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Evidence Base for Large-scale Water Efficiency in Homes

Phase II
Interim Report

February 2010

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Communities and Local Government

defra
Department for Environment Food and Rural Affairs

OFWAT

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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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Foreword

I am delighted to introduce this report – the first of Phase II of the Evidence Base. The original Evidence Base report – in October 2008 – for which I also Chaired the Steering Group, was widely acknowledged to have been extremely useful in plugging the information gaps, and was used by both water companies and Ofwat during the 2009 Price Review.

However, the study posed almost as many questions as it has answered, which is why the UK Environment Minister's Water Saving Group agreed that it should be kept updated. Consequently, a review was carried out to determine how the next phase of the Evidence Base, Phase II, could best assist the water industry, regulators and policymakers in supporting the development of water demand management options as resource options – including in the context of carbon targets.

Since the last Evidence Base report, Ofwat has introduced Water Efficiency Targets for the water companies in England and Wales and there is now a water efficiency duty on Scottish Water. There has been an increase in the scale of water efficiency projects being carried out. Six water companies were allowed investment for large-scale water efficiency programmes as part of Ofwat's final determination for PR09, and other water companies are planning to carry out water efficiency schemes which are self-funded. This represents significant progress but delivering water efficiency continues to face significant opportunities and challenges, which this report highlights.

This report will help companies start to build the case for their future water efficiency retrofitting projects; for companies with the opportunity to plan during AMP5 and all companies during AMP6 in England and Wales and for Scottish Water. In future reports this will be supplemented with data from further domestic trials, but also from non-household areas of water efficiency such as from schools. The recommendations included in this report suggest ways that water companies, manufacturers and retailers can help to make water efficiency a more viable option. Waterwise will release a separate paper which will set out their views on and recommendations for water efficiency policy and regulation drawing specifically on this report. There are a number of areas where more work is required, but the results in this report should give water efficiency practitioners confidence that they can deliver water savings cost-effectively through retrofitting projects.

There is some fantastic work being carried out by UK water companies to take forward large-scale water efficiency, and this report not only draws on these to provide a solid evidence base, but will also influence future work, making it even more cost-effective. I am delighted too that this report contains a comprehensive analysis of the carbon and energy savings to be found in large-scale retrofitting.

I commend Waterwise for an extremely useful piece of work, and look forward to continuing to work with Waterwise and the Steering Group on this important project.

Jean Spencer
Director of Regulation, Anglian Water
Chair, Waterwise *Evidence Base* Steering Group

1 Summary of Findings and Recommendations

Several regions of the UK are already under serious water stress as a result of increasing population density, demographic change, increasing demand due to more intensive lifestyles and a climate in which extreme rainfall events and drought are becoming more and more prevalent. Future climate scenarios and population predictions suggest that more areas will be affected in the future.

In the past, there has been a perception in the water industry that there is insufficient evidence in the UK of the ability of water efficiency to deliver water savings cost-effective enough for it to be able to play its part in a twin track approach to water resource management, in which it contributes as a demand management measure alongside supply-side resource measures. In Ofwat's final determination for PR09, six water companies in England and Wales were awarded funding for large-scale water efficiency programmes.

This shows that water efficiency does have an important role to play in helping the UK to meet these challenges. The Evidence Base represents the best current available knowledge of water efficiency in the UK. This report does the following:

- ⇒ Presents the robust, measured water savings from water efficiency trials and projects in the UK
- ⇒ Explicitly details the uncertainty in the results and reveals structure in the distribution of water savings
- ⇒ Presents the typical costs involved in each trial
- ⇒ Develops a set of scenarios for large-scale water efficiency programmes, which include water savings, Average Incremental Cost (AIC) and Average Incremental Social Cost (AISC).
- ⇒ Compares measured water savings to theoretical water savings to direct future savings estimates for water savings measures
- ⇒ Estimates carbon emissions and energy savings for each trial
- ⇒ Makes recommendations for further work for the Evidence Base and for key stakeholder groups

This report's main findings are:

Water Savings
Measured water savings of up to 34 litres per property per day are possible from applying a multi-measure water efficiency retrofitting method in the traditional way, using current technology and means of engaging customers to encourage behaviour change. However, Anglian Water's Ipswich Area WEM trials resulted in savings of 41.5 lpd, which is the highest reduction in consumption of all the trials analysed in this report. There is a possibility that the fact that this WEM trial was carried out alongside a metering installation programme in the Ipswich area enhanced the results. Customers were made aware of their consumption and how much they could save by opting to be charged via a water meter, and this may have led to significant change in water-using behaviour.

Uptake rates
The results show a range of between 6% and 22% uptake rates for water efficiency trials carried out in general housing stock, whilst for social housing significantly higher uptake rates of between 45% and 60% have been achieved.

Carbon Emissions and Energy Savings

Analysis of the nine water company-led water efficiency retrofitting trials in this report shows a range of between 0.031 and 0.187 $kgCO_2e$ per property per day of carbon emissions saving as a result of the water efficiency retrofitting projects included in this report. It also shows that the cost of energy saved in the trials ranges from 1.3 to 44.3 pounds per property per year. Both carbon emissions and energy savings were dependent on the extent to which hot water was targeted during a trial. Trials which did not target showering or bath-use showed relatively low energy savings. However, this assessment illustrates that there are significant carbon and energy benefits to be gained from water efficiency retrofitting.

Understanding the Costs of Water Efficiency Retrofitting

There is a wide variation in the cost of retrofitting per property, which ranges from £41 to £240 per property. Anglian Water's Ipswich Area WEM trial achieved the lowest cost per property and one of the reasons for this was that the trial was carried out alongside the Ipswich area metering programme. Similarly, Wessex Water's WET, carried out in partnership with a social housing provider, achieved a cost of £49 per property.

Innovative Analysis

Use of linear regression in the analysis of the trials in this report shows that, using our current methods alone, it is unlikely that households consuming 400 litres per day or more will be able to reduce their consumption sufficiently to meet the government ambition of 130 litres per person per day. The main assumption made in this analysis is that the occupancy of the trial properties is similar to the national average occupancy. More effective methods of encouraging customers to reduce their consumption alongside retrofitting will have to be found - in particular, targeting higher consumers. New water-using technologies could play a part in helping to drive down consumption, but it is likely that significant behaviour change will also be necessary, whichever technologies are employed. This ties in with the Final Report of the Walker Review[1] which recommends a multi-stakeholder education campaign on water efficiency for England and Wales.

Scenarios

Seven new scenarios for delivering water efficiency on a large-scale through partnership are presented in this report (see Table 1). Scenarios 1 to 4 show that partnership is an increasingly attractive option for stakeholders who want to deliver water efficiency. The partnership scenarios offer realistic options for water companies, social housing providers, energy companies, local councils, NGOs and retailers to work together to deliver water efficiency on a large-scale and in the most cost-effective way. The most cost-effective of the partnership options is Scenario 2 which describes the opportunity that currently exists for water companies and energy companies to take advantage of the fact that water-efficient measures are now included under the Great Britain-wide Carbon Emission Reduction Target (CERT)[2] scheme, and can, therefore, receive a credit for carbon emissions saved through reducing household water consumption.

Scenario 5 also provides a cost effective way of delivering water savings through a water company integrating its activities to carry out metering on a zonal basis and piggyback on this activity to carry out retrofitting in the same properties. Scenarios 6 and 7 are built around the possibility of the

[1] Defra website - http://www.defra.gov.uk/environment/quality/water/industry/walkerreview/final-report.htm

[2] DECC website - http://www.decc.gov.uk/en/content/cms/what_we_do/consumers/saving_energy/cert/cert.aspx

updating of the Decent Homes Standard[3] to include water efficiency, an additional government action on toilets, and the inclusion of water efficiency retrofitting in existing government energy efficiency programmes: for example through the Community Energy Saving Programme[4] (CESP).

Combinations of the scenarios in Table 1 could result in even more cost effective water efficiency retrofitting projects, for example, combining scenario 1 (social housing partnership) with scenario 2 (energy company partnership) or even scenario 2 with scenario 3 (whole town retrofit).

Partnership Options		Best Estimate	Best Case	Worst Case
Scenario 1: Social Housing	AIC (p/m^3)	41.7	8.0	176.6
	AISC (p/m3)	39.4	5.6	174.6
Scenario 2: Energy company	AIC (p/m^3)	13.0	5.9	110.7
	AISC (p/m3)	-7.5	-14.7	90.9
Scenario 3: Whole Town	AIC (p/m^3)	104.8	21.1	575.4
	AISC (p/m3)	84.3	0.5	555.6
Scenario 4: Retail-Led Retrofit	AIC (p/m^3)	1.2	12.0	236.5
	AISC (p/m3)	-1.2	9.7	235.0

Company-Driven		Best Estimate	Best Case	Worst Case
Scenario 5: Metering	AIC (p/m^3)	45.2	15.4	157.8
	AISC (p/m3)	24.7	-5.2	137.8

Government-Led		Best Estimate	Best Case	Worst Case
Scenario 6: Toilet Amnesty	AIC (p/m^3)	7.9	0.0	30.0
	AISC (p/m3)	-12.7	-20.6	9.7
Scenario 7: Piggybacking on Government Retrofitting Schemes	AIC (p/m^3)	13.5	0.0	75.0
	AISC (p/m3)	-7.0	-20.6	55.2

Table 1 – Summary of AIC and AISC for each of the scenarios

Comparison of actual and theoretical water savings

Some estimates of savings for individual water efficiency measures, which might be used to estimate the water savings from planned trials in Water Resource Management Plans, were compared with the measured savings from the nine trials in this report. It was found that if comparison from trials was viewed across the entire trial population, there was good agreement between the estimates with the measured values from the trials. The estimated savings values that were used are given in Table 2.

Retrofit Measure	Assumed reduction in consumption (litres/property/day)	Source
Newly-installed shower over a bath	73.9	Waterwise estimate - Preston Water Efficiency Initiative(2008)
Conversion of toilet dual flush	30.0	Waterwise estimate from Ofwat Good Practice Register and water company values
Water-efficient showerhead installed	25.2	Essex and Suffolk Water H2eco water audits (2007), United Utilities Home Audit Project (2007), Yorkshire Water - Water Saving Trial (2008), South West Water - Water Efficiency Trial (2006)
Tap Insert Retrofit	0.9	Waterwise estimate - Water Company estimates from the October 2008 Evidence Base report

Table 2- Theoretical water savings calculated from microcomponent assumptions

[3] http://www.decenthomesstandard.co.uk/index.php

[4] http://www.decc.gov.uk/en/content/cms/what_we_do/consumers/saving_energy/cesp/cesp.aspx

1.1 How to use this report

This Evidence Base aims to provide consistent information in a standard format to enable water efficiency programmes to be designed in the most cost-effective way. Organisations planning to undertake water efficiency programmes should use this report as a guide, in conjunction with the WR25 series of reports from UKWIR[5] and Waterwise's Water Efficiency Retrofitting: A Best Practice Guide[6].

1.2 Recommendations

The analysis presented in this interim Phase II Evidence Base report point to some recommendations both for further Evidence Base work and for key stakeholder groups on cost-effective retrofitting.

1.2.1 Further work for the Evidence Base

⇒ There is currently little guidance on how to best carry out cost benefit analysis for water efficiency retrofitting schemes, including how to take into account carbon emission costs and benefits. Research will be carried out in order to understand how best to take account of those costs and benefits which are not currently included and the aim will be to include these in a future Evidence Base report. This will also cover SEPA (Scottish Environment Protection Agency) and WICS (the Water Industry Commission for Scotland) requirements.

⇒ Historically, uptake rates are typically very low in water efficiency programmes; this severely limits the overall water savings achievable from a water efficiency project, and means that the majority of the population are not being engaged. Waterwise will seek to carry out research to understand how to achieve greater uptake rates for water efficiency retrofitting projects.

⇒ There is increasing awareness of the significant role that the changing of attitudes and behaviour towards water efficiency has to play in delivering water efficiency on a large-scale. Waterwise will seek to carry out research to understand how best to encourage customers to save water.

⇒ The Evidence Base Steering Group has discussed the opportunity that exists for water companies to partner with energy companies and gain credit, through the Carbon Emissions Reduction Target (CERT), for carbon emissions savings as a result of hot water savings in the home. More clarity is needed about the protocol that water and energy companies need to follow in order to ensure that they can take advantage of this opportunity to make water efficiency projects more cost-effective, particularly with regard to additionality – whereby water companies cannot claim CERT credits for water efficiency activity that they would have undertaken anyway. In order to work towards a more coordinated approach, discussions should be taken forward between Ofwat, Ofgem, water companies and other key stakeholders.

⇒ There is currently a consensus in the water industry that installation of a water meter leads to a reduction in consumption of 10%. However, there is little contemporary evidence to suggest that this is what is achieved in practice, or whether this varies depending on the tariffs applied. Further evidence of the effectiveness of metering is required in addition to analysis of how this

[5] UKWIR website - http://www.ukwir.org.uk/site/web/content/reports/reports
[6] Waterwise website – Water Efficiency Retrofitting – A Best Practice Guide http://www.waterwise.org.uk/images/site/Research/water%20efficiency%20retrofitting%20best%20practice_final.pdf

combination of metering and water efficiency retrofitting can be synergistic: this will need to draw on water company projects.

⇒ A number of assumptions have been made in calculating the carbon emissions and energy savings due to the water savings in each of the trials in this report. Further water efficiency trials, involving some measurement of energy consumption both before and after, would be helpful in understanding this area more clearly.

⇒ There are a large number of assumptions used in the project; these are based on existing reports or published data, some of which are not evidence-based. Further research is required that is specifically designed to tackle the issue of microcomponent data by finding ways to link estimates to measured values.

⇒ Probably the biggest area of uncertainty in the cost-benefit analysis for water efficiency is how water savings are sustained over time. Further research is required that seeks to understand how well, over the medium- to long-term, water savings are sustained.

⇒ The Evidence Base project will seek to gather more evidence from Scotland – with Scottish Water and the Water Industry Commission for Scotland now that there is a new water efficiency duty on Scottish Water.

⇒ There are a number of areas into which Waterwise will consider expanding the Evidence Base project. Each of these provides an opportunity to save significant volumes of water and at the same time to reinforce positive water-using behaviours.
  - → **Schools** – Several water companies have expressed an interest in sharing the results from their schools projects with the Evidence Base.
  - → **Small and Medium-sized Enterprises (SMEs)** – There is a need to understand the extent to which SMEs are being encouraged to reduce water consumption and identify the most effective approaches to different types of enterprise.
  - → **Tariff Trials** – The Evidence Base could be a means of sharing experiences as water companies use different tariff structures as a tool to manage domestic demand.
  - → **Smart Metering Trials** – There are some elements of the cost benefit analysis for smart metering which are currently not well understood: for example, the impact in home displays on customer behaviour. The effectiveness of different types of intelligent meter also needs to be more fully understood.

1.2.2 For Water Companies and Organisations that Deliver Water Efficiency

The Evidence Base will provide a reference point and economic case for water companies planning water efficiency programmes during AMP5 and for other retrofitting partnerships. Table 12 summarises key information from the trials in this report including the water savings, carbon emissions and energy savings and costs involved in the trial. To further improve the cost-effectiveness of water efficiency retrofitting, the following courses of action could be taken:

⇒ Where it is possible, water companies should seek to justify water efficiency retrofitting alongside metering as a joint project. This approach to integrated demand management was used by Anglian Water in the Ipswich Area WEM trial. Significant water savings can be achieved, and, in addition, the Evidence Base now provides a means of including the value of carbon emissions and energy savings in the cost-benefit analysis.

⇒ Partnership working is another means of improving the cost-effectiveness of water efficiency. Identifying potential partnerships for delivering water efficiency retrofitting can be less than straightforward. Chapter 8 describes seven different scenarios which can provide a blueprint for partnerships that water companies may choose to pursue as they plan future programmes. Please contact Waterwise if you would like further information on any of the scenarios.

⇒ The Severn Trent Water, Thames Water (MVF), United Utilities and Yorkshire water trials in this report have each made use of a multi-measure approach including dual-flush conversion, showerhead replacement and tap inserts and they have also all achieved a consistent level of water savings (i.e. 20 to 30 lpd). This should give companies planning water efficiency projects confidence that the water savings from this multi-measure method of retrofitting demonstrate a relatively high level of repeatability.

⇒ This report presents an approach to cost-benefit analysis of water efficiency projects which is consistent with 'Best Practice Principles in the Economic Level of Leakage Calculation', produced by Ofwat, the EA and Defra in 2002[7]. It includes an assessment of the carbon emissions and energy savings which result from water savings, which must be included to give a true reflection of the value of water efficiency relative to other water resources options.

⇒ The comparison of measured savings with some standard theoretical savings for water resource planning has highlighted that a process by which values are refined as evidence improves should be put in place so that this may feed back to Water Resources Management Plans, annual reviews, and the water efficiency targets.

1.2.3 For Manufacturers and Delivery Agents

⇒ The demand for water-efficient products is increasing as the evidence base for water efficiency improves and the number of projects and trials being commissioned increases. This provides opportunities for suppliers who can deliver water efficiency measures on a large-scale and provide them at a low cost.

⇒ The link between water and energy efficiency is becoming increasingly important because of the carbon and energy savings achievable by reducing consumption of hot water. 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. There are currently (January 2010) three water-efficient products which have been awarded CERT accreditation. However, there is an opportunity for other devices which help to reduce hot water consumption to seek CERT accreditation (see the Waterwise Technical Note on CERT[8])

⇒ One significant challenge that faces the water industry is to deliver water efficiency retrofitting in a more cost-effective way. The speed of installation of devices is a key aspect of achieving this. Currently there is a wide range of variation in the costs of retrofitting a property (and overall cost per property – see Table 12 in Chapter 6). There is a need to ensure that products are developed which are quickly fitted and deliver on asset lifetime in addition to water savings. For

[7] The Tripartite Group, 'Best Practice Principles in the Economic Level of Leakage Calculation' , March 2002 http://www.ofwat.gov.uk/publications/commissioned/rpt_com_tripartitestudybstpractprinc.pdf

[8] Waterwise Technical Note on Shower Devices and CERT - January 2010 http://www.waterwise.org.uk/reducing_water_wastage_in_the_uk/research/technical_notes.html

products already in use, it should be ensured that clear instructions are made available to explain how the device is fitted correctly.

⇒ The market for water-efficient products is relatively young. If manufacturers can work in partnership with stakeholders there are opportunities to develop innovative products and water efficiency projects.

⇒ Further work needs to be done to better understand the feedback between products and consumer behaviour. This can then be used to improve the design process for new water-efficient products.

2 Introduction

2.1 Overview

Climate change impacts are already being felt in the UK. Twelve water company areas have been designated as areas of serious water stress[9], and parts of Scotland and Wales have experienced drought in the last few years. Coupled with this, household water use in the United Kingdom is steadily rising, driven by a growing population, an increase in single-person households, and behavioural changes. There is also a need for new housing to be built in water stressed areas.

As these trends continue, the balance between supply and demand will be a growing challenge. Water use is in danger of becoming unsustainable. The natural environment is also under threat. Improving water efficiency is key to the sustainable use of water resources in the UK, as well as being a key tool in adaptation to climate change (making less water go further) and climate change mitigation (reducing emissions from heating water in homes and buildings and from reduced pumping and treatment of water and wastewater). Already, a government ambition has been for England of achieving 130 litres per capita consumption (pcc) of water in England by 2030. As a way of setting the industry on the road to achieving these targets, Ofwat, the water industry economic regulator for England and Wales, has set minimum water efficiency targets for the water industry equivalent to reducing consumption by 1 litre per property per day from 2010 onwards. And the Water Industry Commission for Scotland has placed a duty on Scottish Water to promote water conservation and water-use efficiency through The Climate Change (Scotland) Act 2009 (section 74).

The UK Environment Minister's Water Saving Group for England (2005 – 2008), on which Waterwise sat alongside Defra, CLG, Ofwat, the Environment Agency, water companies and the Consumer Council for Water (CCWater) identified the lack of a robust evidence base for water efficiency as a barrier to large-scale water efficiency programmes. This was preventing water efficiency from taking its place alongside increased metering penetration and leakage control as a demand management tool to reinforce the twin-track approach to water resource management. Therefore, the Group tasked Waterwise with undertaking a review of the evidence with the aim of identifying gaps, analysing the data and establishing a common set of values for water efficiency measures (WEMs). This Evidence Base project was led by Waterwise with guidance from a Steering Group whose members were drawn from the water industry, regulators and government.

The first phase of the Evidence Base project resulted in a report, published in October 2008, which drew on evidence from the water efficiency trials and projects that had been undertaken by water

[9] Environment Agency, 2007, Areas of water stress: final classification, http://publications.environment-agency.gov.uk/pdf/GEHO1207BNOC-e-e.pdf

companies in the UK. These trials were analysed with a view to filling some of the knowledge gaps which were preventing water efficiency contributing more fully to a twin track approach to water resource management. The October 2008 Evidence Base report accomplished the following:

⇒ extracted information of water savings from water efficiency trials and projects in the UK;
⇒ filtered projects in terms of accuracy and robustness;
⇒ developed a table of WEMs and associated savings;
⇒ described the range of WEMs available for projects; and
⇒ developed a set of scenarios for large-scale water efficiency programmes, with Average Incremental Cost (AIC), water savings and Net Present Value (NPV) presented.

The report was warmly welcomed by the Water Saving Group at its final meeting in November 2008. At that meeting, WSG colleagues "welcomed this useful report and agreed that it should be kept updated to reflect the evidence of future water efficiency projects as they became available in the future".

2.2 The Phase II Work Plan

A review of the work published in October 2008 was carried out which highlighted several areas requiring further work in order to improve the Evidence Base. Points requiring further work included the treatment of uncertainty in reported water savings, ensuring cost data is made available, the robustness of the data included and whether or not water savings decay or are enhanced with time. In addition, the use of the disaggregation method was reviewed and consideration was given to making greater use of the results of consumer attitude and behaviour surveys. The results of the review were presented in the document entitled 'A Work Plan for the Augmentation of the Evidence Base for Large-Scale Water Efficiency in Homes'[10] which was produced by Waterwise in May 2009. This work plan set out five objectives, which presented a structured approach for improving the Evidence Base and ensuring that it is kept live. The objectives are as follows:

Objective 1: Identifying opportunities to improve the Evidence Base
Objective 2: Building upon existing data and analysis
Objective 3: Improving methodology and reporting of the Evidence Base
Objective 4: Working in collaboration to develop trials to fill knowledge gaps
Objective 5: Future Reporting to Guide Policy, Regulation and Practice

These objectives have now been completed insofar as is necessary to produce this first substantive report nine months into Phase II of the project. Objective 4 has been set in motion but it is expected that the research collaborations currently being progressed by Waterwise will reap additional benefits for the Evidence Base project in the medium term. During the process of working towards this report Waterwise has, again benefited from the input of the Evidence Base Steering Group, which is chaired by Jean Spencer, Regulation Director at Anglian Water and includes representatives from the department for Communities and Local Government, the Department for the Environment, Food and Rural Affairs, the Environment Agency, Ofwat, UKWIR, six water companies, Water UK and the Water Industry Commission for Scotland.

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Waterwise, 'A Work Plan for the Augmentation of the Evidence Base for Large-Scale Water Efficiency in Homes', May 2009, http://www.waterwise.org.uk/images/site/Policy/evidence_base/work%20plan%20phase%20ii%20the%20evidence%20base%20report%20final.pdf

2.3 Phase II of the Evidence Base Project

This report is the result of work that has been carried out under Phase II of the Evidence Base for Large-scale Water Efficiency in Homes Project. Phase II of this project is funded by the department for Communities and Local Government (CLG), the Department for the Environment, Food and Rural Affairs (Defra), the Environment Agency (EA) and Ofwat. The water companies have also provided in-kind support and data provision for the project.

2.3.1 What is included in this report

This report summarises the results of analysis carried out as part of Phase II of the Evidence Base for Large-Scale Water Efficiency in Homes. It analyses nine water company projects. It builds upon the first phase of work under this project which was published in October 2008 (Phase I) and aims to improve the evidence base for large-scale water efficiency in the following areas:

2.3.1.1 Water savings

In Phase I of the project the data extracted from water efficiency trials and projects carried out in the UK included a mixture of trials where water savings were measured from monitoring consumption in households and other trials where no monitoring was carried out but estimates of water savings were presented. In response to feedback from stakeholders in Phase II of the Evidence Base project we have used only the most robust and accurate measured water savings data from the water company trials. This has enabled us to improve the quality of the data presented in Phase II of the Evidence Base.

2.3.1.2 Uncertainty

The trials included in Phase I were subjected to an assessment of uncertainty as defined in the UKWIR Sustainability of Water Efficiency Measures report (Report Ref. No. 06/WR/25/2)11. This method places the data into one of three bands with regard to both accuracy and reliability. In order to allow the uncertainty in the water savings to be presented explicitly, Phase II of the Evidence Base Project provides a 90% confidence interval for the water savings in each of the water efficiency trials. In addition, to allow a deeper understanding of the uncertainty in the results the distribution of water savings is presented graphically and the probability of a household saving water has been calculated for each of the trials.

2.3.1.3 Carbon Emissions and Energy Savings

As part of Phase II of the Evidence Base project, Waterwise has developed a methodology for determining the carbon emissions savings and energy savings which result from water efficiency retrofitting in homes. Climate change is now well-established as a policy and economic driver, and further and deeper climate change impacts are predicted which will affect not only the economy as a whole but specifically the availability of water.

Water efficiency is unique in that it has a key role to play in both climate change adaptation and mitigation. In terms of adaptation, predictions are for more drought, and this, combined with population growth, housing growth in water stressed areas, and increases in consumption, means that less water will need to go further. In terms of mitigation, pumping water and wastewater to and from homes, and treating it at water treatment plants, accounts for 1% of the UK's total energy consumption, and domestic hot water accounts for 5% of UK greenhouse gas emissions (almost as

[11] UKWIR Sustainability of Water Efficiency Measures report (Report Ref. No. 06/WR/25/2)

much as the UK airline industry, which accounts for 5.5% (Waterwise Calculation). Wasting less water will reduce these carbon outputs.

Waterwise estimates that where showers, taps and toilets are included in retrofitting projects about 45% of the overall water savings in a home are hot water savings. The carbon emissions and energy savings from trials, presented in this report, will help demonstrate that water efficiency has an important role to play, alongside and in tandem with energy efficiency, in helping the government meet its legally binding targets to reduce greenhouse gas emissions by 34% on 1990 levels by 2020 and 80% on 1990 levels by 2050, and contributing to its 5-yearly carbon budgets.

2.3.1.4 Understanding of costs

Phase II of the project has sought improved visibility on the costs of water efficiency retrofitting. This report includes, for each of the water efficiency trials, a cost per property for retrofitting and customer engagement carried out and also a value for the cost per litre per property per day saved.

2.3.1.5 Scenarios

This report builds upon the work carried out in Phase I to develop a set of scenarios for large-scale water efficiency programmes, with Average Incremental Cost (AIC), water savings and Net Present Value (NPV) presented. Phase II of the Evidence Base presents new scenarios which point to how water efficiency could be delivered effectively in partnership and which are now better informed due to improved water savings and cost data. In addition, carbon and energy savings are now quantified in the scenarios and included in the cost-benefit analysis.

2.3.1.6 Comparison of Actual and Theoretical Savings

Also included in this report is a comparison of the actual savings with some theoretical water savings values which are based on microcomponents of water use. This will be useful for the water companies and for Ofwat as they seek to understand the effectiveness of water efficiency measures for their future water efficiency plans. This is described in more detail in the section 4.4.

Waterwise is keen to find new ways to supplement the Evidence Base for Large-scale Water Efficiency in Homes with further information. If you know of analysis or projects that you believe may be a useful addition to the Evidence Base, please get in touch with Waterwise (iomambala@waterwise.org.uk).

3 Key Issues

This section summarises the key challenges which need to be overcome in order to allow water efficiency to develop as a large-scale demand management option. The relevance of each of the issues is described below. In addition, recommendations are also made with a view to helping overcome any obstacles. These recommendations are also included in Chapter 1 – Summary of findings and recommendations.

3.1 CERT

There is currently an opportunity for water companies to partner with energy companies and gain credit, through Carbon Emissions Reduction Target (CERT), for carbon emissions savings as a result of hot water savings in the home. However, there is a regulatory issue which needs to be overcome in order to facilitate this process.

CERT started in 2008 and runs until 31st March 2011, the UK government is currently consulting 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 CO_2 emissions reduction from homes in Great Britain. These companies are:

⇒ EDF
⇒ Scottish Power
⇒ Scottish and Southern Energy
⇒ EON,
⇒ NPower
⇒ British Gas.

The energy companies are looking for ways to deliver their carbon saving allocation in the most cost effective manner. 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
⇒ evidence supporting the total carbon saved by the device/kit

There are currently (February 2010) three water-efficient products which have been awarded CERT accreditation, all of which are retrofit devices which reduce shower flowrates. Following the success of these three products there are several other water-efficient product manufacturers who are in discussions to follow suit, including showerheads, tap inserts, flow monitors and shower aerators. The current devices have been given a cert rating of 1 tCO_2e savings over a lifetime of 12 years, showerheads are likely to be awarded a CERT rating of 0.5 tCO_2e as they are likely to be judged to have a 6 year lifetime.

There is a great opportunity for UK water companies to use the CERT scheme to promote joint water and energy retrofit schemes. However, there is a regulatory issue with how the CERT scheme might be applied to joint water and energy efficiency retrofitting projects. Additionality is 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 them 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.

There is consensus in the industry that there needs to be a coordinated approach from the water and energy industries to take advantage of the opportunity CERT presents to deliver water efficiency in the most cost effective way. Scenario 2 in the new scenarios presented in this report describes a water company partnering with an energy company to deliver water efficiency and energy efficiency on a large-scale. This is the most cost effective of all seven scenarios presented because of the cost savings achievable through having a single visit to carry out water and energy efficiency retrofitting and through the credit which is available due to carbon savings. Waterwise is happy to advise on the use of CERT for retrofitting programmes[12].

In order to work towards a more coordinated approach, discussions should be arranged between Ofwat, Ofgem, water companies, energy companies and other key stakeholders. Waterwise has been charged with organising this discussion.

3.2 Social and Environmental Costs

There is currently little guidance on how to best carry out cost benefit analysis for water efficiency retrofitting schemes, including how to take into account carbon emissions costs and benefits.

One of the ways in which the cost benefit analysis methodology employed in the Evidence Base has improved from Phase I to Phase II of the Evidence Base is that it now includes the assessment of environmental and social benefits of water efficiency programmes for the presented scenarios (see Chapter 8). An externality is a non-financial cost or benefit that may be environmental or social. The EBSD[13] includes advice on quantifying environmental and social costs under Stage 5 and Appendix A of the Main Report. The Environment Agency's *Benefits Assessment Guidance* (2003) (for England and Wales) advises on the types of externalities to be considered, and defines externalities as follows:

> 'Because impacts on environmental resources remain outside the 'market place', they are commonly referred to as 'external' effects or 'externalities'. A full social cost benefit analysis includes consideration of these 'external' effects in order to estimate the total social costs or benefits arising from a scheme. External costs and benefits include those corresponding to the range of environmental, human health and other non-market social impacts, and occur when the actions of one individual/firm cause a loss in wellbeing (or satisfaction) to another individual/firm, and no compensation has been paid for that loss taking place.'

The current treatment of externalities is not exhaustive but takes into account those for which there is currently sufficient knowledge to make a robust estimate. Table 3 below gives a list of the costs

[12] Waterwise Technical Note on CERT - http://www.waterwise.org.uk/images/site/technical_notes/shower%20devices%20and%20cert%20-%20january%202010.pdf

[13] UKWIR, The Economics of Balancing Supply & Demand (EBSD) Guidelines (02/WR/27/4) - http://www.ukwir.org/ukwirlibrary/80558

and benefits that are either currently included or that require further work before being included in the calculation of average incremental social cost (AISC).

Research will be carried out in order to understand how best to take account of those costs and benefits which are not currently included and the aim will be to include these in a future Evidence Base report. This will also cover Scottish Environmental Protection Agency (SEPA) and the Water Industry Commission for Scotland (WICS) requirements.

Impact/Consequence of Large-scale Water Efficiency Activity	**External Cost**
1. Benefit of reduced energy consumption due to lower water company distribution and treatment costs	Included in the current AISC assessment
2. Benefit of reduced energy consumption due to lower hot water consumption in the home	Included in the current AISC assessment
3. Cost of carbon footprint of water efficiency project	Included in the current AISC assessment
4. Cost of carbon embedded in water-using devices	Further work required
5. Benefit of reduced river abstraction	Further work required
6. Benefit of reduced groundwater abstraction	Further work required
7. Benefit of deferred reservoir construction	Further work required

Table 3 - List of Environmental and Social Costs and Benefits

There is a risk of double counting elements of the AISC calculations for the supply-side and demand-side options. For example, there may be a benefit due to reduced river abstraction from water efficiency but there may also be a disbenefit due to increased river abstraction due to building a new reservoir. This is something that must be taken into account when carrying out this cost benefit analysis. Double counting for CERT is also an issue for projects which aim to make use of the scheme. Since the CERT scheme may provide a benefit to the company from credits derived from carbon savings of water efficiency, including the whole value of carbon saved in the AISC calculation would be inappropriate.

3.3 Uptake

Uptake rates are typically very low in water efficiency programmes; this severely limits the overall water savings achievable from a water efficiency project, and this means that the majority of the population are not being engaged.

When rolling out water efficiency programmes, there are several populations that need to be considered:

⇒ The total number of households in the programme area;
⇒ the households that are invited to participate;
⇒ the households that agree to participate (i.e. the uptake rate);
⇒ the households where access is achieved; and,
⇒ the households where installation takes place (i.e. the installation rate).

The uptake rate is the percentage of customers originally invited to join the trial who take part in the retrofitting project, and is an area of some concern. It has a big influence on the success of a programme, as it influences the overall yield of the programme.

As will be seen from the water efficiency trials included in this report, the uptake rates achieved are very low outside of two social housing based projects, the Preston Water Efficiency Initiative and Wessex Water's Water Efficiency Trial, which achieved 60% and 45% uptake rates respectively. The other seven trials, carried out in general housing stock, achieved uptake of between 6% and 22%. This is an area that could be improved with a better understanding of how to influence customer attitudes to water efficiency.

Waterwise will seek to carry out research to understand how to achieve greater uptake rates for water efficiency retrofitting projects.

3.4 Behavioural Change

There is increasing awareness of the significant role that changing of attitudes and behaviour towards water efficiency has to play in delivering water efficiency on a large-scale.

The interaction of the customer with the water-efficient device is what will lead to the reduction of water wastage. It is not sufficient to retrofit; customers also need to be educated about how to use new products, particularly where saving water relies on the customer interacting with their water-using devices in a different way. If toilets are retrofitted so that they operate as dual-flush then it is important that those who live in such properties are made aware of how to use the short and long flush modes. Also if tap inserts are installed to reduce the flow through taps, it may still require a change of behaviour with regard to tap use to reduce water consumption. Behaviour change should be seen as an integral part of water efficiency retrofitting programmes.

Waterwise will seek to carry out research to understand how best to encourage customers to save water.

3.5 Metering

There is currently a consensus in the water industry that installation of a water meter leads to a reduction in consumption of 10%. However there is little, current UK evidence to suggest that this is what is achieved in practice and whether this varies depending on tariffs applied.

The Walker Review[14] referred to a possible 16% reduction in consumption. However, some monitoring of properties which are going through the change from non-metered to metered, on a similar scale to the Evidence Base, would provide more confidence. In addition, the October 2008 Evidence Base report described the need for a separate study on the role of metering alongside retrofitting of devices and education, as part of an integrated demand management approach. The evidence in this report shows that significant savings were achieved by the one project that put into practice this integrated demand management approach: the Anglian Water Ipswich Area Water-efficient Measures Trial.

[14] Defra Website – Walker Review of Charging for Household Water and Sewerage Services http://www.defra.gov.uk/environment/quality/water/industry/walkerreview/documents/final-report.pdf

Further evidence of the effectiveness of metering is required in addition to analysis of how this combination of metering and water efficiency retrofitting can be synergistic will be possible once further funding is made available to water companies to practice this method of demand management.

3.6 Carbon Emissions and Energy savings

A number of assumptions have been made in calculating the carbon emissions and energy savings due to the water savings in each of the trials in this report.

These assumptions are discussed in Chapter 5 of this report. The model has not yet been validated with empirical data to ensure that the carbon and energy savings it describes relate sufficiently well to how what savings would be achieved in practice in a home.

Further trials, involving some measurement of energy consumption either side of water efficiency trials would be helpful in understanding this area more clearly.

3.7 Microcomponent Data and Assumptions

There are a large number of assumptions used in the project; these are based on existing reports or published data, some of which are not evidence based.

The October 2008 Evidence Base showed that there is a wide range in values used even for basic micro-components. In order to further explore the issue of microcomponent estimates of water savings from trials, this report includes a comparison, for many of the trials, of the actual water savings from the trials to some theoretical level of savings for each device installed. This is the first step in helping to direct future estimates of water savings and presenting realistic forecasts of what is achievable through the installation of water-efficient devices in homes.

Further research is required that is specifically designed to tackle the issue of microcomponent data by finding ways to link estimates to measured values.

3.8 Skills Base

The lack of a sufficient skills base for delivering water efficiency retrofitting is a threat to the industry's ability to deliver sufficiently cost-effective water efficiency retrofitting.

When planning to deliver a large-scale water-efficient project, it is currently difficult to find plumbers with the right skill set to install water-efficient devices. Also, in terms of project management and effectiveness, the UK lags behind Australia where a single installer plumber typically delivers around 10 retrofits per day. This is an extremely important aspect of delivery which needs to be improved if water efficiency is to compete with other resource options.

There is an issue over liability of water companies for products that are installed in customers' properties. If something should go wrong with a device which the company installs, then this could lead to compensation claims from customers. How long any liability should last is also an important question. This is one of the reasons that water companies prefer to contract out the installation

work. So despite there being strong drivers preventing the development of a strong skills base to help deliver water efficiency, capacity needs to be built in this area to facilitate large-scale water efficiency programmes.

3.9 Longevity of Water Savings

Probably the biggest area of uncertainty in the cost benefit analysis for water efficiency is how water savings are sustained over time.

The water companies have supplied excellent quality datasets to help improve this evidence base for water efficiency. However one aspect for which there is a shortfall is evidence for how well water savings are sustained over time. None of the trials or projects currently included in the Evidence Base has been able to add to our understanding of the issue of sustainability of water savings. An assumption of a half-life for water savings was applied to the cost benefit analysis presented in the October 2008 Evidence Base report. In the absence of any evidence from trials, this does seem to be a reasonable assumption, so the same approach will be taken in Phase II of the Evidence Base. This is probably the most significant area of uncertainty that has to be dealt with in the calculation of AIC and AISC. It will be very important at PR14 to gather more evidence to reinforce this aspect of the evidence base.

Further research is required that seeks to understand how well, over the medium to long term, water savings are sustained.

4 The Methodology

The methodology for Phase II of this project draws much primarily from the following three pieces of water industry work:

- UKWIR (2007) "A framework for valuing the options for managing water demand", 073/WR/25/3, referred to as WR25B, from which the cost/benefit analysis procedure and spreadsheet tool have been used;
- UKWIR (2006) "Sustainability of water efficiency measures", 06/WR/25/2, referred to as WR25A; and,
- UKWIR (2002) "Economics of balancing supply and demand", 02/WR/27/3, referred to as EBSD, which is ultimately used to develop the optimum mix of resource and demand interventions to balance supply/demand. The outputs generated from the WR25B spreadsheet tool are designed to be used in the EBSD process.

The method used in this project for calculating average incremental social cost (AISC) is consistent with the WR25B approach, the EBSD and the Water Resource Planning Guidelines. A discount rate of 4.5% has been used as this was the value used by Ofwat within their financial model for PR09. In addition, a 25-year planning horizon has been used as this is common practice for water companies (in practical terms, this means assigning a zero value to all figures after 25 years up to 60 years when calculating the AISC values).

The methodology was applied in five steps:

1. Consult stakeholders to understand the gaps in the current evidence and how these can be filled;

2. Collect evidence from water companies and other water efficiency practitioners, and then assess the quality of the evidence;

3. Analyse the data to extract the following:
   - → Water savings in litres per property per day saved and percentage reduction in consumption
   - → 90% confidence intervals in terms of litres per property per day saved and percentage reduction in consumption
   - → The distribution of water savings
   - → Cost per property of retrofitting and the cost per litre per day of water saved
   - → The probability of a property taking part in the trial and consequently reducing their water consumption
   - → Derive sufficient data to allow linear regression to be applied, enabling the project results to be generalised for water companies and other stakeholders who are considering their own water efficiency plans.
   - → Customer response to the company initiative as described by a percentage uptake rate (i.e. the percentage of customers initially contacted to take part who actually took part in the trial or project)
   - → Carbon emissions and energy savings, calculated by applying a model and methodology that will be presented later in this section

4. Comparison of the measured savings with theoretical saving values

5. Construct Scenarios and analyse the costs and benefits, in terms of water savings, for these scenarios using the spreadsheet tool developed under the WR25B project.

The application of this methodology has yielded useful evidence which should improve the quality of the evidence base and help to provide stakeholders with more confidence when planning water efficiency retrofitting schemes. Phase II of the Evidence Base has also provided a standard methodology and an output format that are flexible enough to enable water companies to develop their own scenarios, with existing and standard tools, for the EBSD process that are consistent with Ofwat's guidance on cost benefit analysis.

4.1 Consulting Stakeholders

Stakeholders were consulted on Phase II of the Evidence Base project in the following ways:

- ⇒ The Evidence Base Steering Group has added value to the Evidence Base project. The Steering Group, which meets quarterly, is chaired by Jean Spencer, Regulation Director at Anglian Water and includes representation from the water companies, CLG, DECC, Defra, the Environment Agency, Ofwat, Water UK, Water Industry Commission for Scotland and Waterwise;
- ⇒ Several visits were made to water companies to discuss how they could contribute and how they would like to see the Evidence Base develop;
- ⇒ Presentations were made to stakeholders at the following events:
  - → the National Housing Federation's Asset Management and Maintenance Conference and Exhibition, Coventry (July 2009)
  - → The Environment Agency Demand Management Group Meeting, London (July 2009)
  - → Waterwise's Technical Symposium on Innovation and Water Efficiency (November 2009)
  - → Waterwise East's "Water efficiency in social housing" Workshop, Peterborough (November 2009);
- ⇒ Minutes of meetings and project updates were distributed to a broad range of stakeholders on a quarterly basis.

4.2 Data Collection

Information was gathered from UK water companies through written data requests, desk study and personal communications. These efforts were followed up by visits to the water companies. Specific project reports and raw data were obtained from the companies. The information was then collated and analysed.

When reviewing the range of water efficiency trials and project reports, a great deal of time was spent trying to obtain the data in its raw form. The water companies were very keen to contribute and were very helpful in providing raw data, and by and large promptly after it was requested. However, there were occasions when a large amount of work was required by companies in order to make the data fit to share, as customer privacy was a key consideration. A good deal of time was spent, in particular, reviewing survey feedback from customers as there were a broad range of approaches to questions that were asked and the storing and management of this data.

4.3 Data Analysis

4.3.1 Water Savings and Monitoring

The measurement of both pre-installation and post-installation water consumption was required so that water savings in terms of litres saved and percentage reduction in consumption could be calculated. Each of the companies that contributed to this report provided data for properties that had been monitored for at least three months before and after retrofitting. However, several companies monitored for longer than two years prior to retrofitting and for up to two years post-retrofitting.

4.3.2 Carbon Emission and Energy Savings

Waterwise has developed a means of determining the carbon emissions and energy savings which result from hot and cold water savings from more efficient use of water. This method has been used in Phase II to apply carbon emissions savings and energy savings to the included trials. This will be described in more detail in Chapter 5.

4.3.3 Confidence Intervals

The trials included in the October 2008 Evidence Base report were subject to an assessment of uncertainty as defined in the UKWIR Sustainability of Water Efficiency Measures report (Report Ref. No. 06/WR/25/2)[15]. This method places the data into one of three bands with regard to both accuracy and reliability. However, in Phase II of the Evidence Base 90% confidence intervals will be applied to the water savings. The aim is to make the uncertainty involved in the water efficiency trials as easily comprehensible as possible. One argument in favour of confidence intervals is that they allow uncertainty in the data to be taken into account in models to which Evidence Base data may be applied such as in UKWIR's EBSD framework.[16] It would be difficult to take uncertainty into account in such models if reliability and accuracy bands were used.

4.3.4 Distribution of Savings

The inclusion of water saving histograms in this report has given us further insight into how customers respond to being engaged by companies through water efficiency retrofitting. It will also show us that there is a fairly predictable structure to the distribution of savings obtained from water efficiency retrofitting projects.

4.3.5 Understanding Costs

It is essential that the Evidence Base presents data that allows the cost of implementation of water efficiency trials to be evaluated. The cost of water savings is something which is clearly defined in each of the water efficiency retrofitting trials in this report. Including cost analysis of the trials in the Evidence Base will help harness the experience gained from budgeting for different sizes and types

[15] UKWIR Sustainability of Water Efficiency Measures report (Report Ref. No. 06/WR/25/2)
[16] UKWIR, The Economics of Balancing Supply & Demand (EBSD) Guidelines (02/WR/27/4)

of water efficiency trial. This will be invaluable when upscaling to large-scale water efficiency projects.

4.3.6 Linear Regression

In Phase II, linear regression has been used 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[17]. For each property, the post-trial consumption (y-axis) is plotted against the pre-trial consumption, so that each property represents one point plotted on the chart. A straight line is then drawn through the points on the chart which is calculated to be a line of best fit. The method of least squares assumes that the line of best-fit of a given type is the line that has the minimal sum of the offsets squared (least square error) from a given set of data[18]. This method of finding a line of best-fit is the most commonly used. In practice, the square of vertical offsets is usually minimised as opposed to perpendicular offsets (see Figure 1).

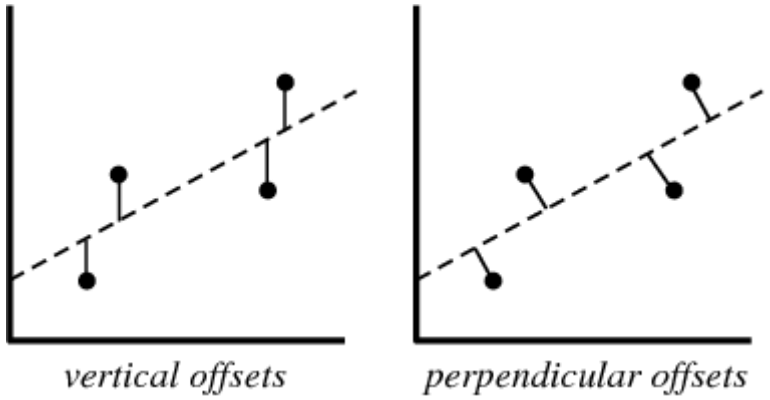


Figure 1 - Diagram showing vertical and perpendicular offsets[19]

In order to understand how good the fit of the line is, a quantity referred to as R^2 can be used. This represents the percentage of the variation in the outcome that can be explained by the model. This provides us with a good way of assessing whether there is a substantive relationship between pre and post-trial consumption. This means that if R^2 is found to be 0.6, then the line of best fit describes 60% of the relationship between the two variables.

The statistical modelling required to accomplish this was carried out in SPSS, but could just as easily be done using Microsoft Excel. Using this technique enables the forecasting of water savings achievable in similar types of project carried out elsewhere.

4.3.7 Uptake Rates

Data was available for each of the trials included in Phase II to allow the level of customer interest, as expressed by the uptake rate to be included for each of the retrofitting trials. The uptake rate simply describes the proportion of customers invited to benefit from the trial who actually end up taking part. This is a useful reference for stakeholders who are planning to carry out water efficiency

[17] Field, A., 2009, 'Discovering Statistics Using SPSS'. Third Edition Sage Publications Ltd.
[18] http://www.efunda.com/math/leastsquares/leastsquares.cfm
[19] http://mathworld.wolfram.com/LeastSquaresFitting.html

projects, as it has previously been difficult to date to gauge how many customers need to be invited in order to ensure a certain level of participation in a trial or project.

4.4 Comparison of the Measured Savings with Theoretical Savings Values

The data received from the companies included details of the products which were installed in many of the properties whose consumption had been monitored in the periods before and after retrofitting. Therefore a comparison was made between the actual savings which would have been achieved based on the following estimates:

	l/prop/day
Toilet conversion to dual-flush	30.0
Cistern displacement device installed	11.5
Water-efficient showerhead installed	25.2
Tap insert installed	0.9

Table 4 - Theoretical savings used for comparison with measured data from trials

⇒ Toilet conversion to dual-flush

It has been assumed that on average conversion of a toilet to dual-flush using a retrofit device will result in an average 2.5 litre reduction in flush volume (for example, a reduction in average flush volume from 7.5 to 5.0 litres). It is also assumed that on average a toilet is flushed 11.5 times each day (Essex and Suffolk Water, 2005 and South West Water, 2007). Hence a saving of 30 lpd was used for the comparison of actual and theoretical savings.

⇒ Cistern displacement device installed

The majority of trials included in this report installed a one litre volume cistern displacement device such as a save-a flush bag. The theoretical savings used in the comparison was based on the assumption of 11.5 flushes per day and hence 11.5 litres per cistern displacement device installed.

⇒ Water-efficient showerhead installed

The theoretical saving for the installation of water-efficient showerheads was based on a pre-trial shower flowrate of 9 litres per minute and average shower duration of 7 minutes (Waterwise, 2007)[20]. It is then assumed that the initial volume of water used in a property (63 litres per person per day multiplied by an average occupancy taken to be 2.4) is reduced by a sixth (Severn Trent Water, 2006 and United Utilities, 2007). These assumptions provide us with a theoretical saving of 25.2 litres per property per day from installing a water-efficient showerhead.

⇒ Tap insert installed

The October 2008 Evidence Base report provided users with a table which presented disaggregated water savings from various water company-led water efficiency trials. The range of savings for tap inserts was 2.07 to 24.89 lpd. However, these values do not take account of how many of the devices are assumed to be fitted or how appropriate the fitting of the tap insert was in that case. It was considered that due to the lack of specific information on the effectiveness of tap inserts in water efficiency retrofitting projects a conservative value should be applied. Using an iterative

[20] Waterwise, The Water and Energy Implications of Bathing and Showering Behaviours and Technologies, April 2009

process, a value of 0.9 lpd per tap insert installed was finally applied to the comparison where tap inserts are installed.

4.5 Creating Scenarios: The Spreadsheet Tool for the Calculation of AIC and AISC

Seven scenarios were created which represent ways in which:

- ⇒ an organisation might deliver water efficiency through partnership
- ⇒ a water company might integrate water efficiency with its other activities such as metering
- ⇒ water efficiency might be included in government schemes such as the Community Energy Saving Programme (CESP) or the Decent Homes standard.

In order to calculate the net present value (NPV), AIC and AISC, the same spreadsheet tool as was used in Phase I of the Evidence Base was employed in Phase II. Screenshots of the tool are provided in Appendix A.

For each step in the spreadsheet tool where data is entered, uncertainty is accounted for with a range of values: a best estimate (i.e. most likely), best case (i.e. an optimistic result) and worst case (i.e. a pessimistic result). For example, for costs, the best case would be the lowest cost and the worst case would be the highest cost. The best estimate would be the most likely cost.

The tool is used in six steps:

4.5.1 Step 1: Target Households

Projected household numbers (i.e. target households) are inputted for up to four subgroups of households in each zone. These subgroups can vary either in the water savings made or costs incurred. For example, the target population may be split between metered and unmetered households or between urban and rural households. Each subgroup can be treated individually with regard to scheme uptake, costs and water savings; however, each household subgroup must be mutually exclusive in order for the total households' yields and AICs calculated to be meaningful.

4.5.2 Step 2: Uptake Rates and Uncertainties

The uptake rate is the percentage of the target population that participates in a scheme. In most cases the uptake rate is crucial to determine the water savings that may be made. Given the unpredictability of behaviour, uncertainties around uptake rate are in many cases the most significant.

In developing scenarios, assumptions need to be clearly stated. For example, "measured households are usually assumed to achieve a higher uptake rate for water efficiency schemes than unmeasured due to the financial incentive to save water" or "uptake rate is assumed to be closely related to what the scheme offers in terms of subsidies for water-saving devices and their installation, and the extent to which the scheme is promoted".

When rolling out water efficiency programmes, there are several populations that need to be considered:

- ⇒ the total number of households in the programme area;
- ⇒ the households that are invited to participate;
- ⇒ the households that agree to participate (i.e. the uptake rate);
- ⇒ the households where access is achieved; and,
- ⇒ the households where installation takes place (i.e. the installation rate).

The uptake rate has a big influence on the success of a programme, as it influences the overall yield.

A scheme can be assessed as a 'one-off' or as a 'periodic implementation'. A one-off implementation assumes that the scheme is implemented in Year 1 and takes X years to complete, with no re-implementation. Periodic implementation allows the planner to implement the scheme as many times as is required throughout the twenty-five year planning period, in order to maintain savings. Periodic implementation can also be used to allow uptake to be delayed until scheme set up is completed, if scheme set up is deemed to take more than two years. All the projects and examples in this report are one-off implementations and assume that there is no replacement or repeat programme led by a water company after the initial installation of devices.

The tool also allows for a change in water savings over time to be included, if supported by evidence; however, for most of the projects there will be limited time series data, typically only one or two years. Therefore, the spreadsheet tool uses a method of projecting water savings forward in time that allows for decay in savings that may be due to behaviour, customer intervention (e.g. removal or replacement of the device) and/or device underperformance.

Water efficiency measures (WEMs) are installed in multiple households and result in a volume of water saved. It is assumed that the volume saved in Year 1 is known and so the savings are calculated as the sum of households multiplied by water savings per household per year. After this time we do not know what the water savings may be: they may continue at the same level or they may decrease. The reason for the decrease may be that a proportion of households each year remove a WEM or that a proportion of the WEM deteriorate such that water saving is reduced. The reduction in water saving may start immediately; therefore, the volume should take into account any fall off in water savings during the first year.

The WEM is assigned a 'half-life' distribution: the years from time of peak savings until only half peak savings are delivered. The half-life represents the length of time in which half of the measures will be replaced or abandoned. It also represents the time taken for deterioration of devices to yield half the peak savings. It is assumed that when the measure is replaced, abandoned or deteriorates, no future water savings are made.

Using this approach, a range of projected water savings is made as best estimate, best case and worst case. The half-life needs to be estimated for each of these cases. Time series evidence can be used, if available, to estimate the half-life; however, in most cases this information will not exist. Therefore, guidance has been developed and applied to ensure consistency:

- ⇒ the best estimate (i.e. most likely) value is given by a half-life equal to half the asset life;
- ⇒ the best case is given by a half-life equal to two times the asset life; and,
- ⇒ the worst case is given by a half-life equal to one quarter of the asset life.

For example, a water saving measure may have an asset life of ten years (where asset life is a distribution with a mean of ten) after which time it is expected that the water savings from this

particular WEM will become zero. The initial water saving is 100 units. Using the process set out above, the savings would have a best estimate half-life of five years, so the savings are halved to 50 units at the end of Year 5 (Figure 2).

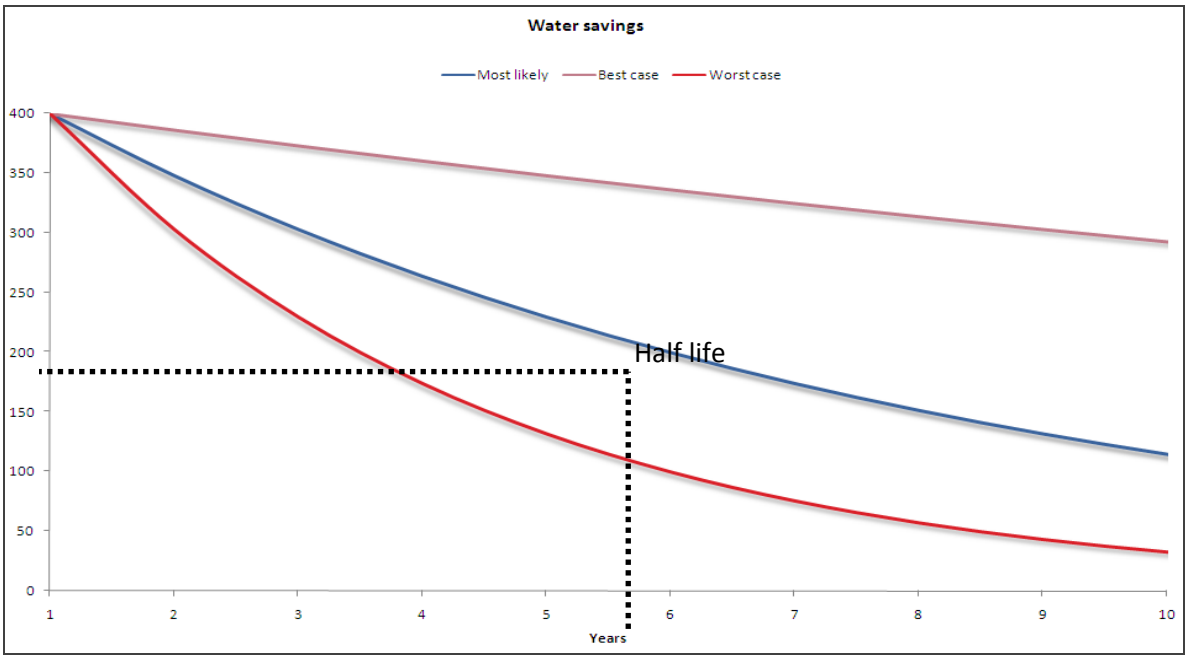


Figure 2. Half-life of water savings from retrofitting trials and projects.

Half-life feeds into the uptake rate calculations and determines how quickly the households that take up the scheme are returned to the 'not taken up' population.

4.5.3 Step 3: Costs

The range of costs for each of the scenarios was established from project analysis. The cost of fitting will depend on whether the scheme includes free professional installation, subsidised professional installation or if the customer is expected to fit the device themselves. If the company employs a plumber to install the device(s) then the cost of installation will be based on the average hourly rates and the average time it takes to fit the device.

Customer recruitment costs apply to the entire target population, regardless of whether they participated in the scheme or not. There are also administrative and data handling costs.

All costs of all devices, visits and installations mentioned in this report were met by the water company or other authorities and none by the customer.

4.5.4 Step 4: Water Savings

Savings (yield) in litres per household per day for the worst case, best estimate (i.e. most likely) and best case for each target population are inputted into the tool.

4.5.5 Step 5: Social and Environmental Costs and Benefits

If data is available, social and environmental costs and benefits should be considered in order to include externalities such as the cost/benefit of the water remaining in the environment and/or the impact of the scheme on householders. There is also the possibility for water companies to generate income through schemes such as Carbon Emissions Reduction Target (CERT) which recognises the role of water efficiency in helping the UK meet its carbon reduction targets. The environmental and social costs/benefits may be entered as the best case, best estimate and worst case savings in megalitres and/or per installation. The net costs/benefits are entered with savings applied as a negative value.

4.5.5.1 Calculation of AIC and AISC for the Scenarios

The spreadsheets used to calculate AIC and AISC for each of the scenarios are given in Appendix A. In this section, the main assumptions required to calculate these costs are summarised. In addition Table 5 gives a description of the costs and benefits that could be applied to this process. This was produced with reference to the 'Best Practice Principles in the Economic Level of Leakage Calculation', that was produced by Ofwat, the EA and Defra in 2002 [21]. Unfortunately, the knowledge-base does not yet exist to include all of the possible components in the cost benefit analysis for large-scale water efficiency.

4.5.5.2 Determining Hot Water Savings in the Home

In order to determine the carbon and energy savings which are achieved through improved water efficiency the amount of hot water saved as a proportion of the total water saving needs to be understood. The assumptions below are necessary to disaggregate the hot and cold water savings.

⇒ If a shower retrofit are included in project it is assumed that 45% of total savings are hot water savings associated with shower and tap retrofit.

⇒ If shower retrofit is not part of the project, it is assumed that 2% of total savings are hot water savings associated with tap retrofit.

Once it is understood how much the hot and cold water savings amount to the Waterwise model for calculating carbon and energy savings, as described in Section 5, can be used to calculate carbon emissions and energy savings, as described in items 1 and 2 of Table 5.

4.5.5.3 Calculation of Carbon and Energy Savings from Hot and Cold Water Savings.

Once the savings have been disaggregated, the following assumptions are used to calculate the carbon and energy savings achieved:

⇒ 0.747 tCO_2e is saved per Ml of water saved (hot or cold)

⇒ 8 tCO_2 are saved per Ml of hot water saved

⇒ 44000 kWh of energy is saved per Ml of hot water saved

[21] The Tripartite Group (Ofwat, EA, Defra), **Best Practice Principles in the Economic Level of Leakage Calculation, March 2002.**

4.5.5.4 Carbon Footprint of a Water Efficiency Product

Item 3 in Table 5 describes the calculation of the cost of carbon emitted in the course of a water efficiency project. In order to carry out this assessment the following assumptions were made:

⇒ Carbon emissions from vehicles involved in the water efficiency device installation range from best case 140 gCO_2/km, best estimate of 160 gCO_2/km and a worst case of 220 gCO_2/km.
⇒ In addition a estimate was made in each case of a best case, best estimate and worst case number of kilometres travelled by a vehicle in the course of water efficiency retrofitting. In cases where properties are less likely to be geographically dispersed, such as the social housing scenario, lower figures can be used than in a scenario such as retrofitting a whole town because this will require more travelling in a vehicle.

4.5.5.5 Impact on Abstraction and Water Resource Management Plans

Items 5 and 6 in Table 5 describe the possible benefits obtainable through carrying out water efficiency on large-scale to have a positive impact on water resources by reducing abstraction from rivers and ground water. If large-scale water efficiency can have such an effect, it would relieve pressure on supply demand balances, and could potentially lead to deferment of investment in large-scale supply options such as reservoir construction. However, further work is required to understand the scale of any such effect and so this has not been included in the AISC calculation in this report.

4.5.5.6 The Cost of Carbon

The cost of carbon in this project was derived from the Department for Energy and Climate Change (DECC) document: 'A brief guide to the new carbon values and their use in economic appraisal'[22]. This document presents a table of carbon values and sensitivities for the period 2009 – 2050. For each year low, central and high carbon prices are presented for two different categories: traded and non-traded. Guidance was sought from DECC as to how these prices should be applied to the two categories of carbon emission that stem from a reduction in water consumption: energy indirect and domestic hot water savings.

"Carbon emissions that are captured under the European Union Emissions Trading System (EU ETS) are known as 'traded' carbon emissions. This is understood to mean that:

1. Carbon emissions produced by the use of electricity, such as for the operation of pumps and treatment of water on the distribution network, should be treated as traded carbon emissions.
2. Carbon emissions produced by the use of gas, such as for the heating of hot water by a gas-fired boiler in the home, should be treated as non-traded carbon emissions."

For 2010, the traded and non-traded, 'central' carbon values are 22 pounds per tCO_2e and 52 pounds per tCO_2e. Hence in order to calculate the carbon price that should be applied to carbon saving in water efficiency projects. Therefore, using the carbon savings from trials in this report, a weighted carbon price was calculated. The following values will be used in the calculation of AISC in the scenarios:

[22] DECC, Carbon Appraisal in UK Policy Appraisal: A revised Approach A brief guide to the new carbon values and their use in economic appraisal

- → For projects where water-efficient showerheads are installed the carbon value will be taken as 47.0 pounds per tonne CO_2e
- → Where shower retrofit is not targeted through the installation of water-efficient showers, the carbon value will be taken as 26.2 pounds per tCO_2e.

These carbon values are derived from the weighted value of carbon figures presented for each trial, which are given in Table 12 (Chapter 6).

4.5.6 Step 6: Results

After all the data have been inputted, a worksheet of the tool displays the AICs and yield/cost profiles over the 25 year assessment period for each of the target household groups, as well as for all households. The spreadsheet tool allows planners to see instantly how cost-effective spending is in different areas by looking at the change in the AIC.

Impact / Consequence of Large-scale Water Efficiency Activity	External Cost	External Benefit	Comment
1. Reduced energy consumption due to lower water company distribution and treatment costs		The cost of carbon emissions and energy saved	Included in the current AISC assessment
2. Reduced energy consumption due to lower hot water consumption in the home		The cost of carbon emissions and energy saved	Included in the current AISC assessment
3. Carbon footprint of water efficiency project.	The cost of carbon emissions from vehicles involved in the retrofitting activities		Included in the current AISC assessment
4. Carbon embedded in water-using devices	The value of carbon embedded in devices		Not currently included in the AISC calculation
5. Reduced River Abstraction		Use (e.g. recreation, angling) and Non-use (e.g. conservation value) benefits of improved river flows	Not currently included in the AISC calculation
6. Reduced Groundwater Abstraction		Use and non-use benefits of improved wetlands and river flows	Not currently included in the AISC calculation
7. Deferred reservoir construction	Avoided benefits of water based recreation (e.g. angling, water sports)	Avoided costs of landscape disamenity and construction	Not currently included in the AISC calculation

Table 5 - External Costs and Benefits of Large-scale Water Efficiency Projects

5 Carbon Emissions and Energy Savings

5.1 Introduction

The benefit of carrying out combined water and energy retrofitting is considerable. There are water and energy saving opportunities within the direct operations of both utilities, but in general these are recognised and are being addressed. The greater opportunity lies in an integrated approach to domestic water and energy use – to tackle the 5% of UK greenhouse gas emissions mentioned above, as well as household water and fuel bills. This will also reduce the carbon and financial costs of the water industry as less water and wastewater will need to be treated, and pumped to and from homes.

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 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 for cost effective water efficiency measures to be included in government retrofitting schemes covering every home in the country in the next two decades.

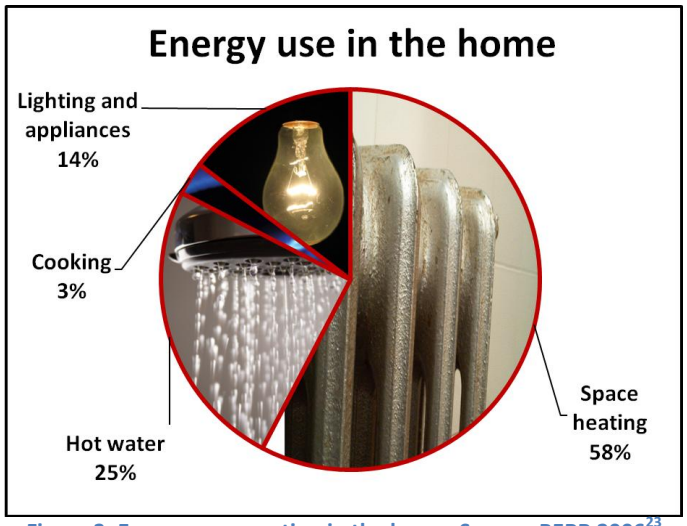


Figure 3: Energy consumption in the home. Source: BERR 2006[23]

This section explains the assumptions made in calculating the energy and carbon values for hot water use in the home and how this will be applied to Phase 2 of the Evidence Base for Large-scale Water Efficiency in Homes. It is important that these figures are taken as estimates, as there are many variables - such as the age and type of heating system, water pressure, and time of year - which will affect how much energy and water is used in each case.

[23] Values calculated from BERR statistics on domestic energy consumption by end use, located at *stats.**berr**.gov.uk/**energy**stats/ecuk3_6.xls,* accessed 13/11/08

5.2 Summary

This section describes the method used to calculate the energy and carbon emissions saved when water consumption is reduced due to a water efficiency retrofitting project. The process starts at Step 1 with estimating the temperatures at which water is supplied to the property, the temperature that it leaves the boiler and the use temperature in baths, taps and showers. Defining these temperatures allows the ratio of hot to cold water which is necessary to deliver water at the required temperature. There are different ratios for baths as opposed to showers and taps because the use temperature is usually higher in baths.

In Step 2, knowing the ratio of hot to cold water allows the calculation of the amount of hot water required and the amount of energy necessary to heat a litre of water to be used in the home. This required energy assumes 100% efficiency so heat source efficiencies are applied in Step 3 to determine the actual amount of energy required. In Step 4 the energy required is then expressed in kilowatt hours and carbon factors (which convert kWh to $kgCO_2$) can be applied which help determine the carbon emissions created as a result of production of that energy.

At the next stage (Step 5), the per-litre energy requirement (for heating water) and carbon emissions can be calculated. The results of these calculations are presented in Table 6. The final step involves using disaggregation of the water savings to determine how much of the measured savings from a trial are hot water savings (e.g. from showers) as opposed to cold water (e.g. from toilets). The energy and carbon emissions saved are determined by multiplying the per-litre values in Table 6 by the disaggregated water savings.

FOR GAS HOT WATER SYSTEMS

Litre type	Energy consumption (kWh)	Direct carbon emissions (Kg CO_2)	Indirect carbon emissions (Kg CO_2eq)
1 litre of hot water for taps and showers	0.039	0.0081	7.47×10^{-4}
1 litre of hot water for a bath	0.044	0.0097	7.47×10^{-4}
1 litre of cold water for indoor use	0.000	0.0000	7.47×10^{-4}
1 litre of cold water for outdoor use	0.000	0.0000	2.71×10^{-4}

FOR ELECTRICAL HOT WATER SYSTEMS

Litre type	Energy consumption (kWh)	Direct carbon emissions (Kg CO_2)	Indirect carbon emissions (Kg CO_2eq)
1 litre of hot water for taps and showers	0.031	0.0171	7.47×10^{-4}
1 litre of hot water for a bath	0.034	0.0191	7.47×10^{-4}
1 litre of cold water for indoor use	0.000	0.0000	7.47×10^{-4}
1 litre of cold water for outdoor use	0.000	0.0000	2.71×10^{-4}

Table 6- Per-litre values for energy and direct and embedded carbon emissions saving for both gas and electricity hot water systems

5.3 The Modelling Process

The modelling process is illustrated in Figure 4 and sections 5.3.1 to 5.3.6 describe the contents of the six boxes shown in the figure.

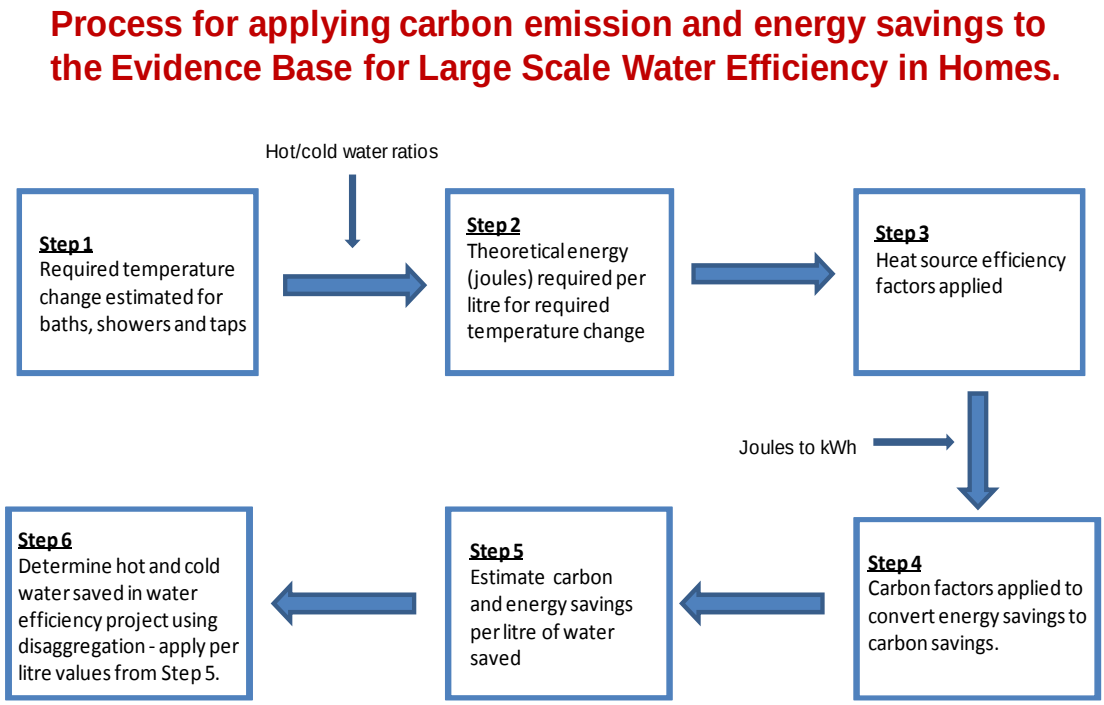


Figure 4 - Diagram of the modelling process

5.3.1 Step 1: Water temperature and hot and cold water mix ratios

The first step is to define the temperatures at which water enters the home, leaves the boilers and is used in bath, showers and baths. These are shown in Table 7.

Component	Value	Source
The temperature of cold water when it enters the home (Tc)	15C	Energy Saving Trust: Hot water study : to be published
The temperature an average boiler heats and delivers water at (Th)	51.9C	Energy Saving Trust: Hot water study : mean average of figures for combi-boilers (49.5C) and regular boilers (52.9C)
The temperature people typically choose for taps and showering (Ts)	41C	Energy Saving Trust: Hot water study : to be published
The temperature people typically choose for baths (Tb)	44C	Energy Saving Trust: Hot water study : to be published

Table 7: Water use-temperature assumptions

Once these temperatures are defined, it is assumed that the system is a closed system with no heat loss which enables the mix ratio of hot and cold water in taps, showers and baths to be determined. The principle used to calculate the mix temperature is, therefore, the following:

Ratio of hot vs cold water = change in cold water temperature / change in hot water temperature

This principle is applied using the temperatures from Table 7 in Equations 1 and 2 below.

For taps and showers: **Ratio = (Ts – Tc) / (Th-Ts)** **1**
For baths: **Ratio = (Tb – Tc) / (Th-Ts)** **2**

5.3.2 Step 2: Theoretical energy requirement

In order to calculate how much energy is needed to raise incoming cold water to the temperature at which it will be used in the home, a basic energy equation is used which takes into account the type of material being heated, how much of it is being heated, and by how much it is being heated. This defines the amount of energy necessary to produce a litre of hot water. The equation is given below.

$$\Delta Q = MC_p\Delta T \qquad 3$$

Where:
ΔQ= Heat /energy required (kJ), M = mass to be heated (kg), C_p = Specific heat capacity of water (kJ/(kg·K)), ΔT = Temperature rise required (K)

5.3.3 Step 3: Heat source efficiency factors

Because the calculation for the amount of energy needed to heat water is theoretical, it does not take into account that boilers are not 100% efficient. Hence the amount of energy actually needed to produce a litre of hot water will be more than calculated in equation 3. The type of fuel used to heat water will affect how efficient the process is, and how much carbon is used. Currently, the most common form of hot water heating is gas, followed by electricity.

Total energy required (Joules) = (theoretical energy required) / (% efficiency) **4**

The heating efficiencies are added to the energy value in the following way[24]:

	%age of UK currently using this heating fuel to heat their water	CERT heating efficiencies (predicted stock average for 2010)
Source BRE (2007)		
Gas	81%	78%
Oil	3%	82%
Electric	14%	100%
LPG	1%	72%
Solid	2%	55%

Table 8 – Breakdown of UK energy source use and CERT heating efficiencies for each fuel

5.3.4 Step 4: Carbon Factors

Once the energy required to heat the hot water has been calculated, carbon factors can be applied which define the amount of carbon emitted in producing that energy.

24 http://www.ofgem.gov.uk/Sustainability/Environment/EnergyEff/InfProjMngrs/Documents1/TM%20Guidance.pdf

The carbon emitted due to domestic water consumption can be divided into two components. One is related to the energy consumption and green house gas emissions **sourced from outside the home** for water and waste treatment and pumping. According to Defra's 'Guidance on how to measure and report your greenhouse gas emissions'[25], this type of emission would be categorised as **energy indirect.** The amount of carbon emitted due to energy indirect emissions is calculated using Table 9.

Embedded carbon factors	Tones CO_2eq / ML	Kg CO_2eq / ML	Kg CO_2eq / L
Tones carbon equivalent per 1ML water supply	0.271	271	2.71E-04
Tones carbon equivalent per 1ML waste treatment	0.476	476	4.76E-04
Tones carbon equivalent per ML supplied *and* waste treated			**7.47E-04**

Table 9: Embedded carbon figures for water supply and waste treatment. Source: Water UK (2009)[26]

The other component is related to the energy consumption and green house gas emissions **sourced from inside the home** for water heating. This type of emission would not be attributed to the water company as it does not result from water company activities, but from customer water use (hot and cold) in the home. In order to ensure that our treatment of carbon emissions is consistent with Defra's guidelines on carbon emissions reporting, a new type of emission '**domestic hot water emissions'** will be defined here. The relevant energy to carbon emission conversion factors for each fuel source is given in Table 10.

Energy Source	CO2 factor (kg CO2/kWh)
Gas	0.21
Oil	0.26
Electric	0.56
LPG	0.23
Solid	0.31
UK average	0.26

Table 10: Carbon weighting factors for various energy sources. Source: Defra (2008)[27]

The domestic hot water emissions due to hot water heating are those which are used to calculate personal carbon footprint, while the energy indirect emissions count towards the footprint of water companies. As Figure 3 shows, the majority of emissions will be from the domestic emissions component. The amount of carbon emitted as a result of heating domestic hot water can be calculated from the energy requirement using the figures in Table 10.

[25] Defra, 'Guidance on how to measure and report your greenhouse gas emissions', September 2009. Available at: http://www.defra.gov.uk/environment/business/reporting/pdf/ghg-guidance.pdf

[26] "Sustainability indicators 2006/7", Water UK (2007), available at: http://www.water.org.uk/home/policy/reports/sustainability/sustindicators06-07?s1=sustainability&s2=indicators&s3=2006%2F7%94%2C, accessed 13/11/08

[27] "Greenhouse gas (GHG) conversion factors for company reporting", Defra (2008), available at: http://www.defra.gov.uk/environment/business/envrp/conversion-factors.htm, accessed 13/11/08

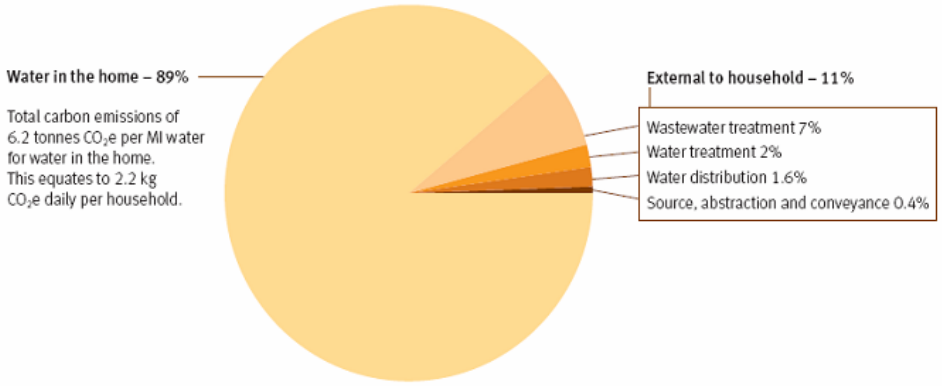


Figure 5: Carbon emissions attributable to domestic water consumption. Source: Environment Agency & Energy Saving Trust 2009[28]

5.3.5 Step 5: Per-litre Carbon and Energy Values

The steps described previously enable the basic per-litre values for energy and carbon emissions saved to be calculated. Table 6 gives the energy consumption, domestic hot water carbon emissions and energy indirect carbon emissions per-litre depending on whether hot or cold water is saved and whether the saving occurs from a bath or a tap or shower.

5.3.6 Step 6: Application of the per-litre Carbon and Energy Savings to Measured Water Savings

5.3.6.1 Estimating Carbon Emissions and Energy Savings from Water Savings

An important addition during Phase II of the Evidence Base Project will be that for each of the trials we will estimate carbon and energy savings which result from reduced water use in the home. The sections above have explained our approach to calculating the per-litre carbon and energy savings values.

This section considers how we apply the per-litre values for energy and carbon to the water savings which are measured from water efficiency trials and projects. However, in order to understand which per-litre values we should apply we need to understand the following:

1. Disaggregate the savings – we need to identify whether the water savings resulted from tap/shower use or bath use
2. Know the fuel source – it is essential to understand whether gas or electricity is used to heat water in the home that was retrofitted.

These two issues are discussed in further detail below.

5.3.7 Disaggregation of Water Savings

Where monitoring of water consumption is carried out during a water efficiency trial, it is normally measured through the water meter that is fitted for the whole house. It is therefore very difficult to

[28] "Briefing note: The greenhouse gas implications of future water resources options", Environment Agency (2008), available at: http://publications.environment-agency.gov.uk/pdf/GEHO0508BOBs-e-e.pdf?lang=_e, accessed 13/11/08

know what the discrete change is for individual water-using devices such as taps, showers and baths. However, what we can do is to apply the knowledge we have of microcomponents of water use in order to estimate, once overall water savings from a water efficiency trial are understood, the most likely distribution of these water savings amongst the retrofitted devices.

The Evidence Base will apply a consistent set of microcomponent assumptions across all its water efficiency trials. The microcomponent data which have been applied to date are given in Table 11 below. This will be updated as the Evidence Base Project progresses.

Retrofit Scenario	Assumed reduction in consumption (litres/property/day)	Source
Newly installed shower over a bath	73.9	Waterwise estimate - Preston Water Efficiency Initiative
Conversion of toilet to dual flush	30.0	Waterwise estimate - water company and ofwat estimates
Water efficient showerhead installed	25.2	Waterwise estimate - Essex and Suffolk Water H2eco water audits (2007), United Utilities Home Audit Project (2007), Yorkshire Water - Water Saving Trial (2008), South West Water - Water Efficiency Trial (2006)
Tap insert installed	0.9	Waterwise estimate - Evidence Base Phase II

Table 11 - Theoretical water savings calculated from microcomponent assumptions

For example, if 50 litres per property per day were saved in a water efficiency trial where toilets and taps were retrofitted across several properties, we could retrospectively estimate how much of the 50 litres saved each toilet and tap retrofit contributes based on microcomponent data.

Table 11 gives the device specific water saving assumptions that will be used to disaggregate the overall water savings from the trial. If we assume that the water savings were achieved by conversion of toilets to dual-flush (30.0 lpd theoretical saving) and the installation of water-efficient showerheads (25.2 lpd theoretical saving), the actual, measured 50 lpd would be disaggregated as follows:

- Theoretical overall saving = 30.0 +25.2 = 55.2 lpd
- Proportion of theoretical savings due to dual-flush retrofit = 30.0/55.2 = 0.54
- Proportion of theoretical savings due to installation of water-efficient showerhead = 25.2/55.2 = 0.46
- These proportions are then applied to the measured savings as follows:
- Disaggregated savings due to dual-flush toilet retrofit = 0.54 × 50 = 27 lpd
- Disaggregated savings due to showerhead retrofit = 0.46 × 50 = 23 lpd

This process enables the amount of hot water saved (23 lpd) and the amount of cold water saved (27 lpd) to be determined, to which the relevant per-litre carbon emission and energy savings values from Table 6 can be applied to calculate carbon and energy saved.

5.3.8 Knowing the Fuel Source

An understanding of the type of fuel (usually gas or electricity nowadays) that is used to heat water in the home is essential to ensuring the best possible estimate of carbon and energy savings. As

already mentioned in this report, electricity has a higher carbon weighting than gas (0.56 versus 0.21 $kgCO_2/kWh$) in the UK. Ideally, this type of information would be collected during the visit to each home so that we can easily understand the proportion of the water savings to attribute to each fuel source. If this information is not available then an estimate will be made based on the type of properties which were included in the trial.

5.3.9 Calculating the Carbon Emissions and Energy Savings Figure

Once we have carried out the two tasks - disaggregating the water savings and finding out whether gas or electricity is used to heat water in the homes visited - we can then apply the relevant figure from Table 6, by multiplying the disaggregated water savings for each of the devices by the relevant per-litre value for carbon emissions and energy savings.

5.4 Figures provided and reporting guidelines followed

5.4.1 Quotation format:

Source of figures: Figures provided by the model should be quoted as estimates; ***they are not projections, nor results of primary research.***

Figure formats: The calculator has been designed to report figures rounded to a level which we feel reflects the accuracy of the calculations. Reverting to finer resolution numbers will not be supported by Waterwise, as there is a risk of a false impression of increased accuracy. Details of the figure formats are provided in the Waterwise report : 'Carbon Emissions and Energy Savings from Water Efficiency' which can be found on the Waterwise website[29].

5.4.2 Data sources

Where figures derived from the Waterwise calculator are provided, the assumptions and sources for those assumptions outlined in this document must be clearly stated. In addition, assumptions on behavioural aspects such as frequency and duration of use must be stated.

[29] http://www.waterwise.org.uk/reducing_water_wastage_in_the_uk/research/publications.html

6 Analysis of Trial Results

Table 12 gives a summary of important results from the trials which are included in this report. To start this section description of what Table 12 contains will be given. Subsequently some further analysis of the results will be carried out in order to determine what can be learnt from the trials and projects in this report.

6.1 Description of contents of results table.

Uptake rate – the proportion of customers initially invited to take part in the project who participated in the project.

No of properties included in the trial/project – the total number of properties which were retrofitted or engaged as part of the trial or project

No. of properties for which data used in analysis – not all the properties included in the trials yielded consumption data which could be used to determine their pre and post-trial consumption. This may have been due to faulty meters or another possibility is that during the analysis of the data that some properties were removed because they were considered to be outliers.

Mean reduction in water consumption (litres/property/day) – the water savings, in litres per property per day, attributed to the longest monitoring period included in the trial.

Mean percentage reduction in water consumption (%) – the percentage reduction in water consumption attributed to the longest monitoring period included in the trial

Mean reduction in control group's consumption (l/prop/d) - if a control group was monitored as part of the trial the litre per property per day reduction in water consumption over the same period as the study group is shown in this column

Mean percentage reduction in control group's consumption (%) – if a control group was monitored as part of the trial the percentage reduction in water consumption over the same period as the study group is shown in this column.

Reduction in consumption incl background effects(lpd) – if a control group was monitored this is taken into account in this column by subtracting the change in background consumption in litres per property per day from the litre consumption change results from the main group.

Percentage reduction in consumption incl background effects (%)-if a control group was monitored this is taken into account in this column by subtracting the percentage change in background consumption from the percentage change in consumption results from the main group.

Probability of water saving (-) – the proportion of all the customers who participated in the trial/project who contributed to the savings. The higher the probability of saving water the less like it is that a few erroneously large savings have distorted the results.

Linear Regression - R2 values – the R^2 value represents the percentage of the variation in the outcome that can be explained by the model. This provides us with a good way of assessing whether there is a substantive relationship between the pre and post-trial consumption. This means that if R^2

is found to be 0.6, then the line of best fit describes 60% of the relationship between the two variables.

Cost per property (£) – this is the cost of retrofitting per property which includes only the costs that would be applicable to a large-scale retrofitting project. Hence costs, such as for monitoring, database upkeep and other aspects which would not apply if the trial was scaled up, have been removed before reporting this figure.

Cost per litre/ day (£) – the cost per property divided by the water savings in litres per property per day. This is not comparable with the average incremental cost but can be used as a simple measure to compare different approaches to trials/projects.

Energy indirect - carbon savings (kgCO2e/day) – this describes the green house gas emissions saved from reduced water consumption, converted into a carbon dioxide equivalent quantity, that is sourced from outside the home for water and waste treatment and pumping.

Domestic hot water - carbon savings (kgCO2/day) – this is the carbon dioxide emissions sourced from inside the home for water heating, which are saved due to reduced water consumption due to retrofitting.

Average carbon savings per property (kgCO2/day) – The combined amount of energy indirect and domestic hot water carbon dioxide emissions which are saved per property as a result of water savings

Domestic energy saving (kWh/day) – the energy saved due to reduced hot water consumption in the home as a result of the water efficiency trial

Cost of energy saved (£/prop/yr) – the domestic energy saving is monetised for each trial using the cost of energy production per kWh

Weighted central value of carbon saved (£/tCO2e) - the value of carbon which are applied to cost benefit analysis in a water efficiency trial depends on the proportion of carbon emissions which fall into the energy indirect carbon savings (traded) and the domestic hot water carbon savings (non-traded), as these are valued differently (i.e. for 2010 traded carbon emissions are valued at 22 pounds per tCO_2e and non-traded carbon emissions are valued at 52 pounds per tCO_2e - see section 4.5.5.6)

Project Name	Project Type	Type of device installed	Uptake rate (%)	No. of properties included in the trial/project	No. of properties for which data used in analysis	Mean reducton in water consumption (l/prop/d)	Mean percentage reduction in water consumption (%)	Mean reduction in control group's consumption (l/prop/d)	Mean percentage reduction in control group's consumption (%)	Reduction in consumption incl background effects(lpd)	Percentage reduction in consumption incl background effects(%)	Probability of water saving (-)	Linear Regression - R^2 values	Cost per property (£)	Cost per litre/property/day (£)	Energy indirect - carbon savings ($kgCO_2$/day)	Domestic hot water - carbon savings ($kgCO_2$/day)	Average carbon savings per property ($kgCO_2$/day)	Domestic energy saving (kWh/day)	Cost of energy saved (£/prop/yr)	Weighted central value of carbon saved (£/tCO2e)
Preston Water Effiiciency Initiative	SH Rtr, Rfb	T, D, L	60	205	189	64.4	13.9	NM	NM	-	-	0.78	N/A	202.0	2.2	9.1	16.7	0.137	238.2	29.3	41.4
Wessex Water WET	SH Rtr	D	45	156	103	33.9	6.6	0.9	0.3	33.0	6.3	0.77	N/A	49.0	1.6	2.7	0.4	0.031	2.3	1.3	26.2
South West WET ***	Gen Rtr	D,C, S, R	22	430	198	-10.8	-4.2	-16.7	-6.5	5.9	2.3	0.58	0.77	197.8	21.8	1.6	8.0	0.049	41.8	13.8	47.0
United Utilities Home Audit Trial	Gen Rtr	D,C, S	9	393	211	20.6	6.8	NM	NM	-	-	0.67	0.67	141.9	6.9	3.3	16.1	0.092	85.4	23.6	46.9
Anglian Water Ipswich Area WEM Trial	Gen Rtr	D, C, S, R	10	1000	552	41.5	14.2	NM	NM	-	-	0.78	0.69	40.8	1.0	17.1	86.2	0.187	418.3	44.3	47.0
Thames Water MVF Trial	Gen Rtr	D, C, S, R	9	1274	727	29.1	7.9	-1.8	-2.2	30.9	10.1	0.69	0.70	240.0	8.2	15.5	78.1	0.129	415.2	33.3	47.0
Yorkshire Water WET	Gen Rtr	D, C, S, R	20	500	378	27.6	8.4	9.5	1.1	18.1	7.3	0.74	0.80	220.2	8.0	8.0	39.2	0.125	190.5	29.4	46.9
Severn Trent Domestic WET	Gen Rtr	D, C, S, R	9	933	717	28.4	8.7	NM	NM	-	-	0.65	0.75	74.1	2.6	15.3	76.7	0.128	400.0	32.6	47.0
Thames Water Self-Audit	SA Rtr	C,S,R	6	980	525	21.9	1.2	NM	NM	-	-	0.54	0.64	110.0	5.0	9.9	13.1	0.044	76.0	8.4	39.1

Key - SH - Social Housing; Rtr - Retrofit; Rfb - Refurbishment; Gen - General; Rtr - Retrofit; SA - self audit; T - New toilets; D - Dual flush conversion device; C - Cistern displacement device; S - Showers; R - Tap inserts, regulators, restrictors and spray taps; L - repair of leaky taps; NM - not measured, N/A - not applicable;
*** This trial was carried out at a time of drought which may have significantly affected the water savings achieved (see section 7.3 for fuller account of SWW WET)

Table 12 - Summary of results from the water efficiency projects in the Evidence Base Phase II report

6.2 Uptake rates

The results show a range of between 6% and 22% for uptake rates carried out in general housing stock, whilst, for social housing significantly higher uptake rates of between 45% and 60% have been achieved. The higher level of participation of tenants in social housing has been put down to:

⇒ Credibility – residents are familiar with the body offering the retrofit
⇒ Visibility – communications are more visible, e.g. retrofits are advertised through the social housing provider's newsletter and residents are more likely to open letters from the social housing provider.

Therefore the involvement of the housing association in the planning, facilitation and execution of water efficiency retrofitting projects in social housing is fundamental to their success in achieving a high uptake rates.

6.3 Water savings

The trials have taught us the following about water savings from water efficiency retrofitting trials:

⇒ Measured water savings of up to 34 litres per property per day are possible from applying a multi-measure water efficiency retrofitting method in the traditional way, using current technology and means of engaging customers to encourage behaviour change.

⇒ Anglian Water's Ipswich Area WEM trials resulted in savings of 41.5 lpd, which is the highest reduction in consumption of all the trials. There is a possibility that the fact that this WEM trial was carried out alongside a metering installation programme in the Ipswich area enhanced the results. Customers were made aware of their consumption and how much they could save by opting to be charged via a water meter, and this may have led to significant change in water-using behaviour.

⇒ Different customers react in widely varying ways after agreeing to be part of water company-led water efficiency retrofitting projects, which results in a broad distribution of water savings. There are some customers who are receptive to being engaged on water efficiency and others how are not at all. However work that has been carried out to present the distribution of water savings shows that there is predictable structure. The proportion of customers that save water in the majority of multi-measure visit and fix projects is between 65% and 78%. This can give those planning future projects confidence that they know what can be achieved.

⇒ Not only do the two social housing projects, the Preston Water Efficiency Initiative and Wessex Water WET, achieve higher uptake than projects in general stock but they also seem to be successful at encouraging those who take part in the projects to save water. The two projects achieved probabilities of saving water of 0.78 and 0.77.

⇒ The Preston Water Efficiency Initiative shows significant water savings, with mean savings of 64 litres per property per day. This result can be viewed as useful evidence that there are significantly higher savings that can be made through refurbishment of water-using devices such as toilets, showers and taps.

⇒ Four out of the nine trials included monitoring of a control group alongside the main study group. These four trials each show a reduction in water consumption after taking into account

background effects, but to varying degrees. South West Water's WET showed an increase in consumption in both the study and control group, but the relative change resulted in a net decrease in consumption of 5.9 lpd. In the cases of Wessex Water WET, Thames Water MVF trial and Yorkshire Water WST, there were appreciable net reductions in consumption of 33.0, 30.9 and 18.1 lpd respectively. Ideally, in the future it will be possible to fill in the gaps in Table 12 by making use of historical billing data from the areas of interest.

6.4 Costs

The projects show wide variation in the cost of retrofitting per property, which ranges from £41 to £240 per property. Anglian Water's Ipswich Area WEM trial achieved the lowest cost per property and one of the reasons for this was that the trial was carried out alongside the Ipswich area metering programme. Wessex Water's WET, carried out in partnership with a social housing provider, achieved a cost of £49.

The cost per litre per day figures provide a means of comparing the relative cost-effectiveness of the different approaches to saving water reflected in the trial. The same two trials are found to be the most cost effective. This corroborates the assertion made in the October 2008 Evidence Base report that the most cost effective ways of delivering large-scale water efficiency is currently through a water company piggybacking retrofitting on other internal activities or through partnership with social housing.

Some of the factors which lead to wide variation in the cost are:

- → Number and type of product installed in properties
- → Different levels of engaging with customers employed
- → Number of visits that the contractor could make each day, which is affected by the geographical spread of properties , traffic disruption and the ease of dealing with customers.
- → Whether additional services such as leakage detection and fixing of leaking taps were offered

6.5 Carbon Emissions and Energy Savings

Table 12 shows that there is a range of between 0.031 and 0.187 $kgCO_2e$/property /day of carbon emissions saving as a result of the water efficiency retrofitting projects included in this report. Also visible in the Table 12 is that the cost of energy saved in the trials ranges from 1.3 to 44.3 £/property/year. Both carbon emissions and energy savings are dependent on the extent to which hot water was targeted during a trial. Trials which did not target showering or bath use will show very small energy savings. However, this assessment shows that there are significant carbon and energy benefits to be gained from water efficiency retrofitting.

6.6 Linear Regression

Linear regression provides a useful tool to provide further insight into the performance of water efficiency projects. The R^2 value gives an indication of how well the model described by the straight line through the data points describes the relationship between pre and post-trial consumption. It can be seen in the blue section of Table 12 that R^2 for the trials in this report varies from 0.64 to 0.80. This tells us that the use of linear regression is useful as it describes between 64% and 80% of the relationship between pre-trial and post-trial consumption.

Table 13 presents a summary of the characteristic equations generated from the water efficiency trial data in this Evidence Base Phase II report. These equations could be useful for water companies planning water efficiency trials in the future because it allows us to estimate the likely impact of applying similarly approaches as were employed during these trials.

Water Efficiency Trial	Characteristic Equation for Trial	Consumption above which not meeting 130 l/hd/day ambition
South West Water - Water Efficiency Trial	$PostMDC2 = 0.96PreMDC + 3$	309
United Utilities Home Audit Project	$PostMDC = 0.92PreMDC$	339
Anglian Water Ipswich Area WEMs Trial	$Post\ MDC = 0.77Pre\ MDC + 20$	380
Thames Water Measured Visit and Fix Trial	$PostMDC = 0.77PreMDC + 38$	355
Yorkshire Water - Water Saving Trial	$Post\ MDC = 0.81 \times Pre\ MDC + 23$	356
Severn Trent Water Domestic Water Efficiency Trial	$PostMDC = 0.78PreMDC + 25$	368

Table 13 - Summary of the characteristic equations generated from water efficiency trial consumption data and consumption levels at risk of not meeting the 130 lpd ambition

In addition Table 13 presents the consumption levels which are at risk of not meeting the government's 130 lpd ambition using current retrofitting methods. This shows us that using our current methods alone, it is unlikely that households consuming 350 - 400 litres per day or more will be able to reduce their consumption sufficiently. More effective methods of encouraging customers to reduce their consumption will have to be found, and in particular, targeting higher consumers. New water-using technologies could play a part in helping to drive down consumption, but it is likely that significant behaviour change will also be necessary, whichever technologies are employed.

6.7 Comparison of actual and theoretical water savings

Some estimates of savings for individual water-efficient measures, that might be used to estimate the water savings from planned trials in Water Resource Management Plans, were compared with the measured savings from the nine trials in this report. It was found that if comparison from trials was viewed across the entire trial population, there was good agreement between the estimates with the measured values from the trials. The estimated device water savings values that were used are given in Table 14.

Retrofit Measure	Assumed reduction in consumption (litres/property/day)	Source
Newly-installed shower over a bath	73.9	Waterwise estimate - Preston Water Efficiency Initiative(2008)
Conversion of toilet dual flush	30.0	Waterwise estimate from Ofwat Good Practice Register and water company values
Water-efficient showerhead installed	25.2	Essex and Suffolk Water H2eco water audits (2007), United Utilities Home Audit Project (2007), Yorkshire Water - Water Saving Trial (2008), South West Water - Water Efficiency Trial (2006)
Tap Insert Retrofit	0.9	Waterwise estimate - Water Company estimates from the October 2008 Evidence Base report

Table 14- Theoretical water savings calculated from microcomponent assumptions

For the 8 trials for which the comparison was carried out, it was found that the actual and theoretical savings for 6 trials resulted in the theoretical savings overestimating the water savings by 2 to 17 litres per property per day. The mean difference between actual and theoretical savings is -4 lpd (which means that the theoretical savings overestimate actual savings by on average 4 lpd). There are two trials for which the actual savings exceeded the theoretical savings: in these cases there the actual savings were 5 lpd and 6 lpd greater than theoretical savings.

The reason for the range of differences in actual and theoretical savings could be:

⇒ Impact of background changes in demand – although this has not expressly been investigated here, where a control group data is available, this would not significantly change the picture presented here about the scale of the discrepancy in values.

⇒ Differences in approach to retrofitting – some companies focus on installing two or three products whereas others offer consumers a basket of measures. There may be a relationship between the number of devices installed and the ease with which we are able to estimate the likely effectiveness of devices at saving water. This is something we that we can look at further in a future Evidence Base report.

⇒ There are differing approaches to engagement with customers who take part in water efficiency projects which may have an impact on the success of project at saving water.

Overall this comparison has shown that the figures in Table 14 do a reasonable job of estimating savings from the trials. There are several areas which need further research and among those is the relative effective of single measures compared to applying a basket of measures in a water efficiency trial, and understanding combinations of devices which are most effective.

Water Efficiency Project	No. of Properties with Robust Data available	Theoretical vs Actual Water Savings (lpd)
Wessex Water - Water Efficiency Trial	156 (22 meters)	-5
Sutton and East Surrey Water – Preston Water Efficiency Initiative	160 (39 meters)	2
South West Water - Water Efficiency Trial	199	15
United Utilities Home Audit Study	274	5
Anglian Water Ipswich Trial	552	-6
Thames Water Measured Visit and Fix Trial	727	2
Yorkshire Water - Water Efficiency Trial	306	2
Severn Trent Domestic Water Efficiency Trial	717	17

N.B. Positive values denote that theoretical savings overestimating the measured water savings

Table 15 - Summary of the Analysis of Actual versus Theoretical Water Savings

7 The Evidence

The Methodology described in the Chapter 4 was applied to the water efficiency trials and projects as presented in this section. The results presented here are further analysed to extract the key learning points in the Chapter 6. This section covers nine water company-led water efficiency trials.

7.1 Preston Water Efficiency Initiative

7.1.1 Summary

The project was initiated and coordinated by Reigate and Banstead Borough Council with funding from the Government's New Growth Points Programme, and was delivered in partnership with Raven Housing Trust, Sutton and East Surrey Water, the Environment Agency, Surrey County Council and Waterwise. The initiative was undertaken in Preston, Surrey, and had a number of components. Firstly, refurbishment was carried out on 160 dwellings within social housing as part of an enhanced Decent Homes programme. This included the installation of:

⇒ Dual-flush toilets: the toilet flushed with 4 litres for the full flush and 2.6 litres for the short flush

⇒ Water-efficient showers and shower curtains: where houses or flats had a combination boiler, a mixer shower was installed

⇒ Water butts: tenants with gardens were also offered a water butt kit. The kit that was selected was manufactured by Blackwall from recycled materials

Secondly, retrofitting of water efficiency devices was carried out on 205 properties within social housing that was not part of the Decent Homes programme. The package of retrofitted measures included toilets, taps, wasted water and leakage and garden watering.

It was originally estimated that 340 dwellings would receive a retrofit; however, at the end of the trial 205 properties had received a retrofit. This was mainly due to difficulties in contacting and accessing these properties rather than the residents refusing to have the devices fitted. Other activities included the installation of a pilot rainwater harvesting system to a block of twelve flats, which also received a bathroom refurbishment. This part of the project did not produce the expected water savings and was costly due to problems with equipment. Hence the water savings from this part of the project have not been presented here. In addition water efficiency devices were fitted in a school and leisure centre, including urinal controls, push taps and new dual-flush toilets. A promotional and awareness campaign, including outreach work, information leaflets, giveaways and discount vouchers was also part of the project.

7.1.2 Results

7.1.2.1 Analysis of water savings

Table 16 shows the results of the Preston Water Efficiency Initiative. Water savings of about 14% resulted from carrying out retrofitting and refurbishment in social housing. Although control groups were monitored as part of the trial design, the data were not considered to be reliable enough to form part of the trial results. Hence the water savings presented here do not take account of underlying changes in the demand for water, which should be taken into account if we are to assess the impact of the water efficiency trial, distinct from external factors. This has an influence on the level of uncertainty associated with the water savings results. Wessex Water carried out a water efficiency trial in social housing for which they measured a 0.3% reduction in a control group's water

consumption so this shows that, even with a small underlying change in consumption, all the observed change may not be able to be attributed to the water efficiency intervention.

Preston Water Efficiency Initiative

	Retrofit	Refurbishment	Overall
No. of properties	121	68	189
Water savings (l/prop/day)	50	90	64.4
Water savings (% reduction)	12.6	15.3	13.9

	Max	Min
90% Confidence interval (% water saved)	43	-17
90% Confidence interval (litres/prop/day saved)	185	-80

Probability of water savings	0.78

Uptake rate (%)	60

	Retrofit	Refurbishment
Cost per property(£)	202	1386
Cost per litre per day (£)	2.24	27.72

	Retrofit	Refurbishment	Overall
Energy indirect carbon emissions saved (kgCO2e/d)	4.5	4.6	9.1
Domestic hot water carbon emissions saved (kgCO2/d)	0.7	16.0	16.7
Energy saving (kWh/d)	3.6	234.6	238.2
Cost of energy saved (£/year)	209.7	5336.8	5546.5
Cost of energy saved (£/prop/year)	2	78	29

Table 16 - Summary of key results from the Preston Water Efficiency Initiative

The confidence interval for water savings in the Preston Water Efficiency Initiative is given in Table 16. This should be viewed in the context of Figure 6, which illustrates the distribution of water savings amongst the properties included in the trials. The results are clearly skewed towards the right which represents a reduction in water consumption. Roughly 75% of properties (or meters that were monitored in the case of groups of properties) included in the trial achieved water savings of 5% of more. Also, approximately 43% of properties showed a reduction in water consumption of 15% or greater.

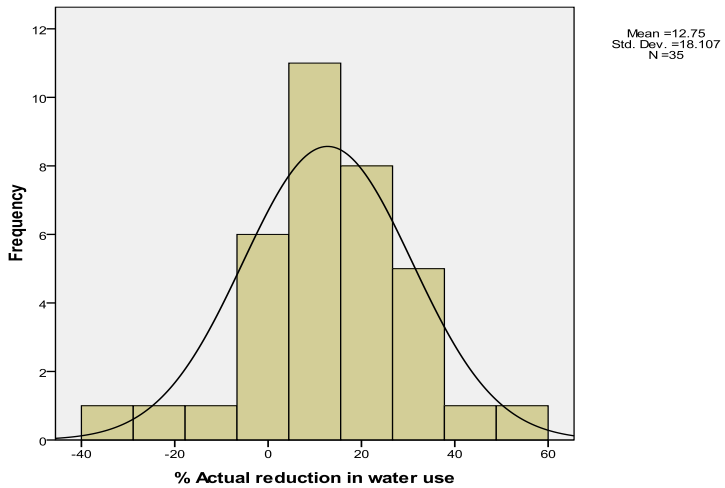


Figure 6 - Distribution of water savings from the Preston Water Efficiency Initiative

7.1.2.2 Linear Regression

The design of this trial, with properties being monitored in blocks in small areas and individual properties, meant that there were not sufficient individual property meter readings to be able to use the linear regression approach to generalising the results.

7.1.2.3 Control Groups

160 properties were included in this trial but none of these was designated part of a control group.

7.1.2.4 Comparison with Microcomponent Data

Figure 7 below shows the comparison between actual water savings and theoretical savings for small area monitored properties in the Preston Project. For refurbished properties the theoretical water saving from installation of a dual-flush toilet was estimated at 30 litres/property/day and the theoretical saving from installing a shower over a bath at 73.92 litres/property/day. For retrofitted properties the theoretical saving from a conversion of a toilet to dual-flush was estimated at 30 litres/property/day and for taps, an average saving of 0.47 litres/day per tap for one cold tap and one hot tap.

For each of the blocks which showed appreciable water savings, the actual water savings exceeded the theoretical. The small area monitoring (SAM) zones of Waterfield and Pitwood were refurbished properties, whereas those in Watermead, Allum and Preston were retrofitted. For Waterfield there were significant water savings of about 14% and for Pitwood there was a small increase in consumption. Retrofitting in the SAMs seems to have been similarly as successful in saving water as refurbishment, which is contrary both to what might be expected and to what was seen in this trial as a whole. It would be interesting to understand the factors that may have led to this during the project execution, or in customer attitudes.

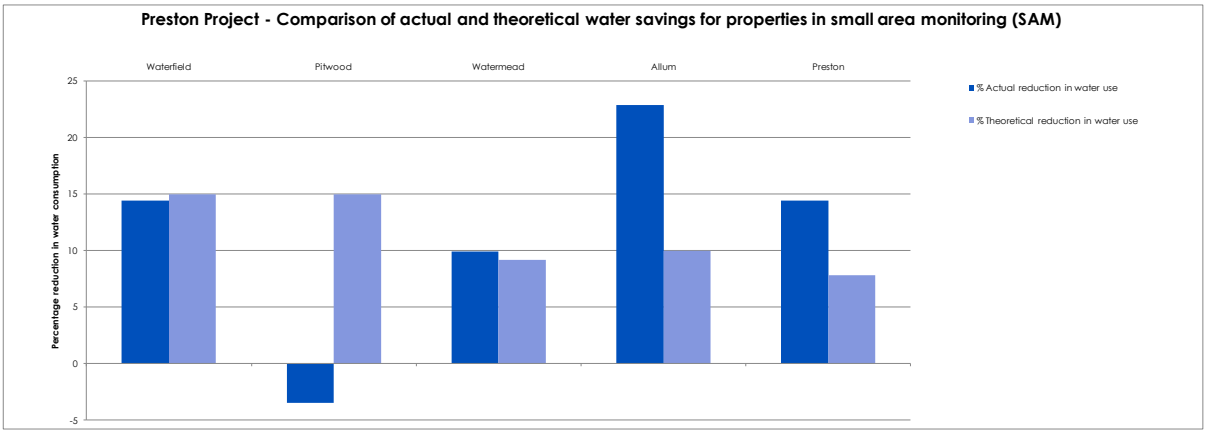


Figure 7 - Comparison of actual percentage reduction in water use with the theoretical reduction for small areas monitored in the Preston Project

For the blocks of flats, Alnod and Merton, the theoretical reduction in water use was significantly greater than what was actually realised. The contrary was true for Merefield and Southwark where actual savings exceeded theoretical savings. Overall the results show that the savings achieved in practice are slightly less than expected from calculating savings from microcomponent data.

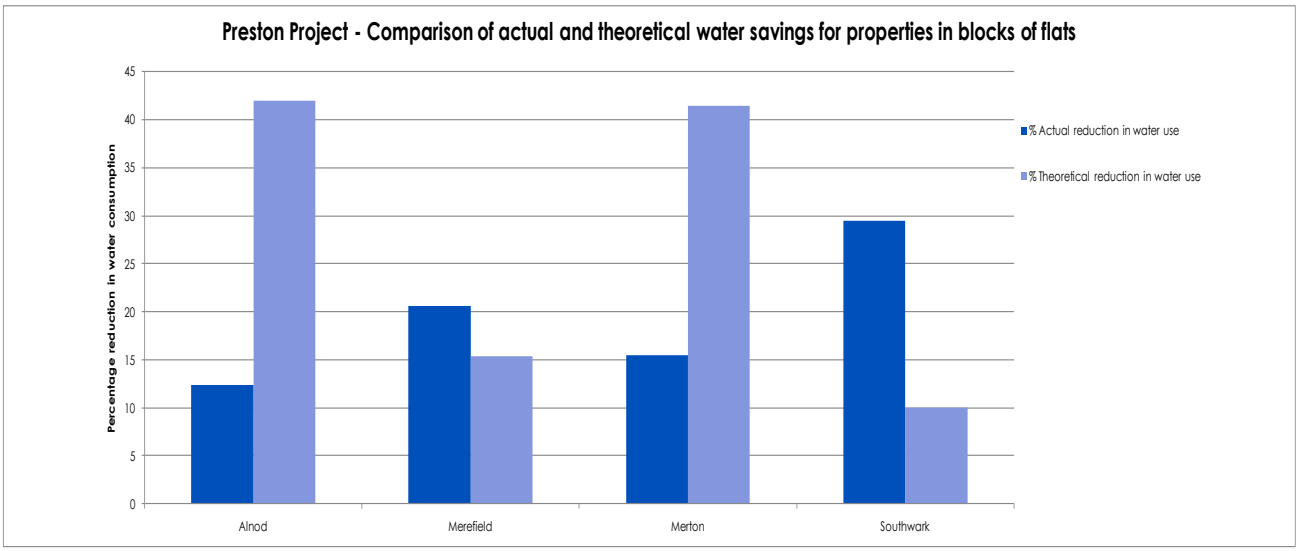


Figure 8 - Comparison of actual percentage reduction in water use with the theoretical reduction for blocks of flats monitored in the Preston Project

7.1.2.5 Estimated Carbon Emissions and Energy Savings

The Preston project resulted in significant savings in carbon emissions and energy. In terms of retrofit, carbon emissions were reduced by 4.52 $kgCO_2e$/day (energy indirect emissions) or 0.89 $kgCO_2$/day (domestic hot water emissions) and 3.86 kWh/day of energy are also estimated to have been saved for all of the properties included in the trial. These savings were significantly greater where refurbishment was carried out, essentially because of the potential for replacing bath use with shower use. The properties which were refurbished were estimated to have saved 4.57 $kgCO_2e$/day of energy indirect emissions, 8.96 $kgCO_2$/day in domestic hot water emissions and 265.15 kWh/day of energy. These are significant savings, which result primarily from the hot water saved as a result of installing a shower over a bath. When the energy saved as part of this trial is monetised, it amounts overall to £5547. This demonstrates that water efficiency retrofitting can result in several social benefits, including lower energy bills for the customers, savings on water bills and a lower carbon footprint.

7.2 Wessex Water - Water Efficiency Trial

7.2.1 Summary

In 2008/2009 Wessex Water undertook a water efficiency trial in conjunction with Somer Community Housing Trust (SCHT), the Environment Agency and Resource Futures. This trial was the second water efficiency trial carried out in partnership with housing associations. The trial involved assessing the uptake, effectiveness and costs of different water efficiency interventions in 24 blocks, containing 156 social housing flats, in Bath. The blocks were split into four groups: device installation, engagement (education) visits, device and engagement, and control (no interventions).

The plumbers were asked to inform the residents for whom they were fitting devices for Somer Community Housing Trust to save water. Where the residents consented to this, the plumbers were advised to fit an EcoBETA where suitable and a *Save a Flush* cistern displacement device where not. Where dripping taps were found, the plumbers were instructed to replace washers where possible. The installation of devices took place in October 2008. It was agreed that the plumbers would make up to three visits to each flat to install the devices. The engagement interventions were led by Resource Futures. A wide range of activities for water efficiency promotion were appraised including pub quizzes, a tour of a water treatment works, children's education days and a travelling information centre. The final assortment of engagement activities were selected on the basis of whether SCHT felt that residents would be receptive to them and whether the activities could realistically be undertaken by water companies in the future.

Water use in each block was monitored before and after the interventions using meters and data loggers programmed to record flow at 5-minute intervals. Uptake rates for the interventions were high. 70 flats (45% of the properties) targeted for device interventions had EcoBETA dual-flush devices retrofitted and 78 householders (50%) in the flats targeted for engagement activities participated in discussions about water efficiency in their home. The trial included a *Water Saving Day* in a village hall which was organised as part of the educational interventions, but attendance was very low (two attendees from 156 invitations to the event).

The data used in the original report has been re-analysed in order to apply a consistent cleansing method to each of the trials in the Evidence Base. This may lead to small differences between results shown here and those in the original trial report produced by Wessex Water.

7.2.2 Results

7.2.2.1 Analysis of water savings

Table 17 shows the key findings from the Wessex Water - Water Efficiency Trial. This trial delivered remarkable water savings in the three different activities that were undertaken. Furthermore, a control group was monitored during this trial which allowed the results from the trial to be adjusted to take into account external factors which influence water demand. The combined device installation and engagement part of the trial resulted in savings of 9.1% compared to 6.2% when device installation was carried out alone and 6.3% when customers were engaged with water efficiency messages and tips. The results provide evidence to suggest that the most effective way to reduce water consumption is through combined device installation and customer engagement.

Wessex Water Water Efficiency Trial

	Retrofit	Retrofit and Engagement	Engagement	Overall
No. of properties	37	33	33	103
Water savings (l/prop/day)	35.8	34.5	31.2	33.92
Water savings (% reduction)	6.2	9.1	6.3	6.3

	Max	Min
90% Confidence interval (% water saved)	18.1	-3.6
90% Confidence interval (litres saved/property per day)	44.1	-22.5

	Overall
Probability of water savings	0.77

	Retrofit	Engagement
Uptake rate (%)	45	50

	Retrofit	Retrofit and Engagement	Engagement	Overall
Cost per property(£)	29.00	70.04	50.54	49.05
Cost per litre per day (£)	0.81	2.03	1.62	1.57

Energy indirect carbon emissions saved (kgCO2e/d)	2.72
Domestic hot water carbon emissions saved (kgCO2/d)	0.44
Energy saving (kWh/d)	2.32
Cost of energy saved (£/year)	135.43
Cost of energy saved (£/prop/year)	1.31

Table 17 – summary of key results from the Wessex Water WET

Figure 9 shows the water savings across the full range of properties targeted as part of the water efficiency trial. In all but two of the blocks of flats included in this trial there was a significant reduction in water consumption observed (between 2.4% and 13.8% reduction). The results show that Wessex Water managed to deliver remarkably consistent water savings in this trial. One interesting outcome is the fact that a higher overall reduction in water savings was observed for properties where only engagement was carried out compared to properties where only devices were installed. This demonstrates that customers can be influenced to change their water use behaviours if they are engaged in the right way.

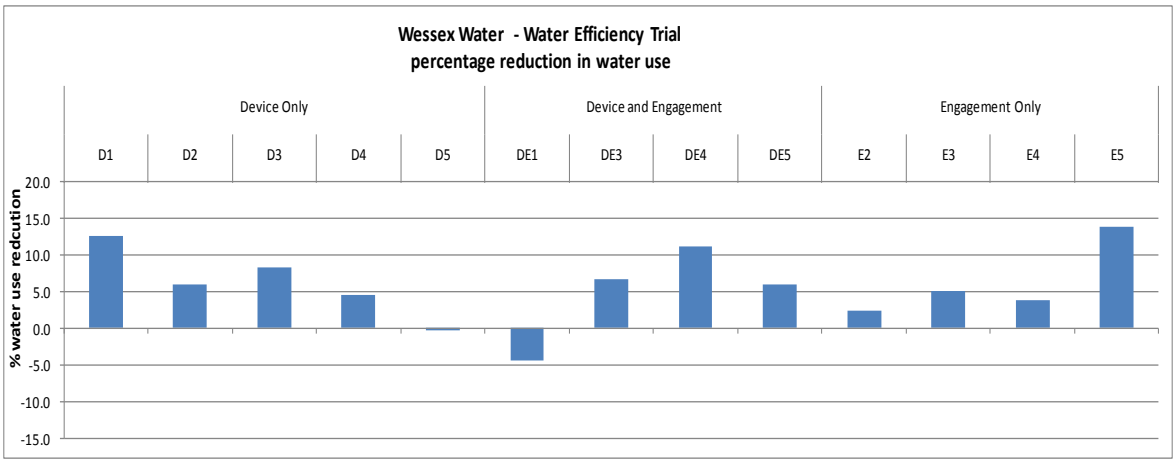


Figure 9 - water use reduction from each block targeted in the Wessex Water WET by type of intervention

7.2.2.2 Linear Regression

The design of this trial, with properties being monitored in blocks, meant that it was not possible to measure before and after trial water consumption for properties on an individual basis. For this reason linear regression was not employed on the Wessex Water trial.

7.2.2.3 Control groups

A control group consisting of eight blocks of flats was maintained during this trial. Three blocks in the control group exhibited reductions in water use over the same period and overall changes varied between -4% and + 11.9% with a small overall reduction of 0.3% in consumption in the control group. In contrast, there was a reduction in consumption in 12 of the 13 blocks which were part of the study group.

7.2.2.4 Comparison with Microcomponent Data

Figure 10 shows that, where devices were installed with no engagement, the water savings achieved were very close to the measured water savings except for the case of D5. Where device installation and engagement were carried out together there was still broad agreement in 3 of the blocks. In the case of DE1 an increase in consumption of about 4% was observed, versus a theoretical decrease of roughly 11%. For DE2, the theoretical saving of 12% was vastly exceeded by an actual saving of 26%. Some possible reasons for the differences between the actual and theoretical savings are:

- → There were differences in the degree to which customer behaviour has been influenced by device installation and engagement and the factors governing this are not yet fully understood
- → Changes in occupancy levels throughout the monitoring period may have affected data reliability

Figure 10 compares the actual water savings achieved in blocks where a dual-flush conversion device and repair of leaking taps was carried out with the theoretical savings. The assumptions used are an average saving of 30 litres/prop/day for the installation of an EcoBETA and an average saving of 0.47 litres/day per tap that had a leak repaired.

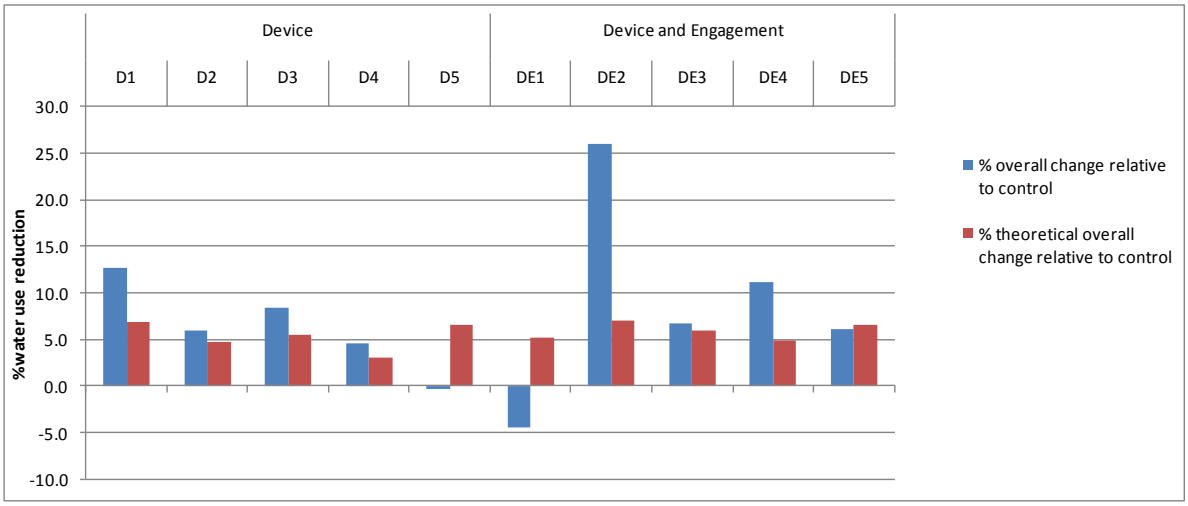


Figure 10 - Comparison of actual water use reduction for different blocks targeted in the Wessex WET with water savings calculated using microcomponents of water use.

7.2.2.5 Estimated Carbon Emissions and Energy Savings

The carbon savings from this project have been estimated at 2.6 $kgCO_2e$/day (energy indirect carbon emissions)and 0.4 $kgCO_2$/day (domestic hot water carbon emissions). Across the 103 properties, 2.3 kWh of energy a day was saved as a result of this intervention. The cost of energy saved on annual basis for the properties retrofitted as part of this trial is £135. The carbon emissions and energy savings from this trial are relatively low because of the fact that hot water use was not specifically targeted. If hot water had been targeted through bath and shower use been targeted then the likelihood is that the carbon and energy savings would have been significantly greater.

7.3 South West Water - Water Efficiency Trial

7.3.1 Summary

The South West Water - Water Efficiency Trial (WET) project involved measuring the effectiveness and costs of fitting a range of self-selected water efficiency devices to measured customers' houses. The trial was set up to measure the effect of a group of customer-selected water efficiency devices and not to measure the effectiveness of any individual device. Therefore the number of customers who selected just one (and the same) device is too small from which to draw statistically valid conclusions. However, comparison can be made between the relative effectiveness of different combinations of water-efficient devices.

The trial was centred in two urban areas: Barnstaple and Newton Abbot. Initially 6,000 customers were selected (3,000 in each area) for a mailshot; this was equivalent to 10 times the number required for the study. Customers who had a meter installed but were not recent meter optants were targeted. Devices installed as part of the trial and quantities of each installed are listed below.

	Device	Number installed
Group 1 - Toilets	Dudley Turbo 88 Retrofit replacement siphon	203
	Hippo Bag	92
	Save-a-flush bag	214
Group 2 – Showers	Challis aerated showerhead	137
	Mira low flow showerhead	99
	Sand Timer	39
	Star Sand Timer	46
	Digital timer	32
Group 3 - Taps	Miracle tap sprayer (kitchen mixer)	198
	Challis aerated tap inserts	102
	Tap Magic spray tap insert (version 1 – single	228
	Tap Magic spray tap insert (version 2 – dual flow)	32
	Restrictor Valve	6
Group 4		
Leakage	Leak Alarm	303
Garden	Spray Gun	325

During the planning for the trial it became clear that meter readings would represent a significant project cost and that savings could be achieved by minimising the distance needed to travel between meters. It was therefore decided to concentrate on urban rather than rural areas for the trials. The principle was to group the households into a relatively small area to enable minimum travel distances between households. But rather than concentrate the trial in one location, two areas were selected, both of which were representative of the SWW operational area. It was thought that this approach would enable any geographical factors affecting the trial to be identified. Hence two areas centred around Barnstaple and Newton Abbott were chosen for the trial.

A total of 430 customers were visited by the plumbers during the trial period with an average of 12 visits per week being achieved. The database holds 535 customers who were part of the trial. A total of 42 dropped out and 10 left incorrect/unobtainable phone numbers. 53 customers proved difficult to contact in the final 2 weeks and so were not included in the trial. Meter readings were collected prior to installation in December 2005, at device installation (January to April 2005) and then in February, May and September of 2006. SWW data was also available on historic meter reads.

7.3.2 Results

7.3.2.1 Analysis of water savings

Table 18 summaries the results from the South West Water - Water Efficiency Trial. The trial resulted in overall savings of 3.5% or 9.1 litres per property per day after 3 months. After 6 months the savings were measured to be 2.3% or 6.0 litres per property per day. However, in addition to determining how much water could be saved overall, this trial set out to understand the relative effectiveness of different devices and combinations of devices. In addition, the data collected enables comparison of water savings both 3 months and 6 months after the retrofitting was carried out.

South West Water - Water Efficiency Trial

No. of properties retrofitted	198	
	Overall - After 3 months	Overall - After 6 months
Water savings (l/prop/day)	9.1	6.0
Water savings (% reduction)	3.5	2.3
	Max	Min
90% Confidence interval (% water saved) after 3 months	30.2	-23.2
90% Confidence interval (% water saved) after 6 months	38.0	-33.4
90% Confidence interval (litres saved /prop/day) after 3 months	40.0	-21.8
90% Confidence interval (litres saved /prop/day) after 6 months	46.6	-34.7
	Overall - After 3 months	Overall - After 6 months
Probability of water savings	0.71	0.58
	Overall	
Uptake rate (%)	22	
Cost per property(£)	197.81	
Cost per litre per day (£)	21.82	
	Overall - After 3 months	Overall - After 6 months
Energy indirect carbon emissions saved (kgCO2e/d)	2.7	1.6
Domestic hot water carbon emissions saved (kgCO2/d)	13.4	8.0
Energy saving (kWh/d)	72.2	41.8
Cost of energy saved (£/year)	4738	2742
Cost of energy saved (£/prop/year)	24	14

*based on a combination of toilet, shower and tap retrofit.

Table 18 – Summary of key results from the South West Water WET

The histograms shown in Figures 11 and 12 show the distribution of water savings in litres per property per day and also on a percentage savings basis. These figures show that there were a majority of customers saving water. Three months after retrofit, 71% of properties had reduced their water consumption. Six months after retrofit this was recorded as lower, at 58%. The seemingly sharp reduction in savings between three and six months after retrofit is difficult to explain. There is no precedent for such a significant reduction in savings so soon after retrofitting has been carried out. Factors which might lead to marked increases in consumption between the first and the second measurements being taken after retrofit were considered and it is possible that the drought that affected the South West region during the period that the trial was carried out (2006) led to an increase in consumption which was unusual for this group of customers.

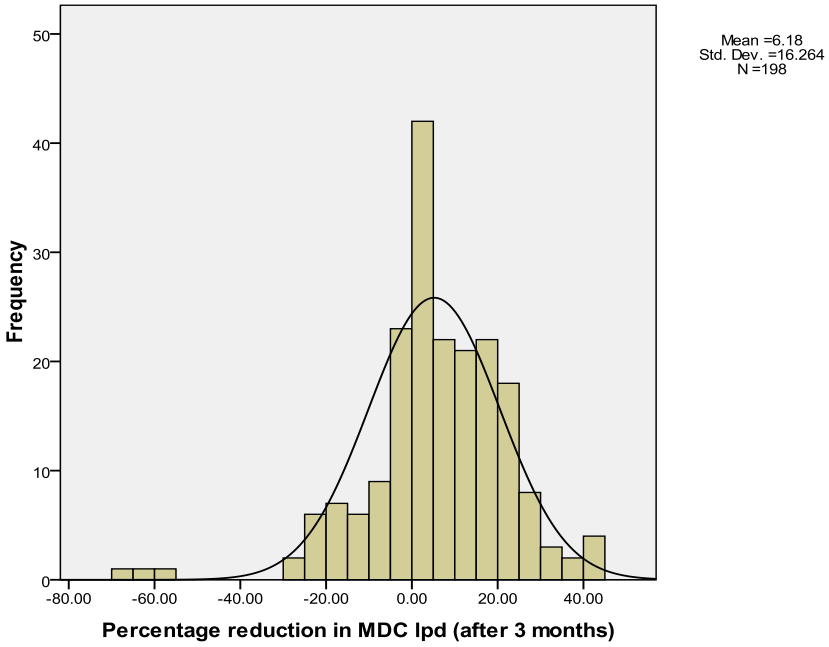


Figure 11 - Distribution of the percentage reduction in water use achieved in the South West Water WET.

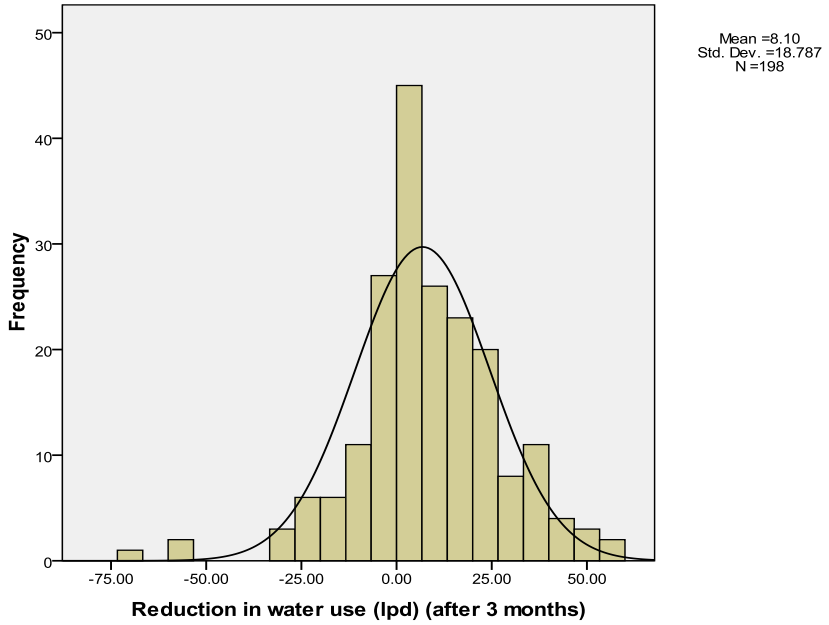


Figure 12 - Distribution of the litre reduction in water use achieved in the South West Water WET.

7.3.2.2 Linear Regression

Figure 13 shows a scatter plot with post-trial mean daily consumption (MDC) on the y-axis and pre-trial MDC on the x-axis. Each point on the graph represents a property's pre-trial and post-trial water consumption. Linear regression using the method of least squares was used to draw a line of best fit through the whole dataset. Two lines of best fit were added: one describing the relationship between pre and post-trial consumption at 3 months and the other describing the relationship at 6 months after retrofitting. This provides a potentially powerful tool to help predict the post-retrofit MDC for projects where a similar mix of devices is installed for a similar demographic.

$$PostMDC1 = 0.88PreMDC + 6 \quad (5)$$

$$PostMDC2 = 0.96PreMDC + 3 \quad (6)$$

Hence, if a similar project was being planned, using the same mix of devices and a mix of properties with similar water-using habits an initial estimate could be made that if pre-trial MDC was 250 litres/property/ day then post-trial water consumption could be reduced to 225 litres/property/day after 3 months and then 242 litres/property/day after 6 months. However it must be highlighted that in the case of this trial the mix of devices used was so varied that it would be very difficult to replicate this elsewhere. This method could be applied to predict the water savings that could be achieved by targeting customers for retrofitting on a large-scale. In order to do this a larger dataset with more specific data (i.e. relating to specific types of retrofitting project) needs to be built to ensure that the results are as representative as possible of the target population and of future retrofitting plans.

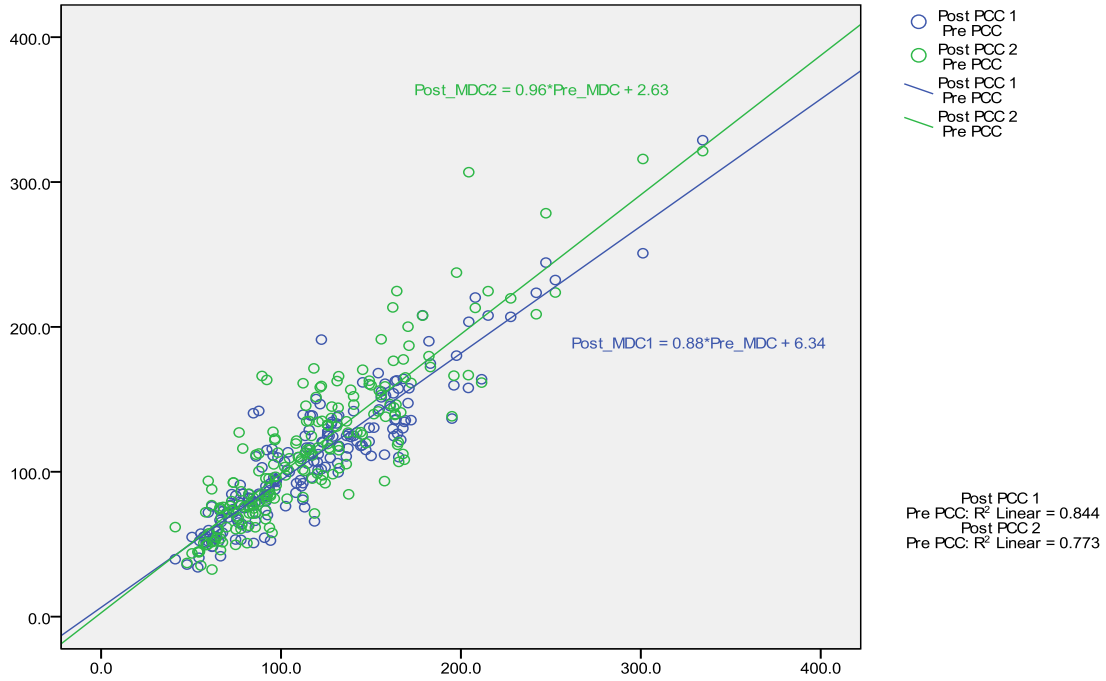


Figure 13 – Use of regression to predict the relationship between the pre-trial MDC (all in litres/day) and the post-trial MDC at (1) 3 months and (2) 6 months.

7.3.2.3 Control Groups

A group of 152 properties were monitored as a control group alongside the study group of 292 properties. Over the first 3 months of monitoring the control group's consumption reduced by 4.39%. However, the consumption of the same control group in the 6 months following installation showed an increase in consumption of 6.45%. The results presented in this section take into account underlying changes in consumption due to climatic, economic and social conditions which occur alongside the effect of the water efficiency intervention.

7.3.2.4 Comparison with Microcomponent Data

The scatter plot shown in Figure 14 compares the actual post-trial water consumption with the calculated theoretical post-trial consumption if commonly assumed microcomponent data are used. In this instance it has been assumed that the Dudley Turbo 2 part siphon device reduces flush volumes from 7.5 litres to 7.5 and 4.5 litres on a 1:2 ratio respectively. This works out to a 30 litres/property/day saving. The results in Figure 3 show that in the vast majority of cases calculated there is close agreement between actual post-trial consumption and the theoretically derived value.

Theoretical savings for retrofit

	l/prop/day
Toilet to dual-flush	30.0
Toilet to save-a-flush	11.5
Shower to water-efficient shower	25.2
Tap inserts	0.9

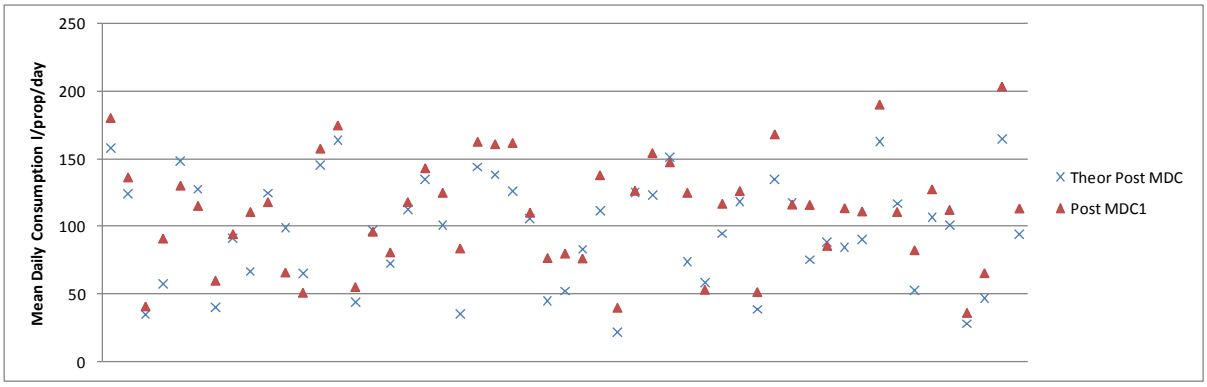


Figure 14 – Comparison of properties with single device retrofit of Dudley Turbo dual-flush conversion device - Theoretical MDC using microcomponent data versus actual MDC post-trial

Figure 14 shows that, on average, using the theoretical savings above overestimates the water savings by about 15 litres per property per day. However, it should be borne in mind that there was a huge range of devices installed as part of this trial, and this makes it more difficult to define a representative basket of measures for this trial. This may explain, partly, the discrepancy between the actual and theoretical values.

7.3.2.5 Analysis of single device retrofits.

There are ways in which, with the right data, the results from this trial could be used to make more informed decisions when choosing water-using devices in future. The South West Water trial includes analysis of the effectiveness of several water efficiency devices when installed as part of a single-device retrofit. Figure 15 compares the effectiveness of the Dudley Turbo dual-flush conversion device with other toilet retrofitting devices. The results show that at both 3 months and 6 months after the retrofit of a toilet using the Dudley Turbo device (as the sole device to be installed), 10% and 13% reductions in water use were achieved. On the other hand, properties where cistern displacement devices such as Save-a-Flush and Hippo bags were installed showed 0% change after 3 months and over a 15% increase in consumption after 6 months.

Other comparative data was available for showers, taps, leakage alarms and spray guns, but sample size was considered to be too low (i.e. less than 10) to be included here. Studies of this type could help inform better choices about which devices to include in water efficiency retrofitting projects. However, it is important to ensure a large enough sample of properties devoted to retrofit with single devices, as well as that the devices are compared for a similar cross section of customers in terms of characteristics such as pro-environmental behaviour category, type of property, age and per capita water consumption.

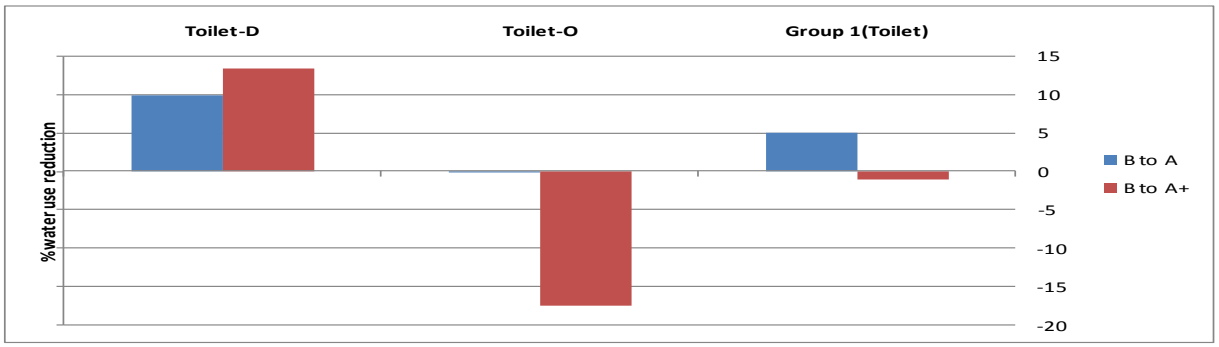


Figure 15 – Water savings from toilet retrofit devices – Dudley Turbo (Toilet-D) and other toilet retrofit devices (Toilet-O)

7.3.2.6 Estimated Carbon Emissions and Energy Savings

The carbon emissions and energy savings from the South West Water trial are summarised in Table 18. Domestic hot water carbon emissions savings were 13.4 $kgCO_2$/day and energy indirect emissions stood at 2.7 $kgCO_2e$/day, measured after 3 months. However, after 6 months these were seen to have reduced to 8.0 $kgCO_2$/day and 1.6 $kgCO_2e$/day respectively. There were also significant energy savings to be reported: for the first 3 months after the trial, an estimated 72 kWh/day. For the first 6 months after the trial, slightly reduced energy savings of 41.8 kWh/day were estimated. The cost of energy saved on an annual basis would be £4738 based on the water savings after 3 months and £2742 based on the water savings after 6 months. The lower carbon emissions and energy savings after 6 months, compared to 3 months earlier, are a direct result of the fact that water savings decreased over the period.

7.4 United Utilities Home Audit Study

7.4.1 Summary

This trial investigated the effectiveness of domestic water efficiency devices. Specifically it was designed to:

1. Determine the practicality of fitting and promoting a range of water-saving devices;
2. Gain a better understanding of the likely costs of fitting these devices;
3. Determine associated savings of these devices through property and District Metering Area (DMA) metering.

4,642 domestic properties in the Greater Sankey area of Warrington were sent an invitation to take part in this study. Customers were asked to respond by filling out a form to confirm they would be willing to take part in the trial.

The target population can be described as financially stable, and living in homes predominantly built since 1990 making them likely to have a water meter installed. Over 95% of the target properties were in ACORN category 1 (Wealthy achievers) or 2 (Comfortably off). The population targeted by the study is therefore not representative of the United Utilities (UU) customer base; however there are a large number of similar areas within the UU region. Once the completed application form had been received, customers were contacted by telephone to arrange a suitable time for a qualified plumber to visit the property and install water-efficient-devices. UU offered only a limited number of Saturday appointments for audits, and it is thought this could have contributed to a lower than expected uptake rate. Overall 23% of the customers who agreed to participate ultimately dropped out of the trial.

Of the 393 customers who underwent an audit, 313 were metered customers and 80 were unmetered. For metered customers, several meter readings were taken during the course of the trial. Initially the customers were asked to provide a meter reading when they responded to the invitation to take part in the trial. Subsequent meter readings were taken when the water audit was carried out, and at one-month intervals for three months following the trial. The post-installation meter readings have been used to calculate a post-trial average daily consumption for each household. Meter readings from the UU billing database from before the trial began were also collated (from as early as December 2006) and used to calculate a pre-trial average daily consumption for each household.

Device Fitted	Number fitted (Percentage of homes)
Showerheads	212 (48%)
Ecobeta dual flush retrofits	193 (34%)
Save-a-flush bags	384 (58%)

Table 19 - Water saving devices installed during the United Utilities Home Audit Project

All customers who had a water audit carried out were given a 'water savers pack' which included a basic shower timer and information on saving water. Further devices were installed where appropriate, including water-efficient showerheads (Challis aerated showerheads), dual-flush retrofit (EcoBETA dual-flush devices) and save-a-flush cistern displacement devices. Customers were given the option of requesting the removal or repair of water-efficient devices for up to three months after they were fitted. Devices were installed by 3 qualified plumbers, who each completed up to 5 appointments per day during the installation window. During the water audit, information was gathered on the types and number of water-using appliances installed in the home, and behaviour on water use. In addition, information on occupancy was confirmed. Where

showerheads were installed, pre-installation and post-installation flow rate readings were measured using a 'shower bag'.

7.4.2 Results

7.4.2.1 Analysis of savings

Table 20 presents some important results from the UU Home Audit Study. 393 customers took part in the trial but the water savings here refer to 211 measured customers who took part in the trial. These results show that there were average savings of 20.6 litres per property per day from the properties that were included in this analysis, which represents a reduction in water use of 6.8%.

United Utilities Home Audits

	Overall	
No. of properties	211	
Water savings (l/prop/day)	20.6	
Water savings (% reduction)	6.8	
90% Confidence interval (% water saved)	47.3	-33.6
90% Confidence interval (litres saved/prop/day)	169.4	-128.1
Probability of water savings	0.67	
Uptake rate (%)	8.5	
Cost per property(£)	141.92	
Cost per litre per day (£)	6.88	
Energy indirect carbon emissions saved (kgCO2e/d)	3.3	
Domestic hot water carbon emissions saved (kgCO2/d)	16.1	
Energy saving (kWh/d)	85.4	
Cost of energy saved (£/year)	4985	
Cost of energy saved (£/prop/year)	24	

Table 20 –Summary of key results from the United Utilities Home Audit Study

The 90% confidence interval covers a wide band of percentage savings: it is 90% certain that between a 47.3% reduction and a 33.6% increase in water consumption. For any individual property there is a large amount of uncertainty. However, looking across the entire sample gives greater confidence that the majority of properties will actually save water during a trial such as UU's. Figures 16 and 17 show the distribution of the litre and percentage water-use reduction achieved for the 211 properties whose data are included in this trial. The histograms show that the majority - 141 customers out of the 211 (about 67%) - reduced their water usage after retrofitting as part of the UU study.

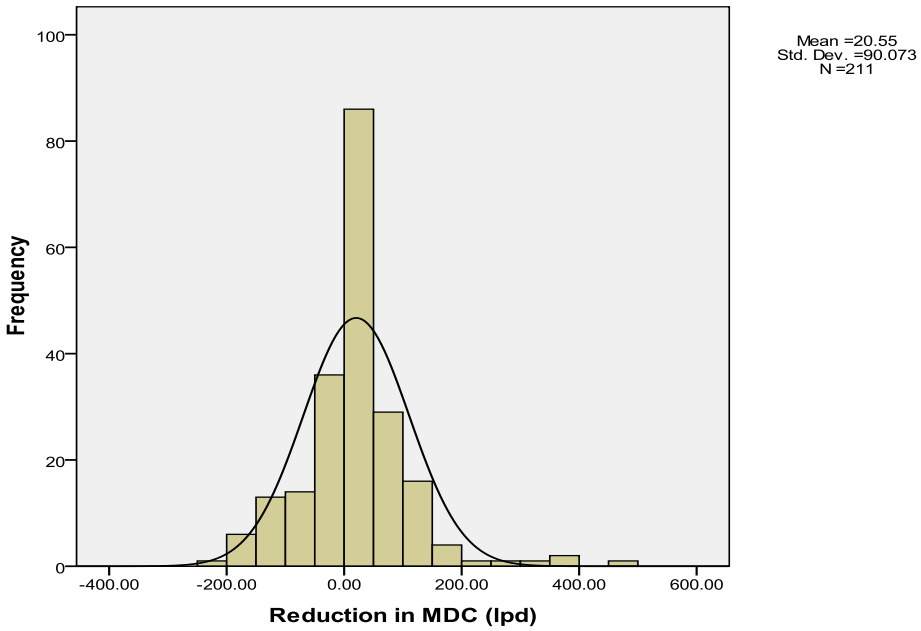


Figure 16- Distribution of the percentage reduction in water use achieved in the United Utilities Home Audit Study.

Figure 18 shows a scatter plot of post-trial consumption against pre-trial consumption for the properties which took part in the trial. Linear regression was again used to model the relationship between pre-trial and post-trial consumption for these customers. This process provides potentially valuable information about predicting the possible savings from retrofitting projects.

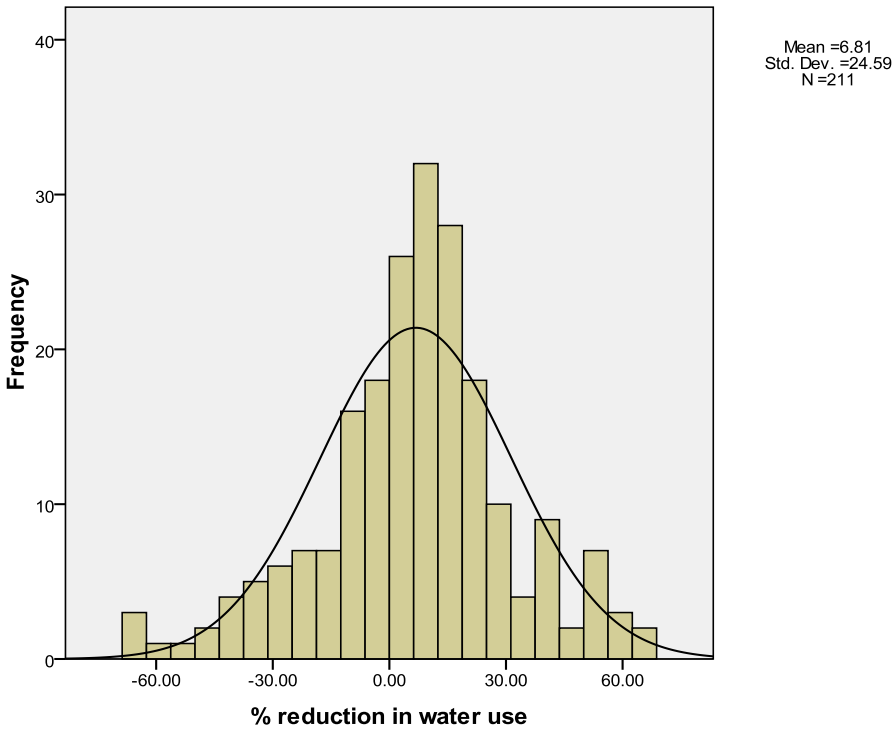


Figure 17 - Distribution of the percentage reduction in water use achieved in the United Utilities Home Audit Study.

7.4.2.2 Control Group

313 metered properties were included but there was no designated control group as part of this trial.

7.4.2.3 Linear Regression

As the evidence base grows this could become increasingly useful, for example in helping decide which water-efficient devices to install for different customers or in prioritising where to carry out large-scale water efficiency programmes. The following equation characterises the relationship between the post-trial and pre-trial mean daily consumption:

$$PostMDC = 0.92PreMDC \quad (7)$$

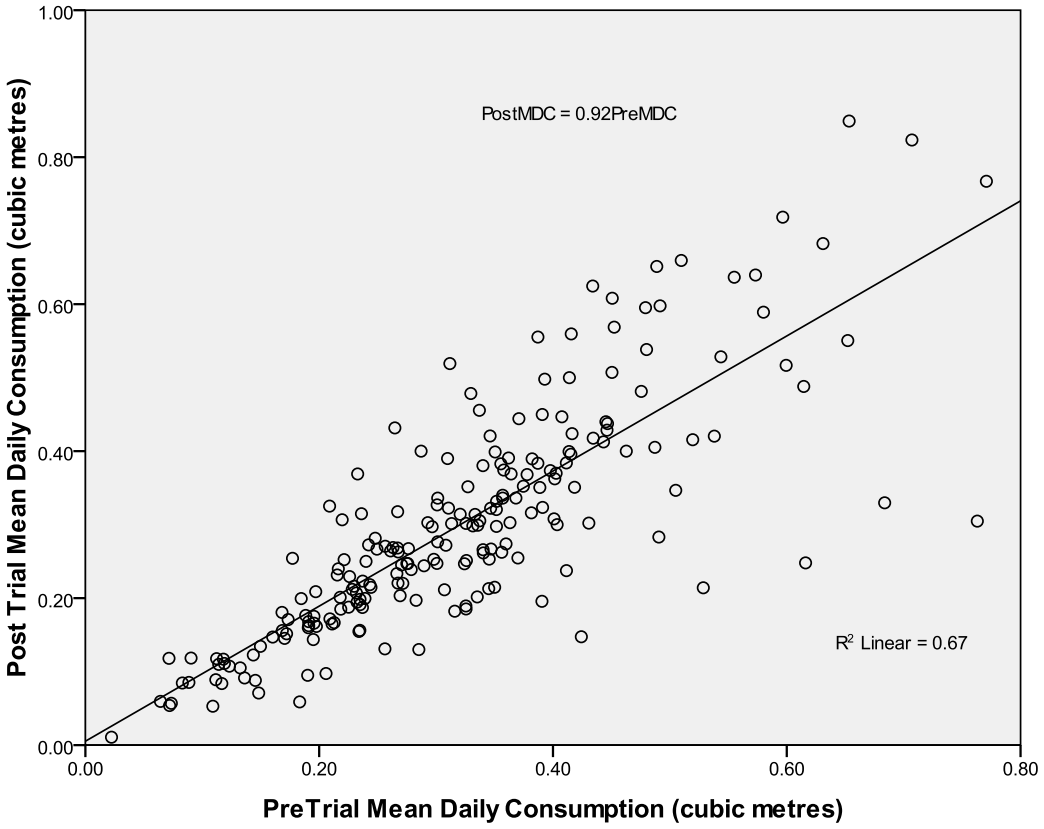


Figure 18 - Scatterplot of post-trial consumption versus pre-trial consumption and using linear regression to model the relationship between them (UNITED UTILITIES HOME AUDIT PROJECT - WRc Ref: UC7803.03 July 2008)

7.4.2.4 Comparison with Microcomponent Data

Figure 19 shows a comparison of the actual and theoretical post-trial mean daily consumption for 169 properties which had water-efficient devices installed as part of the United Utilities Home Audit Project. Using the theoretical savings presented above Figure 19, it can be observed that on average the assumed savings were 5 litres per property per day (lpd) lower than the actual savings measured as part of the trial. From an average pre-trial consumption of 320 lpd the measured actual post-trial consumption was 278 lpd versus a theoretical post-trial consumption of 273 lpd.

Theoretical savings for retrofit

	l/prop/day
Toilet to dual-flush	30.0
Toilet to save-a-flush	11.5
Shower to water-efficient shower	25.2
Tap inserts	0.9

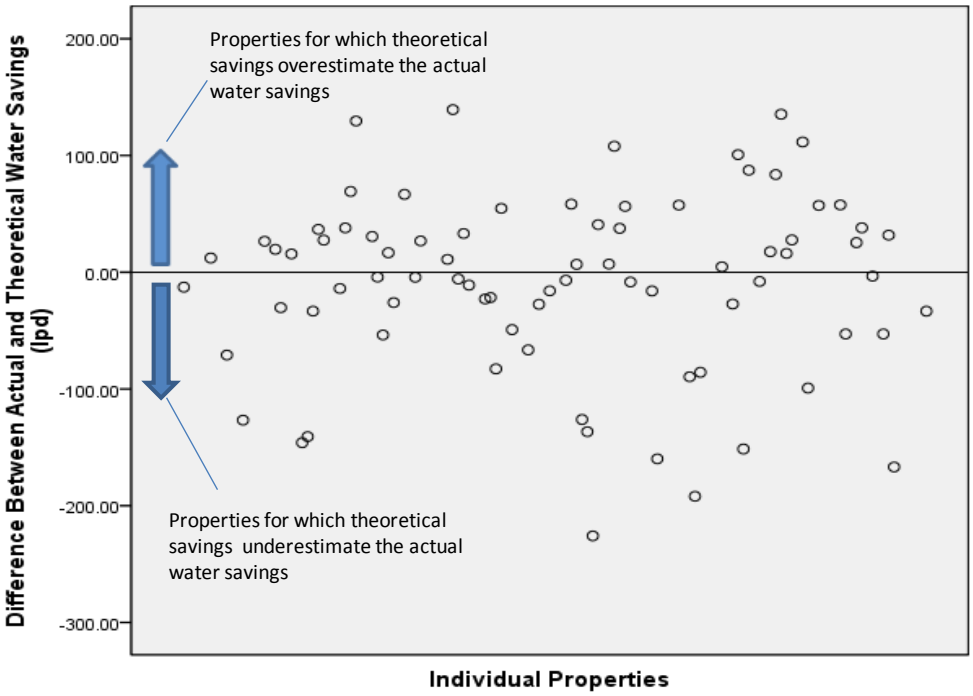


Figure 19 - Comparison of the actual and theoretical savings from the United Utilities Home Audit Study

7.4.2.5 Estimated Carbon Emissions and Energy Savings

Carbon emission savings of 3 $kgCO_2e$/day (energy indirect carbon emissions savings) and 16 $kgCO_2$/day (domestic hot water emissions savings) were estimated to have been achieved through United Utilities' water efficiency home audit study. In addition to this, by saving its customers hot water through the retrofitting of showerheads and fixing taps, United Utilities has saved those customers approximately 85 kWh/day. In terms of cost of energy saved this equates to about £4985. This demonstrates the strong link between water efficiency and energy efficiency, and that focusing to a greater extent on hot water in the home could yield even greater savings.

7.5 Anglian Water Ipswich Area WEM trial

7.5.1 Summary

Anglian Water's enhanced metering project provided meters to un-metered domestic properties in the Ipswich area. It allowed for the least cost option of 'blanket' fitting meters to domestic properties within a single area, for all suitable houses without a measured water supply. This approach allowed Anglian Water to target the area (designated by the Environment Agency as water-stressed) and work sequentially through it, rather than the more usual option of the customers requesting meters across a widely-dispersed number of locations.

In addition to extending domestic metering penetration in the Ipswich area, the opportunity was taken to undertake a pilot programme of a free water audit in which various water efficiency devices would be installed by a plumber, and a questionnaire returned by the participating household. The purpose was to reduce water demand in a water-stressed area. By making customers more aware of their own consumption it was also hoped that they would opt to be charged via a water meter and therefore pay less for their water.

Anglian Water sent out about 10,000 letters over the project life offering customers the opportunity to take part in the water efficiency trial. In addition, effort was made to recruit customers through engagement at events. The target was to provide water efficiency audits and install retrofit devices in 1,000 properties.

A breakdown of the types of water-efficient devices offered and the number installed is given in Table 21.

Device	Number fitted
Tapmagic M24 External thread (9E)	7
Showerhead insert (7)	37
Tap Magic - Dual Flow (9B)	45
Tap Magic - M24 Spray (9C)	45
Tap Magic M24 Dual Flow (9D)	105
Save-a-Flush WC device (5)	169
Miraclespray kitchen tap insert (6)	287
Tap Magic - Single Spray (9A)	323
Flowpoint showerhead (8)	339
ecoBETA WC device (1)	522
Average number of devices fitted per household	2.8
Households with device/s fitted	622
Households without device/s fitted	41
Total devices fitted	1,879

Table 21- Type and number of devices installed in the Anglian Water Ipswich Area WEM Trial

As well as developing Anglian Water's knowledge, it was considered important that the Ipswich water efficiency trial data should contribute to improving the Waterwise Evidence Base, and shared with the rest of the industry. An extensive database was developed to manage information from the trial including pre-trial and post-trial consumption monitoring for on average 20 months and 6 months respectively. In addition a questionnaire survey was carried out in order to gain intelligence from customers about their water-using behaviour, and other socio-economic and demographic characteristics.

7.5.2 Results

7.5.2.1 Water savings

Table 22 gives a summary of some key results from Anglian Water's Ipswich WEMs trial, based on the analysis of data carried out by Waterwise. Almost 1000 customers took part in the trial and data has been presented here for 552 properties (representing a subset where questionnaire data was available and WEMs devices had been fitted). Overall water savings for these properties was found to be 41.5 litres per property per day (lpd), or a mean percentage reduction of 14.2%. These are very encouraging water savings based on results from a large survey population and a robust dataset.

In addition to the 552 properties, a further 47 properties were monitored where it was not possible to install any retrofit devices, which had meters installed, which were actively encouraged to adopt water-efficient behaviour and which were monitored. This group was found to have reduced its consumption by 13.0 lpd or 3.2 % over the monitoring period, which may be attributed to behavioural changes in water use.

Anglian Water Ipswich WEM Trial

	Overall	
No. of properties	552	
Water savings (l/prop/day)	41.5	
Water savings (% reduction)	14.2	
	Max	**Min**
90% Confidence interval (% water saved)	50	-21
90% Confidence interval (litres saved/prop/day)	151	-68
	Overall	
Probability of water savings	0.78	
Uptake rate (%)	10	
Cost per property(£)	40.76	
Cost per litre per day (£)	0.98	
Energy indirect carbon emissions saved (kgCO2e/d)	17.1	
Domestic hot water carbon emissions saved (kgCO2/d)	86.2	
Energy saving (kWh/d)	418	
Cost of energy saved (£/year)	24427	
Cost of energy saved (£/prop/year)	44	

Table 22 –Summary of key results in the Anglian Water Ipswich Area WEM Trial

The 90% confidence interval is also presented in Table 22 and gives a range of water savings of between 151 lpd and -68 lpd. In terms of percentage water savings this is equivalent to a 90% confidence interval of 50% to -21%. Again, a common theme is evident; that the 90% confidence interval covers a very wide band of litre and percentage savings. It means that there is 90% certainty that between a 50% reduction and a 21% increase in water consumption will result.

However, if the distribution of the water savings is considered, it is clear that there is some kind of structure to the results. Figures 20 and 21 show the distribution of the litre per property per day and the percentage water use reduction achieved, respectively, for the 552 properties whose data are included in this analysis. This shows that 78% of properties that took part in this trial reduced their water usage after retrofitting. This is the highest probability of water savings achieved to date in any of the projects in the Evidence Base.

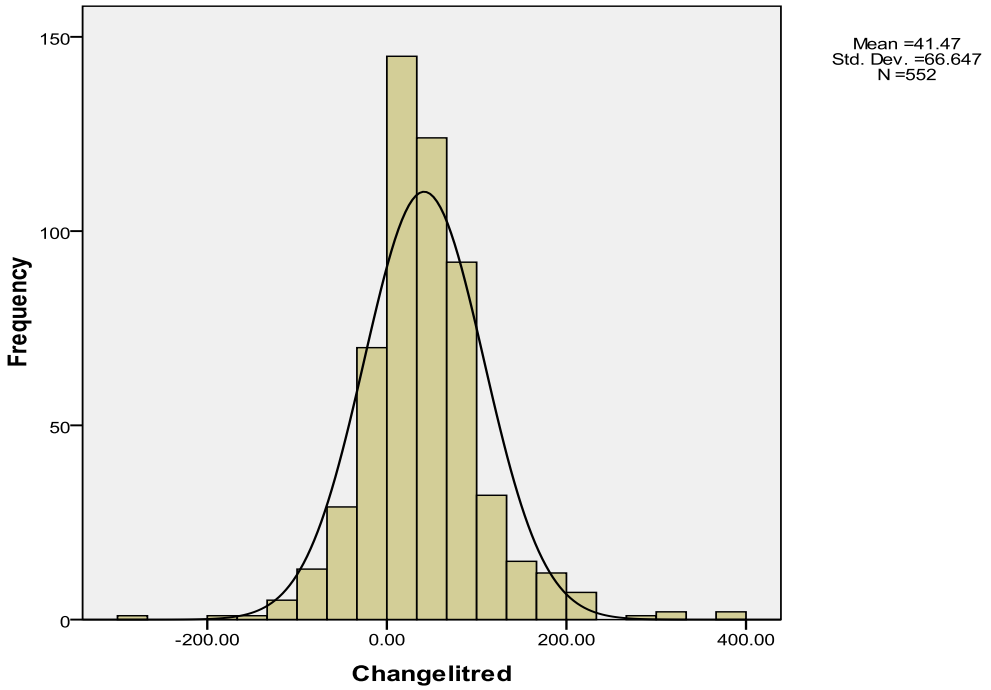


Figure 20 - Distribution of water savings achieved in the Anglian Water Ipswich Area WEM Trial

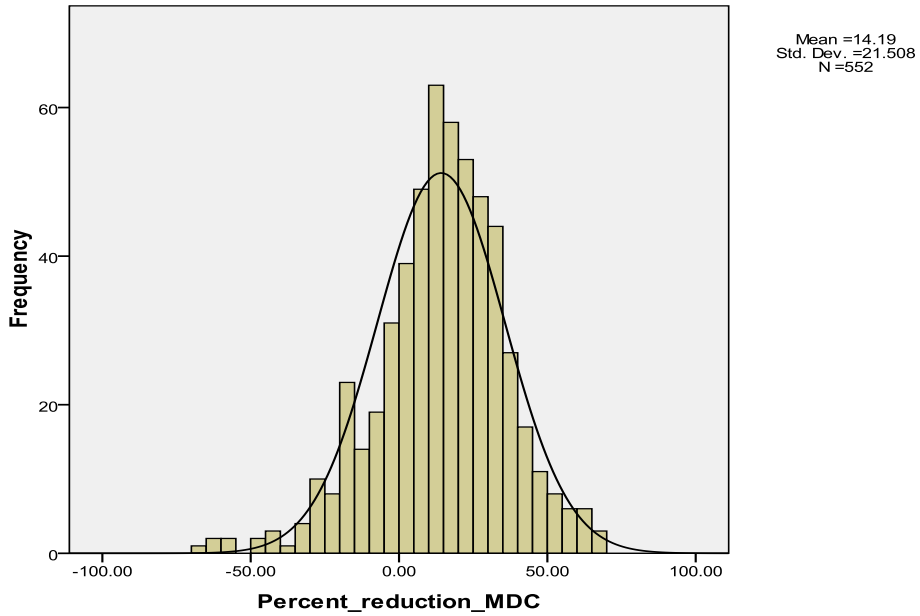


Figure 21 - Distribution of the percentage reduction in water use in the Anglian Water Ipswich Area WEM Trial

7.5.2.2 Linear Regression

Figure 22 presents a scatter plot of post-trial consumption against pre-trial consumption for the properties which took part in the Anglian Water Ipswich area WEMs trial. Again, linear regression was again used to model the relationship between pre-trial and post-trial consumption. This process provides a valuable means of predicting the water savings from retrofitting projects. The following equation characterises the relationship between the post-trial and pre-trial mean daily consumption:

$$Post\ MDC = 0.77 Pre\ MDC + 20 \qquad 8$$

7.5.2.3 Control Group

As this was a WEMs trial carried out alongside an enhanced metering programme, it was not feasible to include a control group from the local area in this analysis.

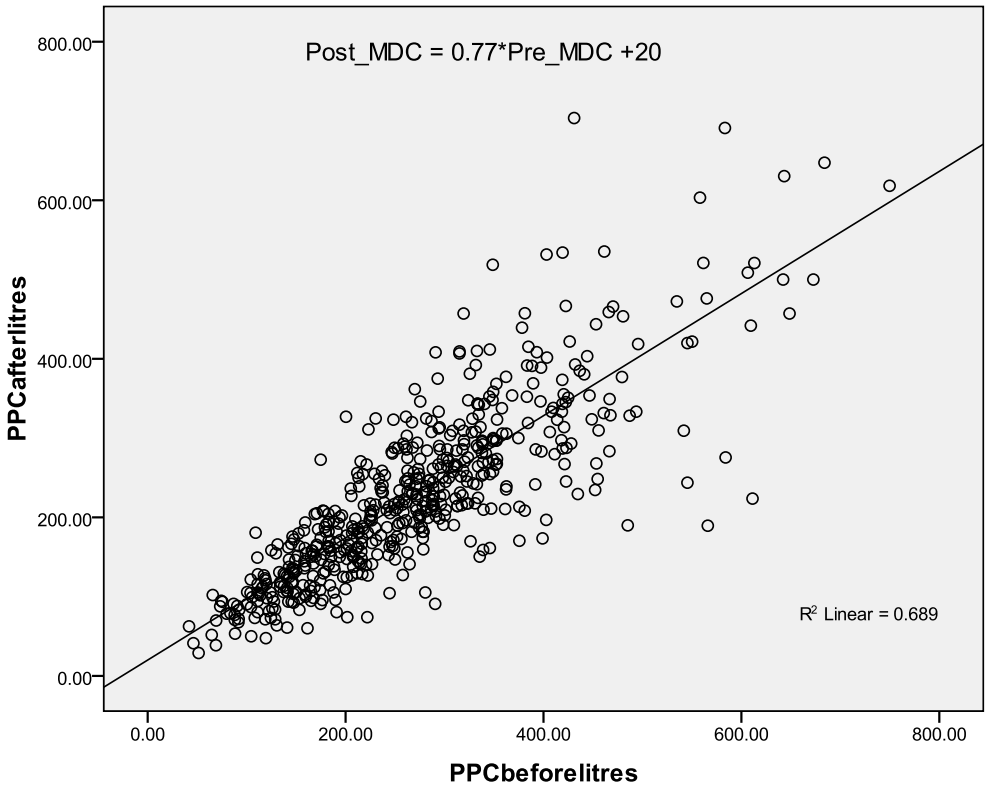


Figure 22 - Scatterplot of post-trial consumption versus pre-trial consumption and using linear regression to model the relationship between them

7.5.2.4 Comparison of actual and theoretical water savings

Data was made available to allow comparison of the actual and theoretical post-trial consumption for 598 properties participating in the Anglian Water WEMs trial. The difference between the actual and estimated water savings is shown graphically in Figure 23. It was observed that the average pre-trial water consumption was 267 lpd and the measured actual post-trial consumption was 226 lpd, compared to the theoretical post-trial consumption of 232 lpd. So in this case the theoretical water savings, shown above in Figure 23, underestimated the water savings by 6 lpd.

Figure 23 shows the difference between actual water saved and the theoretical saving that is estimated to be achieved knowing the devices installed and the estimated water saving that the installed devices produces. For example, if a property is measured to save 35 lpd following retrofitting with a dual-flush conversion device, then the theoretical saving would be 30 lpd (see table adjacent to Figure 23). When this property was plotted on the chart, it would have a value calculated using:

Difference between actual and theoretical water savings = theoretical saving - actual saving

This gives the difference between actual and theoretical savings to be -5 lpd in the given example where the theoretical saving underestimates the actual saving. This process was carried out for each property that was part of the trial. Figure 23 shows that there is a high degree of variability between individual households which makes it difficult to predict how an individual property will respond to water savings. However, if the sample is taken as a whole, the theoretical savings values seem to characterise quite well the mean response that can be expected from a large sample of properties.

Theoretical savings for retrofit

	l/prop/day
Toilet to dual-flush	30.0
Toilet to save-a-flush	11.5
Shower to water-efficient shower	25.2
Tap inserts	0.9

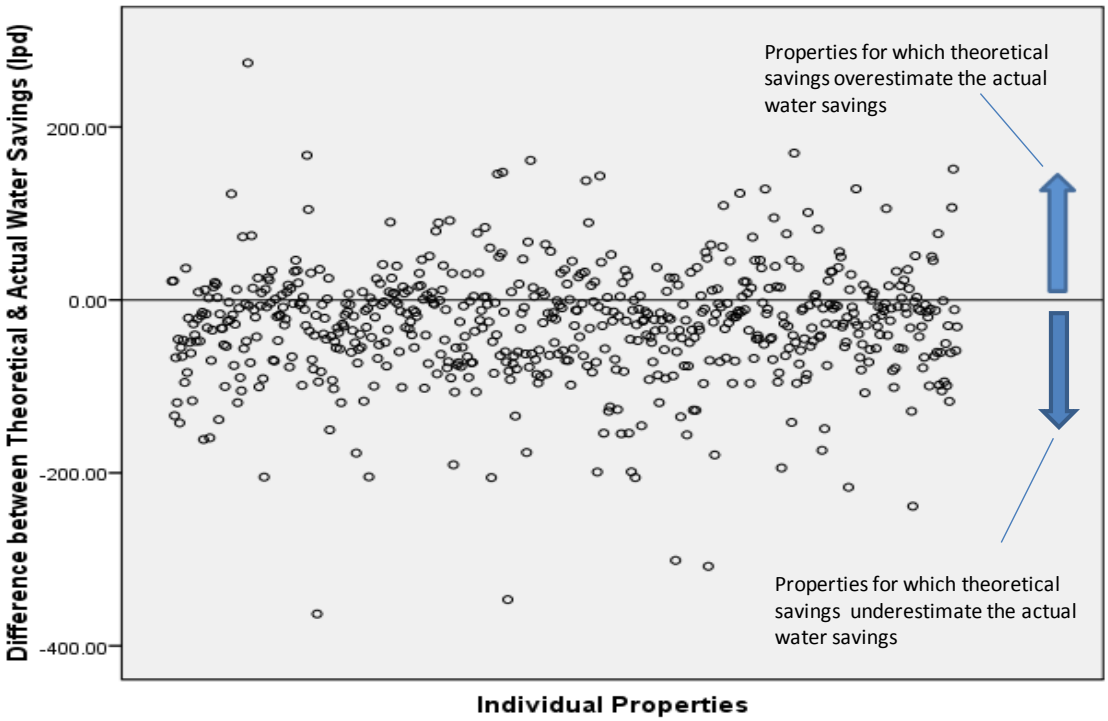


Figure 23 - Comparison of the actual and theoretical savings in the Anglian Water Ipswich Area WEM Trial

7.5.2.5 Estimated Carbon Emissions and Energy Savings

The carbon emissions and energy savings from the Anglian Water Ipswich area WEMs trial are summarised in Table 22 above. From our analysis, domestic hot water emissions savings are estimated to be 82 $kgCO_2$/day and energy indirect carbon savings of 17 $kgCO_2e$/day. As we have seen previously, in addition to the carbon savings there are, again, significant energy savings to be made from carrying out large-scale water efficiency retrofitting projects such as this. We estimate that the Anglian Water Ipswich area WEMs trial was responsible for an energy saving of approximately 401 kWh/day. When monetised this gives an annual saving of approximately £23444 for the 552 properties included in our analysis.

7.6 Thames Water Measured Visit and Fix Trial

7.6.1 Summary

Between November 2006 and July 2008 Thames Water ran two trials sending trained auditors into 1274 customer's households to look at how customers currently use water, fix leaking taps and, with agreement of the householder, install a range of water-saving technologies. The first trial targeted this approach on metered households in Wiltshire and Bromley, whilst the second group of targeted homes paid for water based on the rateable value of their homes but had had a 'sleeping' meter installed as a result of the Victorian Mains Replacement programme in central London.

The aim of the two trials was to increase understanding of household water use and the barriers and incentives to increased water efficiency whilst assessing different water saving technologies. Meter readings were used to analyse what water savings the households made as a result of having water efficiency devices installed. Although all the houses had meters installed, only some of these were used for billing, with the remaining homes paying for water by the rateable value of their home.

Thames Water hoped to enable the occupants of 2000 households to feel informed and in control of their water use, although difficulties engaging customers who pay for their water on the rateable value of their home meant ultimately 1274 homes were audited. 12.5% of metered customers approached, agreed to take part in the study, with 9.2% ultimately having a water audit of their home conducted.

11.6% of rateable-value customers approached agreed to take part in the study after an extensive engagement process, with 4.8% ultimately having a water audit of their home conducted. Engaging these customers was a significant challenge with written invitations, phone calls, flyers for a prize draw and face-to-face project explanation on customers' doorsteps all being employed.

A key incentive for customers to take action with regard to water efficiency was that the Audit Project was offered to them free of charge. Another incentive for the meter customers was that they could save money by having water-efficient devices installed. Some customers also reported a sense of satisfaction that they were doing their bit to save water. The auditor surveyed each house, recommended which products would be suitable and, with the householder's permission, installed these free of charge. Auditors had the following selection of products available;

- Spray swivel Tap (for the kitchen tap)
- Digital shower timer
- Sand shower timer
- Save-a-flush
- Tap washers
- Dual-flush toilet retrofit
- Toilet cistern dual-flush replacement
- Aerating tap inserts
- Restrict-a-flow
- Internal leak alarm
- Aerating Showerhead

The vast majority of the customers were happy with this range and did not think there were too many products. They understood how the products worked with very few not grasping the concepts.

7.6.2 Results

7.6.2.1 Analysis of water savings

Table 23 presents some of the key results from the analysis of results. From 727 properties for which data was included from the Thames trial there was an average of 29.1 litres per property per day water savings. This is equivalent to a reduction of 7.9% in the mean daily consumption from before to after retrofitting was carried out in these properties. The 90% confidence intervals are also given, and these are broad as in other trials analysed in this report.

Thames Water Measured Visit and Fix Trial

	Overall	
No. of properties	727	
Water savings (l/prop/day)	29.1	
Water savings (% reduction)	7.9	
90% Confidence interval (% water saved)	45.7	-29.9
90% Confidence interval (litres saved/prop/day)	153.9	-95.7
Probability of water savings	0.69	
Uptake rate (%)	9.2	
Cost per property(£)	240.00	
Cost per litre per day (£)	8.25	
Energy indirect carbon emissions saved (kgCO2e/d)	15.5	
Domestic hot water carbon emissions saved (kgCO2/d)	78.1	
Energy saving (kWh/d)	415.2	
Cost of energy saved (£/year)	24245	
Cost of energy saved (£/prop/year)	33	

Table 23– Summary of key results from the Thames Water Measured Visit and Fix Trial

However, it is also worth considering Figures 24 and 25 in which the distribution of water savings amongst the properties that took part in the trial is shown. 69% of the properties that took part in the trial saved water and there is a probability of 0.69 of a property being chosen at random to be part of a similar trial and achieving the mean savings of 29.1 litres.

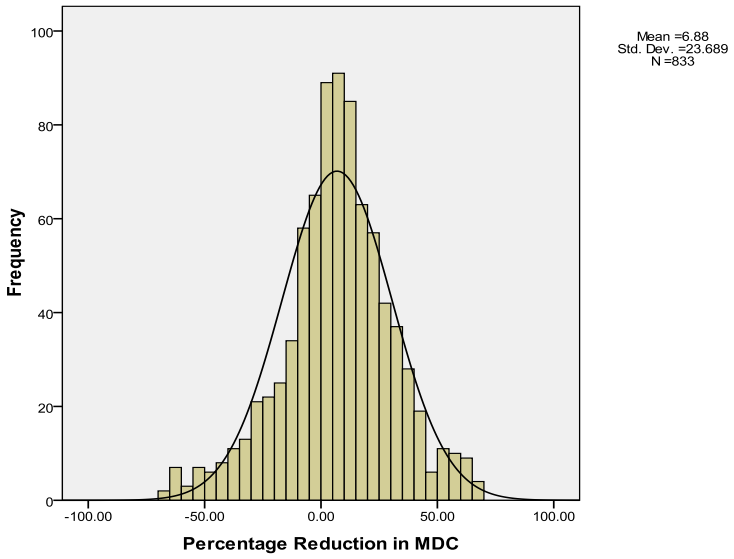


Figure 24- Distribution of the percentage reduction in mean daily water consumption achieved by the Thames Water MVF Trial.

7.6.2.2 The Control Group

A control group was monitored as part of this project. 109 properties did not have water saving devices installed as part of this project or receive any special encouragement to save water. This is a small control sample and as such there is a level of uncertainty which is greater than for the study sample of 727 properties. The data from monitoring the consumption of the control group revealed that that there was a mean saving of -1.8 lpd or -2.2% saving. So, despite the uncertainty, the measured consumption of the control group increased while that of the study group decreased. Also, 48% of the control group properties reduced their consumption over the monitoring period versus 69% of the properties that underwent retrofit.

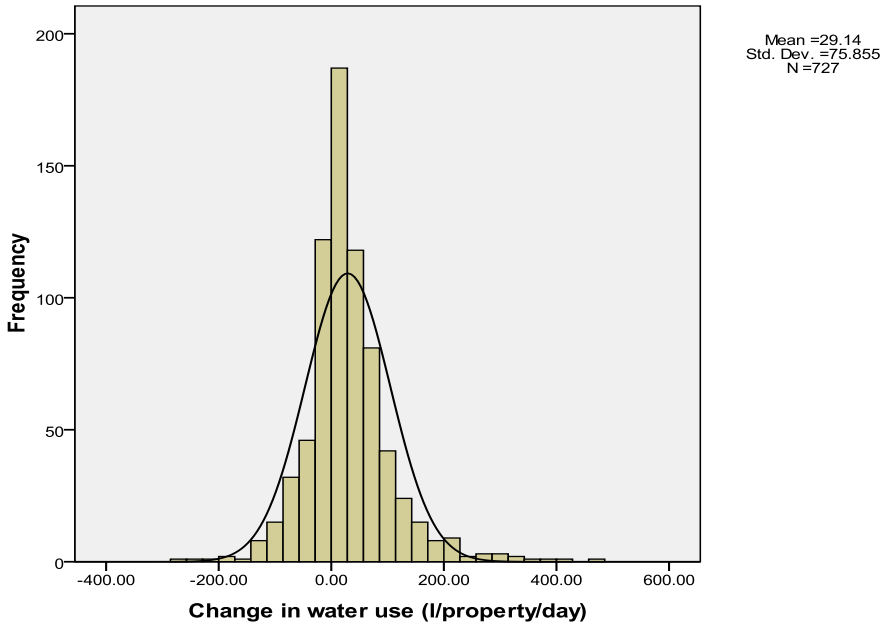


Figure 25 - Distribution of the litre reduction in water use achieved in the Thames Water MVF Trial.

7.6.2.3 Linear Regression

Linear regression can be used to generalise the results of this water efficiency trial. Figure 26 gives the results of this. In order to calculate the predicted post-trial mean daily consumption the following equation can be used:

$$PostMDC = 0.77PreMDC + 38 \qquad 9$$

Using this equation enables planning for water savings from retrofitting projects to be carried out in the future using a similar method installing dual-flush retrofit, cistern displacement devices, showerheads and tap devices for customers.

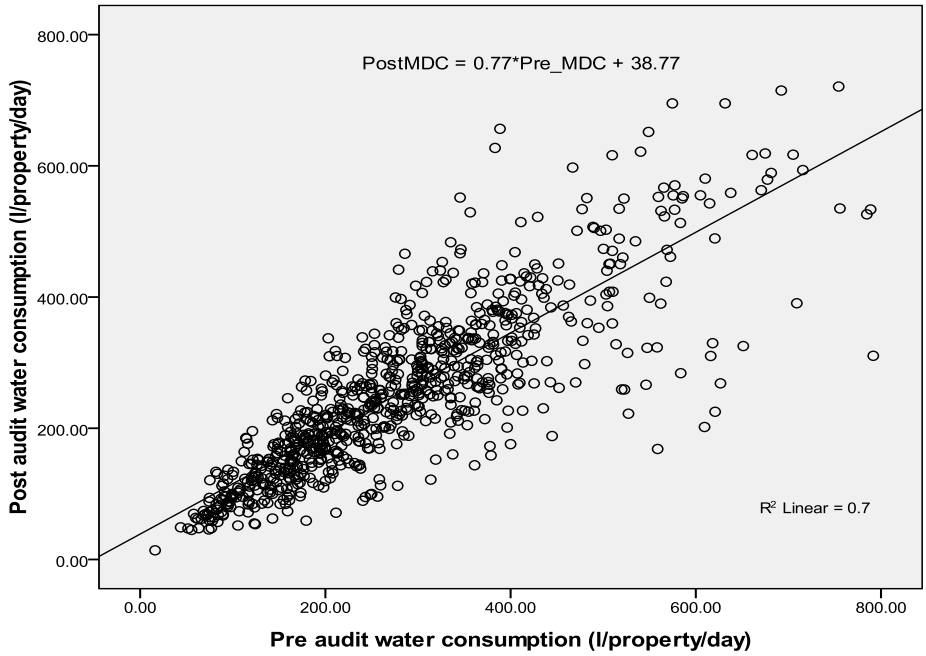


Figure 26 - Use of regression to predict the relationship between the pre-trial and the post-trial MDC consumption

7.6.2.4 Comparison of actual and theoretical water savings

The Thames Water MVF trial achieved mean savings of about 29 litres per property per day. This compares with the average theoretical savings of 31 lpd using the estimates for dual-flush conversion, cistern displacement devices, showerhead and tap insert retrofit given in the table below. Hence on average the assumed values which might be used to estimate the impact of water efficiency retrofitting overestimate savings by 2 lpd on average in the case of this trial.

Figure 27 shows the difference between actual water saved and the theoretical saving that is estimated to be achieved knowing the devices installed and the estimated water saving that the installed devices produces. For example, if a property is measured to save 35 lpd following retrofitting with a dual-flush conversion device, then the theoretical saving would be 30 lpd (see table adjacent to Figure 27). When this property was plotted on the chart, it would have a value calculated using:

Difference between actual and theoretical water savings = theoretical saving - actual saving

This gives the difference between actual and theoretical savings to be -5 lpd in the given example where the theoretical saving underestimates the actual saving. This process was carried out for each property that was part of the trial. Figure 27 shows that there is a high degree of variability between individual households which makes it difficult to predict how an individual property will respond to water savings. However, if the sample is taken as a whole, the theoretical savings values seem to characterise quite well the mean response that can be expected from a large sample of properties. This is evidenced by the fact that the properties are evenly distributed above and below the horizontal axis.

Theoretical savings for retrofit

	l/prop/day
Toilet to dual-flush	30.0
Toilet to save-a-flush	11.5
shower to water-efficient shower	25.2
Tap inserts	0.9

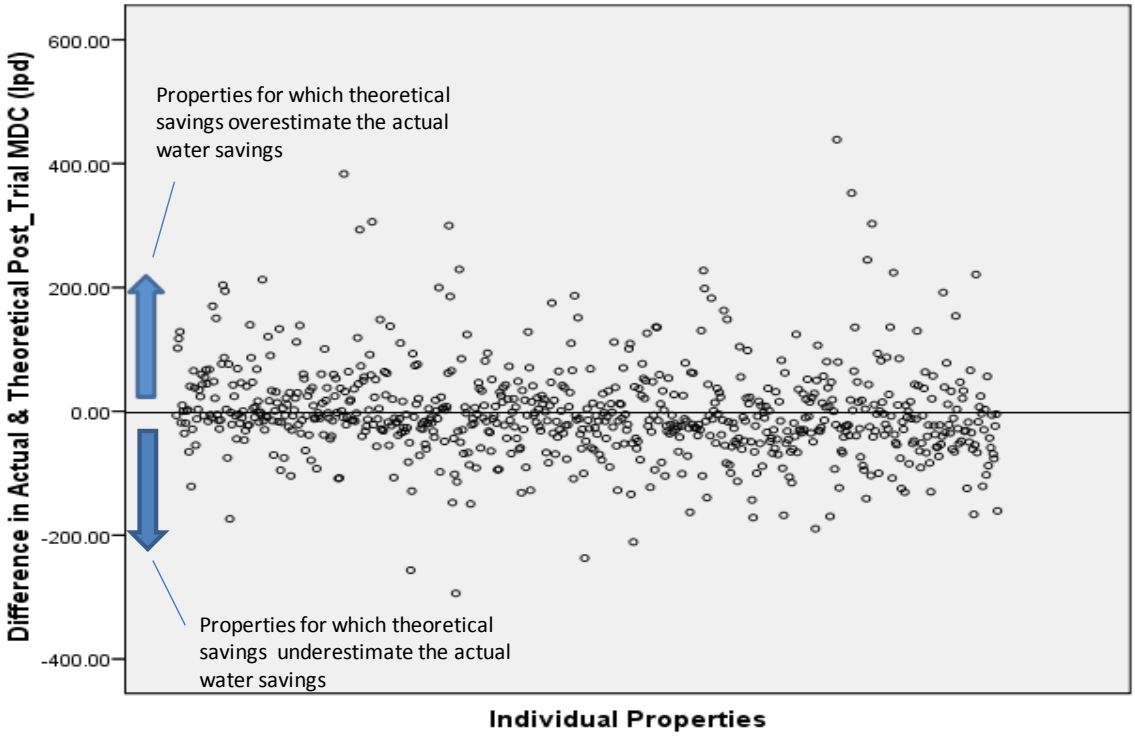


Figure 27 - Comparison of the actual and theoretical savings from the Thames Water Measured Visit and Fix Trial

7.6.2.5 Estimated Carbon Emissions and Energy Savings

The carbon emissions and energy savings from the Thames Water Measured Visit and Fix trial are summarised in Table 23. Domestic hot water carbon emissions savings were 78 $kgCO_2$/day and energy indirect carbon savings were 15 $kgCO_2e$/day. In addition to the carbon savings there are also significant energy savings to be made from carrying out water efficiency retrofitting projects such as this on a large-scale. For the Thames Water trial, an energy saving of 415 kWh/day is estimated, which works out to a saving on an annual basis of £24,245 for the 727 properties included in this assessment.

7.7 Yorkshire Water – Water Saving Trial

7.7.1 Summary

The Water Saving Trial (WST) was carried out to assess the feasibility of reducing water into supply through installing retrofit devices into customers' properties. Data was obtained from householders who agreed to have a selection of water saving devices installed in their properties. The objectives of the trial were to establish:

- the performance of a selection of water saving devices
- the acceptability of water-efficient products to customers
- customers' attitudes to water efficiency
- the volume of water saved through installing water-efficient devices
- the cost of installing water-efficient devices
- the cost-effectiveness of installing water-efficient products on a larger scale.

The project aimed to include 500 properties in the Water Saving Trial. Two areas of the Yorkshire Water supply system were included to provide some variation in the types of households that were participating. The areas chosen were Scarborough and Wakefield.

Wakefield was selected to represent an urban area in the Grid Surface Water Zone with customers connected to the grid system. The grid supplies 96% of Yorkshire Water's customers. Scarborough is part of the East Ground Water Zone and represents a demand area supplied by local groundwater resources that is currently not supported by the grid system. However, a pipeline connecting the two zones will be completed in 2011 and the East Ground Water Zone will become part of the Grid Surface Water Zone. A letter was sent to 5,000 properties in total, 2,500 in each area, to recruit households willing to take part in the Water Saving Trial. The letter included a questionnaire requesting information on occupancy rate, age of occupants, council tax band and type of house.

All of the properties sent the recruitment letter were metered. This meant water savings could be measured from existing meters and no cost was incurred through installing meters. Additionally, metered households had an incentive to take part as the installation of water-efficient products had the potential to reduce their bills. In response to the recruitment letter sent to 5,000 properties, a total of 986 households agreed to take part in the trial. The 500 properties to take part in the trial were selected using the information provided in the questionnaires, with 250 selected from each of the two areas. The 19.72% return rate provided a good variation in property types, occupancy rates and age groups.

As there was a good return rate sufficient information was available to collect meter reads from a control sample and a reserve group in addition to those selected to participate in the trial. One hundred properties were included in the control group: 50 in each of the two areas. The control sample was not made aware that they were part of the trial. Meter readings were also collected from an additional 20 properties in each area to provide a reserve group to replace any selected properties that no longer wished to take part. The reserve group were only made aware they were part of the trial if they were selected to replace a selected property.

	Water Saving Device	Number Installed
Toilets	Dudley Turbo Siphon	4
	Eco Beta Siphon	466
	Close Coupling Kit	0
	Save-a-flush bags	169
Showers	Challis Silver Shower Head	102
	Mira Adjustable Shower Head (White)	70
	Digital Shower Timer	29
	Duck Shower Timer	32
	Star Sand Shower Timer	65
Taps	Miracle Tap Sprayer (Kitchen Mixer)	156
	Dart Valley Flow restrictor	0
	Challis Water Saving Tap Aerator SALSP415	41
	Challis Water Saving Tap Aerator SALSP416	13
	Female Connector	18
	Tap Magic M22 Cartridge	4
	Tap Magic M22 Spraymagic Single Flow	3
	Tap Magic M24 Cartridge	67
	Tap Magic M24 Spraymagic Single Flow	30
	Tap Magic Spraymagic 15-19mm Unifit Round Outlets	8
	Tap Magic M22 Unifit	57
Garden	7 Pattern Spray Gun	63
	Universal Tap Connector	18
Other	EcoSave Leakage Alarm	0

Table 24 - Water saving devices installed during the household water audits

7.7.2 Results

7.7.2.1 Analysis of water savings

Table 25 below gives a summary of the analysis carried out for the Yorkshire Water – Water Saving Trial. This trial achieved mean savings of 27.6 lpd from the 378 properties for which data was used in this assessment, which is equivalent to an 8.4% mean reduction in savings. These are very healthy water savings showing that the methods employed by Yorkshire Water in this trial were very effective in reducing water consumption.

Yorkshire Water Water Efficiency Trial

	Overall	
No. of properties	378	
Water savings (l/prop/day)	27.6	
Water savings (% reduction)	8.4	
90% Confidence interval (% water saved)	41.6	-24.8
90% Confidence interval (litres saved/prop/day)	124.2	-69.0
Probability of water savings	0.74	
Uptake rate (%)	19.7	
Cost per property(£)	220.24	
Cost per litre per day (£)	7.98	
Energy indirect carbon emissions saved (kgCO2e/d)	8.0	
Domestic hot water carbon emissions saved (kgCO2/d)	39.2	
Energy saving (kWh/d)	190.5	
Cost of energy saved (£/year)	11125	
Cost of energy saved (£/prop/year)	29	

Table 25 – Summary of key results from the Yorkshire Water - WET

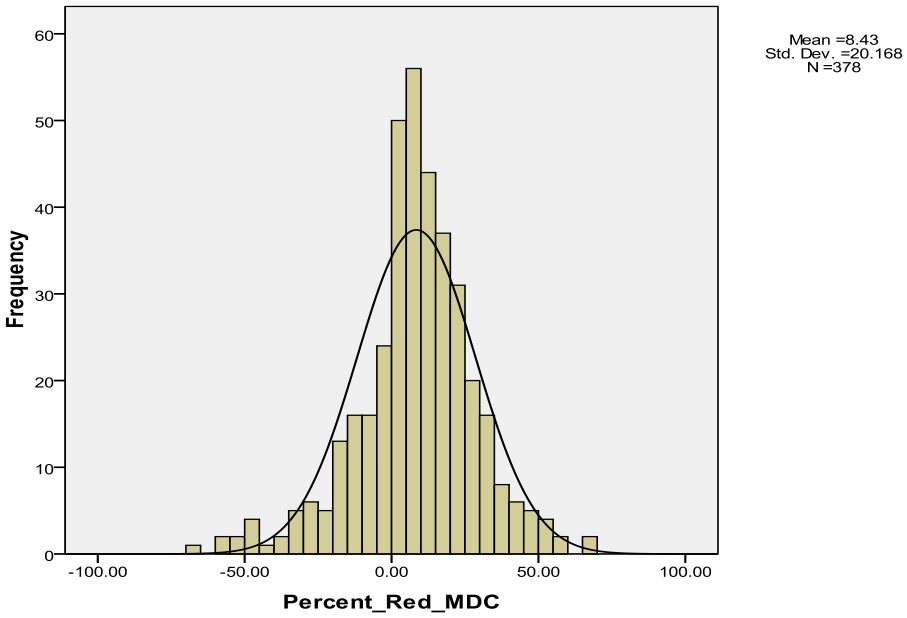


Figure 28- Distribution of the percentage reduction in mean daily water consumption achieved by the Yorkshire Water WST

Figures 28 and 29 show the distribution of water savings in terms of percentage saving and in litre reduction in use per property per day respectively. These histograms show how much of the overall sample is saving water in such a trial. There is a clear majority saving water and this is confirmed by further analysis of the data that revealing that 74% of properties involved in this trial saved water following retrofitting.

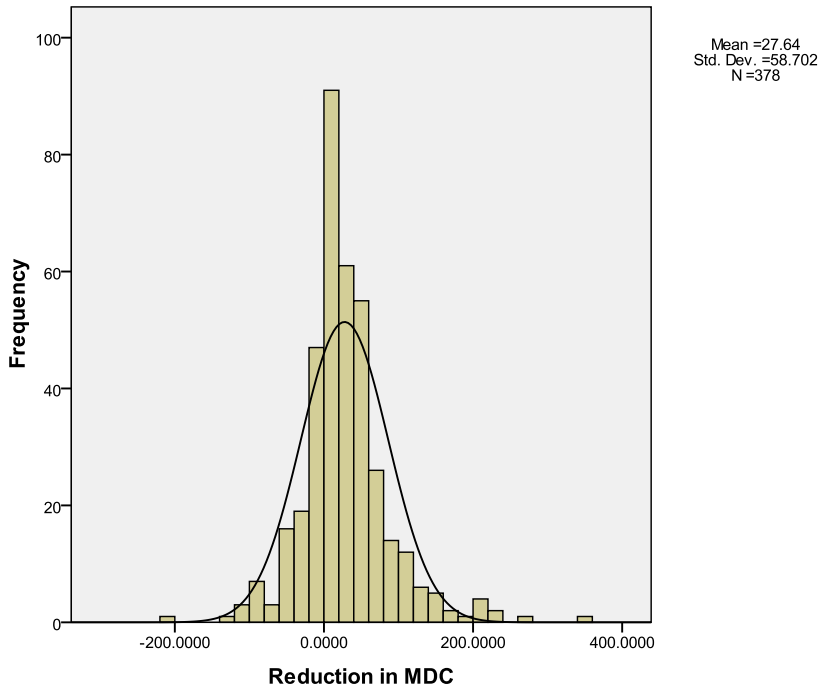


Figure 29 - Distribution of the litre reduction in water use achieved in the Yorkshire Water - Water Saving Trial.

7.7.2.2 Control Group

There was a control group included as part of this trial which included 83 properties. The mean pre-trial consumption for the control and study group are fairly similar (271 lpd for the control group versus 267 lpd for the study group) and this group was chosen for its similarity to the group of properties in the study group. This allows us to take account of the background changes in

consumption due to climatic, social or economic reasons. Over the same period as the study group the control group showed a reduction in consumption of 9.5 lpd. It can therefore be stated with some confidence that this trial achieved water savings of at least 18 lpd, and importantly that the water savings reported in this trial have occurred because of Yorkshire Water's water efficiency intervention and have not just occurred by chance.

7.7.2.3 Linear Regression

Figure 30 shows a scatterplot of post-trial daily consumption against pre-trial mean daily consumption for the study group in the Yorkshire Water - Water Saving Trial. Linear regression can be used to generalise the water saving results in this trial, as with other trials analysed in this report. The following equation can be used to estimate the likely post-trial consumption (PostMDC) by inputting a pre-trial consumption (PreMDC):

$$Post\ MDC = 0.81 * Pre\ MDC + 23 \qquad 10$$

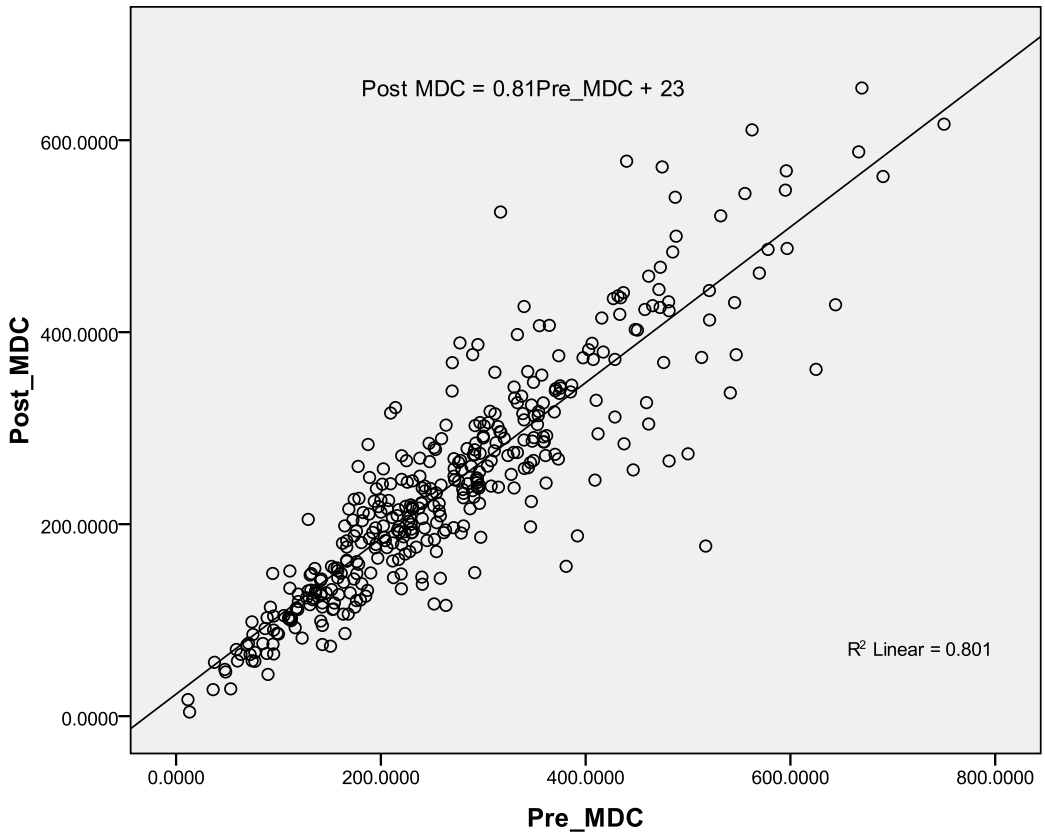


Figure 30 - Use of regression to predict the relationship between the pre-trial and the post-trial MDC consumption

7.7.2.4 Comparison of actual and theoretical water savings

Figure 31 shows the comparison between actual achieved savings and the theoretical savings for 378 properties where retrofitting was carried out as part of the Yorkshire Water - Water Saving Trial. The average pre-trial consumption was 267 lpd compared to an average post-trial consumption of 240 lpd. On average a saving of 28 lpd was made which amounts to a 8.4% water saving. However, using the theoretical savings shown adjacent to Figure 31 it can be seen that water savings are only slightly overestimated by, on average, 2 lpd.

Figure 31 shows the difference between actual water saved and the theoretical saving that is estimated to be achieved knowing the devices installed and the estimated water saving that the installed devices produces. For example, if a property is measured to save 35 lpd following retrofitting with a dual-flush conversion device, then the theoretical saving would be 30 lpd (see

table adjacent to Figure 31). When this property was plotted on the chart, it would have a value calculated using:

Difference between actual and theoretical water savings = theoretical saving - actual saving

This gives the difference between actual and theoretical savings to be -5 lpd in the given example where the theoretical saving underestimates the actual saving. This process was carried out for each property that was part of the trial. Figure 31 shows that there is a high degree of variability between individual households which makes it difficult to predict how an individual property will respond to water savings. However, as seen in several other trials, if the sample is taken as a whole, the theoretical savings values seem to characterise quite well the mean response that can be expected from a large sample of properties.

Theoretical savings for retrofit

	l/prop/day
Toilet to dual-flush	30.0
Toilet to save-a-flush	11.5
shower to water-efficient shower	25.2
Tap inserts	0.9

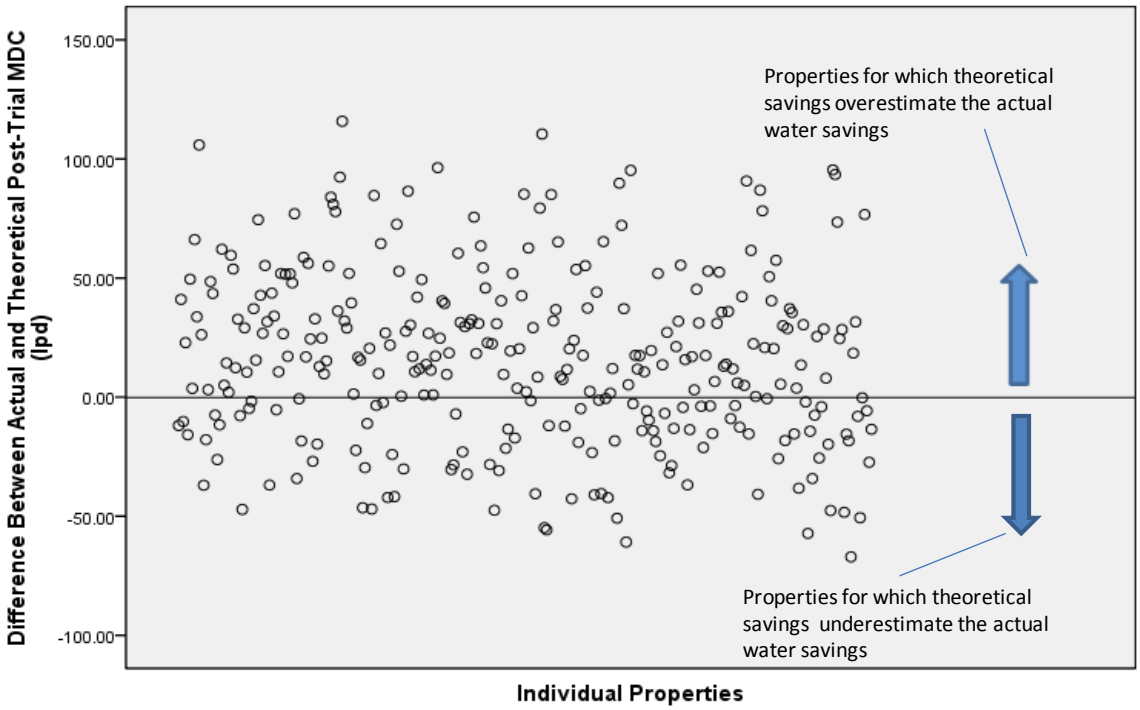


Figure 31- Comparison of the actual and theoretical savings from the Yorkshire Water WET

7.7.2.5 Estimated Carbon Emissions and Energy Savings

The carbon emissions and energy savings from the Yorkshire Water – Water Saving Trial are summarised in Table 25 above. Domestic hot water emissions savings were 39 $kgCO_2$/day and energy indirect carbon savings were 8 $kgCO_2e$/day. In addition to the carbon savings there are also significant energy savings to be from carrying out water efficiency retrofitting projects such as this on a large-scale. It is also estimated that for the Yorkshire Water trial, energy saving of 191 kWh/day resulted, which works out to a saving on an annual basis of £11,125 for the 378 properties included in this assessment.

7.8 Severn Trent – Domestic Water Efficiency Trial

7.8.1 Summary

The data included represents all properties with a valid set of at least three meter readings. In total, 911 properties had such, and were used in the analysis. The primary source of data used was gathered through the meter readings. In May of 2007, information was collected from the Severn Trent Water (STW) accounting database. The records that were obtained included all the properties within the Nottingham (District #11) and Worcester (District #06) areas that were metered. This generated a list of some 220,000 accounts.

A wide range of water-efficient device was retrofitted in the properties which opted to be part of the trial. Dual-flush conversion devices, cistern displacement devices, tap inserts and showerheads were offered.

The selection of the areas in which to conduct the trial programme used a DMA map as the primary reference to select areas that were geographically adjacent, yet diverse enough to satisfy the requirements for ACORN groupings. The DMAs selected from each area were assembled to form 10 groups of approximately 1000 properties. Out of these, 120 properties in each group were to be surveyed. Based on information from previous projects involving the contacting of customers, a 1 in 10 success rate was adopted. In other words, for every ten customers that were contacted by phone, one would actively participate. From October 2007 to December 2007, 9446 letters were mailed. From the same source, a call list was produced for each group, and was provided to the call centre staff.

In January 2008, it started to become apparent that recruitment rates were falling from the predicted 10:1 ratio to 8.5:1. The forecast was that target numbers were not going to be met, and an additional 2,500 addresses were released, all in the Worcester area.

7.8.2 Results

7.8.2.1 Analysis of water savings

Table 26 gives a summary of the key findings from the Severn Trent Domestic Water Efficiency Trial. Water savings of 28.4 litres per property per day were achieved for the 717 properties for which data is included here. This is equivalent to an 8.7% reduction in water consumption for the monitoring periods before and after retrofitting. The 90% confidence intervals for the water savings are 149.8 to -92.9 lpd or alternatively 51.1% to -33.8% water saved. This shows fairly standard variability in water savings, compared with many other trials.

Severn Trent Domestic Water Efficiency Trial

	Overall	
No. of properties	717	
Water savings (l/prop/day)	28.4	
Water savings (% reduction)	8.7	
90% Confidence interval (% water saved)	51.1	-33.8
90% Confidence interval (litres saved/prop/day)	149.8	-92.9
Probability of water savings	0.65	
Uptake rate (%)	8.5	
Cost per property(£)	74.06	
Cost per litre per day (£)	2.61	
Energy indirect carbon emissions saved (kgCO2e/d)	15.3	
Domestic hot water carbon emissions saved (kgCO2/d)	76.7	
Energy saving (kWh/d)	400.0	
Cost of energy saved (£/year)	23360	
Cost of energy saved (£/prop/year)	33	

Table 26 – Summary of key results from the Severn Trent – Domestic Water Efficiency Trial

However, Figures 32 and 33 show that, even though there is clearly a large degree of variability, there is some kind of structure to the distribution in the water savings. It cannot quite be stated that the water savings are normally distributed but the water savings distribution alongside the curve of a normal distribution reveals more than a passing resemblance. It is also found that 65% of the 717 properties included in assessment made savings in their water consumption.

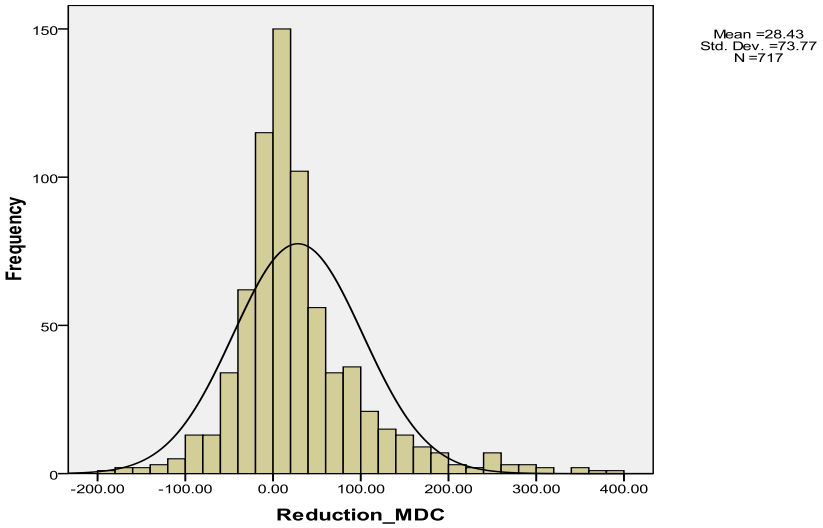


Figure 32- Distribution of the percentage reduction in mean daily water consumption achieved by the Severn Trent – Domestic Water Efficiency Trial

7.8.2.2 Control Group

There was some control group monitoring carried out as part of this trial. This data was not available for inclusion in this report but will be included in the next Evidence Base report.

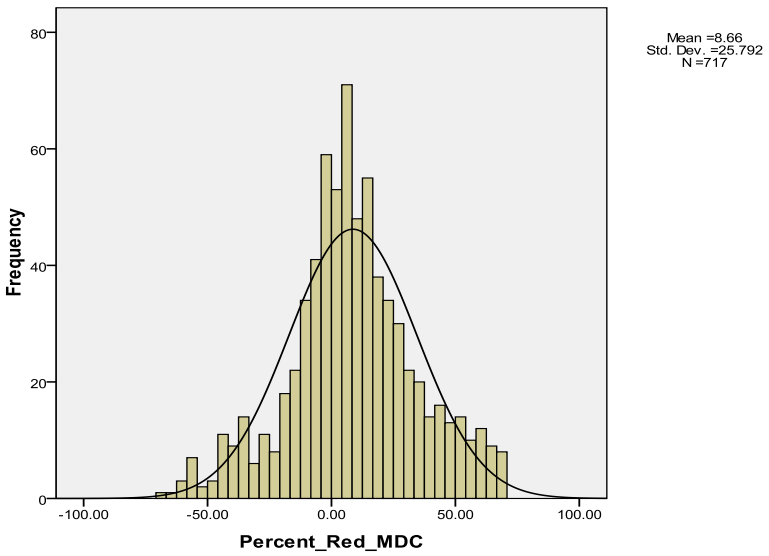


Figure 33 - Distribution of the litre reduction in water use achieved in the Severn Trent – Domestic Water Efficiency Trial

7.8.2.3 Linear Regression

Figure 34 shows a scatter plot of the post-trial and pre-trial mean daily consumption plotted against each other for each of the properties included in the Severn Trent domestic WET. As in the majority of the trials presented in this report, linear regression can be used to generalise the water saving results in this trial. The following equation can be used to estimate the likely post-trial consumption (PostMDC) by inputting a pre-trial consumption (PreMDC):

$$PostMDC = 0.78PreMDC + 25 \qquad 11$$

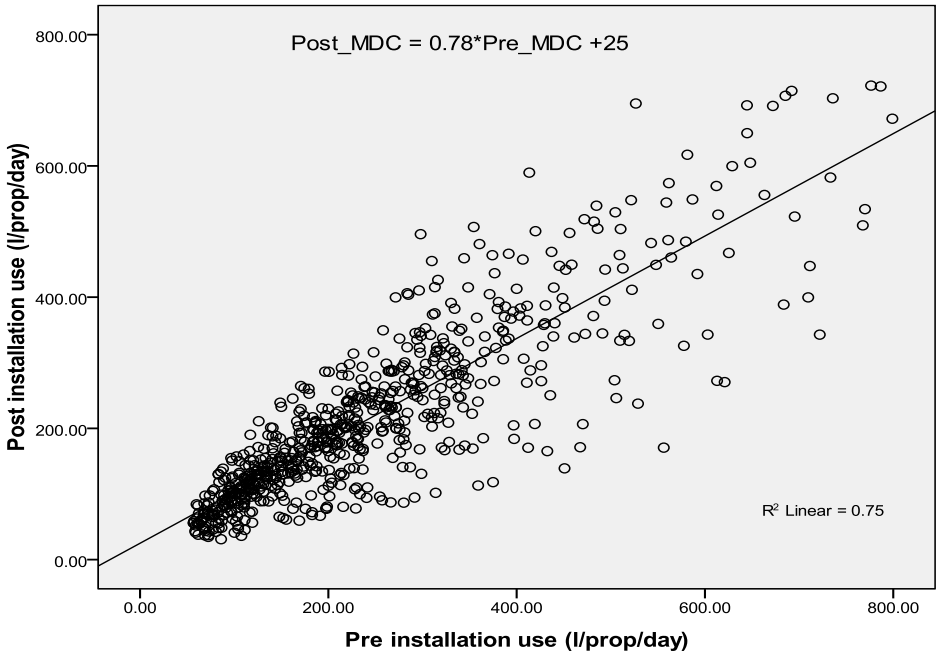


Figure 34 - Use of regression to predict the relationship between the pre-trial and the post-trial MDC consumption

7.8.2.4 Comparison of actual and theoretical water savings

The Severn Trent Domestic Water Efficiency Trial achieved a reduction of about 28 lpd. The mean pre-trial consumption for the 717 properties from which we included data was 243 lpd compared to 215 lpd post-retrofit consumption. Using the assumptions for dual-flush conversion, cistern displacement devices, showers and tap inserts, post-trial consumption has been estimated and compared with the actual measured values. There is a 17 lpd difference between what is measured

and the theoretical savings applied, with the theoretical savings overestimating the measured savings.

Figure 35 shows the difference between actual water saved and the theoretical saving that is estimated to be achieved knowing the devices installed and the estimated water saving that the installed devices produces. For example, if a property is measured to save 35 lpd following retrofitting with a dual-flush conversion device, then the theoretical saving would be 30 lpd (see table adjacent to Figure 35). When this property was plotted on the chart, it would have a value calculated using:

Difference between actual and theoretical water savings = theoretical saving - actual saving

This gives the difference between actual and theoretical savings to be -5 lpd in the given example where the theoretical saving underestimates the actual saving. This process was carried out for each property that was part of the trial. Figure 35 shows that there is a high degree of variability between individual households which makes it difficult to predict how an individual property will respond to retrofitting. However, if the sample is taken as a whole, the theoretical savings values seem to characterise quite well the mean response that can be expected from a large sample of properties.

Theoretical savings for retrofit

	l/prop/day
Toilet to dual-flush	30.0
Toilet to save-a-flush	11.5
shower to water-efficient shower	25.2
Tap inserts	0.9

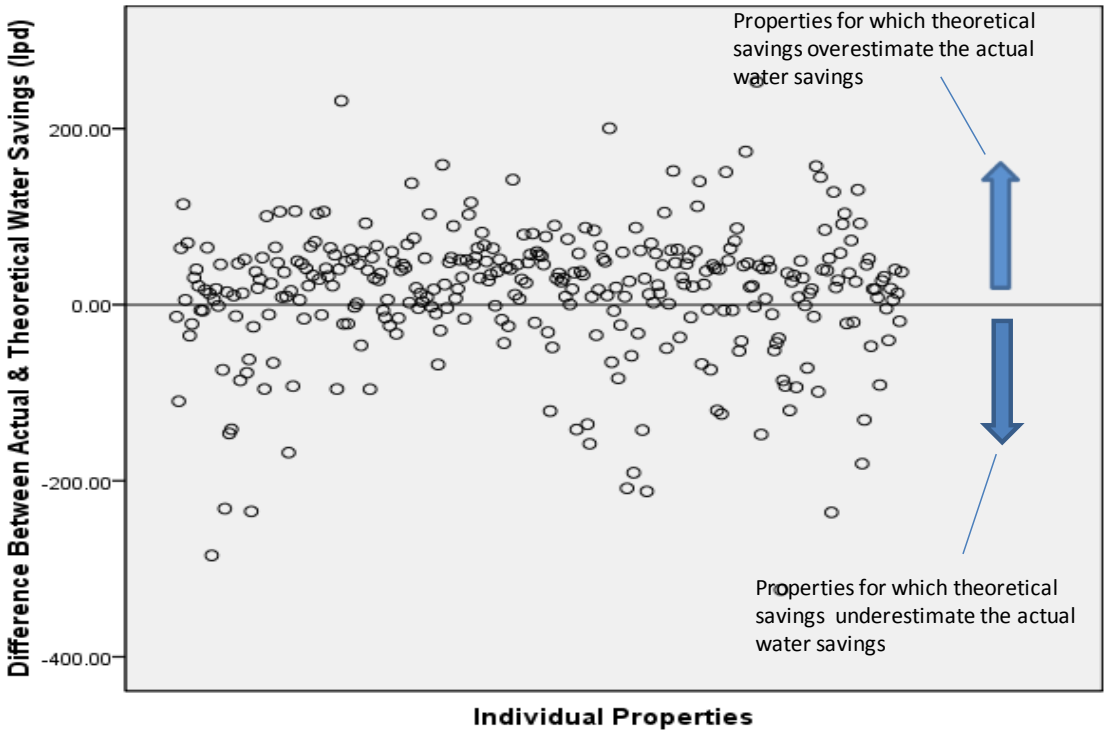


Figure 35- Comparison of the actual and theoretical savings from the Severn Trent Domestic WET

7.8.2.5 Estimated Carbon Emissions and Energy Savings

The carbon emissions and energy savings from the Severn Trent Domestic Water Efficiency Trial are summarised in Table 26. Domestic hot water carbon emissions savings were 75 $kgCO_2$/day and energy indirect carbon savings were 15 $kgCO_2e$/day. In addition to the carbon savings there are also significant energy savings to be made from carrying out water efficiency retrofitting projects such as

this on a large-scale. For the Severn Trent trial, energy savings of 400 kWh/day resulted, working out at an annual saving of £23,360 for the 727 properties included in this assessment.

7.9 Thames Water Self Audit Rateable Value Trial

7.9.1 Summary

Thames Water distributed 1,754 water saving packs to London households between December 2007 and March 2008 to help reduce domestic properties' water consumption. Throughout the project, meter readings were taken at regular intervals, allowing comparison of the water consumption of the participating households before and after the customers receive their water efficiency products. Although all the houses had meters installed, only some of these were used for billing, with the remaining homes paying for water based on the ratable value of their home.

Thames Water wanted to better understand how customers currently use water and how they could use water more wisely. The company also wanted to develop an understanding of the costs and benefits associated with this type of trial to inform our long-term water resources planning.

Educational and physical water efficiency products were supplied to the customers free of charge. Customer feedback was gathered about the following Water Efficiency Products:

- Spray swivel Tap (for the kitchen tap)
- Digital shower timer
- Save-a-flush
- Tap washers (with instructions to help repair leaky taps)
- Shower and tap flow bag
- Bathroom beaker with water saving messages
- Tea towel with water saving messages
- Watering can with water saving message
- Trigger hose gun (available as an option)
- Aerating Showerhead (available as an option)

Most customers rated the products either good or very good. The shower-timers, aerated showerheads and save-a flush were popular and were the most products considered to best conserve water.

Engaging volunteers to take part in the study proved difficult and a number of different approaches were needed to engage the customers despite the products being offered free of charge. Households that paid for water on a metered basis were more likely to volunteer to take part in the study and to return their feedback forms when they did. Thames Water recruited participants by invitation letter, and subsequently by telephone and visiting customers face to face. The key to the success of the self-audit pack was to achieve buy in from the customers who would use the water efficiency products within the pack and complete and return their water diary, not just accepting the water efficiency products. The households which proactively replied to the initial invitation letter seemed far more engaged in the project than those who were recruited through persistent offers and ultimately face to face.

In Thames Water's Business Plan they aim to offer water saving packs to all our household customers between 2010 and 2025. They anticipate that as customer awareness of the water savings possible increases, a greater proportion of customers will take up this offer. Saving hot water in your home also saves energy, so even unmetered customers can save money whilst reducing your environmental impact by saving water.

7.9.2 Results

7.9.2.1 Water savings

Table 27 gives a summary of the key results from the Thames Water Self Audit Rateable Value Trial. Data from 525 properties was used to assess the water savings, an assessment of the uncertainty in the results, the uptake rate, costs information and a summary of carbon and energy savings. Overall water savings for these properties was found to be 21.9 litres per property per day (lpd), or a mean percentage reduction of 1.2%. However, the uptake rate was relatively low, at 6%.

Thames Water Self Audit RV Trial

No. of properties	525	
	Overall - After 3 months	
Water savings (l/prop/day)	21.9	
Water savings (% reduction)	1.2	
	Max	Min
90% Confidence interval (% water saved) after 10 months	44.2	-41.8
90% Confidence interval (litres saved /prop/day) after 10 months	265.2	-221.5
	Overall - After 3 months	
Probability of water savings	0.54	
	Overall	
Uptake rate (%)	6.2	
Cost per property(£)	110.00	
Cost per litre per day (£)	5.03	
	Overall - After 3 months	
Energy indirect carbon emissions saved (kgCO2e/d)	9.9	
Domestic hot water carbon emissions saved (kgCO2/d)	13.1	
Energy saving (kWh/d)	76.0	
Cost of energy saved (£/year)	4436	
Cost of energy saved (£/prop/year)	8	

Table 27 - Summary of key results in the Thames Water Self Audit RV Trial

The 90% confidence interval is also presented in Table 27 and gives us a range of water savings of between 265 lpd and -222 lpd. In terms of percentage water savings this is equivalent to a 90% confidence interval of 44% to -42%. In this case we see that there is a broader 90% confidence interval in this self audit trial compared to the other visit and fix trials in this report.

If the distribution of the water savings is considered it reveals, as in the other trials, that there is some kind of structure to the results. Figures 36 and 37 show the distribution of the litre per property per day and the percentage water use reduction achieved, respectively, for the 525 properties whose data are included in this analysis. This shows 54% of properties that took part in this trial reduced their water usage after retrofitting. The trial also showed that 27% of unmetered and 59% of metered customers saved water.

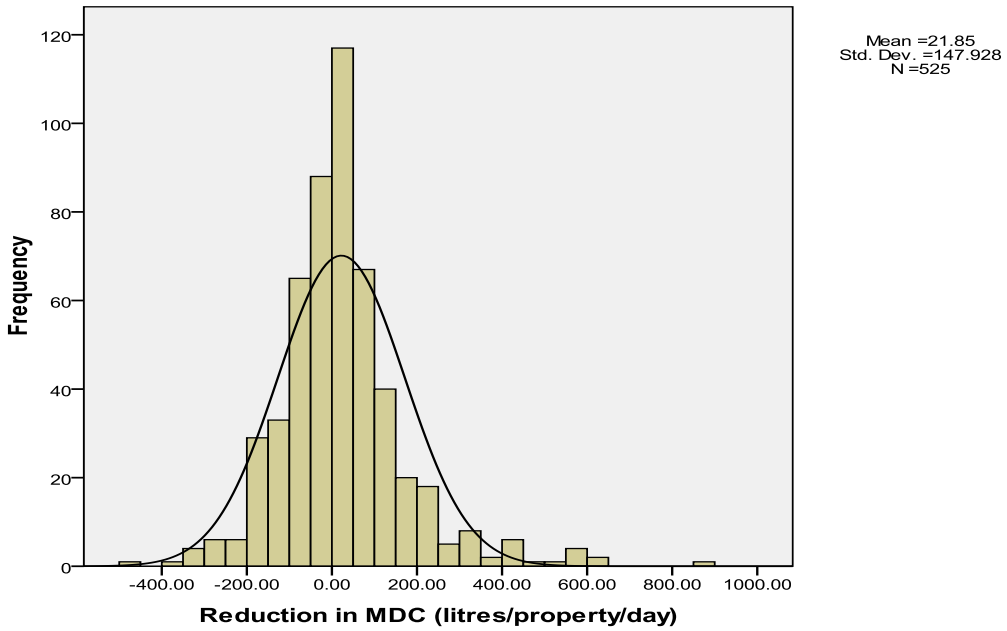


Figure 36 - Distribution of water savings in lpd achieved in the Thames Water Self Audit RV Trial

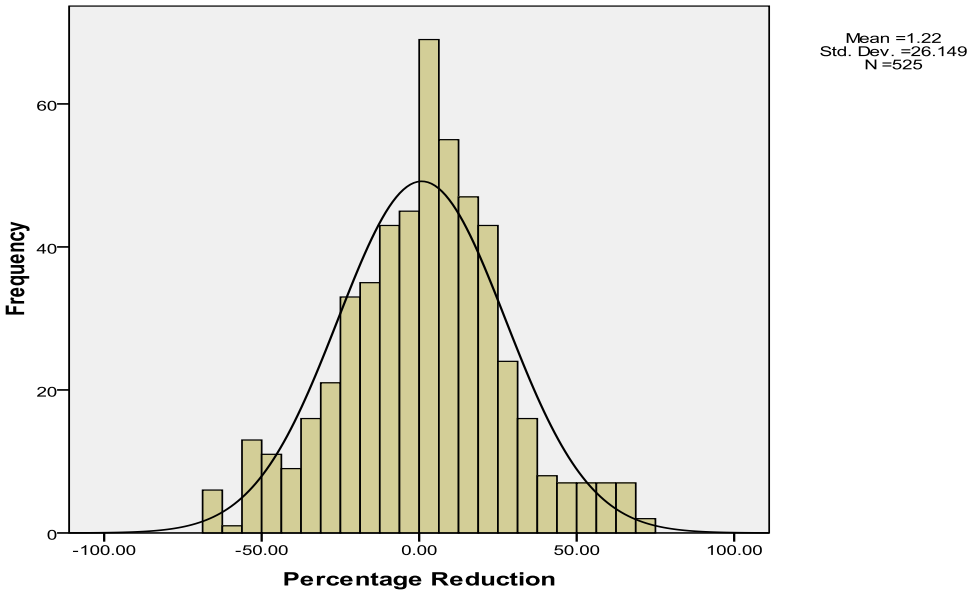


Figure 37 - Distribution of the percentage reduction in water use in the Thames Water Self Audit RV Trial

7.9.2.2 Linear Regression

Figure 38 presents a scatter plot of post-trial consumption against pre-trial consumption for the properties which took part in the Thames Water Self Audit RV Trial. Linear regression was again used to model the relationship between pre-trial and post-trial consumption. This process enables us to generalise the water savings from retrofitting projects. The following equation characterizes the relationship between the post-trial and pre-trial mean daily consumption after approximately 10 months of monitoring:

$$Post\ MDC = 0.78 Pre\ MDC + 89 \qquad 12$$

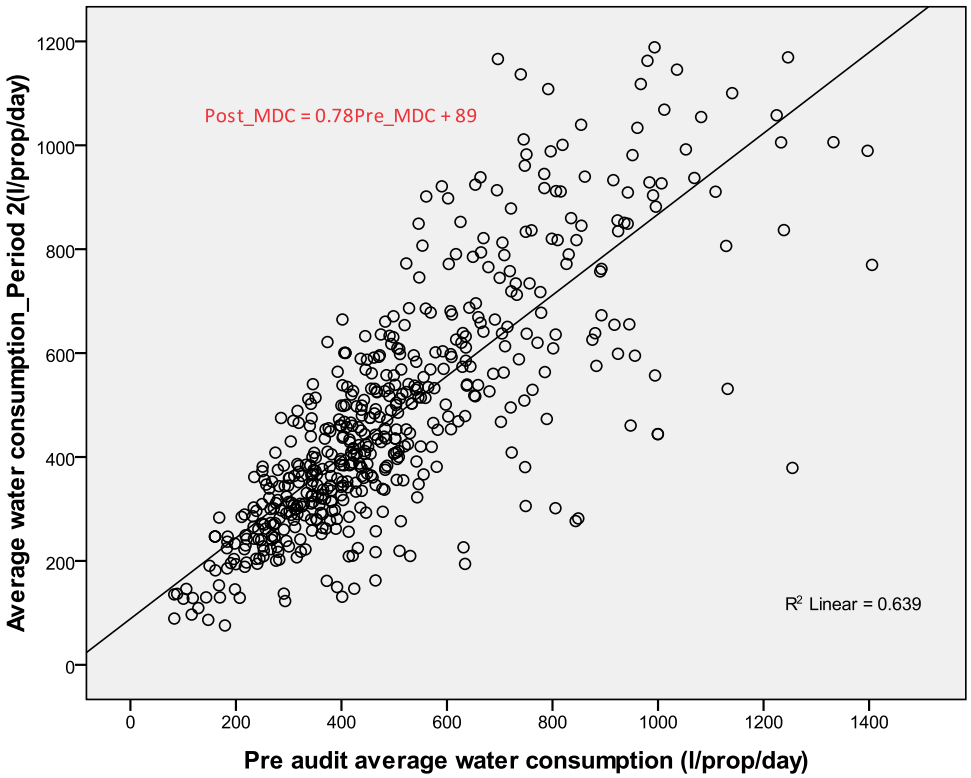


Figure 38 - Scatterplot of post-trial consumption versus pre-trial consumption and using linear regression to model the relationship between them

7.9.2.3 Control Group

There was no monitoring of a control group included as part of this project.

7.9.2.4 Comparison of actual and theoretical water savings

The comparison of actual and theoretical savings was not carried out for this trial.

7.9.2.5 Estimated Carbon Emissions and Energy Savings

The carbon emissions and energy savings from the Thames Water Self Audit RV Trial are summarised in Table 27 above. From our analysis, domestic hot water emissions savings are estimated to be 13 $kgCO_2$/day and energy indirect carbon savings of 10 $kgCO_2e$/day. As we have seen previously, in addition to the carbon savings there are, again, significant energy savings to be made from carrying out large-scale water efficiency retrofitting projects such as this. We estimate that the Thames Water Self Audit RV Trial was responsible for an energy saving of approximately 76 kWh/day. When monetised this gives an annual saving of approximately £4436 for the 525 properties included in our analysis.

8 Scenarios

The Water Saving Group identified problems of transferability as a key barrier to large-scale water efficiency. As a result, the October 2008 Evidence Base report presented scenarios which were extremely well received by the water companies and other stakeholders planning water efficiency projects and trials. Therefore, new scenarios have been developed using the range of savings values identified from the evidence and apply them to a set of possible water efficiency programmes.

The scenarios chosen in order to illustrate how the evidence in this report can be used for water resources planning are as follows:

⇒ Scenario 1: Social Housing
⇒ Scenario 2: Energy company
⇒ Scenario 3: Whole Town
⇒ Scenario 4: Retail Led Retrofit
⇒ Scenario 5: Metering
⇒ Scenario 6: Toilet Amnesty
⇒ Scenario 7: Piggybacking on Government Retrofitting Schemes

Table 28 below summarises the results from the scenarios presented in this chapter. The scenarios have been categorised into 3 different types:

→ Partnership options
→ Company-Driven
→ Government-Led

Partnership options describe ways that various stakeholders, including water companies, social housing providers, local councils and NGOs can work together to deliver cost-effective water savings by retrofitting on a large-scale.

The company-driven option relates to a water company which makes use of the fact that it is carrying out meter installation in a particular area to offer its customers and is able to offer an integrated demand management solution by simultaneously carrying out water efficiency retrofitting in the same homes. In effect the company piggybacks on other internal activities to install devices and engage with customers.

The government-led scenarios require government intervention such as new legislation or funding streams to facilitate novel partnerships and to allow fresh ways for stakeholders to deliver water efficiency in partnership and on a large-scale.

Partnership Options		Best Estimate	Best Case	Worst Case
Scenario 1: Social Housing	AIC (p/m^3)	41.7	8.0	176.6
	AISC (p/m3)	39.4	5.6	174.6
Scenario 2: Energy company	AIC (p/m^3)	13.0	5.9	110.7
	AISC (p/m3)	-7.5	-14.7	90.9
Scenario 3: Whole Town	AIC (p/m^3)	104.8	21.1	575.4
	AISC (p/m3)	84.3	0.5	555.6
Scenario 4: Retail-Led Retrofit	AIC (p/m^3)	1.2	12.0	236.5
	AISC (p/m3)	-1.2	9.7	235.0

Company-Driven		Best Estimate	Best Case	Worst Case
Scenario 5: Metering	AIC (p/m^3)	45.2	15.4	157.8
	AISC (p/m3)	24.7	-5.2	137.8

Government-Led		Best Estimate	Best Case	Worst Case
Scenario 6: Toilet Amnesty	AIC (p/m^3)	7.9	0.0	30.0
	AISC (p/m3)	-12.7	-20.6	9.7
Scenario 7: Piggybacking on Government Retrofitting Schemes	AIC (p/m^3)	13.5	0.0	75.0
	AISC (p/m3)	-7.0	-20.6	55.2

Table 28 – Summary of AIC and AISC results for each of the scenarios

Scenarios 1 to 4 show that partnership is an increasingly attractive option for stakeholders who want to deliver water efficiency. The partnership options offer realistic options for water companies, social housing providers, energy companies, local councils, NGOs and retailers to work together to deliver water efficiency on a large-scale and in the most cost-effective way. The most cost effective of the partnership options is Scenario 2 which describes the opportunity that currently exists for water companies and energy companies to take advantage of the fact that water-efficient measures are now included under the CERT scheme, and can, therefore, receive a credit for carbon emissions saved through reducing household water consumption (see section 3.1 for more about the CERT scheme).

However, Scenario 5 also provides a cost effective way of delivering water savings through a water company integrating its activities to carry out metering on a zonal basis and piggyback on this activity to carry out retrofitting in the same properties. Partnership with a social housing provider remains a good option particularly because of the high uptake rates which are achievable and the potential for housing providers to facilitate customer engagement to encourage behaviour change. The retail-led scenario (Scenario 4) provides a means of working with retailers of water-efficient products, harnesses their close relationships with customers and involves them formally in a retrofitting project. The whole-town approach (Scenario 3) involves several stakeholders including local government and non-governmental organisations who can tailor engagement methods to the particular needs of the town to generate interest and boost participation.

Scenarios 6 looks forward to the updating of the Decent Homes Standard[30] to include the installation of showers over baths, and combines this with a government incentive scheme to replace old toilets in social housing with new ones. Scenario 7 gives a view of what could be possible were existing government energy efficiency programmes extended to include water efficiency, for example through the Community Energy Saving Programme[31] (CESP). It should be highlighted that by working in partnership in a way which combines 2 or more of these scenarios this could lead to further cost savings in large-scale water efficiency projects. For example, Scenarios 2 and 5, integrated demand management in partnership with an energy company, could result in improved cost effectiveness.

[30] http://www.decenthomesstandard.co.uk/index.php
[31] http://www.decc.gov.uk/en/content/cms/what_we_do/consumers/saving_energy/cesp/cesp.aspx

Each scenario is described in detail below, with the input data used in the AISC spreadsheet tool provided. Results from the analyses are displayed for the best estimate, best case and worst case variations of each scenario.

8.1 Scenario 1 – Social Housing

A social housing provider and a water company form a partnership brokered by the local council or Waterwise. They carry out retrofitting of toilets and taps in social housing along with engagement to encourage tenants to change their behaviour with regard to water use.

Table 29 - Data input into the AISC spreadsheet tool for scenario 1

Scenario 1 - Social Housing Partnership with Water Company		
Parameter	**Value**	**Comments / build-up**
Target households		
Best estimate	10,000	Based on the number of homes managed by a relatively small housing association
Max expected	20,000	
Min expected	8,000	
Implemented as a one-off scheme?	Yes	
Asset life (years)	10	Waterwise estimate
Half life of sheme savings (years)		
Best estimate	5	Waterwise estimate
Best case	20	
Worst case	2.5	
Uptake rates		
Best estimate	55%	Captive market; best case based on Sutton and East Surrey Preston estate project
Best case	60%	
Worst case	40%	
Implementation period (years)	1	
Capital expenditure	£0.00	As per WR25b guidance.
Operational costs where scheme taken up		
Equipment costs (per property)		
Best estimate	£15.00	Waterwise estimate; toilet and tap retrofit; one toilet per home; water company pays full cost of devices
Best case	£10.00	
Worst case	£25.00	
Installation costs (per property)		
Best estimate	£15.00	Installation costs shared 50:50 between social housing provide and the water company
Best case	£5.00	
Worst case	£20.00	
Administration costs (per property)		
Best estimate	£0.10	Procurement of EcoBETA and tap inserts
Best case	£0.00	
Worst case	£0.50	
Recruitment costs (per propoerty)		
Best estimate	£0.50	Letter to participants, which may be done by the housing association
Best case	£0.00	
Worst case	£1.00	
Operational costs where scheme NOT taken up		
Administration costs (per property)		
Best estimate	£0.00	
Best case	£0.00	
Worst case	£0.00	
Recruitment costs (per property)		
Best estimate	£0.50	Letter to participants.
Best case	£0.00	
Worst case	£1.00	
Water savings (litres per property per day)		
Best estimate	34.00	Wessex Water - Water Efficiency Trial
Best case	45.00	Sutton and East Surrey Preston project
Worst case	20.00	South West Water - Water Efficiency Trial (dual flush conversion element of trial)

The AIC, AISC and NPV values for Scenario 1 are given in Table 30 followed by a graphical representation of the yield over time and the yield over the range of uncertainties.

Table 30 - AIC, AISC and NPV results for Scenario 1

		Best Estimate	Best Case	Worst Case
	AIC (p/m^3)	41.74	8.03	176.58
	AISC (p/m^3)	39.40	5.64	174.62
NPV values				
	WAFU*(Ml)	323.91	2017.98	59.53
	Capex (£M)	0	0	0
	Opex (£M)	0.13519	0.162	0.10512
	Social & Env Costs (£M)	-0.008	-0.048	-0.001

Figure 39 - Annual yield for scenario 1

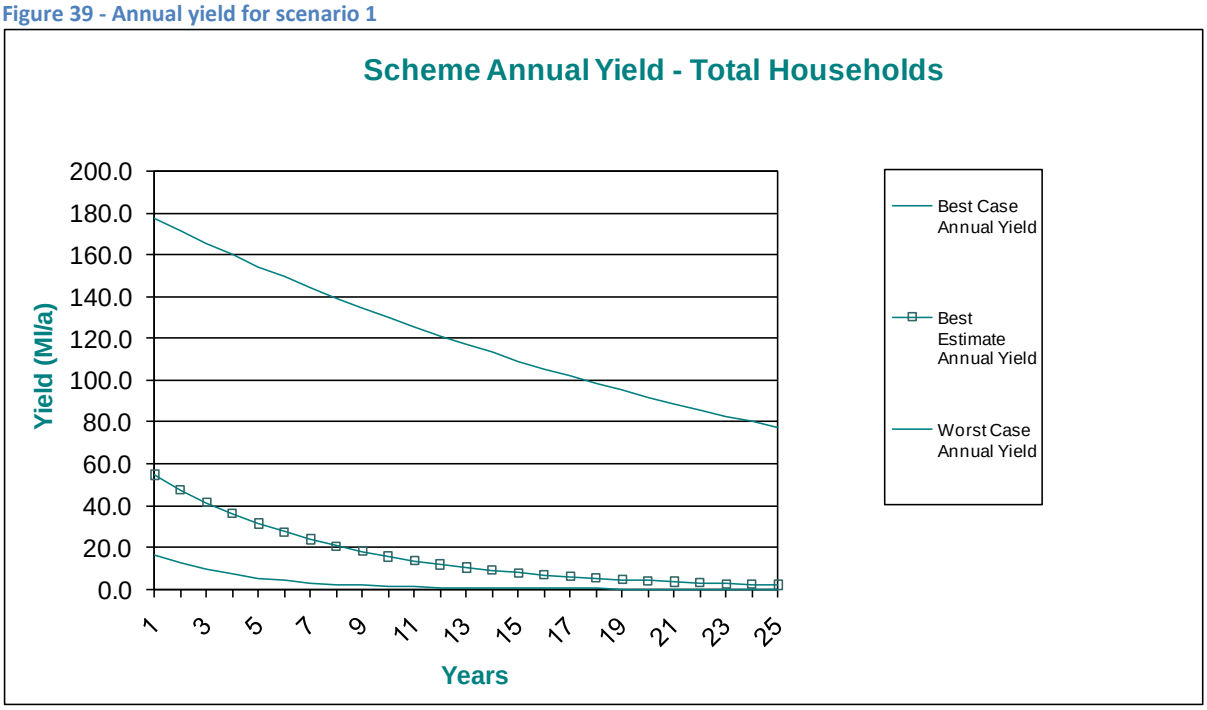
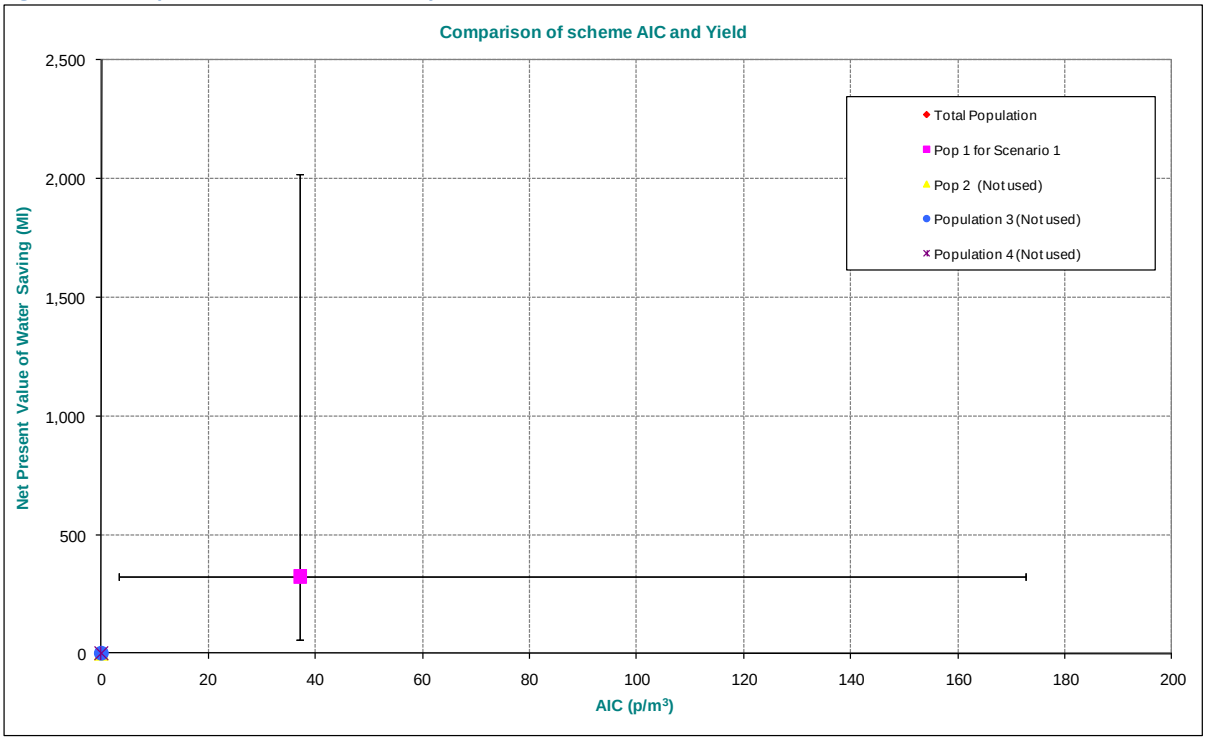


Figure 40 - Comparison of scheme AIC and yield for scenario 1



8.2 Scenario 2 - Energy Company

A water company and an energy company work together to carry out simultaneous water and energy retrofitting in private housing including the installation of water-efficient showerheads, converting toilets to dual-flush and installing inserts and fixing leaking taps. Use is made of the CERT scheme to gain credit for hot water savings made as a result of their planned collaboration. In addition combined water and energy engagement is organised to run alongside the retrofitting to encourage behaviour change with regard to water and energy use.

Table 31 - Data input into the AISC spreadsheet tool for scenario 2

Scenario 2 - Energy Company		
Parameter	**Value**	**Comments / build-up**
Target households		
Best estimate	15,000	Waterwise estimate
Max expected	20,000	
Min expected	10,000	
Implemented as a one-off scheme?	Yes	
Asset life (years)	10	Waterwise estimate
Half life of sheme savings (years)		
Best estimate	5	Waterwise estimate
Best case	20	
Worst case	2.5	
Uptake rates		
Best estimate	15%	Enhanced uptake rates because of involvement of energy company and a coordinated campaign to generate interest.
Best case	20%	
Worst case	10%	
Implementation period (years)	1	
Capital expenditure	£0.00	As per WR25b guidance.
Operational costs where scheme taken up		
Equipment costs (per property)		
Best estimate	£5.00	Waterwise estimate; water company claims cold water savings and energy company claims hot water savings. The result is that the energy company is able to claim credit for carbon savings through the Carbon Emission Reduction Target Programme and uses some of this to pay for the products.
Best case	£0.00	
Worst case	£7.50	
Installation costs (per property)		
Best estimate	£5.00	Installation costs shared 50:50 between the water company and the energy company. This includes customer engagement to help ensure that positive water using behaviours are encouraged.
Best case	£10.00	
Worst case	£20.00	
Administration costs (per property)		
Best estimate	£0.10	Procurement of EcoBETA, showerheads and tap inserts
Best case	£0.00	
Worst case	£0.50	
Recruitment costs (per propoerty)		
Best estimate	£0.50	Letter to participants
Best case	£0.00	
Worst case	£1.00	
Operational costs where scheme NOT taken up		
Administration costs (per property)		
Best estimate	£0.00	
Best case	£0.00	
Worst case	£0.00	
Recruitment costs (per property)		
Best estimate	£0.50	Letter to participants.
Best case	£0.00	
Worst case	£1.00	
Water savings (litres per property per day)		
Best estimate	38.00	Thames Water Measured Visit and Fix Trial
Best case	41.00	Anglian Water Ipswich Area WEM Trial
Worst case	20.00	South West Water - Water Efficiency Trial (results for ecobeta installation)

The AIC, AISC and NPV values for Scenario 2 are given in Table 32 followed by a graphical representation of the yield over time and the yield over the range of uncertainties.

Table 32 - AIC, AISC and NPV results for Scenario 2

		Best Estimate	Best Case	Worst Case
	AIC (p/m^3)	13.04	5.87	110.73
	AISC (p/m^3)	-7.48	-14.72	90.90
NPV values				
	WAFU*(Ml)	148.10	612.87	18.60
	Capex (£M)	0	0	0
	Opex (£M)	0.019305	0.036	0.0206
	Social & Env Costs (£M)	-0.030	-0.126	-0.004

Figure 41- Annual yield for scenario 2

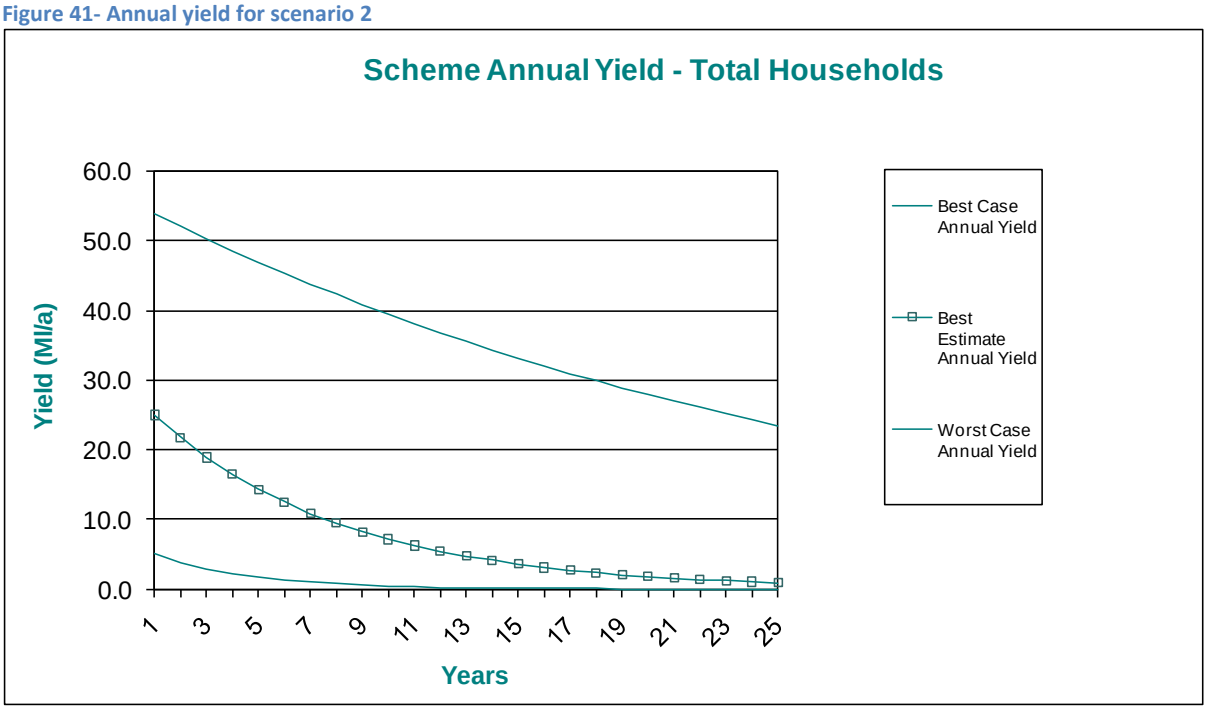
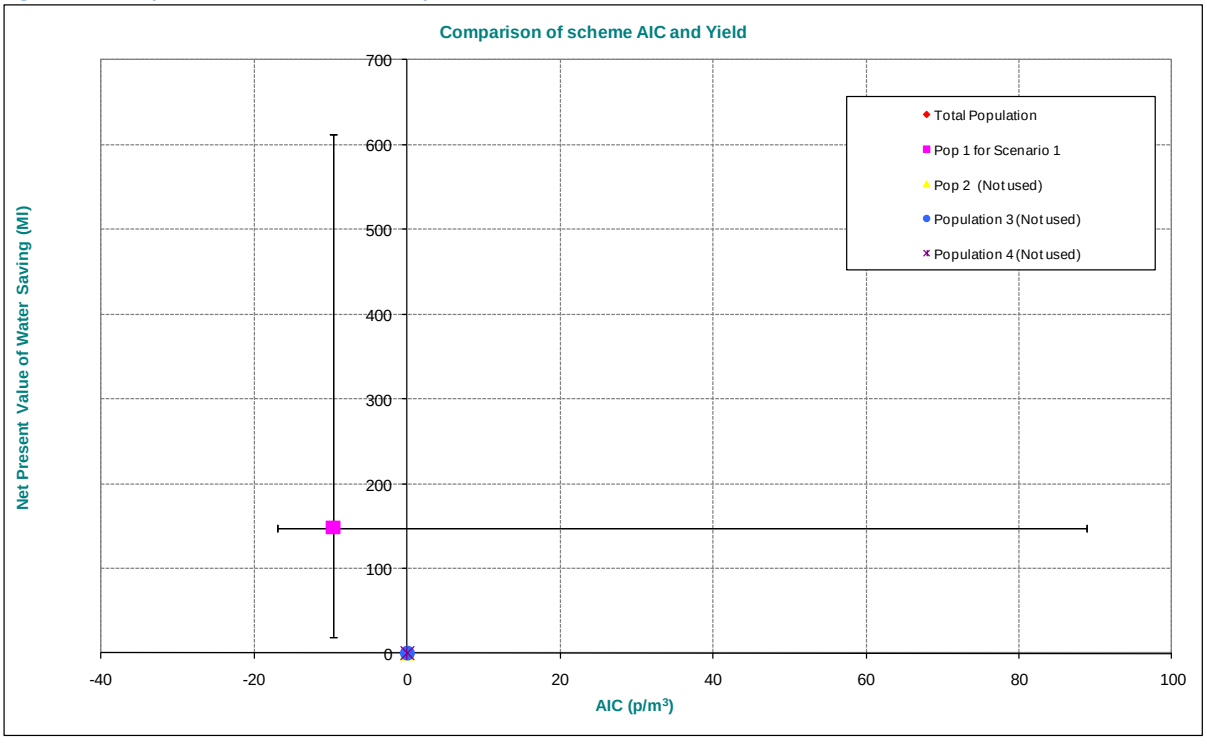


Figure 42- Comparison of scheme AIC and yield for scenario 2



8.3 Scenario 3 – Whole Town

A water company retrofits a whole town to install water-efficient showers and tap inserts in addition to converting toilets to dual-flush.

Table 33- Data input into the AISC spreadsheet tool for scenario 3

Scenario 3 - Whole Town		
Parameter	**Value**	**Comments / build-up**
Target households		
Best estimate	35,000	Based on a plan to retrofit the whole of a medium sized town by a water company in partnership witih local government and non-governmental organisations.
Max expected	70,000	
Min expected	15,000	
Implemented as a one-off scheme?	Yes	
Asset life (years)	10	Waterwise estimate
Half life of sheme savings (years)		
Best estimate	5	Waterwise estimate
Best case	20	
Worst case	2.5	
Uptake rates		
Best estimate	15%	Enhanced uptake rates because of involvement of local government and a coordinated campaign to generate interest.
Best case	20%	
Worst case	10%	
Implementation period (years)	2	
Capital expenditure	£0.00	As per WR25b guidance.
Operational costs where scheme taken up		
Equipment costs (per property)		
Best estimate	£25.00	Waterwise estimate; Could be lower if used CERT credits as in Scenario 2.
Best case	£18.00	
Worst case	£30.00	
Installation costs (per property)		
Best estimate	£60.00	Estimate from Evidence Base Phase II - Severn Trent Domestic WET, United Utilities Home Audit Trial
Best case	£20.00	
Worst case	£120.00	
Administration costs (per property)		
Best estimate	£0.10	Procurement of EcoBETA, showerheads and tap inserts
Best case	£0.00	
Worst case	£0.50	
Recruitment costs (per propoerty)		
Best estimate	£1.00	Letter to participants
Best case	£1.50	
Worst case	£2.00	
Operational costs where scheme NOT taken up		
Administration costs (per property)		
Best estimate	£0.00	
Best case	£0.00	
Worst case	£0.00	
Recruitment costs (per property)		
Best estimate	£0.50	Letter to participants.
Best case	£0.00	
Worst case	£1.00	
Water savings (litres per property per day)		
Best estimate	38.00	Thames Water Measured Visit and Fix Trial
Best case	45.00	Sutton and East Surrey Preston project
Worst case	20.00	South West Water - Water Efficiency Trial (results for ecobeta installation)

The AIC, AISC and NPV values for Scenario 3 are given in Table 34 followed by a graphical representation of the yield over time and the yield over the range of uncertainties.

Table 34 - AIC, AISC and NPV results for Scenario 3

		Best Estimate	Best Case	Worst Case
	AIC (p/m^3)	104.80	21.14	575.43
	AISC (p/m^3)	84.28	0.54	555.59
NPV values				
	WAFU*(Ml)	345.57	2354.31	27.91
	Capex (£M)	0	0	0
	Opex (£M)	0.362145	0.4977	0.160575
	Social & Env Costs (£M)	-0.071	-0.485	-0.006

Figure 43 - Annual yield for scenario 3

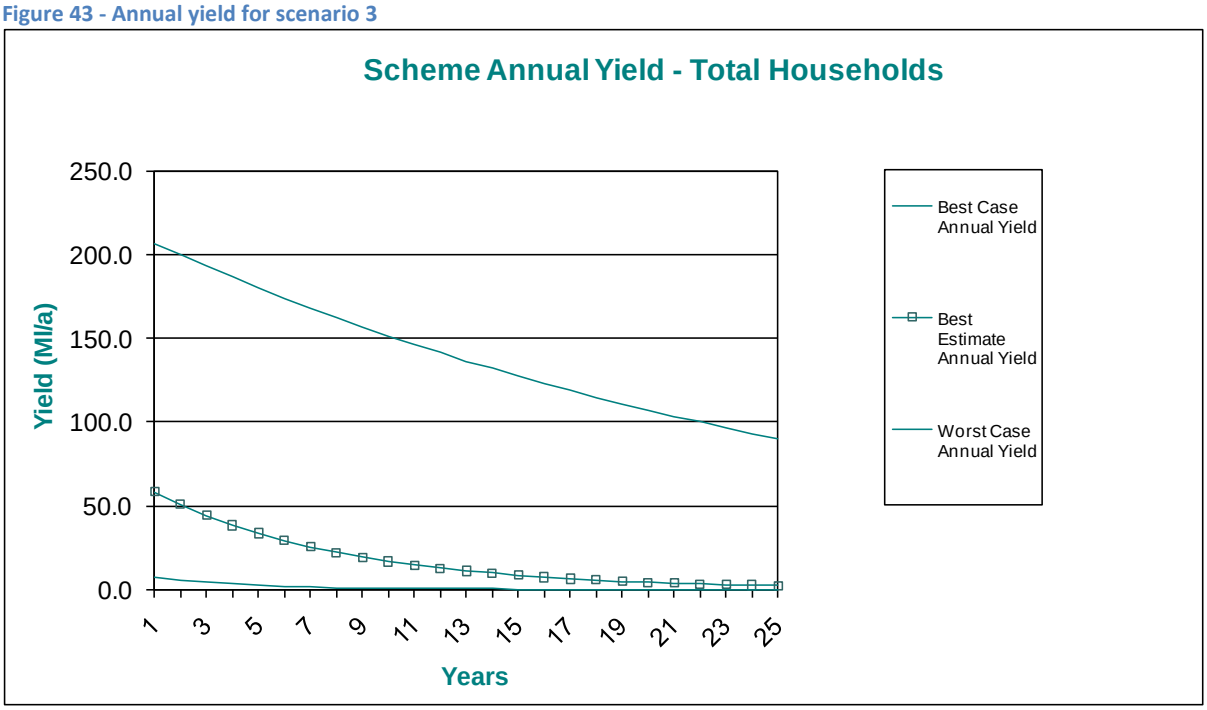
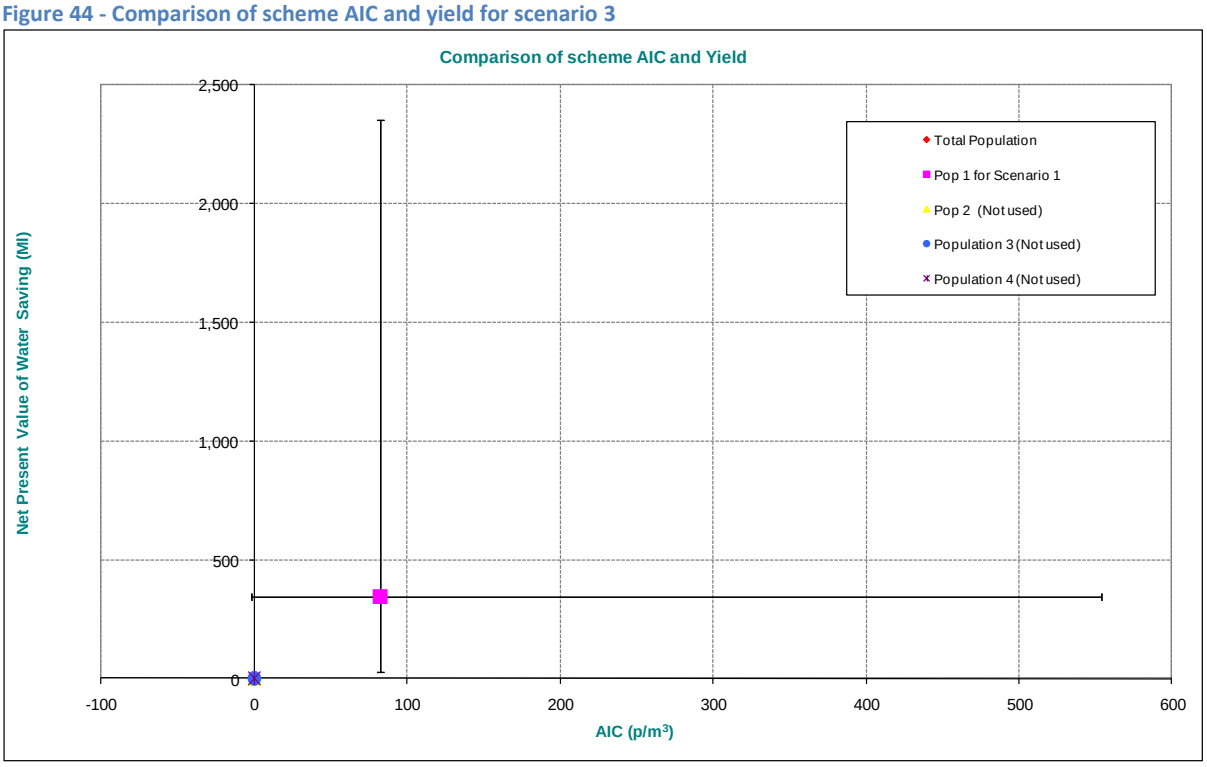


Figure 44 - Comparison of scheme AIC and yield for scenario 3



8.4 Scenario 4 – Retail-Led Retrofit

A retailer partners with a water company to make water-efficient products available to the public in their stores in a specific town at a discounted price.

Table 35 - Data input into the AISC spreadsheet tool for scenario 4

Scenario 4 - Retail-Led Retrofit		
Parameter	**Value**	**Comments / build-up**
Target households		
Best estimate	25,000	Waterwise estimate - based on likely number visitor to the water efficient products section of a large retailer's store in a medium sized town over the course of a year.
Max expected	30,000	
Min expected	20,000	
Implemented as a one-off scheme?	Yes	
Asset life (years)	10	Waterwise estimate
Half life of sheme savings (years)		
Best estimate	5	Waterwise estimate
Best case	20	
Worst case	2.5	
Uptake rates		
Best estimate	10%	Waterwise estimate
Best case	15%	
Worst case	5%	
Implementation period (years)	1	
Capital expenditure	£0.00	As per WR25b guidance.
Operational costs where scheme taken up		
Equipment costs (per property)		
Best estimate	£0.00	The water company contributes £15 to the cost of equipment to be installed in the home, the remainder is paid for by the customer but the retailer may also contribute.
Best case	£15.00	
Worst case	£30.00	
Installation costs (per property)		
Best estimate	£0.00	Installation costs are paid for by the customer but the retailer organises for installation to be carried out by an approved plumber and may choose to contribute towards this.
Best case	£0.00	
Worst case	£0.00	
Administration costs (per property)		
Best estimate	£0.00	Procurement of EcoBETA, showerheads and tap inserts
Best case	£0.00	
Worst case	£0.00	
Recruitment costs (per propoerty)		
Best estimate	£0.50	Letter to participants. Part paid by the retailer
Best case	£0.00	
Worst case	£1.00	
Operational costs where scheme NOT taken up		
Administration costs (per property)		
Best estimate	£0.00	
Best case	£0.00	
Worst case	£0.00	
Recruitment costs (per property)		
Best estimate	£0.50	Letter to participants. Part paid by the retailer
Best case	£0.00	
Worst case	£1.00	
Water savings (litres per property per day)		
Best estimate	25.00	Waterwise estimate
Best case	30.00	Waterwise estimate
Worst case	10.00	Waterwise estimate

The AIC, AISC and NPV values for Scenario 4 are given in the Table 36 followed by a graphical representation of the yield over time and the yield over the range of uncertainties.

Table 36 - AIC, AISC and NPV results for Scenario 4

		Best Estimate	Best Case	Worst Case
	AIC (p/m^3)	1.15	12.04	236.51
	AISC (p/m^3)	-1.16	9.66	234.99
NPV values				
	WAFU*(Ml)	108.26	504.49	9.30
	Capex (£M)	0	0	0
	Opex (£M)	0.00125	0.06075	0.022
	Social & Env Costs (£M)	-0.003	-0.012	0.000

Figure 45 - Annual yield for scenario 4

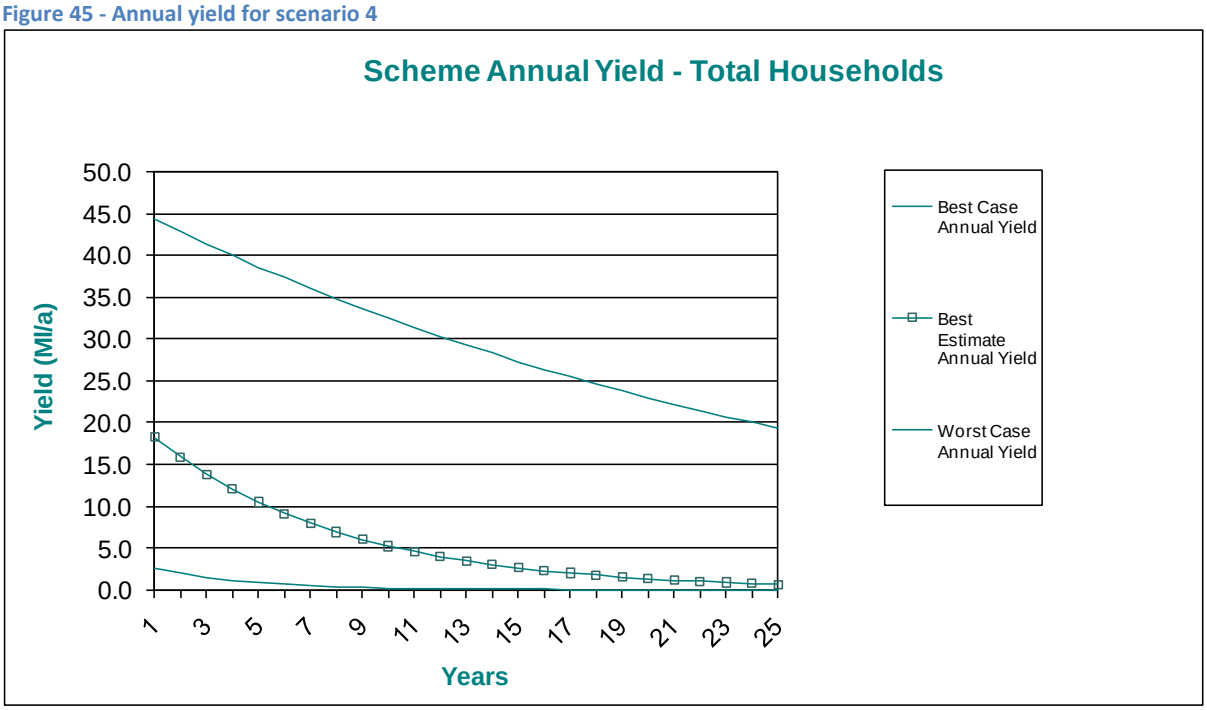
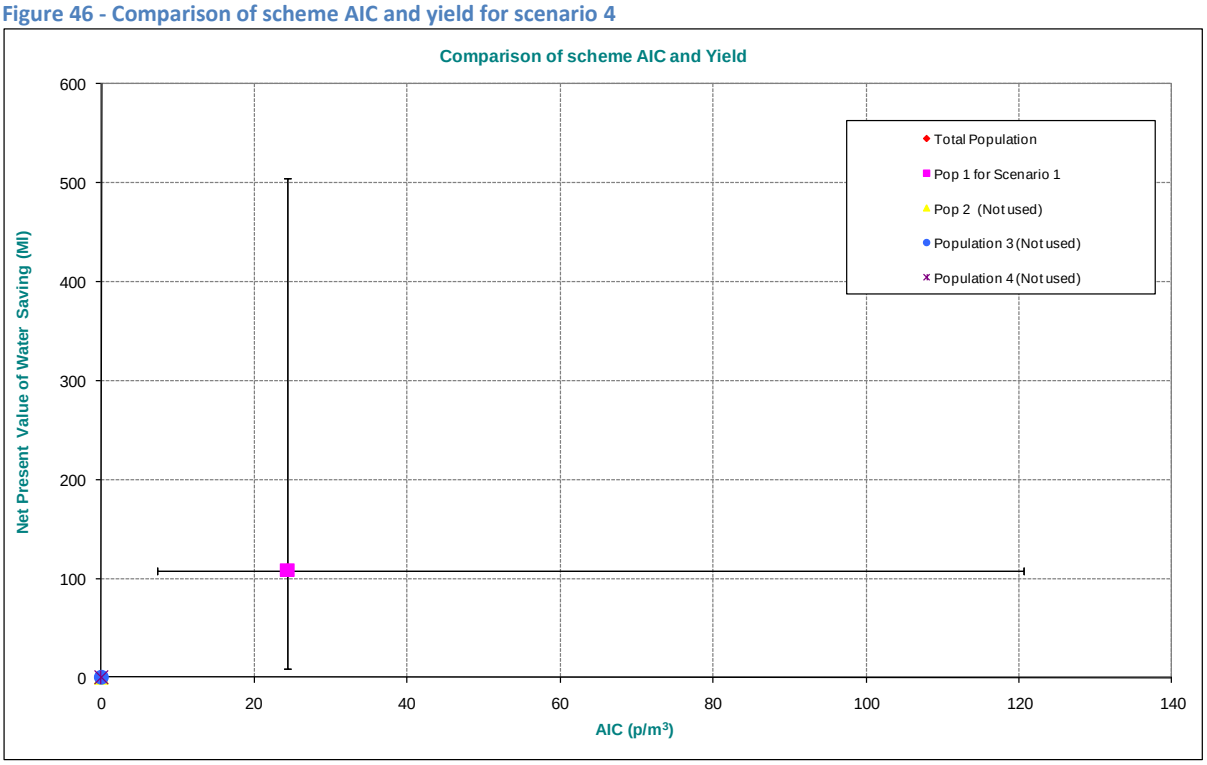


Figure 46 - Comparison of scheme AIC and yield for scenario 4



8.5 Scenario 5 – Metering

A water company carries out an integrated demand management programme consisting of an enhanced zonal metering programme which includes water efficiency retrofitting of showers, taps and toilets in the area chosen to be metered.

Table 37 - Data input into the AISC spreadsheet tool for scenario 5

Scenario 5 - Metering		
Parameter	**Value**	**Comments / build-up**
Target households		
Best estimate	55,000	Based on zonal, compulsory metering of an entire town and offering customers the opportunity to have their homes retrofitted.
Max expected	85,000	
Min expected	35,000	
Implemented as a one-off scheme?	Yes	
Asset life (years)	10	Waterwise estimate
Half life of sheme savings (years)		
Best estimate	5	Waterwise estimate
Best case	20	
Worst case	2.5	
Uptake rates		
Best estimate	10%	Enhanced uptake rates because of because of the compulsory nature of the metering programme, and with the surveyors interacting with customers there is likely to be significant opportunity to convince customers to switch to meter charging and to take part in the water efficiency part of the project.
Best case	15%	
Worst case	10%	
Implementation period (years)	2	
Capital expenditure	£0.00	As per WR25b guidance.
Operational costs where scheme taken up		
Equipment costs (per property)		
Best estimate	£19.00	Waterwise estimate; toilets to dual flush, taps and showerheads included.
Best case	£17.00	
Worst case	£25.00	
Installation costs (per property)		
Best estimate	£20.00	Waterwise estimate; Reduced costs due to the fact that metering work is going ahead and hence can share resources to make water efficiency a seamless part of the enhanced metering programme.
Best case	£15.00	
Worst case	£25.00	
Administration costs (per property)		
Best estimate	£0.50	Procurement of EcoBETA, showerheads and tap inserts
Best case	£0.00	
Worst case	£1.00	
Recruitment costs (per propoerty)		
Best estimate	£0.50	Letter to participants
Best case	£0.00	
Worst case	£1.00	
Operational costs where scheme NOT taken up		
Administration costs (per property)		
Best estimate	£0.00	
Best case	£0.00	
Worst case	£0.00	
Recruitment costs (per property)		
Best estimate	£0.50	Letter to participants.
Best case	£0.00	
Worst case	£1.00	
Water savings (litres per property per day)		
Best estimate	41.00	Anglian Water Ipswich Trial
Best case	50.00	Waterwise estimate
Worst case	25.00	Waterwise estimate

The AIC, AISC and NPV values for Scenario 5 are given in Table 38 followed by a graphical representation of the yield over time and the yield over the range of uncertainties.

Table 38 - AIC, AISC and NPV results for Scenario 5

		Best Estimate	Best Case	Worst Case
	AIC (p/m^3)	45.20	15.41	157.82
	AISC (p/m^3)	24.67	-5.19	137.83
NPV values				
	WAFU*(Ml)	390.60	2382.34	81.39
	Capex (£M)	0	0	0
	Opex (£M)	0.17655	0.3672	0.12845
	Social & Env Costs (£M)	-0.080	-0.491	-0.016

Figure 47 - Annual yield for scenario 5

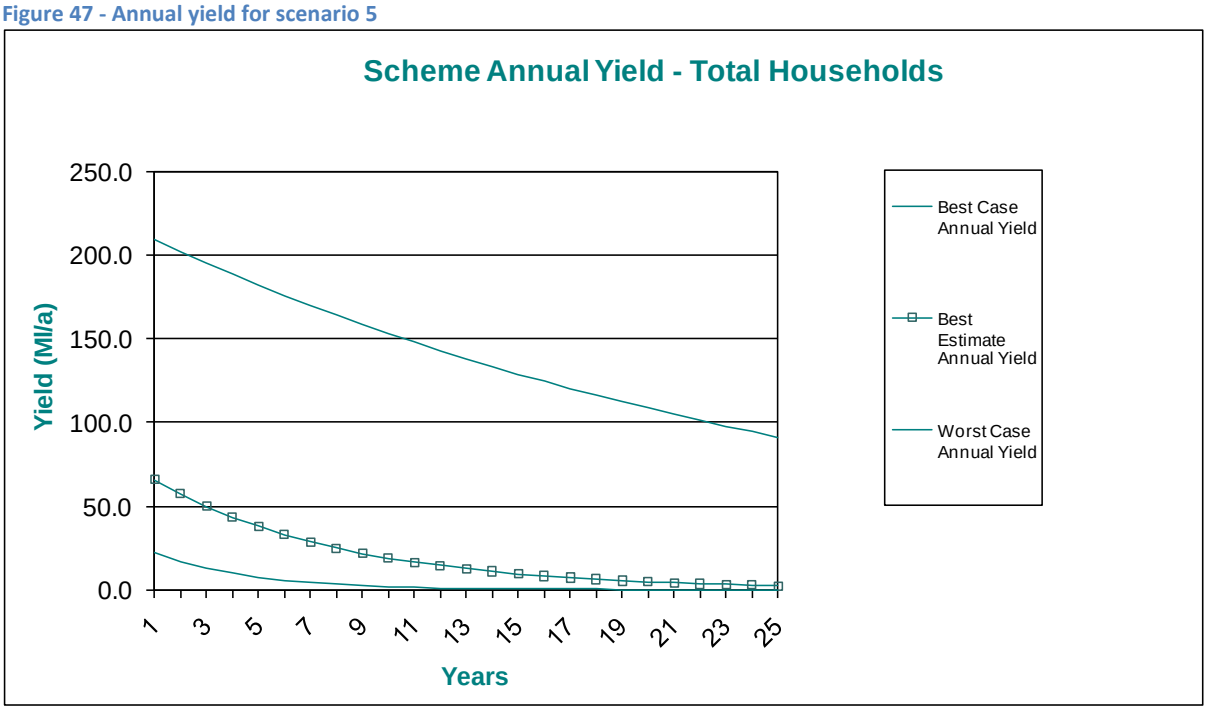
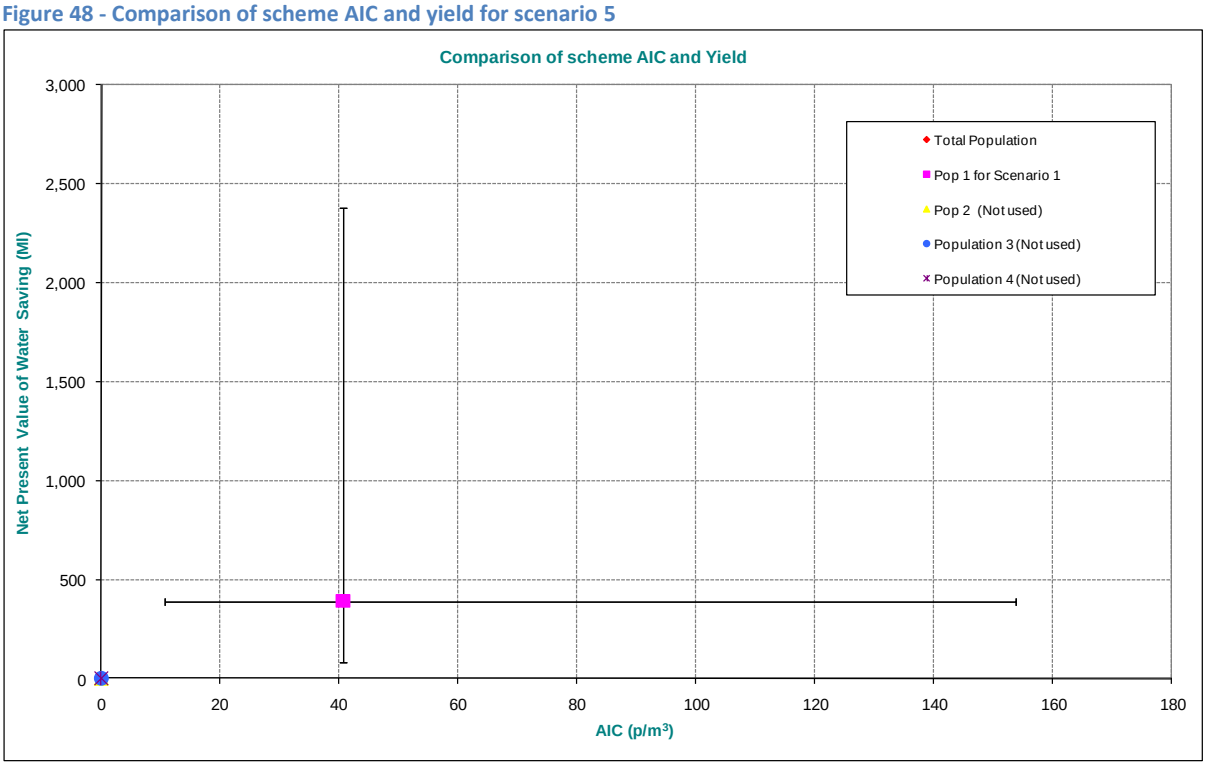


Figure 48 - Comparison of scheme AIC and yield for scenario 5



8.6 Scenario 6 – Toilet Amnesty

A Government sponsored toilet scrappage scheme is introduced which would allows replacement of old, single flush toilets with new dual-flush toilets, and is combined with a revised Decent Homes Programme, which allows for the installation of showers as part of refurbishment work in social housing. Social housing providers would work with water companies to secure Government funding for the proposed refurbishment work.

Table 39 - Data input into the AISC spreadsheet tool for scenario 6

Scenario 6 - Toilet Amnesty		
Parameter	**Value**	**Comments / build-up**
Target households		
Best estimate	5,000	A government sponsored initiative through which water company partners with a social housing providers to deliver refurbishment of water using devices in the home under the Decent Homes Scheme. This includes a toilet amnesty scheme to ensure all toilets are dual flush, installation of a
Max expected	7,500	
Min expected	3,000	
Implemented as a one-off scheme?	Yes	
Asset life (years)	10	Waterwise estimate
Half life of sheme savings (years)		
Best estimate	5	Waterwise estimate
Best case	20	
Worst case	2.5	
Uptake rates		
Best estimate	90%	Enhanced uptake rates due to the involvment of the Decent Homes Initiative and of the social housing provider.
Best case	100%	
Worst case	80%	
Implementation period (years)	2	
Capital expenditure	£0.00	As per WR25b guidance.
Operational costs where scheme taken up		
Equipment costs (per property)		
Best estimate	£5.00	Waterwise estimate; Refurbishment paid for through the Decent Homes Programme. But further equipment such as shower timers may be supplied by the company to encourage behaviour change.
Best case	£0.00	
Worst case	£7.50	
Installation costs (per property)		
Best estimate	£5.00	Waterwise estimate; Installation paid for through the Decent Homes Programme, though the water company may choose to carry out surveys or engage customers to encourage behaviour change.
Best case	£0.00	
Worst case	£10.00	
Administration costs (per property)		
Best estimate	£0.50	Procurement of toilets, showerheads and tap inserts
Best case	£0.00	
Worst case	£1.00	
Recruitment costs (per propoerty)		
Best estimate	£0.50	Letter to participants
Best case	£0.00	
Worst case	£1.00	
Operational costs where scheme NOT taken up		
Administration costs (per property)		
Best estimate	£0.00	
Best case	£0.00	
Worst case	£0.00	
Recruitment costs (per property)		
Best estimate	£0.50	Letter to participants.
Best case	£0.00	
Worst case	£1.00	
Water savings (litres per property per day)		
Best estimate	65.00	
Best case	75.00	Preston Water Efficiency Initiative
Worst case	50.00	

The AIC, AISC and NPV values for Scenario 6 are given in Table 40 followed by a graphical representation of the yield over time and the yield over the range of uncertainties.

Table 40 - AIC, AISC and NPV results for Scenario 6

		Best Estimate	Best Case	Worst Case
	AIC (p/m^3)	7.90	0.00	29.99
	AISC (p/m^3)	-12.65	-20.60	9.69
NPV values				
	WAFU*(Ml)	506.66	2102.06	111.62
	Capex (£M)	0	0	0
	Opex (£M)	0.04005	0	0.03348
	Social & Env Costs (£M)	-0.104	-0.433	-0.023

Figure 49 - Annual yield for scenario 6

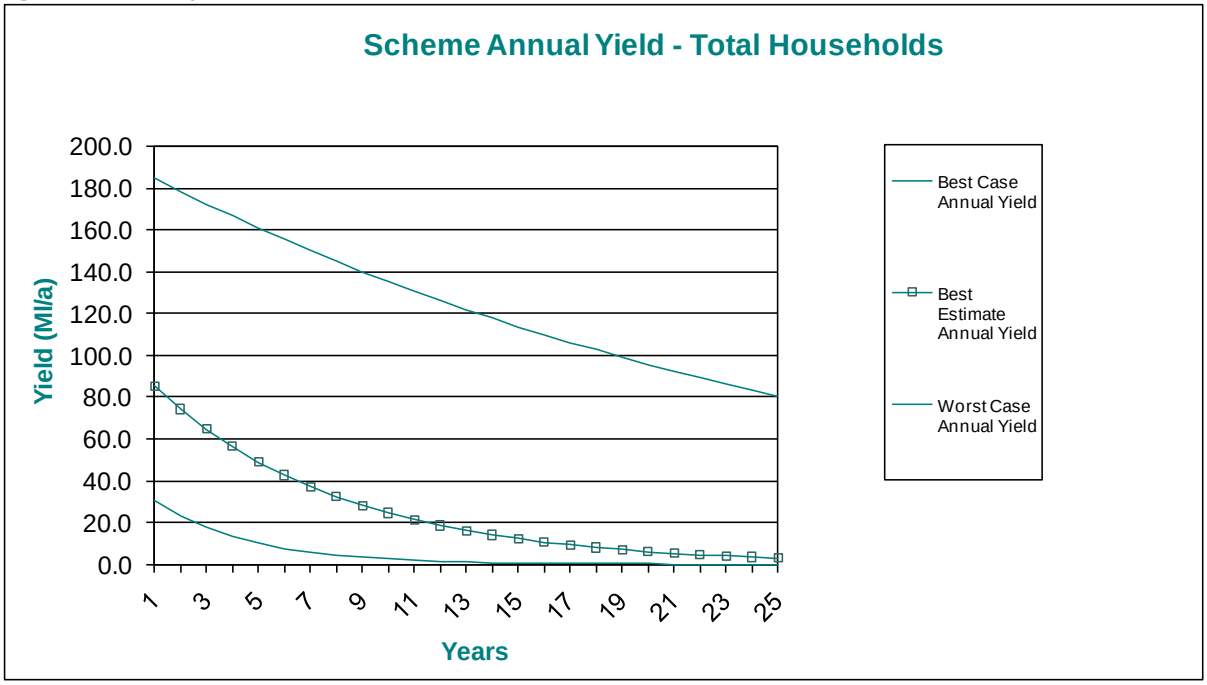
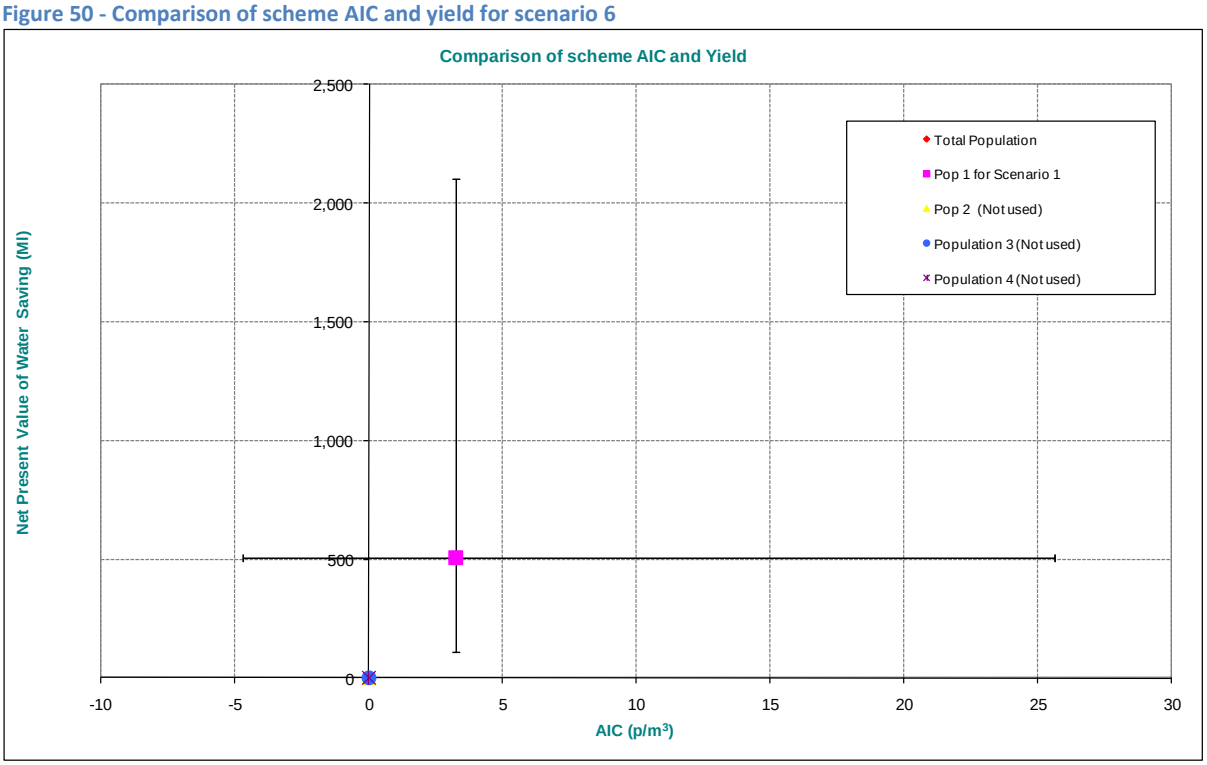


Figure 50 - Comparison of scheme AIC and yield for scenario 6



8.7 Scenario 7 – Piggybacking on Government Retrofitting Schemes

Water companies can deliver cost effective water efficiency retrofitting by piggybacking on the Government's Home Energy Saving Programme (HESP)[32]. Home Energy Saving Programme (HESP) is a £1bn package of measures and proposals including a 20% uplift to the level of CERT and a new Community Energy Saving Programme (CESP) and £74m extra funding for Warm Front in September 2008[33]. Water companies can collaborate with local councils, NGOs and energy companies to carry out house-to-house calls under CESP[34] and to offer water saving measures for taps and showers alongside energy saving measures in some of the most deprived areas of the UK.

Table 41 - Data input into the AISC spreadsheet tool for scenario 7

Scenario 7 - Piggybacking on Government Retrofit Schemes		
Parameter	**Value**	**Comments / build-up**
Target households		
Best estimate	50,000	Water companies can collaborate with local councils, NGOs and energy companies to carry out house-to-house calls under CESP and to offer water saving measures for taps and showers alongside energy saving measures in some of the most deprived areas of the UK.
Max expected	75,000	
Min expected	25,000	
Implemented as a one-off scheme?	Yes	
Asset life (years)	10	Waterwise estimate
Half life of sheme savings (years)		
Best estimate	5	Waterwise estimate
Best case	20	
Worst case	2.5	
Uptake rates		
Best estimate	45%	Enhanced uptake rates due to the involvment of the local government, inclusion of energy efficiency measures and a joint recruitment campaign
Best case	60%	
Worst case	25%	
Implementation period (years)	2	
Capital expenditure	£0.00	As per WR25b guidance.
Operational costs where scheme taken up		
Equipment costs (per property)		
Best estimate	£5.00	Waterwise estimate;
Best case	£0.00	
Worst case	£7.50	
Installation costs (per property)		
Best estimate	£5.00	Waterwise estimate; Installation paid for through the CESP as carried out at the same time as insulation installation programmes. However, the water company may choose to carry out surveys or engage customers to encourage behaviour change.
Best case	£0.00	
Worst case	£10.00	
Administration costs (per property)		
Best estimate	£0.50	Procurement of dual flush conversion devices, showerheads and tap inserts
Best case	£0.00	
Worst case	£1.00	
Recruitment costs (per propoerty)		
Best estimate	£0.50	Letter to participants
Best case	£0.00	
Worst case	£1.00	
Operational costs where scheme NOT taken up		
Administration costs (per property)		
Best estimate	£0.00	
Best case	£0.00	
Worst case	£0.00	
Recruitment costs (per property)		
Best estimate	£0.50	Letter to participants.
Best case	£0.00	
Worst case	£1.00	
Water savings (litres per property per day)		
Best estimate	38.00	
Best case	45.00	Preston Water Efficiency Initiative
Worst case	20.00	

The AIC, AISC and NPV values for Scenario 7 are given in Table 42 followed by a graphical representation of the yield over time and the yield over the range of uncertainties.

[32] http://www.decc.gov.uk/en/content/cms/consultations/open/cesp/cesp.aspx

[33] DECC, Chapter 2: What we delivered in 2008-09 http://www.decc.gov.uk/Media/viewfile.ashx?FilePath=Annual%20Reports%20Accounts%20and%20Business%20Plans%5C2009%5C1_20090720121502_e_@@_annrept0809ch2.pdf&filetype=4.

[34] HESP, CERT and CESP are seen as vital towards the Governments "UK Low Carbon Transition Plan" and "Renewable Energy Strategy" and in applying the Governments ambitions of giving every UK household a "whole house" energy assessment.

Table 42 - AIC, AISC and NPV results for Scenario 7

		Best Estimate	Best Case	Worst Case
	AIC (p/m^3)	13.52	0.00	74.99
	AISC (p/m^3)	-7.00	-20.60	55.15
NPV values				
	WAFU*(Ml)	1481.00	7567.42	116.27
	Capex (£M)	0	0	0
	Opex (£M)	0.20025	0	0.0871875
	Social & Env Costs (£M)	-0.304	-1.559	-0.023

Figure 51 - Annual yield for scenario 7

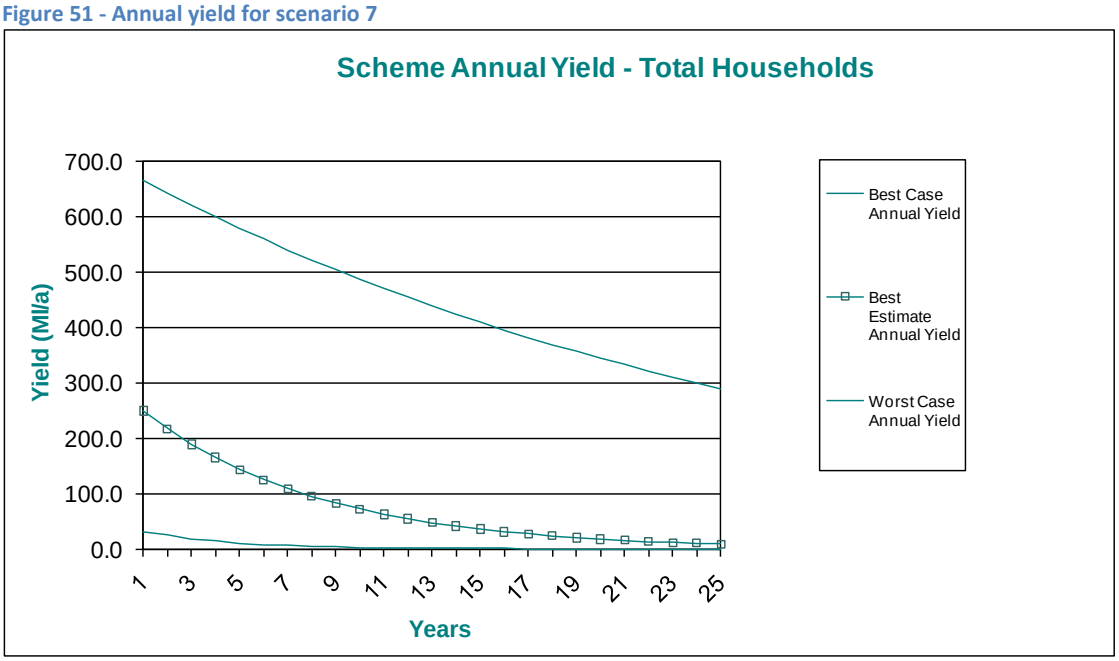
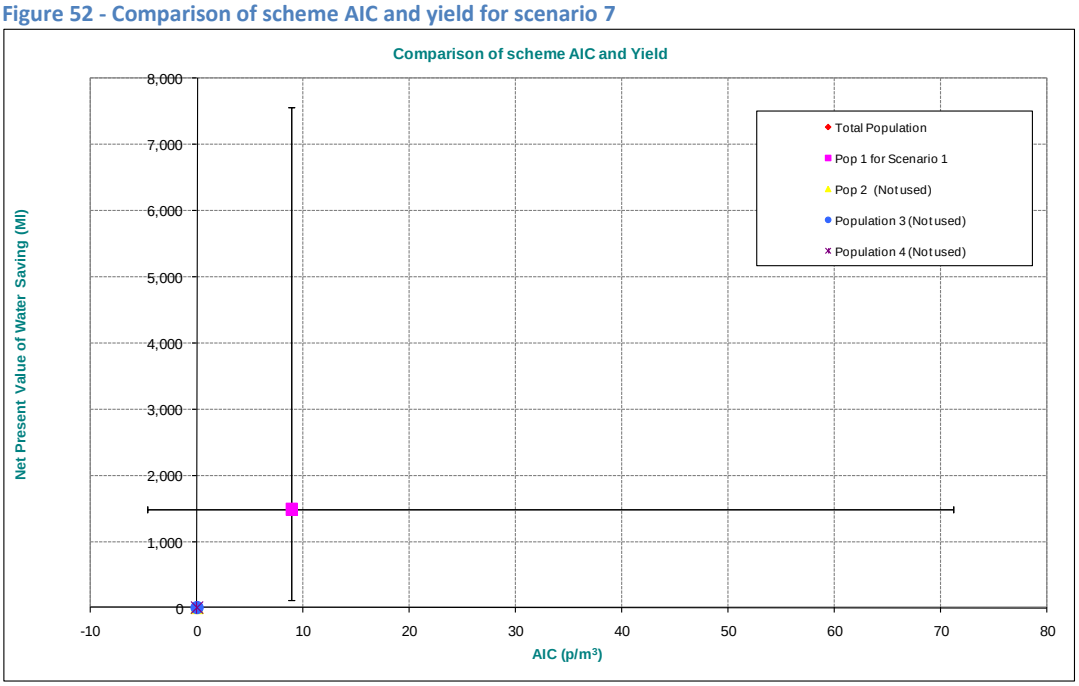


Figure 52 - Comparison of scheme AIC and yield for scenario 7



8.8 Sensitivity of Scenarios to Changes in Discount Rate

The summary of results in Table 28 includes sensitivity to water savings, uptake rates, and costs of equipment and installation. However, it does not include analysis of sensitivity of results to the discount rate used in the calculation of AIC and AISC. Understanding how changes in discount rate affect the cost benefit analysis for water efficiency is extremely important for water company investment plans. In order to understand the sensitivity of the AIC and AISC values calculated in the scenarios to discount rate, some analysis was carried out as shown in Figure 53. The discount rate was varied from its original 4.5% to high and low levels of 6% and 3% respectively.

		Best Estimate			Best Case			Worst Case		
Partnership Options		3% discount rate	4.5% discount rate	6% discount rate	3% discount rate	4.5% discount rate	6% discount rate	3% discount rate	4.5% discount rate	6% discount rate
Scenario 1: Social Housing	AIC (p/m^3)	38.88	41.74	44.54	7.10	8.03	8.98	169.82	176.58	183.16
	AISC (p/m3)	36.54	39.40	42.21	4.71	5.64	6.59	167.84	174.62	181.21
Scenario 2: Energy company	AIC (p/m^3)	12.14	13.04	13.91	5.20	5.87	6.57	106.49	110.73	114.86
	AISC (p/m3)	-8.38	-7.48	-6.60	-15.40	-14.72	-14.02	86.63	90.90	95.05
Scenario 3: Whole Town	AIC (p/m^3)	97.63	104.80	111.85	18.70	21.14	23.64	553.39	575.43	596.86
	AISC (p/m3)	77.10	84.28	91.33	-1.90	0.54	3.05	533.52	555.59	577.06
Scenario 4: Retail-Led Retrofit	AIC (p/m^3)	1.08	1.15	1.23	10.65	12.04	13.47	227.45	236.51	245.32
	AISC (p/m3)	-1.25	-1.16	-1.08	8.27	9.66	11.09	225.90	234.99	243.83

Company-Driven		3% discount rate	4.5% discount rate	6% discount rate	3% discount rate	4.5% discount rate	6% discount rate	3% discount rate	4.5% discount rate	6% discount rate
Scenario 5: Metering	AIC (p/m^3)	42.11	45.20	48.24	13.64	15.41	17.24	151.77	157.82	163.70
	AISC (p/m3)	21.57	24.67	27.72	-6.96	-5.19	-3.36	131.76	137.83	143.73

Government-Led		3% discount rate	4.5% discount rate	6% discount rate	3% discount rate	4.5% discount rate	6% discount rate	3% discount rate	4.5% discount rate	6% discount rate
Scenario 6: Toilet Amnesty	AIC (p/m^3)	7.36	7.90	8.44	0.00	0.00	0.00	28.85	29.99	31.11
	AISC (p/m3)	-13.20	-12.65	-12.12	-20.61	-20.60	-20.60	8.53	9.69	10.82
Scenario 7: Piggybacking on Government Retrofitting Schemes	AIC (p/m^3)	12.60	13.52	14.43	0.00	0.00	0.00	72.11	74.99	77.78
	AISC (p/m3)	-7.93	-7.00	-6.08	-20.60	-20.60	-20.59	52.25	55.15	57.98

Figure 53 - Variation of AIC and AISC with discount rate

9 Conclusions

This interim report of Phase II of the Evidence Base for Large-scale Water Efficiency in Homes has analysed nine water efficiency retrofitting trials carried out by several water companies in the UK. The analysis has provided further insight in the following areas:

⇒ Using water efficiency retrofitting, water consumption can be reduced by up to 42 litres per property per day using a multi-measure approach in general housing stock through converting toilets to dual-flush, installing water-efficient showerheads and tap inserts and engaging customers to encourage behaviour change. If bathroom refurbishment is carried out in social housing then significantly higher water savings are possible

⇒ Uptake rates of between 6% and 22% have been achieved in trials carried out in the general housing stock, whereas in trials carried out in social housing uptake was between 45% and 60%

⇒ The cost of retrofitting per property is given for each of the trials included in this report. The costs presented are typical costs, which would apply if the trials were scaled up to projects targeting tens of thousands of homes (as opposed to one-off costs associated with the delivery of the water efficiency trials)

⇒ Comparison of the measured savings from the trials with theoretical savings derived from company estimates and microcomponent assumptions for individual devices, revealed good agreement between the measured and theoretical savings

⇒ Significant carbon emissions and energy savings are achievable through targeting of hot water in addition to cold water in the delivery of water efficiency retrofitting

⇒ The uncertainty in water savings that result from retrofitting is clearly laid out and the probability of saving water in projects is presented along with the distribution of water savings, which together have revealed a structure, with a near-normal distribution, in the manner that large samples of the population have responded to being part of water efficiency projects which the water companies have carried out to date.

The analysis presented in this report also points to several areas where further work is required:

⇒ There is currently little guidance on how to best carry out cost benefit analysis for water efficiency retrofitting schemes, including how to take into account carbon emission costs and benefits. Research will be carried out in order to understand how best to take account of those costs and benefits which are not currently included and the aim will be to include these in a future Evidence Base report. This will also cover SEPA (Scottish Environment Protection Agency) and WICS (the Water Industry Commission for Scotland) requirements for accounting in Scotland.

⇒ Historically, uptake rates are typically very low in water efficiency programmes; this severely limits the overall water savings achievable from a water efficiency project, and means that the majority of the population are not being engaged. Waterwise will seek to carry out research to understand how to achieve greater uptake rates for water efficiency retrofitting projects.

⇒ There is increasing awareness of the significant role that the changing of attitudes and behaviour towards water efficiency has to play in delivering water efficiency on a large-scale. Waterwise will seek to carry out research to understand how best to encourage customers to save water.

⇒ The Evidence Base Steering Group has discussed the opportunity that exists for water companies to partner with energy companies and gain credit, through the Carbon Emissions Reduction Target (CERT), for carbon emissions savings as a result of hot water savings in the home. More clarity is needed about the protocol that water and energy companies need to follow in order to ensure that they can take advantage of this opportunity to make water efficiency projects more cost-effective, particularly with regard to additionality – whereby water companies cannot claim CERT credits for water efficiency activity that they would have undertaken anyway. In order to work towards a more coordinated approach, discussions should be taken forward between Ofwat, Ofgem, water companies and other key stakeholders.

⇒ There is currently a consensus in the water industry that installation of a water meter leads to a reduction in consumption of 10%. However, there is little contemporary evidence to suggest that this is what is achieved in practice, or whether this varies depending on the tariffs applied. Further evidence of the effectiveness of metering is required in addition to analysis of how this combination of metering and water efficiency retrofitting can be synergistic: this will need to draw on water company projects.

⇒ A number of assumptions have been made in calculating the carbon emissions and energy savings due to the water savings in each of the trials in this report. Further water efficiency trials, involving some measurement of energy consumption both before and after, would be helpful in understanding this area more clearly.

⇒ There are a large number of assumptions used in the project; these are based on existing reports or published data, some of which are not evidence-based. Further research is required that is specifically designed to tackle the issue of microcomponent data by finding ways to link estimates to measured values.

⇒ Probably the biggest area of uncertainty in the cost-benefit analysis for water efficiency is how water savings are sustained over time. Further research is required that seeks to understand how well, over the medium- to long-term, water savings are sustained.

⇒ The Evidence Base project will seek to gather more evidence from Scotland – with Scottish Water and the Water Industry Commission for Scotland now that there is a new water efficiency duty on Scottish Water.

Glossary

BERR – The Government Department for Business, Enterprise and Regulatory Reform
CLG - Communities and Local Government, which sets policy on local government, housing, urban regeneration, planning and fire and rescue

Confidence Interval - Confidence intervals are used to indicate the reliability of an estimate; instead of estimating the parameter by a single value, an interval likely to include the parameter is given

DECC - The Department of Energy and Climate Change (DECC) was created in October 2008, to bring together energy policy (previously with BERR, which is now BIS - the Department for Business, Innovation and Skills[external Link]), and Climate change mitigation policy (previously with Defra - the Department for Environment, Food and Rural Affairs).

DEFRA – the Government Department for Environment, Food and Rural Affairs

District Metered Area - An area within the water supply network that is permanently defined by closed valves or other physical constraints in which distribution losses are measured and managed.

Dual-Flush –This term refers to toilets that provide a choice of two flushing mechanisms; one which makes a full flush available and the other which uses a reduced amount of water.

Logger - An electronic device that records water use data over time either with a built in instrument or sensor or via external instruments and sensors. Loggers are useful because they can help provide a better resolution measurement of water consumption than is possible with a water meter alone.

Microcomponent – Overall domestic water use in the home can be broken down into components which represent water used by individual appliances and equipment in the home such as showers, toilets, washing machines, dishwashers, kitchen and bathroom taps as well as an outside supply. These components that make up water use in the home are known as microcomponents.

Net Present Value – NPV is the present value of an investment's future net cash flows minus the initial investment. If positive, the investment should be made (unless a better investment exists), otherwise it should not.

Ofwat - The Water Services Regulation Authority which is the economic regulator of the water and sewerage companies in England and Wales.

PR09 - Periodic Review 2009; the Ofwat periodic review of price limits to be completed in 2009 to set prices for 2010-2015.

Retrofitting - This term describes the measures taken to allow new or updated parts, for example cistern displacement devices, low-flow showerheads or tap fittings that reduce tap flow rates, to be fitted to old or outdated equipment through which we use water in the home.

The Environment Agency – The EA are an Executive Non-departmental Public Body responsible to the Secretary of State for Environment, Food and Rural Affairs and an Assembly Sponsored Public Body responsible to the National Assembly for Wales. Its principal aims are to protect and improve

the environment, and to promote sustainable development. They play a central role in delivering the environmental priorities of central government and the Welsh Assembly Government through their functions and roles

UKWIR – UK Water Industry Research was set up by the UK water industry in 1993 to provide a framework for the procurement of a common research programme for UK water operators on 'one voice' issues. UKWIR's members comprise 24 water and sewerage undertakers in England and Wales, Scotland and Northern Ireland

Water Efficiency Project – A project, which has as its main purpose to reduce water consumption as a means of water demand management. This involves the implementation in homes of one or more water efficiency measures such as dual flush devices in toilets, aerated showerheads, tap fittings, shower timers, self-audit questionnaires, plumber audits, or customer engagement through education in the need for water efficiency.

Water Efficiency Trial – A study carried out to ascertain the willingness of those approached to participate and improve their water efficiency, the reduction in water consumption achievable through application of the water efficiency measures and any change in behaviour on the customers' part due to engagement during the study. This involves the offer to customers of one or more water efficiency measures such as dual flush devices in toilets, aerated showerheads, tap fittings, shower timers, self-audit questionnaires, plumber audits, or customer engagement through education in the need for water efficiency and the subsequent assessment of the efficacy of the measures.

Water Industry Commission for Scotland - WICS is a non-departmental public body with statutory responsibilities. Established in 2005, WICS took over responsibility for regulation of water and sewerage services from the former Water Industry Commissioner for Scotland.

Water UK - represents all UK water and wastewater service suppliers at national and European level. It provides a positive framework for the water industry to engage with government, regulators, stakeholder organisations and the public.

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   Operation success : 100.0 %

Index creation date : 2013/10/21 21:42:28
```