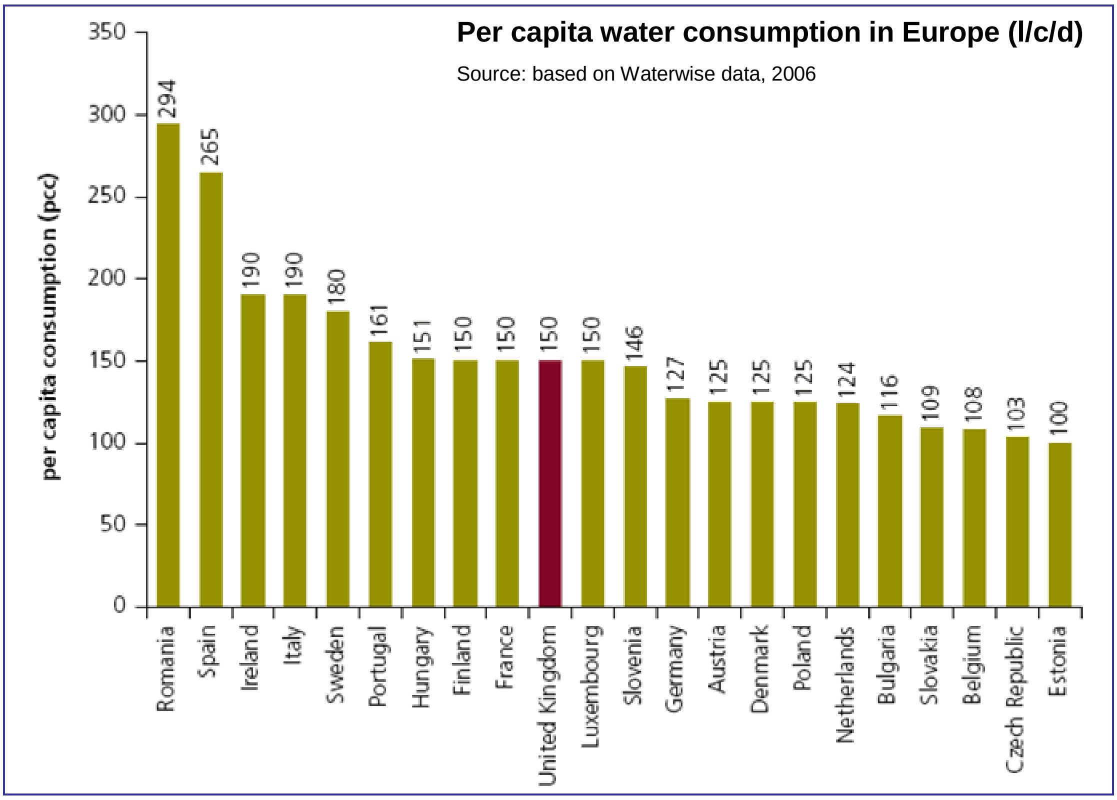
China – UK, WRDMAP
Integrated Water Resources Management Document Series

Thematic Paper 3.2: Urban Water Supply Demand Management

3. Demand Manage-ment

May 2010



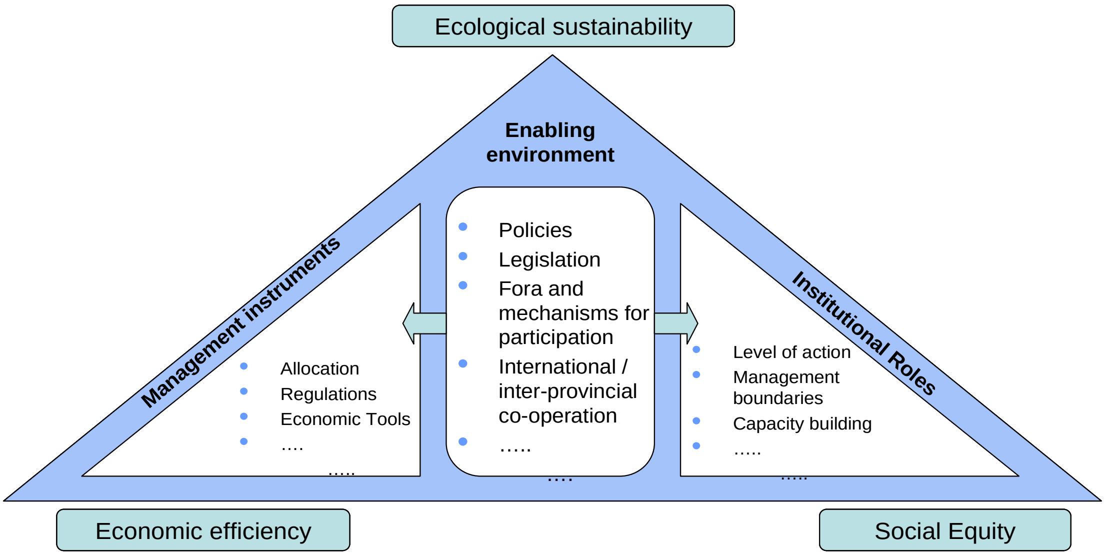
中国水利 CHINA WATER

DFID Department For International Development

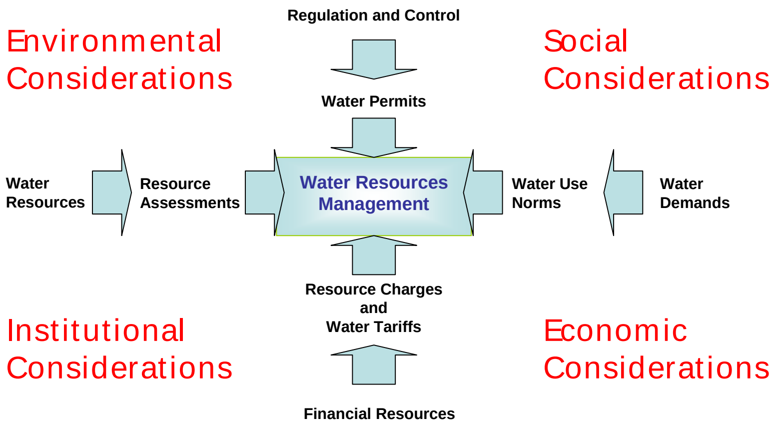
Mott MacDonald

Integrated Water Resources Management (IWRM)

(Basics after Global Water Partnership)



Driving Elements of Integrated Water Resources Management



(Second figure after WRDMAP)

Summary: Demand management is the implementation of measures which serve to control or influence the consumption of water. In the urban water sector the overriding objective of demand management is to promote efficient water use by both the water supply companies and their customers.

This document is one of a series on water that seek to inform on and promote best practice in sustainable management. Using water efficiently is in everyone's interest but it is only as securing adequate resources becomes a problem that all parties recognise their role in achieving a sustainable balance between social, economic and environmental needs.

This document covers the following topics:

- Introduction
- Demand management practices in urban water supply
- Supply-side measures (WSC led)
- WSC-led customer-side measures
- Regulations and Standards as drivers
- Raising awareness and influencing behaviour – public education
- Customer-led actions
- International experience
- Demand management initiatives in China
- Conclusions

This document is one of a series covering topics on sustainable water resources planning, allocation and management. Details are given in the bibliography.

The Ministry of Water Resources have supported the Water Resources Demand Management Assistance Project (WRDMAP) to develop this series to support WRD/WAB at provincial, municipal and county levels in their efforts to achieve sustainable water use.

1 Introduction

The Global Water Partnership (GWP) provide a good introduction to **water demand management**, stating that it reflects a major shift in the approach to water resources management. It moves away from traditional supply development (construction of physical infrastructure to capture more water for direct use) to an improvement in efficiency of use, conservation, recycling and reuse of water.

Demand management is a key element of **integrated water resources management** (IWRM) and it is supported by the wider approaches of IWRM—especially the emphasis on stakeholder participation, the creation of a water aware society and economic and administrative regulation systems. It is the integrated nature of IWRM and demand management which is critical to their success.

"*Changes in technology and behaviour both reduce demand, and metering is a prerequisite for both – but **the biggest impact is when they all happen together**.*"

Environment Agency, UK

Although it may be seen merely as an attempt to persuade people to use less water, the wider aims of demand management are to:

- Prevent wasteful use of water, limit consumption and hence minimise investments needs
- Ensure an equitable distribution of potable water supplies to all customers
- Ensure water supply systems are sustainable, providing customers

with the level of service they want at a price they can afford while covering the total costs of providing water

- Ensure an efficient and equitable distribution of available water resources between municipal water supplies, industry, agriculture and the environment

Demand management is not to be automatically preferred to supply-side investments in every case. However, taking demand management seriously does entail a systematic identification of all demand management options as part of water strategy, and a comparison of all options using a common methodology and criteria, e.g., the cost of a unit of water supplied or saved.

This Paper focuses on long term demand management, to limit the growth of demand in the long term in order to minimise investment. It can, however, also be applied to overcome short term problems caused by droughts or loss of supply capacity.

Many elements of demand management are inherent in the Chinese Government's policy for the establishment of a Water Saving Society.

2 Demand Management Practices

At its simplest, urban water supply demand management comprises two components: customer-side demand (consumption) and supply-side demand (leakage). Water utilities are responsible for supply-side demand management whilst the behaviour of the customer is the focus for the customer-side demand management (see Table 1 and Figure 1).

It is obvious that water supply companies (WSCs) must take the lead in managing supply-side demand by reducing water losses from their networks to economic levels. However, WSCs should also take the lead in getting their customers to use water sparingly, either by enforcement or by encouraging voluntary action.

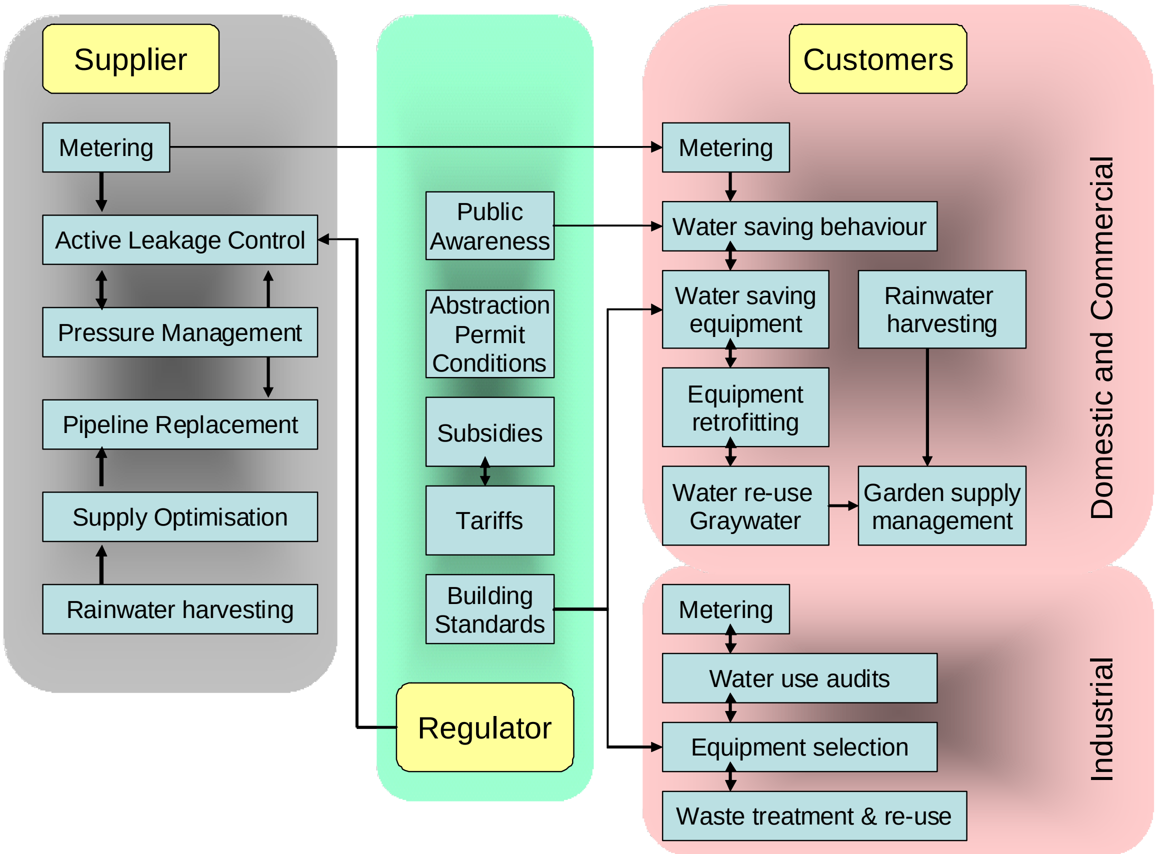
Table 1: Demand management practices

Demand management practice	Supply side	Customer side
WSC-led		
Active leakage control	Y	N
Pressure management – action by WSC	Y	Y(1)
Pipeline replacement	Y	N
Customer metering	N	Y
Tariff setting	N	Y
Free/subsidised repairs on customer supply	N	Y
Customer internal plumbing inspections	N	Y
Industrial customer water audits – by WSC	N	Y
'Temporary' restrictions	N	Y
Education campaigns	N	Y
Administrative regulation		
Abstraction permit conditions	Y	N
Performance targets	Y	y(2)
Building standards-driven		
Rainwater harvesting	Y	Y
Water efficient sanitary fittings	N	Y
Grey-water recycling	Y	Y
Customer-led		
Retrofit water efficient sanitary fittings	N	Y
Choose water efficient appliances	N	Y
Adopt water saving behaviours in home	N	Y
Adopt water saving behaviours in garden	N	Y
Adopt water saving behaviours in commercial premises	N	Y

(1) Reducing network pressures reduces "open tap" flow rates in customers' fittings

(2) Some moves to set WSCs targets for reductions in customer demand

Figure 1: Urban water supply demand management interventions



Customer-led demand management techniques can be implemented by the customer without assistance from the WSC.

A number of the above activities are customer-friendly in that they will cost the WSC in (i) providing additional customer services, and (ii) reducing customer consumption and, hence, revenue (although an appropriate progressive tariff structure that reflects the expected reduction in customer consumption should mitigate the negative impact on revenue). However, in the wider context of water conservation these activities should be economically advantageous to society.

These demand management activities should be supported by a public education programme to raise awareness of the benefits of reducing water consumption.

Table 2 explores the many drivers and potential impediments to the introduction and effective uptake of various demand management measures.

Table 2: Drivers and impediments to the uptake of urban water supply demand management

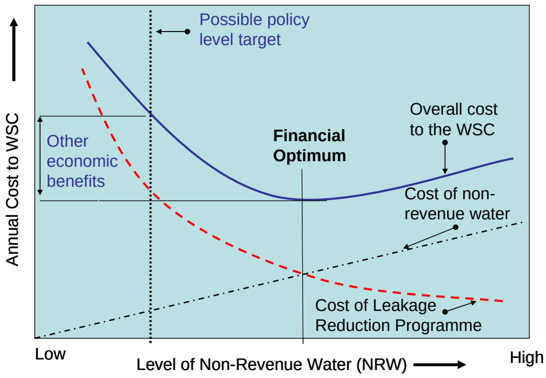
		WSC		Customer	
Driver	**Action**	**Incentive**	**Constraint**	**Incentive**	**Constraint**
Financial	Demand management (general)	Reduced infrastructure construction cost	Uncertainty in funding for demand management action	Reduced bill	Cost of new appliances
	Reduce illegal connections (non-revenue water)	Increase in revenue	Political/historical	Equity	Privileges hard to withdraw
	Leakage reduction	Reduce treatment costs or sell the extra water	Diminishing returns		
	Tariff				
	Metering		Maintenance	Only pay for what is used	
Environmental	Demand management (general)	Reduced water resources fee perceptions		Perception	Willingness to pay
Regulatory	Water abstraction permit conditions and Efficiency targets	Compliance avoids sanctions (fines)	Cost of compliance, try to pass on to customers		
Water scarcity	Demand management general				

3 Supply-side Measures (WSC led)

3.1 Introduction

There are various ways of reducing leakage. The decision on whether and how these should be implemented will depend on the relative costs of the measures and the potential benefits to be obtained. The intensity of leakage control activities should be increased until the marginal cost of leakage control exceeds the marginal value of water saved – the '**economic level of leakage**' (ELL).

Figure 2: Economic Level of Leakage



The means of reducing system leakage are broadly the following:

- Pressure management
- District metering, followed by active leak detection and repair
- Replacement of old pipework that is in poor condition

These are likely to be in order of increasing cost and so pressure management, where appropriate, will offer the greatest benefit cost ratio. Large scale replacement of distribution pipes will be an expensive solution, and only adopted where large sections of pipe are in poor structural condition or badly laid resulting in a high rate of leak repairs.

A fundamental fact about leakage control is that every possible leakage control measure follows a law of diminishing returns on the investment. As more money is spent, the return in terms of water saved due to lower losses, becomes progressively less. Some level of each activity will form part of an economic strategy to reduce water losses or leakage in a system.

Further details of leakage reduction target setting and ELL are given in the accompanying Thematic Paper 3.3 'Active Leakage Control as a Key Component in Increasing Efficiency in Urban Water Supply'.

3.2 Pressure management

Proactive pressure management can play an important part in a demand management strategy. Pressure management can provide some or all of these practical benefits:

- Ensure minimum standards of service for pressure are achieved
- Identify and minimise surge:
  - Reduces new leak frequencies
  - Extends infrastructure working life
- Reduces excess pressures:
  - Reduces flow rates from existing leaks
  - Reduces some components of consumption
  - Reduces new leak frequencies and natural rate of rise of leakage
  - Extends infrastructure working life

For practical predictions of pressure-leakage rate relationships the best practice equations are:

Leakage (L) varies with pressure (P) raised to the power N1, and

$L_1/L_0 = (P_1/P_0)^{N1}$

(It is important to note it is the **ratio** of pressures (P_1/P_0), not the difference in pressures, that is the basis for this predictive equation).

In general large leaks from metal pipes have N1 exponents close to 0.5. However, small background leaks at joints and fittings, and large leaks from flexible non-metal pipes, usually have N1 exponents of 1.5 or more. Consequently, the average pressure-leakage rate relationship for large systems with mixed pipe materials is usually close to linear (N1=1.0). The N1 exponent for small systems can be calculated from a monitored night test. For quick calculations and small changes in average pressure, the predicted reduction in leakage rate will be N1 times the % reduction in average pressure. So a 10% reduction in average pressure for a system with an N1 of 1.5 gives a 15% reduction in current leakage rate.

In addition to cutting leakage pressure management can directly influence some elements of consumption. In particular by reducing unnecessary high night pressures to match the typical night time customer water usage, and also any “open-tap” use in the customer’s supply is reduced, i.e. consumption directly from the pressurised section of the plumbing is reduced.

Maximum pressure has a considerable influence on the frequency of new leaks. Surges are particularly damaging; higher new leak frequencies have been observed in parts of a system with direct pumping, compared to parts supplied by gravity from a service reservoir. Systems with intermittent supply may suffer 10 or even 20 times the annual numbers of new leaks that would be expected if the system operated at steady pressure.

Pressure reduction can be undertaken using various methods. The level of sophistication usually depends on the economic level of leakage and the ability of the utility to maintain the equipment. The most common methods of pressure reduction are:

- Zonal boundaries
- Pump and level control
- Fixed outlet pressure control valves
- Time modulated control valves
- Flow modulated control valves
- Remote node control

In some cases electronics can be retrofitted to existing pressure reducing valves to improve control. All methods should be considered when planning for active pressure management.

> Sao Paolo, Brazil - the installation of hundreds of pressure reducing valves resulted in savings of 260 Mld.
>
> Source: IWA Water Loss Task Force

3.3 Active leakage control

Active leakage control is a technique for measuring and monitoring leakage levels in the pipe network, and reducing leakage by detecting and repairing leaks. There are a number of techniques for detecting leaks from sounding every fitting to the use of noise loggers. Active leakage control is an ongoing activity that maintains leakage levels at the appropriate level to prevent natural rise, ie once leakage has been reduced to the target level, regular active leakage control is required to prevent the leakage level from slowly increasing over time.

Research suggests that up to 65% leakage reduction can be achieved through district metering compared with a passive leakage control policy. However, in practice the reduction achieved will depend on a variety of factors including:

- The existing level of leakage in the distribution system
- The pressures in the system
- The type of pipe in the system. (It is more difficult to detect leaks on non-metallic mains than on metallic mains.)

Advisory Note 3.3/1 (see bibliography) provides guidance on implementing an active leakage control policy in small and medium size WSCs.

3.4 Pipeline replacement

Replacement of the mains pipelines in parts of the network where the mains pipes are in very poor condition will normally reduce leakage levels significantly. Renewal of customer connections and supply pipes to the meter is normally undertaken at the same time if the leakage reduction benefits are to be achieved in full.

Pipeline replacement is normally a more expensive option compared to active leakage control. It is often undertaken for other investment reasons, such as insufficient hydraulic capacity or poor water quality (caused by ingress of pollutants through fractures or poor jointing in the pipeline). In these cases the additional benefit from reduced leakage should be included in the investment evaluation.

Advisory Note 3.3/2 (see bibliography) provides guidance on implementing an asset management system in small and medium size WSCs.

4 WSC-led Customer-side Measures

4.1 Water charges

There is considerable evidence from around the world that heavily subsidised water supplies lead to excessive and wasteful consumption by those who have access to water and shortages for people at high elevation points or at the end of the distribution network, as investment in new resources fails to keep up with demand.

Metering consumers, charging by the amount of water consumed and setting tariffs to meet the full cost of the supply is a key component of any demand management programme. Any significant subsidy sends the consumer a message that water has a low intrinsic value and wastage of water is not important.

Customer metering

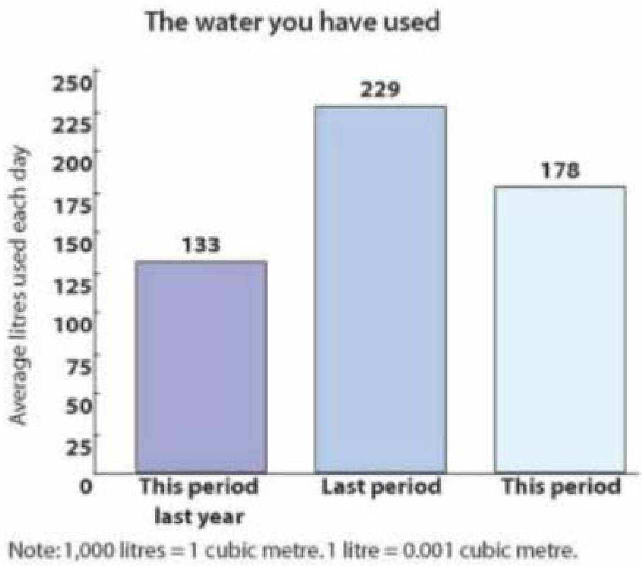
Metering gives customers a financial incentive to save water, and can therefore promote water use efficiency measures and water savings.

Metering offers a number of benefits. It is fair in that customers pay for what they use and it can allow the WSC to introduce a range of tariff structures. Metering has also been shown to reduce average household demand in UK by about 10%. The growth in metering also helps companies identify the leakage for which they are responsible and the estimated 25% of total leakage that is thought to derive from customers' supply pipes. In addition to saving water, meters could also deliver carbon savings both in the home through reduction in hot water use and for the water industry through less need to treat and pump water.

Countries vary in the extent to which metering is established for each type of consumer. The UK stands out from much of Europe in having a very low penetration of domestic metering (33% in 2009) but almost all non-domestic WSC customers are metered. In other countries such as China there is compulsory metering of domestic users. It is however always necessary for the WSC to develop an agreed procedure for estimating un-metered usage because even with compulsory metering there will still be instances of meter breakdown.

Where a customer is metered it is possible to provide additional information on the bill to show graphically how much water they are using with a comparison of best practice. Figure 3 shows an example of part of a quarterly water bill issued to a domestic user in the UK.

Figure 3: Example of WSC providing information on use on a customer's bill



How does your water use compare?

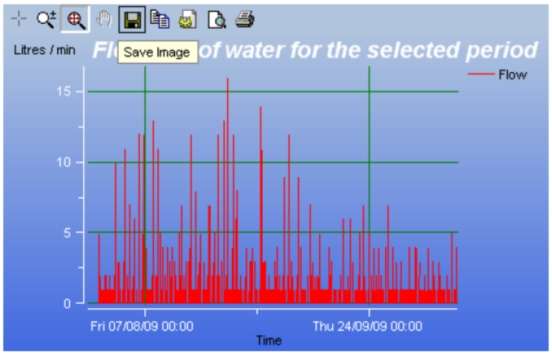
	Water Use (litres/day)	
People	Typical	Efficient
1	175	135
2	315	240
3	450	340
4	580	430
5	710	525
6	840	620

For example, a 4 person household typically uses 580 litres a day, but could use 430 litres a day if water is used efficiently.
For more information on water conservation, please see the back of this sheet.

Source: Sutton and East Surrey Water, UK

Intelligent metering has the potential to further the benefits of metering to both the customer and to the WSC. With intelligent metering the meter equipment can transmit real time information to a small user-friendly device for the customer and to the WSC's data management system. The customer thus has clear evidence of how they use water which can lead to behavioural change to reduce use. In addition the WSC has more detailed information on the pattern of water usage that might be important to tariff design, and also would be able to identify leakage on the customer's premises.

Figure 4: Real time information on water use for the consumer from a smart meter



Tariffs

A water tariff is a powerful and versatile management tool. It is capable of promoting a number of objectives, although tradeoffs among them are commonly required. Water tariffs are often designed to discourage "excessive" or "wasteful" uses of water, thus promoting the conservation of depletable sources, or the sustainable use of renewable water sources.

Customer metering tends to have an impact on consumption only where it is undertaken in conjunction with a progressive volumetric tariff structure that penalises customers financially if their consumption is unduly high. Progressive volumetric tariffs provide an efficient pricing framework to encourage metered customers to use water wisely.

The progressive volumetric tariff should ensure that low income households are able to comfortably pay for a minimum needs level of water consumption with customers who consume additional volumes being progressively penalised financially.

In theory, consumers respond to higher water prices by purchasing less water. However, when water prices are low, consumers are relatively insensitive to price increases. This response is called the price elasticity of demand and must be analysed in association with income elasticity linked with changes in consumer income, see Box 1.

Box 1 Elasticity example using possible price and income elasticities for larger urban areas

	Consumer elasticity	
	Price	Income
Domestic	-0.20	0.80
Industry	-0.25	0.50
Commerce	-0.35	0.70

In this example the impact of the price elasticities is that each 10% real increase in the water tariff would be expected to reduce consumption by 2%, 2.5% and 3.5% for domestic, industrial and commercial customers respectively. This price effect must, however, be offset against the relatively strong income elasticity effect for each customer group, which will continue to drive demand. The income elasticities infer that real tariff increases would have to be over four times the real income increase for domestic customers (around 50%), and twice the real income increase for industrial and commercial customers (around 25%) to actually start to reduce water demand.

Given the potential impact of price elasticity, achieving significant reductions in wasteful consumption may require a more complex approach incorporating both tariff design and other incentives. Box 2 illustrates such a combined approach.

Box 2 Impact of tariffs and discounts on water saving in Zaragoza, Spain

A 3-block tariff structure has been designed to match the socioeconomic attributes and consumption habits of the population. Whereas consumption falling in the first two blocks is subsidised, the upper tariff block is designed to curb excessive consumption and to cover full supply costs.

The WSC has been offering economic incentives to households that reduce their consumption rates. If households reduced their consumption by at least 40% in 2002, they were entitled to a 10% discount on the bill. In subsequent years, the target was reduced to 10% reduction in consumption rate per year. The scheme is being embraced by an increasing number of households, which has contributed to overall reduction in water consumption in Zaragoza.

Source: Smout I et al, 2008 (see bibliography)

Advisory Note 5.4 (see bibliography) provides guidance on setting tariffs for small and medium size WSCs.

4.2 Assisting customers to reduce their water use

Free/subsidised repairs on customer supply

A significant proportion of network leakage can be related to the customer-side supply, i.e. pipework on the customer's land but not within buildings. By offering free or subsidised repairs, reductions in leakage levels can be achieved. However, applying an appropriate tariff will encourage customers to carry out the repairs themselves in order to avoid high water bills.

Box 3 Leaking taps

Typical loss from a leaky tap (continuous 5mm stream) is about 60 litres/hour.
If there are 100 such taps in an apartment block, the loss is 6 m^3/hour.
Over a year this would be 5.26 x 10^4 m^3.

Customer internal plumbing inspections

These inspections are undertaken to identify water fittings losses which drive up demand. They can be done in conjunction with a repair service for customer supplies. Again, an appropriate volumetric tariff will encourage customers to repair any fittings themselves in order to avoid high water bills.

Box 4 Beipiao WSC Findings

A full internal inspection of all apartment blocks within Tianyuan community showed:

Status of apartments	Number
Occupied	2,428
Leaks found	738
Metered	1,779
Meters operating	1,008
Meters not operating	358
Meters unreadable	413

It is clear from these figures that there is a major problem with the internal supplies. The survey found toilet cisterns flowing continuously, corroded pipes, and continuously discharging pipes.

Source; Beipiao Water Supply Company (Chaoyang Municipality, Liaoning Province) reported by the WRDMAP project in 2008.

Industrial customer water audits

Water audits can be undertaken by the WSC staff to aid industrial and commercial customers to suggest ways of using water more efficiently.

This should reduce the customer's demand for water, or at least highlight which elements have the greatest demand. However, to provide this service the WSC needs suitably experienced staff who are knowledgeable about water using equipment and practices.

Table 3 shows some typical water usage figures based on real situation water audits in the UK. As can be seen from the data, there is a wide variation in usage rates reflecting the technology in use in each factory sampled. The 'best' result gives an indication of what potential improvements may be possible.

Table 3: Typical UK industrial water usage

Sector/sample size	m^3/tonne of product		
	Mean	Best	Worst
Metal casting (34)	17	0.01	129
Chemicals (35)	28	0.02	198
Dairy (18)	164	0.03	1786

Source: Envirowise (Environment and Energy), UK

The use of efficient industrial water using equipment is a key aim of the China Water Conservation Technology Policy Outline described in Section 9.

4.3 Restrictions on use

Most WSCs aim to provide all their customers with a continuous supply - in many jurisdictions this is a statutory obligation. However, it is recognised that there will be exceptional circumstances where the WSC is unable to meet this target and the supply will be restricted.

Situations where the WSC needs to restrict supply range from short term emergencies (eg pollution incident, burst main) to longer term problems associated with a shortage of resources (eg drought, under capacity of delivery systems). WSCs should have specific plans in place for dealing with emergencies and for droughts – such plans are often a statutory requirement to ensure that vital services (hospitals etc) will receive adequate water in emergencies.

Restrictions should only be introduced to overcome shortages created by extreme droughts or major unanticipated failure in the supply system. They should be commensurate with the severity of the shortage and should be removed as soon as the shortfall has been eliminated. The introduction of restrictions should be accompanied by a publicity campaign to explain the measures to consumers (Section 4.4).

Common restrictions, imposed during droughts, may include:

- Banning the use of hosepipes to water the garden and for other outside activities
- Closing down car washes
- Restricting watering of parks, sports fields, etc.

More serious restrictions may include:

- Rotational cuts so that part of the distribution system is shut down for a number of hours, other customers receiving the normal service. The rota is usually published to allow users to plan their water use activities.
- Shutting off household connections and providing an alternative supply option eg standpipe in the road or bowser
- If there is a serious water quality incident it may be necessary to provide customers with an alternative safe water source for drinking and cooking (bottled water or bowser)

Reducing pressure can also have the same impact in terms of volume of water distributed as shutting down parts of the network, but it likely to be less equitable since some parts of the distribution system are more likely to suffer.

Restrictions, particularly if they involve limiting hours of supply to domestic customers for any length of time, can cause considerable hardship through disruption of daily life. Intermittent supplies often lead to significant water quality problems due to the ingress of polluted groundwater through holes and cracks in pipes which adds to the hardship and impacts on livelihoods.

Further discussion of possible actions during a drought is given in Advisory Note 2.5 'Developing a Drought Management Plan' (see bibliography).

4.4 Customer education programme

WSCs have a key role in raising awareness of the need for water efficiency among their customers. In this they can contribute to public education measures implemented by governments and water resources agencies to promote sustainable use in river basins. Public education measures for urban demand management are discussed in Section 6, here the focus is on those particular contributions that WSCs can make to further these national objectives.

The WSC engages with its customers through the billing process. Information on demand management opportunities that customers could take up can be sent out with bills. The WSC can also use this mechanism to promote meter use, to advertise services that it offers to assist customers with leaks or water audits, and to provide details on how to report leaks and other problems. Special initiatives can be carried out for World Water Day or China Water Week.

5 Regulations and Standards as Drivers

5.1 Introduction

The problems of water scarcity and the need for demand management are usually articulated in national policy and drive the behaviours of WSCs and their industrial, commercial and domestic customers.

A key component of this top-down process is the role of regulations and standards that set out to force change in a positive direction. This is often accompanied by government-led initiatives for research into water conservation techniques, support for water sector awards and kite marking schemes that publicise best practice, and by adopting best practice in government establishments as an example. The research is often conducted in the form of demonstration projects which can also be very useful in publicising innovative techniques.

In some countries land use planning includes consideration of access to water and some restrictions on development may be driven by concerns about available resources. This may lead to some difficult economic choices since many important urban centres are in areas of water scarcity.

5.2 Water abstraction permit conditions

Depending upon the legal framework water abstraction permit conditions can define quotas; best practice; re-use levels; use of wastewater, and monitoring of water use. The abstraction permit is therefore an important instrument in enforcing sustainable water use, at both the level of the individual permit holder and the wider river basin or aquifer level.

In the urban water supply setting permits are issued to bulk water suppliers (the WSCs) who sell on to domestic and non-domestic users. The link between the demand management targets set out in the permit conditions and individual customers is therefore indirect since the WSC stands between them. Therefore the permitting authority can only influence customer water use through the activities of the WSC (the permit holder).

To ensure that conditions of the permit imposed on the permit holder are translated effectively to the water users such instruments need to be supported by appropriate economic instruments (Section 4.1), advice on technology (Section 4.2) and communication/ awareness (Section 4.4).

Those large industrial users who abstract water directly and hold their own permit can respond directly to the permit conditions and can be expected to reduce water use and improve waste water quality in accordance with best practice. But it is important that permit issuer monitors and enforces compliance.

5.3 Performance targets and measurement issues

For any WSC, the drivers to undertake an active leakage control programme may be low. In a situation where demand problems have always been resolved by supply side interventions, the trouble and cost of significantly reducing leakage is an impediment to action. In many countries, this situation can best be resolved by the intervention and control of a regulator. A regulator can set leakage reduction targets. This issue is addressed in another document in this series: Thematic Paper 4.3 'Regulation of Small and Medium Size Water Supply Companies'.

As a further development the regulator may also set targets for customer-side demand reductions. For example, the 23 private WSCs in England and Wales have a statutory duty to promote water efficiency; from 2010 the water sector regulator, Ofwat, will set mandatory water efficiency targets in addition to mandatory targets for reducing burst water mains and distribution system and overall leakage.

From a water resources management perspective a key issue is **how to assess the effectiveness** of demand management measures. The involvement of a regulator in target setting places a strong emphasis on ways of demonstrating efficiency savings through scientific measurement.

Accurate measurement of all the components of the WSC water balance is required in order to make a reliable assessment of the effectiveness of demand management measures. This clearly must include the volume of water delivered to customers in their properties, and would imply universal metering – however, even where, as in China, domestic metering is compulsory some users will always be un-metered (broken meters, illegal connections, etc).

5.4 Building or planning regulations

New developments should meet the latest building regulations and these should incorporate the latest thinking on such issues as rainwater harvesting, water efficiency standards for sanitary fittings, possibilities for grey-water recycling, etc.

Building regulations may be easily changed to require the use of the latest water saving devices in all new properties or whenever toilets are replaced. The full effect of such regulations is of course only felt over time as more new properties are built and more people have their bathrooms and toilets refurbished. However, this is an effective and economic means of reducing water consumption.

Where rapid urban development is occurring it is particularly important to have regulations that will ensure that water efficiency is high to counteract the impact of many new consumers adding to demand.

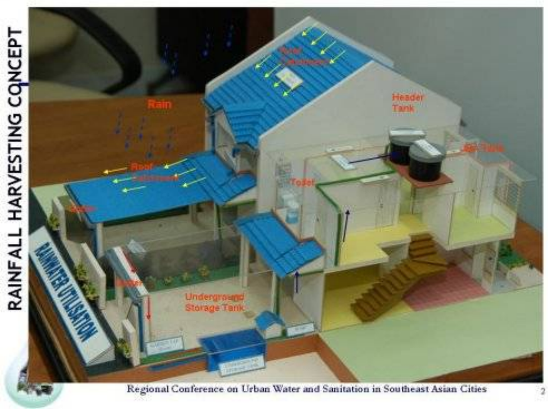
Older properties, which in places like Europe could be more than 85% of the housing stock, present a more difficult problem since the latest building regulations can only be enforced when new work is done on an older building and then only to the new structure.

Rainwater harvesting

Rainwater harvesting is extensively used in rural areas by individual property owners but is not often formally used in urban areas with piped water supply systems. With increasing concern about water scarcity in many parts of the world rainwater harvesting is attracting more interest. There are certain issues related to water quality but simple filtration is often sufficient as long as uses are restricted.

Rainwater harvesting in this context is intended for more than just garden use (see Section 7.1).

The key issues for rainwater harvesting prospects are the local rainfall pattern and the available collection area. Rainwater is usually collected from roof areas so is more suited to houses and factories rather than apartment blocks where the number of users relative to roof area is very high. However office premises may be suitable because the amount of water used by the workforce during the day is much less per capita than domestic use. If rainfall is highly seasonal with a long dry season the approach may not be cost effective because of the volume of storage that would need to be provided. However, this situation is different from country to country.



Example from Malaysia

Standards for rainwater harvesting systems address safety and water quality issues, for example the British Standard BS 8515:2009 'Rainwater harvesting systems - Code of practice'.

Grey water recycling

A recent development in demand management is grey-water recycling which is increasingly being considered as an alternative to treated water for non-potable use. Grey-water is the term used for washwater from baths, showers and hand basins which is reused elsewhere in the same property, typically for toilet flushing or garden watering. The grey-water needs to be collected and routed around the property in a separate system from the incoming supply to avoid contamination (ad hoc recycling of grey-water by householder is discussed in Section 7.1).

It is imperative that the risk of cross contamination of potable water is eliminated, both during initial installation and during future works to the building. In many countries where greywater reuse has been adopted, such as Japan, the reclaimed water is coloured blue or green by a dye added to the water at distribution. This has the benefit of making it immediately obvious that the water is not potable (highlighting any cross contamination', plus making it appear 'cleaner'). Greywater systems should always fail safe i.e. if any disruption of the system occurs, the supply defaults to mains water supply.

Greywater systems require much smaller storage tanks than rainwater systems, as the water is generated constantly throughout the year and used almost immediately. The treatment processes required depend upon how the recycled water will be used within the building or garden. The design must provide for safe storage of water to avoid bacterial growth such as Legionellae. Maintenance is absolutely essential if the systems are to operate correctly and safely.

Building codes can ensure that installations are safe and hygienic to operate, for example British Standard BS8525 'Greywater systems - Part 1 Code of practice', (draft for consultation) September 2009.

Although grey water recycling is in its infancy practical solutions on how it can be developed for widespread use are continually under development.

It should be noted that the potential for grey water recycling is significantly reduced in properties where water efficient fittings and appliances are present.

A two year trial of grey water systems carried out by the UK Environment Agency found that the savings from such individual systems were very variable, with water savings between 5.6 and 32.2%

Whole building standards

The aspiration to achieve sustainable buildings, in terms of energy and water and reflecting all aspects of construction and lifetime occupation, has led to the introduction of 'whole building' standards for new buildings.

In New South Wales Australia the Building Sustainability Index (BASIX) is a major initiative to reduce the amount of drinking water consumed and greenhouse gas emitted by new homes and smaller apartment blocks. In Sydney, the BASIX policy includes a requirement that new dwellings must be built to use 40% less drinking water than the state average. BASIX offers maximum flexibility by recognising a range of water saving measures to suit individual household budgets, homes and lifestyles, and surrounding environmental conditions. It is mandatory to obtain a BASIX certificate before building. The 'Code for Sustainable Homes' launched in 2009 in the UK similarly implements a whole house performance standard within the building regulations.

Research is ongoing to develop standards for new office and new industrial premises that are sufficiently flexible to accommodate the diversity of such buildings.

5.5 Water efficient sanitary and washroom fittings

Design standards for toilets, taps and showers can drive water efficiency in the home and business premises. Local preferences will dictate the most popular design but kite marking schemes can identify the most efficient options on the market. Sanitary fittings are particularly important in achieving water saving but clearly health and safety implications must be fully addressed. In the UK it has been estimated that about 30% of domestic consumption can be attributed to toilet flushing.

National Standards are typically issued for such items because of the public health interest in having appropriate fittings installed at least in buildings open to the public.

Toilets

Dual flush / reduced flush toilets

Where consumers use cistern flush toilets, encouraging them to install dual flush or reduced volume flush toilets can result in savings of around 3 litres per flush.

One UK water company fitted flush volume reducing fittings to all cisterns on its premises to achieve a saving of 1 litre per flush, this resulted in a reduction in water consumption at one of its regional offices from 3,170 l/day to just over 1,000 l/day.

Flush valve toilets

This type of toilet uses a 'flushometer' valve directly connected to the water supply plumbing. Flush volume can be set using a flow reducer and a timer (if fitted).

Passive infrared urinal controls

These devices flush urinals only when they have been used by detecting the presence of a user. The devices can produce significant savings in office, education, and other institutional facilities. One UK water company reported water savings of up to 65% when these devices were fitted in their office premises. Such systems are increasingly seen in China.

Waterless urinals

Many incorporate a cartridge that must be replaced after a certain number of uses. Others use a special liquid filled trap incorporated into the urinal rather than a replaceable cartridge. The trap lets urine go to the sewer but acts as a seal to block odours. The special blocking fluid remains effective for approximately 5000-7000 visits.

Reduced Flow Taps

Push-top Taps

UK trials suggest that these taps can save approximately 2 m^3/person/year if set up correctly. Normally, the taps are set to deliver a reduced flow of 6 l/minute with a running time of 6s per push.

Tap Flow Reducers

A device is available in the UK and elsewhere which, when fitted to existing taps, allows the flow to be modified according to use. With half a turn of the tap the device offers a spray and when the tap is opened further the flow changes to full flow. One UK water company reports that the average water saving per hand wash was around 50%.

Shower units

The latest water saving shower fittings incorporate aeration to enhance the experience during the shower. This is a response to the popularity of the 'power shower', a device that is even less efficient than either a standard shower or taking a bath.

The volume used is obviously a function of how long the shower is on which is in the control of the user. The introduction of efficient shower fittings should be accompanied by a campaign to get users to take less time in the shower to save water.

Table 4: Water use by shower fittings

Shower type	Rate (litres/ minute)	Volume in 5 minutes (litres)
Standard	8	40
Power	21	100
Aerated	5-6	25-30

6 Raising Consumer Awareness and Changing Behaviour

6.1 Targeting the audience

All urban water supply demand management measures should be accompanied by a long-term public education programme to generate and sustain consumer awareness of the need for sensible water use to achieve national objectives on water conservation.

Box 5 Sydney - the benefits of an informed community

Outdoor water conservation:

- 93% of Sydney Water domestic customers are aware of the '**Go Slow on the H_2O**' campaign
- Water conservation website had 348,000 visitors in 2004-05
- 100 billion litres reduction in use each year under restrictions

Indoor retrofits:

- 75% of Sydney Water customers aware of the programme
- 310,000 homes have participated
- 6.5 billion litres saved each year
- A$30-$100 in utility bills saved for each participating household

'Every Drop Counts' business initiative

- over 7.3 billion litres saved each year
- 304 participating partners

Source: 2006 Metropolitan Water Plan

The water sector must target its communications effectively to ensure the best take up of the demand management messages. Clearly initiatives aimed at influencing industrial or commercial users need to be framed differently from mass public education campaigns. Similarly emergency measures required during a drought need to be promoted with a distinct sense of urgency.

Actually reaching the target audience and successfully influencing their behaviour is a difficult task when most urban water users are in an environment where they are constantly bombarded with advertising and information. To catch and hold their attention requires a professional approach to communications, including a thorough evaluation of the success, or otherwise, of all dissemination activities.

6.2 Domestic consumers

Education and publicity are two key components of a demand management policy. School children, who are effective at taking the message of the importance of saving water home to their parents, are a key target audience. Children are generally more receptive to environmental messages particularly invoking wildlife. This can serve as a basis for disseminating other messages. However, it is also important to explain to adults why it is necessary to save water, how they can contribute to savings and how using water carefully can help reduce their water and wastewater bills. This is effective when combined with increases in tariffs and the imposition of new tariff structures that penalise unduly high consumption.

A public education programme can use various communication channels, such as leaflets distributed with water bills, WSC and other web sites, TV and radio messages, posters or public notices in newspapers.

The internet is a powerful tool in awareness raising because of the ease with which anyone seeking information can move from site to site via directed links. A WSC customer may access the WSC's web site and from there be directed to the national standards organisation, or to firms selling water efficient appliances, or to the water resources agency for drought status reports etc.

Education campaigns can cover:

- The importance of not wasting water, including replacing washers on leaking taps, not leaving taps running, not washing-up under running taps, etc.
- Advice on purchasing water saving washing machines, dishwashers, toilets, etc.
- Advice on plants with a low water consumption for the garden
- The implications of excessive water use for the environment and levels of service that can be provided to all customers.

Campaigns can be effective in restricting use in a severe drought. Experience in some areas which can suffer from droughts, e.g. mid-western USA and Australia, has shown people respond well to appeals to save water provided they are kept well informed of the situation and appreciate the need to conserve water. However, such appeals must be used for limited periods (a few months at most) and water supply companies must be open and honest with their customers.

Communication between the WSC and its customers is central to encouraging water saving. Metering saves water and also makes customers more likely to engage in demand management activity. Therefore directing information on demand management opportunities to metered customers with their billing is particularly effective.

Persuading people to invest in devices for the home that use less water will have a long term beneficial effect. The tariff is also an important influence here, since if people are paying the full cost of water and are penalised for unduly high consumption, they will be more likely to recoup the cost of their investments in water saving devices from reductions in their water bills.

6.3 Non-domestic consumers

Influencing business users requires a different approach that aligns with the financial ambitions of the management and recognises the pressures under which they are operating. The permit process and regulator targets also provide means of influencing the behaviour of non-domestic consumers.

Businesses need to be persuaded that while water costs may appear trivial in comparison with turnover, in terms of absolute cost they often represent significant amounts of money; and that considerable reductions in costs can be achieved without requiring large investment. In fact many actions to reduce water-use have short payback periods.

Potential opportunities for water efficiency savings depend on the business sector. There is usually a range from new installations where the latest technology has been employed to older plant, both across the industry and between factories within the same firm. Many industries have a members' organisation that provides an avenue to spread best practice within their industry.

Government programmes to help foster business success are also common. More recently government programmes focusing on environmental improvements have been introduced. Water is usually one of the focus areas, especially in countries where resources are scarce.

Two UK examples are presented in Box 6.

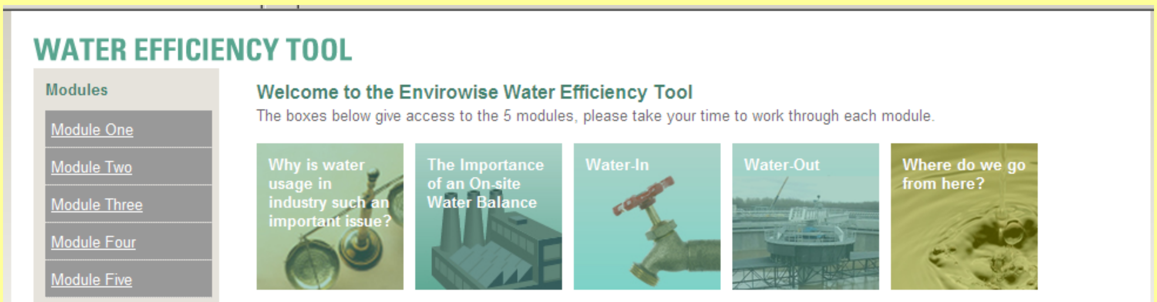
Box 6 Environwise and Waterwise – free advice for business promoting water efficiency

Envirowise and Waterwise are UK government programmes offering free, independent advice on practical ways to minimise waste and convert turnover into profit.

www.envirowise.gov.uk/water

www.waterwise.gov.uk

The Envirowise water efficiency tool is an interactive web-based educational package for business users. This is just one of several tools available to use or download that target water efficiency in the workplace.



7 Customer-Led Actions

7.1 Domestic customers

Water audit

Customers can carry out their own water audit to find out where efficiency savings can be made (see Section 4). In the UK a government sponsored organisation to promote demand management, Waterwise, provides an easy to use household water audit checklist as a free download. This audit checklist is also linked to the individual web sites of the water utilities and sent out with bills to give it maximum exposure.

> Water efficiency offers a triple win – it saves water, saves energy, and can also save on bills.

Refit premises

Where the residence is not of recent construction the householder can choose to replace sanitary and washroom fittings with more efficient modern equivalents. For most householders such a decision will be largely determined by a personal cost-benefit assessment. If the benefits of more efficient fittings in terms of lower water bills will not cover the cost of the purchase and installation of new fittings within a reasonable pay-back period the householder is unlikely to make any replacement. Recognising this some WSCs offer certain water saving fittings free, in other cases subsidies may be available to encourage uptake.

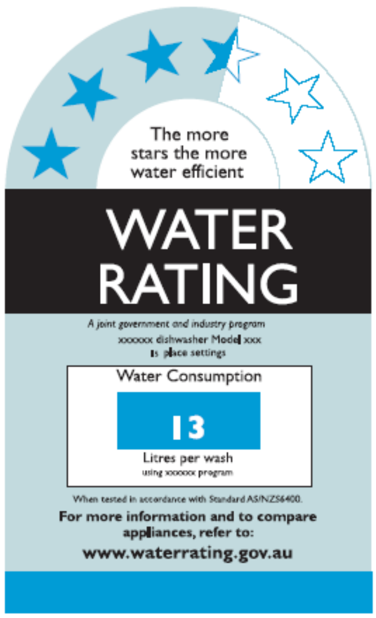
Customers should be able to obtain information on the most efficient fittings, likely cost, payback periods, and availability of grants, etc from the WSC, from organisations such as Waterwise, and often also from sanitary ware manufacturers.

Choosing water efficient appliances

Changes in per-capita water consumption are related to socio-economic development, to the design of domestic appliances, and to social attitudes to water use and water saving. With socio-economic development there is generally a shift to more water using household appliances, and this can result in increased water consumption. Improvements in the efficiency of these appliances have helped to limit the rate of per-capita demand growth in many countries.

Consumers need to have ready access to information on water use for different appliances and the water saving characteristics of different brands for the same appliance in order to make an informed choice. Figure 5 shows the compulsory water efficiency labelling that all water using household appliances sold in Australia must have. The label clearly highlights 'green' or environment-friendly products.

Figure 5: Australian water efficiency label



When such a labelling scheme is present and consumers have an awareness of the need to save energy and/or water then the greener products should sell better – this in turn is a spur to further technological improvement by manufacturers.

Adopting water saving behaviours – home

Raising awareness of the importance of water saving in the home is key to behavioural change as discussed in Section 6.2. Smart meter development provides a means for giving the homeowner direct feedback on their water use, this is expected to enhance uptake of water saving measures in the home.

WSCs can provide their customers with advice (‘ten top tips’) and subsidise water saving products (rainwater butts, energy saving kettle, tap flow reducers etc).

Women are the main water users in the home and water saving publicity campaigns should focus on this target audience. There is scope for considerable savings within the house if the family are aware of the possibilities so educating school children on water saving practices for the home can be very influential.

Assuming that they are reached by the publicity campaigns many people are quite ready to take up water saving in the home including:

- Using displacement devices in large toilet cisterns
- Taking short showers
- Using their washing machine only when full
- Not preparing food under a running tap
- Collecting greywater for recycling in the garden

These activities are usually strongly promoted by WSCs during droughts and compliance may lapse once the drought breaks.

Box 7 Mrs Chan, Penang, Malaysia

The water audit of Mrs. Chan (a woman from Penang, Malaysia) clearly showed that her family could save a considerable amount of water each year if they adopted a range of water saving measures at home.

Estimated annual water use assuming the most and least water-efficient methods

	Most efficient	Least efficient
Laundry	16,425	43,800
Dishwashing	21,900	43,800
Showering	10,950	15,330
Toilet flushing	57,670	114,975
Garden watering	14,600	36,500
Total	121,545	254,405
L/household/day	333	697
L/capita/day	133	279

Source: ‘The Role of Gender in Domestic Water Conservation in Malaysia’, Water Watch Penang, http://www.waterwatchpenang.org/

Adopting water saving behaviours – gardens

Planting drought tolerant native species in the garden can save water – many WSCs provide advice via websites and publicity material.

Ad-hoc use of buckets of greywater to irrigate gardens is common during dry spells, especially when drought restrictions are in place.

In households with gardens and cars, non-potable consumption can be reduced by increasing the use of rainwater collection for garden watering and car washing.

Automatic sprinkler systems should not be used unless they are using recycled water or rainwater. Likewise hoses, which can use 150 litres of water in ten minutes.

In many Australian cities, 40% of mains water is used in gardens, and the drought restrictions are having a big impact in reducing this. Installation of domestic rainwater tanks is fast becoming the norm.

The water needed for car cleaning can be significantly reduced by using a bucket instead of a hosepipe, especially if rainwater or greywater is used.

7.2 Institutional customers

A variety of public services fall into this category and their level of water use, and potential for water saving, reflects this diversity. Institutional customers include bodies responsible for extensive grounds (parks, sports grounds etc) and street planting.

Box 8 Sydney hospitals make savings

Two of the major hospitals, Westmead and Prince of Wales, have participated in water audits that have resulted in significant water savings through reduction of leakage and wastage. Prince of Wales Hospital reduced water use by around 200 million litres per year, and Westmead by more than 60 million litres per year.

Source: 2006 Metropolitan Water Plan

Government and public services should seek to demonstrate best practice. Schools in particular with their role in raising awareness of all forms of water saving should demonstrate high standards of practice themselves.

Procurement requirements need to be designed to ensure that agencies preferentially purchase water efficient appliances, fittings and other water using equipment.

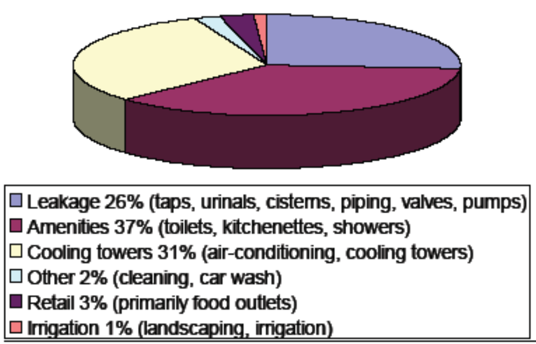
7.3 Commercial customers

Water audit

Businesses can carry out self auditing so that they know how much water is being used within their premises and where. They should also consider having a meter (and sub-meters if required) installed if this is not already done. The WSC will often be able to assist with audits of commercial customers.

Water use by commercial customers depends on the nature of their operations. Audits of office buildings in Australia and overseas indicate that over 95% of water use in modern office buildings is accounted for by amenities, cooling towers and leakage. A typical end use breakdown is shown in the pie chart in Figure 6.

Figure 6 Typical office water use



Source: Water and Efficiency Guide: Office and Public Buildings, 2006, Department of the Environment and Heritage, Australian Government

The NABERS (National Australian Built Environment Rating System) is a voluntary benchmarking scheme covering office buildings and public institutions. It is anticipated that 50% of office space in Sydney will have obtained accredited NABERS OFFICE Water ratings by 2009-10 (www.nabers.com.au).

Following the audit the next step should be to draft a water management plan (WMP) to identify all the necessary actions and resources – these may include new or improved equipment, different processes, changes in behaviour and attitude, and of course, money and staff time. Such a plan need not be overly complicated and can be enhanced and improved over time as feedback is received and data improves. If the business already has an environmental management system (ISO 14001) then the water management plan would constitute a component of the system.

Figure 7 Hierarchy of water saving measures for WMP actions by 'return on investment'

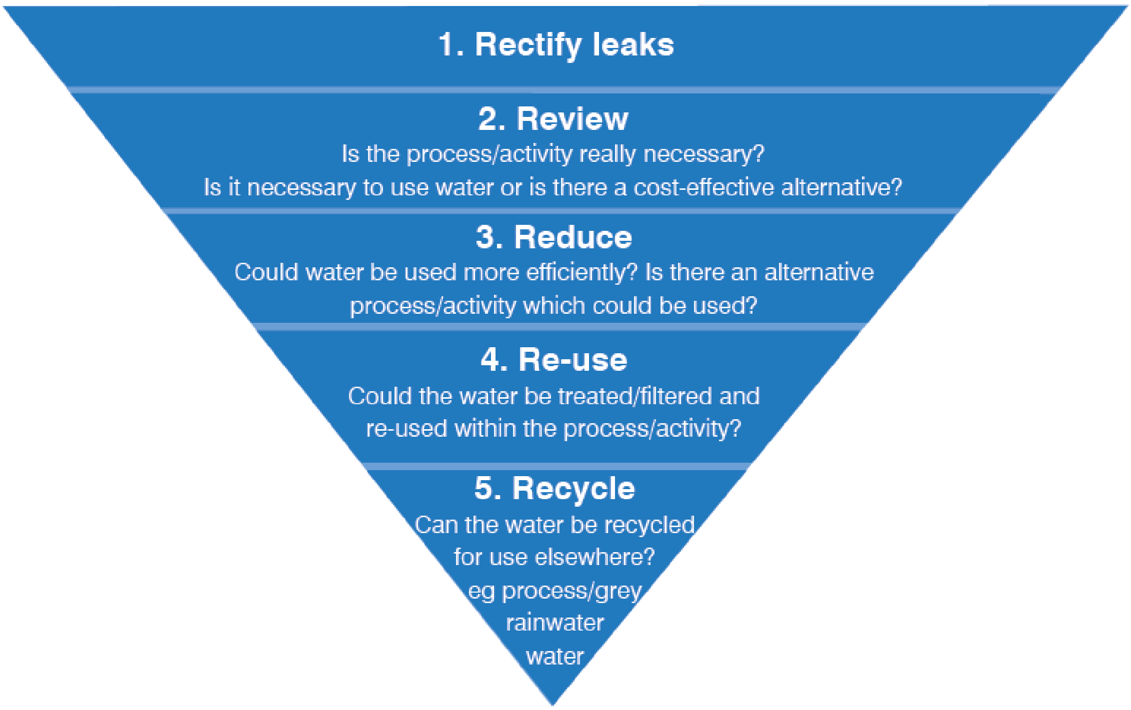


Figure 7 above shows target areas ranked by return on investment.

Rectifying leaks should be completed before any efficiency measures so that a true baseline of consumption can be established against which to check the savings from other measures.

Cooling towers

Many commercial and public buildings, and in particular larger buildings, have roof top cooling towers. They can account for up to 30-40% of such a building's water use.

Evaporation is an essential and unavoidable part of the water cooling process in cooling towers accounting for around 90% of the loss from the tower. Other losses are bleeding (releasing water to allow fresh water into the reservoir whenever a trigger water quality target is reached) and minor spray losses.

The controls and plant configuration should be reviewed to make sure that only the minimum needed is in operation at any time – saving water and energy. This is especially important in multi-tenanted premises which may not always be fully occupied.

Refit premises

Refitting staff facilities can achieve significant water savings:

- Where the urinals operate without flush control install passive infrared sensors, or waterless urinal systems
- Spray taps can reduce water use by 60 - 70% compared with conventional taps
- Install tap aerators and flow restrictors

Box 9 Heat recovery

It may be feasible for heat from condenser water flows to be recovered via heat exchangers and used elsewhere in the building (such as pre-heating the supply to hot water boilers). Energy cost savings can then be made available for funding water saving measures. Any heat extracted by the heat exchanger will reduce the tower cooling load and thereby directly reduce tower water consumption.

Whole of life cycle costs of alternatives to chemical dosing should be investigated should a refit of cooling plant be considered as this would save water.

Motivate staff to reduce water use

Water consumption in the workplace also needs to be tackled. Employees spend up to a third of their day at work. Much of the water usually used for domestic purposes such as toilet flushing and hand washing will, therefore, be used at work rather than at home. Workplaces offer a further opportunity to ‘design in’ water efficiency. Furthermore, if individuals see water being used efficiently at work, they are more likely to adopt the same practices at home.

7.4 Industrial customers

The business case for water saving can be summarised as follows:

- To save the company money
- Compliance with current and future environmental legislation
- To improve the company’s environmental performance and benefit from positive public relations
- Better relationships with stakeholders

In the UK a government sponsored organisation, Envirowise, promotes environmental best practice focusing on the industrial sector. This organisation provides advice on industrial process design, the latest energy efficient and water saving technologies, opportunities for recycling on site, etc.

Box 10 Food processing industry water saving in UK - Walkers Crisps, PepsiCo

Between 2001 and 2007, Walkers achieved a 42% reduction in water use per kg of production.

- 700 million litres of water have been saved at PepsiCo's Walkers plant in Leicester
- Commitment: PepsiCo plans to achieve zero water intake at its Walkers Crisps manufacturing sites within ten years

Walkers achieved a 42% reduction in water use through:

- Gathering robust data on usage and establishing metering in key lines
- Engineering solutions including flow restrictors and line mapping, and feedback loops to reduce usage and create sources for recycled water
- Training for employees, including the establishment of water champions and tracking water usage between lines and shifts.

Source: 'Federation House Commitment Progress Report 2009' (The Federation House Commitment is a joint initiative of the Food and Drink Federation and Envirowise. The Federation House Commitment aims to make a significant contribution to a food industry target to reduce water use, excluding that embedded in products, by 20% by 2020 against a 2007 baseline.)

To help businesses benchmark their water use, Envirowise has developed a free web service called 'water account'. This enables a business to enter in its annual water use, which is shown in a graphical format compared to other businesses within the sector, or for food and drink, within the sub sector. Such benchmarking can be a strong incentive to take action because, if competitor firms use less water, their utility bills are lower providing them with a competitive edge.

Box 11 Need for industrial water reduction targets

In a recent survey of UK businesses, almost two thirds of respondents said they did not measure or monitor their water use, and 85% did not have any water reduction targets in place. In addition, 61% did not know how much their business spent on water each year.

Source: Envirowise

Various websites offer advice on water saving in industry. A dairy industry website from Australia (www.dairyaustralia.com.au) lists and outlines 28 low cost, 10 medium cost and 12 high cost measures. This reflects the serious water shortages in Australia and the need to provide as much guidance as possible to sustain their dairy industry.

Water audit

Managers can carry out a water audit to find out where efficiency savings can be made (Section 4).

Industrial premises can be complex, and have a number of high water using components such as boilers and cooling systems. If there is only a water meter for total water use then purchasing or hiring sub-meters and/or flow-meters would provide the information needed to calculate consumption or flow data for key equipment or process lines.

A regular monitoring system should be established and the data recorded. The advantage of recording the data in this way is that any changes in water usage will be identified earlier than the next bill and any issues, such as leaks, could therefore be rectified, saving the business money.

An in-process water balance is an essential tool for identifying water usage and effluent discharged within a facility.

Water use can be compared against production output for manufacturing companies or against staff numbers for service sectors.

Water use in office premises should also be considered as discussed in Section 7.3.

Encourage staff to reduce water use

The Envirowise web site makes the following recommendations:

- Make sure staff are fully aware of the importance of water minimisation
- Appoint a water monitor within the organisation to undertake periodic site walk-overs to identify water minimisation opportunities
- Train employees how to use water efficiently and establish a recognition and reward programme for employees and teams who do an outstanding job
- Where the firm operates several sites encourage the sharing of best practice

Refit staff facilities

For most industrial users the possible options for amenities are similar to those described in Section 7.3 for office premises.

Changes in the factory and grounds

Having completed a water audit and identified high water use processes (such as cleaning, boiler feed, cooling, etc) it is possible to consider whether there are any technically feasible and financially viable opportunities for water saving and/or water recycling.

Measures that require only moderate investment and can deliver significant savings include:

- Cleaning in place (cleaning interior of process equipment without disassembly - a good cleaning-in-place system will provide substantial savings on water, chemicals, energy and labour time)
- Handling waste in dry mode rather than as a slurry
- Use of high pressure low volume sprinklers for cleaning
- Optimisation of sprinkler timing

- Membrane technologies (small scale process treatment for reuse within the premises)
- Flow controllers/timers
- Meters and monitoring equipment
- Rainwater harvesting systems

There may also be scope for effluent recycling either for low grade water usage applications or, with on-site treatment technologies, reuse for higher quality applications. Feasibility studies would be required to prove the commercial viability of such activities.

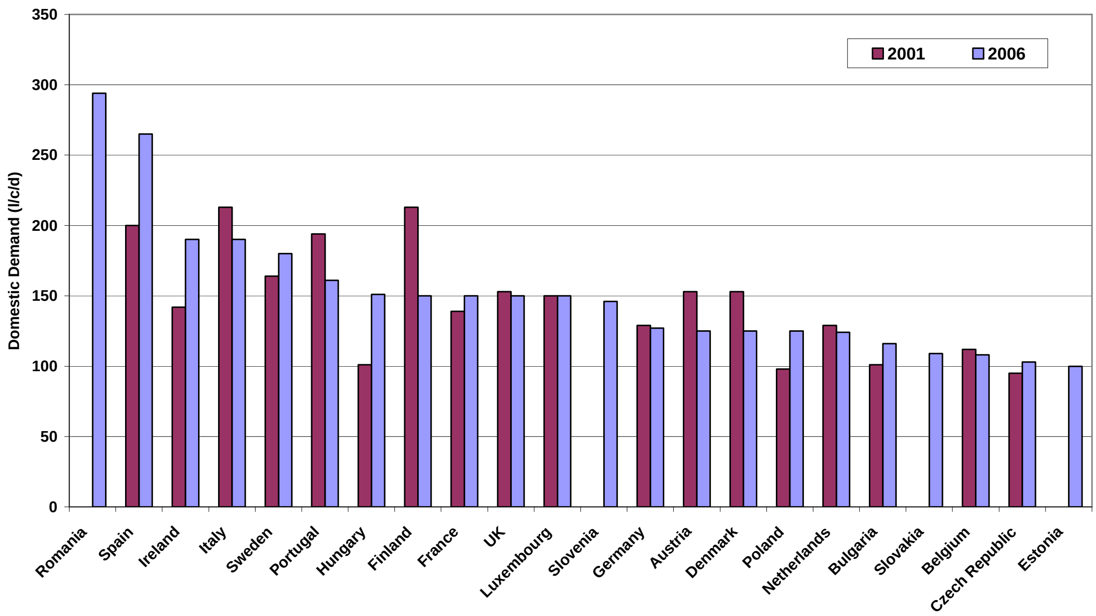
Finally, there may be other cost effective energy saving measures that can also save water; refer back to Box 9 for an example.

If the site has significant grounds with landscaped planting the water use for irrigation can be reduced by selecting drought resistant native species. Mains water use can be further reduced by ensuring that all irrigation is based on either rainwater harvesting or the recycling of treated process water.

8 International Experience

8.1 Curbing water use

The impacts of demand management measures in the urban/industrial sector will vary according to the particular circumstances in the country, or even the district, where they are applied. They will depend on climate, the income levels of consumers, local customs, attitudes to conservation and present water consumption practices.



Variation in domestic demand across different European countries

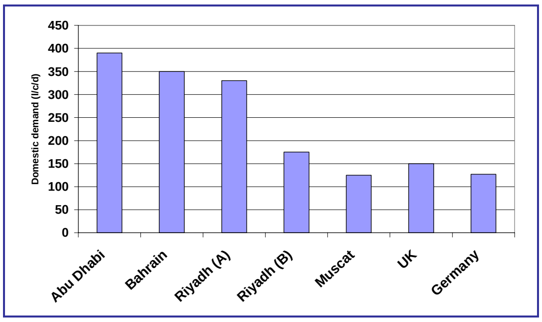
Demography is a fundamental driver in urban water supply and urban populations are generally growing at a faster rate than national populations. The number of households is key, as is the local preference for housing density. The household occupying a suburban house with garden, strongly associated with affluence in such countries as the USA, Canada, Australia, and UK, is a higher water user than a high rise apartment dweller in the same country, largely because of garden water use.

Without any constraint to supplies there is a strong relationship between income levels and *per capita* water usage - the more affluent the lifestyle the greater water use. In UK average *household* demand has increased by around 55% over the last 25 years and continues to increase at 1% per annum. Average consumption of water *per person* in England and Wales in 2005/06 was around 150 l/c/d (litres/capita/day). This compares to an average consumption per person of around 140 l/c/d in 1992/93. This growth in the use of water has been largely attributed to an increase in the number and range of appliances in households and increases in the frequency of their use, and to changes in numbers of households and household size.

Against this background trend towards increasing water use, some countries have managed to hold the line and a few to reduce per capita demand. They have done so by exerting considerable pressure to restrain demand using a number of management tools (see various boxes throughout this paper).

There is little doubt that the tariff is a key element of demand management. Figure 8 shows a comparison of per capita consumption levels in various countries in the Middle East and Europe.

Figure 8: Impact of demand management in the Middle East



The Middle East region is characterised by a hot, arid climate, high levels of urbanisation, and high GDP, yet large differences can be seen in domestic water usage. Demand is very high in Abu Dhabi and Bahrain, which are characterised low tariffs, but much lower in Muscat (Oman) where tariffs cover over 50% of the supply costs. The impact of constraints to supply is demonstrated in the case of Riyadh, Saudi Arabia, where in the early 1990s consumption was similar to neighbouring Bahrain, but has reduced dramatically in recent years. Consumption rates in England and Germany, which are characterised by a temperate climate and tariffs meeting the full cost of supply, are given for comparison. Muscat and Riyadh serve as an indicator of the possible magnitude of reductions in demand that might be expected in the region from metering of supplies and increased tariffs combined with other demand management measures.

Even in the temperate climate and relatively homogeneous economic area of the EU there is significant variation in present water use; with some countries where per capita consumption is increasing, although most are having some success in maintaining or further reducing demand.

The impacts of more widespread metering and higher tariffs in Eastern Europe have had a dramatic impact on water consumption, which has fallen by over 50% where individual flats have been metered and tariffs raised to cover some new investment costs as well as operating and maintenance expenses.

In England, on the other hand, the introduction of metering for household supplies has had a relatively small impact on demand. Prior to 1990, very few household customers in UK were metered. Trials were introduced to assess the impact of metering in the early 1990s. The outcome of these trials indicated that there would be an immediate fall in demand of about 20% on the introduction of metering and charging for water by volume. However, over a period of about a year there was also a recovery in the level of demand, so the long term savings appear to be about 10%.

In the USA studies show that, on average, residential customers respond to a 10% increase in water rates with only a 1 to 3% reduction in water usage. Florida water users are somewhat more sensitive to rate rises; a 10% increase in water rates is expected to generate a 4 to 8% drop in water use.

8.2 Reducing unaccounted for water

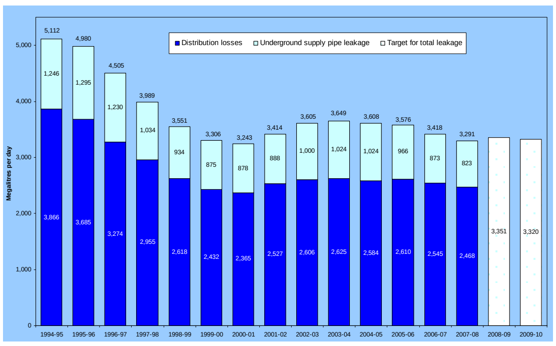
Each year more than 32 billion m^3 of treated water are lost globally through leakage from distribution networks. An additional 16 billion m^3 per year are delivered to customers but not invoiced because of theft, poor metering or corruption (according to the World Bank Discussion Paper no 8 – December 2006). In some low-income countries this loss represents 50-60% of water supplied, with a global average estimated at 35%.

Leakage within a distribution system is inevitable. The initial integrity of distribution systems is dependent on good design, quality of materials and standard of installation but even the best system will suffer some losses. Then these will increase over time: joints tend to leak over time, pipes corrode, ground movement disturbs pipes and there is always the possibility of accidental damage.

The objective of **active leakage control** is to reduce losses either to a technical target level or to an economically justifiable level ie the level where the value of the water lost equals the cost of finding and repairing the leaks.

Figure 9 shows a typical pattern of a significant reduction in losses when an active leakage control policy is first introduced followed by a period of near steady losses maintained at the economically justified level.

Figure 9: Trend in UK leakage showing economically justifiable leakage level



An active leakage control programme must be maintained into the future, although the optimum level of 'economic' leakage may reduce over time as the value of water increases through competition for scarce resources.

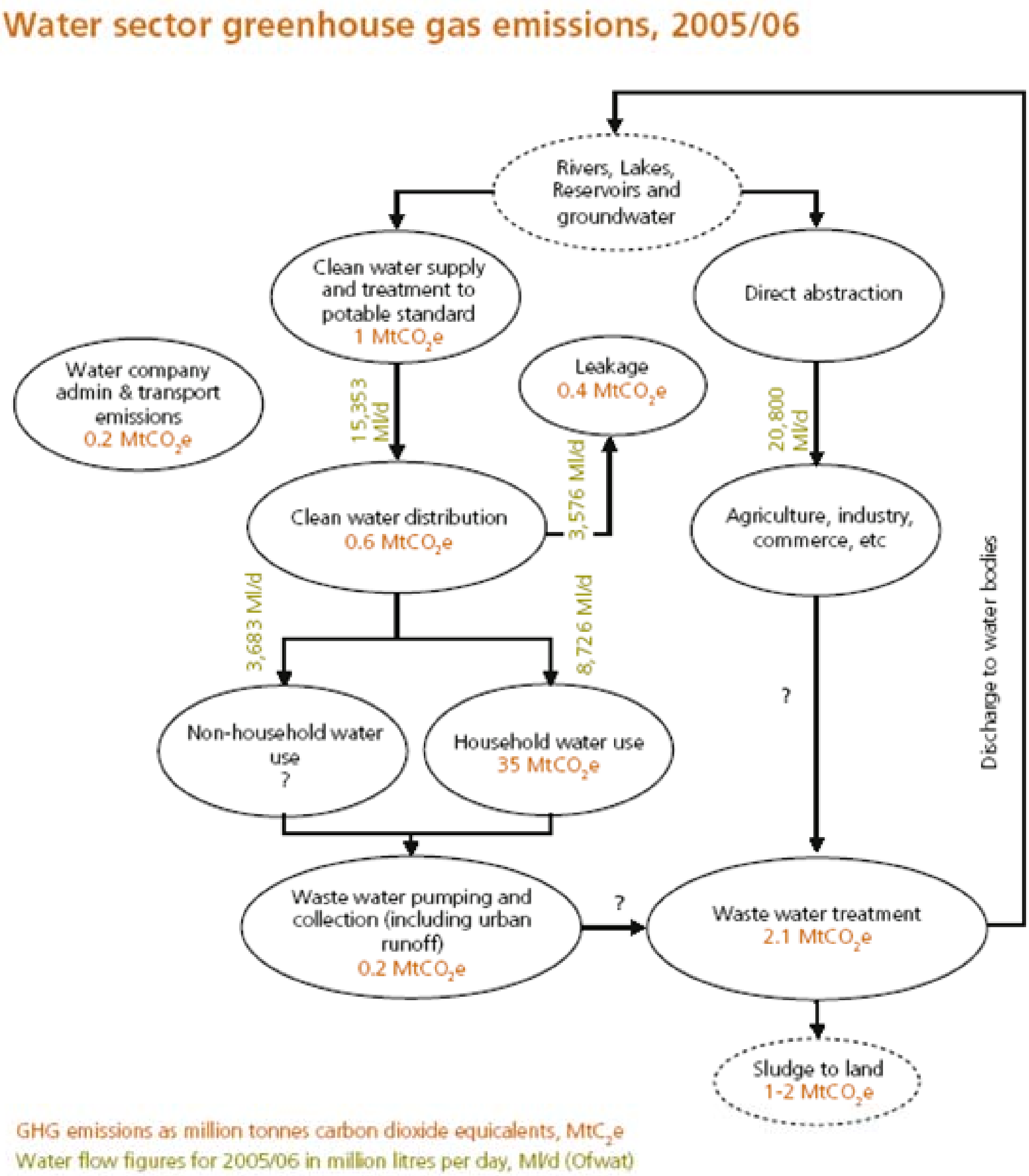
The saved water from leakage control can be used to extend coverage, to improve the reliability of supplies to existing customers or to reduce pressure on water resource systems.

Further information on international practice in leakage reduction can be found in Thematic Paper 3.3 'Active Leakage Control as a Key Component in Increasing Efficiency in Urban Water Supply'.

8.3 Climate change drivers

As countries try to reduce emissions of the greenhouse gases that are driving climate change all aspects of national life are being scrutinised and new approaches sought – the water sector is no exception. New trends in thinking and a new urgency to find sustainable solutions are apparent everywhere, even in places historically viewed as well endowed with water resources.

Figure 10 UK water supply sector carbon footprint (Source Ofwat)



Linking water and energy use - saving water reduces emissions

The way water is pumped, treated, cleaned and heated has profound implications for energy use. The water industry is a major energy user, and together with domestic hot water use, there is a carbon impact that has recently become a prominent concern. Additionally, as each unit volume of water has energy assigned to it the economic value of that volume of water increases. Reducing leakage or wastage of that volume of water becomes more imperative.

The type of water-energy analysis now being undertaken is illustrated by the UK water supply industry. During 2006/07 the UK water supply industry used almost 7,900 GWh of energy in its total operations, and emitted over five million tonnes of greenhouse gases, as carbon dioxide equivalents (CO_2e). Figure 10 shows that in 2005/06 around 56% of the water industry's emissions came from wastewater treatment, 39% from clean water supply and treatment, and 5% from administrative and transport emissions. Domestic water use (including water heating) contributes roughly another 35 million tonnes of greenhouses gases (CO_2e) per year. This is seven times as much as that emitted by the industry itself, and amounts to over 5% of total UK greenhouse gas emissions.

Water efficiency measures are a real win-win solution: they reduce water use as well as energy use, and therefore greenhouse gas emissions.

Research

Sustainable buildings are one area where research has been strongly influenced by the concerns about climate change. While much of the focus is on energy, water is also a central issue. The research is focused on more efficient appliances and sanitary fittings, rainwater harvesting, grey water recycling, reuse of storm drainage and new water treatment processes including using vegetation.

There is also research into the effectiveness of water saving devices in the home in domestic situations – to establish if the hoped for savings are realised. In Australia research on new BASIX homes (see Section 5) has shown that the expected savings are achieved on average, with some households doing better than the target but others using far more water than expected.

Similarly research is being carried out in the UK on means of introducing efficient fittings and appliances in existing housing stock. This is very important because of the very large amount of old housing – effective demand management must achieve significant reductions in water usage in such properties. Some research indicates that it can be difficult to get strong uptake if the approach is not very carefully targeted.

> Box 12 First BASIX performance monitoring study by Sydney Water
>
> Actual water use monitored in 834 BASIX homes over a one year period. While the data showed a spread of performance from dwellings using far less water than predicted by the BASIX target, to those using more, the majority of dwellings (61%) performed at or better than the BASIX target and the average saving over all dwellings was 40.5%.
>
> Source: BASIX Monitoring Report: Water Savings for 2007-8

Changing behaviours

Climate change has brought environmental issues to the forefront of media attention. In terms of altering behaviour towards more sustainable lifestyles the enhanced media interest should help to get messages about the need to use water wisely across – linking messages about water to messages about energy efficiency has considerable potential.

One of the key difficulties in achieving lower per capita urban water consumption was illustrated in Section 8.1. In the UK rising living standards, and social trends towards smaller households, have led to rising household demand despite many homeowners diligently choosing water efficient appliances and fittings. With the pressure to take action on carbon emissions the momentum for water and energy efficiency savings may come to outweigh the negative potential of rising living standards on water demand.

9 Demand Management Initiatives in China

The Chinese government advocates water conservation by encouraging the research, development and application of new technologies and new techniques. It has adopted practical comprehensive legal, economic, technological and engineering measures to promote and develop water conservation by combining:

- Engineering measures with non-engineering measures
- Advanced water saving techniques with conventional techniques
- Mandatory water conservation to promote water use efficiency.

Demand management is clearly expressed at central government level in the 2002 Water Law which, as noted below, is the principal instrument setting policy for the water sector.

This national policy has been reinforced by work undertaken by various authorities in promoting water conservation. For example, the National Development and Reform Commission, Ministry of Science and Technology, Ministry of Water Resources, Ministry of Construction and Ministry of Agriculture have jointly developed the China Water Conservation Technology Policy Outline (Announcement 2005 No.17; issue date: 21 April 2005) with the aim of :

- Providing guidance on the continuing development and application of water conservation technology and promoting its use to improve water use efficiency
- Promoting the sustainable utilisation of water resources.

The Outline is intended to guide the research and industrial development of water conservation technology, key technological investment trends for water conservation projects, promote the wide application of water conservation technology, restrict and eliminate outdated and high water-consuming technologies, techniques and equipment, and provide technological support to water resource planning and water conservation development.

The Outline promotes a "practical" approach to guide the development of water conservation technologies based on the actual situation in China, and in accordance with the applicable natural conditions, socio-economic conditions and the costs and potential of water conservation.

The water conservation technologies referred to in the Outline are technologies that can help enhance water use efficiency and benefits, reduce water losses and replace conventional water resources. They include direct and indirect water conservation technologies.

The Outline provides technological policy support in order to realise the following national water conservation objectives:

- Zero-growth in agricultural water consumption
- Micro-growth in industrial water consumption
- Gradual reduction in overall per capita water consumption in urban cities between 2005 and 2010.

Water conservation measures in industry and urban domestic water supply are addressed. They focus on both supply-side and customer-side demand management using the techniques and measures described earlier. Supply-side measures focus on minimising network losses through active leakage control including improvements in network mapping through the use of GIS. Customer-side measures focus on demand management through appropriate increasing volumetric tariff structures supported by the use of water fittings and appliances that are more efficient in their use of water.

Thus for example national targets have been set for leakage minimisation (Box 13). These represent a major challenge to WSCs, especially those with aging or poorly maintained distribution systems and those in weak financial circumstances.

> Box 13 China leakage minimisation targets
>
> Leakage control standards for Urban Water Supply Pipeline Networks have set the allowable leakage rate at no greater than 12% of distribution input, with an adjustment of -2% to +3% depending on the length of network and water quantity supplied.
>
> Source: Ministry of Housing and Urban-Rural Development, Standard CJJ92-2002

Water Tariff

The 2002 Water Law is the principal instrument setting policy for the water sector. The important features of the Water Law from an economic and financial perspective are summarised below from which it can be seen that there is a legal foundation for the use of progressive water tariffs:

- Chapter 5, Section 49 states– "The use of water shall adopt a system for collecting fees by the amount and progressively increased water prices for above-quota water consumption amount."
- Small scale users will pay only for the water they actually use and at the basic rate
- Volumetric charges with increasing blocks encourage water savings
- Increasing charges for large users matches the increased marginal costs of developing water sources.

Further information on volumetric water tariffs can be found in Advisory Note 5.4 'Tariff Setting for a Small to Medium Size Water Supply Company'.

10 Conclusions

10.1 General

The increasingly high cost of developing new water supply schemes, the lack of available resources, and the sense that there is great scope for making better use of existing supplies, are the basis of demand management as an alternative thrust of water policy.

The advantage in adopting demand management approaches is strengthened in a situation where leakage and unaccounted for water is known to be high whilst new demand centres are increasing as GDP continues to grow.

Although domestic water use is not a major part of water consumption in the world today, it plays a crucial role in people's daily life, and it is directly related to social welfare and public health issues. In an urban situation demand management can significantly improve water supply coverage and reliability, often greatly benefiting poorer neighbourhoods. Therefore, the efficient use of limited domestic water resources is one of the central concerns of policy makers.

Using water efficiently is in everyone's interest but it is only as securing adequate resources becomes a problem that all parties recognise their role in achieving a sustainable balance between social, economic and environmental needs.

10.2 Trends

A number of trends in demand management practices are discernable, they include:

- More pressure on resources has pushed demand management up the agenda even in relatively humid regions
- Rapid urbanisation challenging WSCs and water resource planners how to provide services
- New technologies for industrial process, recycling and effluent treatment
- Tougher regulations and standards to achieve higher efficiency of water use
- Move to whole building standards for sustainable houses, the more complex problem of office buildings and apartment blocks is further behind but efforts are being made to develop appropriate whole building standards with the flexibility to cover the diversity of such buildings
- Rising living standards leading to higher water use
- Rising awareness of environmental impacts and concern about the sustainability of water dependent ecosystems
- Linking of water use with energy use to reflect increasing concern about climate change
- Payment for water should reflect more than just recovery of O&M costs
- Tariff design increasingly complex and targeted
- Recognition of the social aspects of demand management and development of stakeholder participation as an expected part of planning and implementing demand management measures
- New technologies for monitoring water use, detecting leaks, etc

give more control to both WSCs and customers over their water use

- Recognition of the power of the consumer – for good or bad – and adoption of more marketing style to influencing behaviour
- Use of the internet as key medium for reaching different target audiences and influencing behaviour. Development of sophisticated government sponsored websites offering advice to business and industry on water and energy efficiency

List of key documents and web sites for international experience

1. Global Water Partnership: www.gwpforum.org
2. Envirowise www.envirowise.gov.uk/water
3. Waterwise www.waterwise.gov.uk
4. WELS www.waterrating.gov.au
5. www.nabers.com.au
6. www.basix.nsw.gov.au
7. Code for Sustainable Homes www.communities.gov.uk
8. www.ofwat.gov.uk
9. International Water Association http://www.iwaom.org/index.php?name=taskforces

Document Reference Sheet

Glossary:

BASIX	Building Sustainability Index, initiative in New South Wales, Australia
CO_2e	Carbon dioxide equivalent – measure of greenhouse gas emissions
ELL	Economic leakage level - level of leakage at which any further reduction would incur costs in excess of the benefits derived from the savings
Grey water	Wash water from baths, showers and hand basins which is reused elsewhere in the same property, typically for toilet flushing and garden watering
IWRM	Integrated water resources management
NABERS	National Australian Built Environment Rating System
O&M	Operation and maintenance
Price elasticity	Responsiveness of the demand for water to the increase or decrease in its price. As water tariffs rise demand for water (except for that portion used for basic needs such as drinking and cooking) would fall if incomes do not rise also.
WMP	Water management plan
WSC	Water supply company

Bibliography:

British Standard BS 8515:2009 'Rainwater harvesting systems - Code of practice'

China Water Conservation Technology Policy Outline; Announcement 2005 No.17, issue date: 21 April 2005; produced jointly by the National Development and Reform Commission, Ministry of Science and Technology, Ministry of Water Resources, Ministry of Construction and Ministry of Agriculture. Can be found at: www.ndrc.gov.cn/hjbh/jnjs/t20050602_45833

CJJ92-2002 'Urban Water Supply Distribution System Leakage Control and Evaluation Standard', Ministry of Housing and Urban-Rural Development

Smout, I et al (2008), 'Financial and Economic Aspects of Water Demand Management in the Context of Integrated Urban Water Management', 3rd SWITCH Scientific Meeting Belo Horizonte, Brazil

'The Role of Gender in Domestic Water Conservation in Malaysia', Water Watch Penang, http://www.waterwatchpenang.org

'Water and Efficiency Guide: Office and Public Buildings', 2006, Department of the Environment and Heritage, Australian Government

'2006 Metropolitan Water Plan', Sydney Water

Document Reference Sheet

Related materials from the MWR IWRM Document Series:

Overview Document 1	IWRM – International Practice
Overview Document 2	Demand Management
Thematic Paper 1.8	Water Demand Forecasting
Advisory Note 2.3	Water Resources Scenario Development and Scenario Modelling
Thematic Paper 2.5	Drought Management for Water Resources Managers
Thematic Paper 3.3	Active Leakage Control as a Key Component in Increasing Efficiency in Urban Water Supply
Advisory Note 3.3/1	Implementing an Active Leakage Control Programme for Small Water Supply Companies
Advisory Note 3.3/2	Asset Management for a Small or Medium Size Water Supply Companies
Thematic Paper 4.3	Regulation of Small and Medium Size Water Supply Companies
Advisory Note 5.4	Tariff Setting for Small to Medium Size Water Supply Company
Example 5.4	Tariff Setting for Beipiao Water Supply Company
Advisory Note 5.5	Willingness to Pay Surveys (Urban Water Supply)
Thematic Paper 5.7	Financial Management and Modelling in Small and Medium Water Supply Companies

Where to find more information on IWRM – recommended websites:

Ministry of Water Resources: www.mwr.gov.cn

Global Water Partnership: www.gwpforum.org

WRDMAP Project Website: www.wrdmap.com

China – UK, WRDMAP

Integrated Water Resource Management Documents
Produced under the Central Case Study Documentation Programme of the GoC, DFID funded, Water Resources Demand Management Assistance Project, 2005-2010.

3. Demand Manage-ment

Documents will comprise of:

Thematic Papers

Advisory Notes

Manuals

Examples

Training Materials

IWRM Document Series materials, English and Chinese versions, are available on the following project website

WRDMAP Project Website: www.wrdmap.com

Advisory Services by : Mott MacDonald (UK) leading a consultancy team comprising DHI (Water and Environment), HTSPE (UK), IWHR, IECCO (Comprehensive Bureau), CIAD (China Agricultural University), Tsinghua University, CAAS-IEDA, CAS-CWRR, Gansu WRHB and Liaoning WRHB.

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