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Digital metering feedback and changes in water consumption – A review

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ABSTRACT

This review paper investigates the way information is provided to customers through the use of digital water metering and customer engagement, and its impact on water consumption. A review of 25 published detailed customer water-use information feedback studies was undertaken, along with interviews with five water utilities located internationally with practical experience in digital metering rollouts. The results of the review revealed mean savings across all the studies of 5.5%, within the 10th–90th-percentile envelope of 3.0%–8.0% savings (excluding the extreme outliers). The range of savings was found to vary across each of the various parameters investigated, with no single intervention approach clearly standing out as best practice. With large scale rollouts, for which little literature is available, it is typically difficult to attribute the savings to feedback programs alone, since other factors may have influenced the outcomes, and are difficult to account for or were not included in the literature. To better understand and evaluate the impact of a feedback program, and optimise its operation, a well-designed evaluation and related implementation plan should be considered in conjunction with a digital metering rollout. Discrete interventions should be monitored against a control group (or groups) to assess uptake, response and persistence over time (of both uptake and savings), in order to refine a program over the business case period.

1. Introduction

1.1. Background

Digital metering offers the benefits of remote reads and timely information on customer water use through more frequent reads in (near) real-time (Boyle et al., 2013). This facilitates leak detection, both within the customer's property and in the supply network and enables quicker repairs leading to water and cost savings. The potential also exists to provide customers with timely information on their water consumption using any of a number of possible mediums (e.g. letters, a website, mobile phone applications, text alerts and/or emails) to provide greater awareness about water usage and its impact on bills, and enable more informed choices about usage (Liu et al., 2015).

This paper specifically reviews the change in water consumption that can be expected via a rollout of digital water meters involving a customer engagement strategy that targets behaviour change in providing water usage information feedback to consumers in (near) real-time.

1.2. Theoretical underpinnings

The theoretical underpinnings for the provision of consumption information feedback in the literature typically make some form of reference to the so-called 'information-deficit' model of rational economic behaviour (Burgess et al., 1998). The theory suggests that imperfectly informed consumers will systematically evaluate alternative courses of action in the light of new information and respond in such a way as to promote their own self-interest. The provision of water-use consumption information feedback can therefore lead householders to change their consumption behaviours and/or upgrade their household water-using appliances to save water and achieve the associated financial or other gains. The theory presents a simple connection between information and consumption, with an immediate role for the provision of water consumption feedback to end users, but is not without its critics who cite the cognitive limitations of consumers in evaluating information and decision-making, as well as automated or habitual responses (Jackson, 2005). In addition, the concepts of individual choice, action and change have also be called into question by social practice theorists and researchers who instead view people as "carriers of practice" with the effect that "socially, institutionally and infrastructurally configured" practices affecting consumption patterns (for example, in terms of what is socially or culturally "normal" for the practice of laundering) (Shove, 2010). However, in recent work on the provision of detailed water-use feedback, it was noted that such criticisms have not been specifically levelled at particular types of levels of

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detail of consumption information feedback, which it was argued could give rise to differential impacts and provide a closer link to specific water-using practices (Liu et al., 2016a,b).

1.3. Current study

Two important knowledge gaps are to be addressed in this paper. First, the existing literature lacks an overview of the impacts on water consumption via the provision of consumption information feedback (i.e. percentage range of consumption savings achieved) using data collected via digital means. Second, more work is required to understand how savings impacts vary across the various different defining dimensions that have characterised detailed water consumption information feedback studies.

The key objectives of this research are to therefore:

(1) Review existing water consumption information feedback studies and the impacts on water consumption achieved.
(2) Analyse how water consumption savings achieved via the provision of water consumption information feedback vary according to their various key defining features (e.g. medium, content, duration, frequency, program scale, baseline water consumption, context (i.e. drought history); and review results in terms of the persistence of savings effects and uptake of interventions (e.g. online portals).

The research brings together available experience in order to provide an overview of the impacts of detailed water consumption information provision of relevance to a digital customer water metering strategy.

The rest of the paper proceeds as follows. Section 2 presents the literature review approach and methodology and including the analytical framework used to structure the literature review. Section 3 presents the results of the literature review. Section 4 presents the analysis of the results. Section 5 summarises the savings estimates and parameters affecting water savings. Section 6 summarises the key conclusions with a discussion of the implications for digital water metering implementations and business cases and identifies directions for future research.

2. Approach and methodology

2.1. Analytical framework

The research approach draws on a framework developed through our previous research (Liu et al., 2016a,b) as a way to review approaches to customer engagement through digital data information and analyse their effectiveness. This 'feedback implementation framework' is presented in Fig. 1 and highlights key considerations in the design of detailed water consumption information feedback programs. The implementation framework is presented as four embedded concentric circles for heuristic purposes. Of specific relevance to this study is the larger circle, that is the practical design considerations, concerning the questions of 'Why', 'When', 'Who' and 'What':

- The 'Why' element considers the water utility's needs and motivations for introducing detailed consumption information feedback (e.g. customer engagement in water conservation).
- The 'When' element refers to the timing of feedback, its frequency and duration as well as the context and water supply conditions (e.g. normal supply or scarcity as during droughts).
- The 'Who' element concerns the target audience and whether this is population wide or a sample thereof (in which case issues of sample selection, representativeness, sample size and statistical significance are also of relevance); and whether the approach is opt-in or opt-out. Baseline consumption levels can also be used to characterise the audience.
- The 'What' segment refers to the information feedback itself (e.g. leak data, end-use data or comparative use data); and communication medium. Other considerations include who is directing the approach; how the information feedback will relate to other policies; and the customer narrative.

Key elements of the framework are used to categorise the literature review findings, as explained in the following methodology section.

2.2. Approach, methodology and activities

The research involved a review of publically available literature that will be used to understand the percentage range of water use behaviour change that might be expected through a digital metering rollout and investigates the range of impacts according to a range of defining features of feedback programs.

The central research question used to guide the literature review was: What is the range of water consumption savings that can be expected through the provision of water usage information to customers in a digital metering strategy? The sub-research questions used to inform this overarching research question included: (1) What water consumption savings have been achieved through the provision of water usage information to customers utilising digital metering? (2) What were the factors that influenced the level of savings that were achieved? (3) What was the possible influence of other factors in comparing across the different case studies?

The research approach involves a systematic literature review undertaken in four steps: (1) planning, (2) research data collection, (3) analysis and (4) synthesis.

2.3. Literature review

The literature review utilised a variety of sources that covered: academic databases; industry/trade journals; and other 'grey' (non-academic) literature (e.g. reports, newsletters, factsheets and conference presentations). The scope of the literature review focused on studies from within the water sector that reported on water savings achieved via the implementation of a consumption information feedback program in conjunction with digital water metering. The following search terms and alternative combinations thereof were used to identify relevant literature: water consumption; feedback; consumption information; customer portal; portal; report; IHD (in-home display); digital water metering; smart water metering; AMR (Automated Meter Reading); AMI (Advanced Meter Infrastructure); intervention; trial; pilot; study; water savings.

Additional data was collected on water consumption information feedback studies that did not involve data collection using digital metering. This research expanded upon a selected literature review by Byrne and Martin (2016) and the findings were considered where appropriate in relation to results obtained from our review.

Relevant literature from other sectors, including energy, was also reviewed for cross-sectoral insights in relation to the range of savings impacts, their duration and trajectory, and the influence of specific design and contextual factors.

In addition, primary research was conducted in order to obtain (additional) information on the most recent activities in digital metering not currently available publicly by conducting a handful of interviews with water utility digital metering management staff at the New York City Department of Environmental Protection (NYC DEP), San Francisco Public Utilities Commission (SFPUC), Madison Water Utility, Toronto Water, and Thames Water.

2.4. Data collection and classification

The data collection phase involved extracting data for the variables of interest from the collected literature that were deemed as defining