BNWAT24: Performance and efficiency: reviewing and defining showers

Version 1.0

This Briefing Note and referenced information is a public consultation document and will be used to inform Government decisions. The information and analysis form part of the Evidence Base created by Defra's Market Transformation Programme.

1 Summary

The Market Transformation Programme (MTP) identified the need to fully investigate all the factors influencing shower performance and shower resource efficiency with the aim of devising a system of classifying what is a 'good' shower and what is a 'poor' shower. The overall performance of showers is inexorably linked with the pressure of water supplied to the shower and the type of hot water system installed. The shower unit and shower head then further influence the performance. Shower resource efficiency (energy and water) is determined by the shower unit type, the plumbing system and whether or not the shower incorporates a pump. User behaviour is outside the scope of this Briefing Note. There are further factors, such as the 'dead leg' of water which affect both energy and water efficiency. All factors that influence resource performance and/or resource consumption are considered in this Briefing Note, with the aim of defining what constitutes a 'good' shower. This Briefing Note is a summary of the report RPWAT0208 *Performance and efficiency: reviewing and defining showers*, available from MTP.

2 Background

Water use in the UK is increasing and all forms of bathing accounts for about 20% of annual water use in UK households[1]. Showering accounts for approximately 10% of the water used in domestic households[2].

Showering frequency has increased in recent years with a greater number of showers installed in domestic dwellings[3]; this is due to a number of factors including:

[1] Environment Agency *Water Resource - Showers and Baths,* obtained from http://environment-agency.wales.gov.uk/commondata/105385/showers__baths_886738.pdf
[2] WRc plc (2005), *Increasing the value of domestic water use data for demand management - Summary report.*
[3] Market Transformation Programme (2006), BN DW Shower*; Actions to improve shower design and efficiency - Briefing Note relating to policy scenario objectives in Policy Brief* – Accessed from www.mtprog.com

- Growth in the new-build sector and demand for additional housing.
- Increased number of single occupancy households.
- Increased number of en-suite shower rooms.
- Smaller homes becoming more prevalent (which only have space for a shower and not a bath).
- Promotion of showers as saving water compared with baths.
- Lifestyle changes.

There is a perception that ‘power showers’ are desirable. However there is no agreed definition of a ‘power shower’. Frequently the term is used to mean showers that provide a very high flow rate of water, but in other cases the term is used to describe a shower unit which incorporates a pump. Equally ‘water efficient’ showers are frequently associated with poorly performing showers that do not provide a high standard of user experience.

MTP identified the need to fully investigate all the factors influencing shower performance and shower resource efficiency with the aim of devising a system of classifying, or defining, showers such that:

- ‘Good’ showers deliver a high standard of user experience, but with the least resource consumption.
- ‘Poor’ showers are those which either do not provide an adequate standard of user experience or are unnecessarily wasteful of resources.

This project does not cover the factors influencing consumer choice regarding the purchase of a new shower such as style, size, cost etc.

3 Shower performance

Currently there is no single definition of ‘shower performance’ and there is no standard way of measuring it. The overall performance of a shower is the amalgam of several different parameters:

- Flow rate (real or apparent).
- Area of coverage by the spray.
- Force with which the spray acts on the user.
- Effectiveness in washing away soap and shampoo.
- Water temperature.
- Controllability.

Test methods for flow rate and spray pattern are specified in BS 6340-4[4], AS/NZS 3662[5], BS EN 13904[6] and BS EN 1112[7]. There are currently no recognised test methods for the other parameters.

[4] BS 6340-4: 1984, *Shower units. Specification for shower heads and related equipment* British Standards Institution, London.
[5] AS/NZS 3662: 2005, *Performance of showers for bathing* Standards Australia, www.saiglobal.com
[6] BS EN 13904: 2003, *Low resistance shower outlets for sanitary tapware* British Standards Institution, London.
[7] BS EN 1112: 1997, *Shower outlets for (PN 10) sanitary tapware*, British Standards Institution, London.

If any of these shower performance criteria are not met then the shower can be considered not to be fully serving its purpose. However this also provides the opportunity to change one or more of the factors to reduce the water usage whilst providing the optimum shower experience. For example, a reduction in the flow rate could be compensated by altering another factor, such as the force of the spray that acts on the user and/or the area of coverage by the spray.

The above performance criteria are determined by a number of parameters including the:

- Shower unit type.
- Shower head type.
- Type of water supply system and resulting water pressure and flow rate.
- Length of dead leg[8] of the pipe.

The impact of these parameters is discussed further in sections 3.1 to 3.4.

3.1 Hot and cold water supply systems

There are a number of different types of hot and cold water supply systems installed in the UK. The supply system can influence the following performance criteria:

- Flow rate
- Force of spray
- Water temperature
- Controllability (consistency of performance).

For mixer and power showers, the final temperature of the water delivered by the shower will be determined by a combination of the hot and cold water supply, which can vary in pressure and flow rate depending on the type of system installed. The water pressure of the hot and cold water feeds should be similar (ie both should be either high pressure or both low pressure).

Mixing valves are used to obtain the desired temperature by adjusting the flow of hot and cold water. Thermostatic mixing valves maintain a reasonably steady water temperature, which can help to overcome the effects of variability in the hot and cold water supplies to the shower unit.

Electric showers are connected only to the cold water system.

3.1.1 Cold water supply

The cold water supply affects all types of shower, both electric and mixers, and can be either direct from the mains (high pressure) or fed by gravity from a tank (low pressure).

[8] 'Dead leg' is the length of water pipe that leads to a draw-off point and does not form part of a pipe circuit. BS 100: Section 3.3: 1992, *Glossary of building and civil engineering terms. Part 3 Services Section 3.3 Sanitation.*

With high pressure cold water, any type of shower can be installed apart from a pumped shower.

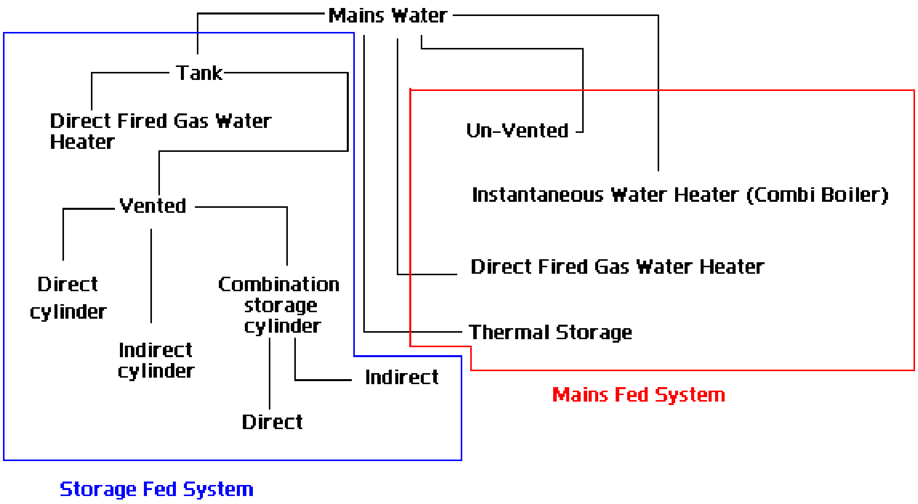
With a low pressure system the shower must be selected to be able to perform at a low pressure. Pumped, electric and normal gravity-fed mixers can be installed. The head of water must be known prior to the installation in order to ensure that the correct pressure is available for the shower unit.

3.1.2 Hot water supply

Hot water supply is important for mixer and pumped showers[9]. The hot water supply, like cold water, can be either mains fed (high pressure) or fed from a tank (low pressure). In addition, the hot water supply can be either instantaneous or fed from a water storage cylinder. How the hot water is supplied will affect the performance of a shower.

Figure 1 shows a breakdown of the hot water systems currently used in the UK[10].

Figure 1 Hot water supply systems in the UK



Combination boilers (mains fed) reduce the flow of the hot water within the boiler to allow it to be heated. Flow rates are generally good when only one outlet is being used. However, simultaneous draw-offs from different outlets will cause the flow to rapidly reduce. Hence it is beneficial to use a shower that is equipped with a thermostatic mixing valve to help maintain an acceptable temperature.

Where hot water is supplied from a storage cylinder, the cylinder must be large enough to supply water to the shower as required, otherwise the hot water feed will run cold and severely impact on shower performance.

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[9] It must be noted that limitations to the hot water which could include inadequate supply (due to a small tank) could lead to an electric shower being installed instead of a mixer.

[10] Full details of the different types of system are given in Appendix A of MTP Report RPWAT0208 *Performance and efficiency: reviewing and defining showers*.

3.2 Influence of the shower unit

There are two main categories of shower: electric and mixer showers. The major difference between the types is that electric showers heat the water in the unit so require only a cold water feed, whilst mixer showers mix inputs from both hot and cold water feeds.

3.2.1 Electric showers

Electric showers draw directly from a cold water supply. The cold water is heated on demand by passing it over a hot element in the control unit.

Electric showers can be fitted onto both mains-fed cold water systems and tank-fed, low-pressure cold water systems. Some electric showers may have a pump on the incoming tank-fed water supply to ensure there is adequate water pressure and flow.

The electric shower fitted should be suitable for the system to which it is installed, in terms of water and power supply. The flow rate of an electric shower will vary throughout the year due to the temperature of the incoming cold mains water. During the winter the flow rates of an electric shower could decrease owing to the water being retained in the unit for a longer time to heat it from a lower initial temperature to the required temperature; this will affect the performance of the shower.

3.2.2 Mixer showers

Mixer showers draw from the hot and cold water supplies and can be installed on both mains and tank-fed systems (providing the mixer valve is appropriate for the water pressure). There are two types of mixer valve, manual and thermostatic; the type that is fitted can affect the performance of the shower.

Pumps can be fitted to mixer showers to increase the flow rate of the water; these can only be fitted to low-pressure, gravity-fed systems. These are commonly referred to as power showers. The pumps can be either integrated into the unit or separate from the unit. Although less common, pumps can be installed on either the hot or cold water supply (tank fed) to equalise the supply of water to the shower.

3.3 Influence of the shower head

The type of shower head installed on the shower unit will affect the following criteria:

- Flow rate.
- Area of coverage by the spray.
- Force with which the spray acts on the user.
- Effectiveness in washing away soap.

There are a variety of different shower heads available with either single or multiple operating modes. Shower heads supplied by the manufacturer of the shower units are designed for those particular shower units or water supply systems (high or low pressure). It is likely that manufacturer-supplied shower heads have been designed to provide an adequate performance under most water supply scenarios. Shower heads of a different design that are retrofitted onto shower units are likely to change the performance of the shower. However, unless the performance criteria of the retrofitted shower head are known, its impact on performance will not be known until it has been fitted.

A water efficient shower head can be fitted that will give a good performance but at the same time using less water, as it operates at lower flow rates. These are only suitable for fitting to showers that previously provided a relatively high flow rate. Different showerheads will have different specifications for this depending on the technology used.

Shower heads should be matched to the output pressure of the water heating system because if a high-pressure shower head is fitted to a low-pressure system, the shower will probably give a low flow and result in a poor shower experience.

3.4 Summary of performance capability

Factors that influence shower performance include: flow rate, spray pattern, force of spray, soap removal water temperature and controllability. Recognised test standards currently exist only for measuring the flow rate and spray pattern. Owing to this, shower performance cannot currently be quantified.

4 Shower resource consumption

When considering the in-use resource consumption associated with showers both energy and water must be included as both of these depend on the following factors:

- Water supply system.
- Boiler efficiency.
- Power rating of the shower
- Type and presence of a pump.
- Water temperature
- ‘Dead leg’ on the pipework.

Providing the shower is delivering a good performance (see section 3), the ideal situation would be for a shower to be using a minimum amount of water and energy to provide that performance. To ascertain which showers are the most resource efficient, all factors influencing consumption need to be investigated.

Showering is a highly user-dependent operation and the duration of the shower is an important factor affecting resource consumption. For the purposes of this Briefing note, it has been assumed that the duration of showering remains constant across all shower types.

4.1 Factors that affect resource consumption

4.1.1 Water supply system

The water supply system for hot and cold water affects the volume of water used for each shower taken, as discussed in section 3.1.

Associated with the water consumption of a shower is the embodied[11] energy of the water used. As the volume of water increases so does the total embodied energy used, although the embodied energy per unit of water remains constant.

4.1.2 Boiler efficiency

Heating water in UK homes now accounts for 24% of UK energy consumption[12]. In many new homes the energy used to heat water for use in the home exceeds the energy used for space heating[13]. Boiler efficiency will affect the energy consumption of the shower; currently in the UK boilers are classified by a SEDBUK[14] rating which is an average annual efficiency by a selected boiler in specific domestic conditions[15]. This value is, however, solely for space heating, there is no value provided for the efficiency of water heating and currently there is no European requirement for this to be declared. For the purpose of this Briefing Note currently available energy efficiency ratings cannot be used as they are not a true representation of the energy used to heat water.

4.1.3 Pumps

Both electric and mixer showers on a gravity-fed (low-pressure) system can have a pump installed, although it is more common with mixer showers. The pump will increase the energy and water consumption of the shower. The embodied energy of the water per litre delivered to the home always remains the same; adding a pump to a shower will increase the volume of water used during showering, thereby increasing the amount of embodied energy used.

4.1.4 Water Temperature

The temperature of the cold feed water and the required temperature of the shower water will influence the amount of energy used. However, there are other factors that determine the temperature of the shower water which is selected by the user, such as the spray pattern and flow rate in addition to personal preference. There are currently insufficient research data to enable further details to be provided on this issue.

4.1.5 Dead legs

A ‘dead leg’ is a length of hot water pipe that leads to a draw-off point and does not form part of the pipe circuit[16]. The length of the dead leg influences the energy and water consumption of a shower. Positioning outlets close to the hot water supply reduces the length of, and hence the heat loss from, dead legs. Insulation of the hot water pipes also reduces their heat loss.

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[11] Embodied energy is the energy used to provide water to households and treat the wastewater produced.
[12] Market Transformation Programme and Energy Saving Trust (2007) *Rise of the machines* - accessed from: http://www.energysavingtrust.org.uk/uploads/documents/aboutest/Riseofthemachines.pdf
[13] Market Transformation Programme, *Product Overview - Water* - accessed from www.mtprog.com
[14] SEDBUK stands for Seasonal Efficiency of Domestic Boilers in the UK.
[15] Further information given in MTP report RPWTA0208 *Performance and efficiency: reviewing and defining showers*.
[16] BS100: Section 3.3: 1992, *Glossary of building and civil engineering terms. Part 3 Services Section 3.3 Sanitation.*

4.2 Summary of resource consumption

A scenario method has been used (below) to compare the relative water and energy consumption associated with different shower units on different supply systems with different pumps. This allows for comparison between the scenarios, which includes whether or not combinations of these factors are possible.

4.2.1 Calculating relative water and energy consumption

Potential shower installations

Before the potential resource consumption of different shower types can be calculated, it is necessary to consider the types of shower that can be installed on different hot and cold water system. These are summarised in Table 1.

Table 1 Possible shower installations

	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 7.0-7.9 kW	✓	✓	✓	✓	✓	✓	✓	✓
Electric 8.0-8.9 kW	✓	✓	✓	✓	✓	✓	✓	✓
Electric 9.0-9.9 kW	✓	✓	✓	✓	✓	✓	✓	✓
Electric 10.0-10+ kW	✓	✓	✓	✓	✓	✓	✓	✓
Electric Integrated pump 120W	✓	✓	✓	✗	✗	✗	✗	✗
Electric Separate pump 450W	✓	✓	✓	✗	✗	✗	✗	✗
Mixer	✓	✓	✓	✓	✓	✓	✓	✓
Mixer & Integrated pump 150W	✓	✓	✓	✓	✗	✗	✗	✗
Mixer & Separate pump 450W	✓	✓	✓	✓	✗	✗	✗	✗

Electric showers can be installed on any type of system as they are connected to only the cold water supply. Mixer showers can be installed on any type of boiler system; pumped showers, however, can only be installed on storage-fed systems.

Resource consumption associated with showering

Resource consumption will be dependent on the type of shower, boiler system and fuel used. Since it is unlikely that a homeowner will change the fuel type of their boiler system the resource consumption has been evaluated separately for different fuel types. Fuel type was divided into homes with oil water heating and those with gas water heating. Electric heating has not been calculated separately but is discussed within the text. Other sources of hot water are not considered within this work.

The water consumption and associated energy consumption were calculated for an average shower duration and flow rate for the following types of shower:

- 7.0 - 7.9 kW electric shower.
- 8.0 - 8.9 kW electric shower.
- 9.0 - 9.9 kW electric shower.
- 10.0+ kW electric shower.
- Electric shower with integrated pump.
- Electric shower with separate pump on water supply system.
- Mixer shower.
- Mixer shower with integrated pump.
- Mixer shower with separate pump on water supply system.

The flow rate and shower durations were taken from the MTP evidence base[17]. The energy consumption was then converted into carbon equivalent, based upon fuel type for hot water heating and electricity consumption for the pumping[18].

After calculation of water and energy consumption, the results for each were ranked, and a further weighted ranking was calculated based on both water and carbon results. The two factors were weighted equally. Table 2 shows both the individual water and carbon rankings and the overall weighted rankings where 1 is the most efficient and 9 is the least efficient.

Table 2 Resource consumption rankings

		Homes with gas heating		
Fuel type	Shower type	Carbon ranking	Water ranking	Overall rank
Electric	7.0-7.9 kW	2	1	1
	8.0-8.9 kW	4	2	2
	9.0-9.9 kW	6	3	4
	10.0-10+ kW	7	4	5
	Integrated pump 120W	8	4	7
	Separate pump 450W	9	4	8
Gas	Mixer	1	7	3
Gas & Electric	Mixer & Integrated pump 150W	3	8	5
	Mixer & Separate pump 450W	5	9	9

		Homes with oil heating		
Fuel type	Shower type	Carbon ranking	Water ranking	Overall rank
Electric	7.0-7.9 kW	1	1	1
	8.0-8.9 kW	2	2	2
	9.0-9.9 kW	3	3	3
	10.0-10+ kW	6	4	4
	Integrated pump 120W	7	4	5
	Separate pump 450W	8	4	7
Oil	Mixer	4	7	5
Oil & electric	Mixer & Integrated pump 150W	5	8	8
	Mixer & Separate pump 450W	9	9	9

Table 2 indicates that electric showers are some of the most resource efficient showers in terms of water and energy consumption compared with oil and gas fuelled boilers. Standard mixer showers are also efficient, ranking the highest in terms of carbon equivalent and the third highest overall for the gas-fuelled boilers. Standard mixer showers rank alongside integrated pumped electric showers overall in the oil-fuelled boiler scenario.

[17] See Market Transformation Programme (2006), BN DW Shower: *Actions to improve shower design and efficiency - Briefing Note relating to policy scenario objectives in Policy Brief,* for more information - accessed from www.mtprog.com
[18] See Market Transformation Programme (2007), BNXS01*: Carbon emission factors for UK energy use - Under consultation* - accessed from www.mtprog.com

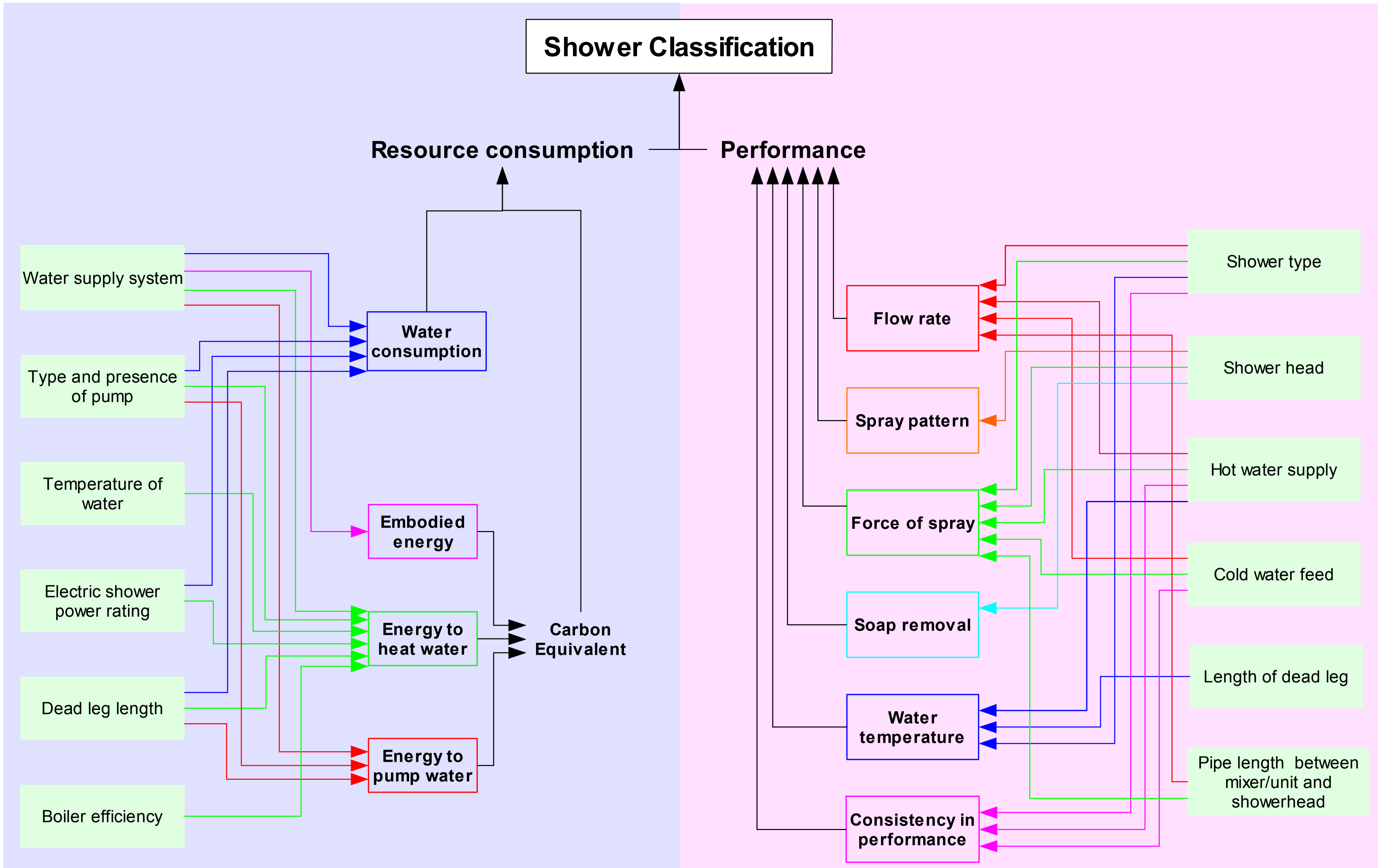
The figures in Table 2 represent the relative efficiency of different shower types based on ‘average’ consumption data. In any given home, the multitude of factors that influence resource consumption (discussed in section 4.1) could result in higher or lower consumption than the average shower. Therefore, it is recommended that in any given situation all factors should be considered to determine if these rankings might be different for the individual scenario.

If water in a home is heated using an electric immersion heater in the hot water cistern, then it would be possible to install both electric showers and mixer showers. In terms of energy use, water supplied to mixer showers will lose heat as it goes through the supply pipe, while electric showers do not lose heat in this way, making them more efficient. However, the heat lost by water when being supplied to mixer showers is difficult to quantify so the carbon equivalent factor for mixer showers using tank-fed hot water is assumed to be the same, irrespective of how the water is heated. Therefore, the overall ranking, in terms of resource consumption, would be entirely dependent upon the water consumption of the shower. Since the average flow rates of electric showers are lower than the average flow rates of mixer showers, the electric showers would appear more resource efficient if ranked.

5 Performance versus efficiency

The shower performance and resource consumption of showers are two important aspects to consider when classifying showers. Both play a key part but in order to come to a conclusion, these two aspects must be viewed together to determine the most efficient, high-performance shower type.

Figure 2 Factors influencing shower performance and efficiency



In order to classify showers, it is necessary to quantitatively assess and compare each of the individual factors of Figure 2. Currently, there are insufficient data to be able to classify showers based on many of the performance factors.

If performance is maximised so that high volumes of hot water are pumped out of the shower head, a considerable amount of energy will be required to heat the large volume of water and to pump the water to the shower head. Whilst this may meet the requirements of the user, it is far from ideal with respect to environmental and carbon impacts.

If water consumption is minimised it is possible that the flow rate will not be high enough to provide adequate performance from the user's perspective. The shower head might not function optimally unless it was designed for low flows, soap removal could take a long time and the shower could perform inconsistently. In this case, the performance could be so poor that the shower might not be acceptable to the user.

Without more information on the performance of showers under different scenarios, the best balance between performance and resource consumption cannot be determined. Information is required to enable the quantification of performance-related factors.

The information provided within this Briefing Note and the associated report could, however, enable selection of the more resource-efficient, high-performing shower on a case-by-case basis, for instance in the planning of new homes[19].

6 Conclusions and Recommendations

The research has shown that to classify showers it is necessary to be able to quantify and classify all factors that are included under both resource consumption and performance. However, this is not possible as current knowledge is not advanced enough to classify showers based on many of the performance-related factors, including soap removal and consistency in performance.

If high flow rate is taken as the principal indicator of performance then large quantities of energy and water will be used. If water consumption is minimised, minimal energy will be used but showers must be specifically designed to operate at low flows or user satisfaction is likely to be low.

More information is required on the performance of showers under different scenarios to enable conclusions to be drawn regarding the optimum balance between performance and resource consumption.

It is recommended that further research is undertaken on:

- The efficiency of the production of hot water by different boiler and fuel types.

[19] An example of this can be found in MTP report RPWAT0208 - *Performance and efficiency: reviewing and defining showers.*

- The development of test standards to enable the performance of showers to be more readily compared (eg soap removal tests, user experience and other related factors).

Related MTP information

- MTP Report RPWAT0208: Performance and efficiency: reviewing and defining showers.
- Briefing Note BN DW Shower: Actions to improve shower design and efficiency - Briefing Note relating to policy scenario objectives in Policy Brief.
- Briefing Note BNWAT06: Showers - water efficiency performance tests.
- Briefing Note BNWAT25: Recycling showers - Innovation Briefing note.
- Briefing Note BNWATSH01: Consumer views about showers - summary report.
- Briefing Note BNXS01: Carbon emission factors for UK energy use - under consultation.

Version

This is the first version of this briefing note

Consultation and further information

Stakeholders are encouraged to review this document and provide suggestions that may improve the quality of information provided, email **info@mtprog.com** quoting the document reference, or call the MTP enquiry line on +44 (0) 845 600 8951.

For further information on related issues visit **www.mtprog.com**