commercial counterparts (e.g. household vs. commercial toilets). Moreover, a large amount of performance data available for commercial WuPs was obtained from countries outside of Europe such as the US and Australia. Representative performance data for commercial clothes and dishwashers was also difficult to identify. Data gathering for industrial WuPs has proven to be a challenge as few studies have focused on water consumption in this sector. Large data gaps are evident in some product areas (such as cooling and steam generating equipment). However, generic cleaning products do appear to have more data provided.

3.1. WATER USE IN BUILDINGS

3.1.1. OUTLOOK OF WATER USE IN BUILDINGS

It is important to note that water use in buildings varies widely across Europe. In the case of households, water is mostly derived from a public water supply system and the technical performances of different supply systems can vary widely among different MS, because of varying leakage rates. Water use variation also depends on the water source and demographics, e.g. household water consumption for different activities will not be the same for United Kingdom and Spain, as living conditions, water supply systems, and use differ a lot between these two MS. This suggests that “household” water use statistics should be interpreted with care (*Dworak et al., 2007*).

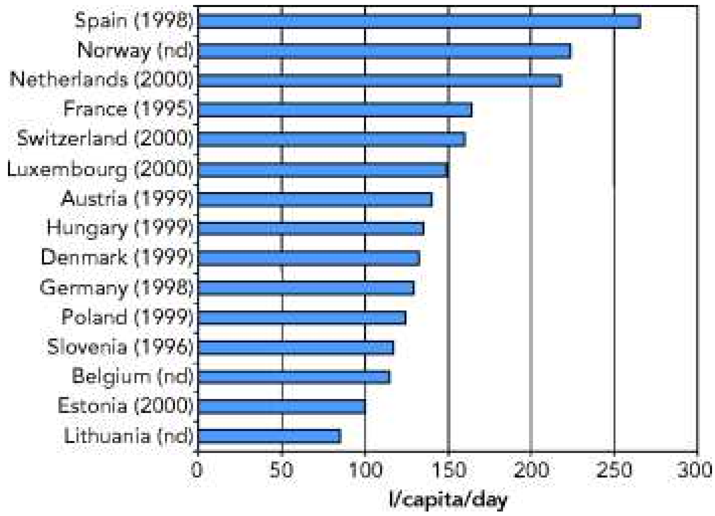
3.1.1.1 Water use in residential buildings

Water use in residential buildings can be attributed to various household activities. According to a report of the Office of Community and Economic Development (OECD) (*OECD, 2002*), approximately 35 to 40% of household water is used for personal hygiene (shower and bath), 20 to 30% for toilet flushing, and 10 to 20% for washing laundry[10] in OECD countries.

As shown in Figure 4 below, the highest per capita water consumption is in Spain followed by Norway, Netherlands, and France. Baltic countries and Belgium have the lowest household water consumption per capita (*Lallana, 2003*).

[10] Similar figures were also given by Waterwise, a British NGO focused on decreasing water consumption and promoting water efficient products.

Figure 4: Household water consumption (Lallana, 2003)



For measuring water consumption in residential buildings, water consumption *per* household *per* day (*l/hh/d*) provides only limited information on water efficiency in residential buildings. Dividing this value by the number of occupants, i.e. litres *per* capita *per* day (*l/c/d*), provides a better indication of efficiency. Table 1 provides *per capita* water demand in households for Western, Southern and Eastern European countries (for different MS for which relevant data and studies have been identified, and covering a variety of climatic and economic conditions in Europe). Although outdoor water use can be expected to be higher in Southern Europe due to the warmer climate, the data in Table 1 does not provide immediate evidence of this. Data from Cyprus and the comments about a peak 3 month period in demand in England and Italy, however, show that higher outdoor water use only increases significantly during the summer months, which is not revealed in the average annual water consumption volumes.

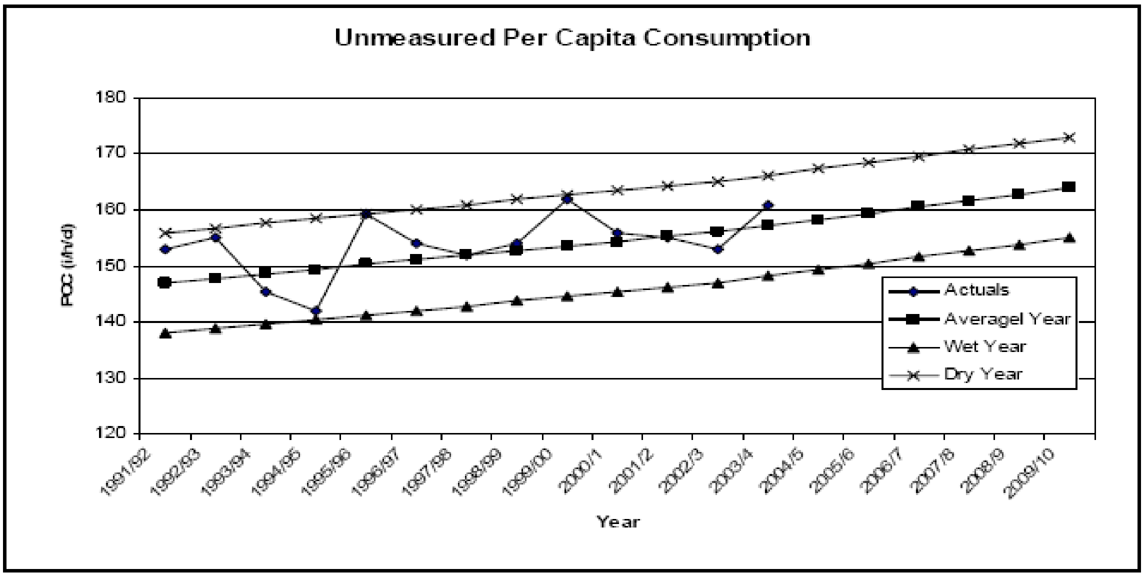
Table 1: Household water consumption in countries in Western, Southern and Eastern European countries

Country	Region	Average household consumption (l/c/d)	Range (l/c/d)	Data source	Comments
Cyprus	all areas	174	107 - 466	*Pashardes et al., 2001*	-
Bulgaria	Sofia	133	105 - 378	*Voda, 2005*	individual boiler supplied hot water
Bulgaria	Sofia	186	106 - 378	*Voda, 2005*	centrally supplied hot water
Poland	Bytom	123	-	*Kloss-Trebaczkiewicz et al., 2001*	decreased from 195 l/c/d in 1990
Poland	Katowice	164	-	*Kloss-Trebaczkiewicz et al., 2001*	decreased from 234 l/c/d in 1991

Country	Region	Average household consumption (l/c/d)	Range (l/c/d)	Data source	Comments
Poland	Sosnowiec	178	-	*Kloss-Trebaczkiewicz et al., 2001*	decreased from 365 l/c/d in 1992
Portugal	Guadiana	210	-	*Water Strategy Man, 2003*	-
Portugal	Algarve	184	-	*Water Strategy Man, 2003*	-
England	Portsmouth	153	74 - 252	*Portsmouth Water, 2005*	peak 3 month period 177-317 l/c/d
Italy	Sardinia	175	-	*EURISLES, 2002*	peak 3 month period 235-315 l/c/d

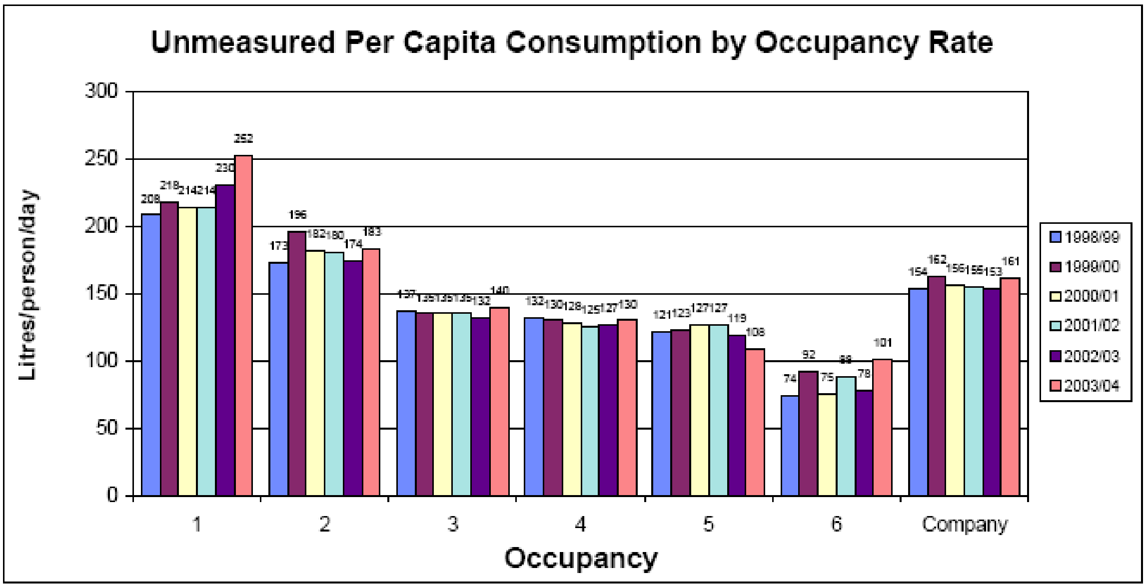
Portsmouth Water in Southern England has run a comprehensive household water demand monitoring database since 1991. Since the Company has no long-term storage, its critical period for balancing supplies with demand is during summer peaks. Therefore, it needs to be able to forecast peak demands in order to ensure it has sufficient resources for the future. In an attempt to measure the climatic effects upon household consumption, the Company has set up a 'Fixed Measured Property Database' of 1 500 properties from whom occupation data has been collected (*Portsmouth Water, 2005*). In this database, *per Capita Consumption* (*PCC*) in households increased from 153 l/c/d in 2002/03 to 161 l/c/d in 2003/04. This is above the average forecast line and is consistent with the warm summer conditions experienced during the summer of 2003 (see Figure 5).

Figure 5: Data from 1500 households in Portsmouth, England reveals an upward trend in PCC (*Portsmouth Water, 2005*)



The overall upward trend is believed to be due to the declining occupancy rate which automatically results in higher PCC. Single person households use 70% more water per person than households with four persons (see Figure 6). The UK Environment Agency has suggested that a further cause of the increasing per capita demand is the increasing use of water intensive white goods such as dishwashers and washing machines, and also water-intensive (power) showers.

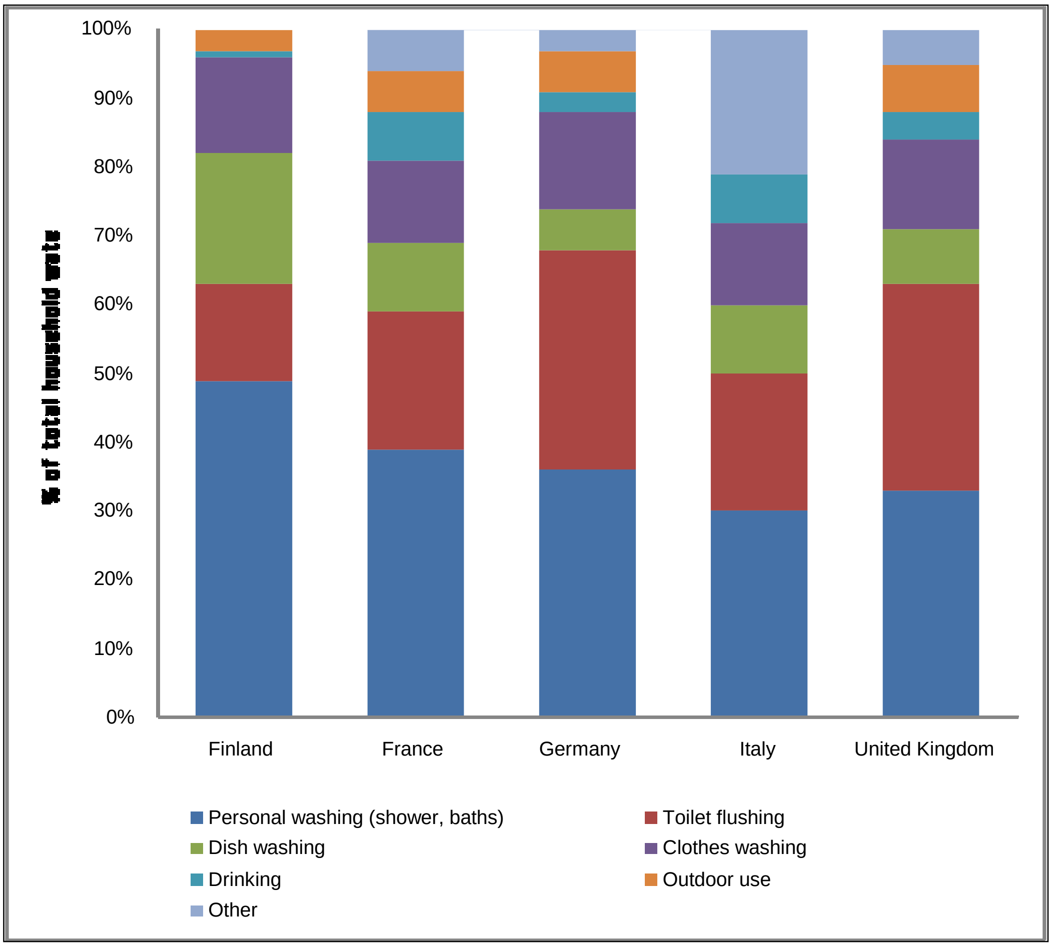
Figure 6: Single person households use as much as 70% more water than those in four bedroom households (*Portsmouth Water, 2005*)



The factors that influence *per capita* household water demand in residential buildings in the Portsmouth Water example, such as different numbers of occupants, show changing trends in residential buildings in the United Kingdom, and are being repeated across much of the Western Europe. On the other hand, evidence from Eastern Europe (*Kloss-Trebaczkiewicz et al., 2000; Aquastress, 2006*) indicates that household water consumption has decreased in recent years, due to higher efficiency in plumbing networks and buildings.

Figure 7 shows the breakdown of the water consumption for WuPs in several MS for which data was identified and covering different climatic and economic conditions in Europe. This data indicates that the majority of water use in residential buildings can be attributed to the following WuPs: toilets, personal hygiene (showers and baths), washing machines, and dishwashers. The figure is based on the most comprehensive data found available for MS based on our literature research.

Figure 7: Household water use in some MS[11]



➢ Drivers for water use in households

Economic growth and increased population growth are the main drivers for water use and demand. These factors have also led to increased urbanisation and higher living standards, which are also major drivers in the increase of water use in buildings in the past century. Table 2 shows some of these drivers in further detail.

[11] Figure based on following data sources:
United Kingdom: Waterwise. Reducing water wastage in the UK. 13 Mar. 2009 <http://www.waterwise.org.uk>
France: Centre d'information sur l'eau. Les consommations à la maison. 21 Feb. 2009 < http://www.cieau.com>
Germany: J Schleich, and T Hillenbrand. Fraunhofer, ISI. Determinants of Residential Water Demand in Germany. Working Paper Sustainability and Innovation, No. S3/2007 (2007).
Italy: Sorella Acqua. Acqua Quotidiana, 2003. 6 Mar. 2009 <http://www.buonpernoi.it/acqua>
Finland: R P Rajala, And T S Katko. "Household water consumption and demand management in Finland." Urban Water Journal, Vol. 1, No. 1(2004): 17–26

Table 2: Main drivers for household water consumption and their impact on behaviour and water consumption (*OECD, 2002*)

Drivers	Household behaviour	Effect on water consumption
Population growth		+
Economic growth (GDP)	Larger percentage of households has access to water supply networks. Investment in improving systems (leakage reduction).	+
Per capita disposable income	More water appliances and increased use: WC, shower, bath, washing machine, swimming pool, garden and lawn care.	+
(together with environmental awareness or economic incentives)	Purchases of more water efficient technologies and appliances.	-
Changes in Lifestyles	Rising "comfort" levels: more frequent use of showers, baths, washing machines; higher water temperatures	+
(together with environmental awareness or economic incentives)	Water conservation and efficiency practices	-
Technological innovation	Water saving appliances such as showerheads, 6l WC, more efficient washing machines.	-
Improved Tariff structuring (Fees, taxes, metering)	Greater awareness of the "cost" of water	-
Environmental information and Awareness	Careful use of water.	-

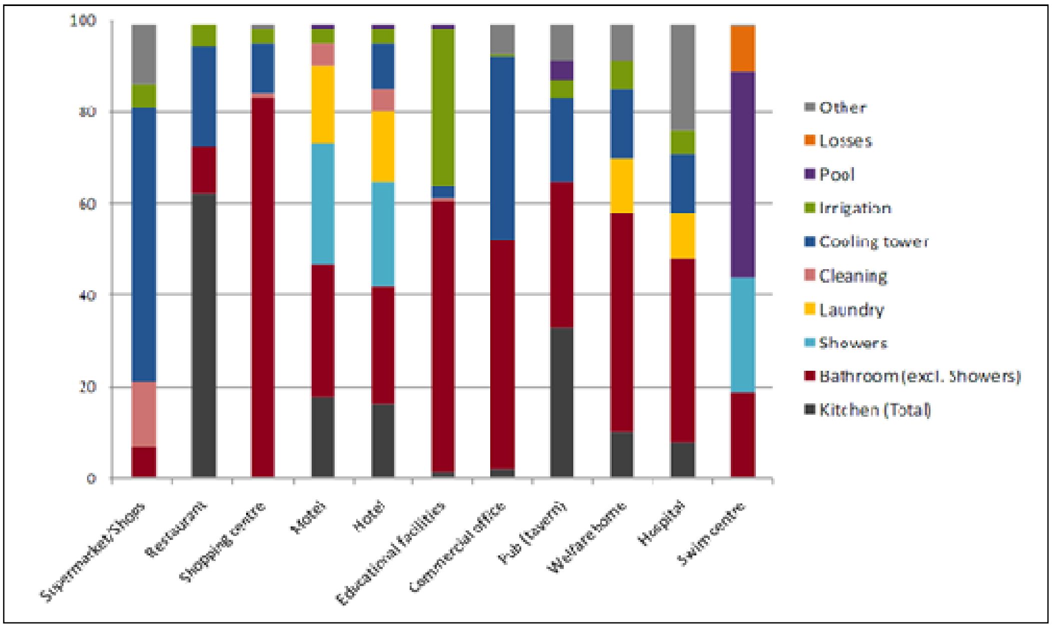
At higher levels of gross domestic product (GDP), more households are connected to water networks and to sewage systems for water treatment. On the other hand, higher household income is also linked to greater water consumption and ownership and capacity of water appliances (e.g. showers, toilets, water heaters, dishwashers, washing machines, sprinklers, swimming pools) (*OECD, 2002*). However, in the long term, higher household incomes mean that more consumers can afford water-efficient appliances. In order for this to occur, however, there must be some external and internal incentives that promote water savings, such as environmental pressure, changes in regulations and markets, environmental awareness, increasing water prices, and/or accessibility of water saving technology, etc. Chapter 4 explores this aspect in further detail.

3.1.1.2 Water use in commercial buildings

Water in the commercial buildings sector (non-industry and non-agriculture) is used for different purposes depending on the principal activities and use of the building, e.g. offices, hospitals, hospitality sector, restaurants, retailers, leisure and community centres, schools and universities, and small businesses.

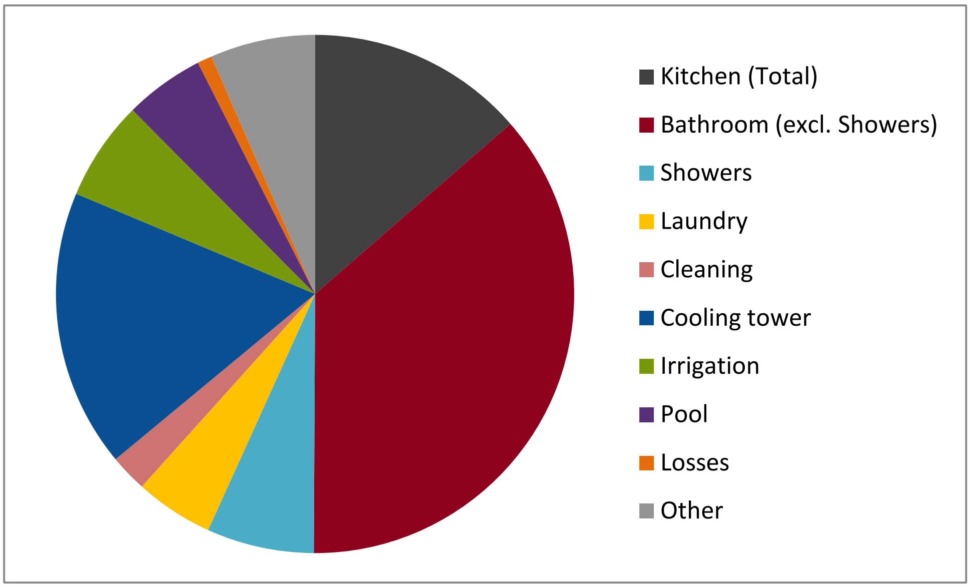
Unlike household water consumption, the distribution of different WuPs, and consequently the pattern of water consumption, can vary greatly depending on the function of each commercial building (*Department of the Environment and Heritage, AU, 2006*). Although Figure 8 refers to water use per product type in Australian commercial buildings, it illustrates wide variations across different types of commercial buildings and also provides an overview of different types of WuPs used in the commercial sector.

Figure 8: Average water use per product type in different commercial settings (in %)



Supermarkets and commercial offices are good examples to illustrate water-use disparities in commercial buildings. Supermarkets rely heavily on cooling towers for refrigeration and air conditioning, and thus represent the major water needs of this sector. Although office buildings also rely heavily on cooling towers, water consumption in restrooms contributes to a greater proportion in this type of building. Figure 9 below shows the total average water consumption per product type across all commercial sectors. It is clear that WuPs used for sanitary purposes (excluding showers, in the kitchen (e.g. dishwashers, ice machines, etc), and cooling towers are the highest in terms of percentage water consumption.

Figure 9: Average water use per product type in commercial buildings (%)



The results in Figure 8 and Figure 9 suggest that it is difficult to consider the total consumption (in litres) of a product across the entire commercial sector.

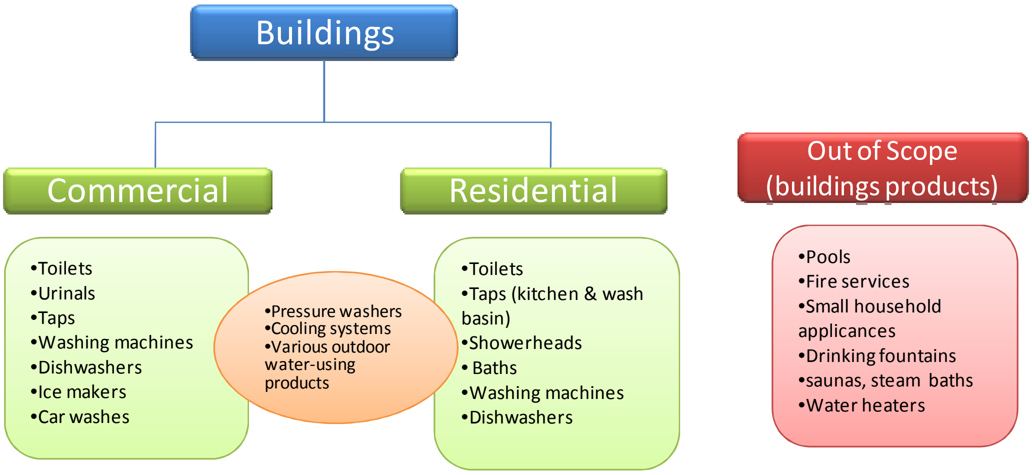
3.1.2. Scope definition

In residential buildings, the most water-intensive activities are toilet flushing, personal hygiene, and clothes washing. These are also the most promising areas for reducing water consumption and should be the focus of further policy initiatives to maximise water savings in these activities and to seek the most effective tools to promote sustainable water use at the residential buildings. In designing policy it is therefore important to focus attention on the main drivers of household water consumption (*OECD, 2002)*.

Results of the literature review have revealed that some of the most significant and widely used WuPs in residential buildings include toilets, showerheads, bath and kitchen taps, clothes washing machines, dishwashers, and outdoor gardening equipment.

Many of the WuPs found in residential buildings are also found in commercial buildings. However, most of these products are designed distinctly for either residential or commercial use because of the different water needs and use frequencies (e.g. urinals are usually found only in commercial settings). Figure 10puts the main WuPs found in residential and commercial buildings in categories and defines the scope criteria of this study. Nevertheless, there exist certain WuPs that are found in both residential and commercial buildings which represent similar characteristics in terms of usage and water consumption (see overlapping products included in Figure 10).

Figure 10: WuPs used in residential and commercial buildings



Explanations for excluding certain WuPs from the scope of the study are provided in Table 3 below.

Table 3: Explanations for excluding certain WuPs from the scope of this study

Product	Explanation for the exclusion
Pools	Pools principally function as water storage products, and less as a "water using" product
Fire fighting Services	Well-being and safety of citizens is a higher priority than water saving potential of the products used in fire fighting services
Small household appliances (coffee machines, steam cookers, rice cookers, etc.)	Many small household appliances are being covered by the Ecodesign Directive, which also addresses water consumption
Drinking fountains	Drinking fountains function very similarly to taps, which are covered under this study, and thus are not specifically addressed. In addition, little information on market data and water consumption was found
Steam and sauna baths	Steam and sauna baths and related products are left out of scope because the use of these products is limited to specific geographic region
Water heaters	Water heaters are not included within the scope of this study because they are covered under the Ecodesign Directive, which also addresses water consumption

3.1.3. Categories definition

This section aims to further analyse the WuPs indentified in the buildings sector (see Figure 10). A description and context of use of the standard product is given, as well as factors affecting water consumption, potential for improved water efficiency, and market trends. This section first addresses WuPs found in residential buildings, followed by WuPs used in commercial buildings. It should be noted that WuPs that are found in residential and commercial buildings are quite similar, with the major difference seen in use patterns. Therefore, for commercial WuPs references are often made to the descriptions of the corresponding residential WuP.

3.1.3.1 Residential toilets

Definition: Toilets dispose of human waste by using water to flush it through a drainpipe to another location. Water-activated toilets (WC) consist of two main components: the pan and the cistern. WC flushing mechanisms can be divided into those with valves and those that are valve-less, with the former sub-divided into single-flush and dual-flush or (for domestic installations) into drop-valves and flap-valves.

- **Description of the standard toilet in the EU**

The most commonly used residential toilets in the EU are single flush toilets. A standard single flush toilet work as follows. A pre-set amount of water is stored in the upper tank. When needed, the user presses a handle that raises a stopper at the tank bottom that opens and allows the water to run by gravity from the upper tank to the bowl that fills and, through siphon action, flows down and out carrying the contents into the drain. Conventional toilets can be installed almost anywhere there is running water.

In a conventional toilet cistern with traditional ball float (inlet) valves and flushing (outlet) valves, there is a great deal of water wasted during the flushing cycle. The majority of wastage occurs because the inlet valve opens as soon as the toilet is flushed and therefore more water ends up being flushed than is originally held in the cistern (*St John's Innovation Centre, 2008*).

Single flush toilets are based on either on 9, 7.5, or 6 litres cisterns. This is due to the fact that some existing houses will have larger volumes. Others will have been renovated to incorporate lower volume flushes and many recent new homes will have 6-litre cisterns.

- **Factors affecting water consumption**

Of all WuPs used in residences, toilets (also referred to as WCs) are one of the most important products in terms of frequency of use and water consumption. As explained earlier, toilets represent about 30% of the total water use in a residence. The main factor affecting the amount of water used per household for toilets is flush volume. The actual flush volumes of installed WCs depend on two factors: the installation and performance of toilets and user behaviour. An effective flush volume is the volume of water needed to clear the toilet pan and transport solids far enough to avoid blocking the drain. Other factors include whether the WC is leaking, and the frequency of use, usually determined by the number of occupants. See sub-section 3.1.4.1 pg. 83 on the water assessment for toilets for estimates on their water consumption.

- **Potential for improved water efficiency**

Research has uncovered several additional types of water efficient toilet systems that are currently available on the market which can be seen in Table 4 (*Ornelas, 2009*). In particular, dual-flush toilets represent an interesting case for improved water efficiency in residential buildings because these toilets not only provide higher water performance compared to the standard toilet but are widely used in the Europe.

Dual flush toilets present significant water savings because they have a split flush button giving the user the choice of pressing a small button or a large button depending on how much water is required to clear the toilet bowl. These toilets typically operate with a handle that can move up or down, or a two-button system. One direction or button will activate the lower flow flush, while the other will activate the higher flow flush. Dual flush toilets are being voluntarily installed as the norm on most modern commercial buildings demonstrating that the water saving advantages of dual flush are accepted in the market place. They act as water saving mechanisms as only one out of five visits to the WC warrants a full flush (*Grant et al., 1999*).

Table 4 shows the current available water efficient toilet systems and shows certain toilet retrofit devices can also be used on existing products to save water without replacing it. Retrofit means adapting or replacing an older water-using fixture or appliance with one of the many water-efficient devices now on the market. While these solutions cost more, they also save the most water and money. Retrofitting offers considerable water saving potential in the home and business. In the case of toilets, **water retention devices, water displacement devices**, and **alternate flushing devices** can be adapted in the tank of an existing toilet to reduce the amount of water used in a flush cycle.

Table 4: Water efficient toilet systems and toilet retrofit devices

Product	Description (advantages and tradeoffs)
Gravity Fed Single-Flush Toilets 	They operate the same way as any standard toilet; however, they use less total capacity per flush.
Pressure Assist Toilets 	These toilets use either water line pressure or a device in the tank to create additional force from air pressure to flush the toilet. The device in the tank could either be a storage device with compressed air that would require replacement or a tank that creates pressure when the tank is being filled. Some pressure assist systems move a greater volume of water at a significantly lesser volume of sound.
Power Assist Toilets 	Power assist toilets operate using a pump to force water down at a higher velocity than gravity toilets. Power assist toilets require a 120-V power source to operate the small fractional horsepower pump. Dual-flush models are also available.
Dual-Flush Toilets 	These types of toilets have a split flush button that determines how much water is required to clear the toilet bowl.
Cistern displacement devices 	The water displacement devices familiar to most people are the plastic bags or bottles filled with water which are suspended inside the toilet tank. These devices displace several litres of water, saving an equivalent amount during each flush. Their chief disadvantage is that they don't save as much water as other devices and, is only beneficial if the existing full flush is excessive.
Alternative flushing devices 	Dual flush retrofit devices are installed in the toilet's water tank and it will enable you to have the option of a regular flush or a half flush. However, a disadvantage would be the potential for double flushing. A variable flush system is fitted onto the siphon in the cistern and allows control of the duration of the flush. By putting the user in control of the amount of water used, it could potentially save up to half the water used in the average flush.
Water retention devices 	The most common water retention device available is the toilet dam. Their main attraction is their low cost and the fact that they are easy to distribute and install for example, as part of a wider municipally-sponsored retrofit program. Their main disadvantage is that they tend to leak over time by slipping out of adjustment and can slip free and interfere with the moving parts inside the toilet tank, if not routinely checked.

Waterless toilets

Most waterless toilets come in the form of composting or incinerator toilets and are completely waterless. These toilets are rare in cities and suburbs because of the difficulty in securing appropriate building permits, but they are more common in rural areas. Composting toilets convert human waste into compost, which can be utilised as fertiliser once it has been treated. Waterless composting toilets (also known as humus closets or biological toilets) are waterless systems that are either continuous or batch. Continuous systems contain one chamber, whilst the batch systems contain several bins, with rotation occurring after each bin is filled. In both systems, chambers or bins are installed below floor level. It should be noted that these products are expensive and require stringent maintenance requirements. The factors of water content, temperature, air flow patterns, pH, toilet usage rate, surface area of compost and oxygen penetration depth, all influence the rate and effectiveness of the biological breakdown of the waste materials (*Central Coast Council, 2007*). Because waterless toilets do not consume any water for operation, it could represent significant water savings in the buildings sector. However, as has already been noted, these products are not currently widely used due to high prices, and complications involving installations and maintenance requirements. According to one source (*EPA, 1999*), for a year-round home of two adults and two children, the cost for a composting toilet system could range anywhere between $1 200 and $6 000, depending on the system. Current waterless toilets are not a simple direct replacement for the WC. For rural and suburban eco-houses and remote toilet blocks they can represent a best available technology but their widespread use is not considered likely in the EU at present (*Grant, 2002*).

Some waterless toilets can also be found in commercial buildings.

Market trends

Toilets offer great potential for decreasing residential water consumption. However, this will depend upon the availability of more water efficient WCs. The replacement cycle for WCs is estimated to be around 15 years and they tend to be replaced for reasons of style, colour etc. rather than failure (except in the case of breakages). Therefore, the current limited availability of styles for very low flush volume WCs will act as a barrier to the selection of these units rather than a less efficient design. However, pricing in the longer term should not be a barrier to uptake as currently available water-efficient WCs tend not to be priced higher than the market average. In the United Kingdom, the long-term (10-year) decline in the price of base-line (inefficient) water-using equipment is expected to be 2.45%. Reductions in the price of water-efficient equipment of between 5% and 15% are expected, but it is recognised that the price of efficient products is never likely to be lower than the price of inefficient products. Current example prices for WCs are approximately €185 for a 6/4-litre dual-flush toilet, €312 for a 4.5-litre toilet, but surprisingly only €135 for a 4.5/3-litre dual-flush2 toilet (*Market Transformation Programme (1), 2008*).

In general, fitting a device to retrofit the existing cistern to dual flush or fitting a new cistern to convert to dual-flush are felt to be more permanent and satisfactory than fitting cistern-displacement devices. Replacement of older cisterns, e.g. high-level cisterns, can lead to the highest savings, but high costs and health and safety restrictions mean that these are less favourable for plumbers to change. Similarly, close-coupled WCs and slim line models impose restrictions.

Some PRODCOM (PRODucts of the European COMmunity) data (see sub-section 3.1.3.17, page 77) has been identified, which can be used to get an overall picture of the market for toilets in the EU.

3.1.3.2 Residential taps (Kitchen and washbasin taps)

Definition: A tap is defined as a 'small diameter manually operated valve from which water is drawn' (BS 61006). Internal taps include both kitchen and wash bin taps.

- **Description of standard taps in the EU**

In Europe, taps and mixers (also referred to as 'brassware') control the water flow in bathroom wash basins, kitchen faucets, and baths. A tap is a valve for controlling the release of water from a hot or cold supply pipe. The conventional pillar tap is the most commonly used type of tap used in kitchens and washbasins. Pillar taps are traditional separate hot and cold taps which do not blend the water. Today most taps are supplied in brass or metal alloy with a chrome plated finish.

Mixer taps are also common but less so than pillar taps. Mixers taps are a form of combination tap assembly, whereby there are separate hot and cold inputs, which have a single output. The inputs can be adjusted to give the required temperature and flow, so as to discharge hot, cold or mixed hot and cold water.

- **Factors affecting water consumption**

Kitchen and bathroom taps can account for more than 15% of indoor residential water use (*Market Transformation Programme (2), 2008*). Both kitchen and bathroom wash basin taps can be used for various purposes (e.g. washing, cleaning and rinsing, or for vessel filling). The frequency of use of washbasin and kitchen taps per household is related to the occupancy of the residence. For example, the number of internal tap events per person reduces as the occupancy of the household increases. Other factors that influence the frequency of tap use is whether a household owns, and uses, a dishwasher. According to findings of the United Kingdom's Market Transformation Programme (MTP), in homes where a dishwasher is installed it is estimated that kitchen taps are used on average just over 17 times a day per household. In homes where no dishwasher is used, kitchen taps are used on average just over 24 times a day per household. This is equivalent to 55% of all tap uses across all homes (*Market*

Transformation Programme, 2008). Thus, it can be assumed that in homes where no dishwasher is installed, kitchen taps are used more than if there was a dishwasher in the home. Wash basin taps (which are most often found in bathrooms) are thought to account for the remaining 45% of all internal tap uses in domestic properties.

- **Potential for improved water efficiency**

Users can change the way they use their taps to reduce overall water consumption. For example,

- Installing a water efficient tap or a tap aerator
- Turn the tap off when not in use and use a washing up bowl instead of washing under a running tap. A washing up bowl is an inexpensive and quick buy that will help cut down on water wastage.
- Avoid thawing frozen foods under running water by trying to prepare the night before.
- Fix leaky taps and check taps regularly and replace worn washers as soon as possible.
- Avoid installing a waste macerator in your kitchen sink because these require a lot of water to operate properly. Instead, dispose of food waste in a compost pile *(Waterwise (1), 2009).*

In addition, many water-saving devices exist, including retrofit devices for taps. These are illustrated in Table 5 and Table 6, and are currently available on the market.

Table 5: Water efficient taps (*UK Environment Agency, 2007*)

Device	Description
Spray taps 	Spray taps can save a significant amount of the water and energy used for hand washing but they can restrict the flow too much to fill the basin quickly.
Sensor faucets for residential use 	Some manufacturers are now offering sensor-activated faucet for the home bath. The electronic circuitry in most home units is powered by standard AA batteries, so hardwiring to the home's electrical system is not required. There also exists a solar-powered faucet with a storage cell that transforms sunlight or artificial light into electrical energy. Another self-sufficient unit operates on hydropower, using a small internal turbine to generate its own electricity whenever the water runs.

Table 6: Retrofit devices for taps

Product	Description (advantages and tradeoffs)
Push Tap 	A push tap is a retrofit tap device which basically only releases water when pressed and shuts off automatically when released; it eliminates the possibility of keeping the tap running unattended
Tap flow restrictors 	The easiest way to save water with existing basins and showers is to fit a flow restrictor. 3.75l, 5l and 6l flow restrictors available to suit taps and showers

3.1.3.3 Market trends

The market for taps in Europe, like most other WuPs, are increasing because of rising demand in additional housing and changing demographic factors (more single person homes). See sub-section 3.1.3.17 , pg. 77 for the summary of market trends for residential and commercial WuPs and for additional information on market statistics for taps in the EU.

3.1.3.4 Showerheads in residential buildings

Definition: A showerhead is defined as the point of discharge of the water.

- **Description of the standard showerhead in the EU**

Showerheads in the EU are usually gravity-fed, electric, or pumped. Electric showers use energy to heat the water in the unit, and thus draw water directly from a cold water supply. These types of showers heat the water as the shower is turned on, by passing it over a heating element inside the shower. Gravity-fed showers allows the hot and cold water to flow and mix under gravity from the hot and cold water tanks to the shower head. A pump shower is a shower that delivers a high flow of water at a high pressure. Pump assisted showers are also commonly known as power showers. The shower is a mixer shower with an integral pump that increases the rate of flow from the shower head. They can only be installed on low pressure, tank fed systems. A dedicated hot and cold water supply is necessary.

- **Factors affecting water consumption**

Showers are also a WuP found in residential buildings that consume a significant amount of water. They make up between 10-12% of the water used in the household (*Waterwise (2), 2009*). The water used by showers in residential buildings is determined by the type of shower already being used there, its flow rate, frequency of use and average time per use.

➢ **Potential for improved water efficiency**

A water efficient showerhead can be fitted that will give a good performance but at the same time use less water since it operates at lower flow rates. These are only suitable for fitting to showers that previously provided a relatively high flow rate. In most cases, but not all, showering is more water efficient than using a bathtub under typical circumstances. For maximum water efficiency, it is suggested to select a showerhead with a flow rate of less than 9.5 l/min (*Market Transformation Programme (3), 2008*).

There are two basic types of low-flow showerheads: aerating and laminar-flow. These types of showerheads are extremely effective at conserving water and reducing energy bills. In fact, water usage is one area most homeowners neglect when performing energy saving evaluations of their homes, but it is one of the easiest to control. Table 7 and Table 8 show currently available low-flow showerheads and retrofit devices to improve the water-efficiency of these products.

In addition to these water-saving devices, modifying use patterns of showers can improve the water efficiency of showerheads. For example, reducing the duration of a shower can be done by using a shower timer, which shows how much time has been spent in the shower.

Table 7: Low-flow showerheads

Device	Description (advantages and tradeoffs)
Aerating showerheads 	Aerating showerheads mix air with water, forming a misty spray. It maintains steady pressure so the flow has an even, full shower spray. Because air is mixed in with the water, the water temperature can cool down a bit towards the floor of the shower. Aerating showerheads are the most popular type of low-flow showerhead. They can also be used with a flow regulator for maximum water conservation.
Laminar flow showerheads 	Laminar-flow showerheads form individual streams of water. It is recommended for those who live in humid climates, because they create less steam and moisture than an aerating one.

Table 8: Retrofit devices for showerheads

Product	Description (advantages and tradeoffs)
Showerhead flow regulators 	Flow regulators for showers are easy to install and offer a quick and inexpensive way of saving water without having to create a whole new bathroom. They provide between 6 and 9 l/min flow rate, both of which allow enough water for a thorough shower. However, flow regulators cannot be fitted to electric showers.

- **Market trends**

Many key factors are currently influencing the market for showerheads. As is the case for most of the other WuPs covered in this study, the demand for additional housing, along with changing demographic factors including a higher proportion of single-person households, will influence the market growth of residential WuPs.

There is a trend towards more powerful showers and shower accessories supported by the availability of larger enclosures designed for use with higher specification showers, shower panels and body jets etc. The replacement of the bath with a shower enclosure is also increasing, particularly in smaller homes where space is more restricted and en-suite bathrooms are less common.

No significant evidence of recycling showers (wherein water once used in the showering process is held in a storage tank and recycled during a portion of the showering process in place of fresh water) was found, so it is assumed that their current impact on the market as a whole is negligible. However, they do exist and may have an impact in the future.

There is also a trend towards more powerful electric showers and features designed to improve installation. Bath/shower mixers remain popular in the new-build sector owing to the installation of en-suite bathrooms which contain a separate shower, in addition to space restrictions in the main bathroom (*Market Transformation Programme (3), 2008*).

As for water efficient showerhead devices, the market is steadily increasing as prices for these products are decreasing and people are becoming more concerned about rising water and heating tariffs.

3.1.3.5 Residential bathtubs

Definition: A bathtub is a plumbing fixture used for bathing. Most modern bathtubs are made of acrylic or fiberglass, but alternatives are available in enamel over steel or cast iron, and occasionally wood. A bathtub is usually placed in a bathroom either as a stand-alone fixture or in conjunction with a shower.

Description of the standard bathtub in the EU

Bathtubs in Europe are usually available in three main materials: reinforced cast acrylic sheet, porcelain enamelled steel, and porcelain enamelled cast iron. Baths come in a variety of designs. They may be fitted into an alcove, in a corner or in a peninsular situation. They may be freestanding and double ended for use by two. They are available in a range of sizes – the most common are 1,600 mm to 1,800 mm long and by 700 to 800 mm wide (*Bathroom Manufacturer's Association (1), 2008*).The conventional pillar tap (which was described in the sub-section on taps, pg. 45) is the most common type of tap used in baths that controls the water supply. See sub-section 1.1.1.1, pg. 95 on the water consumption of baths (for standard baths in Europe).

Factors affecting water consumption

Modern bathtubs have overflow and waste drains and may have taps mounted on them. They may be built-in or free standing or are sometimes sunken. Until recently, most bathtubs were roughly rectangular in shape but with the advent of acrylic thermoformed baths, more shapes are becoming available. The main factors affecting the amount of water used for bathing are the type of bath and its capacity, along with the frequency of usage of the bath.

Potential for improved water efficiency

Studies suggest that to improve water performance of bathtubs, showers should be used instead of taking baths for personal washing, since taking shorter showers uses less water than running a bath.

In addition, since many baths use similar taps that are found on wash basins and kitchen sinks, similar water-saving devices can also be used to improve the water efficiency (see Table 7 and Table 8 for more information).

Market trends

Studies have shown a general trend towards smaller properties, and thus the market for space saving baths and shower baths is growing (*Bathroom Manufacturers Association (2), 2008*). Space saving baths are deeper rather than long and shower baths have a wide shower area for comfortable showering and a normal bath shape at the end for lying down. Although space saving and shower baths are growing in popularity, where space is an issue many people are foregoing the bath and having a shower enclosure or wet room area only. Increasingly baths are regarded as a luxury item and in the wellness arena there will always be a demand for whirlpool baths.

Where space and budget are noobject a concern, baths of varying sizes and designs remain hugely popular with the emphasis definitely on wellness, relaxation and luxury, rather than necessity bathing.

3.1.3.6 Domestic washing machines

Definition: An appliance for automatically cleaning home laundry that has a control system which is capable of scheduling a preselected combination of operations, such as regulation of water temperature, regulation of the water fill level, and performance of wash, rinse, drain, and spin functions.

- **Description of the standard washing machine in the EU**

Washing laundry is a large water user in the average home and accounts for 15% to 40% of the overall water consumption inside the typical household. According to the preparatory study for ecodesign requirements on washing machines, the average capacity of the machines offered in the EU has changed from about 4.8 kg in 1997 to less than 5.4 kg in 2005 (*Presutto et al., 2007*). Water consumption of washing machines has been reduced as well - while in 1997 the majority of machines were reported at a water consumption of 75 litres, this value is now at 50 l/cycle.

- **Factors affecting water consumption**

Water consumption of washing machines depends on the number of occupants in the household and the frequency of use.

- **Potential for improved water efficiency**

In Europe, a number of devices and processes have been proposed to enhance the water performance of washing machines without increasing energy or water consumption, or wear on textiles. For example, intelligent sensor systems (load detection, turbidity sensors, foam sensors, etc.), which can automatically detect loading, staining, etc., can control programme options as well as adjust water/energy consumption accordingly. Others trends in technological advances include new washing programmes, which are suited for new textiles (e.g. sport and functional clothes) or special, delicate garments (particularly hand wash/wool programmes) and new machine time functions: time/start delay options (up to 23 h), time left/remaining, time digital displays which may help in managing the consumer available time (*Presutto et al., 2007*).

- **Changing use patterns**

By changing use patterns, users can also significantly improve the water efficiency of washing machines:

- When using the washing machine, make sure to use a full load every time. Surveys have shown that a typical load of laundry is usually much less than the maximum capacity of the model.
- Be familiar with the washing machine's cycle options. Some settings provide the same cleaning power as a normal cycle, but with less water and energy.

Check the user manual for water consumption information about the various cycles on the model, or contact the manufacturer.

- Avoid pre-washing. Most modern washing machines and washing powders effective enough so that pre-rinse is not necessary (*Waterwise (4), 2009*).

➢ **Market trends**

According to information from the European Eco-label, 13.5 million washing machines are sold each year in Europe (*DG Environment, (2) 2008*). The washing machine market in Europe is characterised by a very high penetration of washing machines in residential buildings with almost saturation in EU-15. In CEE-countries the penetration is increasing continuously. Because washing machines have a long product lifespan (an average of 10 years), replacements occur after 10 years or later. In the future it will be expected that the market will be mainly driven by a substitution of old appliances. For Europe, it was evaluated that 188 million household appliances are older than 10 years of which 40 million are washing machines.

The Energy label (introduced by the EU in 1999) played a decisive role in the development of the market of household appliances in the last decade (within the context of this study, the Energy Label applies specifically to washing machines and dishwashers). It provides the consumer with the opportunity to compare different appliances because it informs consumers about relevant consumption values concerning energy and water and provides information on performance criteria such as capacity, cleaning/washing performance or noise emissions. This leveraging of the information provided to the customer has forced "manufacturers … to introduce new, more efficient products", to remain competitive (*World Energy Council, 2005*).

Other information from the Eco-design study has identified the following main market trends for washing machines that can be applied to this study:

- increasing load capacity
- small machines (i.e. 3 kg) represent a niche but contribute a stable amount of the total available models
- industry has optimised the product's design to meet the energy consumption of the energy efficiency class thresholds
- 31% improvement in specific water consumption from 1997 to 2005 with an annual improvement of 0.28 l/kg
- in 2005 the majority of the models have a water consumption below 50 litre per cycle.

Table 9, Table 10, and Table 11 show market sales trends of washing machines in specific MS (Denmark and France).

Table 9: Sales Trends of washing machines in Denmark (*CECED, 2009*)

2003	2004	2005	2006	2007	% of change between 2003 & 2007
193,520	205,220	204,045	220,390	227,000	**+ 17.3%**

Table 10: Sales Trends of washing machines in France (values expressed in thousands (*GIFAM, 2007*)

2000	2001	2002	2003	2004	2005	2006	2007	2008	% of change 2000 & 2008
2,290	2,225	2,270	2,225	2,290	2,350	2,446	2,490	2,460	**+ 7.4%**

Table 11: Percentage of households in France that own washing machines (*GIFAM, 2007*)

1970	1980	1990	1999	2001	2003	2005	2007
57%	79%	88%	93.2%	95.1%	94.1%	95.4%	**95.3%**

From 2000 to 2008, there was a 7% increase in the sales of washing machines in France and an increase from 57% in 1970 to 95.3% in French households that own washing machines. Overall, these tables support the observation that washing machines will continue to be a popular EU residential WuP in the future.

3.1.3.7 Domestic dishwashers

Definition: A cabinet-like appliance which, with the aid of water and detergent, is designed to wash and sanitize plates, glasses, cups, bowls, utensils, and trays by chemical, mechanical and/or electrical means and a sanitising final rinse.

- **Description of the standard dishwasher**

Dishwashers consume from 6 to 14% of total domestic use of water. All dishwashers employ wash, rinse, and sanitising cycles. The sanitising cycle typically is the chemical reduction of microorganisms to safe levels on any food utensil. The time taken for a dishwasher to complete a cycle is a combination of mechanical action, water temperature, and chemical action. Hot water use varies with the pressure of supply lines, operation speed of the machine, and dish table layout. All these variables are intrinsically linked and any adjustments affect each component. For example, rapid washing cycles necessitate stronger mechanical action and more concentrated detergents for cleaning (*North Carolina Department for Environment and Natural Resources, 2007*).

- **Factors affecting water consumption**

Factors that affect water consumption for dishwashers are similar to that of washing machines and depend on cycle time, as well as frequency of use of the machine.

➢ **Potential for improved water efficiency**

Whilst there is still potential for technical improvement from manufacturers, *the greatest savings are now to be achieved by using the appliances carefully*, for example only washing full loads and not rinsing dishes before putting them in the machine.

New intelligent functions (similar to those mentioned for washing machines) are being developed to help improving water efficiency and include improved sensor systems and functions which automatically detect the loading, the type of tableware and the degree of soiling to efficiently adjust the water and energy consumption as well as the programme duration.

- Changing use patterns

Users can significantly influence the water efficiency of dishwashers by modifying their use patterns:

- When using the dishwasher, make sure to use a full load every time.
- Be familiar with the dishwasher's cycle options. Some settings provide the same cleaning power as a normal cycle, but with less water and energy.
- Avoid pre-washing.

➢ **Market trends**

Around 6 million dishwashers are sold each year in Europe (*DG Environment, 2004*). The dishwasher market in Europe is characterised by varying penetration rates in EU households: especially in the new Eastern MS where the penetration of dishwashers is quite low, with a steady increase of the penetration in almost all other MS. Since dishwashers are a long living product, with replacements happening after 10 years or later, there is also quite a strong substitution of installed dishwashers. The typical lifespan of a dishwasher is approximately 16 years.

The number of models offered on the market has considerably increased in recent years. This is due to increasing population growth and overall penetration of dishwashers. Smaller machines for 4 or 5 place settings (PS) play a very minor role in the market with a share below 1%, unchanged over the years. Only slightly more relevant are larger machines (about 2% of the market share) for 15 PS, replacing machines for 14 PS.

Other new features that have been observed in the market of dishwashers include aspects to improve the consumer's quality of life. For example, the reduction of noise of new appliances (from 30 to less than 60 dB), allows the integration of (silent) dishwashers. Also the reduction of the washing cycle time (up to 50%) and time pre-selecting options will play a major role in the future, because this provides the consumer with more leisure time and autonomy. Safety options (aqua stop systems, child safety, etc), already exist today and will be guaranteed in future too, but these basic features will be supplemented with intelligent options like self fault analysis, self cleaning options, etc. (*Presutto et al., 2007*).

Data from the ecodesign study has identified the following main market trends for dishwashing machines that can be applied to this study:

- the market share of small compact machines (45 cm, below 10 PS capacity) is constant in terms of market share
- very small and very large machines represent a small percentage of the (1-2% of the market)
- 22% improvement in water consumption from 1998 to 2005
- the majority of water consumption is below 15 litre/cycle for 12 PS machines[15]

Table 12: Sales trends of dishwashers in France (*GIFAM (2)*)

Year	2000	2001	2002	2003	2004	2005	2006	2007	2008
Values expressed in thousands	1,000	1,050	1,040	1,055	1,110	1,166	1,237	1,320	1,380

Table 13: Trends of the percentage of households in France that own dishwashers (*GIFAM (2), 2007*)

1970	1980	1990	1999	2001	2003	2005	2007
3%	17%	32%	43.2%	45.1%	48.1%	50.6%	53.7%

Table 12 and Table 13 show sales trends and the percentage of households in France that own dishwashers. From 2000 to 2008, there was a 38% increase in sales of dishwashers in France and an increase from 3% in 1970 to 53.7% in French households that own dishwashers.

3.1.3.8 Commercial urinals

Definition: A fixture, typically one attached upright to a wall, used by men for urinating.

- **Factors affecting water consumption**

The frequency of toilet flushes per toilet is often greater in offices than homes, although the frequency is highly variable from facility to facility. Depending on the type of commercial activity carried out in the building, customers might also incur additional flushing activity. Urinals are often set to flush regardless of use. This could lead to a lot of water is wasted. In addition, urinals must be flushed at the minimum frequency necessary to remain hygienic (*UK Environment Agency, 2007*).

- **Potential for improvement**

Many flush controller designs are available. These either use a timer to match the hours of use or detect the presence of people. This is typically achieved by means of infrared movement detectors or door switches. Mechanical designs use water flow or

[15] Ibid.

variations in pressure caused by taps being used, to open a valve to the urinal cistern. Some controls allow the urinal cistern to fill slowly unless no activity has been detected for a preset period. The following devices in Table 15 can also be used to control flush frequency and increase water efficiency.

- **Market trends**

A recent water conservation market penetration study was carried out in the East Bay Area of California (United States of America - USA) (*East Bay Municipal Utility District, 2002*). The study surveyed the types of urinals used in commercial settings to assess the penetration of water efficient urinals in different sectors.

The study indicated that the total penetration of low flush urinals (with a rated flush volume below 3.8 lpf) was between approximately 22 and 24% (Table 14). In-depth and reliable market data for urinal production, sales and trade in Europe could not been identified. The commercial sector, however, scored very low, accounting for only 5.9% of the market share. Across all sectors there is potential to introduce an increasing number of water efficient urinals.

Figure 11 shows the findings of this study where in most cases there are a high percentage of urinals that use less than 3.8L per flush. However, a large percentage of urinals in the commercial sector were found to use between 4.2L and 7.6 litres per flush. Offices in particular had a high percentage of urinals that operated within this range. This may indicate that offices could be a future target for increasing urinal flush efficiency. It is worth noting however that, with the exception of the commercial sector, the majority of urinals could not be rated according to flush volume (classified as ‘Unknown’).

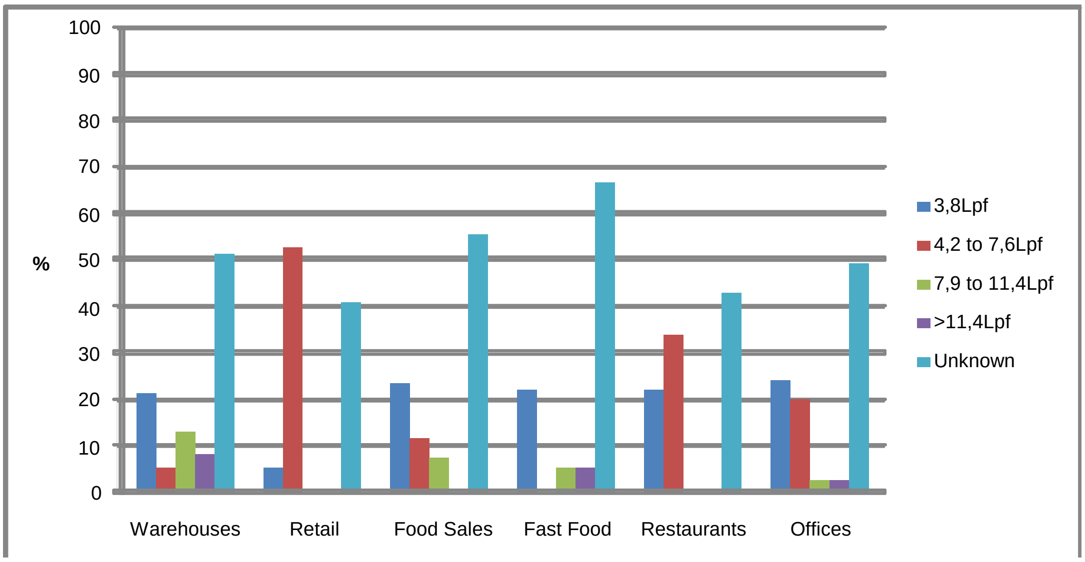
Table 14: Market penetration of low flush urinals

Product	Percentage of Market in Each Sector Surveyed					
	Warehouses	Retail	Food Sales	Fast Food	Restaurants	Offices
Low Flow Urinals	21.6	5.9	24.0	22.2	22.7	24.4

Table 15: Water-efficient urinals

Device	Description
Hydraulic valve 	A hydraulic valve (pressure reducing valve) can be fitted to the inlet pipe work of the urinal system. When the inlet water pressure decreases temporarily through water being used elsewhere in the washroom (e.g. WC toilet flushing or hand washing), the diaphragm operated valve opens, allowing a pre-set amount of water to pass to the urinal cistern. When the cistern is full, the auto-siphon will discharge and flush the urinal. When the washroom is not being used, the pressure remains unchanged and the valve remains closed (*Envirowise, 2005*).
Passive infrared sensor 	Passive infrared sensors identify when the urinal has been used (or when someone has stood in front of it and moved away), and activate the flush. Thus the urinal is cleaned, where with a manual flush it might not have been, but water is not wasted when the toilet is not used. A passive infrared (PIR) sensor can be installed in the washroom to detect use of the urinal facility. This sensor controls a solenoid valve to allow a pre-set amount of water into the cistern per use. When the cistern is full, the auto-siphon will discharge and flush the urinal.
Waterless urinals 	Waterless urinals work without using any water other than for routine cleaning. Some systems are supplied as a complete unit, while others can be retrofitted to standard bowls and troughs. They offer significant water savings and address some of the problems associated with conventional urinals, namely scale, odour, blockage, and subsequent flooding.
Timed Urinals	A timed flush operates automatically at regular intervals. Groups of up to ten or so urinals will be connected to a single overhead cistern, which contains the timing mechanism. A constant drip-feed of water slowly fills the cistern, until a tripping point is reached, the valve opens (or a siphon begins to drain the cistern), and all the urinals in the group are flushed. Electronic controllers performing the same function are also used. This system does not require any action from its users, but it is wasteful of water where the toilets are used irregularly.
Cistern valve Adjuster	Flush volumes can be optimised by reducing the cistern size or by installing a cistern volume adjuster (CVA). It is a simple device is either filled with or absorbs water (1.5 - 2 litres) once it is inserted in the cistern, thus reducing the volume of the cistern. However, each pan design has a minimum flushing volume and not all CVAs are appropriate for all types of cistern.

Figure 11: Distribution of urinals by rated flush volume



3.1.3.9 Commercial taps

➢ **Description of the standard commercial tap in the EU**

Taps can waste large amounts of water, as they are the most heavily used water source in kitchens. Information on commercial taps is similar to those found in homes. See section 1.1.1.1, page 45 on residential taps for a general description of the standard tap.

➢ **Potential for improvement**

Spray taps can save a large amount of water and energy used for hand washing but they can restrict the flow too much to fill the basin quickly. A clever invention that aims to address this problem is the Tap magic insert, which can be fitted to most taps with a round outlet hole or standard metric thread. At low flows, the device delivers a spray pattern suitable for washing hands or rinsing toothbrushes. As the flow is increased, the device opens up to allow full flow to fill the basin.

Sensor taps and timed turn-off push taps prevent wastage and flooding where taps may be left running. They also offer improved hygiene, as the tap does not have to be touched after hands have been washed. To make sure savings are achieved and the user is satisfied, the fitting must suit the water pressure and allow for correct adjustment.

Another innovation is a water-saving cartridge for single-lever mixer taps. As the lever is lifted, resistance is felt. If a higher flow is needed, the lever can be pushed past this step. Some designs make sure that only cold water comes out when the lever is in the middle position.

Where water is supplied at mains pressure, an aerator or laminar flow device can eliminate splashing. These devices can incorporate flow regulators and provide the illusion of more water than is actually flowing. Available flow rates for basin taps include 8, 6 and 5 l/min. All provide plenty of flow for using directly or filling a small basin (*UK Environment Agency, 2007*).

Water-saving devices for commercial faucets are very similar to those discussed for taps used in homes.

- **Market data and trends**

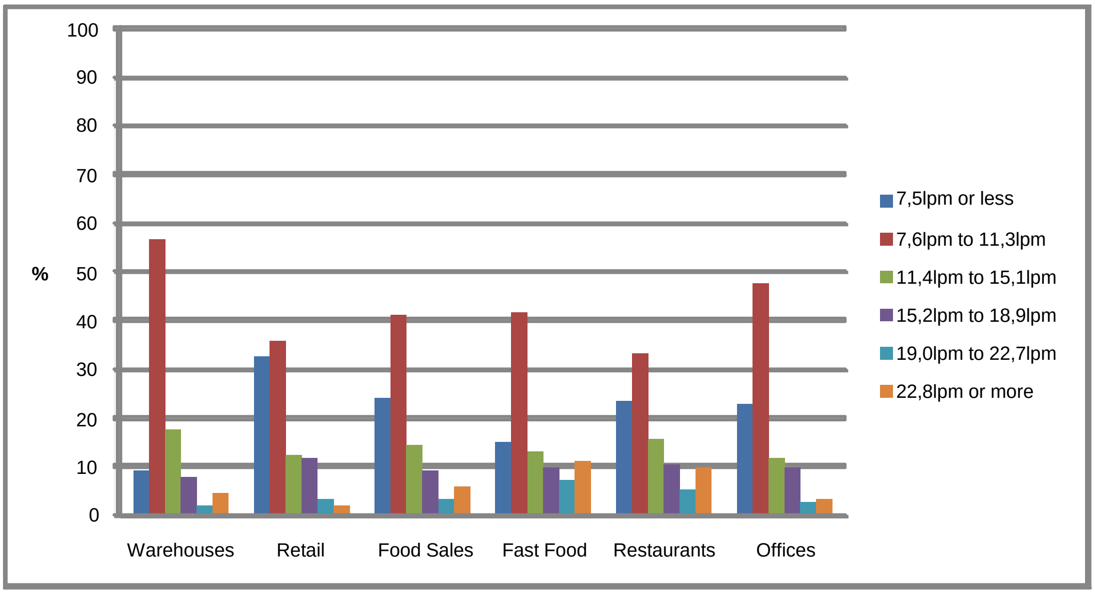
Data from the U.S. East Bay Area study has revealed that across all commercial sectors, the majority of taps use a flow rate of 7.6 to 11.3 l/min. With the exception of warehouses, low flow taps take up the second largest share across all sectors.

Despite the low percentage of lower flow taps in the warehouse sector, it has one of the highest market penetration percentages for tap aerators. It is rivalled only by offices, where aerators have a 78.3% market share as is indicated in Table 16.

Table 16: Market penetration of tap aerators

Product	***Percentage of Market in Each Sector Surveyed***					
	Warehouses	*Retail*	*Food Sales*	*Fast Food*	*Restaurants*	*Offices*
Taps containing Aerators	72.2	65.9	60.8	60.1	57.5	78.3

Figure 12: Distribution of non-residential taps by flow rate



Aerators appear to take up a large share of the non-residential tap market, although there appears to be room for increase. It is important to note, once again, that the above figures relate to a specific area within a non-European country. Aggregated production data has been obtained from the PRODCOM database which does not distinguish between residential and commercial taps. This data has been included in sub-section 3.1.3.17, page 77 below on overview of markets trends for WuPs found in the building sector.

3.1.3.10 Commercial toilets

- **Description of the standard commercial toilet in the EU**

Commercial toilets can be found in establishments such as schools, hospitals, businesses, airports, etc. According to Defra, toilets can comprise half of the water used in commercial offices (*Defra, 2008*). It is important to distinguish toilets in commercial and residential settings because there are significant differences – both in their physical construction and operation – between these toilet installations.

For example:

- Installation settings: commercial fixtures are often installed on 4-inch diameter drain pipes set at a 1% slope whereas residential fixtures are typically installed on 3-inch diameter pipes set at a 2% slope
- Use capacity: commercial toilets, which are often required to flush paper toilet seat covers, paper towels, large amounts of toilet paper, etc., are typically subjected to a much greater waste loading than residential toilets
- Drains and sewage systems: the lengths of drain runs are often much longer in commercial installations, and
- Supplemental flows: supplemental flows are often much less in commercial installations (supplemental flows from bathing, clothes washing, etc., help transport waste through drain lines) (*Alliance for Water Efficiency (4), 2009*).

- **Factors affecting water consumption**

As already mentioned in the section on residential toilets, the frequency of toilet flushes determines overall water consumption. The frequency of toilet flushes per toilet is often greater in offices than homes, although the frequency is highly variable from one facility to another. Similar to commercial urinals, depending on the type of commercial activity, customers might also incur additional flushing activity.

- **Potential for improvement**

Water saving toilets have been introduced into residential applications because of favourable conditions such as smaller diameter drain piping, steeper slope, and availability of supplemental flows; however, there has been some debate about the use of these toilets in all commercial applications. The main issues in installing them in commercial sites are the drain lines. With little or no supplemental flows, drain line problems can occur because of the decreased flush volumes of the highly efficient toilets and lack of supplemental flows (from showers and tap use). Therefore, careful attention should be made when deciding whether to install High-Efficiency Toilets (HETs).

- **Vacuum toilets**

Vacuum toilets are not usually found in buildings. These types of toilets are often seen in transportation facilities such as aircrafts, ships, and trains. However, some exceptions do exist in the case of vacuum toilets found in buildings. For example, some hospitals provide vacuum toilets to collect the excreta of people treated by radioactive substances. Vacuum toilets are so far used under conditions, where there are special requirements for transport or the necessity of storage of the toilet's effluent. Vacuum toilets use between 0.3 to 1.4 litres of water per flush (*Maksimović et al., 2003*; *Grant, 2002*).

All available vaccuum toilet systems use zero water but some require electricity. Dry toilet designs are evolving but are mostly intended for rural sanitation. Vacuum technology may have wider application but would require some technical problems to be solved if it is to be used on the domestic scale whether in individual dwellings or blocks of flats. Finally cost and life cycle issues must also be considered (*Grant, 2002)*.

- **Market trends**

As shown in Figure 13 , non-residential toilets with a rated flush volume below 6.1 litres appeared to take up a greater share of the market across all sectors, with the exception of warehouses (*East Bay Municipal Utility District, 2002*). If the scenario is assumed to be comparable to that of Europe, there is potential for improvement. When looking at the overall market penetration within each sector, low flush toilets appear to lead, with a minimum of 31.8% of the market share.

Figure 13: Distribution of non-residential toilets by rated flush volume

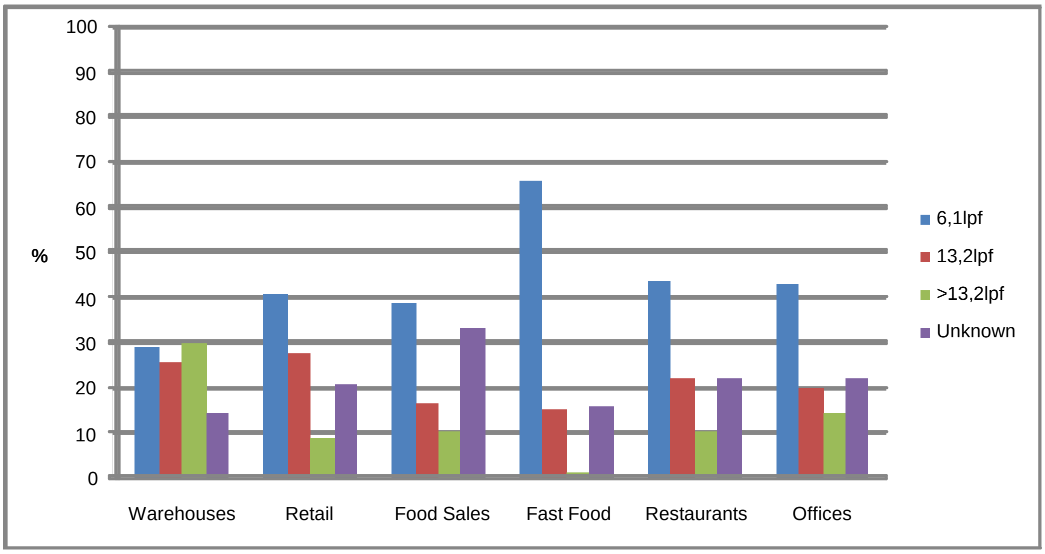


Table 17: Market penetration of non-residential ultra low flush toilets

Product	*Percentage of Market in Each Sector Surveyed*					
	Warehouses	*Retail*	*Food Sales*	*Fast Food*	*Restaurants*	*Offices*
Ultra Low Flush Toilets	31.8	45.4	47.2	68.0	44.1	49.8

A recent study identified that in restaurants, the percentage of non-commercial low flush toilets used has grown significantly, from 11.9% to 44.1% over a period of 10 years (until 2001) (*East Bay Municipal Utility District, 2002*).

Once again, the above data may provide some information on market penetration; although the figures may not be applicable to Europe. Aggregated production data has been obtained from the PRODCOM database which does not distinguish between residential and commercial toilets, which is seen in Table 17. This data has been included in sub-section 3.1.3.17, page 77 below. In depth market data for commercial toilet production, sales and trade in Europe could not be identified.

3.1.3.11 Commercial ice makers

Definition: Ice-makers are machines used to produce ice either ice cubes, flake ice or crushed ice. Typical applications include ice storage in food preparation and display (hostel, restaurants), for ice sales to customers, fish storage on boats, and for drinks in food retailing.

- **Description of the standard commercial ice maker in the EU**

Ice-makers are present in many commercial sites such as in hospitals, hotels, restaurants, retail outlets, schools, offices, and grocery stores.

There are two basic ice-maker equipment designs: air-cooled refrigeration units and water cooled refrigeration units.

Ice-makers can be of different types depending on the type of ice produced, e.g. ice cubes, ice nuggets, ice flakes. The type of ice produced is foreseen as a significant parameter to take into account, e.g. one leading manufacturer of ice-makers in the US states that nugget ice-makers have advantages over cube type machines in both energy consumption and water consumption.

- **Potential for improvement**

The performance of ice-makers can be improved by a range of measures, some of which are applicable to most refrigeration systems. These typically include the use of:

- appropriate thermostatic controls, time-clocks and/or switches to control the operation of the ice maker;

- capacitor start compressors: these increase compressor efficiency from around 45% to between 50% and 55%;
- incoming water to help loosen ice rather than heating already chilled water;
- high-efficiency motors for the condenser fans, where relevant;
- high efficiency fan blades;
- mechanical assist defrost;
- a heat exchanger to pre-cool the incoming water, using the cold drain water;
- high insulation levels for ice storage bins;
- careful selection of the correct size of machine and bin.
- an efficient ice machine uses no more than 20 gallons per hundred pounds of ice made; and
- flake ice machines are even more water efficient, using 12 gallons per 100 pounds of ice (*Mark Ellis and Associate, 2004*).

➢ **Market trends**

Worldwide commercial ice machine shipments increased by 62% between 1989 and 1999 (Table 18). It is believed that as the number of food and beverage related businesses grow, so too will the number of ice machines produced. At present the current European ice machine stock is estimated to be above 3.3 million units. Furthermore, sales are estimated to be around 0.4 million units per year, indicating a potentially significant market in Europe.

Table 18: Worldwide shipment value of ice machines (*Deneen, 2001*)

Product	***Shipment (millions of dollars)***		
	1989	*1994*	*1999*
Ice Machines	830	1,040	1,345

In-depth information on market trends for these types of products could not be identified.

3.1.3.12 Commercial washing machines/laundries

Definition: A commercial washing machine is intended for more frequent, a tougher duty cycle, and long-term usage than a domestic washing machine.

➢ **Description of the standard commercial washing machine in the EU**

Many commercial washing machines are built for use by the general public, and are often installed in publicly accessible laundromats or launderettes, operated by money accepting devices or card readers. The features of a commercial laundromat washer are more limited than a consumer washer, offering just two or three basic wash types plus an option to choose wash cycle temperatures. Such washing machines are also found in commercial settings such as hotels, nursing homes, prisons, universities, and hospitals.

Commercial washers for business include some extra features that are not seen in domestic washing machines. For example, many commercial washers offer an option for automatic injection of five or more different chemical types, so that the operator does not have to deal with constantly measuring soap products and fabric softeners for each load. Instead a precise metering system draws the detergents and wash additives directly from large liquid-chemical storage barrels and injects them as needed into the various wash and rinse cycles.

Liquid chemicals are usually preferred because of the ease of administration through a series of peristaltic metering pumps. These pumps are programmed to deliver precise amounts of chemical during the appropriate phase of the wash and take their signal from the washer controls.

- **Potential for improvement**

Although laundries consume large amounts of both energy and water, conservation opportunities in this arena are relatively untapped, and thus are ripe for the introduction of new technologies that can meet the industry's reliability and cost-effectiveness expectations.

Several factors must be met for any new technology to be successful in the laundry environment. Not only must the technology meet all of the customer's financial criteria, it must also meet operational and maintenance requirements, and physical space constraints. Naturally, the technology must work with very high reliability and it must be maintainable by the "in-house" maintenance personnel with minimal additional work or have a low cost program for maintenance available from the manufacturer (*Riesenberger, 2005*).

- **Market trends**

Aggregated production data has been obtained from the PRODCOM database which does not distinguish between residential and laundry type washing machines, which is seen in Table 19. This data has also been included in sub-section 3.1.3.17, page 77.

Table 19: Water efficient technologies for commercial washing machines

Device	Description
AquaRecycle	AquaRecycle is a wastewater recycling system designed and sold only in commercial laundry applications by EMI Water Recycling Systems since 1998. It is considered a full recycle system and is designed to recycle 100% of the wastewater from the wash and rinse cycles and it reapplies this water throughout the entire array of succeeding wash and rinse cycles. Aquatex 360 - Wastewater Resources, Inc. (WRI) has developed a system called Aquatex 360, specifically designed for recycling water in commercial laundries
Ozone Laundry Systems	Ozone is a very strong oxidant that works well in cold water thereby saving a great deal of water heating energy when compared to conventional laundry processes. Additionally, because of the unique oxidation properties of ozone, there is a theoretical Since ozone is so unstable and cannot be shipped or stored, it must be made at the point of use.
Rinse Water Recovery Technologies	One of the concepts utilised in laundries in the past has been rinse water recovery. This type of system works by diverting water recovered from rinse-only cycles into a large holding tank near the laundry wash line. Whenever a washer calls for water in a soak, suds or wash cycle, the water stored in the rinse water holding tank is pumped into the washers. One manufacturer, Thermal Engineering of Arizona (TEA), has been successful in installing their system in several institutional properties, such as Veterans Administration hospitals and state prisons, but these systems are not found in typical commercial laundry applications. They involve high initial cost, and very long payback periods, making them often unattractive in commercial settings

3.1.3.13 Commercial dishwashers

Definition: A cabinet-like appliance which, with the aid of water and detergent, is designed to wash and sanitise plates, glasses, cups, bowls, utensils, and trays by chemical, mechanical and/or electrical means and a sanitising final rinse.

➢ **Description of the standard commercial dishwasher in the EU**

Commercial dishwashers are considered to be one of the largest water consumers in commercial kitchens, often using more than two-thirds of the overall water use. The equipment can vary widely in size and shape. Classes of commercial dishwashers include under counter, stationary rack door type, rack conveyor machines and very large flight type (continuous conveyor) machines. Each of these product classes may employ single or multiple wash tanks, and use hot water (high-temp machines) or chemicals (low-temp machines) to achieve final rinse dish sanitisation.

All commercial dishwashers have at least one tank that provides hot water with a temperature ranging from 110°F to 140°F. High-temp machines require an additional booster water heater to provide sanitised hot water above 82.2°C (180°F) during the rinse cycle.

Using water softener can reduce mineral deposits on the heating element and will help the machine work more efficiently. Otherwise, the salts that break out of the water during the heating process can attach themselves to the heating element and to pipe work, where they can cause serious damage to the machine.

- **Potential for improvement**

Lowering the rinse water consumption not only saves water, but also presents the most significant opportunity for energy savings for this product. Several additional devices exist that can be fitted onto or used in conjunction with commercial dishwashers to improve water performance. Following are some examples:

Typically, large restaurants and food service operations utilise commercial dishwashers. Prior to loading the dishwasher, plates and dishes receive manually sprayed water (pre-rinsed) to remove loose or 'sticky' food. The washing of dishes typically consumes two-thirds of all water used from the restaurant. Water used in this pre-rinsing operation is often twice the volume of water used by the dishwashing equipment. The most cost-effective water conservation measure in a commercial food service operation is improving the efficiency of the pre-rinse spray valve.

Technologies that can improve the energy and water efficiencies of commercial dishwashers include:

- Wash tank insulation
- Wash compartment insulation
- Sensors to control conveyor movement
- Multi-staging systems that reuse rinse water to pre-rinse dishes
- Built-in booster heaters
- Built-in heat exchangers
- Advanced rinse nozzles
- Infrared burners
- Double wall construction

Since the life expectancy of a commercial dishwasher is 20 to 25 years, high efficiency units offer the potential for substantial energy and water-use savings. Extra cost for efficient dishwashers over standard models suggests a total lifecycle cost for efficient models is always a wise investment when a consumer is already planning to purchase a dishwasher.

The high cost of dishwashers may thwart early replacement (where a pre-existing dishwasher is still operating) efforts based on water and energy savings alone; local utility prices and volume of use for the equipment will dictate the cost-effectiveness for early replacements. Large restaurants with all day service (often found in large hotels) will save water at a faster rate than small, single meal service type restaurants. Utility agencies need to analyse if cost-effective financial incentives are great enough to induce restaurant owners to replace dishwashers still in good operating condition. Water agencies often accept payback periods as long as 20 years; while restaurant owners seldom invest in any energy and water efficiency with more than a 5 year payback period (*Food Service Warehouse, 2009*).

Using water softener can reduce mineral deposits on the heating element that will help the dishwasher work more efficiently. Otherwise, the salts that break out of the water during the heating process can attach themselves to the heating element and to pipe work, where they can cause serious damage to the dishwasher.

- **Market trends**

Data gathered from the PRODCOM database, category 29.24.60.00 '*Non-domestic dish-washing machines*' has revealed that non-domestic dishwashers have a large share in the European market, with over 373 000 units produced in 2007 (Table 20). Production in Europe has increased by approximately 14.4% between 2004 and 2007.

Table 20: Production of commercial dishwashers in Europe

Product	2004	2005	2006	2007
Non-domestic dish-washing machines	329 895	346 280	343 999	373 219

However, trade figures for this period show that a large number of units are exported from the EU, more than the units imported (Table 21). In 2007, exports accounted for approximately 27% of total production. However, the percentage of exports to annual production is similar for previous years. This confirms that the commercial dishwasher sector is a growing market.

Table 21: European trade data for commercial dishwashing machines

Product	2004		2005		2006		2007	
	Exports	Imports	Exports	Imports	Exports	Imports	Exports	Imports
Non-domestic dish-washing machines	91 130	8 381	102 480	12 808	74 659	15 831	100 778	20 587

3.1.3.14 Commercial car washes

- **Description of the standard commercial car wash in the EU**

Commercial car washes constitute a highly visible use of water in the commercial sector. There are three main types of professional car washers – conveyor, in-bay automatic, and self-service car washes.

Conveyor Car Wash - There are two types of conveyor cars washes: full-service and exterior only. The professional full-service wash cleans the exterior and interior and the customer waits outside the car while the wash proceeds. During the professional exterior only wash, the driver stays in the car. The car moves on a conveyor belt during both types of washes. In addition to the division based on level of service, there are two basic technologies for the wash cycle, friction, and frictionless. The friction conveyor uses brushes or other material or curtains made of strips of cloth, while the frictionless conveyor uses high-pressure nozzles for a touch-free wash.

Roll-over/In-Bay Automatic Car Wash (IBA) - Mostly found at gas stations and the coin-operated car wash, the driver pulls into the bay and parks the car. The vehicle remains stationary while a machine moves back and forth over the vehicle to clean it, instead of the vehicle moving through the tunnel. Professional in-bay car washes use nylon brushes or other material, soft cloth strips or touch-free automatic washers.

Self-Service Car Wash - This car wash allows the consumers to wash the car themselves. A high pressure hose dispenses water and cleanser at varying amounts and pressures. Often a low-pressure brush is offered to assist in the wash cycle (*Brown, 2002*).

- **Potential for improvement**

Several actions and technologies exist to improve the water efficiency of professional car washes.

- **Water reclaim technology**

The primary function of a wash water reclaim unit is to collect, treat, store and re-use the effluent produced from washing vehicles. These units offer cost and space effective solutions to reduce water consumption.

There are two sub-categories of water reclaim units: partial reclaim and full reclaim systems. Partial reclaim systems are generally cheaper than full or total reclaim systems and, as a result, are more common. Typically, a partial reclaim system will recover up to 65% of wash-water and requires significant water input from an additional source to compensate for the losses from previous washes. However, this may be done in a sustainable way if the supply is augmented from, for example, harvested rainwater.

Although there is an obvious benefit of a wash-water reclaim unit in reducing water costs, it should be noted that the system requires continual maintenance. Typical issues include changing and cleaning filters, as well as regular checks to ensure the equipment is in good working order. The following example illustrates how a carwash could save money through investment in vehicle wash-water recycling technology:

A typical carwash will wash 84 vehicles per day using 21 cubic litres at a cost of £30.66 per day. Over 1 year, the cost of water would be about £11 190. A Total Water Reclamation System would recover 95% of the water used, generating a saving of £10 630 and reclaiming 7 282 litres of water per year. The cost of a Total Water Reclamation system (including civil works) would be in the region of £17 000; so payback would be approx 1.5 years (*Eco-water, 2008*)

Professional car wash water reclamation has been in use and growing in sophistication for at least three decades. Reclamation is getting more attention in the past several years from regulators and manufacturers as a means of water conservation and quality control (*Brown, 2002*). Some of the possible options to reduce water consumption in commercial car washing services are listed in Table 22.

Table 22: Actions to reduce water consumption at car washes (*Brown, 2002*)

Type of Car Wash	Steps to reduce water consumption
Self-Service	• Reduce nozzle size. • Reduce pressure. • Turn-off spot-free rinse. • Discontinue bay/lot wash down. • Discontinue landscape water. • Reduce hours of operation.
In-Bay Automatic	• Cut out soap pass, if more than one pass. • Reduce nozzle size. • Eliminate spot-free rinse, underbody rinse, rocker panel pass. • Increase speed of cycle times. • Reduce pressure. • Discontinue bay/lot wash down. • Discontinue landscape water. • Reduce hours of operation.
Conveyor	• Utilise all steps from self-service/in-bay automatics. • Place floats on towel washing machines. • Speed up the conveyor - Reduce rinse cycles to no more than 40 seconds per car. Increasing conveyor speed is the easiest means of achieving water savings in this manner. • Turn off one or more arches. • Reduce prepping, turn off prep guns. • Re-arrange nozzles on the top and sides of arches - use gravity to assist the wash and rinse process: bigger nozzles placed on top, and smaller nozzles on sides.

Waterless car wash

A waterless car wash or dry wash is a technique used to wash a vehicle without using of water. This technique uses a product that contains a mix of ingredients, including wetting agents, lubricants, surfactants and protectants. Many of these products currently exist on the market. See Figure 14 for some examples.

Figure 14: Examples of waterless car wash products available in the EU


(UK)[19]


(DE)[20]


(FR)[21]

Market trends

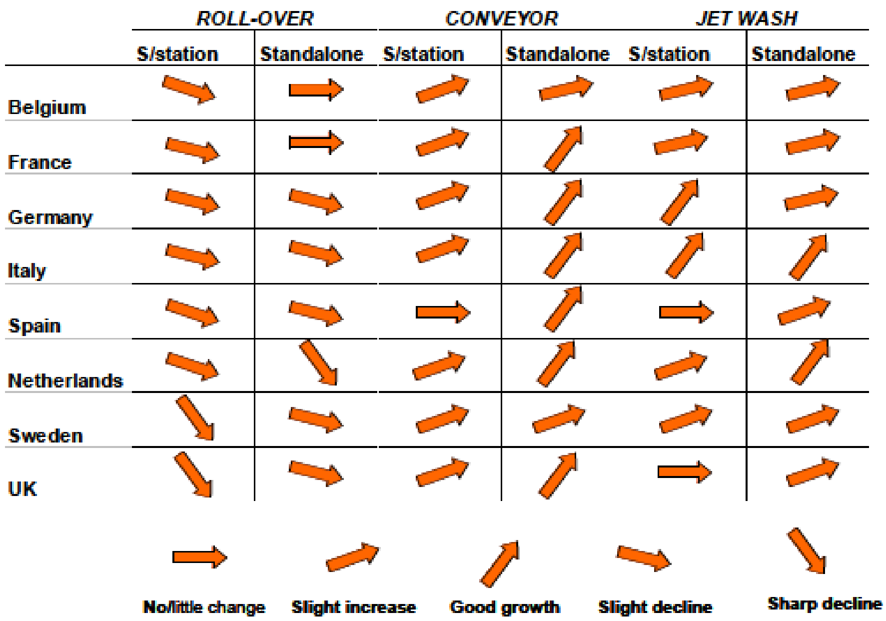
[19] http://www.aquanought.co.uk/shop/

[20] http://www.saramedia.de/shineneu.htm

[21] http://www.econo-ecolo.org/

Recent surveys show that France, Belgium and the Netherlands are expected to be the fastest growing car wash markets in 2007. Average site throughputs in Belgium were the highest in 2002 and are expected to increase for both tunnels (conveyer) and jet wash to 2007. German and Spanish motorists washed their cars most frequently in 2002 (*Research and Markets, 2003*). Figure 15 illustrates the trends that were expected to occur in the carwash market for 8 MS in 2007. The figure shows the number of roll-over installations was expected to decrease in all MS, both in service stations and as stand-alone washers. Conversely, the number of conveyer car washes was expected to increase, especially stand-alone washers. Finally, jet washes (which can include self service car washes) were predicted to experience a slight increase in both number of sites and stand-alone installations.

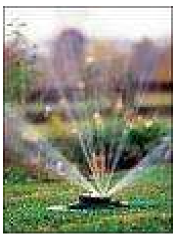
Figure 15: Growth in car wash sites/installations by type (*Datamonitor, 2001*)



3.1.3.15 WuPs in both residential and commercial buildings

The products discussed in this sub-section are those that are found in both residential and commercial buildings with little differentiation in terms of product design, user behaviour, or product functionality. This includes mainly outdoor WuPs such as sprinklers, hoses, and pressure washers and cooling systems.

- **Residential and commercial outdoor WuPs**



Definition: A watering system using various technologies to disperse water for growing plants, watering a lawn, or washing a vehicle.

The most common reason for outdoor water use in households is to maintain gardens and lawns, as well as for washing cars. Businesses (excluding those in the agricultural sector) that use irrigation equipment use similar devices that are found in residential properties except at a larger scale. Examples of businesses that use these types of larger scale irrigation equipment include golf courses (to maintain golf terrains) and landscaping companies. Irrigation equipment includes devices such as hoses, impact rotor sprinklers to valves, controllers, and drip emitters.

- **Sprinklers**

While sprinkler heads come in myriad sizes, shapes, brands, and styles, there are four basic types of sprinkler heads:

- Pop-up spray and rotor heads
- Impact rotors
- Gear-driven rotors
- Large turf rotors

In the United Kingdom, lawn areas are normally watered using popup sprinklers, which rise up from within the lawn when watering commences. Inside each sprinkler there is a gear drive which causes the sprinkler head to rotate back and forth. Once watering has finished they retract down below the turf level, making them virtually invisible. Larger models even have turf caps to make them completely invisible.

Depending on the model, a sprinkler can cover a radius between 3 m and 30 m. Sprinklers are spaced out to ensure a reasonable overlap between sprinklers. Windy sites need a greater overlap than sheltered positions as the wind will cause drifting. Sprinkler heads, are an integral part of many residential irrigation systems designed to distribute water to the landscape. An automatic sprinkler system can be simply programmed, turned on and left to run.

- **Hose-pipes**

A hose-pipe or garden hose is a flexible tube used to carry water. There are a number of common attachments available for the end of the hose-pipe, such as sprayers and sprinklers (which are used to concentrate water at one point or over a large area). Hose-pipes are also used for filling of portable water buckets to wash vehicles and water gardens.

Hoses are usually attached to a hose spigot (tap), which is connected to the house's main water supply. Hose-pipes are typically made out of synthetic rubber or soft plastic, reinforced with an internal web of fibres. As a result, most hose-pipes are flexible and their smooth exterior facilitates pulling them past trees, posts and other obstacles. They are also generally tough enough to survive scraping on rocks and being stepped on without damage or leaking.

For most normal sized residential gardens, using a hosepipe instead of sprinklers are much more efficient however, manual watering is more time and labour intensive and requires regular attention and vigilance.

- **High pressure hoses (or pressure-washer hoses)**

A pressure washer relies on a high pressure jet of water to clean surfaces. Pressure washers may be supplied as either electric or fuel powered (diesel, gasoline or gas) units. They are often used in residential and commercial settings to wash homes, buildings, and sidewalks. Besides cleaning dust, dirt, or bird residuals from the house or building, pressure washing houses can be done in preparation for new paint by removing chalking residues from old oil or latex paint. Deck cleaning is another common use for pressure washers. These hoses are similar to those found in industry. See sub-section 3.2.3.3 pg. 123 on industry cleaning equipment and pressure washers for further information.

➢ **Factors affecting water consumption**

The average amount of water used outdoors (which includes watering gardens, lawns, and washing cars) in European households varies greatly according to climatic conditions. For example in the UK, water used outdoors accounts for only about six per cent of the amount of domestic water used each year. However, on hot summer days, when supplies are tightest, over 70% of the water supply may be used for watering gardens. Thus, average household water usage demand tends to be highest in the warmer months, at times when water can be in short supply.

➢ **Potential for improved water efficiency**

Table 23 lists existing water-saving technologies to improve the water efficiency of outdoor WuPs. In particular, smart controllers are an emerging technology for adjusting watering applications based on actual weather and soil conditions. According to the Irrigation Association's Smart Water Application Technology (SWAT) program, smart controllers estimate or measure depletion of available plant moisture to operate an irrigation system that replenishes water as needed while minimising excess. A properly programmed smart controller makes irrigation adjustments throughout the season with minimal human intervention. The technology to control irrigation application automatically has been included in large-scale commercial systems for some time, but is relatively new to the residential and small commercial sectors. Over the past five years the number of smart controller products on the market has increased dramatically with different manufacturers opting for different control technology solutions. Two fundamental irrigation control technologies have been implemented to manage water use in the current crop of smart controllers - (1) sensor based control; or (2) signal based control (*Alliance for Water Efficiency (2), 2008*).

- **Hose-pipe bans**

Hose-pipe bans have been imposed in Europe, which means that people are not allowed to use a hosepipe or sprinkler for watering domestic gardens or washing cars. Hosepipes and garden sprinklers can use as much water in an hour as a family of four in a day, so restrictions on their use can make a real difference, particularly at times of high water demand. A hosepipe ban mainly affects domestic customers and is designed to reduce water consumption with the least impact on lifestyle and livelihoods (*Horton et al., Date unknown*).

Changing use patterns

Modifying use patterns of outdoor WuPs can have a significant impact on overall water efficiency. The following sub-sections show ways users can change their use of outdoor WuPs for water-savings (*Cambridge Water Company, 2008*).

- *Watering gardens and lawns*

Using rainwater is an excellent way to save water when maintaining gardens and lawns. Collecting the rainwater in a water butt (see Table 23) fed by gutters is an effective way of storing rainwater to be used later for watering. Some water used in the home can also be recycled and reused for use on the garden, i.e. water that has been run-off, or water used to clean vegetables. For lawns, grass can survive for long periods without water and will quickly recover from drought, thus it can be watered less frequently. In addition, heavy watering of lawns encourages the roots to come to the surface, thus rendering it less tolerant to dry conditions.

Automatic watering

Hosepipes and sprinklers are expensive to use because of their high water consumption rate and thus play a factor in their use patterns. Trigger devices are available which fit onto hosepipes so the water can be turned off easily. Sprinklers that project water high up into the air waste water because much is lost through evaporation. Sprinklers or any other kind of watering system which uses water from the mains should have a water meter fitted as this will measure all the water used at the property so that users pay for what is used. Finally, taking a car to a commercial car wash instead of washing it at home can also provide significant water-savings (see 3.1.3.14 on commercial car washes).

Market trends

Preliminary market research on residential and commercial outdoor WuPs has not uncovered any significant data sources for this product sector. However, some PRODCOM data was identified in Table 23 that can be used to get an overall picture of the market for residential garden irrigation products. Overall the data shows that “agricultural or horticultural water appliances” have increased since 2004, although there was a slight decrease in production from 2006 to 2007. It should be noted however, that the PRODCOM classification for “agricultural or horticultural watering appliances” does not specify whether data is for both or either domestic or commercial products, nor does it specify particular watering appliances.

Table 23: Production quantity for “Agricultural or horticultural watering appliances”—Classification according to PRODCOM

2004	2005	2006	2007
5 600 000[22]	4 889 810[23]	9 402 636[24]	9 234 588[25]

[22] This total has been rounded to the base given in the BASE indicator
[23] This total is constructed from the EU25 total shown, plus the sum of the "EU2" countries rounded to the base given in the BASE indicator
[24] At least one of the national figures in this EU aggregate is estimated

Table 24: Water efficient home watering systems

Device	Description
Sensor Based Controllers	A sensor-based controller uses real-time measurements of one or more locally measured factors to adjust irrigation timing. The factors typically considered include: temperature, rainfall, humidity, solar radiation, and soil moisture. A sensor-based system often has historic weather information (i.e. an ET curve) for the site location programmed into memory and then uses the sensor information to modify the expected irrigation requirement for the day.
Signal Based Controllers	A signal-based controller receives a regular signal of prevailing weather conditions via radio, telephone, cable, cellular, web, or pager technology.
Recovering rainwater/Water butts 	Rainwater from guttering can be used untreated (after coarse filtering to remove leaf and other debris) on gardens or for vehicle cleaning. It involves collecting the water from roofs. The most common method of storage is to use a water butt. Afterwards, using rainwater from a water butt can be used to water plants or in a drip irrigation system.

3.1.3.16 Cooling systems used in residential and commercial buildings

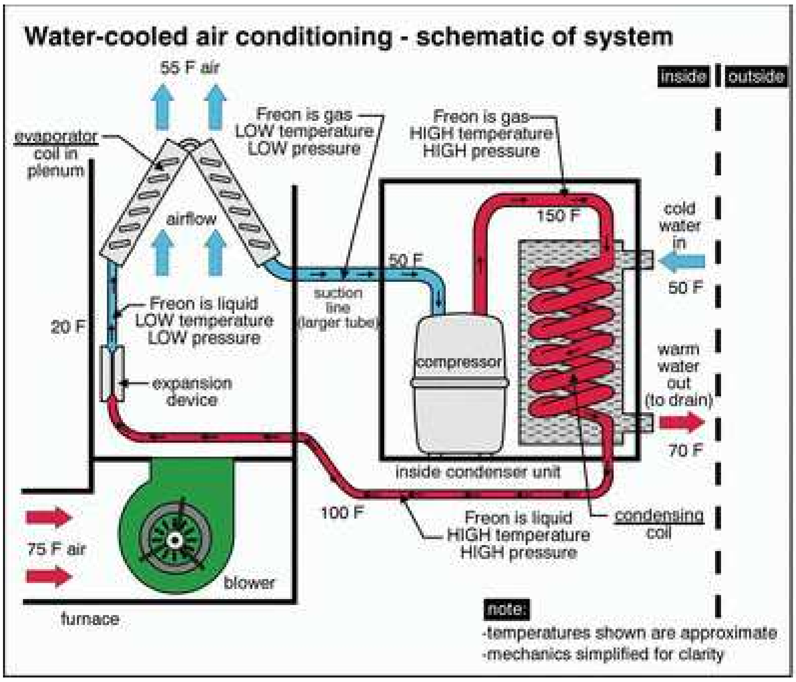
Cooling systems that are found in both residential and commercial settings are conditioners. There were two main primary functionalities among air conditioners: (i) to maintain air temperature inside a room (cooling *and* heating) and (ii) to maintain air temperature inside a room (cooling only) leading to two distinct categories (reversible air conditioners and cooling only air conditioners) *(Armines, 2008).* Contrary to cooling systems in industrial settings, cooling systems in residential and commercial buildings are used for comfort instead of process applications. Comfort applications aim to provide an indoor temperature that remains relatively constant in a range preferred by humans.

There are three types of cooling systems technologies found in buildings that use water: water cooled, cooling towers, and evaporative coolers.

Water-cooled air conditioning systems (also referred to as mini chillers) work essentially in the same way as conventional systems which are air cooled. Water-cooled air conditioning systems use water (instead of air in air-cooled systems) as a chiller to remove heat from the high temperature gas in the compressor/condenser unit. Once the water has cooled the gas back down to a liquid, the warmed water must be disposed of and usually goes down a drain. Figure 16 below shows how the water-cooling process works. Nevertheless, cooling is not delivered directly to the air but via a water network that supplies water, by the intermediary of a water pump, to cooling floors or panels and fan coil units.

[25] At least one of the national figures in this EU aggregate is estimated

Figure 16: Water-cooled air conditioning system



Evaporative coolers, also called "swamp coolers" rely on the evaporation of water to cool building air, rather than the movement of a refrigerant through cooling coils. Cooling towers, swamp coolers, and even a simple window fan blowing air across a pan of water and into a room are types of evaporative cooling systems. Swamp coolers systems may use less energy than a refrigerant-gas and compressor type air conditioner but are limited by one major factor – humidity. The more humid the outdoor environment, the less effective they become.

For commercial buildings such as large office buildings, hospitals, and schools, one or more cooling towers are used as part of their air conditioning systems. Cooling towers are heat rejection devices used to transfer process waste heat to the atmosphere. Cooling towers may either use the evaporation of water to reject process heat and cool the working fluid to near the wet-bulb air temperature or rely solely on air to cool the working fluid to near the dry-bulb air temperature. Cooling towers found in commercial settings operate in the same way as cooling towers found in industrial processes except that they are used for comfort applications. Refer to the sub-section 3.2.3.1 pg. 116 on cooling equipment in industry for further information. There is little research on how people occupying air-conditioned dwellings actually use their units. However, future levels of ownership of air conditioning in dwellings will depend on such factors as market penetration, price, and the severity of summers.

➢ **Potential for improvement**

Evaporative coolers are increasingly being considered as a clean and green alternative for cooling homes, especially in countries such as Australia. Evaporative coolers provide a number of benefits over refrigerated air conditioners, including lower capital costs, less energy costs, no refrigerant requirements, and increased comfort in drier areas due to the higher humidity provided compared to the dry air of refrigerated units *(Sean MacGown, 2009)*. Next generation evaporative coolers currently under development are expected to include controllers enabling the motor to operate at high efficiency at all flow rates.

Regardless of the cooling system used in the building, there are several things users can do to decrease water use in general. Some include:

- Install a thermostat and timer on your cooler so it only operates when necessary.
- Use a two-speed blow motor. Operating at low-speed uses less water and is more energy efficient.
- Inspect your cooler monthly and perform maintenance as necessary to be sure that your cooler is operating efficiently.
- Use alternative methods of cooling, including ceiling fans or keeping air circulated in rooms by leaving windows open

➢ **Market trends**

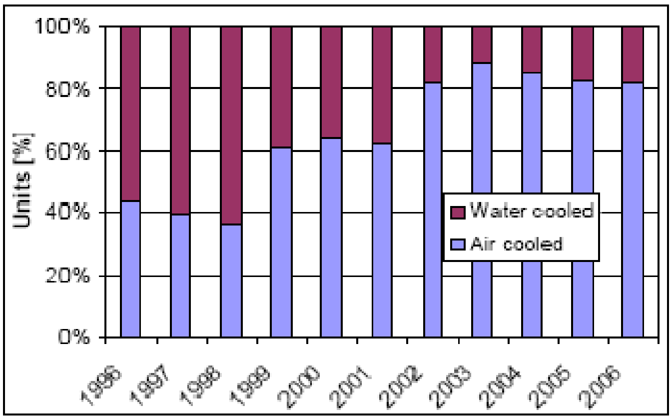
Air conditioners are often bought as an 'impulse purchase', meaning that most consumers only think about purchasing an air conditioner when they face sudden heat waves. As a result, sales vary widely through the year, by geographical area, and by year based on climate, therefore it is difficult to make general market trends at the EU level. Nevertheless, market research uncovered some data for water-cooled air conditioners.

There currently exists no PRODCOM classification for evaporative coolers, thus market trends at the EU level for this WuP is not available from Eurostat. Therefore, no market data has been identified or supplied by stakeholders at the moment for Europe. On the other hand, evaporators as a separate product are likely to have very low environmental impact because of supposed small market shares *(Armines, 2008)*.

For water-cooled air conditioners, data shows that their production is decreasing, and Figure 17 illustrates this trend. The fact that water-cooled units require either a water loop (which is difficult to install and implement) and imply important water consumption levels seem to explain this trend *(Armines, 2008)*. To date, data shows that water-using cooling systems used in buildings have a lower penetration rate compared to air-cooled cooling systems.

As for cooling towers found in commercial buildings, recent market research shows that the market for cooling towers is saturated, with little scope for technological innovations. Customer preference for air-cooled products is also expected to affect the market for packaged cooling towers (*PR WEB, 2008*).

Figure 17: Non moveable air conditioners, share of water cooled and air cooled package air conditioners (Cooling capacity < 12 kW) in number of models *(Armines, 2008)*



3.1.3.17 Summary of market trends for residential and commercial WuPs

WuPs found in residential and commercial buildings include a diverse range of products and market trends. An understanding of market trends is important to anticipate if a particular WuP will continue to have a significance presence in the market in the future. Several different data sources were used to find product market information to enable the widest range of data interpretation and analysis possible.

- **PRODCOM data**

The PRODCOM statistics have the advantage of being the official EU-source that is also used and referenced in other EU policy documents regarding trade and economic policy, thus guaranteeing EU consistency. PRODCOM data are based on products whose definitions are standardised across the European community and thus allow comparability between member country data. PRODCOM classifies WuPs used in buildings in a wide range of NACE codes. The NACE code system is the European standard for industry classifications. It assigns a unique 5 or 6 digit code to each industry sector. For the WuPs that have been identified, NACE categories include NACE 29.71 “manufacture of electric domestic appliances”, NACE 29.54 “manufacture of machinery for textile, apparel and leather production”, NACE 29.13 “manufacture of taps and valves”, NACE 25.23 “manufacture of builders ware of plastic” and NACE 26.22 “manufacture of ceramic sanitary fixtures”. These categories include a large range of products, though certain WuPs in buildings explicitly appear in this classification. For example, the product category “plastic toilet parts” is included because other products such as plastic lavatory pans, flushing cisterns and similar sanitary ware are also taken into account in the product data. In the context of this study, the flushing cistern is what interests us the most as it is the mechanism of the toilet that controls flushing and therefore water consumption. Although the product categories “ceramic sinks, wash basins, and baths and plastic baths, shower-baths, sinks, and wash basins”, do not specify whether the products include taps (the component responsible for water usage), it gives an overall idea of the extent that these products are being produced and traded.

Because few criteria are used to identify the different types of products, PRODCOM data will need to be supplemented by other sources of economic data. For many of the WuPs used in buildings, PRODCOM does not distinguish between those used in residential or commercial buildings. For example, for washing machines, several different PRODCOM categories exist for this product and no clear separation was made between domestic and non-domestic washing machines. In fact, PRODCOM lists washing machines as being either residential or laundry-type (which most likely refers to the commercial machines in laundromats). Thus, in the tables below, data for washing machines include both residential and commercial type washing machines. For certain products such as for dishwashers, PRODCOM specifically lists residential and non-residential dishwashers separately. For illustration, Table 25 lists WuPs used in the building sector according to PRODCOM. Table 26 shows import and export quantities and Table 27 shows production information for residential WuPs issued from PRODCOM data. Finally, Table 28 shows the percentage of change from 2004 to 2007 in production quantities. The time period shows data from 2004 to 2007 for EU27 totals.

Table 25: WuPs as classified by PRODOM

WuPs in buildings	NACE category & description		PRODCOM code & description	
Residential dishwashers	29.71	Manufacture of electric domestic appliances	29.71.12.00	Household dishwashing machines
Non-residential dishwashers	29.24	Manufacture of other general purpose machinery	29.24.60.00	Non-domestic dish-washing machines
Washing machines (for both residential & commercial)	29.54	Manufacture of machinery for textile, apparel and leather production	29.54.22.30	Household or laundry-type washing machines of a dry linen capacity > 10 kg
	29.71	Manufacture of electric domestic appliances	29.71.13.30	Fully-automatic washing machines of a dry linen capacity <= 10 kg
Taps	29.13	Manufacture of taps and valves	29.13.12.35	Taps, cocks and valves for sinks, wash basins, bidets, water cisterns, etc
	25.23	Manufacture of builders ware of plastic	25.23.12.50	Plastic baths; shower-baths, sinks and wash basins
	26.22	Manufacture of ceramic sanitary fixtures	26.22.10.50	Includes ceramic sinks, wash basins, baths... and other sanitary fixtures
Toilets	25.23	Manufacture of builders ware of plastic	25.23.12.90	Plastic lavatory pans, flushing cisterns and similar sanitary ware (excluding baths; shower-baths, sinks, and wash-basins, lavatory seats and covers

WuPs in buildings	NACE category & description		PRODCOM code & description	
Cooling systems[26]	29.23	Manufacture of nondomestic cooling and ventilation equipment	29.23.12.20	Window or wall air conditioning systems, self-contained or split-systems
Outdoor WuPs[27]	29.32	Manufacture of other agricultural and forestry machinery	29.32.40.10	Agricultural or horticultural watering appliances

Table 26: Export and Import quantities from 2004-2007 for WuPs in buildings as classified under PRODCOM[28]

WuPs in buildings	Unit	2004		2005		2006		2007	
		Exports	Imports	Exports	Imports	Exports	Imports	Exports	Imports
Residential dishwasher	p/st[29]	2 044 776	489 621	1 442 611	755 591	1 604 657	1 359 928	1 577 795	1 763 538
Non-residential dishwasher	p/st	91 130	8 381	102 480	12 808	74 659	15 831	100 778	20 587
Residential and non-residential washing machines	p/st	5 729 090	2 001 178	6 536 147	2 581 660	6 063 041	3 304 148	6 004 043	3 467 022
Taps	kg	19 035 200	30 516 700	19 365 500	32 495 300	20 015 900	35 542 600	19 939 800	34 893 700

Table 27: Production quantities from 2004-2007 for WuPs in buildings as classified under PRODOM

Water-using product	Unit	2004	2005	2006	2007
Residential dishwasher	p/st	8 968 445	9 178 301	9 887 949	9 614 846
Non-residential dishwasher	p/st	329 895	346 280	343 999	373 219
Residential and non-residential washing machines > 10kg	p/st	17 352 898	17 980 971	18 124 136	18 296 193
Taps (kitchen wash basin)	kg	275 834 800	245 700 203	210 000 000	280 000 000
Plastic toilet parts	p/st	115 795 300	108 793 017	139 451 979	149 048 393
Ceramic sinks, wash basins,	p/st	10 836 231	10 073 330	9 625 534	10 814 016

[26] Air conditioners are only covered by this NACE Code. They do not fall under the list of electric domestic appliances (NACE 29.71), not even movable air conditioners. Both air cooled and water-cooled air conditioners seem to be included in this classification.

[27] Please note that PRODCOM definition does not distinguish between the different types of watering appliances, therefore it is uncertain the exact products statistics will contain.

[28] Please note that import and export information from PRODCOM was not available for toilets, cooling systems, and outdoor WuPs.

[29] p/st = pieces/sticks

Water-using product	Unit	2004	2005	2006	2007
baths					
Plastic baths, shower-baths, sinks, wash basins	p/st	13 072 442	17 143 356	20 327 170	18 325 016
Cooling systems[33]	p/st	1 592 045	1 864 338	2 814 190	2 984 055
Outdoor WuPs	p/st	5 600 000	4 889 810	9 402 636	9 233 193

Table 28: Percentage of change from 2004 to 2007 in production quantities of WuPs in buildings

Residential water-using product	% of change (- or +)
Residential dishwasher	+ 7%
Non-residential dishwasher	+ 13.13%
Residential and non-residential washing machines	+11.2%
Taps (kitchen wash basin) in kg	+ 1.5%
Plastic toilet parts	+ 29%
Ceramic sinks, wash basins, baths	- 0.2%
Plastic baths, shower-baths, sinks, wash basins	+ 40%
Cooling systems	+46%
Outdoor WuPs	+39%

According to PRODCOM product classification and data, almost all products that were identified as a WuP in the building sector show increasing production rates, with the exception of ceramic sinks, wash basins, and baths, which show a slight decrease of 0.2%. This does not necessarily mean that there is a decreased production of taps, but perhaps just a decreasing number of ceramic products associated with taps (e.g. sinks and wash basins). Furthermore, it should be noted that for cooling systems and outdoor WuPs, data is extremely uncertain because the PRODCOM classification does not distinguish between individual products within the product category. Therefore, it is difficult to say whether these figures correspond to water-using cooling systems and outdoor WuPs that have been identified in the building sector.

- **MTP (United Kingdom) data**

According to studies conducted by the MTP, the demand for additional housing, in line with changing demographic factors including a higher proportion of single person households, will influence growth in the market of residential WuPs. The increasing number of households has a direct impact on the number of WuPs being sold, installed, and used across the EU. Emphasis on emerging designs and styles has also driven refurbishment projects and increased the replacement rate of kitchens and bathrooms. In addition, many homes are having en-suite and additional facilities installed. However, the significant cost of replacing a bathroom or kitchen means that the purchase is more likely to be deferred during times of economic uncertainty (*Market Transformation Program (6) 2008*).

3.1.3.18 Overview of the use behaviour and market trends

The following table summarises the information already presented in previous sub-sections.

Table 29: Summary of the use, market trends and potential for improvement of some WuPs

WuPs category	Use patterns (key parameters)	Potential for improvement	Market trends
Residential buildings			
Toilets	- Flush volume - Nb flush/pers/day	Dual flush	→ (replacement cycle of 15 years)
Taps	- Flow rate - Nb use/household/day	Aerators, sensors	→
Showerheads	- Flow rate - nb use/household/day	Aerating, laminar showerheads	→
Baths	- bath capacity - nb use/household/day	Reduced volume	→
Washing machines	- litre/cycle - nb cycle/week	Intelligent function (load detectors...)	→(10 years lifespan)
Dishwashers	- litre/cycle - nb cycle/week	Intelligent function (load detectors...)	↗(10 years lifespan)
Outdoor WuPs	- climatic conditions	Sensors (moisture sensors for instance)	↗(according to PRODCOM)
Commercial Buildings			
Urinals	- Flush volume - Nb flush/pers/8 hrs shift	Low flush and flush control	.
Taps	- Flow rate	Spray taps, sensors, timed turn-off taps	.
Toilets	- Flush volume - Nb flush/pers/8 hrs shift	Idem residential	.
Ice makers	.	Intelligent control	.
Washing machines/ laundries	- litre/cycle	Waste water recycling	.
Dishwashers	- litre/cycle	Improve overall energy efficiency	.
Outdoor uses	Idem residential	Idem residential	.
Car washes	- litre/car wash	Water reclaim Waterless washing	↗
Industrial			
Cooling towers	.	Water recycling Blow-down management	↘
Boilers	.	Blow-down management	↘
Pressure Washers	- Flow rate	Increased pressure Increased temperature	.
Steam Cleaners	- Flow rate	Increased pressure	.

WuPs category	Use patterns (key parameters)	Potential for improvement	Market trends
		Increased temperature	
Scrubber driers	- Flow rate	Detergent concentration	.

3.1.4. Water performance assessment of WuPs in buildings

The approaches to assess the water use efficiency of domestic WuPs fall into the categories presented in Box 1 below.

When designing field-based performance assessments, the larger the sample size the more accurately the results will reflect the behaviour of the wider population and for this reason, sample size becomes an important issue. In general, the confidence interval that can be applied to the results is inversely proportional to the square root of the sample size. As a rule, to get within +/- 5% the confidence interval requires a sample size of around 400 to 500 households.

Where possible, the case studies used in the following sub-sections on WuPs are based on studies with large sample sizes.

Box 1: WuPs performance assessment approaches in residential buildings

- Large-scale projects: these range from self-audits in which water efficient fitting are installed by the householder, to visit-and-fix projects in which installation of fittings is done by the water company. Results can then be measured based on changes in the metered household water consumption.
- Component studies: these examine one particular type of WuP, e.g. showers, WCs, faucets, etc. Data collection in such studies historically requires special meters, known as data-loggers, to be fitted to the specific appliance which can be somewhat intrusive. More recently though, meters have been developed that can be calibrated to sense the flow signal or pattern of a specific WuP, e.g. in the Identiflow study (WRc, 2006) reported below, and these can be fitted to the supply pipe so are less intrusive.
- Other studies: such as community projects or those that focus on metering, leakage, new homes, tariffs, etc, may rely on single households, i.e. revenue, meters, sub-meters on multi-unit blocks, or meter reading at the boundary of district metering zones.

3.1.4.1 Residential toilets

- **Standard product**

Residential water consumption by toilets, or WC, is determined by the WC's flush volume, whether the WC is leaking, and the frequency of use, usually determined by the number of occupants. Of the appliances that use water in a house, the WC uses the most; about 30–40% of domestic water use. Therefore, optimising the water used by toilets can make the greatest savings.

The main factor affecting the amount of water used by households for toilets is flush volume. The actual flush volumes of installed WCs depend on two factors: the installation and performance of toilets and user behaviour. An effective flush volume is the volume of water needed to clear the toilet pan and transport solids far enough to avoid blocking the drain.

Generally, the age of the toilet dictates the maximum allowable stored volume of the cistern. Table 30 below provides examples for two MS.

Table 30: Estimated flush volumes for WCs given the year of installation

Year	United Kingdom	Finland
Prior to 1976	9+ l/flush	9 l/flush
1976-1989	9+ l/flush	6 l/flush
1989-1993	7.5-9.5 litres dual flush	4 l/flush
1993-2000	7.5 l/flush	2-4 litres
After 2001	6 l/flush	2-4 litres

Results of empirical studies of WC usage for four European countries are presented in Table 31. The results from the European studies are compared with a representative study from the USA.

Table 31: Summary of water consumption and frequency of use for toilet flushing

Country	Average water consumption per flush (litres)	Frequency of toilet flushing (per day)	Average total water consumption per day (litres)	Data source
England	9.4	11.62	109.2	*WRc, 2005*
Bulgaria	9.5	12.5	118.8	*Dimitrov, 2004*
Portugal	9.1	9.3	84.8	*Viera et al., 2007*
Finland	6.0	-	-	*Etelmaki, 1999*
Range (Europe)	**6.0 – 9.5**	**7 - 11.62**	**84.8 – 118.8**	*Etelmaki, 1999*
USA	13.7	12.97	177.7	*Mayer et al., 2000*

➢ **Water-efficient alternatives**

Table 32 below presents results from experiments with water efficient WCs, and expected consumption ranges.

Table 32: Results of WC trials

WC Type	Expected average volume/flush	Actual average volume/flush	Notes	Trial name
4/2 litres dual-valve	2.4 litres	4.6 litres (3.1-6.1)	Sticking mechanism not identified during trial	Holmewood (Bradford)
6/3 dual-valve	3.6 litres	4.6 litres (3.7-5.4)	Sticking mechanism not identified during	Holmewood (Bradford)

WC Type	Expected average volume/flush	Actual average volume/flush	Notes	Trial name
			trial	
4/2 litre dual valve	2.4 litres	3.83	5 years trial, valve jammed twice	Portsmouth Water Co.
6/3 litres dual-valve	3.6 litres	6.1 litres	Women's WCs only	Portsmouth Water Co.
6/3 litres dual-valve	3.6 litres	8.6 male 6.5 female	Problems identified during analysis of data logger	Millennium Dome Water Cycle Experiment
6/3 litres dual-valve	3.6 litres	5.4 male 5.1 female	Jamming mechanism fixed	Millennium Dome Water Cycle Experiment
6 litres single siphon flush *initial*	6 litres	6.2 male 5.2 female		Millennium Dome Water Cycle Experiment
6 litres single siphon flush *after retrofit*	6 litres	5.5 male 5.5 female	Water levels adjusted	Millennium Dome Water Cycle Experiment

A review of the current literature shows that, with good pan design, full flush volumes down to 4 litres do not present a problem in terms of 'normal' drains and sewers being able to dispose of the solid and liquid wastes (*Lillywhite, 1987*). This can be achieved with a leak-free siphon. For example, recent studies in the United Kingdom (*Waterwise (1), 2008*) have involved WCs imported from Sweden and led to the development of the Ifö Cera ES4, a 4 litre siphon-flush suite, initially as a stopgap to meet the United Kingdom's old Water Byelaws. Commentators have said that, if the siphon does go out of fashion then it would be possible to look forward to significant water wastage in the future from leaking toilets. Technical solutions to problems such as button-operated siphons or leak-detecting valves are possible, but seem unlikely to happen unless driven by regulations and (independent) water-use labelling schemes (*Grant et al.,1999*).

Other WCs are available with a 4 and 2 litre dual flush, and this should theoretically beat a 4-litre single flush WC, but as the studies in Table 32 (above) indicate, this is not guaranteed and for public toilets and commercial buildings single flush would be more recommendable to use single flush rather than this type of low volume dual flush.

The information in the above table only provides a limited picture of the potential for improvement. Figure 18 and Figure 19 (below) were developed from data collected in a study (*WRc, 2005*) of 449 households carried out in 2002 in Southern England and show the spread of flush-volumes of WCs and the number of flushes per day in households with different occupancies. The example provides results that can be applied to the wider population with ±5% confidence limits. For example, using the average flush-volume and average flush frequency in Figure 18 and Figure 19, if 4-litre siphon flush WCs were installed in 30% of houses in the sample, assuming an average saving per flush of 5.4 litres, i.e. 9.4 - 4, the water manager could expect a daily saving of 62.7 litres per household or 22.88 m^3 per household per year. However, if all WCs with a flush volume of, say, 7.5 litres or over (average flush volume = 10 litres) were changed to efficient 4-litre models the savings would be 25.4 m^3 per household per year. These savings correspond to recorded savings from installing dual-flush WCs. For all of London, assuming a penetration rate of 60%, this equates to potential water savings of 50,800 million litres (ML) per year.

Apart from the obvious reductions in water abstractions, this would also result in significant energy savings. On average, 1M L of water requires 468 kWh to supply it, producing 209 kg of CO_2, while 1M L of wastewater requires 437 kWh to be treated, producing 195 kg of CO_2 (*Building Research Establishment, 2004*). These values will vary depending on the source of water and the amount of pumping and treatment involved.

The data on flush frequencies in different occupancy households in Figure 18 show that WCs in single occupancy households are only flushed on average 7 times per day, but in 2-6 occupancy households, they are flushed 11-14 times per day, indicating that the total water use over the WC's lifetime, and therefore the potential saving, would be significantly higher in higher occupancy households. A study in Sofia, Bulgaria (*Dimitrov (1), 2004*) has showed that household occupancy can have a significant impact on the economic efficiency of water efficient WCs. Figure 20 shows the payback period calculated for replacing 9 litre-flush WCs with 3/6 litre dual-flush WCs, based on different occupancies and per unit water prices.

Figure 18: WCs water use assessment example: Flush-volumes of WCs in 449 households (*WRc, 2005*)

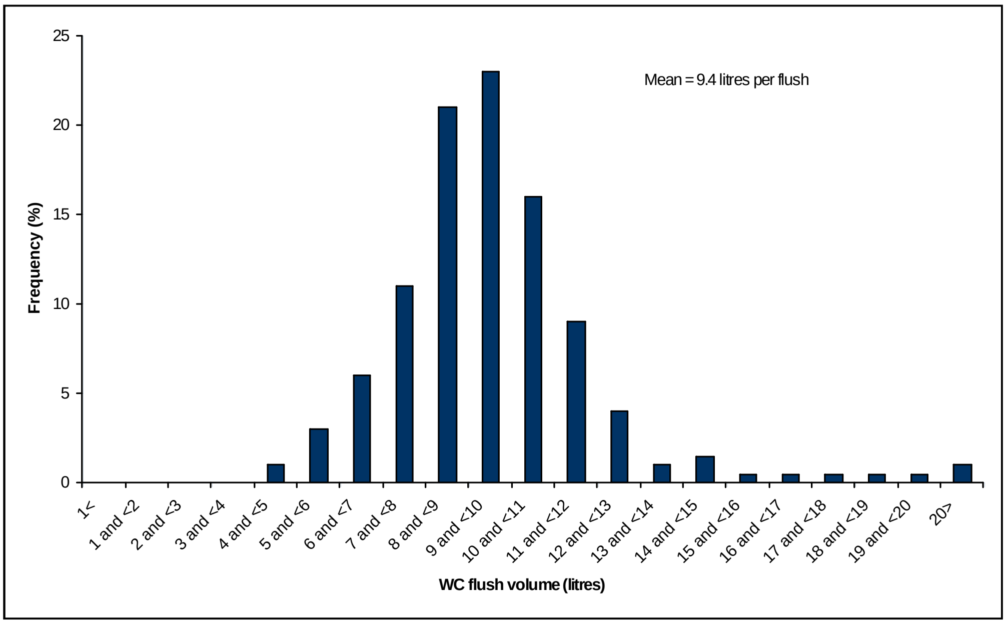


Figure 19: Water use assessment example: Frequency of use by occupancy (*WRc, 2005*)

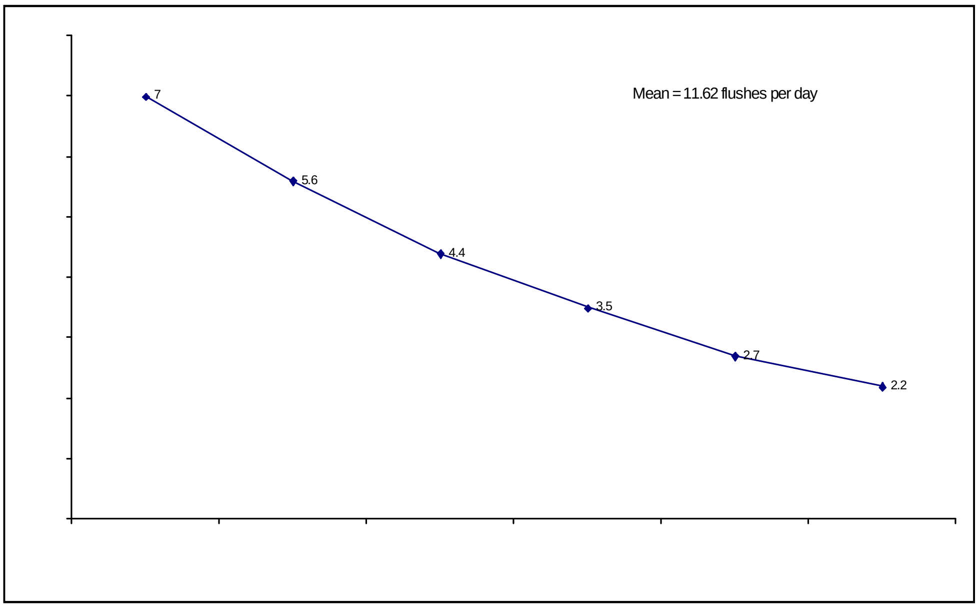
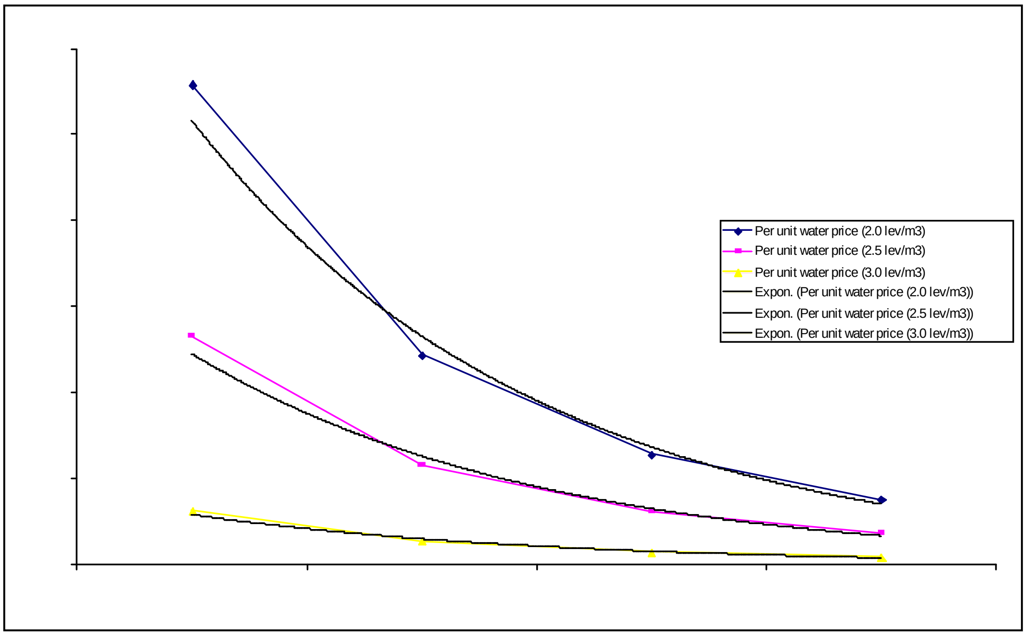


Figure 20: Economic assessment example: variable payback period for WCs, based on changing occupancy and per unit water price (*Dimitrov (1), 2004*)



Because most water conservation programmes involve a combination of measures, usually including showers, WCs, leakage checks and tap aerators, it can be difficult to confidently associate savings with a specific appliance. Table 33 reports disaggregated savings from 21 recent WC replacement programmes in the United Kingdom.

Table 33: Water savings assessment example: Results from WC replacement programmes in the United Kingdom between 1997 and 2008 (*Waterwise (1), 2008*)

Company	Project	Year	Cistern displacement device	Dual-flush toilets	Dudley turbo	ecoBETA dual-flush retro-fit device	Ecoflush retro-fit device	Variflush retrofit device
ESW	Moulsham	1997	25.00	-	-	-	-	-
ESW	Chelmsford-retrofit	2005	11.07	-	22.14	-	22.14	22.14
ESW	Chelmsford-full	2005	6.66	-	-	-	-	-
ESW	Brentford	2004	9.44	-	-	-	-	-
ESW	Romford	2004	10.80	-	-	-	-	-
ESW	Toolkit	2006/07	17.46	-	23.98	-	-	23.98
SWW	Multi-measure	2005/06	2.10	-	4.19	-	-	-
SWW	Single-measure	2005/06	0.01	-	24.39	-	-	-
TW	Liquid assets	2006	10.97	-	-	10.97	-	-
EA	Variable flush	2003/2004	-	-	-	-	16.90	24.00
ESW	Witham	2002	3.77	-	-	-	-	-
ESW	Thurrock	2006/07	12.89	-	-	-	-	-
ESW	H2eco	2007/08	10.35	-	-	10.48	-	-
ESW	ecoBETA	2007	-	-	-	31.38	-	-
SES	Preston-retrofit	2007/08	-	145.29	-	53.49	-	-
SES	Preston-refurb	2007/08	-	61.32	-	-	-	-
UU	Showerhead offer	2007	-	-	-	-	-	-
UU	Home audits	2006/07	34.60	-	-	34.60	-	-
YOR	Water Saving Trial	2007/08	5.73	-	11.46	5.73	-	-
STW	Water Efficiency Trial	2007/08	11.22	-	11.22	11.22	-	-
ANG	Water Efficiency Audit	2007	11.38	-	-	11.38	-	-
Number of projects included in assessment			16	2	6	8	2	3
Savings range for assessment (l/prop/day)			0.01-34.60	61.32-145.29	4.19-24.39	5.73-53.49	16.90-22.14	22.14-24.00

ANG = Anglian Water; SES = Sutton & East Surrey Water; TW = Thames Water; ESW = Essex & Suffolk Water; STW = Severn Trent Water; UU = United Utilities; EA = Environment Agency; SWW = South West Water; YOR = Yorkshire Water

3.1.4.2 Residential taps (kitchen and washbasin taps)

➢ **Standard product**

The water consumption of taps, which include kitchen and bathroom taps, is dependent upon the flow rate of the fitted device, the time per use, and the frequency of use. When assessing the performance of a tap, an initial check of each tap should take place and dripping taps should have their washers replaced by the surveyor.

Excessive flows and/or leaks from taps in bathrooms and kitchens can be a significant source of water wastage. A single dripping tap can waste more than 24 000 litres per year (*Department for Natural Resources, Mines and Water, 2006*). Unregulated flows can reach 15-20 l/min when 6 l/min or even less is enough for hand washing. Reducing flows from hot water taps has the added benefit of saving energy. Such savings typically exceed the water cost savings by 2 or 3 to one.

A review of existing reports identified that there have been very few examples of faucet monitoring studies in households in EU MS.

The graphs in Figure 21 and Figure 22 below, shows the volume per use and the uses per day of taps in different occupancy households in England (*WRc, 2005*).

Figure 21: Water volume per use, taps (*WRc, 2005*)

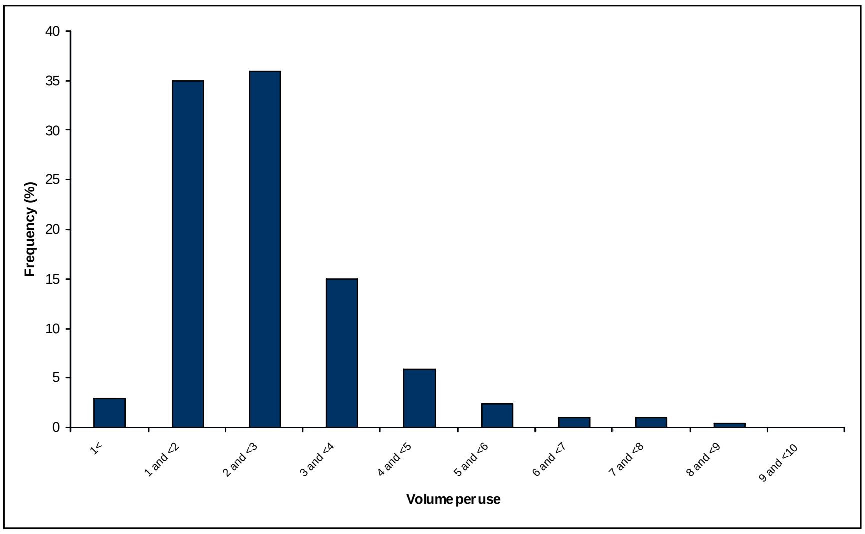
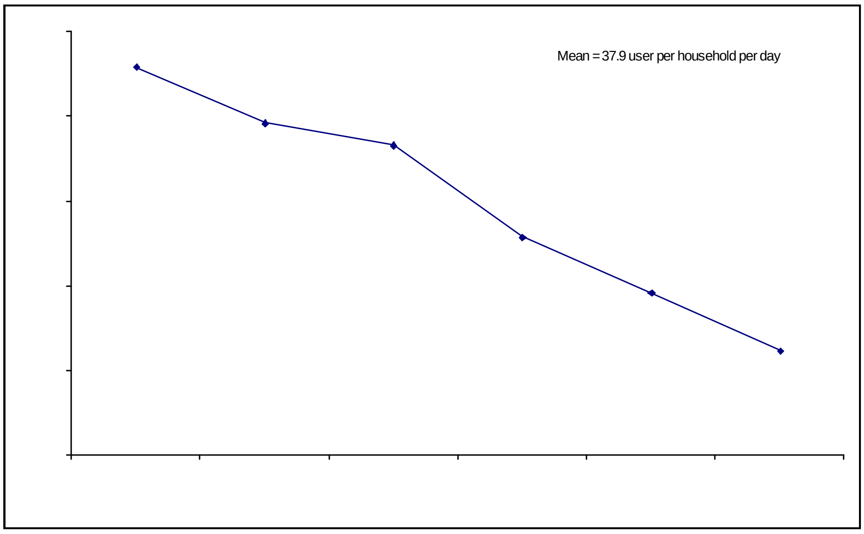


Figure 22: Frequency of tap use for different occupancy households (*WRc, 2005*)



The results in Table 34 below are from empirical studies. Anecdotal evidence (*Alitchkov, 1996*), however, indicates that consumption for taps may be up to 50% higher in other EU countries.

Table 34: Summary of faucet usage in EU MS

Country	Average water consumption per use (litres)	Frequency of use (use/household/day)	Average total water use per day (litres/household/day)	Data source
England	2.3	37.9	87.2	*WRc, 2006*
Portugal	5.84	10.6	61.9	*Viera et al., 2007*

- **Water-efficient alternatives**

Some very simple and inexpensive retrofit measures are available for existing devices that save water as well as energy whilst improving user amenity and safety. Savings of 20-30% are common with paybacks of less than 2 years. A range of measures is summarised below:

- Fit new water efficient tap-ware. New low-flow and aerating models may use as little as 2 l/min, depending on the intended application.
- Fit low flow aerators to basin spouts which may reduce the flow to less than a third (6 l/min or less). This is an inexpensive option but devices are subject to clogging and tampering.
- Fit long life tap washers (usually with a rubber O-ring and mechanical protection against over tightening) as insurance against future unreported leaks and to reduce maintenance costs. This should be done in conjunction with almost all the above measure (*Vickers, 2001; Sydney Water and Clubs NSW, 2008; Sydney Water, 2001*).

Results from recent programmes in the United Kingdom involving maintenance or replacement of existing faucets with water saving technology are presented in Table 35 below.

Table 35: Results from faucet maintenance and replacement programmes in the United Kingdom between 1997 and 2008 (*Waterwise (1), 2008*).

Company	Project	Year	Tap inserts and restrictor	Tap washers	Turning the tap off when brushing teeth
ESW	Moulsham	1997	-	5.25	-
ESW	Brentford	2004	-	9.90	26.73
ESW	Romford	2004	-	13.08	29.75
ESW	Toolkit	2006/07	11.83	-	-
SWW	Multi-measure	2005/06	2.07	-	-
SWW	Single-measure	2005/06	24.89	-	-
TW	Liquid assets	2006	10.82	-	-
ESW	Witham	2002	3.77	-	19.41
ESW	Thurrock	2006/07	-	0.47	10.31
ESW	H2eco	2007/08	10.35	9.01	-
YOR	Water Saving Trial	2007/08	5.66	-	-
STW	Water Efficiency Trial	2007/08	11.07	-	-

Company	Project	Year	Tap inserts and restrictor	Tap washers	Turning the tap off when brushing teeth
ANG	Water Efficiency Audit	2007	11.23	-	-
Number of projects included in assessment			9	5	4
Savings range for assessment (l/prop/day)			2.07-24.89	0.47-13.07	10.31-29.75

ANG = Anglian Water; SES = Sutton & East Surrey Water; TW = Thames Water; ESW = Essex & Suffolk Water; STW = Severn Trent Water; UU = United Utilities; EA = Environment Agency; SWW = South West Water; YOR = Yorkshire Water

3.1.4.3 Residential showerheads

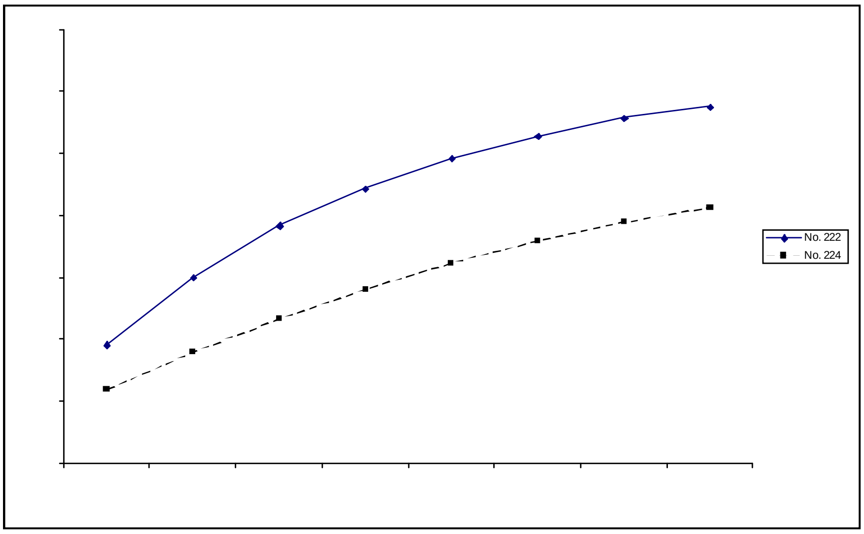
- **Standard product**

As was mentioned earlier, there are three main types of showers available: gravity-fed, electric and pumped. The water used by showers in residential buildings is determined by the type of shower already being used there, its flow rate, frequency of use and average time per use.

About 45% of households in the United Kingdom have an instantaneous electric shower (*Waterwise (2), 2008*) and because the volume of water that needs heating limits flow rates, these devices cannot be improved for water efficiency. The United Kingdom and Ireland are unique as far as electric showers are concerned. Most countries do not have electric showers or low pressure systems so shower water use is usually higher compared to the United Kingdom.

For gravity-fed showers, the graph in Figure 23 demonstrates the impact of pressure on shower flow rates.

Figure 23: Effects of system pressure on flow-rate of two types of self-mixing shower-heads (*Dimitrov (2) 2004*)



Results of empirical studies in EU MS are presented in Table 36. The results from the European studies are compared with a representative study from the USA by (*Mayer et al., 2000*).

Table 36: Summary of water consumption and frequency of use showerheads

Country	Flow rate (litres/minute)	Average shower duration (minutes)	Average frequency of use (use/household/day)	Average water consumption per use (l/shower)	Average total water consumption per day (l/household)	Data source
England*	11.78	2.2	1.46	25.7	37.5	*WRc, 2005*
Portugal	10	-	2.5	58.4	146	*Viera et al., 2007*
Finland	-	-	-	60.0	-	*Etelmaki, 1999*
Germany	-	-	-	30-50	-	*Etelmaki, 1999*
France	16	-	-	-	-	*Etelmaki, 1999*
United Kingdom**	10.8	5	1.43	54	77.22	*United Kingdom Environment Agency, 2007*
United Kingdom***	6	5	1.43	30	43	*United Kingdom Environment Agency, 2007*
Range (Europe)	**3.9 - 16**	**NA**	**0.75 - 2.5**	**25.7 - 60**	**37.5 - 146**	*United Kingdom Environment Agency, 2007*
USA	8.48	7.91	0.51	68.4	34.88	Mayer et al., 2000

*449 households
**non-efficient new-build
***water efficient new-build

Frequencies of shower flow rates in a study (*Critchley, 2007*) of 40 households and frequency of use from a study (*WRc, 2005*) of 449 households are shown in Figure 24 and Figure 25.

Figure 24: Flow-rates of showers in 40 households (*Critchley, 2007*)

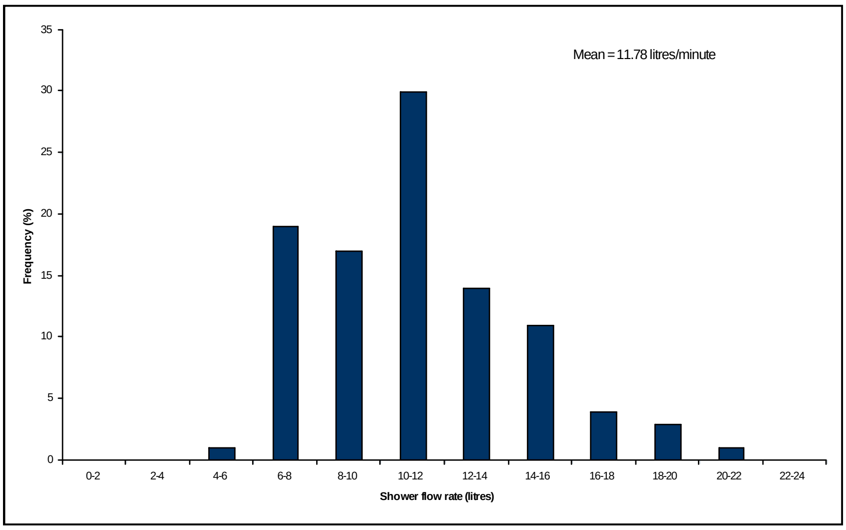
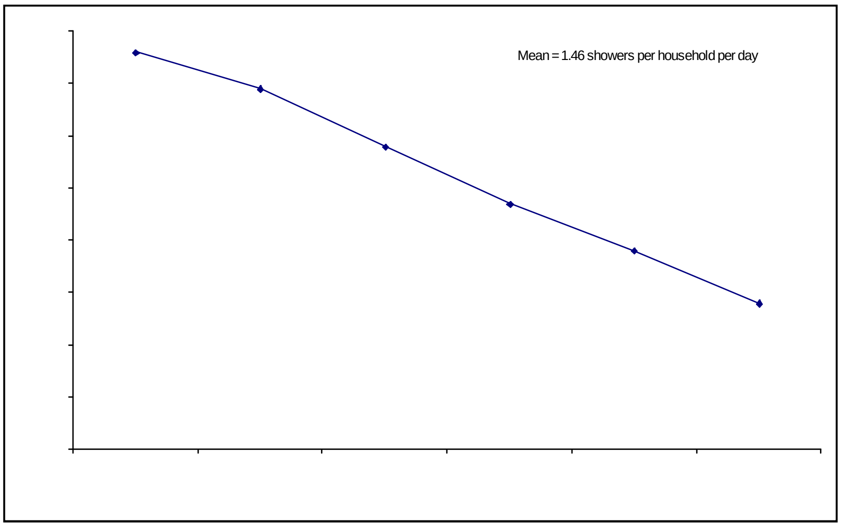


Figure 25: Shower frequency in households with different numbers of occupants (*WRc, 2005*)



➢ Water-efficient alternatives

Gravity-fed showers can have their flow rate reduced by using a flow restricting device or by using a low flow showerhead – these restrict the flow by altering the spray pattern or by introducing air into the showerhead. An aerated showerhead seems to provide the best solution as it appears to deliver a higher flow than it actually delivers and so provides the user with the experience of a power shower, but with significantly less water. However, aerated showerheads will not necessarily work on gravity fed systems and need a pressure of at least one bar to function correctly.

Non-gravity fed showers come in several different types, from instantaneous electric showers with average flow rates of around 4 to 6 l/min to pumped showers fed off hot water tanks that can deliver up to 30 l/min. Combo boilers and non-vented systems are becoming popular and these can deliver high flow rates to showers.

To help people limit showering durations, a shower timer can be used. These come in two types, either a sand timer set for a fixed duration or a digital alarm that the user can pre-set. As for limiting the frequency of showering it is not felt to be appropriate (unless switching from baths to showers) as this may be seen to be dictating lifestyles.

Table 37 below reports the results from 15 recent shower replacement programmes in the United Kingdom.

Table 37: Results from shower replacement programmes in the United Kingdom (1997-2008) (*Waterwise (1), 2008*)

Company	Project	Year	Shower timer	Shower-flow restrictor	Showerheads	Bath measure	Replace bathing with shower
ESW	Moulsham	1997	-	-	8.00	-	-
ESW	Brentford	2004	-	-	19.11	-	-
ESW	Romford	2004	-	-	22.36	-	-
ESW	Toolkit	2006/07	1.95	-	6.51	-	-
SWW	Multi-measure	2005/06	0.23	-	1.14	-	-
TW	Liquid assets	2006	1.23	-	5.95	-	-
ESW	Witham	2002	0.53	-	-	-	-
ESW	Thurrock	2006/07	26.05	-	-	-	37.31
ESW	H2eco	2007/08	-	-	5.69	4.44	-
SES	Preston-retrofit	2007/08	2.67	-	-	-	39.46
UU	Showerhead offer	2007	-	-	39.50	-	-
UU	Home audits	2006/07	-	-	18.77	-	-
YOR	Water Saving Trial	2007/08	0.64	-	3.11	-	-
STW	Water Efficiency Trial	2007/08	-	-	6.23	-	-
ANG	Water Efficiency Audit	2007	1.27	6.18	-	-	-
Number of projects included in assessment			8	1	11	1	2
Savings range for assessment (l/prop/day)			0.23-26.05	6.18	1.14-39.50	4.44	37.31-39.46

ANG = Anglian Water; SES = Sutton & East Surrey Water; TW = Thames Water; ESW = Essex & Suffolk Water; STW = Severn Trent Water; UU = United Utilities; EA = Environment Agency; SWW = South West Water; YOR = Yorkshire Water

- **Showers and energy use**

In addition to water use, showers are also widely known to be associated with high energy use, both for heating and pumping water. Customers with an existing mixer or pumped shower operating at over 8 l/min can enjoy a financial payback within a few months from installing a water saving showerhead that does not impair customer satisfaction. The available data was also used to estimate average annual water, energy and carbon use in the home for each method of personal washing, as presented in Table 38 below.

Table 38: Showers' impact on water and energy consumption of households

Type of shower	Flow-rate	Duration	Vol. per event	Energy per use	Cost to customer	Water use per household per year	Energy use per household per year	Total carbon use per household per year
Electric shower	3.9 l/min	5.8 min	22.6 l	0.95 kWh	£0.20	14,000 litres	580 kWh	249 kg
Mixer shower (short duration)	8 l/min	5.8 min	46.4 l	2.8 kWh	£0.26	28,000 litres	1,720 kWh	327 kg
Mixed shower (long duration)	8 l/min	9 min	72 l	4.3 kWh	£0.40	44,000 litres	2,650 kWh	503 kg
Pumped shower	12 l/min	9 min	108 l	6.5 kWh	£0.60	66,000 litres	3,980 kWh	756 kg
Bath	n/a	n/a	73 l	4.9 kWh	£0.43	35,000 litres	2,330 kWh	443 kg

The findings presented in Table 38 suggest that many mixer and pumped showers may consume more water, electricity and carbon than washing by bath. This is due to a combination of factors: water flow-rates of mixer and pumped showers can be significant, and the frequency and duration of showering are much greater than for bathing, particularly due to the ease of having a shower.

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

3.1.4.4 Residential baths

The main factors affecting the amount of water used per household for bathing are the type of bath and its capacity, and the usage pattern of the bath.

The size (volume and shape) of the bathtub and the level to which the user fills the tub also affect water use. Tapered or peanut-shaped baths may provide more space for bathing with less water. With the exception of whirlpool and jetted tubs, the size of standard bathtubs globally has generally decreased over time. Very few modern baths hold less than 130 litres, which is about 60 litres of water with a submerged adult. Some larger baths hold more than 300 litres, equivalent to the average volume of water two people use each day (*Waterwise (3), 2008*). Key existing bath product types are included in Table 39.

Table 39: Bath types, capacity to overflow and volume of water per usage, MTP modelling (*Market Transformation Program (4), 2008*)

Bath Type	Capacity to overflow (litres)	Usage (litres)
Undersized, 1, 600 mm primarily	165	65
Corner baths	140	65
Shower baths	250	100
Standard baths	225	88
Roll-top baths	205	80
Whirlpool/Spa baths	225	88
Large outdoor spa baths		1,500

3.1.4.5 Residential washing machines

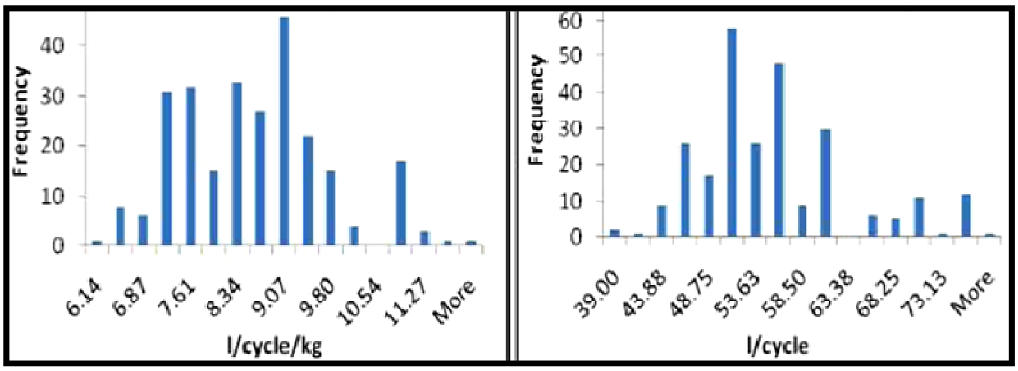
➢ **Standard product**

Efficiency of washing machines is measured either by the water volume used *per* cycle (l/cycle), or the volume used per kg or dry load (l/kg dry load).

A database (*Waterwise (4), 2008*) containing over 260 washing machine models that were available on the United Kingdom market in 2007, representative of over 25 brands, showed that wash capacities vary from 3 to 10 kilograms, with the most common loads being 5-6 kg. Mean water consumption for 6 kg machines was 50.20 l/cycle with a mean water efficiency index[38] of 8.37 l/cycle/load.

Mean water consumption overall was 54.08 l/cycle with a mean water efficiency index of 8.44 l/cycle/kg. Median water consumption was 53.00 l/cycle, and the median water efficiency index was 8.43 l/cycle/kg. Figure 26 illustrates the distributions of water consumption and efficiency in the United Kingdom (2007) database.

Figure 26: Distributions of water consumption and efficiency of washing machine models



Information on washing machine usage in households was collected from other European studies and is presented in Table 40 below.

[38] The water efficiency index was obtained by dividing total water consumption per cycle by wash capacity, to obtain litres consumed per kilogram (or place setting) washed.

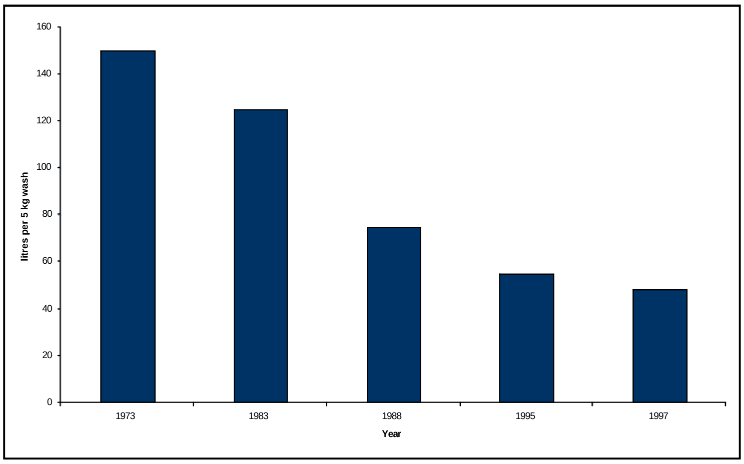
Table 40: Summary of water consumption and frequency of use of washing machines

Country	Average water consumption per cycle	Frequency of use (use/ household /day)	Average total water consumption per year or per day	Data source
United Kingdom	39-78	-	-	*Waterwise, 2008*
Portugal	82	0.6	82.6	*Viera et al., 2007*
England	61	0.81	48.8	*WRc, 2006*
France	75	-	-	*OFWAT, 1997*
Germany	72-90	-	-	*OFWAT, 1997*
England	80	-	-	*Etelmaki, 1999*
Finland	74-117	-	-	*Etelmaki, 1999*
Range (Europe)	**39-117**	**0.6-0.81**	**48.6-82.6**	**-**

Water-efficient alternatives

Washing machines have become much more water efficient over the past twenty years. AEG provided figures of average water usage of their machines, which twenty years ago were about 150 l/cycle, whereas today these machines average about 50 l/cycle, with the most efficient machines using about 35 l/cycle. The water consumption of front-loading washing machines has been reduced by 76% since 1970, from 30 l/kg in 1970 to 13.6 l/kg in 1990 to 7.2 l/kg today. An example of the efficiency improvements of 5kg Bosch washing machines since 1973 is provided in Figure 27 below.

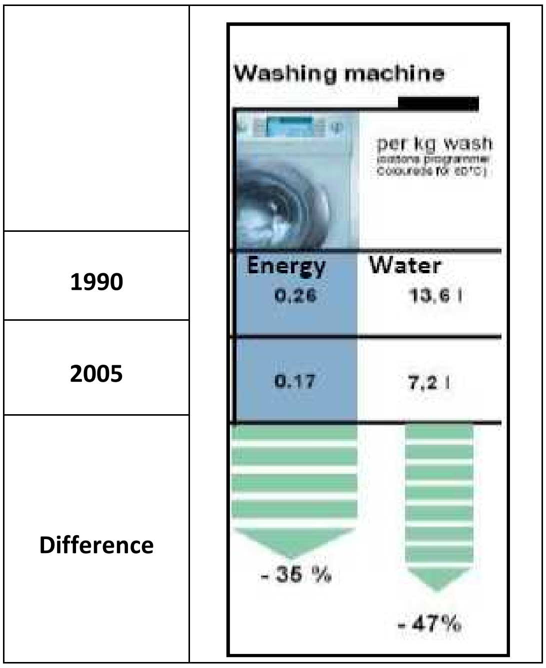
Figure 27: Water used by Bosch washing machines for 5kg hot wash – l/cycle (*Grant, 2002*)



Washing machines and energy use

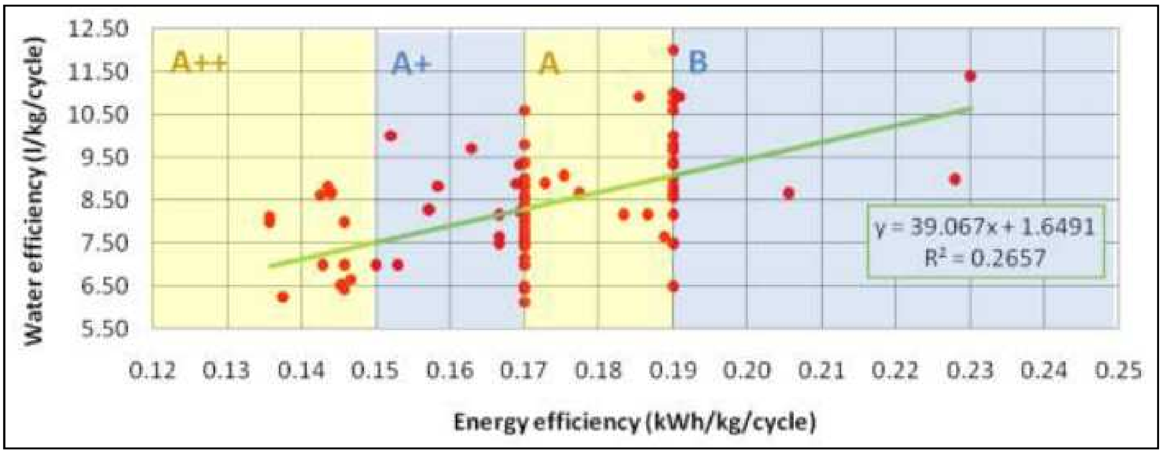
Water use in washing machines correlates to energy use. Figure 28 shows trends in energy and water consumption of Bosch und Siemens Hausgeräte appliances from 1990 to 2005.

Figure 28: Trends in energy and water consumption of Bosch und Siemens Hausgeräte appliances (*Otto, 2006*)



Comparison of *per* cycle water and energy use (Figure 29) in different models shows that there is a positive correlation between water and energy use (R^2 = 0.27).

Figure 29: Relationship between energy use and water use of washing machines adjusted for capacity (*Waterwise (4), 2008*)



3.1.4.6 Residential dishwashers

Similar to clothes washing machines, cycle times and frequency of use of the washing machine for a load of laundry will also determine water consumption levels.

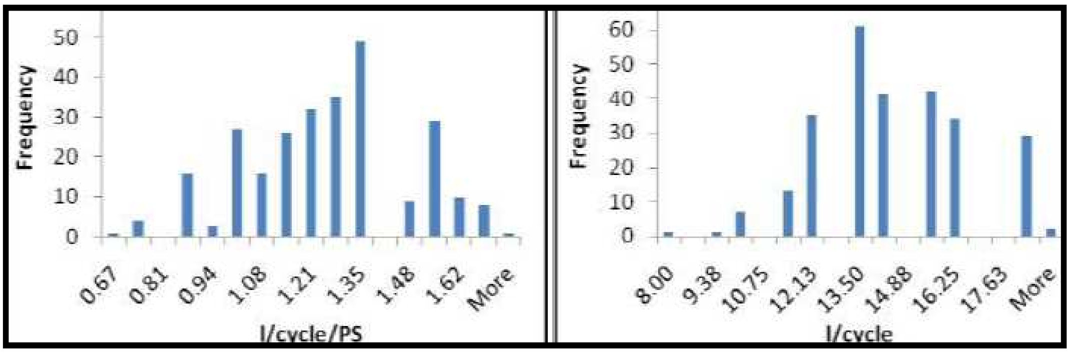
In general, the use of a dishwasher may be more water efficient than washing up by hand (*Market Transformation Program (5), 2008*). In practice, however, the water and energy impacts of washing up are heavily dependent on the individual users' behaviour. Typical per cycle water usage for dishwashers is shown in Table 41.

Table 41: Typical per cycle water usage for dishwashers

Component	Typical consumption (litres per load)	Range of consumption (litres per load)
Manufactured before 2000	25	15-50
Manufactured post-2000		
Normal setting	14	7-19
Eco-setting	10	8-12

A database of dishwasher models available on the British market in 2007, which is representative of about 30 brands shows that capacities vary from 6 to 15 PS, with the most commonly occurring capacity being 12 PS. Overall, mean water consumption was 14.10 l/cycle, with a mean water efficiency index of 1.22 l/cycle/PS. Mean water consumption for 12 PS machines was 14.62 l/cycle, with a mean water efficiency index of 1.22 l/cycle/PS. Figure 30 (below) illustrates the distributions of water consumption and water efficiency in the United Kingdom in 2007.

Figure 30: Distributions of water consumption and efficiency of dishwasher models available on the United Kingdom market



Information on dishwasher usage in households collated from European studies is presented in Table 42 below.

Table 42 : Summary of water consumption and frequency of use of dishwashers

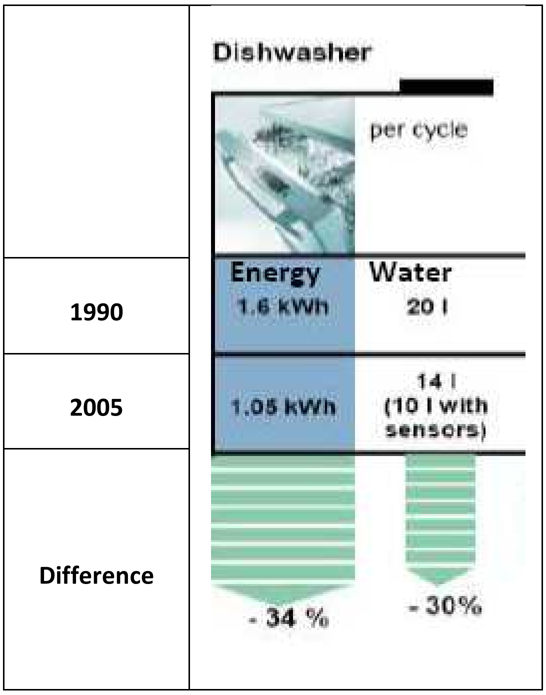
Country	Average water consumption (l/cycle)	Frequency of use (use/household/ day)	Average total water consumption (l/day)	Data source
England	21.3	0.71	15.12	*WRc, 2005*
Portugal	29.0	0.5	14.50	*Viera et al., 2007*
France	24	-	-	*Etelmaki, 1999*
Germany	27-47	-	-	*Etelmaki, 1999*
England and Wales	35	-	-	*OFWAT, 1997*
Finland	25	-	-	*OFWAT, 1997*
Range (Europe)	**21.3-47**	**0.5-0.71**	**15.12-33.37**	**as above**

- **Dishwashers and energy use**

As with washing machines, water use in dishwashers correlates to energy use.

Figure 31 shows trends in energy and water consumption of Bosch und Siemens Hausgeräte appliances from 1990 to 2005.

Figure 31: Water consumption of Bosch und Siemens Hausgeräte dishwashers from 1990 to 2005



3.1.4.7 Garden irrigation (water hose + sprinklers)

➢ **Standard product**

Flow rates for standard technology for reticulated and manual garden irrigation are summarised in Table 43.

Table 43 : Flow rates for standard technology for reticulated and manual garden irrigation (*Waterwise (1), 2008*)

Component	Typical consumption (litres per hour)	Range of consumption (litres per hour)
Hosepipe with trigger gun/nozzle	600	400-800
Hosepipe without	1 000	600-1 200
Sprinkler	1 000	600-1 200

➢ **Water-efficient alternatives**

For houses with gardens, water saving devices can be offered together with literature advising customers of how to be water efficient in the garden. Examples of good devices to offer customers include water butts and trigger hose guns (if no hosepipe ban exists in the customers' area).

The impact of 10 water conservation programmes in the United Kingdom involving options to reduce outdoor use are presented in Table 44.

Table 44 : Results from household irrigation programmes in the United Kingdom between 1997 and 2008

Company	Project	Year	water butts	Hose gun	Soil crystals
ESW	Moulsham	1997	2.47	-	-
ESW	Chelmsford-full	2005	1.58	1.20	-
ESW	Brentford	2004	-	1.58	-
ESW	Romford	2004	-	1.58	-
SWW	Multi-measure	2005/06	-	0.28	-
ESW	Witham	2002	-	0.74	-
ESW	Thurrock	2006/07	-	1.51	-
ESW	H2eco	2007/08	1.79	1.35	0.02
SES	Preston-retrofit	2007/08	4.76	-	-
YOR	Water Saving Trial	2007/08	-	0.76	-
Number of projects included in assessment			4	8	1
Savings range for assessment (l/prop/day)			1.58-4.76	0.28-1.58	0.,02

ANG = Anglian Water; SES = Sutton & East Surrey Water; TW = Thames Water; ESW = Essex & Suffolk Water; STW = Severn Trent Water; UU = United Utilities; EA = Environment Agency; SWW = South West Water; YOR = Yorkshire Water

3.1.4.8 Cooling systems used in residential buildings

In general, there is an absence of data on how much water is typically used by cooling systems in households. However, some general observations can be made. The water use for air-conditioning units shown in Table **45** below is based on a 3.5 kW per unit capacity.

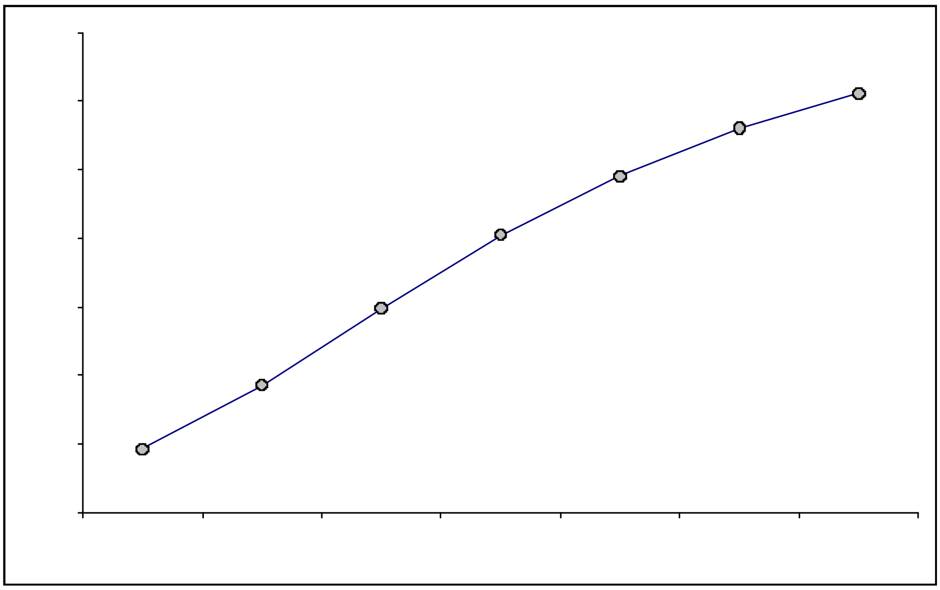
Table 45: Lifetime water use for 3.5 kW air-conditioning unit (reversible and cooling only) (*Armines, 2007*)

Type	Lifetime water use for cooling (litres)	Expected lifetime
Moveable Room Air-Conditioners (RAC)	165 098	12
Split cooling only	170 230	12
Reversible split	353 016	12

Available information states the environmental impact of larger units does not differ much from 3.5 kW units, except that, being less efficient, the importance of the use phase is still emphasised. No data were available to verify whether this means that water use is the same for higher powered units.

The graph in Figure 32 is from an assessment of the total water use of Room Air Conditioner between 2005 and 2030 over EU-25 (*Armines, 2007)*. This is essentially the business as usual case and assumes no changes in the product, or the way in which it is used (e.g., cooling demand which needs to be met).

Figure 32: Assessment of the total water use of Room Air Conditioner between 2005 and 2030 over EU-25



3.1.4.9 Commercial urinals

➢ **Standard product**

A recent Water Efficiency Solutions report (*ECA, 2008*) estimates that the flushing of urinals accounts for between 20% and 30% of a commercial organisation's water consumption. The report also cited the calculation that a single urinal with a half-hour flush pattern consumes nearly 125 000 litres of water per year.

Urinal flushing mechanisms can be cyclic 'fill and dump' units, which as mentioned above are highly inefficient, manually operated cistern (concealed push button or exposed overhead chain-pull), lever operated flush-o-meter, or a movement sensor controlled solenoid valve.

Water volumes per use for urinals are commonly as high as 3-4 litres per flush. Urinals can be either a multi-user trough or individual wall hung pods. Consumption depends on usage levels, equipment type and settings, and can vary from 50 m^3 to 100 m^3 per year (30-70 flushes of 4 litres each per day).

➢ **Water-efficient alternatives**

As shown in Table 46, from an example of using different types of urinals in commercial buildings in Sofia, Bulgaria (Dimitrov, 1998), a key design criterion that affects water consumption for urinals is the mechanism that controls the flush frequency.

Table 46: Potential water savings from replacement of urinals in commercial buildings

Building type	Occupant	Urinals (no. of flushes per month)			Urinals (volume used per month)			Potential saving %		
		Self-flushing	Cycle	Sensor	Self-flushing	Cycle	Sensor	Self-flushing	Cycle	Sensor
Offices	12	5 400	148.5	6 534	162	44.55	19.6	Standard	72.5%	87.9%
Restaurant	250	8 640	3,000	15 000	259.2	90	45	Standard	65.3%	82.6%
School	100	4 320	650	3 750	129.6	19.5	11.25	Standard	85.0%	91.3%
Public WC	1,200	14 400	9 360	36 000	432	280.8	108	Standard	35.0%	75.0%

A number of case studies where urinals have been replaced in commercial buildings in Europe, Australia and the USA are presented in Box 2 below.

3.1.4.10 Commercial taps

- **Standard products**

Conventional taps, with typical flow rates of 9.5 to 15 l/min, can waste as much as 150 litres of water a day when not fully closed (*North Carolina Department for Environment and Natural Resources, 2007*).

About one third of the water used in every office comes through the tap. Installing taps with high quality flow regulated sprays can reduce this amount by up to 80 per cent. When installing new taps, specifying models with metric outlets, allows the flexibility to add a range of outlet devices such as sprays and aerators *(UK Environment Agency, 2007).*

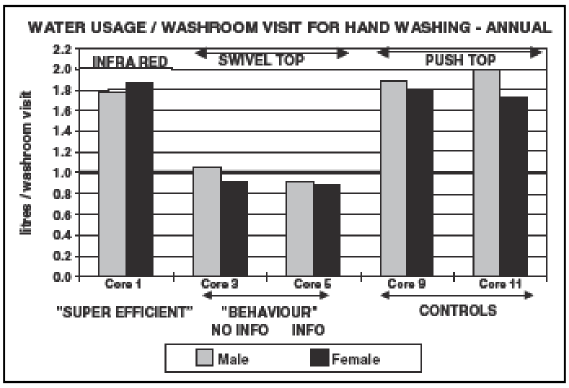
- **Water-efficient alternatives**

If infra-red technology is installed, care needs to be taken when installing and setting-up the equipment. In one of the largest studies of its kind – the Millennium Dome WaterCycle experiment (*Hills, 2001*) – three types of tap were evaluated, infra-red activated (48 in total), push-top (96 in total) and conventional swivel top (96 in total). Surprisingly, over the year the conventional swivel top taps used significantly less water than the purported more efficient types (see Figure 33) with each user of the swivel top taps using, on average, just less than 1 litre of water.

For manually operated swivel top taps, the optimal value for a single hand wash would appear to be approximately 0.9 litres per use (see Figure 33).

During the course of the Millennium Dome study, problems with the functioning of the infra-red and push top taps were identified from the metering data. These were again traced to problems of poor installation and set-up. A retrofit of the push top taps, so they flowed for 7 seconds rather than 15 seconds after activation, resulted in a significant reduction in water usage.

Figure 33: Mean volume of potable water used for hand-washing (litres per washroom visit) by males and females



Positive results for infra-red sensitive taps have, however, also been recorded. In the Hafod Country House Hotel, near Llanrwst in the Conway Valley, North Wales, where more than a third of the water use for the building is used within the kitchen, leaking kitchen taps that were also commonly left running were replaced with infra-red controlled taps and were found to be very effective. In combination with other efficiency measures, the total water use of the hotel was reduced by 15 per cent per guest, per day, resulting in a saving of £139 per year.

Box 2: Impacts of Urinals replacement programmes

Europe

- The Arenson group, which is involved in office furniture manufacturing, implemented a number of simple water saving measures in the non-manufacturing processes (installing passive infrared detectors in urinals, for example, to prevent unnecessary flushes, on-going maintenance to maintain spring-loaded taps, check water meters to ensure no water is wasted from leaks, etc). As a result, water use in factory/office washroom environments was reduced by 45% from 3,800 m^3/year to 2,100 m^3/year, equivalent to cost savings of £3,000/year.
- The Wilton Park Conference Centre employs 51 to 60 persons. It has installed new urinals set to save 511 cubic metres of water each year. The urinals cost £1,000 to install, and have a payback period of approximately two and a half years.
- The Environment Agency offices in North West England were found to be using more than 300 litres of water per hour when the office was unoccupied. By changing urinal controls were changed, this reduced to 10 litres per night.
- The Gwesty'r Llew Coch Hotel at Dinas Mawddwy in North Wales is a rural hotel with only six rooms, and not connected to sewerage mains. Despite this, the hotel used more than 15 000 litres of water per guest, per day. On investigation, more than one third of this was found to be from a single uncontrolled urinal. Replacing this urinal immediately saved more than £100 per year.

Australia

- The city of Borondara decided to replace full flush toilets with dual flush toilets and 7 water flushing urinals with waterless urinals at four public facilities. Potential savings have been assessed at 789 m^3 per year with a cost of $38 315.
- The Newmarket State School expects to save more than 150,000 litres per year by installing 18 dual flush toilets, 2 waterless urinals, using rainwater collected in tanks to supplement toilet water supply and installing irrigation controllers for the garden with rainfall and soil moisture sensors. The cost of the total project is estimated at $45 454.

3.1.4.11 Commercial toilets

- **Standard products**

WCs or toilets can use anywhere from 11 l/flush for the older models down to 4 litres for the latest designs. WCs in commercial buildings are generally used more frequently than those in residential buildings, meaning higher potential lifetime water savings, and they also have different design requirements, e.g. faster cistern refilling times.

For commercial and public buildings, a relatively high utilisation rate of 50 flushes per day can provide total water savings of about 170 l/day (more than 60 m^3 per year) by the replacing of an 11 litre single flush by a 4 litre single flush or 4.5/3 litre dual flush unit. Water savings and costs of implementation will vary greatly depending on the level of use, specific water savings measures, type of pan installed, and factors such as the plumbing arrangements, and the architectural finishes. It is usually considered uneconomic to replace older style WCs except as part of a major building or floor upgrade.

- **Water-efficient alternatives**

It is not always feasible to replace less efficient WC units completely, but there are retro-fit options available. For example, some toilet bowls with 11 litre cisterns can accept a simple replacement cistern, e.g. 6/3 litre dual-flush cistern, and this is can be very cost effective (payback period of 2-3 years or less). However, some bowls will not clean solid waste properly with the reduced 6 litre flushing volume and for this reason, British buildings regulations[39] state that "if any existing flushing cistern needs to be replaced without changing the WC pan, the new cistern should be of the same flush volume as the one being replaced, which may be a single or dual flush. A single flush cistern may not be replaced with a dual flush cistern. Where dual-flush cisterns are renewed the lesser flush volume is not to be greater than 2/3 of the total flush volume".

3.1.4.12 Commercial ice makers

Ice makers use more water than just the water contained in the ice. This equipment can often be very inefficient in water use depending on the type of machine and the desired type of ice. Ice machines are composed of the following components: a condensing unit used for cooling, an evaporator surface for ice formation, an ice harvester, an ice storage container, and, in some models, a dispenser. The type of condenser an ice machine uses will have the largest effect on water use. Two types of condensers are available: air-cooled and water-cooled.

The air-cooled units are usually more water efficient; while the water cooled units are usually more energy efficient, however, not all literature sources agree on this. Both types vary greatly in water efficiency, even for a given design type. Ice-makers are

[39] Water Supply (Water fittings) Regulations 1999: WC Suite Performance Specifications.

often located above an insulated storage box and are specified by their nominal capacity, defined as the weight of ice produced per 24 hours. Typically the capacity of ice-makers ranges between 110 kg/24 hrs and 650 kg/24 hrs. They are typically referred to as “automatic ice-makers”.

The typical icemaker can use up to 2 or 3 times more water than needed to make the ice. A number of factors influence water consumption, such as technologies used to produce different types of ice, the degree of water recycling; and the frequency of ‘flushing through’ with fresh water (*Mark Ellis and Associate, 2004*). Generally, water consumption is measured in terms of the volume required per mass of ice produced - ‘litres of water per kg of ice produced’. Most ice makers’ water use ranges between 1.5 to 16.7 litres of water per kg of ice.

3.1.4.13 Commercial washing machines/laundries

Depending on the machine type, volume of water consumed per cycle varies greatly. The initial wash cycle uses the most water because it must saturate the material and fill the wash wheel. These larger volumes also help to carry away the larger proportions of contaminates encountered in the initial wash phases. Rinse cycles use the least amount of water, sometimes as little as 35-60% of the amount used in the initial wash. Water is extracted between each step of the wash cycle before clean water is injected into the wash wheel (*Sullivan et al., 2008*).

3.1.4.14 Commercial dishwashers

The gallons/rack rating is a function of water use (in gallons per hour) and wash, rinse, dwell, and load time.

Water usage across commercial dishwasher classes does not appear to be directly related to the size of the machine and varies from 1.25 litres per dish rack (or per full load of dishes). A typical commercial dishwasher consumes approximately 15 litres per dish rack (*Alliance for Water Efficiency, 2008*).

3.1.4.15 Commercial garden irrigation (golf terrains and sprinklers)

See section 3.1.4.7, page 108.

3.1.4.16 Commercial car washes

- **Standard product**

Table 47presents typical water use for automatic carwashes.

Table 47 : Typical consumption for carwashes (*Brown, 2002*)

Component	Typical consumption (litres per event)	Range of consumption (litres per event)
Drive-in, conventional	150	80-300
Drive-in, reuse water	30	10-50
Drive-in, pressurised spray	50	45-55
DIY, hosepipe with trigger gun/nozzle	300	150-400

Component	Typical consumption (litres per event)	Range of consumption (litres per event)
DIY, bucket	35	10-70

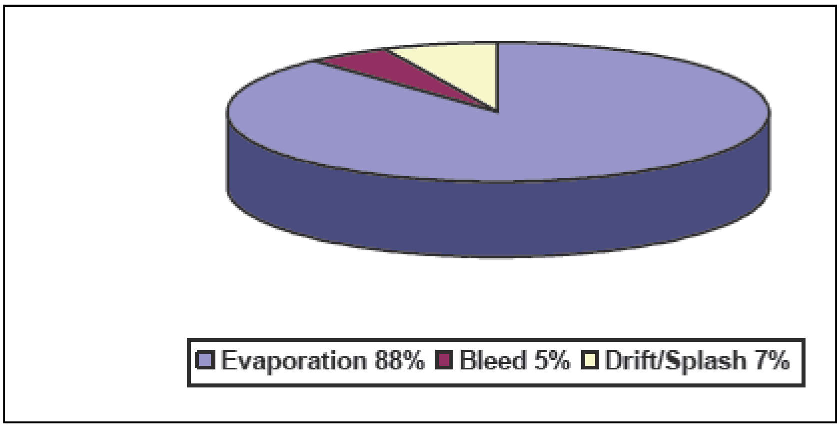
- **Water-efficient alternatives**

A US study claims that, on a gallon-per-vehicle (gpv) basis, professional car washes use a minimal amount of water when conservation equipment, including reclaim systems, is installed. When no reclaim system is installed, water use can range from a low of 15 gpv for self-service car washes to a high of 85.3 gpv in a frictionless conveyor car wash for basic wash using equipment and optimal operating parameters for water efficiency. For professional car washes using separation reclamation, the range varies from 30 gpv for in-bay automatics to 70 gpv for frictionless conveyor car washes. When a reclaim system with full filtration is used, the range is estimated from 8 gpv for in-bay automatics to 31.8 gpv for frictionless conveyor car washes.

3.1.4.17 Cooling systems used in commercial buildings

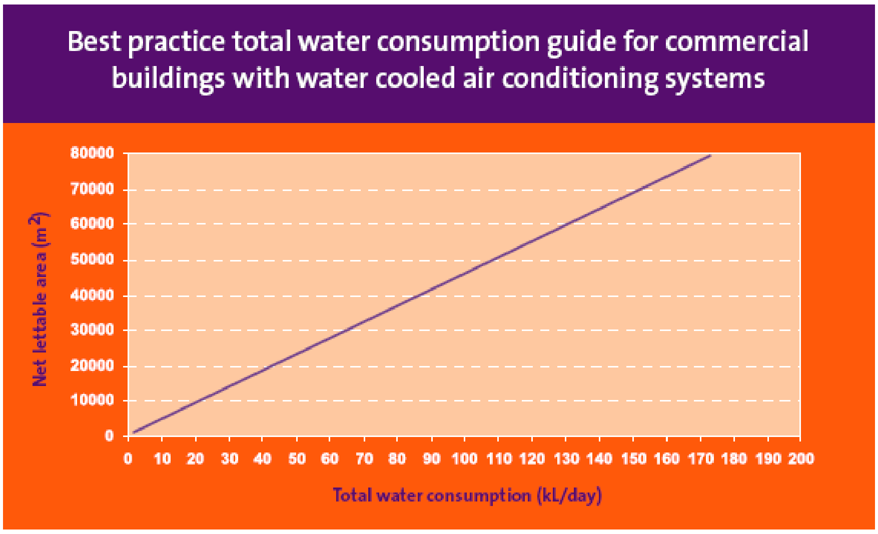
The pie-chart shown in Figure 34 is based on Australian data, and shows a typical breakdown of evaporation, bleed/blow-down, drift and splash (these terms are explained below) in a well-designed tower. In Australia, AC units can account for 30-40% of total water consumption in buildings with cooling towers. This percentage can be higher if the system has leakage, water treatment or overfilling problems. These losses are compensated by make-up water (usually from the potable water supply) which is added to the basin and regulated via a float valve. The percentages shown are of the circulating cooling water. For a 1050 kilowatt tower this could be 25 l/minute. The bleed shown is for cycles of concentration ratio of 2. Improving this ratio from 2 to 12 can save 45% of water use (10-11 l/min).

Figure 34: Water consumption for a well-maintained cooling tower



A benchmarking study *(Sydney Water, 2008)* has developed a water consumption guide for commercial buildings with water-cooled air conditioning systems, which includes the graph shown in Figure 35.

Figure 35: Best practice guideline for cooling towers: Sydney water



3.1.4.18 Overview of water efficiency of different WuPs in buildings

Consumption data for different WuPs were collected for this study, and are summarised in Table 48 below.

This summary data indicates that average daily household water consumption in Europe is approximately 326 litres. Assuming an average occupancy rate of 2.5 persons per household, this equates to a daily per capita consumption of 137.7 litres. It should be noted that these figures have been calculated based on some assumptions in order to determine potential water savings, and should not be taken as an accurate indication of the actual consumption in Europe. This figure appears to follow the 150 l/capita determined in the literature (*Dvorak et al, 2007*).

Some discrepancies can be expected as the methods of calculation, product types, and base figures considered may differ across MS. However, despite these differences, the pattern of household consumption seems to be in agreement with figures determined in other studies. In a study running in parallel to this one (*BIO, 2009*), it was determined that household consumption takes up a 60 to 70% share of EU **public water supply**[40]. For a total of 197 million households in Europe[41], and a calculated yearly consumption of approximately 125 698 litres per household, the total yearly household consumption is estimated to be 25 trillion litres. This represents approximately 60% of the EU public water supply. Furthermore, considering the results of a previous study on water saving potential in Europe (*Dworak et al. 2007*), which considers a yearly household consumption of 136 969 litres (150 l/capita/day, for a 2.5 person household), this is equivalent to 66% of the yearly public water supply.

[40] Note here that public water supply refers only to the water destined for use by residential and commercial buildings, as well as small industries which do not have access to a private water supply (i.e. not possessing a water extraction permit).
[41] Number of households in EU ≈ EU population/average number of person per household

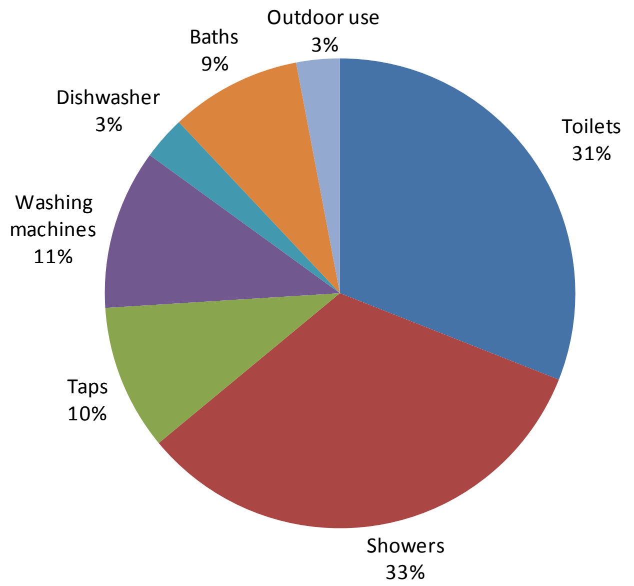
Figure 36 shows the average percentage of total household consumption, broken down for different WuPs present in residential buildings, based on data presented in Table 48.

Table 48: Summary of residential WuPs consumption data for EU MS

WuPs	Average water consumption per use	Frequency of use per person, per day [a]	Average water consumption (l/household/day)	Share of household consumption (l/household/day)
Toilets	9.5	4.2	100	31%
Showers	50	0.85	107	33%
Taps	1.1	1	31	10%
Washing machines	60	0.6	37	11%
Dishwasher	20	0.57	11	3%
Baths	80	0.14	29	9%
Outdoor use	4.3	1	11	3%
Total	-	-	**326**	-

[a]Assuming a 2.5 persons/household
[b] Maximum for European range (Table 31)
[c]Based on a five minute power shower using 10 l/min of water (*Sim et al., 2007*) with 6 showers per person, per week.
[d]Assuming 12 uses per person per day (*Sim et al.,* 2007), 6.5l/min and an average 10 sec use.
[e]Asssuming 4.3 washes per household per week.
[f]Assuming 4 washes of 20 litres per week (*Stamminger et al., 2004*).
[g] Assuming one bath taken per person, per week.
[h] Assuming an annual averaged value of 4.3 litres per head per day (*Herrington, 1996*).

Figure 36: Average household water use percentage per product type



If we disaggregate this overall water reduction potential by individual WuPs, it is evident that the highest savings can be achieved through promoting high-efficiency toilets (53%) (Table 49). All products could potentially achieve reductions in water consumption around the 20% mark. It should be noted that, with the exclusion of toilets, the majority of the figures have been based on the water consumption of newest available standard products. The figures for consumption savings could be considered somewhat conservative for the most cases, and actual savings may be much higher. By installing water efficient devices, the literature estimates a water savings potential between 29 and 41% per household (with the exclusion of outdoor WuPs) (*Dvorak et al., 2007*). Using the data presented in Table 49 our results correspond to those in the literature, showing potential water saving in **household** consumption of approximately 32%.

Table 49: Potential household water savings from water efficient appliances

	Standard product		Water efficient product		Standard vs. efficient
WuP	*Litre/use*[a]	*Litre/household/ day*	*Litre/use*	*Litre/household/ day*	*% reduction*
Toilets	9.5	100	5 [b]	53	53
Shower	50	107	40 [c]	86	20
Taps	1.1	31	0.8 [d]	24	23
Washing machine	60	37	41 [e]	25	32
Dishwasher	20	11	9 [f]	5	55
Baths	80	29	65 [g]	23	19
Outdoor	4.3	11	3.3 [h]	8	23
Total	**-**	**326**	**-**	**224**	**32**

[a] Assumed use patterns are from in Table 48, unless otherwise stated.

[b]Based on a 6/4.5 dual flush toilet (assuming 1:2 use ratio, at an approximate average of 5l/flush).

[c] At a water consumption of 8 l/min.

[d]Assuming water consumption of 5l/min.

[e]Based on average ecodesign requirements.

[f] Based on average ecodesign requirements.

[g] Reduction figure based on Ecologic report (*Dvorak et al., 2007*)

[h] Estimated 3.3 litres per head per day when replacing sprinklers and hosepipes with hose guns.

Table 50 provides a summary of water consumption and frequency of use per unit for WuPs used in commercial buildings. Most of the data in the literature is provided as either water usage per person (e.g. employee, guest, patient), usage per floor-space (i.e. m^2) or as an end-use percentage (kitchen, laundry, swimming pool etc.). This review suggests that there is a requirement for more detailed micro-component studies for different types of buildings (i.e. offices, schools, hospitals, hotels etc). From the collected information, however, it can be concluded that the high frequency of usage in commercial buildings makes it a priority to take further action on improving water efficiency of urinals, taps, and WCs at large commercial offices, schools, hospitals and hotels.

Table 50:
Summary of WuP water consumption in commercial buildings

WuP	Average water consumption per use	Frequency of use per day	Average water consumption per day (l/unit/day)	Range water consumption per day (l/unit/day)
Urinals	1-4 l/flush	30-70*	150*	30-280*
Taps	2-20 l/min	5-50	-	-
WCs	4.0 - 9.5 l/flush	5-50**	247.5**	20-475**
Dishwasher	1.25 l/dish rack	-	-	-
Washing machines	-	-	-	-
Commercial car washer	50-150 l/use	-	-	-
Cooling towers	0.2 l/m^2 floor-space	-	171	114-228

*The range of reported savings from replacing urinals indicate that, in some cases, flush frequencies and consumption of older self-flushing urinals in commercial buildings can be much higher than the volumes quoted here.
**This evidence is anecdotal

3.2. WATER USE IN INDUSTRY

3.2.1. OUTLOOK OF WATER USE IN INDUSTRY

Most industries are dependent on the adequate supply of water for steps such as production, processing, cleaning, cooling, and/or heating. Indeed, energy production has been identified as the most significant water consuming sector in Europe (see Figure 1, pg. 17 and Figure 37, pg. 113). Furthermore, industry represents between 11% and 15% of total water abstraction in EU. In the past, water quality in industries, both for supply and discharge, has received a great deal of focus. As water scarcity becomes an increasingly important issue in Europe, industries will also be compelled to optimise their water consumption.

3.2.1.1 Industrial water use in Europe

The total water use for industry in Europe is 34 194 Hm^3 /year which accounts for 18% of its consumptive uses. In 2001, industrial water use represented 37% of the consumptive uses in Western Europe (central and Nordic), and 13% of the consumptive uses in southern Europe.

The amount of water used by industry has decreased in all the European regions during the period 1990-2001, as illustrated in Figure 37, as a result of measures to reduce demand and due to economic restructuring. Indeed, different changes occurred during this period, which influenced the industrial water use: decline of industrial production, use of more efficient technologies with lower water requirements, and the use of economic instruments (charges on abstractions and effluents).

The intensity of water use [m^3/(€1 000 gross value added)] varies tremendously from one industry to another, e.g. in Finland it is about 138 m^3/(€1,000 gross value added) in