid long-term goal in homes with sufficient water pressure. Increased water pressure may be introduced through the combined upgrade of a conventional open/vented boiler with an unvented boiler, such as combination boilers, and a high efficiency mixer shower then introduced.

Introduction

Population growth, development, lifestyle changes as well as climate changes will necessitate - in fact already require - a reduction in water demand.

A large proportion of household water use is attributed to 'personal washing', which includes showering, bathing and in some cases basin tap use; these account for about one-third of water use in homes and are the largest growth areas of domestic water consumption according to many water company resource plans. For this reason, water efficiency programmes that have long targeted toilet flushing are now beginning to target personal washing.

What is of concern is that much less is understood about personal washing than toilet flushing. Anecdotal evidence suggests that personal washing technologies may interact with user behaviours in such a way as to produce unexpected results; for example, more efficient showerheads may lead to an increase in the duration of showers, resulting in the same volume of use or even an increase in net use. A more thorough understanding of personal washing and specifically of the dynamic between technologies and behaviours will help to inform water demand management strategies and hopefully increase their effectiveness, thus contributing to a more stable supply/demand balance and a healthier natural environment. Any reductions in water use, particularly in hot water use, will translate into energy savings and so into reductions in greenhouse gas emissions; about one percent of total UK green house gas emissions are attributed to clean water supply and treatment, wastewater collection and treatment, and about five percent is attributable to heating of water in homes (Defra 2008).

Purpose and aim

The purpose of this review is to identify gaps in knowledge and understanding of personal washing, focussing on showering and bathing in particular because of their contribution to per capita consumption. Basin taps have been purposely left out in part because little research exists on the component, especially with regard to the interaction between basin taps and showers and baths, and in part because the contribution of basin taps to consumption is less of a concern than showering and bathing.

This review aims to synthesize the existing evidence base on showering and bathing in order to provide recommendations for its strengthening so that demand management programmes, regulation and policy decisions are as effective as possible in managing demand.

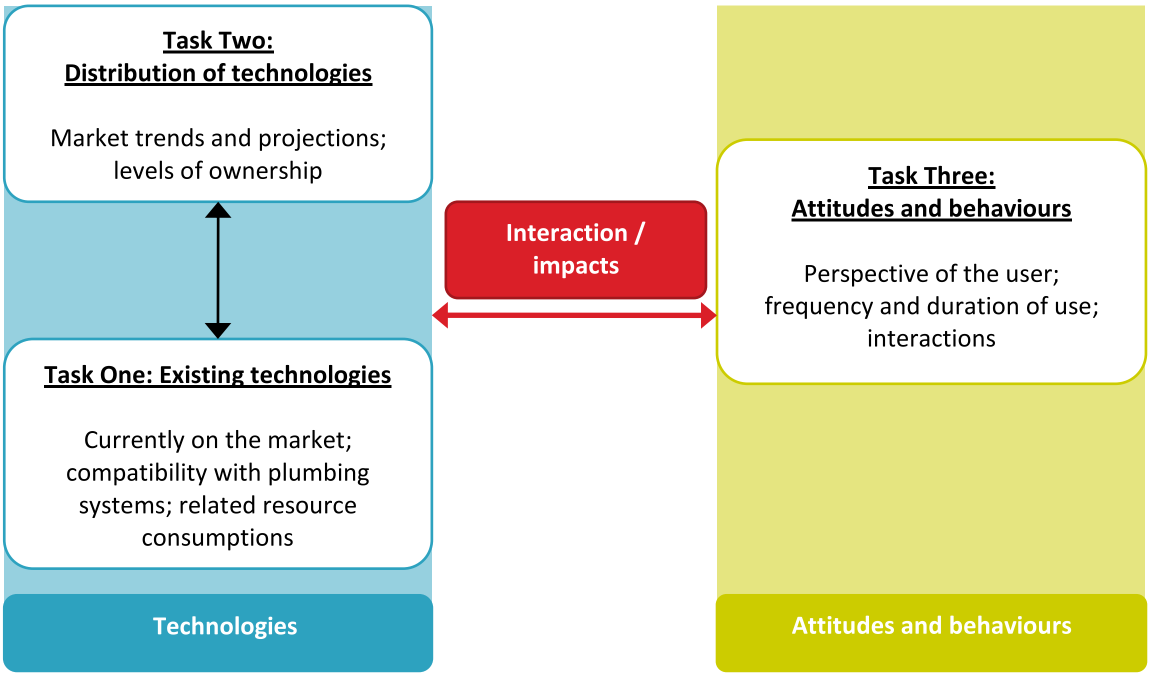
Methodology

This report attempts to synthesize published materials from a variety of sources including government and the water industry. More evidence likely could have been gleaned from academia, but resource limitations prevented a comprehensive review. The author is aware of a handful of studies that will contribute significantly to the understanding of showering, but these studies are yet to be published. In addition, the author has reviewed some unpublished data from, for example, the British Library and water companies. Draft Water Resource Management Plans have also been reviewed, but are subject to revision as only a limited number of plans were available at the time of reviewing and may have since been updated.

Structure, theory and uncertainties

The report is divided into several tasks that when taken together provide an overview of bathing and showering. This division is based on a simplified version of Kurz *et al*'s (2002) model of behaviour-technology interactions and resulting resource consumptions (figure 1). Kurz's model aims to extend beyond traditional choice models, i.e. of utility maximization, by accounting for limited rationality, rebound effects and prior conditions.

FIGURE 1. Behaviour-technology interactions and task divisions (after Kurz 2002).



This model of resource consumption aims to capture what might be labelled as "irrational" behaviour by more classical economic theories of resource consumption such as choice theory. Choice theory based on utility maximisation assumes that agents in a free market are rational, that their decisions are based on an understanding of consequences and on a desire to gain maximum benefit. Therefore, an individual will optimise their use of a limited resource to gain maximum benefit. The use of resources such as water and energy is determined by weighing the desired effects of their use against their (limited) supply.

The technocratic approach to managing resources consumption is underpinned by this theory of utility maximisation. Technologies that provide the same benefits whilst reducing resource consumption are deemed as Pareto optimal in that they introduce new benefits without detracting from existing ones. For example, improvements in vehicle fuel efficiency has allowed for the same journeys to be made with less fuel. The retrofit of efficient devices is often justified under this model: fixtures and fittings with lower water/energy consumptions that still perform as well as inefficient models are deemed the better option because they reduce net consumption.

The weakness in this approach is that it assumes that technologies alone are a complete solution to end use efficiency; human behaviour is not taken into account. The oversight of behaviour exposes demand management programmes to increased risks of failure, which will often be dependent on people's willingness to adopt and maintain new technologies as well as their not altering behaviours to compensate for perceived shortcomings in the introduced technology (for example, increasing shower duration to compensate for lower flow) (Deorio *et al*. 2001). Unless drivers for technologies uptake, patterns of use and interactions are accounted for, efficiency initiatives remain highly susceptible to failure; the 'human dimension' must be acknowledged to reduce the risk of failure (Pahl-Wostl 2002; Midden *et al*. 2007).

For example, there are many uncertainties associated with the take-up and replacement of water efficient bathing and showering technologies. How willing are people to accept and maintain ownership of shower flow regulators, aerated showerheads or shower timers? There is no guarantee that water/energy efficient technologies will be able to compete in a free market and that those technologies introduced through a top-down programme will be kept in the longer term. The Environment Agency has highlighted this uncertainty as a potential barrier to shower retrofit programmes (EA 2003).

In addition, there are uncertainties associated with consistency in patterns of use. Will the introduction of shower flow regulators lead to increases in showering duration? Or will the introduction of water efficient showerheads result in an increase in frequency of use? The 'bounce back' effect has been well documented for energy and fuel consumption (Hertwich 2005), but less so for water consumption.

Recent research has shown that habits, cultural norms, normative social pressures and levels of environmental awareness all influence water consumption, besides utility maximisation (Barr *et al*. 2006; Shove *et al*. 2008). With regard to personal washing, it has been noted that the 'daily shower' is a recent phenomenon resulting from the availability of affordable shower installations and from the now accepted cultural norm of washing every day (Hand et al. 2006). This newly established norm, particularly when combined with increasing sales of power showers and other 'luxury' fittings such as whirlpools, is leading to an increase not only in water use for personal washing, but to water consumption overall (See Task 3 of this report).

The conceptual model used in this report to discuss the drivers water consumption in personal washing is drawn from a school of social theory which aims to describe how people perceive the advantages and disadvantages of using different technologies, and how these perceptions affect the way they use technology on Kurz *et al*. (2002). This document therefore goes beyond reviewing existing technologies and assessing how much water and energy they consume under an assumed constant behaviour, but also discusses how the attitudes and related behaviours of those using those technologies will affect the final level of consumption.

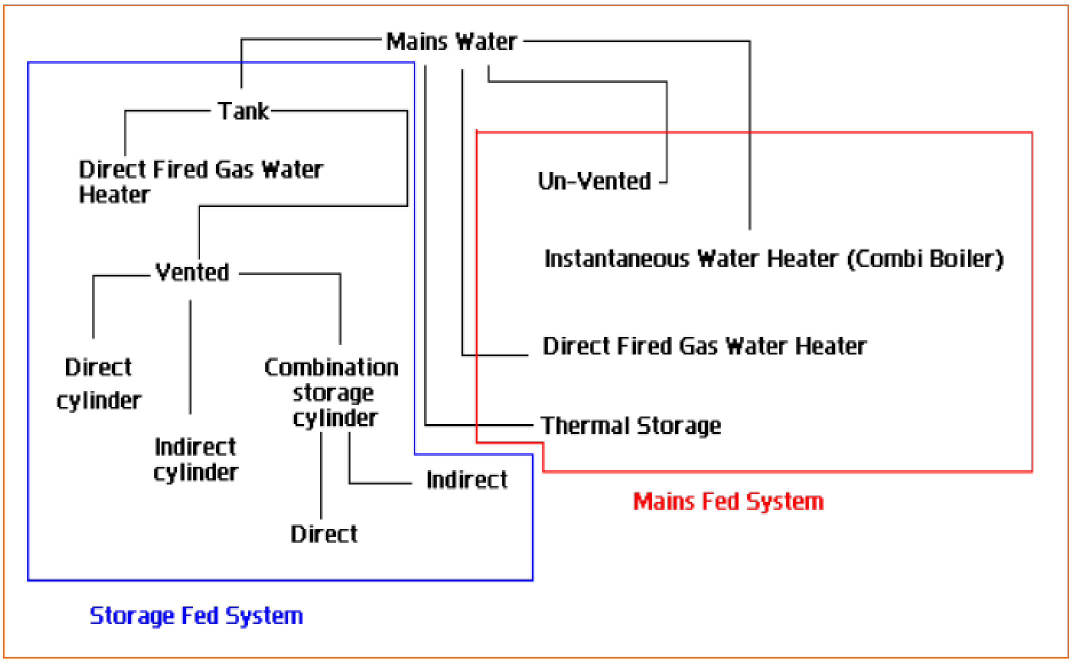
Task one: existing technologies

The pressure and temperature at which hot and cold water are supplied to the bathroom determines the range and performance of bathroom fixtures and fittings. Plumbing systems, which vary amongst UK households, are important determinates of shower system compatibility.

Hot water supply systems

Hot/cold water supply can be broadly divided into two systems: mains-fed and storage-fed (figure 2). In mains-fed systems, which are more common in newer buildings, water is supplied directly to the user from the supply pipe, relying only on adequate pressure within the distribution network. Storage-fed systems, also known as gravity-fed systems, store water in holding tanks (usually in the attic) that then transfer water throughout the house. Storage-fed systems are common in older buildings and are also typically characterised by a supply pressure that is lower than mains-fed supply pressure.

FIGURE 2. Hot water supply systems in the UK (MTP 2008c).



Supply systems are further dived according to the method used for heating and storing water. Water supplied from a storage/gravity-fed system (table 1) is vulnerable to a loss of pressure when the tank begins to empty. Hot water supplied from a storage system tank is also vulnerable to inconsistencies in temperature, particularly if high flow fittings are in use, as the tank will be rapidly emptied of hot water and replaced with unheated water. In contrast, water supplied from a mains-fed system (table 2) will tend to be of a higher pressure and provided the flow rate does not exceed the capacity of the heater to deliver hot water, will provide a more consistent temperature; the use of multiple and/or high flow fittings may lead to a demand in hot water at a faster rate than the system is able to produce.

TABLE 1. Storage / gravity-fed systems (Plumbing Pages 2009).

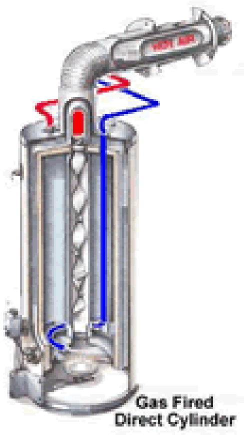
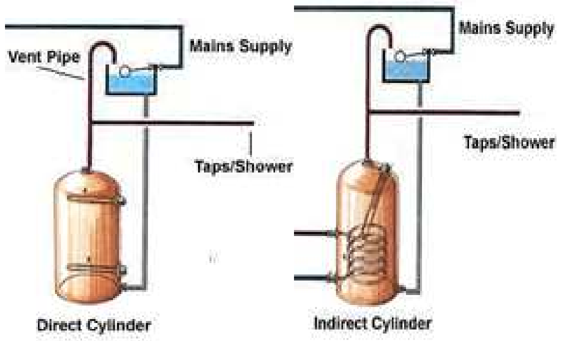
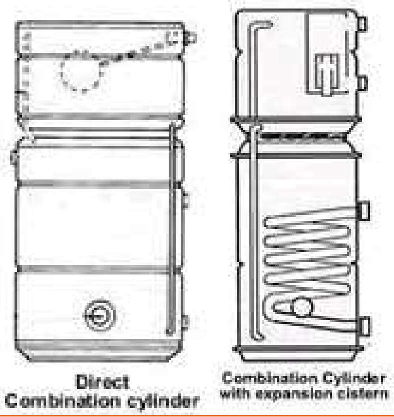
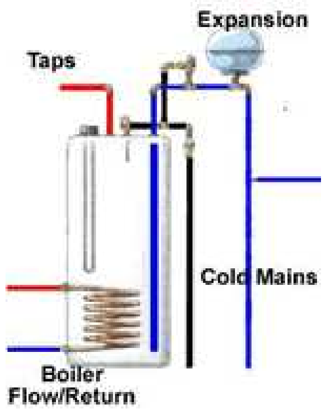
	**Gas fired cylinders:** a storage tank fitted with a gas burner at its base. Cold water is pumped to the base of the tank and rises as it is heated. Thermal stratification therefore occurs, allowing for hot water to be siphoned from the top of the tank. Perhaps the most common systems installed in homes. A thermostat controls the rate and frequency of heating to ensure constant temperatures. Gas fired heaters can be used in both direct and indirect systems. Direct systems are those in which water comes into direct contact with the heating elements.
	**Vented cylinders:** water is heated via emersion elements or a remote boiler. Hot water is stored in an insulated cylinder that is equipped with a vent pipe to prevent excessive pressure build-up. When the pressure become too great, hot water is released via the vent into the cold water storage tank. Water that passes through radiators and pipes for home heating needs to be chemically treated to prevent corrosion and deposit build-up. Vented systems provide the advantage of having one heating mechanism but with a separation of water for heating and for consumption. Vented systems can be either direct or indirect.
	**Combination cylinders:** composed of an upper cold water cylinder and a lower hot water cylinder. Combination systems tend to be problematic in terms of water storage since the cold water tank has very little headroom relative to the hot water tank, which means that plumbing must be designed specially to ensure sufficient water pressure. Available in direct and indirect forms.

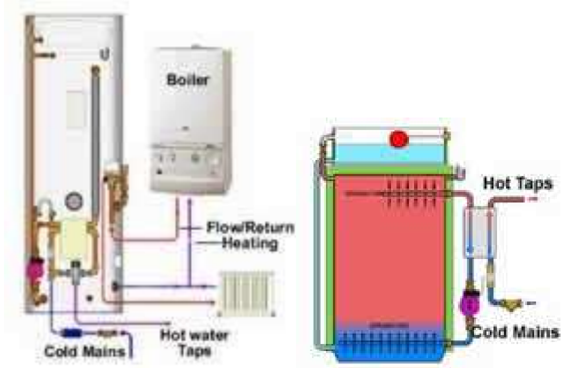
TABLE 2. Mains-fed systems (Plumbing Pages 2009).



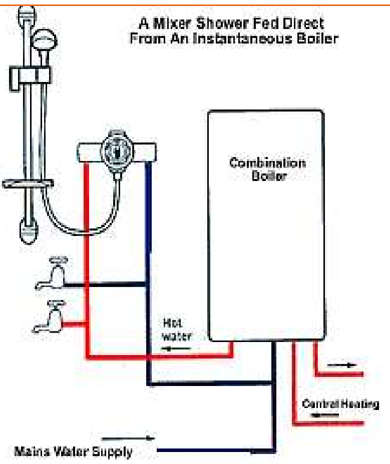
Un-vented: cold water is fed from the mains to the base of the cylinder where it is heated and rises. Hot water is then delivered from the top of the cylinder using mains pressure. Since the cylinder is sealed, the build-up of pressure due to the heating of water is allowed for by either an internal or extern expansion unit as well as a pressure relief valve to prevent dangerous levels.

The advantage of these systems is that water tends to be supplied at a high pressure, which is particularly important in multi-storey properties and those with high flow fixtures and fittings.

Un-vented models are available with direct or indirect heating systems.



Thermal: these systems reverse the indirect water heating principle. Water that passes through the central heating system and boiler also passes through the cylinder. The water that is in the cylinder never changes; it simply flows around the vented or unvented heating circuits, being reheated by the boiler. The build-up of scale within the cylinder is therefore eliminated and extra system protection is achieved by the addition of corrosion/scale inhibitors. If required, anti-freeze may also be added.



Combination-boiler: these systems heat water on demand, and can vary from the small hand washing units seen in public buildings to electric showers to home combination boilers. These systems combine the traditional capabilities of a standard central heating boiler with the added functionality of being able to utilize full boiler capacity to heat water instantaneously. They also offer the increase in water pressure seen in other unvented systems

A note on distribution: Vented cylinders have been up until recently the most popular method of water heating. Most hot water systems installed in the past 25 years will use some form of vented heating. A good indicator for vented systems is the presence of a water tank in the roof of the house.

Combination boilers have begun to grow in popularity, particularly in cases where space is at a premium, for instance in flats and city dwellings. As they are unvented, they are also a potential solution to low water pressure which may affect shower quality.

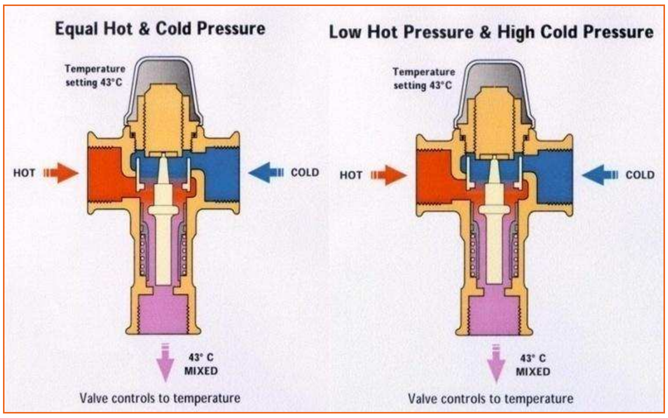
Fixtures and fittings

Just as the method for heating and storing hot water will affect the pressure and temperature characteristics of water delivered to fittings, the fittings themselves will also affect the rate of consumption of water and in the case of thermostatic mixing valves, the consistency of temperature of water delivered.

Thermostatic mixing valves

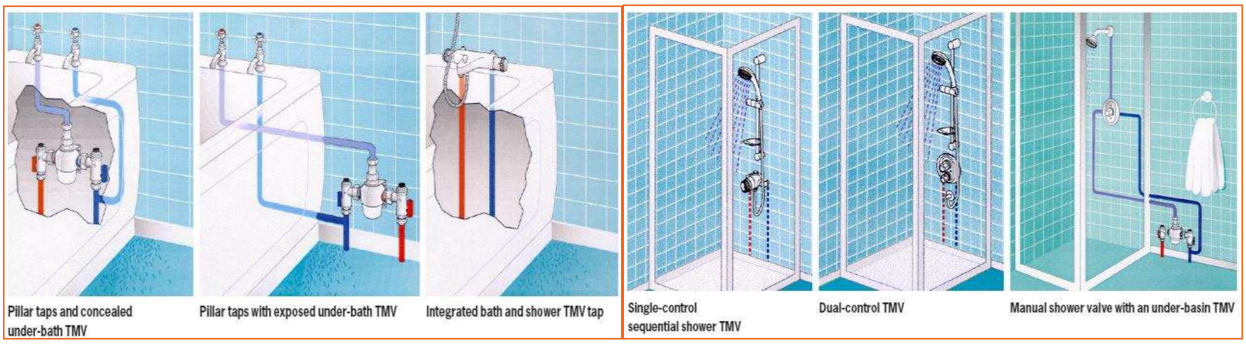
Thermostatic mixing valves (TMVs) (figure 3) automatically compensate for variations in water supply pressures to deliver water at a constant user determined temperature. TMVs shut down automatically if cold water supply fails, protecting from the risk of scolding. While TMVs' most important function is to prevent scalding, these valves also provide the benefit of a constant temperature supply to showers, taps and baths. TMVs therefore allow for a safe temperature of supply whilst also allowing for hot water storage temperatures to be high enough to protect against *Legionella*.

FIGURE 3. Thermostatic mixing valves (BRE 2003).



TMVs in baths (figure 4) are typically set to a maximum value of 44-46°C (higher setting used for metal baths to allow for heat loss). Valves are ether installed in addition to conventional tap systems or they replace the entire system.

FIGURE 4. *Left*: TMVs in baths; *right*: TMVs in showers (BRE 2003).



In showers (figure 4), building guidelines suggest a maximum delivery temperature of 39-43°C; however, some valves are equipped with an override button that allows users to specify the maximum temperature. As with baths, TMVs may sit inside the showering unit or independently.

Anecdotal evidence and manufacturer claims indicate that TMVs may also promote water efficiency, as users spend less time adjusting the controls of showers and baths to achieve the right temperature and therefore waste less water.

Baths

The typical consumption of a bath is often estimated to be about 80 litres per event. The Market Transformation Programme (MTP) (2008a) has classified baths according to type and has also determined volume to capacity and actual consumption (table 3).

TABLE 3. Bath types and capacities (MTP 2008a).

Bath type	Capacity to overflow (litres)	Actual usage (litres)
Undersized	165	65
Corner	140	65
Shower	250	100
Standard	225	88
Roll-top	205	80
Whirlpool spa	225	88
Outdoor large spa	400	300

Some manufacturers have expressed interest in developing 'water efficient' baths that have reduced water volumes, which can be achieved, for example, by shaping the bath like a peanut so that is hugs the body more closely.

Shower systems

Electrical showers employ a point-of-use heating system and are sometime referred to as 'kettles-on-walls'. Cold water is heated within a wall unit that is adjacent to the shower and connected via built-in electrical filaments. These systems do not require hot water and so are the most versatile in terms of plumbing compatibility. Power ratings for the heating element of electric showers range from 7-10 kW.

Because water is heated on demand flow rates tend to be lower than for other shower systems, ranging from three to five litres per minute compared with about six to twelve litres per minute for a non-electrical shower. Flow rates are primarily determined by the power rating of the device and the extent of temperature rise required by the user. Flow rates vary throughout the year according to the ambient temperature in the bathroom and the temperature of the incoming water supplied. In some cases, electrical showers may have an integrated or separate pumping mechanism to ensure adequate supply flow.

Mixer showers mix hot and cold water, which are supplied through the domestic plumbing system, to provide water at the required temperature. Temperature control is achieved either through a manual control that allows the user to adjust the hot/cold water inputs or through a TMV that the user sets to a desired temperature and which then adjusts itself automatically as pressure varies. TMV mixer showers have become popular because they are easy to use and also prevent scalding. The current revision of Part G of building regulations is due to be published in April 2009 and is likely to encourage further uptake of TMVs through regulations concerning temperature restrictions and guidelines for regulatory compliance.

Pumped/power showers are mixer showers with additional external pumps, which achieve significantly higher flow rates of ten to twenty or more litres per minute. There are two variations: 1) integrated power showers, in which the TMV and pump are integrated into one unit, are usually placed on the wall adjacent to the shower and achieve flow rates of approximately eighteen to twenty litres per minute; 2) separated pump showers, in which the TMV and pumping unit are purchased and installed separately, are typically installed when users require higher flow rates of about twenty litres per minute.

Showerheads

While shower systems determine how water is heated and delivered, showerheads determine the pattern and rate at which the water is delivered. Flow rate is influenced by the shower head through the presences of flow restricting valves, pressure regulators, and fixed or variable spray patterns. The design of a showerhead influences the translation of internal shower pressure to experienced skin pressure, as well as consistency of shower spray patterns over varying pressures (Critchley and Philips 2007). Showerheads tend to be designed with a particular shower system in mind; therefore, showerheads are often only compatible with a specific range of flow rates and water pressures.

There are several types of **water efficient showerhead** that attempt to balance performance with flow rate. Balance is often achieved by evenly distributing water across the user's body (giving the impression of a higher flow rate) through a large showerhead that distributes pressure evenly across its diameter. Other water efficient showerheads mimic the feel of high flow through twin jet technology in which jets of water collide upon exiting the showerhead, producing a fine stream of water droplets.

Aerated showerheads are designed to make use of the Venturi effect. Put simply, the Venturi effect describes a rapid change in the pressure of water as it is forced through a constricted valve. As water enters the valve, a rapid drop in pressure occurs followed by a rapid rise. During this rise the water 'explodes' inside the showerhead, combining with air. The mixture is then sprayed out of the showerhead at a ratio of about 3:1 air:water. Aerated showerheads can achieve a reduction in water flow of about thirty percent without compromising performance (Critchley and Philips 2007).

On the opposite end of the consumption spectrum are **luxury and other high flow shower fixtures**, which are used in conjunction with high pressure supply systems (often pumped). These shower fixtures typically have a flow rate of fifteen or more litres per minute. Models range from single high-flow showerheads to high flow, multiple head towers and deluge showers. Whilst these fittings are relatively rare, their popularity is rising as disposable incomes increase (see Task 3 of this report).

Compatibility

Not all shower systems are compatible with all hot water systems, and not all showerheads are compatible with all shower systems. This must be taken into account when installing a new shower system.

Most water efficient showerheads, for example, are designed to be installed in inefficient shower systems with relatively high water pressures; therefore, the retrofit of efficient showerheads must often be restricted to pumped and mixer showers, and may not be suitable for electric shower systems.

Work undertaken for the MTP (2008c) has resulted in some guidance on compatibility of combinations (table 4). Incompatibilities arise with pumped showers, which might only function on stored hot/cold water supplies and not with mains fed systems. In the case of mixer showers, incompatibilities with plumbing systems may arise due to particularly low pressures, this is not outlined in table four, as a constant pressure is assumed, but it should be noted that the relatively high proportion of ownership of electric showers discussed in task 2 is likely to be due to the installation of showers in low water pressure homes which previously relied on baths.

TABLE 4. Compatibility of shower systems and plumbing systems (MTP 2008c).

	Tank-fed cold water			Mains-fed cold water				
	Tank-fed hot water				Mains-fed hot water			
	Direct fired gas heater	Vented cistern	Storage combi	Storage combi	Unvented cistern	Instant combi	Thermal storage	Direct fired gas heater
Electric 7.0-10+ kW	✓	✓	✓	✓	✓	✓	✓	✓
Electric integrated pump 120W	✓	✓	✓	✗	✗	✗	✗	✗
Electric separated pump 450W	✓	✓	✓	✗	✗	✗	✗	✗
Mixer	✓	✓	✓	✓	✓	✓	✓	✓
Mixer and integrated pump 150W	✓	✓	✓	✓	✗	✗	✗	✗
Mixer and separated pump 450W	✓	✓	✓	✓	✗	✗	✗	✗

A note on combination boilers

Anecdotal evidence arising from some retrofit campaigns has suggested that the low flow rates achieved by efficient tap and shower heads are incompatible with combination boilers as the flow rate is insufficient to trigger the heating mechanism in the boiler. A report commissioned by the Environment Agency concluded that regulated spray taps would only be compatible with combination boilers which use a stored reserve of hot water and employ a temperature change in that reserve as a trigger for heating rather than a minimum flow rate. Low flow showers were reported to have less compatibility issues, but a risk of combination boilers intermittently triggering on and off causing inconsistent delivered temperatures. Compatibility was found to be highest in modern modulating combination boilers and storage combination boilers which were likely to accept flow rates of both low flow taps and showers (Grant 2007).

Resources consumption

The MTP (2008b) have estimated flow rates for various shower systems (table 5) and have calculated resource efficiency rankings (table 6).

TABLE 5. Estimated flow rates of shower systems (MTP 2008b).

Shower type	Sub-sector	Flow rate estimate, 2006, litres per minute
Mixer	Gravity	7.88
	Integrated pump	9.85
	Separate pump / pressurised	11.82
	Bath / shower mixer	6.00
Electric	7.0-7.9 kW	3.46
	8.0-8.9 kW	3.96
	9.0-9.9 kW	4.52
	10.0+ kW	4.99

TABLE 6. Resource efficiency rankings (MTP 2008c).

Homes with gas heating					Homes with oil heating				
Fuel type	**Shower type**	**Carbon rating**	**Water rating**	**Overall rank**	**Fuel type**	**Shower type**	**Carbon rating**	**Water rating**	**Overall rank**
Electric	**7.0-7.9 kW**	2	1	**1**	**Electric**	**7.0-7.9 kW**	1	1	**1**
	8.0-8.9 kW	4	2	**2**		**8.0-8.9 kW**	2	2	**2**
	9.0-9.9 kW	6	3	**4**		**9.0-9.9 kW**	3	3	**3**
	10.0-10.9 kW	7	4	**5**		**10.0-10.9 kW**	6	4	**4**
	Integrated pump 120W	8	4	**7**		**Integrated pump 120W**	7	4	**5**
	Separate pump 450W	9	4	**8**		**Separate pump 450W**	8	4	**7**
Gas	**Mixer**	1	7	**3**	**Oil**	**Mixer**	4	7	**5**
Gas and electric	**Mixer and integrated pump 150W**	3	8	**5**	**Oil and electric**	**Mixer and integrated pump 150W**	5	8	**8**
	Mixer and separate pump 450W	5	9	**9**		**Mixer and separate pump 450W**	9	9	**9**

Per litre energy implications of showering

From a theoretical perspective, the amount of energy consumed per litre for baths and showers is determined by the temperature rise required and the efficiency of the heating process. Temperature rise in turn is determined by the temperature of the water entering the home and the temperature selected by the user, whilst the efficiency of the heating process is affect by boiler efficiencies and heat loss from storage tanks and pipes inside the building. Waterwise has made estimates of energy consumptions due to shower and bath use using a basic model of energy consumption which accounts for gas boiler efficiencies of stock average (72% efficiency), assumed a 100% heating efficiency in electric showers, and assumes a temperature rise from 15C to 41C. These estimates have been compared to other quoted estimates found in literature reviews, and have been found to be in agreement in terms of order of magnitude (Table 7).

TABLE 7. Energy content of domestic hot water: example values

Source	Type	Quoted Value	Quoted Units	Value in kWh/Litre
California: Biermayer (2005)	Electrically heated shower	0.112	kWh per gallon	0.025
California: Biermayer (2005)	Gas heated shower	498.000	BTU per gallon	0.032
California: NRDC (2004)	Electrically heated shower	0.130	kWh per gallon	0.029
Critchley and Phipps (2007)	Electrically heated shower	0.042	kWh per litre	0.042
Critchley and Phipps (2007)	Mixer (mostly gas) shower	0.060	kWh per litre	0.060
Critchley and Phipps (2007)	Pumped mixer shower	0.060	kWh per litre	0.060
Waterwise Calculations[1]	Electric Shower	0.030	kWh per litre	0.030
Waterwise Calculations	Gas heated shower	0.042	kWh per litre	0.042

[1] Details of calculations available upon request from Waterwise

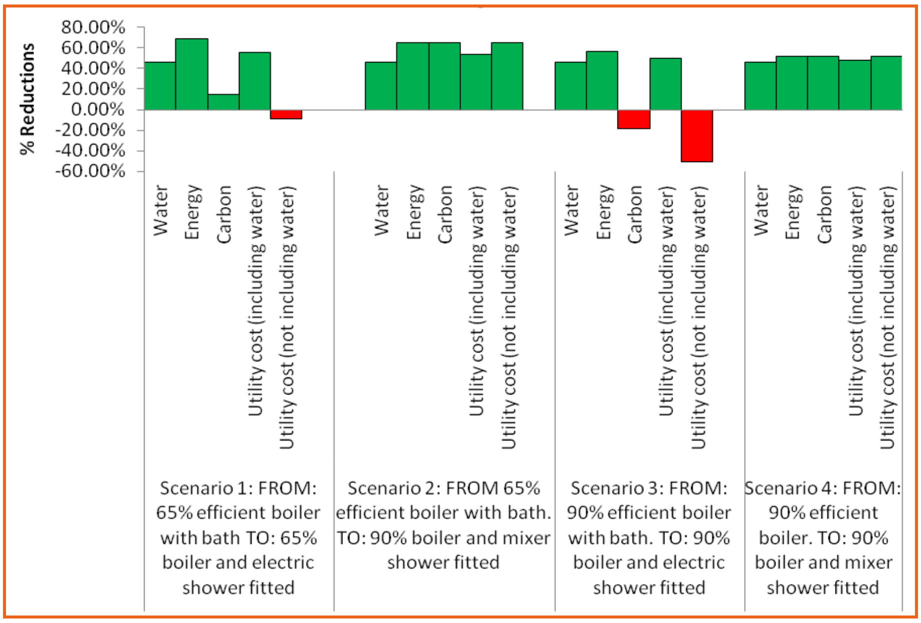
Water, energy and carbon tradeoffs in shower types

The water, energy and carbon implications of shower use are extremely difficult to determine to any degree of accuracy due to the variability of in home plumbing and heating methods, the water pressure delivered to the shower head, and the settings selected by the user. However, there are some general trends in consumption on water, energy and carbon between shower types which introduce some difficult trade-offs when selecting a shower head.

Electric showers will tend to deliver lower flow rates than mixer showers, and in water terms are more efficient. However, electricity is a much more carbon intensive energy source than gas (which is the typical heat source for mixer showers) and therefore any energy savings made due to lowered water consumptions are not proportional to carbon savings when comparing gas with electric showers. For this reason, the MTP classifies electric showers as being the lowest water consumers but second to mixer showers in terms of carbon. The average cost of electricity per unit energy delivered is also relatively high when compared with gas, affecting any cost benefit decisions made from the perspective a household considering a shower type.

To demonstrate this trade off, scenarios for the replacement of a bath with a shower are outlined below in terms of % changes in resource consumption (water, energy, carbon, and utility charges) (figure 5). Scenarios 1 and 2 assume an original bath filled through an inefficient (65%) gas boiler, whereas scenarios 2 and 3 assumed an original bath filled through an efficient (90%) gas boiler. It should be noted that this comparison is not a litre-for-litre comparison, as water consumption through a bath has been assumed at 69.4 litres per use, and showers at 37.52 litres per use. These figures are based on Waterwise Evidence Base figures for bath retrofits in social housing. Energy calculations have been made using an in-house calculator, the outline of which is available upon request from Waterwise.

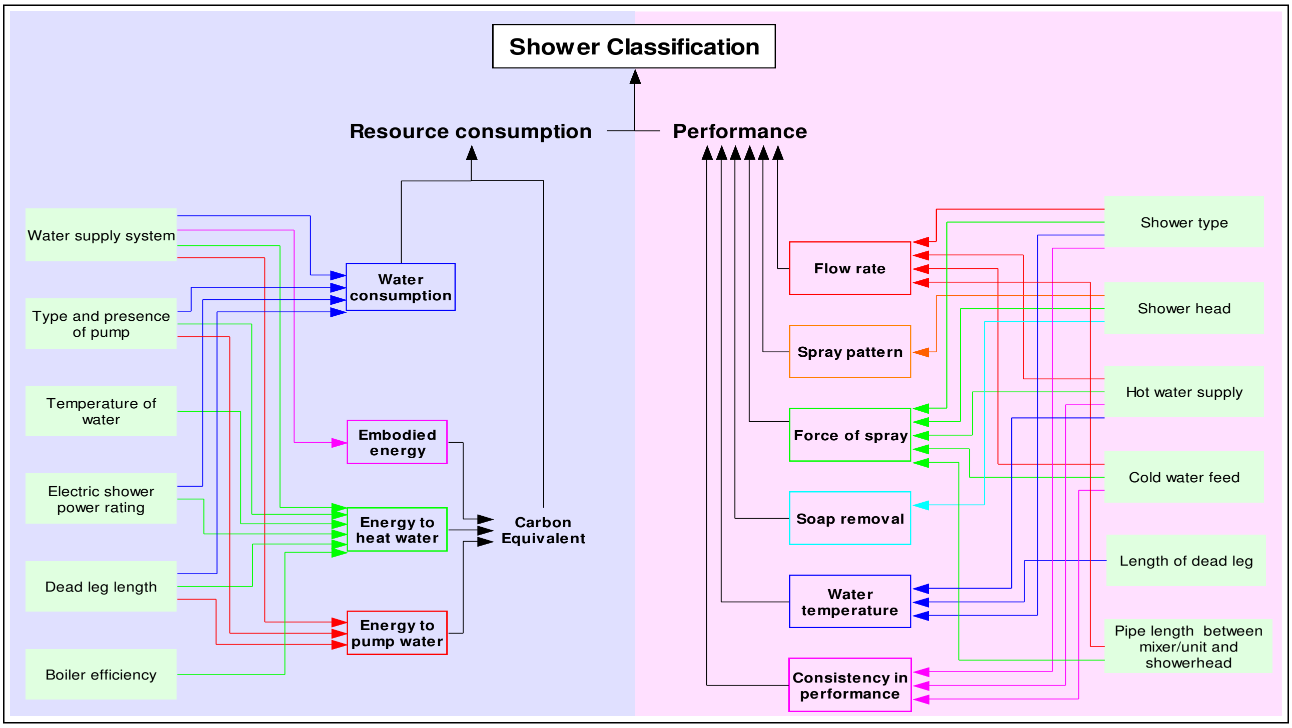
FIGURE 5. Water, energy, carbon, and utility cost impacts of bath replacement with showers



Performance

Much debate has been had about how to assess the 'performance' of shower systems and showerheads, which does not necessarily correlate with high flow rate. Work undertaken through the MTP (2008c) has attempted to identify the variables that influence performance and consumption (figure 6).

FIGURE 6. Factors contributing to shower 'performance' and consumption (MTP 2008c).



Performance was examined in more detail in 2007, when United Utilities and Liverpool John Moores University undertook a study to determine a methodology for measuring shower performance and to rate a selection of shower systems and showerheads using developed methodology (Critchley and Philips 2007). Flow rate, spray pattern, water temperature gradient and skin pressure were all examined.

The UU/LJMU study found that **flow rates** could be accurately described by the following linear equation:

> *(EQ1)* $Q = kP_{int}$, where Q = flow rate in litres per minute, K = constant of proportionality related to showerhead design, P_{int} = water pressure measured inside the showerhead. (Critchley and Philips 2007).

It was hypothesized that the constant of proportionality, *k* (EQ1), was directly related to the 'equivalent diameter' (the diameter of a single circular orifice at the pipe outlet that gives an equivalent flow rate to the showerhead) of the showerhead.

Electrical showers were found to be a special case since point-of-use heating involves automatically adjusting flow rates to suit the heating capacity of the unit. Flow rates for electrical showers are determined by the temperature rise demanded as well as the rate at which the shower unit is able to heat water. The relationship between flow rate, temperature change and power rating in electrical showers is described by the following equation:

> *(EQ2)* $= 14.3 * R / T$, where *(EQ3)* is the flow rate in litres per minute, *R* is the kW rating and *T* is the temperature rise in °C. (Critchley and Philips 2007).

In addition to flow rate, the ability of a showerhead to maintain a constant **spray pattern** (i.e. radial distribution) over a range of flow rates was also found to be an important aspect of performance. For a single showerhead with multiple settings it was found that the consistency in spray pattern was relatively unaffected by flow rate. When comparing across different showerheads, however, it was found that the consistency in spray pattern did vary significantly with flow rates. When flow rates were reduced is was found that central patterns became more dominant and outer spray patterns reduced significantly. It was suggested that this could be intentional, to give the impression of a higher flow rate at low pressures.

The **water temperature gradient** (the rate at which temperature declines after it leaves the shower head) was also used to measure performance. Temperature performance was determined by the amount of heat loss from showerhead to ankle height and was found to be dependent on a combination of condition variables such as ambient temperature, relative humidity and shower droplet size. It was observed that there was little difference in the rate of temperature loss in aerated and regular showerheads, however a weak inverse correlation was found between temperature loss and flow rates.

Lastly, **skin pressure** also has an effect on performance. In the UU/LJMU study, skin pressure was indirectly measured using a pressure sensitive membrane. It was observed that skin pressure increases nonlinearly with flow rate. The study found it hard to determine the effects of such a relationship on shower quality experience; however, it was suggested that the ratio between the pressure at the showerhead to that delivered to the users' skin is relatively constant for flow rates and showerhead and may serve as an important indicator of more subjective measures of shower quality.

The UU/LJMU study concluded that whilst flow rate will have significant effects on performance variables, the nature and degree of these effects will be largely determined by showerhead design. Modelling work carried out through the MTP (MTP 2008c) indicated that acceptable levels of performance in terms of spray distribution and temperature gradient are achievable through alterations to the design of showerheads rather than to total flow rates.

As small part of the UU/LJMU study examined user-defined performance requirements: nine homes were fitted with flow restrictors and another nine with aerated showerheads. Results from this limited trial suggested that aerated showerheads were far more likely than flow restrictors to provide adequate performance. Eight of the nine households with aerated showerheads chose to keep the models after the study, but only three of the nine households with flow restrictors chose to keep. The aerated showerheads and the flow restrictors achieved similar reductions in consumption, to about 3.2/3.3 litres per minute. Users rated the aerated showerheads -1 to +10, while the restrictors received ratings of -2 to -19.

Task two: distribution of technologies

Shower and bath market trends are indicative of changing user preferences and so to some extent indicate the likelihood of pro-efficiency market transformations. Task 2 reviews past, present and projected trends in baths and showers, drawing on archived market data, water company surveys, manufacturers' information, Waterwise survey results, projections were gathered from the Market Transformation Programme, industry journals and water company assumptions.

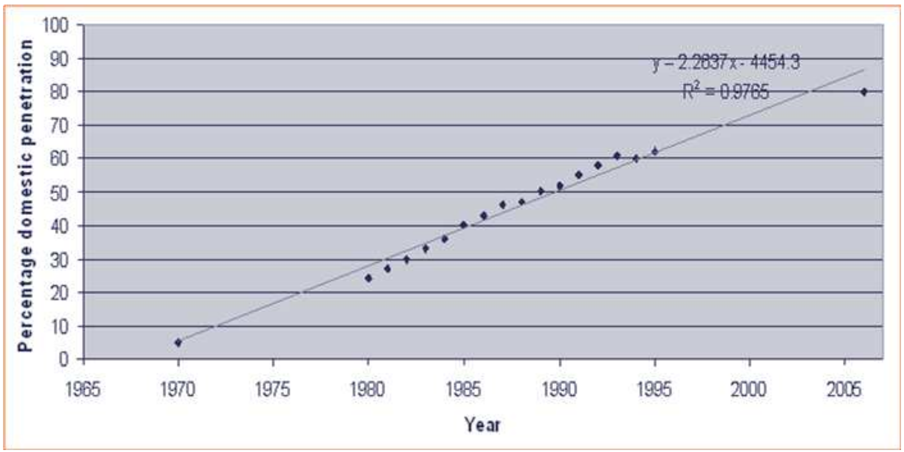
Past trends

A necessary precursor to the spread of showers was the introduction of domestic plumbing and hot water systems to UK households (Hand *et al*. 2006). The supply of hot and cold water inside homes is a relatively new concept. Prior to the 1930s, middle-class family homes were not normally fitted with hot/cold water systems, and it wasn't until the 1950s that hot/cold water supply became the norm in working-class homes. The introduction of direct electricity supply to homes from the 1940s to 60s allowed for the rise of domestic water heating systems.

The privacy afforded by direct water supply and the convenience of on-demand hot water played a large role in transforming showering from a novel, therapeutic practice performed in public baths to a frequent, private and necessary component of maintaining personal hygiene.

Ownership of showers has been steadily rising since the mid-1970s. The industry attributes this growth to marketing programmes that have emphasised showers as time-savers (BRA 1980 - 1995), and to growing preferences for daily washing. Increases in disposable income have partly contributed to the installation of showers in existing homes, whilst the development of new homes may have also helped expand the market since showers have quickly become standard and expected. Shower penetration has therefore risen rapidly, from about 5 percent of households in 1970 to approximately 80 percent today (figure 7).[2]

FIGURE 7. Penetration of showers in households, 1970-2006, and projection to 2010 (based on archived BRA data).



Shower sales began to overtake bath sales in the 1980s (figure 8). This takeover, however, should not be interpreted to mean that consumers' preferences shifted from baths to showers since the majority of showers in the UK are installed over baths. A study done through the MTP estimated that 80 percent of showers were located over baths and that an estimated 67 percent of households had showers. Taken

[2] Figure 7 is based on archived industry reports from the Business and Research Associates for 1970 and 1980-1995, and a best estimate for 2006 based on industry and water company literature. A linear trend line of 1st order gives an estimated cumulative growth in penetration of 2.3 percent per year.

together, it was then estimated that 54 percent of all households had a shower over a bath. A survey carried out by Roman Showers in 2005 (figure 9) indicated a slightly higher figure for showers over baths, approximately 67 percent of homes (Roman Showers 2005).

FIGURE 8. Unit sales of baths and showers, 1981 -1993 (based on archived BRA data).

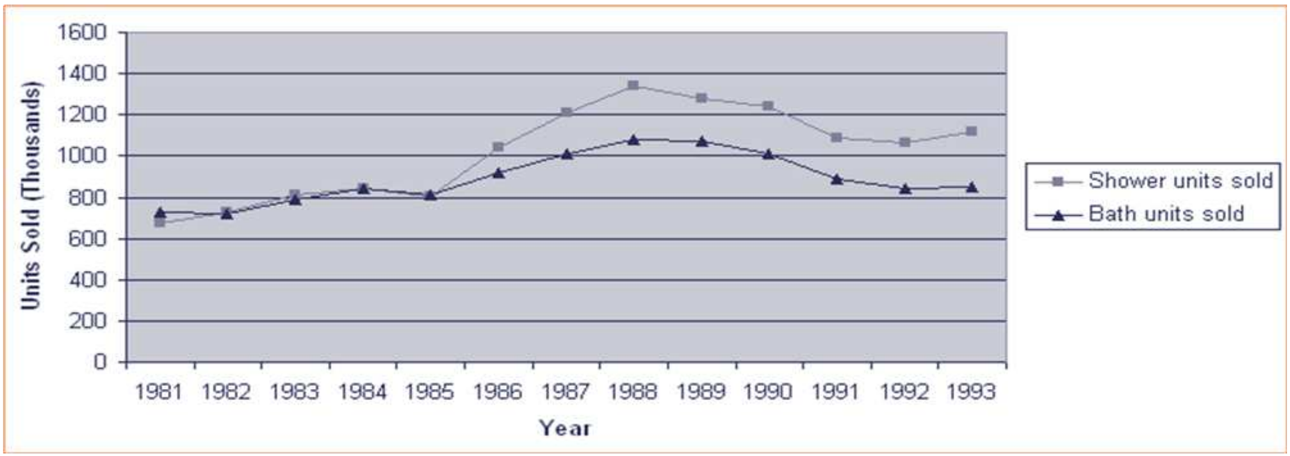
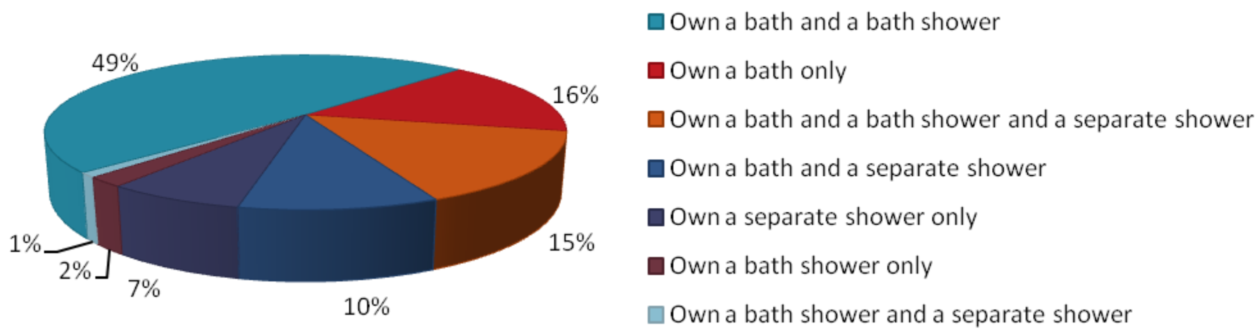
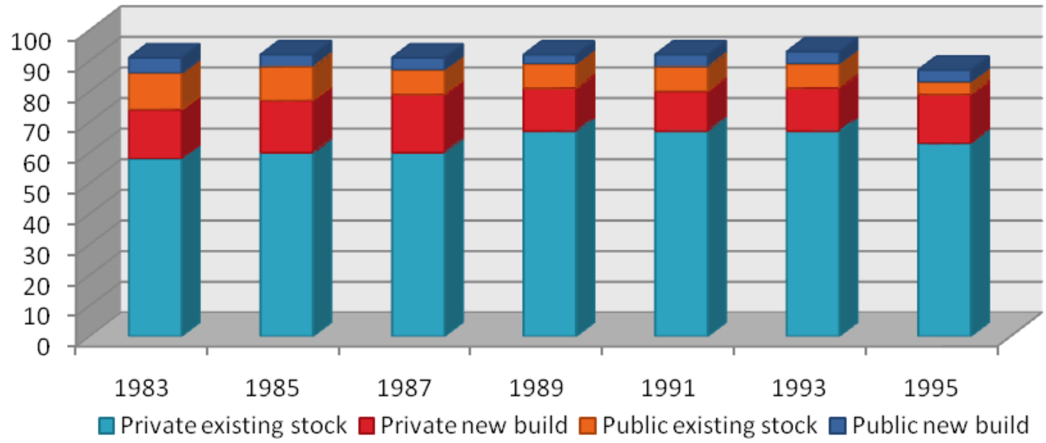


FIGURE 9. Bath and shower ownership by type (Roman Showers (2005) market survey; base 1,271). Note: "Own a bath shower only" *(sic)*



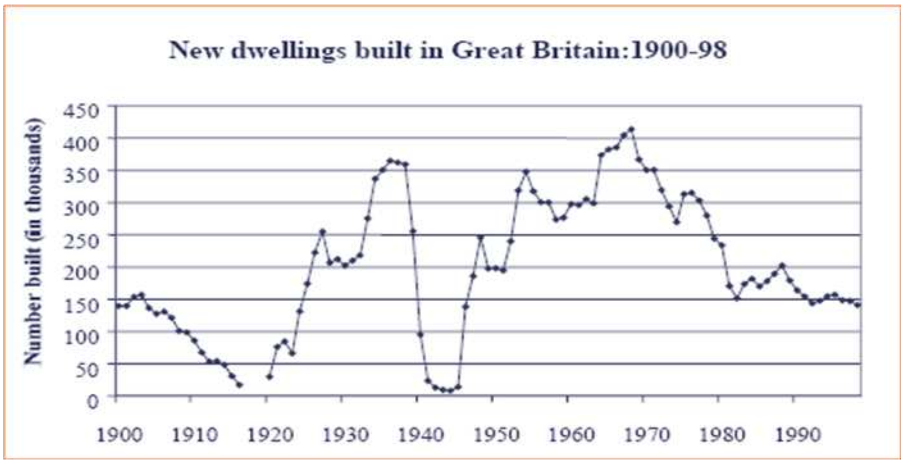
Market data for 1983-1995 also indicates that shower sales were dominated by installations for existing homes (figure 10), suggesting ease of retrofit. The data also show a relatively constant ratio of 7:3 existing to new build in shower purchases. This sales pattern is not unique to showers; the overall market share for bathroom equipment, which includes showers, sanitary ware, accessories, baths and spas, was of similar distribution in 2003 (21 percent new housing, 71 percent home improvement and 8 percent commercial) (MSI (1998 - 2004)), however it must be noted that these figures reflect much more recent market figures.

FIGURE 10. Percentage shower sales by housing sector, 1983-1995 (archived BRA data).



A comparison of bath and shower sales (figure 8) and new build development (figure 11) suggests that the rate in new build may have influenced the rate of take-up of showers, despite bath/shower sales for new build being relatively small. The net increase of bath/shower sales from 1985 onwards seems to roughly match the acceleration in housing stock growth over the same period. It may be that the growth in new build may be responsible for the growth in shower/bath sales, and/or that demand for standalone showers is greater for new build than for retrofit of existing stock. This latter hypothesis would then suggest a growth in the number of bathrooms that contain a shower only. Neither of these hypotheses can be verified, however, since adequate data is not available, particularly in regards to multiple bathrooms per property.

FIGURE 11. Number of houses built, in thousands, 1900- 1990 (Hicks and Allen 1999).



While sales of showers fluctuated during the 1980s and 90s, the proportion of sales of each type of shower remained relatively stable. Between 1983 and 1995, electric showers accounted for about 58 percent of unit sales (figure 12).[3] Between 1998 and 2003, electric showers accounted for about 54 percent of market value (figure 13). Unfortunately, the data sets used for figures 11 and 12 are not consistent with definitions or measurement, and so it is difficult to draw any conclusions across the years 1983-2003.

[3] Data categories are not clearly defined in the BRA reports. It is assumed in that 'bath/shower mixers' refers to older models of showers that retrofit into existing plumbing and make no use of mixing valves; 'shower mixing valves' are taken to mean those with TMVs.

FIGURE 12. Unit sales by shower type, 1983-1995 (archived BRA data).

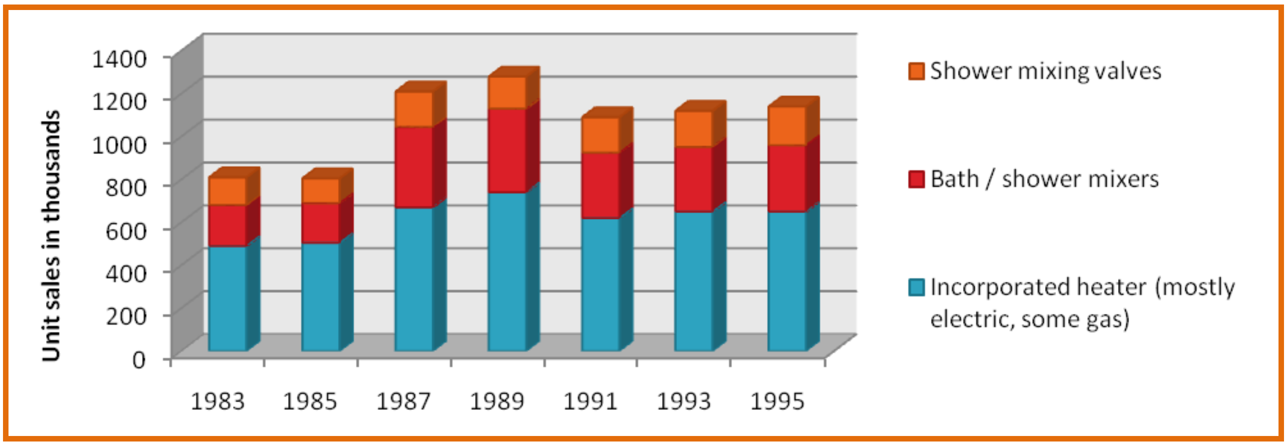
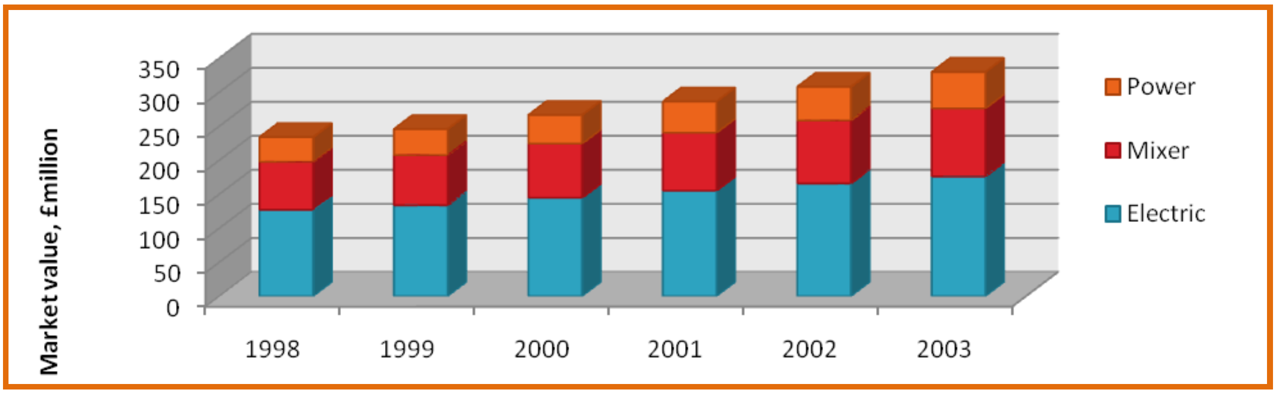


FIGURE 13. Market value by type, 1998-2003 (archived MSI data).



Discussion

The rapid uptake of showers is divided between two broad categories; mixer showers and electric, the definition between the two being that electric showers operate relatively independently from household plumbing at low pressures and generating their own hot water supply. Mixer showers on the other hand operate at higher pressures and hence flow rates, and use the hot water supply system of the home. The further distinction between bath mixers (not explicitly defined in data source, but assumed to be attachments to bath taps) and power mixers (a standard mixer with an additional pump for added water pressure) can be ignored when considering retrofit compatibility. Figures 12 and 13 indicate that electric showers have represented slightly more than 50% of the market, which is most likely due to the majority of shower installations being in existing homes where water pressure and reliable hot water supplies are limited. This pattern may not be the case in the future, as the plumbing and water pressure standards increase and allow for mixer shower installation.

Present distribution

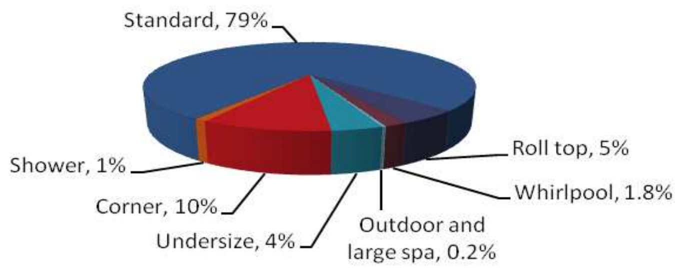
Baths

Data sets indicate that between 80 and 90 percent of homes have baths (table 8). The majority of baths are standard models, with corner, roll top and undersize models making of the remainder (figure 14). Whirlpools, outdoor and large spa models account for about 2 percent of baths.

TABLE 8. Bath and shower penetration in UK households.[4]

Source	Year	Baths, percent	Year	Showers, percent
Essex and Suffolk Water (2008)		91.0		90.8
MTP (2008)	2007	96.0	2006	67.9
Northumbrian Water (2008)		91.0 (Unmeasured and existing homes) 94.7 (New homes)		82.4 (Unmeasured homes) 89.4 (Existing and new homes)
Three Valleys Water (2008)		88.0		95.0
Waterwise (2008)		79.0[5]		85.0
WRc (2005)		88.1		85.2

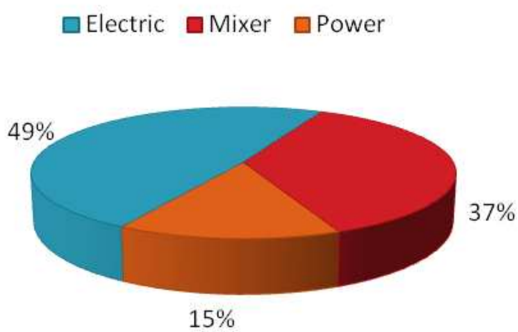
FIGURE 14. Distribution of bath types (MTP 2008a).



Showers

Penetration of showers varies more than baths; with water companies reporting a range of 68 to 95 percent penetration (table 8). Data on the distribution of shower types across the nation is difficult to gather, particularly because reporting is not uniform in terms of definitions of property type and shower type. The MTP (2008b) estimates that approximately half of homes have electric showers, and the majority of the remainder own mixer showers (figure 15). Power showers account for about 15 percent of models.

FIGURE 15. Distribution of shower types (MTP 2008b).



Market projections

There are several factors that affect the shower and bath markets, particularly the influence of new build and DIY or assisted retrofits.

Projected growth in the new build sector (e.g. government's projection of 1.2 million new homes in the south east by 2016) was expected to stimulate shower and bath markets (MTP 2008b), however the current slowing of the housing sector may make these projects invalid.

[4] Figures from water companies were obtained from company draft Water Resources Management Plans, and so are applicable only within the company area and not necessarily representative of the entire UK population.
[5] In the Waterwise survey, the low figure for penetration of baths may be due to the 'not used' response being assumed to mean 'not present'.

Several factors will influence the types of showers/baths that are fitted to these new homes:

- Changes to building regulations, which may then encourage take-up of efficient showers in order to meet whole-building water use requirements;
- Consumer preferences for en-suite bathrooms, which may lead to the installation of 2+ showers in single properties;
- Consumer preferences for high specification products, which usually are high consumption such as power showers and 'wet rooms';
- A trend toward larger shower enclosures that require higher flow rates and greater flow spreads; and,
- The growth in high pressure domestic hot/cold water supplies will encourage increased uptake of mixer showers.

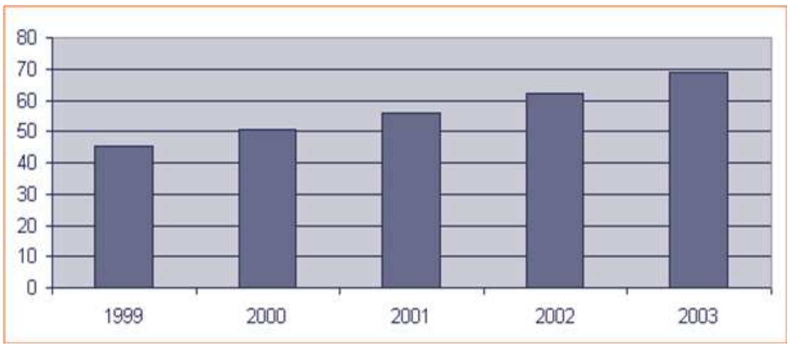
In existing homes, the retrofit of showers/baths will be influenced by:

- The replacement of baths with shower enclosures by owners of smaller properties who wish to conserve space, or by those whose preference is for showering,
- Shower marketing campaigns led by DIY televisions programmes and lifestyle magazines, which are raising awareness of the types of showers available, and
- Further penetration into homes that do not yet have showers.

Baths

The role of baths seems to be changing (MTP 2008b; MTP 2006b; BMA 2009).Whereas baths used to be used frequently for practical purposes; they now seem to be used less frequently and more for 'luxury' purposes. This change in roles has led to the increased popularity of showers, and also to the development of a new market in novelty/luxury units such as spas and whirlpool units (figure 16).

FIGURE 16. UK market value (£million) for whirlpool baths, airbaths (Jacuzzi style) and spas, 1999-2003.



The MTP projects an overall decrease in ownership of baths, from 96 percent in 2007 to 91 percent in 2020. Corner and standard baths are projected to decrease in proportion, with shower baths increasing (table 9). Though the MTP projects that whirpool baths will remains stable as a proportion, both the MSI as well as the BMA project an increase (MSI(1998 - 2004); BMA (2009)).

TABLE 9. Projections for bath distribution under business as usual conditions, 2008 - 2020 (MTP 2008a).

	Reference					
	Undersize	Corner	Shower	Standard	Rolltop	Whirlpool
2008	6.0	10.0	4.0	74.5	4.0	1.5
2009	6.0	10.0	4.0	74.5	4.0	1.5
2010	6.0	10.0	4.0	74.5	4.0	1.5
2011	6.0	9.0	5.0	74.5	4.0	1.5
2012	6.0	9.0	5.0	74.5	4.0	1.5
2013	6.0	9.0	5.0	74.5	4.0	1.5
2014	6.0	9.0	5.0	74.5	4.0	1.5
2015	6.0	9.0	5.0	74.5	4.0	1.5
2016	6.0	9.0	6.0	73.5	4.0	1.5
2017	6.0	9.0	6.0	73.5	4.0	1.5
2018	6.0	9.0	6.0	73.5	4.0	1.5
2019	6.0	9.0	6.0	73.5	4.0	1.5
2020	6.0	9.0	6.0	73.5	4.0	1.5

Showers

The MTP has estimated that over the next twenty-five years, ownership of showers is projected to increase from a current estimate of 40 percent to 50 percent for mixer showers, and from 38 percent to 42 percent for electric showers (MTP 2008b). The absolute values for ownership by shower type are not consistent with estimates made in figure 15; however MTP projections still serve as a useful means of discussing expected trends and ratios of ownership. The ratio of mixer to electric is expected to remain relatively constant due to the restrictions of plumbing systems (outlined earlier). Within the electric shower category, models that are 7.0-7.9 kW and 8.0-8.9 kW are expected to decrease, while those that are 9.0+ kW are expected in increase.

The trend that will have the most significant impact on water demand will be the projected rise in ownership of power/separately pumped showers relative to mixer showers (table 10). Water companies have therefore predicted a growth in the proportion of household water consumption attributed to personal washing.

TABLE 10. Projections for mixer shower distribution under business as usual conditions, 2008 - 2020 (MTP 2008b).

	Ref				
	Mixer	Mixer with Integral Pump	Separate Pump	Mixer - Pressurised	Bath/Shower Mixer
2008	42.6	18.2	10.4	20.6	8.3
2009	43.2	17.6	10.4	20.6	8.3
2010	43.7	17.0	10.5	20.6	8.3
2011	44.2	16.4	10.5	20.6	8.3
2012	44.7	15.9	10.6	20.6	8.3
2013	44.9	15.5	10.6	20.8	8.3
2014	45.0	15.2	10.6	21.0	8.3
2015	45.0	14.9	10.6	21.2	8.3
2016	45.1	14.6	10.6	21.4	8.3
2017	45.2	14.3	10.6	21.6	8.3
2018	45.3	14.1	10.6	21.8	8.3
2019	45.3	13.8	10.6	22.0	8.3
2020	45.4	13.5	10.6	22.2	8.3

Task three: attitudes and behaviours

The volume of water consumed per person is a result of the routines in which users engage in as well as the effect of the technology that allows for this use (Sharp 2006). For example, the volume of water attributed to showering is influenced by the duration of showers as well as the frequency of showering (both user routines), and the flow rate delivered by the shower system (the technology).

Based on this observation, Sharp classifies water efficiency programmes into two distinct categories: 1) those that aim to change the behavioural routines of the user (e.g. promotion of shorter showers), and 2) those that hold routines as constant and instead introduce water efficient technologies (e.g. installation of aerated showerheads).

Task Three builds on this distinction, whilst introducing theory on behaviour-technology interactions (briefly outlined earlier). In particular, Task Three explores how to move beyond holding behaviour constant whilst superimposing new technologies. Instead, literature will be reviewed with an aim to describe the dynamics between user preferences, behaviour and technology.

Evidence from academic, government, and independent research

A substantial amount of social research has been undertaken with regard to water use, but much less research has looked specifically at bathroom use or at showering / bathing. We summarise published evidence below.

2009 Waterwise East Survey

In 2008, Waterwise East commissioned a Savills / YouGov to estimate the current levels of ownership of water efficient appliances and willingness to pay for homes with water efficient devices. The questionnaire assessed the reported ownership of water efficient showers and found that 45% of those who had purchased a new home in the past 6 months reported owning what they identified as a water efficient shower, and 35% in those that had not recently purchased a new home (Waterwise 2009).

2007 Waterwise

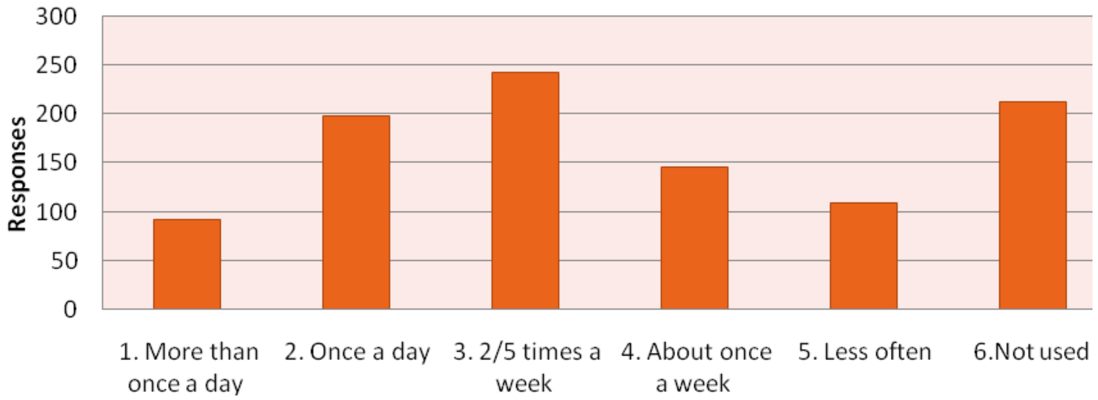
In 2007, Waterwise commissioned IPSOS/Mori to conduct a cold-calling survey of 1,001 individuals across Great Britain as part of a water saving campaign with Ariel that was encouraging people to take shorter showers. On a scale of one to ten, with ten being completely agree, participants were asked to respond to several attitudinal statements relating to showering and water use (table 11).

TABLE 11. Attitudes to showering and water use (Waterwise 2007).

Statement	Response by age			
	18-34	35-44	45-64	65+
"I like to spend time enjoying the whole shower experience, usually more time than is necessary simply to wash myself."	4.69	4.21	3.56	3.47
"The longer I spend under the shower the cleaner I feel."	4.45	3.54	3.00	3.34
"If water saving appliances or devices cost less, I would be more inclined to use them."	7.44	7.45	7.15	6.20
"Cutting down on the household's water consumption might be unhygienic."	3.98	3.93	4.4	5.09
"Cutting down on the household's water consumption will not make any difference to my quality of life."	5.91	5.93	6.00	5.95
"Saving more water in the home will not have much of an effect on global climate change."	3.81	4.48	4.71	4.37

With regard to bathing, participants were asked to indicate how many baths were taken in their household per week (figure 17).

FIGURE 17. Baths per household per week (Waterwise 2007).



The mean frequency per household per week was 3.7 baths. Assuming an occupancy average of 2.36, frequency was 0.2 baths per person per week. There was a statistically significant difference between households on a meter (3.3 baths per household per week) and households not on a meter (4 baths per household per week).

With regard to showers, it was found that there was no statistically significant difference between the frequency of showering of metered and non metered households. There was a statistically significant difference between the duration of weekend showers and the duration of weekday showers. Weekday durations were found to be 6.93 +/- 0.33 minutes while weekend durations were found to be 7.59 +/- 0.36 minutes. Assuming one shower per day, the overall mean shower duration for non-zero values was 7.11 +/- 0.34 minutes. However, it should be noted that these are self-reported values, selected from bracketed values (eg 0-5 minutes), and so absolute values are not particularly useful. However, the significant difference in weekend versus weekdays is of interest and merits further investigation.

Responses did not indicate any differences in the behaviour of men and women. There was some evidence to suggest that younger people shower for longer. Reported weekday shower durations for 18-34 year olds were compared with aged 35+ respondents; it was found that the younger group showering for 2.16 +/- 0.84 minutes longer than the older group.

2007b Defra

In 2007, British Market Research Bureau undertook for Defra a nationwide survey of public attitudes and behaviours to the environment, to inform Defra's behaviour change strategy and future policies (Defra 2007b). The survey probed into travel, waste disposal, energy efficiency and water efficiency, amongst other topics. A random, clustered, stratified sampling technique was used to collect the data and quotas were imposed for predefined socioeconomic groups.

Results from the 3,600 face-to-face interviews show, with regard to showering and bathing (table 12), that 21 percent of respondents always or very often take a bath instead of a shower, while 37 percent never choose baths. Women tended to choose baths more frequently than men, and those 65+ chose to do so more frequently than those aged 16 to 40.

TABLE 12. How often do you take a bath as opposed to a shower (Defra 2007b).

		Gender		Age		Household income	Social grade
	Total	Men	Women	16-40	65+	Less than £20,000	DE
Always/very often	21	18	23	18	26	26	27
Quite often	11	9	12	12	8	10	12
Sometimes	11	11	12	13	11	12	12
Occasionally	20	20	20	22	11	18	16
Never	37	42	33	35	44	34	34
Base: All for whom question was applicable	*3,263*	*1,559*	*1,704*	*1,389*	*599*	*1,008*	*918*

2007a Defra

Defra (2007a) commissioned Kathryn Rathouse Social Research and Consultancy to undertake a quantitative study investigating consumer attitudes to the water efficiency of bathroom fittings, including an examination into consumers' decision-making, expectations, willingness to pay and types of initiatives that might promote consumer take-up of water efficient fittings. In March 2007, eighteen questions were included in an ONS omnibus survey, which utilised a multi-stage stratified cluster sample drawn from the Postcode Address File. Interviews were carried out mainly face-to-face with 1,088 respondents all aged 16+. Findings follow:

What are the main decision-making factors by which consumers choose bathroom fittings? The study found that only 19 percent of respondents had paid or would pay attention to water efficiency when choosing showers, compared to 37 percent who would consider efficiency when choosing a WC (the study notes that interest in water efficiency across all fittings may have been over-reported). Only a very small number of respondents looked for showers, taps and WCs that actually used more water than average.

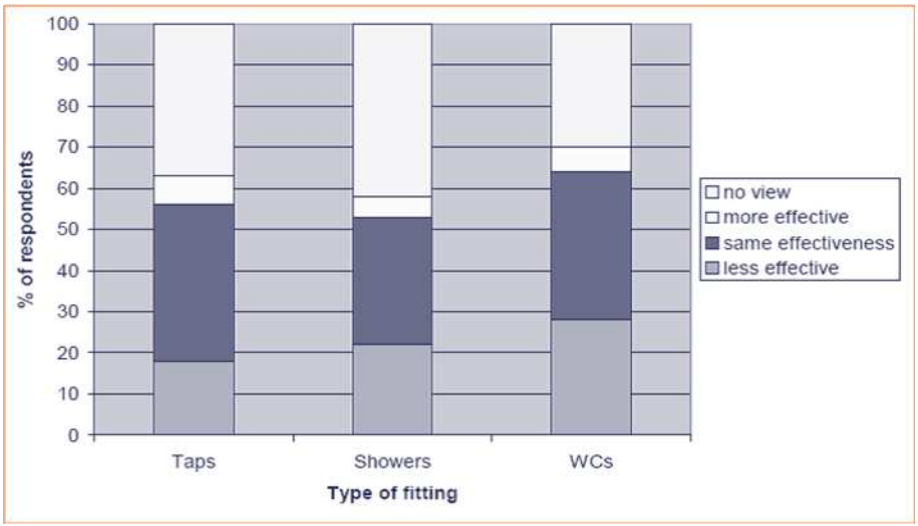
In general, including for showers, the study found that price and appearance were taken more into account than efficiency, which tended to be only one of several considerations (table 13). Respondents on water meters or those with high water charges were much more likely to pay attention to efficiency; those buying fittings from builders/plumbers merchants were also more likely to give efficiency priority than those buying from DIY stores.

TABLE 13. Factors influencing decision to purchase a bathroom fitting (Defra 2007a).

	% respondents choosing each factor		
	Basin taps	Shower	WC
Looks	72	56	61
Price	68	66	60
Ease of use	44	49	31
Effectiveness for washing or of flush	19	38	43
Ease of cleaning	27	25	29
How much water the product uses	17	21	39
Comfort	n/a	20	n/a
Came with basin/bathroom/suite	14	n/a	19
Brand	11	17	13
Other	*	*	*
Base	*567*	*561*	*559*

What are consumer expectations about water efficient bathroom fittings? Respondents (base of 1,039) were more likely to express a view about the running costs of water efficient fittings than their performance or comfort. A substantial minority held negative views about the performance of water efficient fittings; however, positive views on running costs were more widespread (figure 18). For showers, negative views were not much more common than for basin taps or WCs.

FIGURE 18. Expectations about effectiveness (Defra 2007a).



Are consumers willing to pay more for water efficient fittings? Just over 40 percent of respondents (base of 524) said that they would be willing to pay more for a water efficient shower, with approximately half of those stating a willingness to pay a premium of over 20 percent. The study notes, however, that these responses should be treated with caution because they are not entirely consistent with the finding that respondents considered price much more often than they considered water efficiency when choosing fittings. Those on water meters and those who bought fittings at high street bathroom shops were most willing to pay extra. Expectations about performance also influenced what respondents were prepared to pay.

What would promote take-up of water efficient bathroom fittings? Overall, respondents indicated a high level of support for initiatives to encourage consumers to make their bathrooms more water efficient. Initiatives that emphasised money savings were most popular among all respondents (table 14). Among those who were planning on buying fittings within the next five years, discount vouchers proved most popular. Initiatives providing information about careful water use were least popular among all respondents.

TABLE 14. Support for initiatives to promote water efficient bathroom fittings (Defra 2007a).

Initiative	% of all respondents	% of those planning to buy a fitting(s) within five years
Information on possible running cost savings	60	69
Discount voucher	55	71
Information on how much water fittings use	46	49
Information on using water carefully	39	46
Base	*1055*	*252*

The study also found that different initiatives appealed to different respondents, for example, low income respondents preferred information about savings on running costs rather than discount vouchers. Only about 10 percent of respondents stated that they would be influenced by non-financial incentives.

The study notes that findings do not give a clear indication of how effective *real* initiatives would be. Answers to hypothetical questions do not tend to predict actual behaviour reliably. Furthermore, when answering questions about initiatives respondents were not given details that could affect their impact, for example, the size of the discount.

2006 MTP

Kathryn Rathouse Social Research and Consultancy, commissioned by the Market Transformation Programme, undertook focus groups in three regions of the UK to examine consumer views of showers, focusing particularly on flow rates (MTP 2006a). Three focus groups were carried out: one in an affluent area with average water charges; another in a less affluent area with average water charges; and a third in an area with higher water charges. Sample sizes for the focus groups are too small to be projected onto the entire population, but findings nevertheless shed some light on the views of consumers:

- *Flow rate and comfort*: flow rate was seen as a key indicator of shower performance. Focus group participants had several explanations for why they believed flow to be an indicator, ranging from its (perceived) relation to the ability to wash off soaps and shampoos to the sensation of high pressure on the skin. Some participants, however, felt that pressure can often be too high and thus uncomfortable. Some also mentioned that high pressure was preferable in the morning. Participants also mentioned temperature consistency, body area covered and droplet size as key indicators, as well as shower surroundings (e.g. a warm and draught-free bathroom).
- *Flow rate and water consumption*: participants were uncertain as to whether baths or showers use more water. They were also uncertain about whether high flow showers use more than low flow showers, stating that shower duration was the key determinant of water consumption. When asked about high flow showers, some felt that a higher shower quality might lead to shorter showering durations.
- *Priority given to water consumption*: participants were divided as to whether it was important to save water by taking showers as opposed to baths or by taking short showers. Views were influenced by whether the respondent was on a meter (if so, and where charges were higher and the area less affluent, respondents gave more consideration), whether s/he was concerned about the environment (the belief that there is no point because was is perceived as abundant was widely held), whether s/he believed that showering accounts for a large percentage of their water consumption and whether s/he considered energy as well (most didn't). While there were some participants who would consider the efficiency of a shower, most did not, in part because they believed that behaviours (shower rather than bath and/or shorter showers) made water savings as opposed to water efficient showerheads. Participants also tended to prioritise comfort and effectiveness than water saving.
- *Water labels*: those who take water efficiency into account indicated that they would welcome a water efficiency label; the unconcerned indicated that a label would be disregarded and might even lead some to purchase a non-labelled product for fear of poor shower performance. Participants also felt that point-of-sale information (e.g. label or leaflet) was unconvincing, and would rather see and feel the showerheads in action. Respondents also suggested that the provision of information might not be enough to influence their purchases, that they would most be persuaded by financial incentives.

2006 Per Capita Solutions

Per Capita Solutions were commissioned by Essex and Suffolk Water to investigate shower use patterns and factors influencing use and choice, to support ESW's water resources management planning (PCS 2006). Ninety-nine face-to-face interviews were carried out within the ESW area, and an additional 299 cold-call interviews. Results follow:

- *Shower types*: the study found that electric showers (32 percent) were the most popular in ESW's area, followed by power (23 percent), hand held (20 percent), mixer storage tank (16 percent) and mixer combi boiler (8 percent).
- *Purchasing*: only 35 percent of respondents indicated that the shower(s) in their home was present upon moving in. Of the 65 percent who said that their shower was replaced after moving in, the

majority (70 percent) indicated that the shower was chosen by themselves (as opposed to a plumber).

- *Purchasing criteria*: performance and price were the most commonly cited criteria (28 and 21 percent, respectively) with water consumption ranking third (11 percent), just passing appearance (10 percent). Energy consumption (9 percent) ranked among the lowest. There was no significant difference between the response of metered and unmetered customers with respect to indicating that consumption was a criterion. The lack of a significant difference might suggest that tarrifs are too low to encourage water saving and/or that showering is not seen as a major use of water. Samples sizes are too low to draw a conclusion.
- *Water efficient showerheads*: when asked, "If you were to replace your shower, would you consider a high performance water efficient shower?" 65 percent responded positively while 22 percent didn't know and 13 percent said no. There was no significant difference between un/metered.
- *Most important purchasing criterion*: while water consumption ranks third as a commonly cited criterion, in terms of importance consumption ranks fifth with energy consumption at the bottom (table 15).

TABLE 15. Most important factor in choosing a shower (PCS 2006)

	Main bathroom	En-suite 1	En-suite 2	2nd bathroom	Other	Total	Rank
Performance	58	11	4	3	3	79	1
Other (specify)	34	3	0	0	0	37	2
Price	32	1	0	1	0	34	3
Best type for plumbing system	21	0	0	0	0	21	4
Water consumption	15	3	0	0	0	18	5
Appearance	7	2	0	0	0	9	6
Energy consumption	5	0	0	1	0	5	7

- *Winter v. summer use*: of those who have a choice between showers and baths (base of 283), 80 percent prefer to shower all round the year with no variation in seasonal use.
- *Frequency*: responses indicate that each person respondents' households had on average 4.5 showers per week and 1.4 baths, with children under five bathing (88 percent) more than showering.
- *Preference*: the majority (73 percent) of respondents (base of 328) indicated a preference for showering over bathing, with 4 percent indicating no preference. Responses did not differ between un/metered. The most popular reason cited for preferring showers was that they were quicker (78 percent); 28 percent also responded that they use less water.
- *Use*: when asked whether they ran the shower for more than one minute before entering, almost half said no, but a significant minority (36 percent) said always and another 11 percent sometimes.
- *Type*: only 7 percent of respondents homes has aerated showerheads, though 19 percent did not know whether they did or not.
- *Plumbing systems*: 30 percent of respondents could not recognise the type of system in their homes (i.e. mains fed, combi boiler or gravity fed).
- Flow rates: 175 respondents allowed the surveyor to check the flow rate of their shower. 85 percent of these showers had flow rates of less then 10 litres per minute, with the average across these showers being 6.5 litres per minute (ranging from five to eighteen).

2006 Consumer Council for Water

In 2006, CCWater commissioned a quantitative study (CCWater 2006) into water users' perceptions and needs. The project was led by MVA Consulting in association with WRc, who used face-to-face interviews with 2,006 participants. The sample was stratified to include persons living in areas that had experienced water restrictions, areas that are under water stress and areas with plentiful supply.

Important to note is that the research was undertaken during a period of drought, during which water companies and the Environment Agency were promoting water efficiency. The period was also characterised by high media attention to water company leakage and to Thames Water's proposals for a new reservoir and desalinisation plant.

With regard to bathing and showering, the quantitative study found the following:

- Of 1,992 respondents, 72 percent always or sometimes limited time spent in the shower to save water/energy; only 10 percent stated that they didn't and did not want to limit their time. Respondents in water-stretched areas were more likely to report limiting their time, particularly in areas with restrictions, as were bill-payers, older people and metered customers.

- Of 1,999 respondents, 63 percent stated that they always take a shower rather than a bath, with only 9 percent stating that they always choose a bath. Of the 1,442 who always or occasionally chose showers, 67 percent said that they did so to save water. Those on a water meter were more likely to always take a shower rather than a bath. Those aged 61+ were more likely to state that they take baths.

- Reasons given for never taking showers were habit (42 percent), preference for baths (30 percent) and that they did not want to have a shower (16 percent).

- 28 percent of respondents had a power shower in their home.

- On average, respondents believed that showering used 45 percent less water than bathing. When asked to estimate the volume of water used for a shower and for a bath, the mean for a shower was 40.13 (1,585 respondents) and for a bath 89.31 (1,560 respondents). The study notes that wide ranges were given by respondents.

- When asked whether they had water efficient showerheads in their homes, 55 percent stated that they did not, 29 percent that they did and 16 percent that they didn't know (base of 1,191). These results must be treated with caution as it is likely that some respondents may be mistaken as to whether they do/do not have water efficiency showerheads.

- Of those that stated that they did not have a water efficient showerhead (base of 1,034) in their home, the reasons given for not owning one were no need for one (12 percent), they didn't know about them (57 percent), they were concerned about performance/appearance (4 percent), cost was preventing them from purchasing one (13 percent) and that they were not applicable (10 percent). Other reasons included not thought about it, not got around to it and in rented/council accommodation.

2006 Hand, Shove and Southerton

Hand et al. (2006) attempt to explain the increasing popularity of showering, particularly why and how showering has been rountinized and standardized in the UK. They begin by pointing out that the supply of hot water in middle class homes was only achieved by the 1930s and that the widespread presence of showers in homes can only be traced back to the 1970s. Therefore, showering/bathing practices are recent developments, driven by rapid changes in standards, the penetration of technology, the evolution of the concepts of self and personal hygiene, and lifestyle routines.

Hand et al. argue that the increase in water/energy consumption attributed to showering/bathing is the result of the interaction of several components:

- *Instantaneous hot water and high pressure pumping*: the increased availability of on-demand hot water supply in the home (attributed to the rise in electrical heating systems from the 1940s onwards, which in part were promoted for their ability to supply hot water immediately) and the ability to pump this water at a high pressure (as compensation for low pressure supplies, thus paving the way for 'power showers') facilitated the rise in showering.

- *Cleanliness, freshness and fitness*: the notion of self/personal maintenance has evolved in such a way as to lead to the frequency of showering/bathing increasing. Showering was originally undertaken in communal areas where the focus was care and regeneration and in public facilities, such as hydrotherapy and military showering lines, which focussed the body as a sight for disease, social and moral disorder. With the introduction of private shower cubicles for the home, Hand et al. argue that that role of showering has now evolved to include notions of self-presentation, invigoration and continual self-renewal, all supported by a growing product base marketing these aspects. Showering is now unique from bathing in that it is considered as invigorating or as 'shock therapy' and is related to social perceptions of getting dirty, such as from sports or from a typical working day. Bathing is now considered to be a more drawn out process promoting relaxation.
- *Temporal organisation and immediacy of showering*: in line with the cleanliness, freshness and fitness component, showering is now associated also with speed and convenience in the context of the widely held belief that lifestyles have become more fast paced, with less time for 'luxuriating' in bathtubs. Showering is thus seen as a means of personal washing that affords more time, and so enables the routinization of daily showering, which has come to be a social norm.

Evidence from draft Water Resource Management Plans

In addition to the evidence presented above exists other data in the draft water resource management plans (dWRMPs) of water companies. Water companies provide data to support their plans, which describe the average contribution of baths and showers to net demand as well as project future demands. Such data are of limited use in understanding the drivers of consumption, but do allow for a discussion on variances in estimates of consumption and the role of showering/bathing in demand. It should be noted that little more than an account of water company estimates can be drawn from reviewing this data; the methods used to derive these figures vary greatly in both sample sizes and collection methods (ranging from direct monitoring to self-reported questionnaires).

Table 17 summarizes the information presented in the dWRMPs of the companies, with table 16 presenting a key to the abbreviations used. In general water company data are usually presented as percent ownership, frequency of use and volume of water per use. These variables combine to give a basic estimation of water use in terms of average contribution to demand that can either be calculated on a per property or per capita basis:

Contribution to demand = % ownership * frequency of use * volume of water per use

TABLE 16. Key for table 17.

KEY	
O	Percentage ownership in water company area
F	Frequency, i.e. uses per person (per property for Portsmouth and Southern) per day
V	Volume of water per use in litres
I-PCC	Contribution in litres to daily per person consumption in the area, NOT taking into account ownership; i.e. this figure is the actual consumption per person per day for those that own a bath, shower and/or power shower; this figure should be used in reference to the consumption contribution of baths, showers and/or power showers for those that own them
C-PCC	Contribution in litres to daily per person consumption in the area, taking into account ownership; i.e. consumption is averaged across all customers including those that may not have a bath, shower and/or power shower; this figure should be used in reference to the consumption of baths, showers and/or power showers in the area
D	Duration, i.e. length of time in the shower, in minutes
Fl	Flow rate of the shower, in litres per minute

TABLE 17. Data from the 2008 draft water resource management plans of the water companies.

Water company	BATHS					ORDINARY SHOWERS							POWER SHOWERS							Notes / other information
	O	F	V	I-PCC	C-PCC	O	F	D	Fl	V	I-PCC	C-PCC	O	F	D	Fl	V	I-PCC	C-PCC	
Anglian Water																				
Details not available in the draft Water Resource Management Plan																				
Bournemouth and West Hampshire Water																				
Company does not forecast using micro-components																				
Bristol Water																				
Unmeasured					29							19	Not distinguished from ordinary showers							Unmeasured PCC 160: 18% baths and 12% showers; measured PCC 126: 20% baths and 14% showers; meter optants 136 PCC: 19% baths and 13% showers; new build 119 PCC: 21% baths and 15% showers
Measured					25							18								
Meter optants					26							18								
New homes					25							18								
Cambridge Water																				
Company does not forecast using micro-components																				
Cholderton and District Water																				
Company does not forecast using micro-components																				
Essex and Suffolk Water																				
Unmeasured - Essex	91	0.32	88	28	26	71	0.62	6.6	5 or 10	33 or 66	20 or 41	14 or 29	19	0.62	6.6	12	79	49	9	Flow of 5 l/min is used for electric and low pressure showers and 10 l/min for high pressure showers, both of which are 'ordinary' showers; unclear how the two are taken into account separately
Unmeasured - Suffolk	88	0.31	87	27	24															
Existing - Essex	91	0.30	70	21	19															
Existing - Suffolk	82	0.32	70	22	19															
New - Essex	96	0.30	80	24	23															
New - Suffolk	95	0.32	75	24	23															
Folkestone and Dover Water																				
Unmeasured	89	0.32	88	28	25	54	1.00	5	6	30	30	16	10	1.00	5	12	60	60	6	
Measured		0.29		26	23	66	0.87				26	17	17	0.88				53	9	
Northumbrian Water																				
Unmeasured	91	0.32	88	28	26	72	0.70	6.6	5 or 10	33 or 66	23 or 46	16.63 or 33.26	10	0.70	6.6	12	79	55	6	Flow of 5 l/min is used for electric and low pressure showers and 10 l/min for high pressure showers, both of which are

Water company	BATHS					ORDINARY SHOWERS							POWER SHOWERS							Notes / other information
	O	F	V	I-PCC	C-PCC	O	F	D	Fl	V	I-PCC	C-PCC	O	F	D	Fl	V	I-PCC	C-PCC	
Existing	91		70	22	20	77		6		30 or 60	21 or 42	16.17 or 32.34	12		6		72	50	6	'ordinary' showers; unclear how the two are taken into account separately
New	95		80	26	24	69						14.49 or 28.98	20						10	
Portsmouth Water																				
Unmeasured	100	0.90*	73	66*	66*	80	2.30*			25	58*	46*	20	1.5*			67	100*	20.1*	*per property
Severn Trent Water																				
Unmeasured	93	0.80	70	56	52	82	1.19			25	30	24	No distinction is made between showers							
Measured	91	0.59	58	34	31	86	1.11				28	24								
Meter optants	93	0.55	70	38	36	82	0.83				21	17								
New	91	0.61	58	35	32	86	1.14				28	25								
South East Water																				
Details not available in the draft Water Resource Management Plan except for the below, which does not separate baths from showers:																				
Unmeasured	*Consumption*: 58 l/person/day for bathing/showering; *Frequency*: 0.67 showers and/or baths/person/day																			Overall, bathing/showering accounts for 33 percent of PCC
Measured	*Consumption*: 50 l/person/day for bathing/showering; *Frequency*: 0.67 showers and/or baths/person/day																			
South Staffordshire Water																				
Unmeasured	88	0.21	80	17	15	56	0.46			45	21	12	41	0.46			75	35	14	
Meter optants	36	0.26		21	8	71	0.26				12	8	29	0.26				20	6	
New	68	0.14		11	8	76	0.56				25	20	24	0.56				42	10	
South West Water																				
Unmeasured	93	0.10	80	8	8	75	0.64	8	5	40	26	19	11	0.64	8	15	120	77	8	*assumed to be slightly less for measured homes
Measured	92	0.08	80	6	6	80	0.59	*		36	21	17	10	0.59	*		111	65	6	
Southern Water																				
Unmeasured	88	0.95*	73	69*	61*	85	1.46*			26	38*	32*	No distinction is made between shower types							*per property; baths account for 16.5 percent of PCC and showers for 8.6 percent
Sutton and East Surrey Water																				
Across supply area	96	0.33	73	24	23	56	0.50	4	9	36	18	10	36	0.33	4	15	60	20	7	Assumes 1 shower/bath per person per day with proportional split between baths, ordinary showers and power showers

Water company	BATHS					ORDINARY SHOWERS							POWER SHOWERS							Notes / other information
	O	F	V	I-PCC	C-PCC	O	F	D	Fl	V	I-PCC	C-PCC	O	F	D	Fl	V	I-PCC	C-PCC	
Tendring Hundred Water																				
Unmeasured	38	1.10	80	88	33	70	1.25	5	7	35	44	31	14	1.25	5	9	45	56	8	
Measured	29			88	26		1.20				42	29	19	1.20				54	10	
Thames Water																				
In London and the Thames Valley, baths account for 12 percent of PCC; in London power showers account for 5 percent and in the Valley for 6 percent; ordinary showers account for 25 percent in London and 21 percent in the Valley																				
Unmeasured	n/a	*	80			n/a	*	8	6	65				*	8	12	120			*model assumes that all people use either/both a bath and a shower and the proportionate split between the two is provided by the frequency value. An explicit value for ownership or usage is therefore not used. Baths/showers are treated as proportions of cleansing events during a week. Overall frequency is 0.82 per person per week for unmeasured customers and 0.87 for measured.
Measured																	116			
Three Valleys Water																				
Across supply area	90	0.30	80	24	22	73	0.60	8	6	48	29	21	24	0.60	8	12	96	58	14	
United Utilities Water																				
Unmeasured					26							17	No distinction is made between showers							Overall, bathing accounts for 17 percent of PCC while showering accounts for 12 percent.
Measured					13							18								
Weighted average					23							17								
Wessex Water																				
Overall, baths account for 24 percent (32 litres per person per day) of PCC while showers account for 29 percent (39 litres per person per day																				
Yorkshire Water																				
Details not available in the draft Water Resource Management Plan																				

Evidence from WRc Identiflow data

WRc's Identiflow system[6] is capable of quantifying microcomponent consumption. Monitoring undertaken for six to more than twenty-eight days during different times of the year in 447 households demonstrated that bathing and showering events were drivers of daily peak demand (table 18) (WRc 2005). Data on frequency of use (figure 19) and volume per use (figure 20) were also obtained for baths and showers.

TABLE 18. Results from Identiflow monitoring of 447 households (WRc2005).

Device	% ownership	Uses per property per day	Litres per use	Household consumption (litres per property per day)[2]	% of total consumption
Toilet	100	11.52	9.4	108.29 (2.52)	29.2
Internal tap	100	37.9	2.3	87.17 (2.08)	23.5
Bath	88.1	0.95	73.3	61.35 (2.95)	16.5
Washing machine	93.7	0.81	61	46.30 (1.63)	12.5
Shower	85.2	1.46	25.7	31.97 (1.61)	8.6
External tap	65.2	0.89	46.7	27.10 (5.30)	7.3
Dishwasher	37.0	0.71	21.3	5.60 (0.69)	1.5
Unknown	19.2	0.53	20.4	2.08 (1.90)	0.6
Water softener[1]	1.6	0.39	182.5	1.14 (2.88)	0.3

1 - Eight households in the sample used a water softener. One property was visited twice in the sample.
2 - The standard error of mean is shown in parentheses. This is a typical difference between the mean based on the sample and the true unknown mean over all households.

FIGURE 19. Frequency of use of baths and showers (per household per day) (WRc 2005).

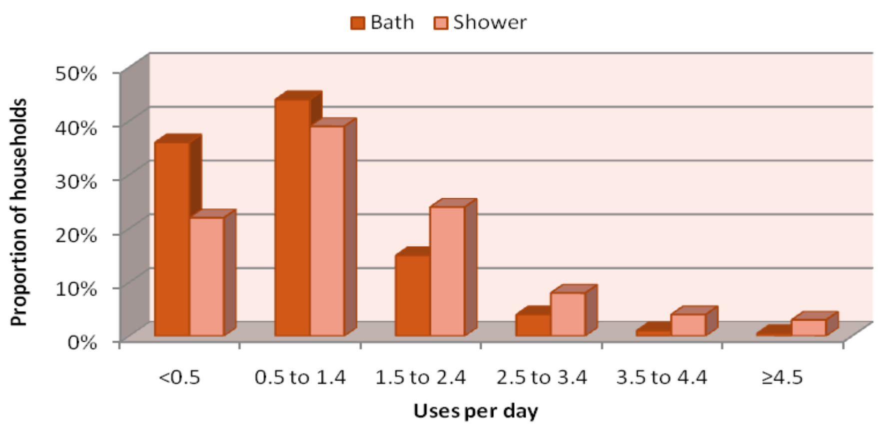
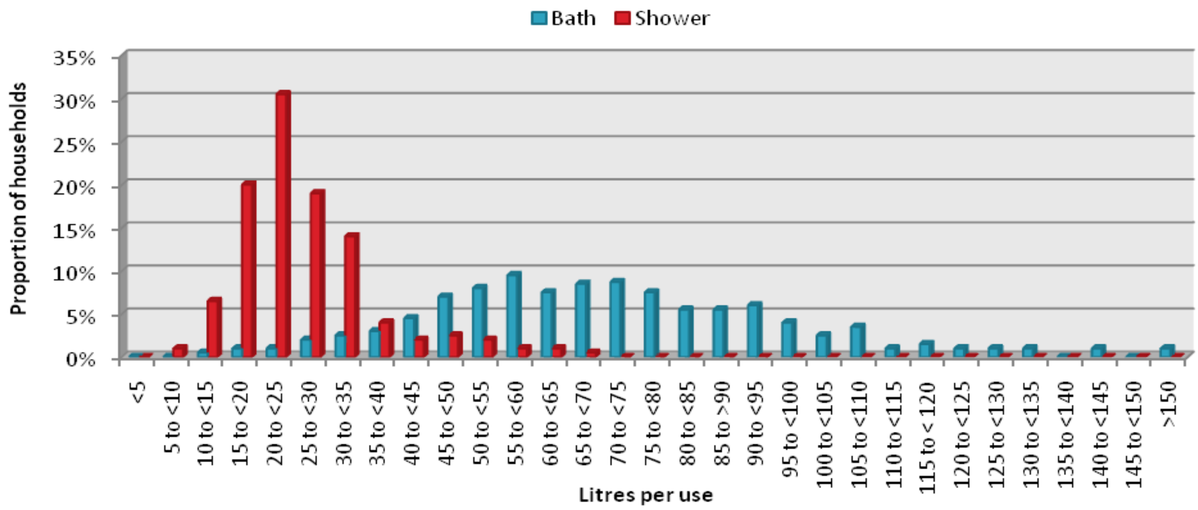


FIGURE 20. Volume used per bath/showers (WRc 2005).

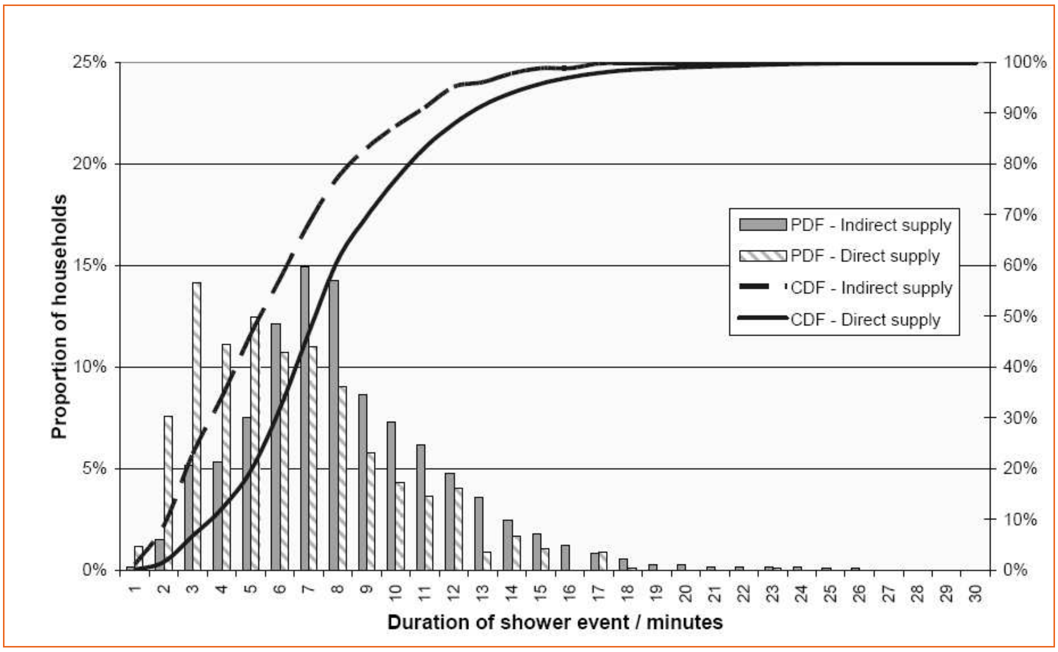


[6] For more information, go http://www.wrcplc.co.uk/pdf/Identiflowflyer07.pdf.

WRc carried out another Identiflow study in 2007 for United Utilities, this time focussing specifically on shower usage patterns (WRc 2007). Data was captured for 311 properties and analysed for flow rates, durations, volume per uses, frequencies, any relationships between variables and whether plumbing type impacted on frequency.

As discussed in Task 1, hot water can be delivered to mixer showers through direct and indirect water heating systems. It was found that use volume and duration were significantly different between direct and indirect supplies[7] (figure 21); those with indirect supplies showered for longer than those with direct supplies. Upon further investigation, it was determined that this difference was due the refilling of the water tank in indirect supplies, which biased results. Therefore it would be inaccurate to conclude that the supply method affects user behaviour based on this data.

FIGURE 21. Shower durations by supply type (WRc 2007). PDF = Probability Density Function (units on right hand side y axis), CDF=cumulative density function (units on left-hand side axis)



Data from a subset of thirty-four properties (the rest were excluded due to issues with data quality) were analysed to determine the relationship between shower flow rates and durations (figure 22). Data points for each property were averaged and then linear interpolation was applied in order examine relationships. It was found there is an inverse relationship between shower flow rate and duration (figure 23); higher flow rates have lower mean durations. This study was, however, limited by the low sample size.

[7] See Task 1 for a description of

FIGURE 22. Original data on mean shower flow rates and shower durations (WRc 2007).

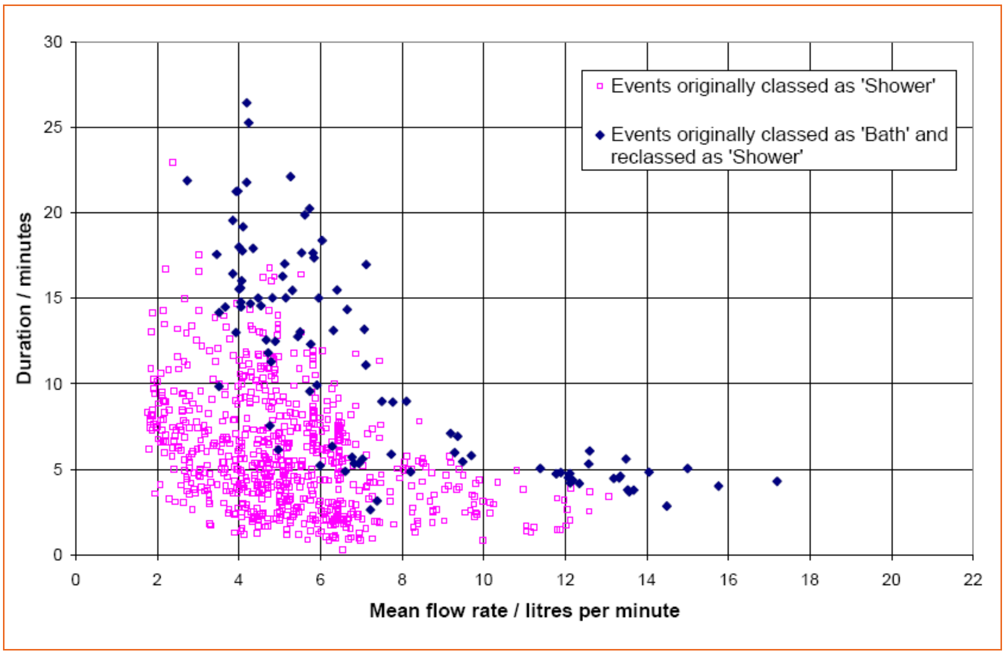
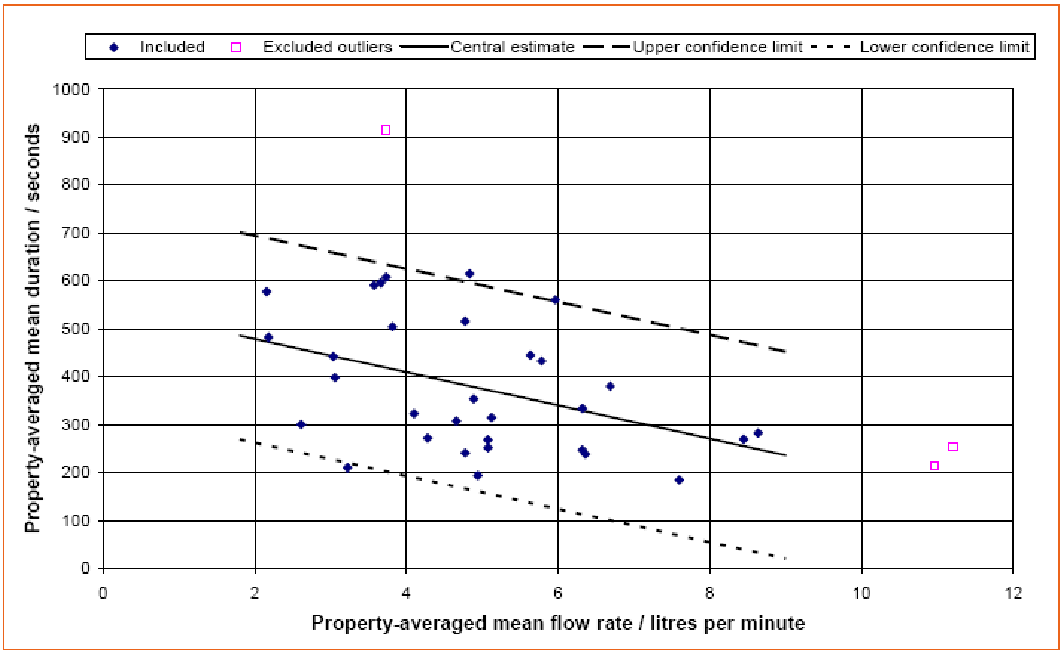
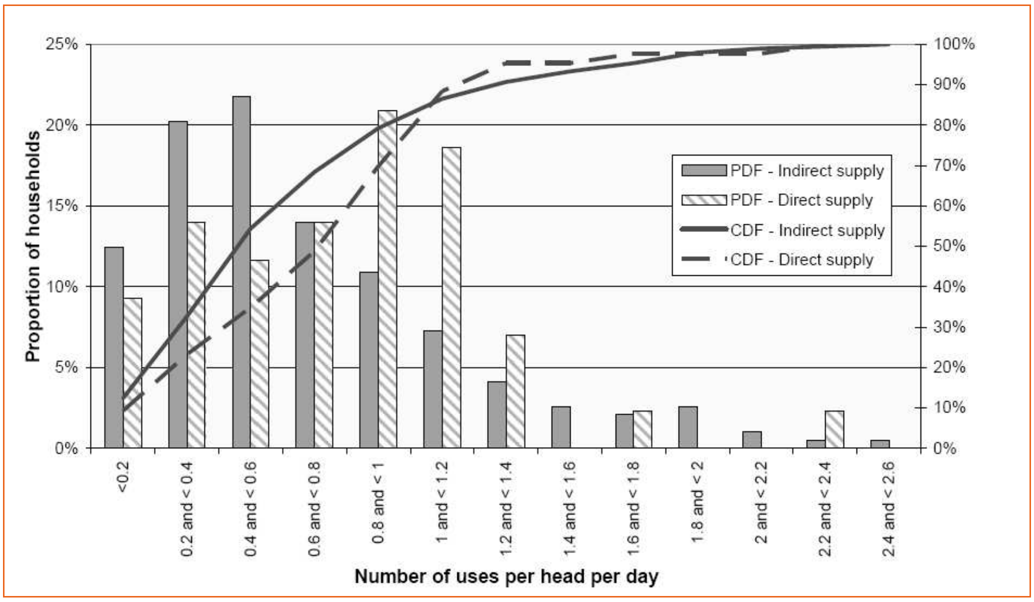


FIGURE 23. Linear regression applied to property duration and flow means (WRc 2007).



With regard to frequencies of use, the study found that the households showered, on average, 1.45 times per day. Common use values were grouped between 0.5 and 2.5 showers a day. But it was also found that the nature of the plumbing system (i.e. direct or indirect) resulted in a significant effect on the mean (figure 24). It was found that this difference was likely a result of occupancy. Households with indirect supply were found to have an average occupancy of 2.67, whereas directly supplied households had an average occupancy of 2.28.

FIGURE 24. Showering frequency by direct and indirect plumbing type (WRc 2007).



Analysis of data from direct supply households (figure 25) also revealed that there was a significant positive relationship between volumes per use and flow rates (figure 26); however, it should be noted that this difference is likely to be due to a biased 'tail' for flow rate, due to storage tanks refilling in indirect supply systems. The decision was therefore made to focus analysis on directly fed systems only.

FIGURE 25. Mean flow against volume for direct supply systems (WRc 2007).

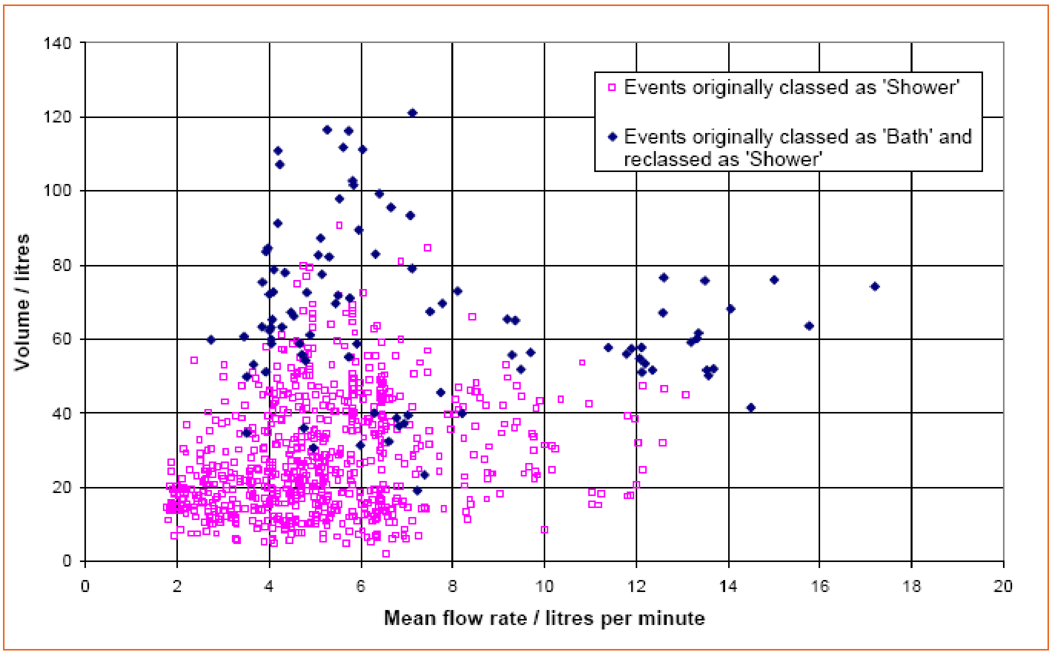
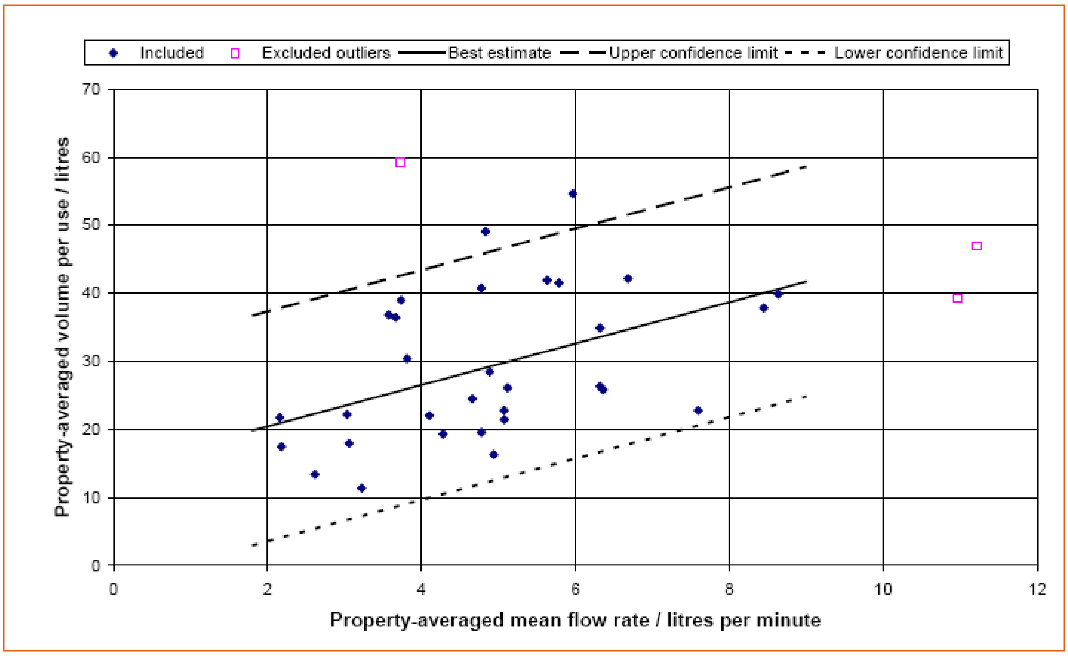


FIGURE 26. Linear interpolation applied to mean flow rates and volumes per use (WRc 2007).



Discussion

The review of evidence in this report is intended to present a clear picture of the role of personal bathing in domestic water and energy consumption, as well as to assess possible reductions in the consumption of each through technology retrofits, market transformation, and behavioural change.

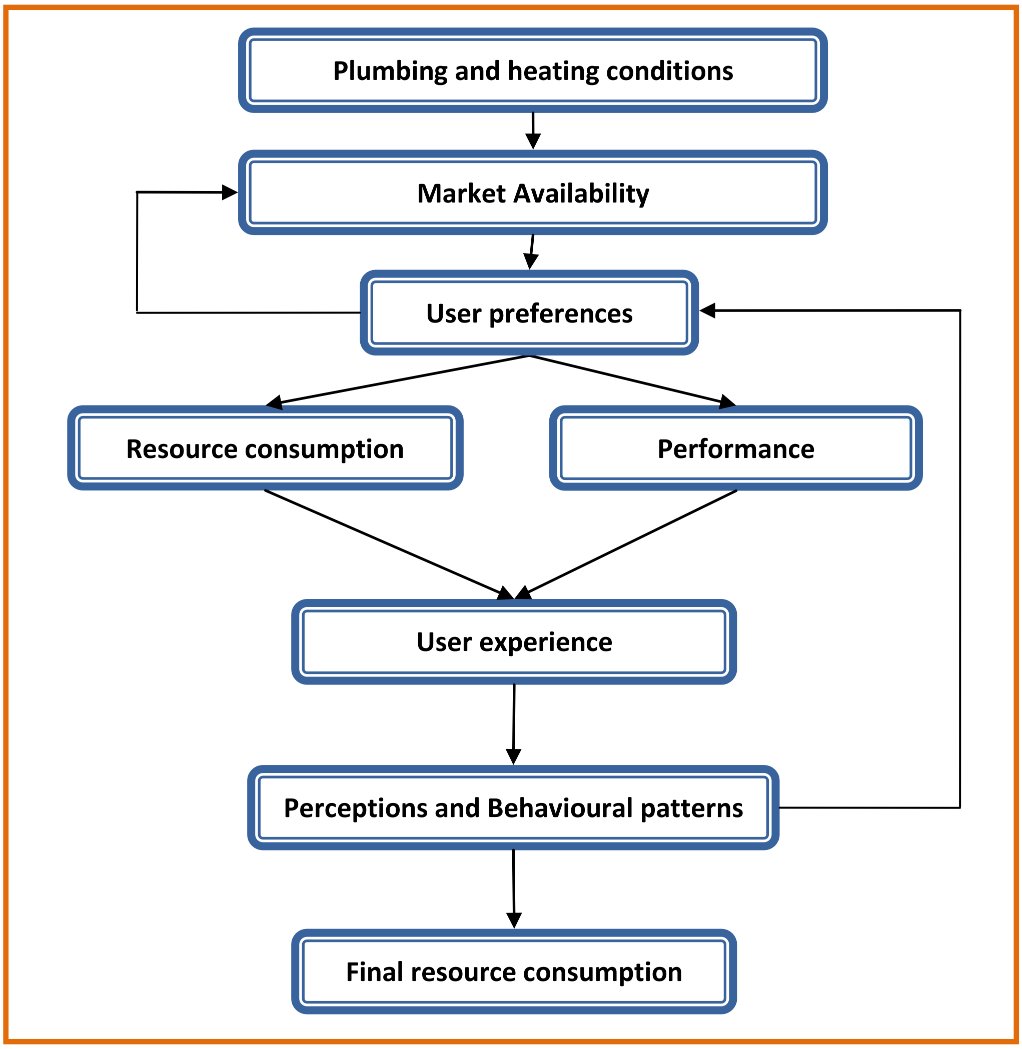
Retrofits

The rapid spread of showering has resulted in a market largely dependent on retrofit and replacement, rather than new build installations. Electric showers represent the largest portion of this market, presumably due to their compatibility with most plumbing systems, both in terms of pressure and hot water supply (See Task 2: Compatibility). In addition, the dominance of retrofit in shower markets appears to have driven shower-over bath installations as most common. This may change in the future as baths become less of a necessity and more of a luxury in the eyes of consumers. However, this mix of shower types and associated plumbing means there is no one size fits all for retrofits and that consumers are restricted by their plumbing systems in the shower technologies they can install. For those using electric showers (already with low flows), there may be little or no room for improving water efficiency. For those planning to replace a bath with a shower, water pressure and hot water delivery methods will affect a choice between electric and mixer showers, which in turn will affect the degree to which water, energy and carbon consumption might reasonably be assumed to be reduced (due to the heavy carbon weighting and low flow rates of electric showers).

Where they are able to choose bathroom fittings, individuals are driven by criteria of “performance” (likely to be equated with flow rates), appearance, and cost. These aspirations are particularly strong in showers and baths, as marketing and social research indicate that fittings which consume large volumes of water have a social and economic status attached. When presented with the environmental benefits of reduced water consumption, respondents have been receptive, but this should be taken in the context of all other aspirational aspects being satisfied (performance, appearance, price). Given this order of preferences, there is a risk that the uptake of water efficient showerheads will be extremely limited if confidence in performance is low, which may currently be likely given the association between performance and flow rates. Research which investigated attitudes to efficient appliances revealed a wide-spread awareness of the potential economic benefits due to lowered operating costs and a substantial minority who were willing to pay more for an efficient appliance. However, a substantial minority also raised concern over the performance of efficient devices. This concern over performance as well as a preference for price and appearance should therefore be the main aspects addressed in campaigns to encourage the up-take of water-efficient showers. Incentives for encouraging up-take of efficient showers have been explored with customers and have revealed a preference for economic incentives such as discounts on products, as well as information on savings in utility bills.

In addition, performance may to some degree affect the way in which technology is used, in particular there is a risk of individuals increasing shower times or selected temperatures in order to compensate for a perceived under-performance of showers. The potential for retrofits to reduce water and energy consumption therefore hinges on designing technology which meetings individual’s standards of performance. This will contribute to the gradual separation of flow rates and performance in the attitudes of shower users, expand the market for water efficient goods, and reduce the risk of altered behaviour to compensate for poor performance.

FIGURE 27. Proposed model of retrofit process for showers.



Market transformation

Under a business as usual scenario, it is speculated by the MTP that the relative market share of electric to mixer showers will remain constant, but that flow rates in each will increase with improved plumbing and the further marketing of "power" (separately pumped) showers. This has been a sufficiently substantiated claim for water companies to plan for increased consumption due to showers in their demand projections. The future of baths and their contribution to water demand is more uncertain; MTP reports conflict with industry-based reports on the future role of baths, the prior expecting a fall in luxury items such as Whilrpools and Spas, the latter expecting a rise based on past sales data. What does seem apparent is that baths will begin to play a secondary role in personal washing in the future, serving as a means of recreation and relaxation, rather than a means of washing.

If a market transformation towards efficient goods is to be achieved, the association between performance and flow rates must be broken, which in turn requires a better understanding of performance indicators and a development of minimum performance standard for showers to ensure that performance is not compromised by reduced flow rates. A reciprocal relationship exists between the market availability of the product, customer perceptions and experiences of the product, and subsequent demand. Neither the market nor customer attitudes can be addressed separately; the status quo of customers lacking awareness and confidence in efficient fixtures due to limited availability and lack of information whilst there being limited availability due to a lack of customer awareness and confidence is one that must be addressed through informed design, creative marketing, and public information to develop confidence. As discussed, efficient product design must hold performance as a premium, followed by appearance and price. Marketing in turn may need to emphasise water efficiency as a consequence of good design rather than as the principle selling point; so for instance a shower head which aerates water may be better sold as a "luxury" good, with "optimised" or "high tech" flow patterns, rather than a "low flow shower head".

In supporting this transformation, private marketing alone may not be sufficient. Should universally accepted standards in shower performance be enforced, alongside standardised labelling of water consumption in shower heads, consumer awareness and confidence will increase.

Behavioural and attitudinal change

Personal washing patterns have changed significantly over the past 40 years, primarily due to the rapid growth in shower ownership over this period. Limited data exists concerning what these patterns actually are, but there is evidence that baths and showers and now taking on distinct roles. Showers have come to be seen as a component of the daily routine due to their time saving potential, associated with cleanliness and invigoration. Baths on the other hand are increasingly seen as time consuming and a leisure activity, associated with relaxation and indulgence. Beyond this basic distinction, evidence to date suggests a high variance in average bath and shower frequencies, and shower durations, rendering any discussion of "average" figures difficult to interpret with any meaning.

What is required is the further development of evidence for the drivers of behaviour; what makes people shower more or less frequently and for how long? How does shower and bath use interact in the home? There is currently limited data on the impact of independent variables such as demographics (age, gender and income) and technology (flow rates, heating systems, shower design) on dependent variables of shower duration and frequency, as well as a limited discussion on the effects of weekly and seasonal timing of showers. Waterwise data showed that shower times for respondents aged 18-24 were longer by a statistically significant margin of approximately 2 minutes, but showed little difference between genders. There was also a reported increase in shower times during weekend of approximately 0.60 minutes. This increase in time during weekends should be taken into consideration alongside a reduction in average frequency; due to respondents favouring a bath at weekend (should it be present). This again tends to confirm the distinct role baths and showers are beginning to play in washing routines, in which baths are increasingly seen as a luxury experience rather than for personal washing. However, data was in the format of self-reported estimates based on the selection of bracketed values (e.g. 0-5 mins, 5-10mins) and so must be assumed to have value only in detecting trends in responses rather than reporting absolute values.

Identifying the drivers of behaviour may in turn help to underpin a discussion of the most effective means of achieving behavioural change in personal washing, in particular individuals reducing the duration of showers. A change in behaviours will have to address the current attitudes held by the public in regards to water efficiency and water resource issues in general. Research indicates that over-all awareness of water scarcity issues lag behind that of climate change, energy and waste. There is also evidence to suggest that there is a low awareness of the relationship between water and energy efficiency through both the embedded energy in water supply and direct energy consumption in heating water. A review of research into public attitudes to the environmental impacts of their behaviour in general (through Defra's "promoting environmental behaviour" research agenda) as well as research more specifically targeted on resource consumption, indicates that awareness of water lags behind issues of energy consumption, waste, and climate change. In cases where respondents were asked to order actions they currently take to reduce their impact on the environment; the awareness of energy, carbon and waste over water was reflected in the preference for actions such as recycling, reducing direct energy consumption and installing insulation over reducing water use. It is also uncertain whether customers are aware of the indirect energy consumption of energy due to water use, both through the embedded energy in cold water supply and in heating water. In addressing water resource issues, the responsibility of government and water companies is placed before that of individual users; in particular the issue of leakage is believed to be the most pressing means of addressing water waste.

Defining performance

Definitions of efficiency in showers are currently ambiguous. Shower heads which are defined by manufacturers as efficient refer to aerated systems which deliver flow rates of around 4 litres per minute. Given that there are electric showers which often deliver flow rates similar to or lower than this, there appears to be no agreed definition. “Efficiency” also implies a standard of performance as well as resource consumption; research carried out by United Utilities reviewed in Task 2 explored the role variables such as flow rate, spread, and droplet size in defining performance and provided methods of measurement. There still however remains no defined balance between these performance indicators and over-all resource consumption, a point that has been acknowledged by the MTP in their review of shower efficiency. To develop such a definition would require an assessment of user preferences which moved beyond the conventional understanding of performance as a direct function of flow rate and incorporated the variables discussed by United Utilities. The outcomes of such research can then feed into agreed minimum performance standards for showerheads. These may then further underpin any labelling scheme for water using appliances where information on water consumption must be taken into account alongside performance.

Gaps identified

What are the drivers of shower and bath use behaviour?

Little evidence exists concerning why people use baths and showers the way they do. The huge range in consumption values indicates that average values are insufficient when discussing behaviour and a better understanding of what influences these patterns of consumption is needed. Individual attitudes and behavioural patterns as well as the dynamics between household members, baths, and showers have not yet been investigated. In addition, there has been little work on discussing any correlations between household type and makeup and personal washing patterns, if such a correlation exists, this may prove useful for targeting messaging and behavioural change campaigns.

What is the potential for behavioural change to reduce water consumption independent of and in conjunction with retrofits?

Given the difficulties in plumbing compatibility and public perception of efficient shower heads, the potential for water savings through behavioural change alone should be explored. Research should explores the potential of different formats of messaging to influence behaviour, for example; normative messages concerning "typical" consumption patterns, economic incentives and payback periods, environmental impacts (in both water and energy terms), aesthetic or cultural values, or specific targeting of drivers of behaviour identified in the above research question.

What are acceptable levels of shower performance? How do shower users weight the importance of each of the indicators defined by the Market transformation Program?

Shower performance is currently poorly defined. Identifying how users perceive performance and establishing minimum performance standard would provide a level playing field and allow shower manufacturers to design technology which minimises water use whilst ensuring a positive user experience. This in turn will help encourage uptake, minimise the risk of replacement with high flow models, and erode the connection between performance and flow rates.

Given any established standards of performance, what is the most appropriate means of marketing showers as both efficient and high performance? How can customers' perceived conflict between the two be addressed?

Waterwise have noticed a significant improvement in the aesthetic aspects such as design in showering, and feel that an appropriate approach to efficient showers would be to peruse a message of good design which minimizes waste, rather than relying on the environmental and economic benefits of efficiency to override aesthetic short-fallings. A best case scenario would be to incorporate efficiency into products which are marketed as "luxury" or "high tech". This will prove challenging as performance and luxury as often associated with flow-rate. Economic instruments to encourage the up-take of efficient showers will require a close cooperation between government, manufacturers and retailers which may lie beyond the remit of this research. However, given there is evidence that customers are willing to take utility savings into account when buying a shower, and that this may have an effect of willingness to pay, there is potential benefit in defining the balance between costs and savings more clearly. It is also unclear as to how these savings should be communicated. MTP research indicates a number of concerns over a water efficiency labels for showers. The current lack of consumer information on shower performance and efficiency is a serious barrier to informed purchasing decisions and the ultimate market transformation towards more efficient fittings.

How can retro fits be effectively targeted?

Given the wide range of compatibility issues identified in the review, it is impossible to promote a single water efficient shower device without risking poor performance due to low water pressure or the variety of hot water systems. Research which investigates how best to identify homes which are likely to own high consumption mixer showers can then feed into targeting for efficient showerhead uptakes.

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