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Water Efficiency Retrofitting: A Best Practice Guide

Environment Agency

Communities and Local Government

defra
Department for Environment Food and Rural Affairs

OFWAT

Acknowledgments

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Authorship

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About us

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

Our aim is to reverse the upward trend in how much water we all use at home and at work. We are developing a framework supported by a robust social, economic and environmental evidence base to demonstrate the benefits of water efficiency. To achieve our aims we work with water companies, governments, manufacturers, retailers, non-governmental organisations, regulators, academics, agricultural groups, businesses, domestic consumers, the media and other stakeholders. We conduct our own research and also undertake work as consultants.

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Introduction

In March 2008, Waterwise published 'Water efficiency audit programmes: a best practice guide' and this was useful for several water companies, many of whom were embarking on their first water efficiency trials. This update to the best practice guide will summarise current best practice for water efficiency retrofitting, for those wishing to carry out large scale projects and for companies wishing to carry out water efficiency trials to contribute to the evidence base. We will do this by building on the experience gained by those who have been involved to date in water efficiency retrofitting. However it is also important that we extract further meaningful insight from the water efficiency projects that we carry out in the future.

We have learned, for example, how to carry out water efficiency in social housing through three major projects in this area: the Preston Water Efficiency Initiative, the Wessex Water – Water Efficiency Trial and the ongoing SHARE Project (Social Housing Action on Resources and the Environment). And we are already in a position to learn from these experiences how to carry out larger scale retrofitting projects in social housing in the most cost-effective way. However, there are a number of areas of uncertainty where further understanding from industrial practice, regulatory and policymaking perspectives would be helpful in driving water efficiency even further. So in this best practice guide we also suggest ways in which trials can contribute to the still-expanding Evidence Base. Some such areas that need further work are:

- the water savings we can expect from carrying out water efficiency retrofitting under different scenarios such as water companies working in partnership with social housing providers, energy companies, or local energy advice providers, or piggybacking on other water company activities such as metering to deliver showerhead or toilet retrofits.
- how we can carry out water efficiency retrofitting in a more cost-effective way
- identifying which water efficiency devices provide most effective savings
- how the water savings observed in water efficiency trials compare to microcomponent data we currently use to estimate demand
- the carbon emissions reductions associated with water savings from trials
- whether retrofitting multiple devices per home is more effective at saving water than a single device retrofit

Through these trials water companies are able to contribute to the body of evidence required to ensure improved regulation and policy. For example, understanding such issues could be of direct consequence to the Periodic Review, water efficiency targets and Water Resources Management Plans as well as cost benefit analysis for metering programmes. Therefore, in this best practice guide, we will place more emphasis than before on ensuring that at the end of a trial we are able to present the results needed to fill the gaps in the current evidence base.

The Evidence Base for Large Scale Water Efficiency was published in October 2008 and brings together about 20 of the largest scale water efficiency trials and clearly stating the water savings and evaluating the level of uncertainty in the savings. The trials carried out have helped water companies, policymakers and regulators start to gain a better understanding of the potential contribution of water efficiency to the supply-demand balance.

The Evidence Base has provided an improved source of information about costs and benefits of retrofits, as well as advice on how best to carry these out. It is therefore highly relevant to government policy, and regulation for example delivering the government's

Future Water ambition of 130 litres per person per day by 2030, as well as ensuring that new and existing homes are water efficient, including through its plans to retrofit every home in the country for energy efficiency in the next two decades, and to make all homes zero carbon by 2050: these programmes will need to include water efficiency measures if they are to deliver their aims. The Evidence Base will also help make progress towards the government's legally binding 80% greenhouse gas emissions reduction target, and contribute savings to its 5-yearly carbon budgets, as well as the water industry's own water efficiency and greenhouse gas emissions targets.

The Evidence Base has also been useful to the water companies in their preparations for PR09, and through the Water Resource Management Plans process, and has been used by Ofwat in PR09 and as the water efficiency targets are further developed. A record six enhanced water efficiency schemes were approved for funding in Ofwat's final determinations for PR09, and the Evidence Base played an important role. One of the purposes of this best practice guide is to reinforce the connection between water company-led water efficiency retrofitting projects and the need to build an evidence base to support large scale water efficiency.

Bewl reservoir, Kent

Planning of Water Efficiency Projects

Overview

The planning phase is the most important part of any water efficiency project/trial, as it is at this point that each aspect of the project/trial including budget, project objectives and the overall approach of the project are decided. Hence, in this guide, we will place great emphasis on the different aspects of the planning phase of the water efficiency projects.

Figure 1 summaries the key decisions that need to be made in the planning process for water efficiency projects involving domestic customers. The process involves an iterative approach whereby we make initial decisions in six areas which are critical to the success of the project. These six decisions ensure that we have fully defined our water efficiency project.

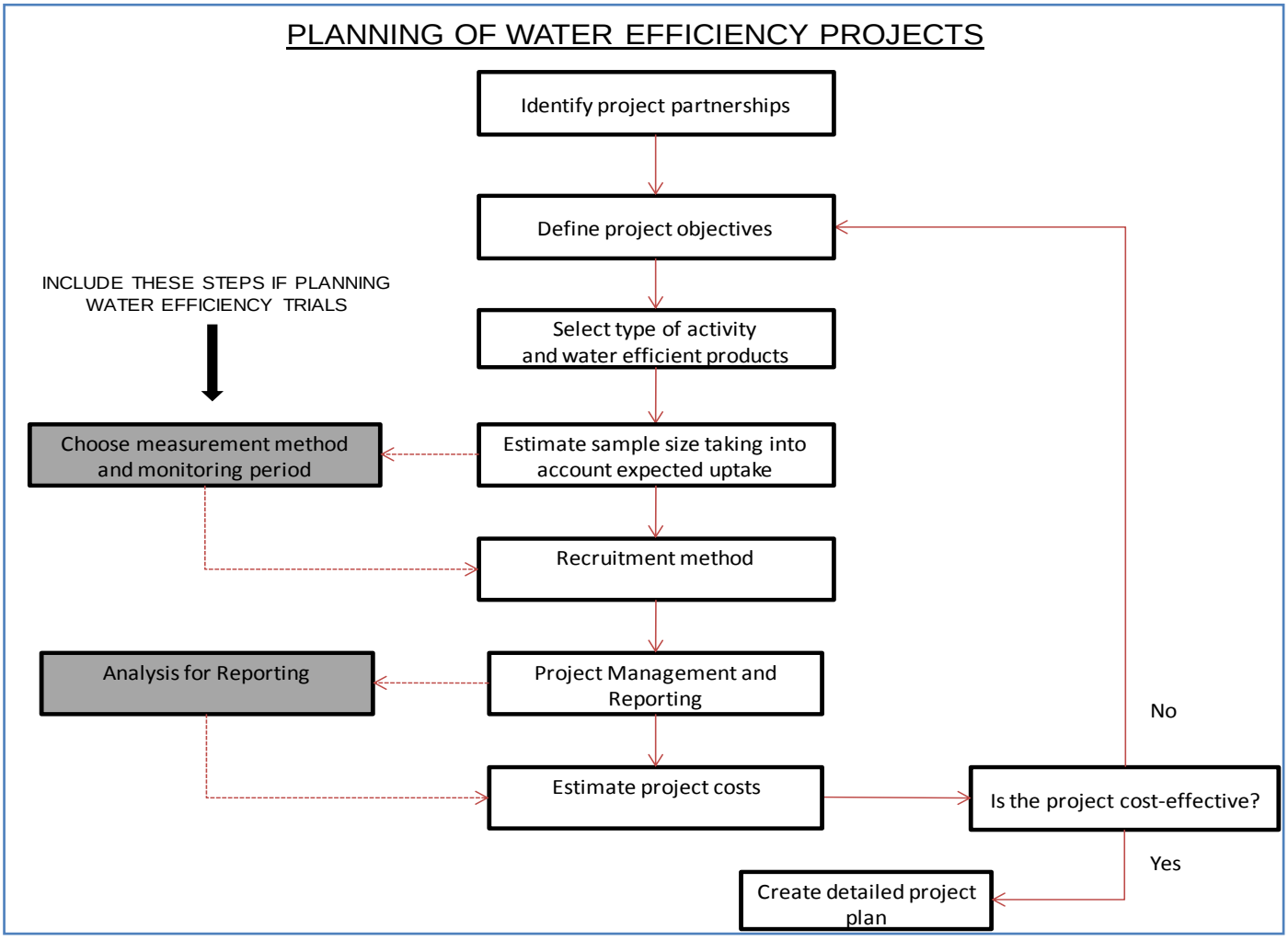


Figure 1: Flow chart showing important considerations during the design of water efficiency interventions

In the next section, we will consider each of the steps shown in Figure 1 and explain what we need to consider. The aims of the process are to:

- Specify the requirements for water efficiency projects that engage customers and deliver significant water savings
- Ensure that trials collect robust data which can expand and improve the Evidence Base for Large Scale Water Efficiency in Homes
- Decide how the project will be managed from a technical and data management point of view
- Estimate project cost and compare this to budgetary constraints.

Project Partnerships

One of the most important lessons from Waterwise's Evidence Base report published in October 2008[1] was that the most cost effective ways for a water company to deliver water efficiency is by piggybacking on other water company activities such as metering or leakage projects or in partnership with a social housing provider or an energy company. Working in partnership spreads cost and risk and increases engagement.

The Evidence Base report included scenarios which estimated the water savings and then calculated the average incremental cost (AIC) for a water company carrying out water efficiency retrofitting in several types of project partnership. The AIC results for each of the scenarios that the Evidence Base created are shown in Table 1.

	AIC (p/m^3)
	Best case
Scenario 1 - social housing	7.2
Scenario 2 - water resource zone	46.8
Scenario 3 - energy company	7.8
Scenario 4 - energy advice centre	4.9
Scenario 5 - Internal piggybacking	1.0

Table 1 - Scenarios from the Evidence Base for Large Scale Water Efficiency in Homes

The report demonstrated that there are huge savings to be made by coordinating water efficiency projects internally with metering or leakage programmes and through partnerships with social housing providers or energy companies. These are each explored below.

Coordinating Water Efficiency with Other Water Company Activities

The October 2008 Evidence Base[1] report identified that piggybacking on other water company activities such as metering programmes was one of the most cost effective ways to carry out water efficiency retrofitting. The cost savings from choosing this method of delivering water efficiency are derived from:

- Taking advantage of a visit to properties where meter installation is planned to retrofit water using devices. Normally when a meter is due to be installed there will be a pre-installation survey which can also be used for a surveyor to assess suitability and compatibility for retrofitting of water using devices such as toilets, showers and taps.
- Training the contractors who carry out meter installation so that they can carry out water efficiency audits and install water efficient products. The importance of ensuring that contractors are well trained should not be underestimated. There is an excellent opportunity to engage customers and encourage behaviour change with regard to water use. In cases where meter installation is being carried out on a compulsory basis, the contractor will have the job of encouraging customers to switch from rateable to metered tariffs.

[1] Waterwise, 'The Evidence Base for Large Scale Water Efficiency in Homes', 2009. http://www.waterwise.org.uk/reducing_water_wastage_in_the_uk/research/the_evidence_base.html

Case Study 1: Anglian Water – Ipswich Enhanced Metering Project

Our knowledge of how best to carry out enhanced metering programmes has been reinforced by lessons learnt from the recently completed Anglian Water Ipswich enhanced metering project. The Enhanced Metering project was set up by Anglian Water to extend domestic metering penetration in the Ipswich area. It allowed for the least cost option of fitting meters to domestic properties by working within a single area on all suitable properties in that area. This approach allows the company to choose the area and work sequentially through it rather than the more usual option of the customer requesting meters in random areas.

However, in order to make full use of the meter the customer needs to agree to measured charging or otherwise the property remains paying on an unmeasured basis until change of ownership takes place. This is a prime area where water efficiency can be used as an incentive to persuade the customer to sign up to the metered tariff. Water efficiency devices allow a household to reduce water consumption. Anglian Water offered a household water audit and selected devices were supplied and fitted free of charge to customers' properties. The initial aim was to target those households not switching to measured charging. Although this was thought to be an incentive to switch, take up of the offer was very low.

Therefore the project was extended to including existing metered customers within the Ipswich area. This project shows that an integrated approach to metering and water efficiency is an effective way to deliver demand management but that we need to develop innovative approaches to ensure increased uptake rates.

Partnership with Social Housing Providers

There has recently been a huge amount of interest from social housing providers in partnering with water companies on water efficiency, having become aware of the potential opportunities for saving water and energy, and reduced bills, and in driving more sustainable behaviour, through such projects. Waterwise's Evidence Base for Large Scale Water Efficiency in Homes contains some examples of successful partnerships of this kind. Some social housing providers are keen to link water efficiency retrofitting with existing retrofitting and refurbishment programmes, including those being undertaken under the Decent Homes standard (a statutory national scheme). Others wish to undertake stand-alone programmes. Water companies have been identified by many large and smaller social housing providers, and local authorities as key partners to deliver these ends. Furthermore, there is great interest in forming multi-utility partnerships and the possibility that in the near future the Carbon Emissions Reduction Target might be applicable to a range of products such as showerheads and tap inserts (see section on Partnership with Energy Providers below). Hence, at an early stage of project planning it could result in significant cost savings if some thought is given to potential partnerships.

Waterwise is currently working with social housing providers in three regions of the United Kingdom as part of the SHARE programme (Social Housing Action on Resources and the Environment). If you would like information about how to go about setting up a partnership with social housing providers in your area please contact Joanne Zygmunt, Head of Research at Waterwise jzygmunt@waterwise.org.uk

Partnership with Energy Providers

One of the opportunities currently emerging which will facilitate partnership between water companies and energy companies to deliver joint water and energy efficiency projects is the Carbon Emissions Reduction Target (CERT) programme. It began in 2008, building on the former Energy Efficiency Commitment, and runs until 31st March 2011, but the government has consulted on extending it to 2012. The programme is for energy suppliers (electricity and gas) who have over 50,000 customers. Six energy companies have an obligation to achieve CO2 emissions reduction from homes in Great Britain. These companies are EDF, Scottish Power, Scottish and Southern Energy, EON, NPower and British Gas.

The energy companies are looking for ways to deliver their carbon saving allocation in the most cost effective manner – this is an opportunity for water companies to develop partnerships. They submit their proposals for carbon emissions savings delivery

mechanisms to OFGEM, which include the specification of:

- The device/ kit required
- The distribution method for the device/kit
- The uptake rate
- Estimate of the total carbon saved by the device/kit

Through a Contractor
Currently the energy companies have agreements with third parties such as EAGA and the Mark Group to deliver the energy efficiency work that will result in carbon emission savings in the home. The majority of the carbon savings will be earned through installation of insulation, with the third party carrying out the insulation work, providing proof that the installation has been carried out and transferring the carbon credit to the energy company.

Bilateral CERT agreements
These are arrangements between an energy company and a retailer which see CERT credits sold by the retailer to the energy company for selling energy efficient kit. The simplicity of the above two mechanisms for delivering carbon savings for an energy company is that the carbon savings are bundled up and delivered 'in a box'. Packaged together, and arranged with Ofgem are the kit approval and, clearly defined carbon savings, and the auditing ensures that the work is delivered according to procedure.

Large scale giveaways
CERT credits can also be gained through large scale giveaways, such as through a national newspaper such as the News of the World or through an organisation like GALA bingo. However, although this method can result in distribution to householders en masse, there is currently concern at the number of devices such as energy efficient light bulbs which are not actually being installed in the home. As a result, this method is becoming less frequently used.

First generation energy saving light bulbs were initially mass marketed via this route, but they were found not be the best quality and consumers ended up owning several and not installing them in their homes. This type of incident has led to careful consideration of distribution mechanisms becoming a key element of assessment of the CERT scheme. In addition there is thought being given to what type of messaging should be used when promoting CERT approved products to the public.

Pre CERT approval
CERT credits are awarded for energy efficient kit based on the product lifetime once it is installed and the carbon emissions savings over its lifetime. OFGEM assesses products on a case by case basis in order to determine what level of carbon savings can be applied to them.

As of November 2009 two water efficient products had been awarded CERT accreditation. The first of these was Eaga's Showersmart shower flow regulator which gained CERT approval in partnership with Scottish Power. The device was tested in collaboration with Durham University and it was awarded a 12 year lifetime with savings based on average shower duration of 6.53 minutes. Consequently Neopearl partnered with EON in order to gain CERT approval for their Showersave shower flow regulator.

Following the success of these two water efficient products in gaining CERT accreditation there are several other water efficient product manufacturers who are in discussions to follow suite, including showerheads, tap inserts, flow monitors and shower aerators. Showerheads are likely to be awarded half the CERT credit as shower flow regulators as they will be awarded a 6 year lifespan. The assumptions for shower duration will be used in future product applications unless the manufacturer can provide evidence that a different shower duration or product lifespan should be used.

Additionality

Additionality could be defined as the extent to which a new input (action or item) adds to the existing inputs (instead of replacing any of them) and results in a greater aggregate. In broad terms, when this is applied to water efficiency targets it means that energy companies cannot partner with water companies to attempt to apply CERT credits to work that a water company has already planned to carry out. However, in principle, if the water company and the energy company agreed to work together prior to then together defining suitable projects that save water and energy in the home (particularly by saving hot water), then this should be a way of overcoming the issue of additionality.

Recommended way forward for Water Companies

- Talk to each of the energy companies and assess how you can work together on joint water and energy efficiency projects
- Be aware of the product options that are available to you – the list of approved products is likely to expand gradually
- Discuss with the energy company CERT credit available to the energy company and negotiate over how the value should be shared
- Waterwise is happy to assist water companies in this area

Defining Project Objectives

The planning stage starts with defining project objectives. This is important because it will define the goals which will guide the decision making process throughout the planning of the project. There may be a specific issue that a company wants to investigate such as:

- How effective a specific device is at saving water
- Which is the most effective out of a group of devices such as cistern displacement devices, dual flush conversion devices, showerheads, tap inserts or flow regulators
- How much water could be saved by large scale water efficiency retrofitting of a whole city or town
- Whether a well-run customer education programme can save additional water over and above what is achieved through retrofitting
- Whether we expect that water savings achieved from retrofitting will be maintained over the long term
- If there is a particular type of customers that we would like to find out more about, such as metered or unmetered customers

Experience has shown that we are well advised to keep the objectives simple because there will be plenty of other complicating factors in the subsequent stages of the project. Therefore, it is recommended that each trial is designed with a specific research question in mind that we would like to use the trial to understand better.

Type of Water Efficiency Project

There are essentially two types of water efficiency retrofitting that can be carried out with domestic customers. The two methods relate to whether we choose to use a plumber (or a person who is competent) to fit devices such as dual flush conversion devices , showerheads or tap inserts, or alternatively provide a product such as a cistern displacement device such that the customer can install it themselves.

- Visit and Fix – water efficiency projects in which installation of fittings is done by the water company. This often involves sub-contracting any installation or plumbing work to a third party. The visit to the property provides the opportunity to engage customers face to face with water efficiency awareness messages or to carry out an audit and fix household leakage.

- Self Audit – water efficiency project in which water efficient devices are installed by the householder. The audit packs containing the water efficient devices are mailed to the customers' addresses.

Alongside the visit-and-fix or self audit project we can also choose to carry out a public awareness campaign. This may include the distribution of self-audit leaflets or media campaigns promoting efficient water use. It is recommended that some form of public awareness accompanies retrofitting projects to help customers understand why the work is being done and to promote positive changes in water using behaviour. If the company sets up a partnership with social housing providers or energy companies, this means that either the housing provider will be responsible for fitting the devices in the home or a surveyor skilled in the installation of energy and water products would be required. Hence we need to ensure that the correct training is provided to supply the best possible installation service.

Water Efficient Products

Water efficient products are constantly changing, with some products well established and others just emerging. Some products are only suitable for the visit-and-fix approach because they require the assistance of a plumber; others can be sent to households with instructions for self-fitting.

There are a few labelling schemes and awards to help consumers to make better choices of water efficient product.

1. The Waterwise Marque is awarded annually to products which reduce water wastage or raise the awareness of water efficiency. 65 products have now been awarded the Marque across a broad spectrum of products including dishwashers, showerheads, water storing gels for the garden, toilets and urinals, drought resistant turf, domestic water recycling products, water butts, a waterless carwash, tap flow restrictors, a shower timer and devices to reduce the amount of water used when flushing your toilet, amongst others.

2. The BMA Water Efficient Product Labelling Scheme (Scheme) aims to encourage the installation of water efficient products within the domestic and commercial markets, maintaining individual choice at the same time as reducing the amount of water used. The Scheme was launched in September 2007 and now embraces over 600 registered products, across the five categories. It is now supported by 18 well known major brands in the marketplace.

For large-scale visit-and-fix projects, a package of water efficiency devices can be offered to each household. Some will be acceptable and practical to install in that particular household, whereas others will not. This will be decided on the visit to the household by the plumber/contract surveyor who will,

1. assess the suitability of each device for the household;
2. discuss the device with the householder;
3. fit the appropriate device(s); and,
4. leave full instructions and a telephone contact number.

The package of measures should involve several aspects of saving water in the household. For a comprehensive approach, areas of saving should include toilets, showers, taps, washing machines, outdoor water use and, possibly, leakage. These are the main areas where water is used and in some cases where that usage is increasing year on year. However, the disadvantage of this approach is that it may not be possible to disaggregate the savings and cost benefits accruing from each item or appliance. So, from the point of view of developing the Evidence Base it would be useful to have more trials carried out which focused on a single device.

For self-audit, the water company should choose a package that is easily fitted and where proven savings can be made. For example, cistern displacement devices such as save-a-flush and Hippo bags and tap inserts (aerators and regulator) are devices that can save water when fitted correctly. In the case of cistern displacement devices if they are installed where the toilet cistern is already low volume, this may lead to multiple flushes which may waste more water. One approach being used to avoid this type of problem is to send out an initial questionnaire asking the customer to specify what equipment they have in their home so that we may check suitability of the different products before sending out.

As part of project planning, there needs to be an awareness of the long delivery times of some products, particularly if they need to be imported or branded for the water company. In addition, many products ordered in bulk will be delivered on pallets requiring a forklift for unloading. If the water company's stores are not near to the project location, there may be additional costs involved in the movement of materials or rental of local offices/stores.

A discussion follows on products associated with each area of savings.

Toilets

The approach taken will depend on whether the cistern is siphon or valve operated. For siphons, an initial check of cistern volumes should be made by the surveyor who may then need to carry out adjustments to ensure that volume is not greater than allowed by the Water Fittings Regulations or byelaws for Scotland. There should be a maximum water level line on the inside of the cistern to help the surveyor, but this is frequently not the case.

Each toilet should be assessed for suitability to have a cistern displacement or retrofit device fitted. Generally, the age of the toilet dictates the maximum allowable stored volume of the cistern:

- Before 1989: 9+ litres;
- 1989 to 1993: 7.5-9.5 litres dual flush;
- 1993 to 2000: 7.5 litres; and,
- After 2001: 6 litres.

There are three ways in which toilet flush volumes may be reduced, depending on the age and suitability of the existing cistern:

1) Fit a retrofit device to convert the existing cistern to dual flush;
2) Fit a complete replacement cistern to convert to dual flush; or,
3) Fit a cistern displacement device.

To assess which of these options is most suitable the Water Fittings Regulations should be consulted, with particular reference to the type of toilet being converted. Generally, options 1) or 2) are felt to be more permanent and satisfactory than option 3).

Plumber fits a save-a-flush bag to a toilet cistern (image couteousy of Thames Water)

The flush volume of older cisterns, e.g. high-level cisterns, can be reduced the most, but expense and health and safety restrictions mean that these are less favourable for plumbers to change. Similarly, close-coupled WC's and slim line models impose restrictions.

For valve operated cisterns, a check should be made for leaks using either a dye or dry paper test. The dye test involves putting a dye into the toilet cistern and observing whether it leaks into the bowl. The paper test involves applying paper to a part of the toilet bowl which is normally dry and observing whether, when the valve should be shut, water still flows through which wets the paper.

Showers

An initial check of each shower should take place and the flow rate determined by using an appropriate test bag, of which there is a selection available from retailers. Shower flow rate can also be measured very simply using a bucket, a timer and a measuring jug, as follows[2]:

1. Turn on the shower on the setting you normally use and hold the bucket under the flow of water for ten seconds.
2. Measure the water collected (in litres) using the measuring jug.
3. Multiply the volume of water collected by 6 to give the shower flow rate in litres per minute.

Showers come in several different types, from instantaneous electric showers with average flow rates of around 4 to 6 litres per minute to pumped showers fed off hot water tanks that can deliver up to 30 litres per minute. Combination boilers and non-vented systems are becoming popular and these can deliver high flow rates to showers.

[2] Essex and Suffolk Water website: http://www.eswater.co.uk/Showerenergycalculator.aspx

About 45 percent of households in the UK have an instantaneous electric shower and because the volume of water that needs heating limits flow rates, these devices cannot be improved for water efficiency. The UK and Ireland are unique as far as electric showers are concerned. While water and energy savings are relatively assured when installing showers (within reasonable patterns of behaviour), the distinction between mixer showers (typically using water heated by gas) and electric showers becomes relevant when accounting for the carbon dioxide and utility impacts of showering; due to electricity having approximately three times the carbon dioxide weighting per unit energy than gas, and on average being double the cost, electric showers should be avoided where possible under the current carbon weighting of electrical supply. As the UK moves towards its legally binding emission targets, the carbon content of electricity will reduce to a level where this concern will become limited or invalid when compared with a gas energy source[3].

All other 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 normally work on gravity fed systems as they need a pressure of at least one bar to function correctly.

Shower timers

As well as flow rates, two other parameters need considering:

1) duration of showers; and
2) frequency of showering.

To help people limit showering durations, a shower timer can be used. These come in several types of design. There are sand timers set for a fixed duration, digital alarms that the user can pre-set and others which sound an alarm after a certain volume of water has been used.

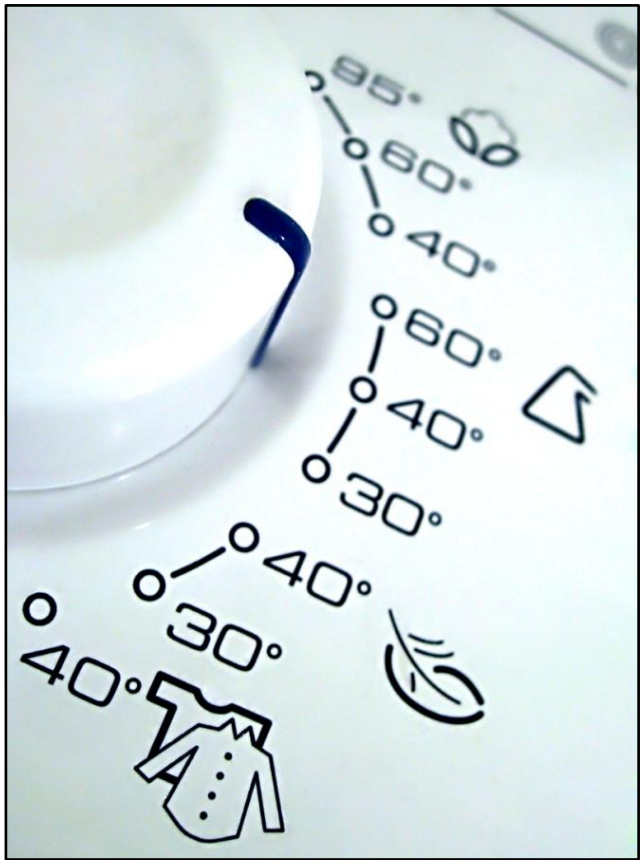
Washing machines and Dishwashers

Washing machines and dishwashers have become much more water efficient over the past twenty years. AEG provided figures of average water usage of their washing machines, which twenty years ago were about 150 litres per use – today these machines average about 50 litres per use, with the most efficient machines using about 35 litres.

Dishwashers, together with the kitchen tap, account for about 8-14 % of water used in the home, so there exists a huge opportunity here to reduce water wastage. A common misconception is that dishwashers use more water; in fact, dishwashers can be water savers – if used wisely. In the 1970s, dishwashers used as much as 50 litres per cycle, but modern models can use as little as 10 litres – sometimes even less than washing up by hand.

[3] Waterwise, 'Evaluation of the water saving potential of social housing stock in the Greater London Area', Prepared for the Greater London Authority, 2009. http://www.waterwise.org.uk/images/site/Research/water%20efficiency%20in%20greater%20london%20housing%20sept%2009.pdf

See the Waterwise website (www.waterwise.org.uk) for a list comparing water use in all current washing machine and dishwasher models[4].



While washing machines and dishwashers have become more efficient, frequency of use has gone up dramatically, particularly over the past five to ten years (according to figures from water company surveys). It is therefore important for the surveyor to offer an advice leaflet on these machines and how to use them efficiently: some sort of incentive for households that are thinking of changing their machine can also be offered. This could be in the form of a voucher to the customer that could be used when they are ready to purchase a machine. Vouchers can be partly funded by the manufacturer and partly by the water company, as in the Preston Water Efficiency Initiative, which delivered savings of over 50 litres/property/day and great success in getting customers involved.

Taps

An initial check of each tap should take place and dripping taps should have their washers replaced by the surveyor. Two options then exist to reduce the flow rate of taps:

1. Install a tap insert device into the tap – these do not fit all taps but are very effective in reducing flows without reducing the feel-good factor. Two types exist, aerated or spray; both can be effective.

2. Fit a flow regulator before the tap – this can only be fitted where sufficiently high pressure exists in the house.

The surveyor should assess which device, if either, is most appropriate before fitting, depending on the type of fitting, supply pressure and ensuring that the desired tap flow rate is suitable for type of basin. Under certain circumstances a pressure reducing valve can also be fitted to control the pressure on the water supply to the property.

Leakage

Visual checks should be carried out both inside and outside the property, including examining storage cistern and toilet overflows and any leakage from toilet cistern drop valves and flappers. In addition, supply pipe leakage should be checked for visual leaks and, if the property is metered, the meter can be checked for movement when no water is being used in the house.

If appropriate, a leakage alarm should also be offered to the customer. This device attaches around the incoming water supply pipe and can be set to detect continuous water flows over 1-to 4-hour periods. These rely on having the incoming water main accessible.

4 http://www.waterwise.org.uk/reducing_water_wastage_in_the_uk/house_and_garden/kithcen_products.html

Garden

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

Selecting the sample

If we are carrying out the water efficiency retrofitting with the aim of gathering data to help improve the evidence base for large scale water efficiency then we need to ensure that we give some thought to the design of the study.

Sample size

The larger the sample size the more the resulting data will be representative of the population.

The sample size must be 'big enough' that an effect which is big enough to be of scientific significance will also be statistically significant. It is also important that a sample is not too big such that an effect of little scientific significance will nonetheless be statistically detectable[5]. This has yet to be identified as a problem in any of the water efficiency trials that have been carried out to date but is worth bearing in mind as we look to do trials on a larger scale.

UKWIR's publication 'Quantification of the Savings, Costs and Benefits of Water Efficiency' includes a thorough discussion of the theory relevant to selection of sample size.[6] In particular, the document describes methods for defining the sample size that is required to give us a meaningful result when making a comparison between two groups of properties: a study and a control group.

$$sample\ size = 16 \times \frac{s^2}{d^2}$$

Where,

s = within sample standard deviation of the difference between the study and control groups.

d = 'effect size' – the presumed underlying or worthwhile difference between the study and control group.

For example, if the standard deviation, s, is taken as 30 litres per property per day (lpd) reduction and the effect size, d, is 15 litres per property per day, then this would give the following:

$$sample\ size = 16 \times \frac{30^2}{15^2} = 64$$

Hence if we were planning to carry out a case control monitoring study in the circumstances described above, we would ensure that we had a sample of at least 128 properties and from this sample we would, ideally, select at random 64 properties as the study group in which to intervene, leaving 64 properties that we would monitor as the control group. In each instance, we need to use the best available information to assess the values of s and d. A good source of this type of information is previous trials from the Evidence Base for Large Scale Water Efficiency in Homes[7].

Design of Case-Control Studies

Extremely relevant to this discussion is whether or not a control group is included in the study. The majority of trials that are included in the Evidence Base are designed as case-control studies. There are several other types of study[8] but case control studies

[5] Lenth, R., 'Some Practical Guidelines for Effective Sample Size Determination', The American Statistician, August 2001, Vol. 55, No. 3, p. 187-194

[6] UKWIR Quantification of the Savings, Costs and Benefits of Water Efficiency (Report Ref. No. 03/WR/25/1)

[7] Waterwise, The Evidence Base for Large Scale Water Efficiency in Homes (2008) http://www.waterwise.org.uk/images/site/Policy/evidence_base/evidence%20base%20for%20large-scale%20water%20efficiency%20in%20homes%2C%20waterwise%2C%20october%202008.pdf

[8] UKWIR Quantification of the Savings, Costs and Benefits of Water Efficiency, p.25 (Report Ref. No. 03/WR/25/1)

have been found most suitable by water companies to date and provide some crucial elements which enable us to assess the benefits of water efficiency retrofitting. These characteristics include side by side control and before and after control, which are illustrated in Figure 2.
This diagram demonstrates these features relative to a water efficiency trial timeline for the two featured groups: group X, which is the sample of properties which are due to be retrofitted, and group Y, which is the sample of properties which are used as a control for the properties in group X (and hence are monitored without undergoing any retrofitting or engagement).

Side-by-side control
The group of properties retrofitted with water efficient devices and where customer engagement was undertaken to change water using behaviour, is compared at least twice (and ideally at three or more points in time) with a second group which is not retrofitted, while seeking to ensure these are not subject to any engagement whatsoever. In Figure 2, side by side control is represented by comparisons between groups X and Y over periods 1, 2 and 3, i.e. SS_1, SS_2 and SS_3.

Before and after control
For the group of properties that is retrofitted, we compare the water savings over an initial period prior to retrofitting with the water savings achieved over a period of time after retrofitting. To provide us with additional data, we may choose to carry out a second comparison and even subsequent comparisons with the consumption of the initial period. This will provide us with further insight into how water savings post-retrofit evolve over time.

In Figure2, before and after control is represented by comparing the consumption of group X properties prior to retrofitting (during period 1) with the consumption of the same group of properties over a period of time post-retrofitting. Hence if the comparison is made in the change in consumption in a property between periods 1 and 2 then the result is BA_{12} and if comparison is made between the change in consumption between periods 1 and 3, the result is BA_{13}. In much the same way, the equivalent before and after measurement for the control group Y is CBA_{12} and CBA_{13}.

Combined control
When side-by-side control and before-and-after control are employed together in the same study, it is termed combined control and, from the point of view of developing the Evidence Base for water efficiency, this is the preferred method of control for water efficiency retrofitting and engagement projects. The use of this type of control enables us to maintain a view of how effective our water efficiency intervention is, in spite of how the underlying demand for water varies, for example due to seasonal changes in demand and how this evolves with time.

However an important issue here is selection of a control group which is similar to the study group, such that a meaningful comparison can be made of how their consumption evolves. The characteristics that we aim to maintain as similar between the study and control groups are:

- Water consumption
- Mix of type of dwelling, whether it be a flat, house, bungalow or cottage
- The number of homes with a garden
- Occupancy
- Geographical location
- The number of households with retired occupants
- Household's pro-environmental behaviour category or ACORN group[9]

A preferred method of selecting the study and control groups is to select one sample from the entire population and then select at random from these properties which are to be part of the study group and control groups. When properties are assigned randomly to the study or control group this is known as a randomized controlled trial.[10] There may be practical issues with this, such as increased cost due to wider geographical spread of properties or more complicated project management, which may make this choice less appealing. However, the need for the control group to have an equivalent mix of properties to the study group is an important detail if we are

[9] Directory that groups the UK residential areas into 39 types, according to age, composition, facilities, household size, income, marital status, mode of travel to work, occupation, ownership of car, ownership of home, etc. It's based on the concept that areas with similar demographic and social characteristics tend to share common life styles and patterns of buying behaviour.

[10] Hopkins, W. G., 'Quantitative Research Design', Sportscience 4(1), sportsci.org/jour/001/wghdesign.html, 2000

going to produce robust evidence from water efficiency trials.

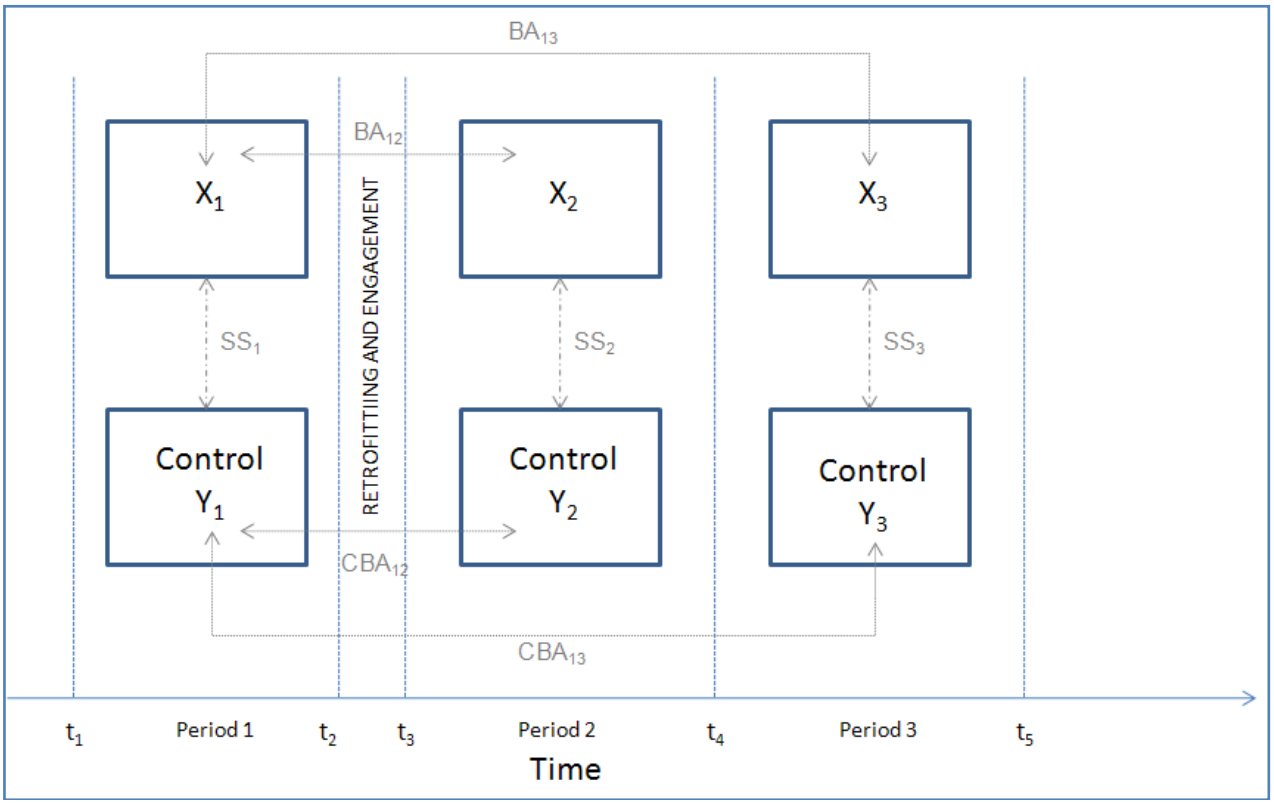


Figure 2 - Diagram illustrating side-by-side control, before-and after control and combined control for water efficiency trials

Sample selection

We want to ensure that we are able to generalise from the sample which is part of the trial to the population of interest. But to generalise from the sample to the population, the sample has to be representative of the population. When the sample is not representative of the population then selection bias is a possibility.[11] A key source of bias in water efficiency trials is low uptake rates which essentially mean that there is a large proportion of the population not particularly motivated to become involved in water efficiency retrofitting projects.

We may be interested in a particular type of customer that we would like to understand better. We may, on the other hand, want to understand how to reduce water consumption in a particular group such as social housing tenants, or in a particular district metering area (DMA) or perhaps in a specific town. If we want to learn more about a specific geographical area, then it is advisable to use a **stratified sample procedure** to ensure that we have proportional representation of what we see as the key customer characteristic in the context.

Methods which have been employed in past water efficiency trials include council tax band or pro-environmental behaviour category. Hence in these examples, the sample was selected to ensure that the percentages of the different council tax bands or pro-environmental behaviour category seen in the entire town's population were reflected in the sample selection. Furthermore, we need to ensure that the samples are balanced in terms of other key variables that could have a significant impact of the study (e.g. occupancy, type of dwelling, whether the property has a garden, etc.).

Customer Recruitment

The success of a survey or audit is dependent on how the water company deals with the customers involved in the survey. If customers are bought in and involved in the survey with easy to read explanatory information or face-to-face visits, they will generally be much more cooperative and enthusiastic.

Publicity surrounding the survey or audit is also very important in explaining what benefits the water company and its customers will gain from the work. Most people are interested in information relating to domestic household water use and are very surprised by how much water is actually used. This lack of

[11] Hopkins, W. G., 'Quantitative Research Design', Sportscience 4(1), sportsci.org/jour/001/wghdesign.html, 2000

awareness extends to water resources availability in the UK.

A few customers are likely to be critical of the money collected from water bills being spent on the provision of devices that they did not want, and some may be confused by a commercial business trying to reduce sales of their product. Other customer issues relate to,

- mailing;
- feedback from customers;
- incentives to customers; and,
- guarantees on water saving devices.

Initial mailing involves writing an informative, carefully worded letter to groups of customers usually living in selected postcodes or DMAs (District Meter Areas). Follow up mailings relate to acceptance or non-acceptance of the house into the survey, and possibly inviting customers to share the results of the survey at its conclusion.

During the survey it is essential to collect information from customers. This information is of two types:

1) Information relating to the house, its occupants and their water using devices; and,
2) Feedback from the customers on how effective the water saving devices turned out to be.

Feedback from customers on the devices themselves (type 2) can be collected on forms or through telephone surveys, both/either following on after a suitable period post-installation. Such surveys can provide information about whether devices are still in use, how well they have performed, whether they have met customers' needs; and, the sustainability of the water savings.

The main problem here is getting customers to fill in and return forms. Some companies have found using customer incentives to be very beneficial for getting customer feedback. Incentives offered to customers range from free entry in a prize draw to small gifts or cash. The incentive can also be used to promote water efficiency messages. It is also good practice to provide feedback to the customers at the end of the project, to inform them of the water savings that have been achieved, and to demonstrate that as individuals they have made a difference. This can be useful in reinforcing the water efficiency messages given during the project, and to encourage further actions by the customers.

It is very important to decide who is responsible for the new devices from the outset of the project. Generally, the water company retains responsibility during the trial period with the customer being offered the option of retaining the devices (at their own risk) or reverting to their old devices at the end of the initial survey period (usually three to six months). Provision of a 24-hour emergency plumbing service may be required.

Measurement

Water efficiency trials have been undertaken on metered or non-metered properties:

If metered properties are included in the trial, accurate meter readings can be obtained. If non-metered properties are included, we recommend that, where ever possible, an effort is made to measure the savings which result from the trial. Some innovative solutions that have been employed by water companies to date are:

- Use of small area monitoring
- Use of district metering areas
- Installing temporary meters for trial monitoring purposes for individual or groups of properties.

If mixtures of metered and non-metered properties are used, estimates of savings can be made from the number of devices fitted and microcomponent data, but the findings are unlikely to be representative of the population of interest. This is because there is a huge amount of uncertainty in the microcomponent data and so using this to estimate savings does not advance our understanding of how to save water through retrofitting.

But this approach does not adequately take into account perhaps the most significant variable in water use: how customers interact with retrofitted devices. It is precisely this uncertainty behind how human beings interact with retrofitted devices that we do not understand and need to be able to quantify in terms of water savings in order to carry out a robust cost benefit analysis.

For small samples, using metered property data loggers can enhance the data collection process. These can monitor readings over a more regular frequency (down even to every few minutes) and are the most accurate way to measure changes in water use. However, unless we want to know whether leaks are present in the property or understand intra-day water demand, then daily consumption data is sufficient to assess changes in water use.

One method currently being used to gain a better understanding of the microcomponents of water use is the Identiflow system. This comprises:

- A flow meter and logger system which can be installed in an external meter boundary box. The meter and logger system record 1/250th of a litre of consumption at 1 second intervals for periods of up to 8 weeks.

- Identiflow [12]software with a facility to identify and classify microcomponent events and an interactive facility which permits the experienced user to review and refine the analysis

Data loggers such as this allow estimates to be made of the components of use within the household, thus identifying which devices save most water. For larger projects, a sub sample can be selected for data loggers.

Measurement Frequency

Monitoring is a costly aspect of the trial. We are most interested to find out how daily consumption changes over time due to the retrofitting intervention, so if we have finer resolution such as 15-minutely data this will, in the end, be aggregated to obtain daily consumption for analysis. Hence unless we want to understand how consumption varies during the day we would not require higher resolution than daily consumption data.

Coarser data, such as monthly readings, has been used regularly to produce good project results. There is a larger degree of uncertainty associated with less frequent monitoring as there is lower resolution on the data and it is less clear how consumption evolves over time. However, as long as we check regularly that leakage is not having a an effect we have found that monthly readings are perfectly adequate to be able to assess water savings. As a result, if there is an extremely high daily consumption (due to leakage) or an unrealistically low consumption (occupancy changes or nobody is living in the property) then we will not be able to detect this. Hence, we advise that daily consumption data be collected where possible where the aim is to determine water savings from retrofitting or customer engagement.

[12]For more information about Identiflow see: http://www.wrcplc.co.uk/pdf/Identiflowflyer07.pdf

Monitoring Period

Climate is one of the main factors which affect water consumption, alongside demography, socio-economic circumstance and extent of metering. There is also evidence that the amount of water consumed tends to increase with higher mean temperatures[13]. Monitoring periods also need to take account of holidays and areas where high visitor numbers are expected.

With this in mind we would ideally like to carry a water efficiency trial over a period where there was not expected to be any large changes in the temperature. One approach taken to avoid this is to omit the summer months when scheduling the monitoring period. However, we would question this method because it leads to the exclusion of data from three months of the year without any guarantee that we are successful in capturing period in consumption habits are significantly different from the majority of the year.

In addition, it means that the mean daily consumption will not be representative of the customers' actual water consumption as we are excluding possibly the months of highest water consumption from the trial. There are other reasons why water consumption over a specific period might not be representative of a customer's normal consumption. For example, there may be a change in occupancy or the customer may experience a change in employment circumstances.

If side-by-side control is included as part of the study design then any variation will be accounted for in the study results (i.e. a control group is monitored alongside the study group). Hence if a control is used then monitoring can take place over any part of the year without any need to exclude parts of the year from the trial.

We also have to consider what measurement frequency we have chosen when considering the monitoring period. In general we should aim for a minimum 3 months' pre-trial monitoring followed by a minimum of 3 months' post-trial monitoring. If we are considering monitoring using monthly meter readings it is advisable to use slightly longer monitoring periods because we want to avoid the

[13] Butler, D. & Davies, J.W. (2000) Urban Drainage, E & FN Spon, London, ISBN 0 419 22340 1, 485 pp.

possibility of calculating consumption based on two readings if there is an error in taking a reading.
Hence we would ask for a minimum of four months' monitoring pre-trial and post-trial where monthly meter readings are being used.

Measurement Frequency	Minimum Pre-Trial Monitoring Period	Minimum Post-Trial Monitoring Period
Daily	3 months	3 months
Weekly	3 months	3 months
Monthly	4 months	4 months

Table 2 - Monitoring periods and desired minimum durations

Note that the monitoring periods in Table 2 above are minimum duration. In terms of monitoring post-retrofit an important area that we need to understand better is how water savings evolve over time. How savings are enhanced or decay over time has a huge effect on cost benefit analyses. **To help build a more robust evidence base, therefore, we would encourage monitoring to continue for as long as possible post-retrofit.**

Project Management

Project management of water audit projects and trials is the same as for other projects, but perhaps the main difference is that few contractors have any experience of previous water audit projects. This may affect their interpretation of project objectives or, if they have wrongly estimated how long various processes will take, they may look to recoup lost costs. However, the first trials carried out by a water company may be seen as a loss leader that is likely to positively affect the results of future projects carried out on a larger scale.

The success of a project is dependent on contractor's performance. One company's experience has been that the take-up rate by customers for the same project has been variable depending on the marketing and staff management done by the contractor, rather than characteristics of the customers. Clear objectives, targets, and milestones contribute to successful project management. Arrangements need to be made to ensure that data entry is quick, facilitating up-to-date information on progress.

One of the key pieces of learning from water efficiency trials to date is the different skills needed in the initial part of the trial compared with the later part where analysis of large data sets is necessary. The initial part of the trial is very much about the installation of the devices, carrying out surveys and (although this too may be undertaken by a specialist contractor) engaging customers, teaching them how to use the devices and passing on water saving tips and information. We would suggest that consideration is given to using a contractor who has proven skill in analysing data and producing good quality reports.

Contractors

Most water companies will want to engage contractors to carry out the main survey work that will also include the installation of devices. We consider here some important areas to issues to bear in mind when setting up contracts for water efficiency retrofitting.

Tendering process

Tendering will depend on the water company's procurement procedures. Generally, however, full details of the objectives and intended delivery methods need to be provided in order that clear and shared expectations exist between client and contractor, and to enable the contractor to accurately produce an overall cost of the project. Project management will be facilitated by the inclusion of detail at this stage. Topics to be considered for inclusion are,

- background to the project
- objectives
- timescales
- audit process
- mailing, customer details, property selection
- data protection
- office and storage requirements
- availability of materials
- database
- ownership of data and intellectual property rights
- training
- staff clothing and identification
- communications
- code of conduct
- progress meeting
- guaranteed service agreements

- customer concerns and complaints
- quality assurance
- data analysis and reporting
- monitoring programme
- follow up surveys
- staffing
- costing
- criteria for tender assessment
- reporting requirements
- service level agreements.

Payment methods

Generally, payment methods will depend on how the contractor has been engaged. Many water companies have framework agreements with specific contractors for certain types of projects. Where this is the case, unit rates may already have been agreed and these will apply to an audit project. Where a specific tendering process has occurred the company will have had the choice of how to pay. The main issue with payment is which party bears the business risk. To the water company, a payment method closely linked to performance may be attractive, but care needs to be taken that this does not backfire by the contractor finding ways to increase their payments without delivering the full benefits of the audits. It also needs to be recognised that there are significant fixed costs associated with project management and initial set-up of the project. Payment for this element can be separated from the less certain plumbing and delivery costs.

Plumbers

Depending on the nature of the project, staffing requirements will vary. Where plumbing work is to be undertaken water companies will generally require the contractor's plumbers to be qualified in plumbing, to be registered under the Chartered Institute for Plumbers and Heating Engineers (CIPHE) and the Water Industry Approved Plumbers Scheme (WIAPS) (or Water Company Schemes) and to provide an out-of-hours service should remedial repairs be required.

Database

A well-designed database is essential for the efficient management of an audit programme. As well as controlling the customer elements (e.g. mailing, appointments, audit details), the database can be used for financial management, for ongoing recording of meter readings at properties, and for weekly and final reporting. The project manager should be required to be able to analyse the database themselves in order to manage the project effectively and avoid unnecessary time delays in answering client queries. Careful checks need to be made to ensure that there are adequate data validation components, e.g. preventing ambiguous entry of dates (e.g. 1/4/07 versus 4/1/07) or the fitting of a water butt in a second floor flat. Fields should be well defined so that there can be no confusion caused by different users querying the database and producing different answers. Similarly, checks need to be made so that the final report returns the same numbers as the database.

It should be noted that the needs of the contractor may be somewhat different from those of the water company. For example, the main use of the database by the contractor is to view individual customers' records one at a time to make appointments or to enter data. For the water company there will be a requirement to select all or groups of customers in order to look at patterns.

Analysis of Water Efficiency Trials

Overview

A well defined and managed project can not only enhance a company's reputation with its customers but can also advance company understanding of water efficiency and industry knowledge through contributing to the Evidence Base for Large Scale Water Efficiency in Homes – as well as delivering water and carbon savings

The Evidence Base for Large Scale Water Efficiency in Homes seeks to understand the value of water efficiency by bringing together trials carried out by different water companies and presenting the insights that the trials offer. This plan of analysis presents the data required and the methods to be used to analyse the data that is received from water companies.

The benefit of carrying out combined water and energy retrofitting is considerable, as discussed above. However, to quantify this, there is a need to understand how household energy bills are affected by improved water efficiency as energy saving is potentially a very significant benefit from managing household water demand. In a similar vein, it is also important to be able to apply carbon savings to specific water efficiency measures so that they can be compared side by side with energy efficiency measures. If this can be done, there is great potential to have water efficiency measures included in the huge government schemes for retrofitting every single home in the country in the next two decades. Hence the Evidence Base project will attach carbon emissions savings and energy savings to the results of the water efficiency trials. The method used to do this is explained in the Waterwise report 'Carbon and Energy Savings from Sustainable Water Use'[14]

Pre-installation and post-installation water consumption

The measurement of both pre-installation and post-installation water consumption is required so that graphical comparison can be made between them. As outlined in the Design of Case Control Studies section, which describes before and after control, it is recommended that we take more than one post retrofit meter reading/measurement of consumption. By including measurement of consumption over at least two periods post consumption we can verify our results and also gather more data to understand how savings decay or are enhanced over time. Examples of how the data will be represented are given in Figure 3 below. This enables water savings (litres per property per day or percentage reduction) to be calculated for each meter or logger that was used to measure water consumption in the property.

Use of Linear Regression

We can use linear regression to attempt to model the relationship between the pre-trial water consumption and that post-trial. The model depends linearly on the unknown parameters to be estimated from the data. This type of model is known as a "linear model." [15] This type of statistical modelling can be carried out in Microsoft Excel as well as using statistical analysis packages such as SPSS. If it is able to model real world water savings successfully, we should be able to predict or forecast water savings achievable in similar situations elsewhere.[16]

[14] Waterwise, 'Carbon and Energy Savings From Sustainable Water Use' – Details of assumptions and calculations to be applied to the Evidence Base for Large Scale Water Efficiency in Homes.

[15] http://en.wikipedia.org/wiki/Linear_regression

[16] Field, A., 2009, 'Discovering Statistics Using SPSS'. Third Edition. Sage Publications Ltd,

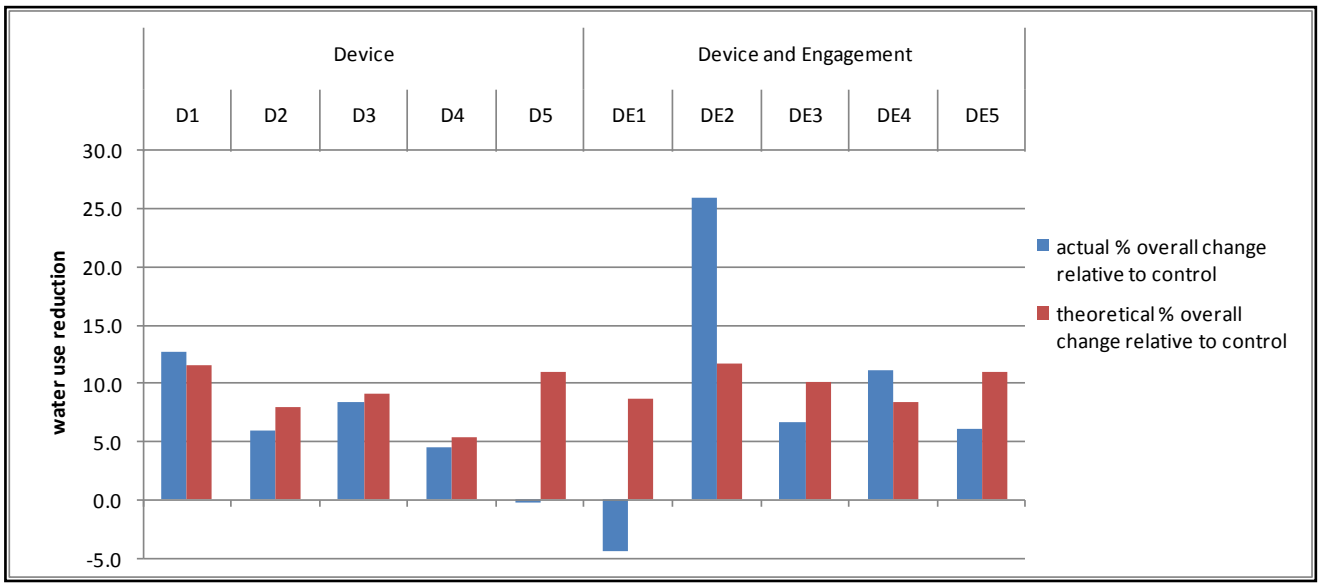


Figure 3: Bar chart illustrating comparison between pre and post-trial water consumption

Standard Deviation of Water Savings

The standard deviation of the water savings for each of the properties/meters in the sample can then be calculated, which will then enable confidence limits to be placed on the water savings data. Whether we apply 90% or 80% confidence intervals will depend on what the results are going to be used for. For example we may want to apply 90% confidence interval to savings which will be used for investment decisions. Uncertainty should be shown using confidence limits which are presented numerically and if appropriate illustrate on graphical output.

The issue of uncertainty in water savings has been a source of great discussion in recent Evidence Base Steering Group meetings and as we build the Evidence Base we will gain a better understanding of what distribution of savings we can expect to achieve. Please consult the latest version of the Evidence Base report if you would like further information on the distribution of savings we can expect from different types of water efficiency retrofitting projects.

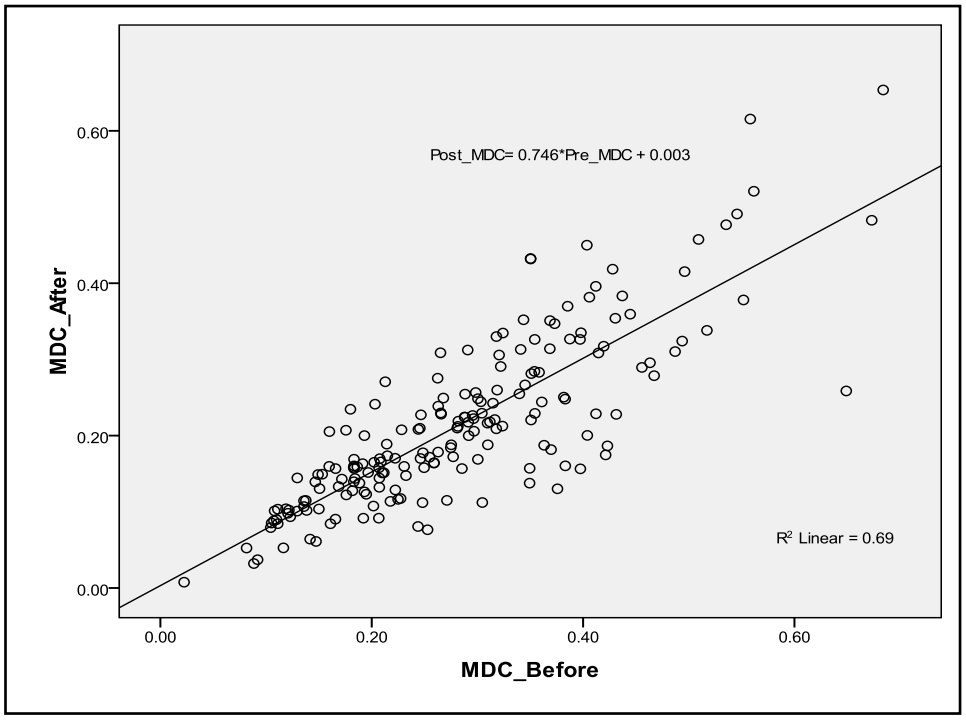


Figure 4: Scatter plot illustrating comparison between pre and post-trial water consumption

Cost Data

The breakdown of cost to the lowest resolution possible is required. For the purposes of estimating costs to scale up to projects involving tens of thousands of homes, we need to be in a position to exclude costs which would not be relevant. For example the costs of measuring water savings need to be set out separately so that they may be discounted in when considering upscaling scenarios. If the trial consists of different types of audit (e.g. self audit and plumber assisted) then the costs associated with the different elements need to be understood.
It would also be help to have the separation of costs defined as follows:

- Cost of recruiting customers, public relations and promotion
- Total cost of water efficiency devices installed
- Cost of installing devices
- Cost of monitoring/measuring saving
- Cost of customer surveys carried out as part of the water efficiency trial
- Project management costs
- Cost of analysis and producing report
- Staff costs

With this data and the water savings we can determine from pre and post-trial consumption data, we are able to calculate the cost of water efficiency per metre cubed of water saved or per litre per property per day.

Uptake Rates

The Evidence Base will seek to understand what level of interest there is amongst water company customers in being part of water efficiency trials across the country. Trials to date have achieved uptake rates of between 8% and 60%, which demonstrates a huge variation and many factors. Experience from retrofitting projects carried out in partnership with social housing providers in the Preston Water Efficiency Initiative (60% uptake achieved) and a trial carried out by Wessex Water (45% uptake achieved) show that working in this type of partnership helps to significantly boost uptake. High levels of participation, is one aspect which helps to make partnership with social housing providers one of the most cost effective ways to carry out water efficiency.
We want to be able to easily identify the uptake achieved in each trial and understand the methods used to achieve them. Hence we would suggest data describing the following being included in trial reports:

1. The number of consumers initially approached
2. The number of customers who indicated that they would like to take part in the trial
3. The number of customers who actually took part in the water efficiency trial.

Type of Water Efficient Device Installed

It is one of the aims of the Evidence Base to be able to provide insight into which water efficient devices actually deliver water savings in homes. Data is required for each individual property so that we can determine which devices have been installed in each home. Pearson's chi-square test can be used to determine whether there is a relationship between, for example, the installation of cistern displacement devices (or any other device) and the level of water savings achieved from a water efficiency trial. This method should be used to try and deliver more verifiable evidence that certain devices are more likely to deliver water savings. In essence this type of statistical test helps us understand whether a water saving device consistently achieves savings across a large sample of properties to the extent that we can be satisfied that the observed water savings are not due to chance[17].

Survey Data

The Customer Feedback section of this guide gives guidance on how to design surveys and how to extract information from these which can tell us more about customers' behaviour. Survey data should be analysed to attempt to gauge the attitudes of customers towards water efficiency. It is recommended that both pre and post trial survey data is collected so that the comparison can be made between attitudes before and after the installation of devices in the home.
A simple means of representing survey data should be used. If there is any particular attribute that is brought out in the responses to the survey questions, this can then be compared with the water savings data to determine whether this attribute is shared by those properties in which water savings are particularly high or low. This can be done using the Pearson chi squared test.

Supplementary Customer Information

When analysing the results from water efficiency activities, we seek to gain the most in depth understanding possible of water efficiency retrofits. It is only by analysing the water savings from trials and looking for patterns in the results relative to the

17 http://www.celiagreen.com/charlesmccreery/statistics/chisquare.pdf

features of the property, such as those in Figure 5, that we are going to be able to better inform future projects.

Property Characteristics
Property Type
Pro-environmental behaviour Category
ACORN Group
Property Age
Occupancy
Metered property? Yes/No
Logger Fitted at property? Yes/No

Figure 5 – supplementary customer information required for the Evidence Base

Depending on the particular details of the trial, a simple frequency of how often each of these characteristics are seen in properties which exhibit either high or low water savings could be useful for discussion. In addition, it may be possible to use the Pearson chi square test to determine the strength of the relationship between the characteristics from Figure 5 and the water savings if these are made available together.

Cost Benefit Analysis

It is recommended that some cost benefit analysis is carried out for each water efficiency trial as this is important internally, from a water company point of view and also from an Evidence Base perspective. The average incremental cost (AIC) is a method for establishing cost-effectiveness which provides a basis for comparing projects with different benefit profiles over time, and for estimating the average unit cost of service provision. It can also be used for comparing the relative costs of the various components of a strategy. Adopting such an approach to cost benefit analysis will be useful for companies as they plan towards meeting the water efficiency targets from 2010 onwards. With Ofwat's introduction of the revenue correction mechanism in PR09 water efficiency will now provide better overall returns for the companies.

However Ofwat's least cost planning methodology is based on the calculation of the average incremental social cost (AISC) for water resources options and hence it would fit well with other water company decision making processes is this method was adopted. AISC divides the present worth of social costs incurred in the construction, operation and maintenance of the demand management option by the present worth of the water saved[18]. Some of the costs and benefits that will be included in the AISC calculation are as follows:

- Cost of traffic disruption as a result of water audits
- Cost of embodied carbon in the water efficiency devices
- Energy savings associated with using the devices
- Carbon savings associated with reduced treatment energy
- Carbon savings associated with home energy savings
- Other social and environmental benefits that result from improved water efficiency.

This is important from a demand management point of view in which we aim to compare metering, leakage and water efficiency on a level playing field. When seeking to calculate an AISC value from a water efficiency trial, it is useful if we try and consider only the costs which would apply if the retrofitting programme was being rolled out on a large scale (e.g. tens of thousands of properties). Hence we would discount the cost of monitoring and consider where else economies of scale might be applied.

The approach to cost benefit analysis in this guide is consistent with the cost benefit analysis methodology set out in UKWIR best practice guidelines, specifically:

- Quantification of the Savings, Costs and Benefits of Water Efficiency, 2003 [19]
- Sustainability of Water Efficiency, 2006 [20]
- A Framework for valuing the Options for Managing Water Demand, 2007 [21]

[18] Butler, D. and Fayyaz M., Eds (2006): Water Demand Management. IWA Publishing, London(p.243-251)

[19] UKWIR, 'Quantification of the Savings, Costs and Benefits of Water Efficiency',2003 (Report Ref. No. 03/WR/25/1)

[20] UKWIR, 'Sustainability of Water Efficiency', 2006,(Report Ref. No. 06/WR/25/2)

[21] UKWIR, 'A Framework for valuing the Options for Managing Water Demand', 2007 (Report Ref. No. 07/WR/25/3)

Reporting

Report Contents

The project report should include sections on the following, as appropriate:

Executive Summary
Introduction
Background
Project Scope
The Area and its Composition / sample selection
Aims and Objectives
Project Management Team
Staff Training
Programme Schedule
Programme Approach
Description of Audit Components
Delivery Technique
Promotion
Communications
Ensuring Uptake
Recording the Audit
Database
Data Tables
Data Cleaning
Functionality
Validation
Errors
Training
Additional Properties
Database Issues
Results Quality Checks
Project Results
Mailing
Customer Participation Trends including breakdowns such as metered/unmeasured
Process Timings
Water Savings
Savings by component/device
Savings by customer groups eg metered/unmeasured
Overall Savings
Customer Satisfaction
Additional Information/Advice
Evaluation of Programme
Cost Benefits of Audit Components
Effect of Audit on Customer Behaviour and Perception
Project Successes
Project Limitations and Learning Points
Conclusions
Quantified contribution to company's water efficiency targets
Recommendations and Lessons Learnt
Appendices, e.g. letters, press releases, etc.

Reporting Requirements for Water Efficiency Trials

Once the water efficiency trial has been completed and the report produced, it is important that the results are made available so that they can inform future water efficiency activities and other practitioners may build on the work that has been carried out. In order to facilitate this Project Managers should ensure the output from the trial is included in the following:

The UKWIR Water Saving Database

The UKWIR Water Saving Database22 should be updated with the relevant details, including a project description, water savings and project costs. The UKWIR Water Saving Database is a portal that provides the ability to collate and compare an archive of water efficiency projects.

The Evidence Base for Large Scale Water Efficiency in Homes

Data from the water efficiency project should be shared with Waterwise so that the trial can contribute to the Evidence Base for Large Scale Water Efficiency in Homes23. The Evidence Base report seeks to guide industrial practice, regulation and policy on large scale water efficiency retrofitting activity by improving our understanding of key aspects such as water savings, costs, and uncertainty in savings and the impact of individual devices.

[22] http://www.water-saving.org/site/WR25c/wr25c-home

[23] Waterwise, 'The Evidence Base for Large Scale Water Efficiency in Homes', 2009. http://www.waterwise.org.uk/reducing_water_wastage_in_the_uk/research/the_evidence_base.html

Customer Feedback

Design of Self-Completed Questionnaires

Introduction

Self-completed questionnaires or surveys have become an integral part of the water efficiency projects carried out by the water companies. These surveys are most commonly sent to customers by post as part of the recruitment for water efficiency trials. A further questionnaire is often distributed to those who take part in the projects/trials as a means of following up. For companies carrying out water efficiency retrofitting on a scale of tens of thousands of homes and for those companies who want to carry out water efficiency trials, this provides an opportunity to:

- Understand customer needs better prior to retrofitting or sending out self audit packs.
- Pass on water saving tips and encourage efficient water use sustainable water use from customers.
- Understand customers' motivations for being involved with water efficiency projects and trials and helping understand how to boost uptake of the offer to retrofit homes in the future.
- obtain feedback for improving future water efficiency projects, such as understanding how products such as showerheads or dual flush conversion devices perform following retrofit

The aim of this section is to give some guidance to those wishing to produce a survey to complement water efficiency retrofitting work which they are planning. This guidance will consist firstly of some suggestions which result from literature review[24] and secondly some case studies which will highlight some success stories from water efficiency project surveys that water companies have carried out to date. There has been a lot of good work by companies in this area and several excellent water efficiency projects have been done which have included the use of surveys to gather customer feedback. We have chosen three examples for this guide which demonstrated the quality and diversity of the work that has been carried out to date.

Suggestions for producing surveys to be completed by customers

There are a few principles which ought to be borne in mind when creating questionnaires to be filled out by customers. Below we outline some of the most important lessons learnt by practitioners in producing surveys to be completed by customers.

[24] Converse, J. M., Presser, S.,1986, 'Survey Questions: Handcrafting the Standardized Questionnaire', Beverley-Hills CA: Sage Publications Inc

Specific questions are better than general ones

When producing surveys it is better to be more specific with questions and to avoid being too general. If we are too general:

- We receive a wider range of interpretations by the respondents
- Greater susceptibility to order effects (the order of questions affecting how the questions are answered)
- Poorer prediction of behaviour

Examples

General question	In what ways do you think that your showering and bathing habits have changed since we installed your water efficiency showerhead?
Specific question	Which of the following best describes how your showering and bathing habits have changed since we installed your water efficient showerhead? (show list)
General question	Were you happy with the service you received: yes or no?
Specific question	How would you describe the product installation service provided by Company B: very happy, pretty happy, indifferent, not happy at all?

Closed questions are usually preferable to open questions

This is mostly because coding and analysing open questions is much more difficult. But there are circumstances when closed questions are very useful. For example where there is insufficient knowledge of possible answers to propose standard responses.

Offer a 'no-opinion' option

There is evidence that if a no-opinion option is given in a survey then substantial numbers of people manufacture an opinion for the survey. Also, many people (a third to an eighth of respondents) will choose this option if it is explicitly presented. The size effect depends on how the option is offered. For example, consider the following questions:

- By using water more efficiently in my home and garden I will save money on my water and energy bills. Do you agree, disagree, or not have an opinion on that?
- By using water more efficiently in my home and garden I will save money on my water and energy bills. Do you have an opinion on that? If yes, do you agree or disagree?

- The latter question would produce a larger effect, so it is worth paying attention to how questions are phrased and responses offered to respondents.
- Omit the middle alternative and then measure intensity

There is disagreement over whether it is wise to include a 'middle alternative'. On the one hand it may encourage a non-committal response, but on the other hand it allows for an additional gradation of opinion. Typically, around 20% of respondents will use the middle category but it appears that its inclusion or exclusion does not affect the relative proportions of those actually expressing opinions. Most often, the respondents choosing the middle category are those without a strong opinion on the issue, so one option is not to provide the middle option and then follow up the question with an intensity item, thus enabling the separation of those with strong opinions from those who are just leaning slightly one way.

Examples

No middle category	Has the installation of product X made it easier or more difficult for you to save water in your home?
Middle category	Has the installation of product X made it easier, more difficult or made no difference to your ability to ability to save water in your home?

Note on the strength of opinion

Example

The following approaches are commonly used:
How strongly do you feel about saving water in the home? Extremely, strongly, very strongly, somewhat strongly or at all not strongly.
or, how strongly do you feel about saving water in the home? Where would you place yourself on this scale?
Extremely strongly 1 2 3 4 5 6 7 Not at all strongly

Use of forced choice rather than 'agree/disagree' statements

Agree/disagree statements (as commonly used in attitude measurement) suffer from 'acquiescence response set' i.e. the tendency of respondents to agree irrespective of item content. Generally forced choice items appear more apt to encourage a considered response than agree /disagree statements.

Examples

Forced-choice	Do you believe that the devices that have been installed in your bathroom by West Water have a) made it more difficult for me to save water b) made it easier for me to save water c) have not made any difference to my ability to save water.
Agree/disagree	Do you agree or disagree with this statement? The devices that West Water has installed in my home are helping me save water.

Question order

The meaning of almost any question can be altered by a preceding question. However, research has not to date suggested any general rules to order question, beyond the suggestion that general questions should precede specific questions.

Wording Effects

Small changes in wording can have large effects on the answers of many respondents and it is extremely difficult to predict in advance whether or not a particular change in the wording will have any effect. This indicates the importance of not basing conclusions on results from a single question. Strategies for doing this include:

- Creating split-sample comparisons

Different forms of words can be worked into the surveys that will be administered to different people. This can be handled by multiple questionnaires, or different skip patterns in a single questionnaire.

- Asking several questions on a topic

This is essentially the solution adopted when attitude or other scales are used.

If you would like more detailed explanation of the recommendations provided above, please refer to Converse and Presser, 1986[25].

[25] Converse, J. M., Presser, S.,1986, 'Survey Questions: Handcrafting the Standardized Questionnaire', Beverley-Hills CA: Sage Publications Inc

Case Study 2: Focus groups on Folkestone and Dover Water Service's proposed Lydd retrofit trial

In March 2009, Folkestone and Dover Water Services (FDWS) commissioned four focus groups with customers in Lydd before beginning a retrofit trial. The main aim of the focus groups was to find out how to boost take up of the retrofit offer. The focus groups were carried out by independent researchers. Each group was attended by between five and seven customers, 24 in total, invited along by the water company and selected to include men and women of different ages. The discussion focused on whether the retrofit offer appealed, how it could be publicised, and what other information needed to be provided. It also covered interest in saving water and concern about water bills, to put the discussion about the retrofit in context. Participants were encouraged to discuss issues in an open ended way rather than answering a preset series of questions.

Some of the key findings from the focus group were that:

- Interest in the retrofit offer varied enormously from strong enthusiasm to vocal opposition. There was most interest from customers who were keen to save water for cost or environmental reasons, welcomed the water company carrying out tasks that they could not do themselves, and trusted the water company to act in their best interests.
- Of the devices on offer, the ones for WCs appealed most. There were widespread and serious concerns about tap inserts and low flow showerheads. Checks on supply pipes were seen to be a useful service, even by some customers who were not interested in other aspects of the offer.
- Customers who were interested in the offer were sometimes prepared to pay a minimal charge, say £5, but no more. Paying towards the retrofit was seen to imply a guarantee from the water company.
- The following recommendations were made for boosting the uptake in the trial:
- Use letters as the main route for publicising the offer. To start with, ideally send a single page with a tear off slip, in a personally addressed envelope, with an enticing message on the outside of the envelope, and possibly a small giveaway in the envelope. Remind customers of the offer on/with their next bill and smart communication.
- Use the following slogan on envelopes: 'Claim your free leak, tap & toilet check and save buckets! Apply to Folkestone & Dover Water today. Offer only open to Lydd residents.'
- Ideally keep the information sent to customers about the offer on one double-sided page of A4. To build on the perceived benefits of the offer, give a feel for potential savings on bills and emphasise that the check includes free fitting of devices and fixing of simple problems where appropriate. To address concerns about the offer, reassure customers that the devices are suitable for the water pressure in Lydd and can be easily removed later if needed; make it clear that customers will be able to choose whether the suggestions from the audit are implemented; and explain that appointments will be booked.
- Focus the retrofit on devices that are most likely to be acceptable and least likely to raise concerns about effectiveness. Include checks for leaks on the supply pipe. Offer a 'DIY option' so that customers can request devices to fit and guidance on how to do checks themselves

Case Study 3: United Utilities Water Efficient Showerhead Offer

In order to gather more data about the potential of aerated showerheads, United Utilities undertook a study about the feasibility of a mail order showerhead offer. Its main aims were to establish how willing customers were to install free showerheads, determine customer opinion on aerated showerheads and retention rates, investigate how much water and carbon aerated showerheads could save, understand the likely cost of distributing showerheads by post to customers to install themselves and establish the feasibility of using postal services as a mechanism for distributing free showerheads.

Uptake of the Showerheads

It was demonstrated that the 'mail order' approach to showerhead distribution can be effective. Uptake rates for the trial were slightly lower than the 11% see for similar trials into assisted household audits (United Utilities Home Audit Project, 2008) but this is likely to be down to the fact that not all showers are suitable for the type of showerhead trialled. It is clear that this approach to distributing showerheads offers a viable low cost alternative to visiting customers' homes. To encourage customers to apply for an aerated showerhead in future the messages about their benefits should be simple and care must be taken not to overwhelm customers with too many communications.

Showerhead Retention

The showerhead proved relatively popular in terms of people continuing to use the showerhead - again slightly more popular with optant customers. The showerhead proved easy to install and most people installed it in their main bathroom, suggesting they

were keen to use it regularly. This in combination with the fact most people said they would continue to use it means there is significant potential to save water.

Acceptance of the new device

The two most common sets of ' experience question' answers show that customers found all aspects (appearance, body flow, hair flow, air and water temperature) of using the showerhead similar or better to using their previous showerhead and the force of the water was just right. This suggests that the showerhead offers a viable alternative to current pumped and mixer showers, as the showering experience is very similar. There are a number of small changes that can boost customer acceptance. Offering a wider range of colours/finishes for the showerhead or alter the angle of the showerhead could boost acceptance. Also reducing the degree to which the showerhead reduces flow could also increase retention rates; however this will reduce water savings.

For more information on the United Utilities Showerhead Offer Project please go to: http://www.unitedutilities.co.uk/UU_Showerhead_Offer_22-08-08_-_FINAL.pdf

Case Study 4: Essex & Suffolk Water – Water Saving Toolkit Project and H2eco Project

Having carried out numerous water efficiency home survey projects over the past decade, Essex & Suffolk Water (ESW) understand and can demonstrate the importance of improving literature and survey questionnaires based on customer feedback. Undertaking various forms of customer research has enabled ESW to develop and improve their large-scale water efficiency projects year-on-year and has provided the means to assess whether or not new innovative methods of engaging with customers work. The importance of customer feedback cannot be underestimated. ESW believe that carrying out the following forms of customer research following every home survey project has resulted in consistently achieving the highest take-up rates of their sort within the industry.

1. Satisfaction survey. A questionnaire left with all participating customers, providing an opportunity to gauge customers' perceptions on the project whilst it is running. This acts as an effective project management tool in ensuring that issues are rectified quickly, and to ensure that customers are receiving the highest levels of service. ESW often use the completion and return of a satisfaction survey as the entry to the project prize draw.
2. Participant's follow-up questionnaire. An in-depth questionnaire, sent within 6 months of the customer taking part in the project, focusing on all aspects of the project. This questionnaire is sent to either (1) every customer that took part or (2) a sample of at least 1,000 customers.
3. Non-participants follow-up questionnaire. An in-depth questionnaire, sent within 6 months of the initial mailing, focusing on all aspects of the project. This questionnaire is sent to a sample of at least 1,000 customers that did not participate in the project.
4. Focus groups. Carried out by an independent research body, these sessions provide an atmosphere whereby customers feel comfortable in sharing their thoughts, experiences and views on the project they participated in. They also provide the opportunity to retrieve more information than a satisfaction survey or follow-up questionnaire.

The amendments made to the survey questions and literature following ESW's Water Saving Toolkit project before starting Phase 1 of H2eco, provides an excellent example of how improvements can be made in response to listening to our customers. Doing so also resulted in maintained high take-up rates and improved water savings. A full evaluation of the Toolkit project, including all methods of customer research as outlined above, revealed complexities in the method of delivery, such as the extent of the range of products and limitations for fitting some products. The feedback from customers resulted in ESW rethinking the project, the way in which it was delivered via literature and the implementation of a project re-brand to emphasise the environmental credentials of the project. Below are examples of how specific customer feedback was used to improve our audit projects:

- Customers thought that literature was motivational in causing those attending to respond. However, several comments were made about where the catch was and whether it was free, resulting in the need to read things several times to understand the offer. In response, ESW kept the fresh branding associated with the project, but emphasised that the project was free on the front page of workbook and in detail in the accompanying letter.
- Customers stated that the thick glossy paper, although appearing attractive, detracted from the environmental credentials of the Toolkit project. In response, the H2eco survey workbooks were reduced in size to A5 and were printed on thinner paper. Following similar feedback following H2eco Phase 1, the workbooks in H2eco Phase 2 were printed on uncoated paper, enhancing the

environmental appearance of the literature.

- The credit system approach used in the Toolkit project (customers having a number of credits to spend on products) to select items was successful in encouraging thought and discussion on household water usage. However, customers told ESW that they often felt limited by the system. In response, ESW reduced the number of products/services on offer from 20 in the Toolkit project to 11 in H2eco Phase 1 and scrapped the credit system. This not only meant customers could chose as many water saving products and services as they wanted, but also improved the cost-effectiveness of the project as plumbers were fitting more products.

As a result of making the above changes, along with a variety of other amendments, the take-up was maintained at 20% in the H2eco project and the water savings were more than doubled from 13.85 l/prop/day to 30.55 l/prop/day. There is no doubt regarding the importance of understanding customer's views on the projects the water industry carry out. It is not sufficient to simply carry out satisfaction surveys, but instead a variety of forms of research should be conducted to ensure we listen to customers and in turn ensure we deliver improved projects in the future.

For further information on the trials referred to: Water saving Toolkit project and the H_2eco project, please go to the Essex & Suffolk Water website:

http://www.eswater.co.uk/Homesurveys.aspx

Conclusion

This update to the best practice guide has summarised areas of recent learning in best practice for water efficiency retrofitting trials, particularly resulting from the Evidence Base Project. We have considered all aspects of the process of planning a water efficiency trial from early planning through to putting together the trial report. There are a number of areas of uncertainty where further understanding from an industrial practice, regulatory and policymaking perspective would be helpful in driving water efficiency even further. Following the guidance in this document will enable us to build an even stronger evidence base for water efficiency. It will also enable water companies to develop robust cost-benefit analysis of water efficiency projects they undertake, contributing to meeting water efficiency targets and supply-demand balances as the effects of climate change on water resources on is felt to an increasing extent and the regulatory framework develops to address this.

Waterwise would be keen to include any water efficiency trial work you are planning in the Evidence Base for Large Scale Efficiency in Homes. So please get in touch as we would like to find a way to use the data you have to improve the Evidence Base. It should be emphasised that this guide is a live document which will be updated on a regular basis with the experience of water efficiency practitioners. So if you have any comments or wish to contribute to this Best Practice Guide please contact Ike Omambala at Waterwise, iomambala@waterwise.org.uk. Also, if you would like any information or need any help in organising any aspect of your water efficiency work, Waterwise would be happy to help you.

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