



Motivating metrics for household water-use feedback



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ARTICLE INFO

Article history:

Received 30 October 2014
Received in revised form 11 May 2015
Accepted 12 May 2015
Available online 7 August 2015

Keywords:

Smart water metering
End-use analysis
Household water conservation
Water-use feedback
Behaviour change
Sustainable water

ABSTRACT

Motivating more sustainable water consumption is important since population growth and climate change are placing increased pressures on water supplies in Australia and elsewhere. Smart water metering creates new possibilities for feedback of detailed water-use information to householders as a signal of potential opportunities to save water, and a number of recent feedback studies have shown water saving results. However, existing literature lacks an overview of the available options for the presentation of detailed household water-use information; and research into what households understand, and value and prefer in terms of feedback. This paper introduces a framework for the possibilities for feedback; and further explores dimensions of the framework via a detailed post-intervention evaluation of a recent smart water metering trial involving detailed end-use feedback to a sample of households in New South Wales, Australia. The householder evaluation survey and interviews investigate engagement with customised water-use metrics presented during the trial, and explore wider preferences for water-use feedback. Understanding how householders relate to different types of information has an important role to play in maximising household engagement and the potential for more detailed water-use feedback to guide household water management. Therefore the framework and evaluative research findings carry implications for future deployments of residential smart water metering involving feedback. Particularly, the high level of interest and engagement of many study householders with the detailed water-use information highlights important potential for feedback, and lends support to the business case for utilities to pursue smart water metering trials and roll-outs. However, with heterogeneity of customer preferences and responses, more carefully considered approaches to water-use feedback are advised (e.g. more judicious feedback design, and potentially the use of tailoring and/or customer segmentation) to facilitate a greater contribution towards more sustainable water consumption.

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1. Introduction

1.1. Smart water metering opportunity

The recent advent of smart water metering enables the collection of higher resolution water consumption data than under conventional metering. By logging usage at highly frequent intervals (e.g. of seconds or minutes), smart metering creates a far larger database of water consumption according to time of use and allows for analysis of end-use patterns. Deployments of smart water meters are growing rapidly in many developed countries, with over 250,000 units either planned for, or already in operation by Australian water utilities (Beal and Flynn, 2015). The water industry is

therefore now beginning to embrace new levels of data and means for its analysis and communication. However, while many water utilities are focusing on the benefits in terms of internal planning or network efficiency (see Boyle et al., 2013), not all implementations have been extended to provide more detailed water-use feedback to householders. An underexplored opportunity therefore remains for collected data to be analysed for translation into significantly more detailed water consumption feedback for household consumers.

1.2. Householders: feedback, responses and preferences

Householders may not be entirely aware of their water usage nor of opportunities to save. Therefore, consumption feedback may help to address these knowledge gaps. Recently, Beal et al. (2013) found that householders which received feedback on how their water consumption compared to other homes could more accurately match perceptions of their water consumption to their actual usage. Beyond raising awareness, the provision of informa-

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tion on opportunities to save can further improve householders' knowledge of how to save; and knowledge and water-saving skills have been found as important determinants of water conservation behaviours (Corral-Verdugo, 2002; Corral-Verdugo et al., 2012).

The provision of consumption feedback has been shown to help customers monitor and more effectively manage resource use (see Abrahamse et al., 2005), and positive impacts through feedback have been found via research across a variety of domains, including household energy and recycling behaviours (Schultz et al., 2014). Through raising awareness and changing consumption behaviours, feedback on household water-use also has the potential to contribute to more sustainable consumption patterns and practices, and potentially reduce the demand on constrained water resources.

A number of recent research studies, which particularly involve smart water meters, have shown that various different forms of water-use feedback can effectively reduce household water consumption (Wetherall, 2008; Doolan, 2010; Willis et al., 2010; Erickson et al., 2012; Anda et al., 2013; Fielding et al., 2013; Joo et al., 2014). These studies tested for quantitative changes in water consumption and reported savings ranging from 5 to 10%. The recent Home Water Update (HWU) study, to which this present work relates, also signalled initial savings of 8% through feedback of detailed water and end-use metrics in paper-based reports, although with the moderate sample size and measurement periods, these savings could not be confirmed as statistically significant (see Liu et al., 2015, submitted for publication).

Despite the reports of overall quantitative savings and some documentation of specific changes in behaviour, relatively few feedback studies have conducted a detailed post-intervention evaluation to understand how householders engaged with the different forms of water-use information provided. In the few cases where comprehensive post-trial surveys and/or interviews were actually conducted (e.g. Doolan, 2010), householder information preferences were investigated only briefly among a wider set of trial related issues. Erickson et al. (2012) took the novel approach of investigating pilot usage of an online water portal via internet click-counts, which showed where users were spending most time, and thus sheds some light on user interactions with available data and functions. However, both in this and most other studies, it is unclear what additional or alternative types of information householders might have preferred. It is furthermore uncertain in each of the studies which pieces of information specifically motivated changes in behaviour towards water conservation.

Fielding et al. (2013) took another innovative approach by using study sub-groups from the outset to compare impacts of customised end-use data against procedural information and against descriptive norms on ways to save. The distinct feedback groups obtained significant savings relative to the control group, but not relative to one another (Fielding et al., 2013). The study scope did not include an evaluation of how householders within the different groups interacted with the different forms of feedback provided, or their other preferences.

Parallel work from within the field of sensor technologies (Froehlich et al., 2012) represented a first attempt to obtain wider insights into householder information preferences for more detailed water-use information. However, the study's use of prototypes meant participants were unable to engage with any real, customised, water-use data reflecting their own household consumption.

Research is currently underway to explore alternative ways of analysing household water usage data collected via smart water meters. This includes improvements in end-use categorisation via the automation of flow trace analysis using pattern recognition and event probability functions (Nguyen et al., 2013); as well as the detection of water-use signature patterns, which cluster meter reads on the basis of calendar dates, times and volumes to iden-

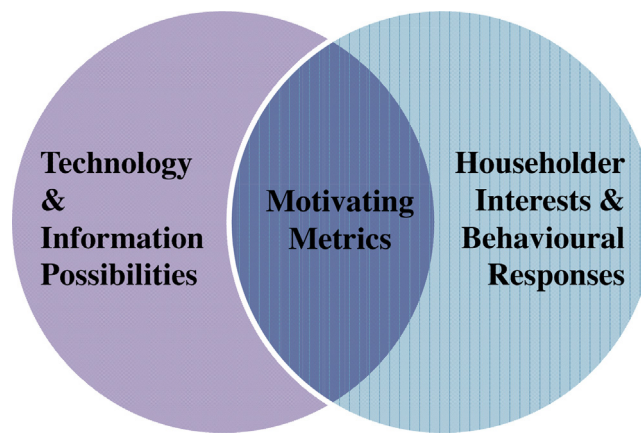


Fig. 1. Research focus.

tify target behaviours for reducing consumption (Cardell-Oliver, 2013). Within the energy sector, there have already been further advances in terms of automating smart meter data analysis and producing customised household energy reports for mail distribution (e.g. Laskey and Kavazovic, 2011). This suggests that further developments can well be expected within the water sector to facilitate the creation and provision of more detailed consumption feedback to householders.

Amid these growing prospects for more advanced water-use feedback, our review of existing literature found a clear need for additional work in this emerging field to understand the forms of water-use feedback that householders might prefer and could help motivate savings. This remains essential in shaping the role for feedback via smart metering to promote water conservation. While scarcely researched for the water sector, this need has been more clearly recognised within the residential energy sector, where detailed feedback is also more established.

Energy-related research has specifically cautioned that care must be taken when choosing the information the consumers are given and with the way in which it is presented. . . that the information provided to consumers is relevant and enables them to make sustainable decisions about their energy use and so the study of what kind of consumption feedback consumers understand and prefer is required (Karjalainen, 2011). Within the energy sector, insights from behavioural science (e.g. the fields of influence and persuasion) have also been recommended to help develop the right ways to present the right information for maximum impact (Laskey and Kavazovic, 2011). Such considerations also need to be applied to the design of water-use feedback, whereby well-designed feedback can help householders to better monitor their consumption and ultimately save water.

1.3. Current study

Our review of the existing literature highlighted two important knowledge gaps to be addressed in this paper. First, the existing literature lacks a comprehensive overview of the extensive water-use feedback possibilities specifically made possible via smart metering. Second, more work is required to understand the specific forms of information that householders prefer, and could help motivate behaviour changes toward more sustainable water use in the home.

The research topic is depicted in Fig. 1 below, where one circle represents the set of household water-use feedback information that is technically possible; while the other circle represents the set of informational interests and behavioural responses of householders. The area of overlap is designated with the term motivating

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