Journal of Cleaner Production xxx (2015) 1–12

Contents lists available at ScienceDirect

Journal of Cleaner Production

journal homepage: www.elsevier.com/locate/jclepro

Urban water conservation through customised water and end-use information

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ARTICLE INFO

Article history:
Received 2 July 2014
Received in revised form
28 May 2015
Accepted 1 October 2015
Available online xxx

Keywords:
Smart water metering
End-use analysis
Residential water conservation
Information
Feedback
Sustainable water

ABSTRACT

Water conservation in urban centres is an ongoing challenge in which new technologies can play an important role. Smart water metering in conjunction with end-use analysis enables the collection of more detailed information on household water consumption than was previously possible. This presents a new and currently underexplored opportunity to promote more efficient water use via the provision of detailed customised water-use information to householders. Among the variety of possible approaches, is the option of paper-based reports containing a highly detailed 'snapshot' of household water use. This paper describes a mixed methods study in which customised paper-based 'Home Water Updates' were provided to a group of households in Australia to explore the idea of providing detailed feedback, including detailed end-use consumption information on uses of water within the home. The methods used within this research are described in detail to disseminate experience in this relatively new area of research. Analysis of the post-intervention householder evaluation survey showed the provision of detailed water-use information via the Home Water Updates appealed to the vast majority of householders; and further resulted in changed behaviours (e.g. shorter showers and full washing machine loads) and installations of new infrastructure. These research findings suggest a role for customised household water and end-use information via smart metering. However, more work is required to optimise approaches to enable a significant contribution towards more sustainable urban water management.

1. Introduction

As the need for greater sustainability in urban centres becomes increasingly apparent (Agudelo-Vera et al., 2012, 2011; McCormick et al., 2013), new technologies and behaviours which can contribute to a more sustainable consumption of important resources are becoming of increasing interest. In particular, ways to reduce consumption of energy and water require the attention of researchers, industry professionals and consumers alike.

Smart metering is an innovative measurement technology which offers the potential to contribute to a more efficient use of electricity, gas and water resources in both commercial and residential buildings. Essentially, smart metering technologies introduce new opportunities to collect more detailed information on resource consumption practices and patterns than was previously possible under conventional metering. The opportunity exists to convey this information both to the utility and the consumer to inform and guide water management (Boyle et al., 2013). Particularly in the water sector, however, comparatively less attention has been on the *communication* of the detailed water-use information to customers.

1.1. Water consumption data advances

Within the water sector, residential meters have traditionally been read up to once per quarter, yielding no more than four data points per meter per year (Britton et al., 2008). By contrast, smart water meters record the flow of water consumption every set number of seconds (e.g. every 15 or 60 s). The technology therefore opens the door to significantly greater data resources and the possibility of understanding water consumption according to time of use within the day, taking also variations in weather and seasonal

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http://dx.doi.org/10.1016/j.jclepro.2015.10.002
0959-6526/

changes into consideration. Further analysis of detailed smart water meter data can be conducted using trace flow (end-use) analysis, a process which assigns end-use tags (e.g. shower, toilet, washing machine etc.) to each water-using event (Willis et al., 2009). This allows metrics to be obtained for each individual water-using event including start and finish time, duration, flow rate (maximum, minimum, average) and volume (Liu et al., 2013; Mayer et al., 2000). This analysis of high resolution water consumption data collected via smart water metering can therefore prelude a detailed understanding of where water is used in the home (Giurco et al., 2010). This can in turn be used to support more targeted water conservation efforts as well as to assess the effectiveness of demand management interventions (Stewart et al., 2010).

1.2. Water conservation and the role of information campaigns and detailed feedback

Water utilities and public agencies around the world have at times used information campaigns to encourage residential water conservation. A variety of modes have been used to inform households of ways to save, including leaflets, bill inserts and websites. The particular mode of informational delivery (e.g. paper versus online) is likely to have implications for its reach. Similarly, the content of water-use information and its format may influence impacts on consumption behaviours. Here an important distinction needs to be drawn between generic information (e.g. aggregate data for a supply location) and disaggregated feedback at the household level. To date, water conservation campaigns have been based on the former, often presented in terms of averages. However, as explained by Aitken et al. (1994), customised feedback can provide a more accurate basis for assessment and action thereby enabling progress towards a (conservation) goal. Therefore, disaggregated water-use feedback may promote conservation at the individual and household levels. Moreover, the more detailed or specific that the customised feedback is, the clearer the signal of real water-saving opportunities may be.

Information-based approaches are often linked to an 'information deficit' model of rational behaviour (Burgess et al., 1998), which suggests households will respond to additional information to their own gains. However, the explanation is not without its critics, who have questioned whether the provision of information alone is effective and if additional interventional support may be required (e.g. McKenzie-Mohr and Smith, 1999); or whether a focus on information is wrong, since households may depart from the assumptions of rationality in various important ways (e.g. Shove, 2010). Yet these critiques are not specifically levelled at particular types or levels of information, which could plausibly yield varying impacts.

1.3. Householder smart metering opportunity

The high resolution data obtained from smart meters creates the potential for far greater informational resources than under traditional metering. The data collected can be analysed with the goal of providing significantly more detailed household-specific information to household water consumers for a potentially more effective provision of information to promote conservation (Liu et al., 2013).

Until now, however, more research has been conducted within the residential energy sector on the potential role of customised feedback via smart metering (see e.g. Darby, 2010; Faruqui et al., 2010 for reviews). While a couple of residential energy-focused studies took novel steps to incorporate real-time online water use feedback, the impacts on water consumption were comparatively small (3% in Petersen et al., 2007), or not reported (Fróes Lima and Portillo Navas, 2012). Over the past few years, a handful of studies have emerged specifically investigating the impact of more detailed, customised water-use information via smart water metering. Studies involving paper-based interventions e.g. leak notification letters (Britton et al., 2013) and feedback postcards (Fielding et al., 2013), as well as in-home displays (Doolan, 2010; Wetherall, 2008) and online portals (Erickson et al., 2012; Joo et al., 2014), have reported a positive impact of between 5 and 10% water savings. The opportunity still remains, however, to allow householders to engage with a variety of detailed types of water-use feedback, including at end-use levels.

1.4. Research aims

This research belongs to a larger program which investigates the potential for detailed water-use information obtained via household smart metering to promote behavioural changes towards more sustainable water consumption. Within this wider scope, this paper explores how householders respond to the provision of detailed, household-specific water and end-use information communicated specifically via paper-based reports.[2] A unique variety of detailed and water-use measures are presented within the study to specifically allow householders to experience different types of information. The study adopts a mixed methods approach in which the impacts of detailed water-use information are analysed using smart meter and end-use data, with the novel inclusion of a post-intervention householder evaluation survey. The study methods and limitations are further described in detail. Deeper insights are thus provided into the approaches adopted to guide future industry and research activities within the emerging field of household smart water metering, end-use analysis and feedback programs.

2. Materials and methods

2.1. Background

The study location is Tea Gardens/Hawks Nest, suburbs located within the service area of MidCoast Water (MCW) in New South Wales, Australia. In a prior study (2009–2011) MCW introduced smart metering to 141 homes in the area to investigate the impact of pressure management on household water demand. To compare pre- and post-intervention water use the 'Datamatic Firefly' loggers were set each summer (December/January) and winter (June to August) to record water use intensively for a period of between two to five weeks each. This water-use data, which is collected at 1-min intervals with a resolution of 0.5 L per pulse, is subsequently analysed by MCW using SmartMon software (Redskink Pty Ltd., 2011) to disaggregate the flow data into end-uses (i.e. shower, toilet, washing machine, taps, outdoors and leaks).

While the smart metering technology has since remained in place, and moreover the detailed data is continually being collected each summer and winter and also being disaggregated to end-use levels, no detailed data had previously been communicated to the residents of the smart metered homes. This existing organisational setting therefore led to an interesting opportunity to explore the idea of communicating smart water meter information to the respective households, which forms the focus of the present 'Home Water Update' study (2012–14). Importantly, the existing setting provided a relatively low-cost research environment, since the metering and end-use analysis technologies and the data collection

[2] The comparative role for online water-use information will also be investigated within the greater ongoing research project later in 2015.

Please cite this article in press as: Liu, A., et al., Urban water conservation through customised water and end-use information, Journal of Cleaner Production (2015), http://dx.doi.org/10.1016/j.jclepro.2015.10.002