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DISCUSSION PAPER FOR WWF's ITCHEN INITIATIVE

EXPLORING THE POTENTIAL FOR SMARTER DEMAND MANAGEMENT: FORECASTING AND TARGETED INTERVENTIONS

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Background

The Itchen Initiative is a WWF project that aims to develop solutions that will enable England and Wales to meet the challenges of water scarcity, to benefit both people and nature. The Initiative is named after the River Itchen, one of the world's most beautiful and iconic rivers, now threatened with over-abstraction of water, a growing population, and climate change. The Initiative is intended to inform, in particular, Defra's 2011 Water White Paper and Ofwat's review of the regulatory arrangements.

WWF commissioned a number of discussion papers to inform the Itchen Initiative process including this discussion paper, authored by Waterwise, which considers how aspects of the current approach used by companies to forecast demand may be improved and how this could lead to more effective demand management.

Contents

Executive summary

As part of the Itchen Initiative, WWF-UK tasked Waterwise to explore the potential for smarter, more targeted and responsive interventions to reduce demand. Waterwise reviewed how companies use information and assumptions relating to actual water use in their demand forecasts, including the different approaches used, how per capita consumption is derived and how companies account for variability in demand.

The report recommends that demand forecasting be improved by including more considered assumptions about customers' water using behaviour and future changes in customer lifestyles, in the context of government policy.

A vital part of being able to deliver smarter, responsive interventions would be to achieve universal metering which would provide the information needed to tackle the twin challenges of high consumption and affordability. Apart from enabling a range of tariffs to be used in a targeted way, where most needed, and particularly in the case of vulnerable customers, the additional information that would be available to water companies would be a powerful tool to help them to understand their customers' consumption, to target demand management advice and assistance in areas such as retrofitting, and also to forecast demand better.

Although standard meters would be a step forward, the installation of smart water meters in homes would provide an improved basis from which to launch short-term, responsive demand reduction interventions. Smart water metering would shorten the feedback loop between the water company and its customers, enabling hourly or daily water consumption to be viewed by customers on PCs and mobile devices or in-home displays. Such devices would provide a convenient tool for providing advice and information to customers about how to reduce their water consumption in general, and particularly in peak demand periods and during drought events, but also as a means to help customers save money on their water bills.

Customer segmentation tools, designed to help companies better target water efficiency activities (whether during a drought or in periods of normal demand), should take into account aspects of how households consume water. Although some companies produce demand forecasts for different types of household based on different property types, the tools currently used do not adequately consider water-using behaviour. Benchmarking of dwellings should also be considered as a means of targeting water efficiency activities - this has already proved to be a useful tool in targeting water efficiency interventions for schools and for businesses. Developing an appropriate tool for domestic properties would be more complex due to the many different types of dwelling. However this would be a powerful tool for targeting and also as a means of helping customers to compare their own consumption to customers in similar types of dwelling. Benchmarking could be used in tandem with segmentation in order to target actions based on the characteristics of the customer and of the dwelling in which they live.

Finally, this stream of the project has highlighted that although Ofwat do allow some funding for evaluation of water company activities such as metering programmes and water efficiency projects, there is a perceived lack of funding for research to help understand water consumption better. Further funding is required for research in order to fill the gaps in our knowledge of how people in the UK use water. For example, a deeper understanding is required about why two identical and neighbouring homes, with the same occupant composition, could have radically different water consumptions. This could help us to understand how uptake rates of retrofits can be maximised, and what messaging works best. A Quinquepartite Group study in 2007[1] made recommendations on further review work and research which could help the industry to explain why consumption varies so much, and why it varies regionally. A deeper understanding of these

[1] Final report from Quinquepartite Group , Leakage methodology review: variation in per capita consumption estimates, November 2007, Tynemarch Engineering

areas will help improve the robustness of demand forecast and provide the foundations for smarter demand reduction interventions.

1 Recommendations

1. Water companies should employ standardised definitions and common terminology related to demand management in their Water Resource Management Plans (WRMPs) and Business Plans to ensure consistency. This would also make it easier to engage customers in what their water companies are proposing. For example, the distinctions between demand and use - and supply variables such as ‘distribution’ sometimes used as surrogates for demand - need to be clearly made. In addition a common basis for domestic consumption monitors would give additional confidence in per capita consumption forecasts.

2. The Water Resources Planning Guidelines need to be reviewed to take into account the latest evidence on water saving from water efficiency programmes and to ensure a strong link between the WRMPs and the water efficiency targets. The impact of the multiple assumptions included in the Guidance is a huge source of uncertainty in the overall supply demand balance over a 25 year period. Better integration and consistency between the WRMPs, Drought Plans and the Business Plans could also provide a more robust approach to effective and targeted demand interventions.

3. Demand forecasting could be improved by including more considered assumptions about customers’ water using behaviour and scenarios of future changes in customer lifestyles, in the context of government policy and technological developments. Environmental psychologists could contribute to the process along with engineers and economists. A national household water-use survey would be a good way of maintaining an overview of how, when and where people use water across the country.

4. Universal metering is an important part of improving information needed to tackle high consumption and the challenge of affordability. The installation of smart water meters in particular would provide time-series information and an improved basis from which to launch short-term, responsive demand reduction interventions. Smart meters can help shorten the feedback loop between the water company and its customers, enabling hourly or daily water consumption to be viewed by customers on PCs and mobile devices or on in-home displays.

5. The approach to demand reduction interventions should be refocused by bridging the gap between every-year demand management activities and drought year event management activities, with enhanced/escalating attention to use of water when and where it is in shorter supply, before things become critical.

6. The Base Service Water Efficiency (BSWE) and Sustainable Economic Level of Water Efficiency (SELWE) targets could be reformed to encourage a more innovative approach to targeting water efficiency activities. This could mean targeting activities in areas which are water scarce, or with customers deemed to be high priority such as vulnerable customers.

7. Customer Segmentation tools, which are designed to help companies to target their water efficiency activities better, both during droughts and when demand is at ‘normal’ levels, should take into account aspects of how households consume water. Benchmarking of dwellings should be considered as a means of targeting, in tandem with segmentation.

8. Further funding is required for research in order to fill the gaps in our knowledge of how people in the UK use water. Existing research points to behaviour as the key driver. Examining what drives these differences in behaviour is key to understanding and influencing water use.

2 Introduction

As part of the Itchen Initiative, WWF-UK tasked Waterwise to produce a report to assist WWF in understanding the potential for smarter, targeted and responsive interventions to reduce demand for both short term and long term. Waterwise has reviewed how companies use information and assumptions relating to water demand in their demand forecasts and the relationship between use and demand. This has led to the identification of key assumptions which underpin the demand forecasting process used by the water companies and from this point, key issues have been identified. By tackling these issues it is possible to improve our understanding of domestic water use in order to identify ways to target interventions to manage demand more effectively.

Responsive demand interventions are tailored to the particular context in order to maximise their effectiveness in terms of the impact on the supply demand balance. The particular aspects of the zone that the interventions could be tailored towards are:

- The water resource situation as reported by a measure such as water availability or the extent of water scarcity in a resource zone
- Particular aspects of customers' water use such as garden, toilet or shower use

Such demand interventions are smart because they make use of information from customers' meters, from district meters, climate data or perhaps information related to water availability to determine when and where interventions should be targeted.

2.1 AIMS AND OBJECTIVES

The overarching aim of the work undertaken in this study was to understand the potential for smarter, targeted and responsive interventions to reduce future water demand within the framework of the supply and demand balance as articulated in the water companies' water resources management plans (WRMPs).

This element of the WWF-UK Itchen Initiative consisted of three separate tasks:

1. Literature and case studies review to understand water demand forecasting
2. Scoping the potential for targeted demand reduction interventions
3. Building future scenarios for demand management interventions

Section 3 of this report, titled 'Background – Water Demand Forecasting' presents a summary of some of the key information from Task 1. Section 4 then summarises some of the issues which arose during the review of demand forecasting in the WRMPs in particular. Section 5 discusses how demand reduction interventions may be better targeted and considers the use of approaches such as segmentation and benchmarking. Section 6 presents the conclusions that can be drawn from this work in the form of ten recommendations.

3 Background - Water Demand Forecasting

Demand forecasting is a key component of water resource management within water companies. Companies currently use different methodologies and assumptions to arrive at their demand forecasts. There are two primary methodologies used in domestic demand forecasting; the first is micro-component based, the other trend analysis modelling[2]. In this section, the background to the two demand forecasting methods is presented along with water company per capita consumption estimates for 2008 and forecasts for 2009 and 2010.

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[2] Sim P., McDonald A., Parsons J., Rees P.(2007) 'Complementary use of DCM and micro component records for domestic water demand forecasting', School of Geography, University of Leeds

3.1 MICRO-COMPONENT ANALYSIS

Micro-component analysis which is used by the majority of water utility firms and supported by the Environment Agency[3] has the advantage of simplicity and breaks demand down into components of specific water use such as the water use of showers, washing machines or hosepipes, thus allowing for drivers of demand change including the increasing efficiency of domestic appliances, changes in government regulation or behavioural changes to be considered when forecasting future demand[4]. Furthermore it provides an easily understandable framework for the impact assessment of demand reduction projects such as the use of metering or media campaigns and allows analysis of the specific components of peak demand, for example the changes in hosepipe water demand over the course of a year, and particularly during dry spells and droughts[5].

However the accuracy of micro-component analysis relies heavily on reliable data collection which, due to its nature is very expensive, and intrusive to sample participants. This leads to the use of relatively small sample sizes (generally of no more than a few hundred households), which introduces a significant level of uncertainty into the results[6]. Furthermore due in part to the intrusive nature of the methodology, data is generally not recorded for extended periods of time which therefore provides the analysis with very little data on the impacts on demand of long term temporal, socio-economic or household changes[1].

3.2 TREND ANALYSIS MODELLING

Trend analysis is used by a minority of water utilities and studies past water demand data collected from billing systems and domestic consumption monitors (DCM) as well as detailed questionnaires to formulate a model that extrapolates future demand levels. Furthermore due to the use of large scale DCM data collection, trend analysis modelling allows large samples of demographically representative consumers to be studied which can provide a very accurate overview of total consumer demand. The primary benefit of using this methodology is that it provides very accurate short term forecasts that can give insights into socio-economic, regional and temporal variations[7].

However trend analysis modelling does not directly consider changes in demand from sources such as changes in specific component water use, household structure change or government regulation reform with such analysis having to be produced externally to core historical trend analysis. This has the effect that unlike micro-component analysis forecasts can only be generated at the macro level, removing the analysis of the actions of individual customers on total water demand[3]. Furthermore any long term projections that are made are reliant on the accuracy of the assumptions made about demand change. The use of micro-component analysis provides a more robust framework for assessing uncertainty in demand forecasts[2].

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[3] Environment Agency (2008), 'Water Resources Planning guidelines', [Online], http://www.environment-agency.gov.uk/business/sectors/39687.aspx

[4] South West Water (2009), 'Water Resource Management Plan', [Online], http://www.southwestwater.co.uk/index.cfm?articleid=1556

[5] Anglian Water (2009), 'Water Resource Management Plan', [Online], http://www.anglianwater.co.uk/environment/water-resources/resource-management/

[6] Southern Water (2009), 'Water Resource Management Plan', [Online], http://www.southernwater.co.uk/Environment/managingResources/publicConsultation.asp

3.3 PER CAPITA CONSUMPTION IN ENGLAND AND WALES

From analysis of water company Water Resource Management Plans and June Returns, a map has been created which shows the most recent national profile of annual average per capita water consumption (PCC). Figure 1 *(see page 10)* presents a map showing the annual average measured and unmeasured PCC levels for each of the water company regions of England and Wales for the year 2008-2009, which was a normal year. Veolia Water Central has the highest PCC levels in England and Wales with its measured customers consuming on average 153 litres per head per day (lpd) and its unmeasured customers consuming about 176 lpd. Veolia Water East has the lowest PCC levels in England and Wales, with its average measured consumption at 110 lpd and 128 lpd for unmeasured customers. Table 1 shows measured and unmeasured average period normal year per capita consumption for each of the English water companies for the periods 2007-08 and the normal year forecasts for 2008-09 and 2009-10.

Water supplier	2007-2008		2008-2009		2009-2010	
	Measured	Un-measured	Measured	Un-measured	Measured	Un-measured
Anglican Water	142.2	157.8	139.1	157.6	132.9	162.6
Bournemouth and West Hampshire	153.4	155.8	154.2	156.0	150.9	156.1
Bristol Water	125.5	157.6	122.6	158.9	121.2	154.8
Cambridge Water	129.8	143.1	128.4	146.0	128.7	150.3
Dee Valley Water	110.8	154.8	114.2	156.6	114.3	166.5
Dwr Cymru Welsh Water	123.5	156.3	124.2	160.1	117.3	158.8
Essex and Suffolk Water	143.4	162.8	147.0	163.4	146.0	163.6
Northumbrian Water	128.9	147.0	129.5	141.7	133.0	144.7
Portsmouth water	132.1	161.6	128.0	164.7	126.2	170.6
Veolia Central	153.3	175.5	141.6	175.3	146.9	178.6
Veolia East	110.9	128.3	112.6	132.4	113.1	126.8
Veolia South East	140.3	162.2	125.2	179.4	122.7	182.5
Severn Trent Water	114.7	140.7	111.8	135.0	110.2	130.1
South East Water	143.4	171.6	157.5	177.3	155.8	179.4
South Staffordshire Water	126.9	147.5	124.7	141.0	131.7	139.2
South West Water	131.2	154.0	126.8	151.7	120.8	161.8
Southern Water	137.9	154.4	136.8	149.3	132.0	151.7
Sutton & East Surrey	139.2	164.3	137.2	170.1	140.7	177.9
Thames Water	143.8	157.6	142.1	162.6	141.8	170.5
Three Valleys	116.3	143.5	111.6	143.5	113.1	142.1
United Utilities	116.3	143.5	111.6	143.5	113.1	142.1
Wessex Water	135.9	148.9	135.5	147.7	132.7	150.8
Yorkshire Water	132.8	150.4	113.8	148.2	115.3	155.6

Table 1- Measured and unmeasured PCC forecasts for water companies in England and Wales – 2007-2010

3.4 PEAKING FACTORS

Peaking factors are multipliers that are applied to the average day demand to approximate other peak water demands. They are commonly used to convert annual average consumption values into peak period consumption due to the fact that water use can vary greatly depending on the time of day and the time of year. These factors are often estimated because of the lack of detailed water use data.

UKWIR's 'Peak Demand Forecasting Methodology'[8] sets out for water companies how to approach calculation of peak factors. The peak factor relates demand to the climatic factors of temperature and rainfall based on historical records of climate and the current behaviour of our customer base. The calculation of the peak factor for water consumption is, therefore, based on

8 UKWIR (2006), Peak Water Demand Forecasting Methodology, Ref: 06/WR/01/7, Available at: http://ukwir.forefront-library.com/reports/06-wr-01-7/91316/90208/90255,90213,90208/90255 records of peaks in historical distribution input, and meteorological data. However, relationships between weather and demand have been found to be poor, because some of the components of demand are weather sensitive, and others are not. A robust approach to taking account of the effect of weather on demand is to disaggregate into micro-components, with peak demand of individual components being found by weather relationships, and then added to consumption of non-weather sensitive components

There are peak factors for measured and unmeasured household demand in addition to measured and unmeasured non-household demand. The effect of peak demands varies between water resource zones due to factors such as the location of holiday resorts, heavy industry and also due to socio-economic factors reflected in the type and age of housing stock and customers' behaviour.

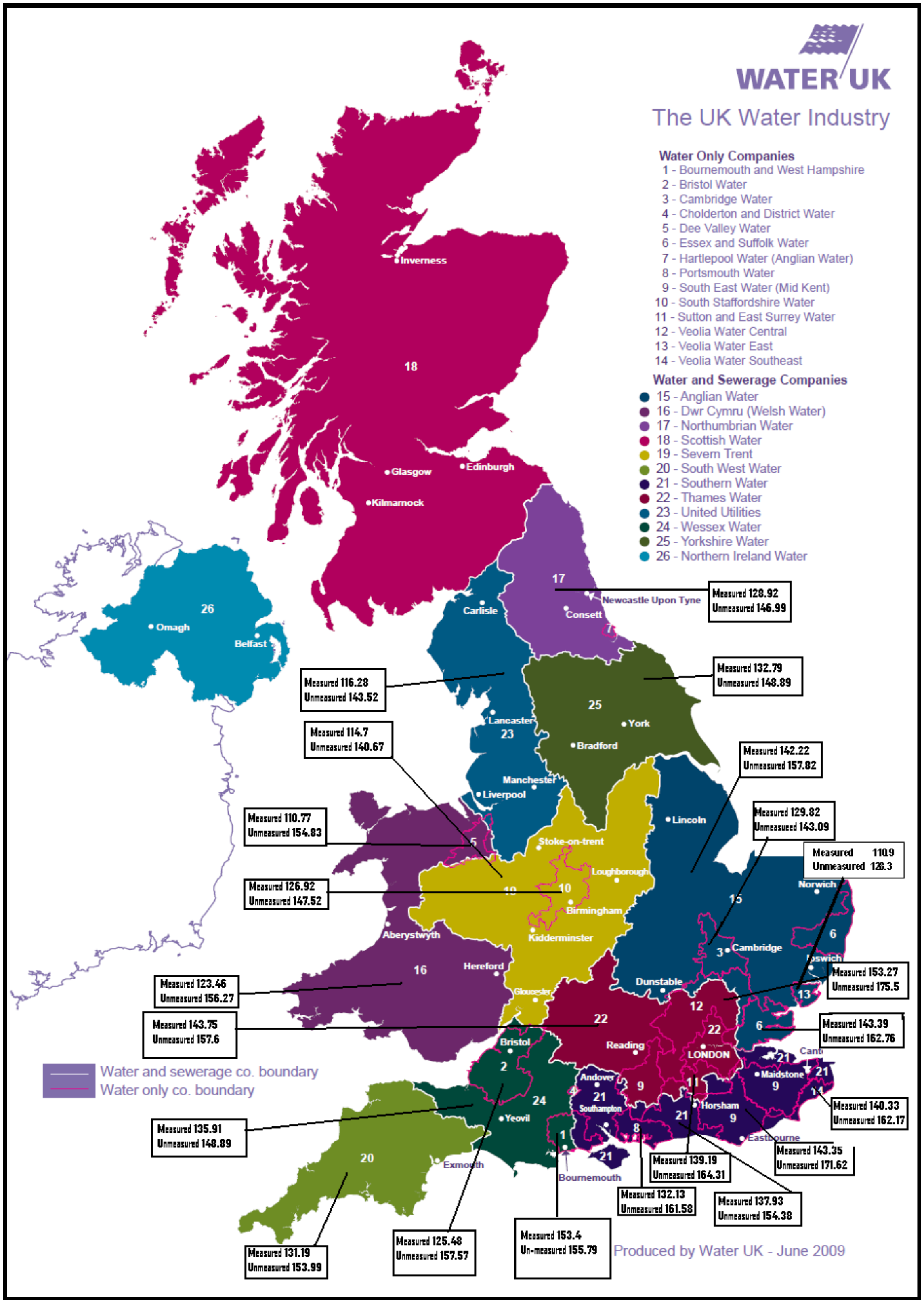

Figure 1 - Map Showing the Measured and Unmeasured Annual Average Per Capita Consumption for Regions of England and Wales – 2008-09 – Actual values from Water Company June Returns (2010). Map from WaterUK (2009)

3.5 THE SIGNIFICANCE OF THE DROUGHT PLANS

3.5.1 Drought Plan

Water companies have a duty to prepare and maintain a drought plan under the provisions of the Water Industry Act 1991 as amended by the Water Act 2003. The Drought Plan Direction 2005 sets out the requirements for the preparation of a drought plan. The legislation defines a drought plan as "a plan for how the water undertaker will continue, during a period of drought, to discharge its duties to supply adequate quantities of wholesome water, with as little recourse as reasonably possible to drought orders or drought permits".[9]

This put in place the statutory requirement for all water companies to produce a drought plan that considers the implications and actions of a drought period on the supply and demand of water in the areas of supply. Drought plans provides an example of how water companies can target demand-side measures to ensure that the effects of water shortage are alleviated.

Water companies use water efficiency measures such as customer engagement through community events and media campaigns, retrofitting in homes and offering customers self-audit packs as a way to manage demand every year and as a matter of course. At times of drought, water companies use other demand reduction measures such as hosepipe bans and restrictions of non-essential use. The difference between the two approaches to demand reduction is that the first seeks to persuade the customer and the second seeks to compel them to reduce their consumption. A more progressive approach to demand reduction programmes may be to employ intermediate measures and activities which seek to reduce demand in a progressive, proportionate way, ramping efforts up when and where supplies begin to come under pressure, before droughts lead to imposition measures.

An approach like this could be applied by targeting demand reduction activities at areas where water availability is low and at times of peak demand, with triggers are defined, in a similar way as they are in drought plans, to determine exactly when and how different interventions should be utilised. It may also be feasible, as water companies start to improve customer segmentation and benchmarking tools, that these smarter interventions may be targeted at specific customers. The potential for this type of intervention is discussed further in section 5.

However, by gaining an understanding of how water is being used across a water resource zone (end-use monitoring), water companies can also ensure that they target their resources in the most cost-effective way. This is a lesson that could be applied to a drought but equally at peak demand or when carrying out long term demand reduction planning.

However, there are issues about the consistency and robustness of estimates, used by water companies in drought plans, of expected water savings by implementing the above measures. However, the principle of demand management (DM) as described in the drought planning process is one which can inform this project and perhaps learn from it if the potential for smarter, targeted and responsive interventions is realised.

Due to the fact that droughts are highly variable in their location and severity, a high level of flexibility is required to allow efficient implementation of drought response mechanisms. Drought plans, in a similar way to the Water Resource Management Plans take stock of different scenarios. However, in Drought Plans triggers are defined as a way of determining when different measures should be implemented. These triggers currently refer to the supply side, referring to reservoir levels, groundwater levels and also water availability. Demand is generally

[9] http://publications.environment-agency.gov.uk/pdf/GEHO0308BNTR-E-E.pdf

not considered as a factor in deciding when demand management measures should be implemented, although, for example, the use of escalating DM measures are linked to reservoir stocks and control rules in the Lower Thames Operating Agreement. The case for monitoring demand at a time of drought is a strong one as this enables resources to be targeted to where the largest water savings can be made.

A primary tenet of the drought plans is to provide a stated methodology to monitor the severity of the drought to allow for responsive preparation and implementation of drought alleviation measures. The monitoring should be responsive enough to allow for gradual changes in the use of drought mitigation actions as severity increases or decreases. There is an obvious relationship between this and what would be required in order to implement smart and responsive demand reduction plans, wherein current water demand would need to be continually monitored to allow measures to be targeted temporally, geographically and even to individual customers.

In the process of putting together drought plans water companies are required to consider where and why water resources are likely to run low and consider how to alleviate problems in these areas. The companies produce a table of targeted interventions and make assessments of how much water is likely to be saved. The following are possible courses of action for a company during a drought:

- run publicity campaigns to encourage customers to use water wisely;
- work with large businesses to reduce their water use;
- increase work to find and fix leaks and reduce water pressure;
- implement water conservation schemes;
- obtain water to augment supplies from back-up emergency sources;
- introduce hosepipe and sprinkler bans;
- apply for drought permits or drought orders to abstract water;
- apply for drought orders to ban non-essential use of water;
- apply for drought orders in relation to discharges of water and abstractions by others;
- as a last resort, apply for emergency drought orders to introduce standpipes, tanker supplies and rota-cuts for water supplies.

Drought plans describe in detail the demand reduction measures available to water companies in a drought, considering all impacts of their use and a description of at what point they would be implemented. However, what is clear from the drought plans is that there is not currently a consistent approach to quantifying the water savings which result from demand reduction measures. Publicity campaigns are the corner stone of water company drought plans. It is not uncommon to see savings of 5 Ml/day quoted for a publicity campaign within a single resource zone or 30 Ml/day for a medium sized water company area[10].

To put into context what this represents, the entire water efficiency target for England and Wales is 23.31 Ml/day. Waterwise's Evidence Base for Large Scale Water Efficiency in Homes[11] presents evidence of the water savings possible from about 7000 homes. If the average savings from these domestic retrofitting projects (41 litres per property per day) were extrapolated to a large scale (10000 homes) project, this would yield savings of 0.41 Ml/day.

Therefore, this raises concerns that the level of savings which are currently attributed to measures which are used to manage demand during drought may be significantly overestimated. There is some evidence to suggest that the use of measures such as hosepipe bans[10], accompanied by a communications campaign which ensures that customers are aware

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[10] UKWIR/EA (1998), Evaluating The Impact Of Demand Restrictions, Main Report, 98/WR/06/1

[11] Waterwise (February 2010), The Evidence Base for Large-scale Water Efficiency in Homes,[Online], http://www.waterwise.org.uk/reducing_water_wastage_in_the_uk/research/publications.html

of the need for urgent action in the face of a serious water shortage, can lead to a 20% fall in demand over drought periods[12]. However the actions taken in drought plans to reduce water consumption rely very heavily on the effectiveness of publicity campaigns in themselves to reduce demand. There is little evidence for how much water publicity campaigns, carried out in isolation, may be responsible for saving[13].

The Drought Plans provide a useful approach to managing and targeting demand interventions. The principle of using triggers which could be based on criteria such as water availability in a resource zone or level of customer demand is one which the companies could apply to targeting demand interventions as part of the next Water Resource Management Plan and Periodic Review processes. It is absolutely essential that a consistent approach to quantifying savings is found, both to assist with drought planning and more generally to robust demand forecasting and improved security of supply. If the drought plans are to be trusted to deliver the water savings required at the time of a drought then urgent work needs to be done to ensure that the water saving yields are robust.

4 Key findings on assumptions used in demand forecasting

The following key points on the assumptions which relate to demand forecasting were raised following the review of the water company WRMPs (the final plans of Anglian Water, Southern Water, South West Water, United Utilities and Veolia Water South East were reviewed) June Returns and the literature. Assumptions used by the water companies clearly highlight social changes in demographics: a growing population, changes in water-using devices and appliances and a trend towards lower occupancy households and higher per capita consumption. The following key points raised the issues which the Itchen Initiative will seek to remedy through the ten recommendations.

- The assumptions used to estimate the effectiveness of demand reduction measures have a large level of uncertainty associated with them. The uncertainty in demand forecasting and demand management is included in target headroom. However, the extent to which headroom is sufficient to adequately account for the uncertainty in the numerous demand assumptions needs to be reviewed in the light of the latest evidence. The assumptions used to estimate the impact of metering (10% – 15% reduction in consumption) and water efficiency measures in homes are likely to lead to huge uncertainty.

- Demand forecasts are based on unrestricted demand and therefore do not factor in potential restrictions in place during a drought. The Water Resources Planning Guidelines require that the demand forecast is for a dry year, without use of restrictions. This is because there is in place a consistent, common definition, with the water resource management plans planning for the dry year event, and the drought management plans for drought events, when restrictions are in play, at whatever frequency of use. But one company's dry year is another's drought year, because levels of service vary between companies. So comparing dry year forecasts between companies is not consistent, because the frequency of the dry year is not consistent between companies.

- Each company sets their own 'level of service' about what level to start to constrain plans (e.g. 1 in 20 year hosepipe ban, 1 in ten year, etc) and this has major impact on forecast demand. The dry year for one company could be 1 in 9 years, and another 1 in 19 years, if

[12] OFWAT , 'Patterns of demand for water in England and Wales 1989-1999', Office of Water Services, Birmingham, 2000
[13] UKWIR, Estimating The Water Savings For Baseline Water Efficiency Activities, Ref: 09/WR/25/4, ISBN: 1 84057 550 6. Available At: http://www.ukwir.org/reports/09-wr-25-4/93162

they have levels of service for use of restrictions of 1 in 10 years and 1 in 20 years respectively.

- Metering is included in assumptions to derive assumed savings. However, it is not easy to identify how metering will influence demand forecasts and a reduction in PCC and this might be linked to the early days of introducing widespread metering across the supply areas. Metering will is most likely accompanied by other important aspects such as different types of tariff, educational materials, water efficiency retrofitting or even face-to-face customer engagement. A key challenge for the demand forecasts is to be able to identify how the different combinations of these measures, offered to customers alongside metering, will impact on consumption.

- Although the economic level of leakage is part of the demand forecasts, it seems still to be considered as part of mobilising new resources: "low level of leakage is desirable because it defers the need for investment in new resources which will otherwise be required to meet increase in demand over time"; the same could be said for other demand management options such as metering and water efficiency activities.

- Forecasting demand is difficult because of the uncertainty linked to population, economic growth, changes in water use and potential future requirements for the environment.

- The connection between achieving the water efficiency targets and demand forecasting is unclear and ambiguous. The water savings assumed for installation of water efficient products and the assumed levels of uptake for self-audit packs under the water efficiency targets are overestimated and are unlikely to be realised.

- Extrapolating historical trends of per capita consumption is useful for assessing past demand and for providing a baseline to compare demand. They currently do not take into account important factors that will influence demand, such as changes in and introduction of (new) policies and regulations as well as changes in technologies and modification of the behaviour and changes in use and not factoring these elements may result in further significant uncertainty.

- The application of the micro-component modelling, as currently carried out, should take into account using more sophisticated approaches which look at how customer lifestyles and behaviour will evolve; possible changes in technology performance; and how people behave indoors and outdoors which will consequently influence water use.

- The social component of water demand and how people behave and consume water at point of use are not currently taken into account. The micro-component approach to demand forecasting is an attempt to do this. However, this need to improve and could do so with the assistance of social researchers, behavioural economics and other specialists outside of the traditional engineering domain.

- At the point that the last round of WRMPs were finalised, demand management investment plans were not confirmed as funded through Ofwat's Periodic Review process. Therefore the levels of leakage activity, metering coverage and water efficiency activities in the WRMPs could vary significantly from what is actually implemented by most companies. There is also a complete mismatch in timing and funding which needs to be addressed.

5 Targeting demand reduction interventions

In the last price review a number of demand reductions were planned by water companies, ranging from installation of meters, water efficiency (self-install kits and home retrofit) and leakage reduction. These interventions were focused on water resource zones which were in danger of a supply demand deficit within the next 5 years.

Targeting of water efficiency interventions on customers by understanding how and when customers use water would have advantages in terms of ensuring interventions are most effective. For example:

- Water efficiency interventions have been found to be more effective when installed where water use is high[14]
- Certain areas and certain households are more likely to respond well to particular interventions (e.g. water efficiency can be less popular in areas with low water pressure; participation in water efficiency retrofit can be higher in social housing).

Messages can also be targeted: messages regarding water scarcity are going to be far more effective where and when water is scarce[15] (at other times messages could focus on the other benefits of reduced consumption). There is significant potential to reduce the cost of demand management interventions by carefully targeting. For example, to date one of the key costs relating to water efficiency retrofit is the cost of generating participation. By targeting promotional activities to households that are more likely to participate and more likely to save water, such costs can be reduced, and the cost-benefit return improved.

In order to better target interventions, information is needed about the nature of demand in time and place. Unlike demand forecasting, an average per capita consumption value is not as useful in this case, and instead the full understanding of how consumption varies is required. In order to ensure that the water efficiency targets are met (resulting in actual water savings) and that customer investment in demand management is most effective there is some need for guidance to help companies develop more sophisticated demand reduction plans. Section 8 sets out some potential 'responsive' and 'resilient' demand reduction interventions. The plan for the next stage of the work would be to develop demand reduction planning and understand what information is needed to inform it.

5.1 METHODS FOR TARGETING DEMAND REDUCTION PROGRAMMES

There are broadly two approaches to targeting demand reduction plans. The two approaches are:

- Customer segmentation
- Benchmarking of domestic properties

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[14] Waterwise (February 2010), The Evidence Base for Large-scale Water Efficiency in Homes, [Online], http://www.waterwise.org.uk/reducing_water_wastage_in_the_uk/research/publications.html

[15] U.S. Army Corps Of Engineers Institute For Water Resources (1994), Managing Water For Drought - National Study Of Water Management During Drought, [Online], http://www.drought.unl.edu/plan/handbook/nds8.pdf

Each of these methods and how they might be implemented are discussed in this section.

5.1.1 Customer Segmentation

Customer segmentation tools use personal characteristics such as those given in Table 1 to understand which customers are best targeted with demand reduction interventions. Two examples of segmentation tools which are currently used by water companies are MOSAIC and ACORN.

ACORN[16], produced by CACI, is the first geo-demographic tool to identify and understand the UK population and the demand for products and services. ACORN categorises all 1.9 million UK postcodes using over 125 demographic statistics within England, Scotland, Wales and Northern Ireland and employing 287 lifestyle variables. The classification system of ACORN contains 56 types of household under the 14 groups in 5 categories.

Mosaic is a geo-demographic segmentation system developed by Experian[17]. Each of the nearly one-quarter million block groups was classified into sixty segments on the basis of a wide range of demographic characteristics. The experience of the use of these segmentation tools as a means of targeting water efficiency and metering programmes has been that they are of limited use. There is very little correlation between the segments that are defined and the amount of water consumed by a customer or how much water a customer is likely to save.

Age and Sex Race Educational Attainment Educational Enrolment Marital Status Group quarters population by type Place of birth Foreign born by year of entry Households by type Size of household Household type by presence of children Age of head of household Language spoken at home and linguistic isolation Tenure Vehicles available Households by income Median income, average per capita income Median income by age Households by type of income Workers in family Income/Poverty ratio Labour force status by sex (incl. military) Labour force participation rate Employment by occupation Employment by industry	Income/Poverty ratio Labour force status by sex (incl. military) Labour force participation rate Employment by occupation Employment by industry Class of worker (e.g. private corporation, federal government, unpaid family, etc.) Veteran status Travel time to work Worked at home Dwellings by occupancy status (owned, rented, vacant) Housing value of owner occupied housing Median housing value Contract rent Median contract rent Units in structure Year structure built Median dwelling age Mortgage status (e.g. no mortgage, first only, first and second) Year moved in Population density metropolitan statistical area size Distance to metropolitan statistical area centre

[16] http://www.caci.co.uk/ACORN.aspx
[17] http://www.appliedgeographic.com/mosaic.html

Table 2 - The group categories of variables included in the creation of the MOSAIC typology[18]

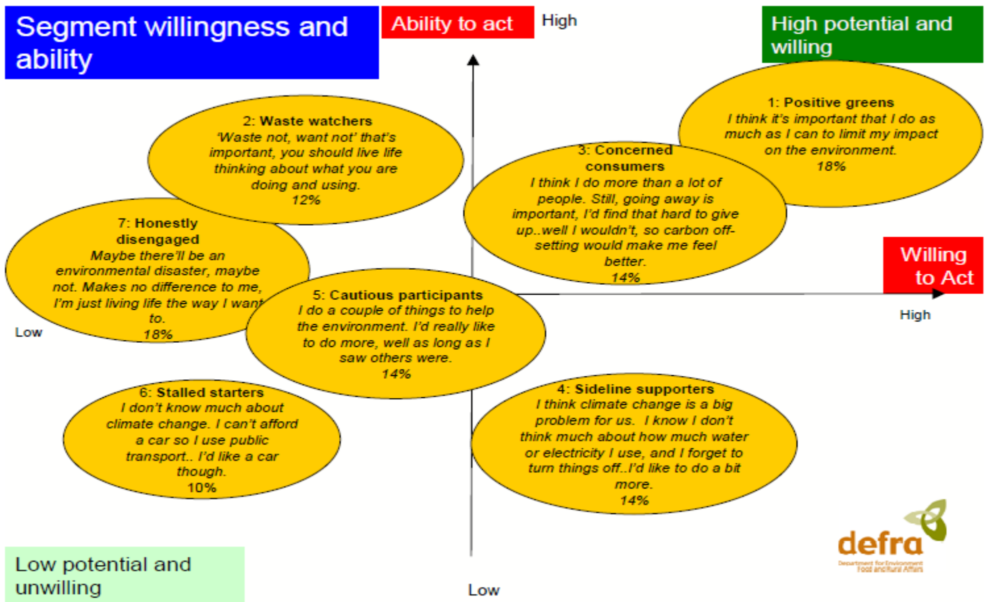

Figure 2 Segmentation by attitudes to pro-environmental behaviour (from Defra, 2008a).

Formulation of behavioural change policy is often based on extensive surveys of attitudes. For example, Defra's Framework for Pro-Environmental Behaviour[19] is based upon quantitative attitude surveys (face to face interviews with a large sample of people) and supported by in depth focus groups. The surveys are used to segment the population based on attitudes and beliefs and draw conclusions about likely behaviour, motivators and barriers to behaviour and the potential for behavioural change. Figure 2 illustrates the approach.

The most important point about ACORN and MOSAIC segmentation tools is that there is doubt as to the appropriateness of using these tools as a means of forecasting customers' water use. The Evidence Base for Large Scale Water Efficiency in Homes shows that the single biggest factor in determining how much water a customer will save following an intervention is the property's consumption prior to the intervention. Any tool designed to help companies to target their water efficiency activities better during a drought or in a normal period should take existing household water consumption into account.

The University of Leeds produced a working paper in 2007 which presented results of analysis of consumption data from demand consumption monitors (DCMs) in two water resource zones, one in Thames Water's region and the other in Essex and Suffolk Water's region. Analysis was carried out on the correlation of independent variables Accommodation type, Rateable value, Ethnicity, Number of Day Residents, ACORN category, ACORN type and Tenure.[20] It was found

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[18] http://www.tetrad.com/demographics/usa/ags/agsmosaic.html

[19]DEFRA (2008), A Framework For Pro-environmental Behaviours, [Online], http://www.defra.gov.uk/evidence/social/behaviour/documents/behaviours-jan08-report.pdf

[20] Sim, P., McDonald, A., Parsons, J. and Rees, P. (2006). MACROWater: a Top-down, Policy-driven Model for Forecasting Domestic Water Demand. Working Paper, School of Geography,

that the correlation of the ACORN-related variables and tenure with water consumption was poor whereas Accommodation type (e.g. detached house, semi-detached house, terraced and flat) was found to correlate the best to water use.

5.1.2 Benchmarking of Domestic Properties

Another approach to targeting water demand reduction measures is to benchmark based on daily consumption. This is essentially segmentation of properties or areas (rather than people) based on their water use. This method can be applied at two different consumption monitoring levels:

- Individual property
- District Metering Area (DMA)

In order to facilitate this approach, the consumption in each property or DMA needs to be known. Metering is a fundamental prerequisite to applying the benchmarking approach to help target measures more effectively. The method will be described here for a household level meter but the approach could easily be applied to DMAs within a Water Resource Zone with one or two slight alterations. This is discussed later in this section.

5.1.2.1 Steps to producing a benchmarking tool

The following steps describe broadly what data is required to produce benchmarking tool.

1. Mean consumption over a long period (e.g. one or more years) for each of the properties within the area of interest (DMA, WRZ or a town)

2. A sample needs to be defined which is representative of the company area in terms of type of property and the size of the sample. These should be assessed on a company-by-company basis as per capita consumption varies significantly by region.

    - Type of property

    One option for defining the framework for a benchmarking tool is to use the number of bedrooms as the characteristic that is used to compare properties. Hence flats and houses with, for example, one bedroom could be compared against each other, but could also be treated as different types of property if evidence suggested this was preferable. See Table 2 for an example of what a basic benchmarking tool might look like. Another option is to benchmark properties based on the total number of rooms in a home. Due to the importance of garden water use to water demand, separate categories should apply to properties with gardens as in Table 3.

    - Assessing the required sample size for benchmarking

    A sample of homes which represent the cross-section of water consumption in a company area is required. For example, for each of the columns in Tables 1 and 2, each of which represent one category of home, a sufficiently large sample of homes would be required to ensure that the benchmarking tool would be representative of home in its area. This should be assessed using statistical analysis of consumption in the region and a power calculation which helps determine the most appropriate sample size to achieve the research aims.

University of Leeds. Available at:
http://eprints.whiterose.ac.uk/4981/1/MACROWaterWorkingPaper07_1.pdf

3. Required sample size is defined for each category (number of bedrooms in Table 1) of property and a representative spread of properties are included in the sample.

4. The consumption levels for properties in each category are listed in order of increasing consumption. The more efficient homes come first.

5. The 25% of properties with the lowest of water consuming properties are first quartile. The next 25% of properties below this are second quarter (down to the median which is the middle value) and so on for the third and fourth quartiles.

6. Once the tables have been defined it is possible to categorise any property for which water consumption is known as first, second, third or fourth quartile. Then, when seeking to target interventions, the poorest performers (highest consuming properties) relative to other similar properties (fourth quartile) can be prioritised over third quartile which in turn can be targeted ahead of first and second quartile properties.

	Number of bedrooms without garden				
Quartile range	1	2	3	4	5
25%	130 l/d	250 l/d	425 l/d	650 l/d	880 l/d
50%	150 l/d	330l/d	520 l/d	730 l/d	950 l/d
75%	250 l/d	425 l/d	675 l/d	860 l/d	1070 l/d

Table 3 Example of Benchmarking tool by property without garden

	Number of bedrooms with garden				
Quartile range	1	2	3	4	5
25%	155 l/d	275 l/d	450 l/d	675 l/d	905 l/d
50%	175 l/d	355l/d	545 l/d	755 l/d	975 l/d
75%	275 l/d	450 l/d	700 l/d	885 l/d	1095 l/d

Table 4 - Example of benchmarking tool by property with garden

5.1.3 Benchmarking DMAs

The discussion above focuses on individual properties but it is also feasible for benchmarking to be applied at DMA level. Determining whether there should be a characteristic DMA is more complicated with DMAs than it is with individual properties. . Perhaps benchmarking in DMAs could be approached on a consumption per property basis. This is best considered on an individual region basis. However, there are other factors which could be taken into account such as the number of properties per DMA and the concentration of gardens within the area. However a trial would help to determine whether these things are worth taking into account.

5.1.4 Benchmarking and Smart Metering

Where smart metering is installed, and consumption data are at the disposal of water companies, the options for targeting demand management are significantly increased. In terms of how benchmarking is applied in practice, smart metering would allow much more dynamic implementation. Whereas with ‘dumb’ meters the process would rely on biannual or at best quarterly manual meter readings, smart meters would be able to re-evaluate how properties perform on a regular basis (daily, weekly or monthly). The peak period data thus revealed – in respect of both the magnitude and the timing of peak demand - are likely to be of particular value.

If smart metering is available along with a method for the customer to be provided with information about their water consumption, this provides a means of shortening the feedback loop with customers and provides a means of delivering a tailored messages to consumers who are relatively high users of water and when it is needed the most. It also provides a plethora of options for communicating with the customer through PCs, mobile phones and portable device, via email, text message or via social networking media. Benchmarking would help companies determine who should be receiving which tailored message. Other demand reduction measures do not rely on smart metering; retrofitting homes with water efficient devices, delivery of leaflets, engaging customers at the doorstep and via telephone.

During a drought, different restrictions could be placed on different customers according to their benchmarked use of water. Smart metering in combination with benchmarking would provide a very powerful means of targeting smarter demand reduction measures. Benchmarking on a DMA level may be justified in its own right (working alongside a tool for individual properties) as it will help to prioritise pressure reduction on areas which provide the biggest water savings.

5.2 TIMING OF THE INTERVENTION

Water companies measure the total amount of water put into supply on a continuous basis. Supplies generally peak during the summer periods although horticultural demand earlier and the week and month of peak demand in a given resource zone can vary from one year to another. However, during the summer water demand from both domestic and commercial customers increase - usually in response to dry weather. Daily fluctuations are smoothed out by storage in treated water service reservoirs but the average daily input over seven days gives an accurate indication of overall water demand.

Figures 3 and 4 gives profiles of recorded daily distribution input (DI) for Bristol Water in 1995/96 (which was a drought year) and from Portsmouth Water in 2008/09 and 2009/10 (non-drought year). The two profiles are similar with respect to the shape of the profile; they both have a period during the summer months during which is significantly higher distribution input than during the rest of the year. However, the time at which the peaks occur is slightly different in the two cases. In Figure 3 the DI peaks around the end of June and the second peak ends approximately at the end of August. In Figure 4 the ‘peak demand period’ starts around mid-May and ends approximately mid-August.

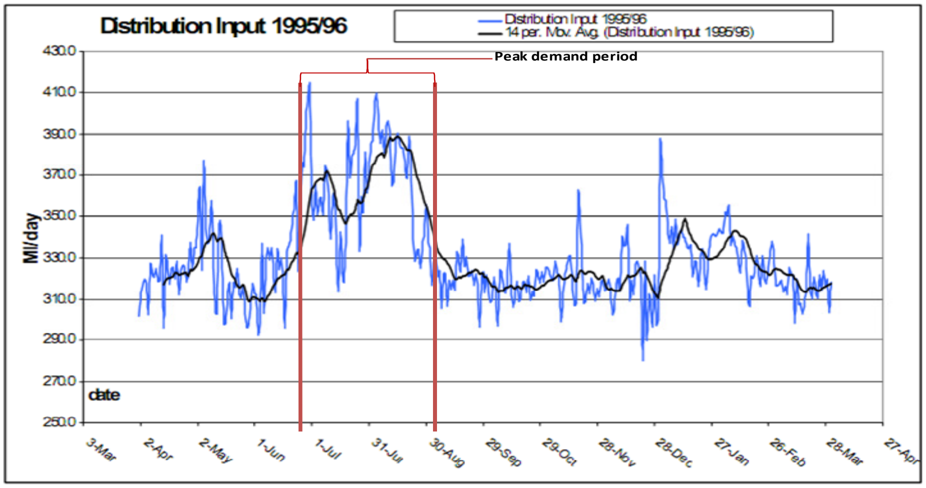

Figure 3 - Distribution input (DI) recorded daily for Bristol Water in 1995/96

Peak demand will vary depending on the climate and regional/local weather conditions. The examples in Figures 3 and 4 show that in both drought years and non-drought years, in different company areas, peak demand is a phenomenon which may be targeted with specific demand reduction activities and by focusing on reducing the amplitude of the peak significant quantities of water can be saved.

There is much still to be learnt about what elements of water demand change from average demand to peak demand, but it is known that where weather and climate are hotter, and a large proportion of customers engage in gardening, increased outdoor water use can be expected.

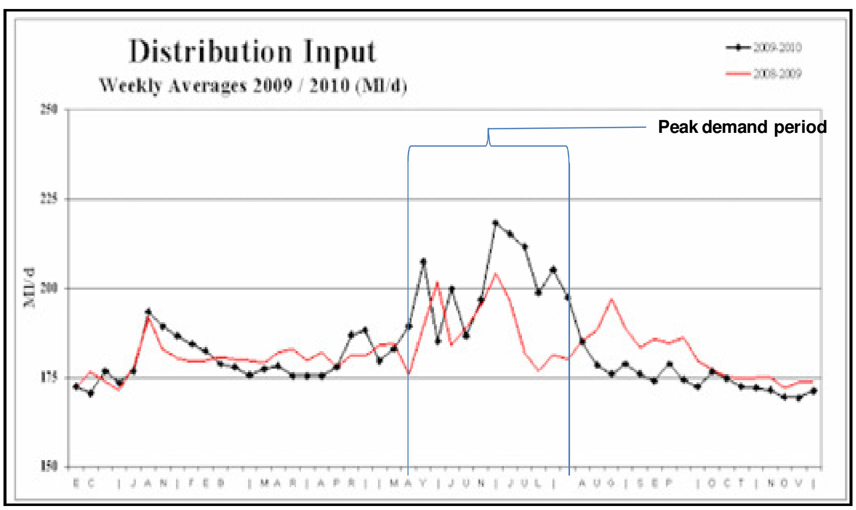

Figure 4 - Distribution input (DI) recorded daily for Portsmouth Water in 2009/10

When deciding how to target water demand reduction measures, there are broadly two options:

- Targeting peak demand (responsive interventions) which focuses specifically on reducing the size of the peaks during summer time in Figures 3 and 4. This approach necessitates understanding which components of demand influence peak demand, assuming that components such as outdoor water use represent a high proportion of peak demand than they do of average demand.
- Targeting average demand (resilience intervention) which does not seek to target demand at a particular time which means that it is not possible to focus on specific seasonal changes

in the way customers use water. It is likely that such an approach is not as effective at reducing peak demand but it is probably simpler to implement.

5.3 DISCUSSION

There is currently a debate in the water industry about the relative benefits of carrying out responsive and resilience interventions. Under conditions of drought or where there is a chronic need to reduce water consumption to conserve resources, then responsive interventions are commonplace, as shown in the Drought Plans which all companies are obliged to produce. The question is whether the principle of responsive interventions could be applied for example in areas where water is scarce or where for an individual customer, property or an area, water use is above a certain level deemed to be normal either in absolute terms or relative to other customers, properties or areas.

5.3.1 Metering and Tariffs

It may be argued that the required information is not currently available on the scale necessary to be able to carry out responsive interventions. End-point use monitoring is required in order to understand where, when and how much water is being used. Meters installed in every home would provide the information necessary to understand better how customers use water and to take action from this better informed standpoint. There are wider benefits for metering including potential for influencing customers' water-using behaviour through charging for water based on water consumption and the fact that metering enables innovative tariffs such as rising block and seasonal tariffs in addition to tariffs which help customers for whom bills are not affordable. Schemes such as the Assist tariff from Wessex Water and the WaterSure scheme from South West Water are excellent examples of water companies assisting customers who have problems paying their bills. In the case of South West Water, customers with affordability concerns are also targeted with water efficiency activities to help them save water on their bills.

Universal metering would allow issues with affordability to be tackled in the context of customers' water consumption. Water companies would be able to help customers to reduce their water consumption through retrofit and engaging them and providing the customers with information, in addition to looking at potential use of social tariffs. So metering is also a fundamental pre-requisite for tackling affordability.

5.3.2 Smart Metering

Automated Meter Reading technology collects readings from the customer's water meter on a regular basis, for example every 15 minutes. This would enable the customer to track their water consumption in graph form, using a website, a smart mobile phone, an in-home display or potential using a key fob, which downloads data from the meter when the customer walks past it (as used in Southern Water's Universal Metering Project).

This minimum specification for smart metering would allow customers to take ownership of their water consumption. It would also enable water companies to provide a better service to customers, for example, through:

- Detecting supply pipe leakage
- Notifying customers when their pattern of water consumption changes significantly
- Providing tailored water saving advice to customers
- Being better able to forecast demand and so manage water resources more effectively

It is important that as meters which are not considered smart continue to be installed that they have the potential to be upgraded to smart capability. It is possible to install clip-on devices to basic meters which would convert them to AMR specification meters and unlock the increased potential of smart meters.

Metering Case Study – Melbourne, Australia

Melbourne city is faced with a growing water scarcity problem with limited room for further resource development. Metering on a per-building basis has been central to Melbourne's demand management strategy since the 1950s, leading to widespread meter coverage. South East Water, one of three municipal bodies serving the city, currently has sub-meter coverage of approximately 93% of its 600,000 customer base. The remaining 7% are largely older developments in which plumbing prevents cost-effective sub-metering.

The drive for sub-metering has primarily been through tenant demand in multi-flat buildings. Awareness of scarcity is high in the city, and water is valued culturally. Due to this awareness and disputes over the fairness of distributing costs between tenants, there was a significant push for legislation to underpin sub-metering in condominiums. The result was the updated Residential Tenancy Act of 1998, which allows for the installation of sub-meters by the utility and the direct billing of tenants, with a small service charge sent to the property owner. Similar actions are being taken nationally with Queensland recently passing a bill according rights to landlords to meter tenants (Queensland 2006)

To encourage retrofitting, the utility has established a free sub-meter installation scheme for existing buildings. However, the cost of the necessary plumbing to install the sub-meters is borne by the property owner, occasionally making retro fitting prohibitively expensive in older buildings. Currently, South East Water's retro fitting programme stands at 1500-2000 units a year, a relatively small number. New-build uptake is more rapid, with sub-metering of multi-unit developments now a requirement for the connection of new properties (South East Water 2007). Under these conditions, the developer pays a 120$ Aus (£51[21]) for meter installation, which covers for the provision of the meter and associated administrative costs.

Automatic Meter Reading (AMR), in which meters are able to be remotely read through a radio signal, has allowed the utility to work around cases where a standard meter would be inaccessible to read. AMR meters employed in Melbourne were quoted to last approximately 10 years after installation; however, South East Water observes that after 13 years of operation, AMRs are still operating without battery failure and may eventually prove to be as robust as conventional sub-meters (lasting on average 15 years). South East Water has over 50,000 AMR sub-meters installed, with a large portion of these forwarding consumption data back to the utility on a daily basis. Where installed, it is required that the property developer pay for the additional cost of 210 Aus $ (£89.5[22]) per sub-meter for an AMR.

The ultimate aim in Melbourne is a 30% reduction in 1990s per capita demand values by 2020. Currently the reduction stands at approximately 22% and the introduction of sub-metering has been instrumental in proceeding towards this figure, supporting the signalling of costs to customers through the step tariff system, as well as providing significant data at a unit resolution, and an improved response time to leaks.

[21] Exchange value was 1 AUD = 0.43 GBP on 17/12/2007; Exchange value was1 AUD = 0.63 GBP on 07/02/2011

[22] Exchange value was 1 AUD = 0.43 GBP on 17/12/2007; Exchange value was1 AUD = 0.63 GBP on 07/02/2011

Smart Metering Case Study – New York City, United States

New York City's Department of Environmental Protection (DEP) is automating its water meter reading capabilities to increase billing accuracy and provide customers with the tools they need to better manage their water usage.

The Automated Meter Reading (AMR) system consists of small, low-power radio transmitters connected to individual water meters that send daily readings to a network of rooftop receivers throughout the city. In most cases, the transmitters will be placed where water meter remote receptacles are currently located. The AMR receivers will be part of the Department of Information Technology and Telecommunications' (DoITT) New York City Wireless Network (NYCWiN).

This new AMR technology will send accurate readings to a computerised billing system up to four times a day and will largely eliminate the need for estimated bills. Since it is an automated system, AMR eliminates the need for meter reading personnel to visit customer properties.
DEP is also providing AMR-installed customers with an online application that lets property owners view and manage their consumption on a daily, weekly, monthly, and yearly basis. This application will be made available to residents of each borough of New York City on a rolling basis.

AMR is a key part of DEP's ongoing transformation of the Bureau of Customer Services (BCS). As part of this initiative, customer service and billing practices have improved significantly, with more robust, accurate and easily accessible information now available to all 834,000 water and sewer account holders throughout the City.

5.3.3 Water efficiency targets

From 2009/10 Ofwat introduced water efficiency targets in order to help to quantifying companies' performance, highlight the work water companies do to help consumers to use water more wisely. It was also hoped that the targets would help to demonstrate clearly companies' contribution to the then Government's ambition to see a 20-litre reduction in daily per capita consumption by 2030.

The targets set by Ofwat are in two parts:

- Base service water efficiency (BSWE); and
- The sustainable level of water efficiency (SELWE).

5.3.3.1 Base targets

Ofwat proposed that the BSWE target should apply equally to each company. Base targets represented the minimum level of water efficiency activity expected from each company to meet its statutory duty to promote water efficiency to its customers. The proposed targets had three components:

- An annual target to save an estimated one litre of water per property per day through approved water efficiency activities.
- A requirement to provide information to consumers on how to use water more wisely.

- A requirement that each company takes an active part in improving the evidence base for water efficiency.

5.3.3.2 SELWE targets

Beyond the base water efficiency targets, Ofwat require companies to consider additional water efficiency activity above the base level. The companies are expected to plan for such activity if it forms part of a sustainable, economic approach to balancing supply and demand. During the Price Review in 2009, six companies were awarded funding for additional water efficiency projects under the SELWE scheme.

5.3.3.3 Water Efficiency Targets in the Context of Targeted Interventions

The current approach to setting water efficiency targets does not incentivise water companies to target water efficiency activities beyond the extent to which they can be shown to be a least cost means of removing a forecast supply-demand deficit. Neither do the targets in their current form acknowledge that the choices that water companies make in terms of where, to whom and when to carry out demand reduction interventions might have an impact on the level of the water savings achieved.

It could be argued that the understanding of how best to segment water users and/or benchmark properties is not yet in place to justify a particular approach to targeting demand interventions. However, there is already in place an understanding of where and when water is most scarce. The water companies have a keen eye on the supply demand balance in their water resource zones. Furthermore one of the criteria used by Ofwat when assessing whether to allow water companies to undertake projects as part of the SELWE targets is whether there is a forecast supply demand deficit in that area over the next ten years. This raises the following key points:

- There is already an implied targeting of water efficiency activities within the SELWE targets framework. Limiting the period over which there needs to be a supply demand deficit to just ten years seems arbitrary considering that there plans are produced for a 25 year period.

- There are currently a number of gaps in our understanding of how customers use water. This is holding back innovation which would see better demand forecasting and a better service being delivered to customers through identifying and filling their specific needs. Although Ofwat allow some funding for evaluation of water company activities such as metering programmes and water efficiency projects, there is a perceived lack of funding for research to help understand water consumption better. Further funding is required for research in order to fill the gaps in our knowledge of how people in the UK use water.

- The Base and SELWE targets should incentivise a more sophisticated approach to targeting water efficiency activities. This would mean driving water efficiency more in areas which are water scarce, or with customers deemed to be high priority, such as vulnerable customers at one end of the scale, or 'profligate users' at the other. Building an additional level of sophistication into the targets would provide an incentive to companies to plan activities more effectively.

This report has identified that there is a large amount of uncertainty in the assumptions used to produce the demand forecasts in the water resources management plans, particularly in the demand management domain. Given that there is a likelihood that water savings assumptions during the last price review overestimated savings from interventions, there is a possibility that supply demand deficits may actually occur sooner than forecast. In order to avoid any future shortfalls, demand forecasts should be updated with the latest evidence of water savings and should fully take into account the uncertainty in any assumptions by carrying out a sensitivity analysis.

6 Conclusions

This paper was produced as part of the Itchen Initiative, for which WWF-UK tasked Waterwise to produce a report to assist WWF in understanding the potential for smarter, targeted and responsive interventions to reduce demand. Waterwise sought to understand what tools and approaches are available to water companies to enable them to target water demand reduction interventions by understanding how water companies forecast demand through the Water Resource Management Plans and how demand forecasting relates to the Price Review and the Drought Planning Process. This work has led to ten recommendations which are explained below:

1. **Standardised definitions and common terminology related to demand management should be employed in the WRMPs and Business to ensure consistency and make it easier customers to be engaged by what their water companies are proposing.** For example, the distinction between demand, use and supply variables such as distribution sometimes used as surrogates for demand needs to be clearly made. In addition a common basis for domestic consumption monitors would give additional confidence in per capita consumption forecasts.

2. The Water Resources Planning Guidelines propose assumptions that companies should use for water savings from meter installation although the onus is on companies to evaluate and justify savings in their area/RZs. **The basis of the assumptions used to estimate water savings from water efficiency projects should be reviewed to take into account the latest evidence.** Where there is uncertainty in the assumptions for savings from different resource options, there should be on the conservative side rather than overestimating the contribution that they are likely to make. The guidelines should make use of Waterwise's Evidence Base to define the assumptions that should be used by companies to build their plans. Installing a meter is generally assumed to lead to a saving of 10 - 15%. However there is little robust scientific evidence that this is the case and no evidence that installing a meter on its own, without education, customer engagement, retrofitting or appropriate tarifs will have a substantive effect on customer consumption. The impact of these assumptions on the overall supply demand balance over a 25 year period is a huge source of uncertainty. Furthermore, the demand management framework in the drought plans is useful starting point for demand reduction planning. **Better integration between Water Resources Management Plans, Drought Plans and the Ofwat Price Review would provide a more robust approach to effective and targeted demand interventions.**

3. **Demand forecasting could be improved by including more considered assumptions about customers' water using behaviour and future changes in customer lifestyles, in the context of government policy**. Water resource management in water companies is currently an engineer's domain, but it would benefit from further consideration of customers' water using behaviour and how this might evolve, for example from a Environmental Psychologist's view point. This could be incorporated into the demand forecasting process by giving a greater role to scenario planning and adaptive management. **A national household survey of water use would be a good way of maintaining an overview of how, when and where people use water across the country.**

4. **Universal metering is an important part of improving information needed to tackle high consumption and the challenge of affordability.** This includes information on consumption that would be shared with the customer so that they become more aware of their consumption, which is also a powerful tool for water customers to help them forecast demand. Furthermore, demand reduction planning, which uses metered data to consider actual use in order to target interventions, will help ensure that demand side solutions are as

effective as possible. Universal metering should be accompanied by social tariffs to protect vulnerable groups and a water efficiency package. **The installation of smart water meters, in particular, provide time-series information and an improved basis from which to launch short-term, responsive demand reduction interventions.** Smart water metering would shorten the feedback loop between the water company and its customers, enabling hourly or daily water consumption to be viewed by customers on PCs and mobile devices or in-home displays. Such devices would be a convenient tool for providing advice and information to customers about how to reduce their water consumption in the event of drought, but also as a means to help customers save money on their water bills.

5. Responsive interventions would be triggered by an increase in water demand or by chronic water scarcity issues. This would utilise a similar framework to that outlined in the Drought Plans. **Sophisticated, responsive interventions are needed to address peak demand when and where water is scarce.** A better understanding of how people use water, alongside weather forecasts and historical consumption data could also allow peak demand to be tackled using interventions planned to predict when this will take place.

6. Ofwat's Water Efficiency Targets have provided a helpful framework within which companies can plan and quantify savings from their water efficiency activities. However, it is clear from this work that **the Base and SELWE water efficiency targets could incentivise a more innovative approach to targeting water efficiency activities.** This could mean targeting water efficiency in areas which are water scarce, or with customers deemed to be high priority such as vulnerable customers. Building an additional level of sophistication into the targets would provide an incentive to companies to plan activities more effectively.

7. **Customer Segmentation tools**, which are designed to help companies target their water efficiency activities better during a drought or in a normal period, **should take into account aspects of how households consume water.** Currently the tools used do not adequately consider this. **Benchmarking of dwellings should be considered as a means of targeting water efficiency activities.** Benchmarking has proved a useful tool in targeting water efficiency interventions for schools and for businesses. Developing an appropriate tool for domestic properties would be more complex due to the many different types of dwelling. However this would be a powerful tool for targeting and also as a means of helping customers to compare their own consumption to customers in similar types of dwelling. Benchmarking could be used in tandem with segmentation in order to target based on characteristics of the customer and of the dwelling in which they live.

8. Although Ofwat allows some funding for evaluation of water company activities such as metering programmes and water efficiency projects, there is a perceived lack of funding for research to help understand water consumption better. **Further funding is required for research in order to fill the gaps in our knowledge of how people in the UK use water**. For example, not enough is known about why two identical and neighbouring homes, with the same occupant composition, could have radically different water consumptions; why consumption varies so much, and why it varies regionally; how uptake rates of retrofits can be maximised, and what messaging works best; or what are the triggers of behaviour change. Existing research points to behaviour as the key driver: examining what drives these differences in behaviour is key to understanding, and influencing, water use.

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7.1 ACRONYMS AND ABBREVIATIONS

Abstraction	The removal of any water from any source
Abstraction License	The authorisation granted by the Environment agency to abstract water
Annual average daily demand	The cumulative demand in a year, divided by the number of days in the year.
Base Year	The year from which data is used to extrapolate future changes in water supply/demand
CCDeW	'Climate Change and Demand for Water', Defra Report on the effects of climate change on supply and demand
Consumption	Water delivered billed less supply pipe losses
Critical Period	The period when the supply-demand balance is at its minimum
DEFRA	Department for Environment, Food and Rural Affairs
Demand management	Use of policies which are designed to control or influence the consumption or waste of water
Demand management option	Single option designed to influence demand for water
Demand Scenario	A theoretical scenario that considers the implications of a particular set of regulatory/behaviour/technological/socio-economic changes on water supply/demand
Distribution input	Amount of water that enters the distribution system at point of production, often measured as demand by customers
Distribution Losses	Losses from distribution pipes, reservoirs and communication popes
Dry Year	A year in which unrestricted demand can only just be met by available supplies
EA	Environment Agency
EIA	Environmental Impact Assessment
Households	Occupied properties that receive water for domestic purposes
Internal metering	Meters that are installed within household boundaries that measure consumption
June Returns (JR08)	June Returns (2008) Information provided to Ofwat on a year basis covering water supply/demand, investment and financial information.
Leakage	The sum of distribution losses and underground supply pipe losses
Measured Households	Households with a meter installed on the premises and are on a consumption tariff, wherein water is paid for by total used.
Meter optants	Households which have had a meter installed at the request of occupants
Micro-component analysis	The methodology of calculating estimates of present/future demand based on expected changes in the ownership of, frequency of use of and volume per use of specific water using facilities, appliances or devices.
Ml/d	Megalitres per day (Megalitre= one million litres)
Non-households	Properties that receive water for domestic purposes but not occupied domestically such as factories and properties that include multiple households such as blocks of flats.
Normal Year	A year which is statistically average in terms of rainfall and temperature
Ofwat	The Water Services Regulation Authority
ONS	Office of National Statistics
PCC	Per capita consumption (Consumption per head of population)
Peak demand	The point at which the highest demand occurs can be measured hourly, daily, weekly monthly or yearly.
PHC	Per Household Consumption (Consumption of all occupiers of a single

	household)
Resource zone	The largest zone, in which all water resources can be shared, also referred to as Strategic Supply Areas.
Selective metering	Enforced metering of selected households or areas
Strategic Supply area	The largest zone in which all water resources can be shared, also referred to as a Resource Zone
Target headroom	The minimum buffer a water utility should allow between supply and demand to allow for unavoidable uncertainties in estimates of supply and demand
UKWIR	United Kingdom Water Industry Research Limited
Unmeasured Households	Households without a meter on the premises and are on a rateable tariff, wherein the amount they pay is dependent on the size/value of the household.
Water balance	The allocation of water inputs across a period of time (e.g in the current year or base year of demand forecasts)
Water UK	Trade association that represents the water industry
WRMP	Water Resources Management Plan
WRP	Water Resources Plan