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Integrating behavioural change and gamified incentive modelling for stimulating water saving

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ABSTRACT

Stimulating consumers to save water is a challenge and an opportunity for water demand management. Existing ICT systems for behavioural change often do not consider the underlying behavioural determinants in a systematic way. This paper discusses the design of the behavioural change and incentive model combining smart meter data with consumption visualisation and gamified incentive mechanisms to stimulate water saving. We show how the design of such a system can be related to a holistic behavioural change model and how this systematic mapping can inform the design of an integrated incentive model combining different incentive types (virtual, physical, social). The model is implemented in the SmartH2O system and deployed in two pilots. We present the preliminary results for the Swiss pilot, which indicate reduced water consumption, positive user feedback and overall suitability of the designed incentive model.

1. Introduction

Enabling new ways of water demand management through ICT has become a major challenge for supporting water efficiency. Different strategies are being explored to address this challenge, ranging from the use of efficient water flow devices and new adaptive pricing policies, to awareness campaigns for sustainable water consumption (Stewart et al., 2010) and the analysis of smart meter data for demand profiling (Cominola et al., 2015). The investigation of new approaches to saving water becomes even more important when considering the significant energy impact of urban water systems and water use in particular, identified by systemic approaches to the modelling and analysis of the water-energy nexus (e.g. Kenway et al., 2015).

Even though large savings can be gained by having consumers buy and install efficient appliances (e.g. water-efficient washing machines), as well as through structural improvements to houses (e.g. installation of a dual water system), these decisions are taken sporadically, have significant financial impact, and are difficult to anticipate and influence. Therefore, water utilities are increasingly attempting to influence the habitual behaviour of consumers towards improving water consumption. Water saving through consumer behaviour change has been traditionally addressed with awareness campaigns (Russell and Fielding, 2010; Seyranian et al., 2015) and financial incentives (Jorgensen et al., 2009). Recent efforts explore the visualisation of consumption data (Fielding et al., 2013) and game-like approaches for engaging users in water saving (Wang and Capiluppi, 2015). Previous studies of awareness campaigns report savings of 5–10% (e.g. Fielding et al., 2013; Ferraro and Price, 2013), but also point out a number of issues regarding the sustainability of the achieved behavioural change (e.g. rebound effects). As demonstrated in a large-scale trial by Ferraro and Price (2013), personalised mailings with appropriate motivational elements (e.g. social norm messages extended with social comparison) can significantly impact the effectiveness of such approaches. Yet, even in such successful trials, the effectiveness of such messages decreased over time.

Determinants and processes of behavioural change for environmentally conscious behaviour have been extensively studied in

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environmental psychology (e.g. Steg and Vlek, 2009) and persuasive systems (e.g. Oinas-Kukkonen, 2013), but the influx of these findings into the development of ICT-systems for water saving has been rather limited. In particular, little work has been reported that systematically builds the design of a system and associated incentive model on a theoretically-grounded model and subsequently validates it in real-world pilots. At the same time, some trials with direct feedback systems have reported water savings of up to 22-27% (Tiefenbeck et al., 2016; Willis et al., 2010), indicating a large potential of such solutions. However, research in both the water and the energy domain suggests that consumption feedback alone is incapable of inducing a durable change of behaviour (e.g. Schultz et al., 2014; Nachreiner et al., 2015; Fréjus and Martini, 2016). Similarly, while game-like motivational mechanisms have been successfully applied to influencing user behaviour in different domains (e.g. Sintov et al., 2015), the use of gamification for stimulating water efficiency has been limited and its effect is scarcely documented in scientific literature (Galli et al., 2015).

In this paper we discuss the design of a behavioural change system and of the associated incentive model to induce a sustainable change in water consumption behaviour. The model combines smart-meter based consumption visualisation with gamified incentives to stimulate water saving. We show how the design of such a system can be systematically related to a holistic behavioural change process model to obtain an integrated incentive model combining different types of incentives (virtual, physical, social), adapted to the characteristics of two different pilot types (small-scale, large-scale). We illustrate the model by describing its implementation, deployment and evaluation in a real-world setting. We report on the first results from a small-scale pilot, including impact on water consumption, analysis of platform activity and evaluation with end-users.[1]

2. ICT-enabled systems for residential water saving

While in the energy domain different behavioural change systems have been explored, ICT-based systems that stimulate water efficiency in households are much less investigated (Tiefenbeck, 2014). The progressive adoption of smart meters by water utilities has recently increased the attention for such systems. They visualize consumption data from smart meters to provide consumption feedback to users and raise their awareness about water consumption (e.g. Froehlich et al., 2012). In this section we review existing solutions, and outline the contribution of the SmartH2O approach to the knowledge about smart meter-enabled behavioural change systems. One class of systems provides consumption feedback at the level of an individual appliance through a device that is directly attached to it, and is based on the assumption that feedback is most effective when delivered close to the cause of the consumption (Kappel and Grechenig, 2009). Examples include a "Waterbot" that displays water consumption at the tap in the kitchen (Arroyo et al., 2005), a shower display, which visualizes consumption with coloured LEDs (Kappel and Grechenig, 2009) or a "Shower Calendar" showing the water consumption of household members on a calendar display in the shower (Laschke et al., 2011). Similarly, the Amphiro on-shower device combines in-shower visualisation with reports viewable on web-based and mobile apps (Tiefenbeck et al., 2016; 2016).

Other systems present water consumption data at the level of the household as a whole, through in-home displays, web-based or mobile apps. Such systems feature reporting functionalities for both end-consumers and water utilities. A prominent example is WaterSmartWaterSMART (2016), providing a software service for utilities, allowing customers to compare their consumption against neighbors and like-sized homes on the basis of interactive (web, mobile) and paper-based monthly reports, including water saving tips and incentivizing use through rebates (from water suppliers). Their recent pilot in a Californian district reported about 5% savings per household (Mitchell et al., 2012). Progress on disaggregation algorithms is about to enable a reliable breakdown of water consumption at the appliance level without requiring special sensors (e.g. Nguyen et al., 2013), paving the way for future applications with fine-grained feedback that may further increase water saving rates.

Several on-going EU projects follow similar approaches with some differences. The SmartH2O project (Rizzoli et al., 2014) differentiates itself through daily consumption feedback and integrated gamified incentive model (discussed in this paper), going beyond social comparison and rebates of WaterSmart, and combining visualisation and saving tips with personal, social, virtual and physical rewards (Section 4). Several other efforts are worth noting, even if they have not yet reported details of their approaches or results in scientific literature. The WATERNOMICS project focuses on integrating personalised feedback on water consumption, sensor data and fault detection algorithms, and enabling dashboards and decision support systems for water saving (Clifford et al., 2014; Chambers et al., 2015). The WISDOM project aims at behavioural change through near real-time water consumption feedback on an in-home display and a digital game (Terlet et al., 2016).

Even though limited in size, number and duration of trials, evaluations of such systems provide encouraging results on the perceived usefulness of different types of displays and feedback (e.g. Froehlich et al., 2012). Only few evaluations address the impact on water consumption. As an exception, Willis et al. (2010) report a 27% water consumption reduction after deployment of shower alarms alerting household members when using more than a set amount of water, though in a rather short pilot (two-weeks pilot with 44 households). Most recently, Tiefenbeck et al. (2016) have reported a 22% consumption reduction after deployment of on-shower devices with real-time feedback on water and energy consumption in a large-scale field experiment (697 households). These are promising results, even though long-term impact is unclear, due to the limited duration of the trials and possible rebound effects after the interventions. Similarly, while approaches to engaging consumers through game-like motivational mechanisms in non-game contexts (gamification) have been widely explored in the energy domain (e.g. Sintov et al., 2015), the use of gamification in the water sector has been so far limited and scarcely documented in academic literature (Galli et al., 2015). Two recent examples are the aforementioned projects WISDOM, developing a virtual game for water saving (Terlet et al., 2016) and WATERNOMICS, which envisions "games and interactive learning applications" for water saving (Clifford et al., 2014). However, for these projects neither the system implementation, nor an evaluation of the impact on water consumption have been published yet. A systematic grounding in a behavioural change process also hasn't been available.

The addressed systems are often based on the premise that feedback will increase 'awareness', which in turn will induce a change in behaviour. However, recent studies give rise to doubts about this single-focus behavioural change strategy. Smart metered feedback alone has proven to be incapable of inducing a *sustainable*

[1] This paper is a thoroughly revised and extended version of the paper "Behaviour change and incentive modelling for water saving: first experiences from the SmartH2O project" presented at the 8th International Congress on Environmental Modelling and Software Toulouse, France, Sabine Sauvage, José-Miguel Sánchez-Pérez, Andrea Rizzoli (Eds.) http://www.iemss.org/society/index.php/iemss-2016-proceedings.