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Smart metering for residential energy efficiency: The use of community based social marketing for behavioural change and smart grid introduction

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ABSTRACT

Community-based social marketing (CBSM) has shown to be very effective at inducing behavioural change due to its pragmatic approach. It has been found that nonintegrated intensive approaches towards changing individual's behaviour, such as education and economic self-interest are not successful.

This paper will explain how a large urban electricity meter replacement program can achieve a reduction in peak demand and overall energy consumption through the use of advanced metering infrastructure (AMI or 'smart meters') coupled with CBSM, which in turn enables the progression towards a 'smart grid'. In order to measure success the following targets were set:

- Peak demand reduction (peak lopping) of 20% from the households participating in the Behaviour Change Programs (BCPs).
- Peak demand shifting (load shifting) to reduce energy consumption during 'super peak' by 10% in BCP participating households.
- Average total energy use reduction of 10% in BCP participating households.

The energy efficiency actions discussed with householders during eco-coaching, and other feedback communications, are identified by utilising the information regarding barriers and benefits generated from the research phase prior to coaching. These actions can include referral to other initiatives such as the provision of reduced cost solar PV power systems, direct load control devices for domestic air-conditioners, the time-of-use pricing product, the provision of in-home-displays (IHD) and other devices necessary for development of a 'smart grid'.

1. Introduction

Electricity consumption shows distinct temporal patterns, whether daily, seasonally or annually, and these patterns are heavily influenced by the behaviour of consumers. A very visible consequence of the growth in uptake of consumer appliances, for example the uptake of home air conditioners, and the consequences of this growth have been discussed [1]. The solution to date has often been to increase generation, and upgrade network infrastructure. In order to curtail the growth in expense to both end-users and the energy stakeholders, the behaviour of consumers must be addressed.

The benefits of the smart grid can only be fully achieved by engagement of end-users. Understanding the causality of end-user consumption and behaviours is beyond the scope of this paper (see Owens and Driffill, 2008 [2] and Lopez, 2012 [3]), but it can be made clear that to provide these benefits, end-users must engage with desired behaviour changes. Experience with consumption-driven grid issues [4] has shown that end-users, to a degree, can engage with behaviour changes such as:

- Adoption of AMI for bi-directional communication of data at fine-time intervals for accurate consumption metering;
- Modification of consumption in response to a signal to do so (such as through the implementation of In-Home Displays (IHDs)), with the desired response of applying energy conservation measures, and changing levels of consumption;

Abbreviations: AMI, Advanced metering infrastructure; BCP, Behaviour change program; CBSM, Community-based social marketing; DLC, Direct load control; IHD, In-home display; PV, Photovoltaic; SWIS, South Western Interconnected System.

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- Adoption of a demand response system, Direct Load Control (DLC) to automatically reduce non-critical elements of consumption;
- Adoption of energy efficient appliances, at time of replacement, to reduce ambient or characteristic demand.

With the aid of feedback mechanisms, behaviour change programs (such as modifying habits that waste energy) can result in an activated consumer who reduces consumption. In turn these support the real-time requirements (via price signals) of the utility, through the automation of smart appliances and set and forget technologies. With encouragement and incentive, consumers can accept minor curtailment for the benefit of the network [4,5]. With positive outcomes resulting from this partnership, participation by end-users may culminate in further smart grid driven adaptation of technology, such as the installation of renewable energy systems and storage devices.

CBSM has shown to be very effective at inducing behavioural change due to its pragmatic approach. McKenzie-Mohr [6] and others [7] identified that un-integrated intensive approaches towards changing individual's behaviour, such as education and economic self-interest are not successful.

The author has completed a number of large behaviour change programs across thousands of households in Western Australia to reduce residential water consumption. The North West H2ome Smart program was one of the first of the Water Corporation's BCPs to be run in Western Australia. The program was conducted during 2011, with 4338 participating households and water savings was conservatively estimated to be 6.9%, which equated to 186,000 kL [8]. The Perth BCP was completed in 2012, with 10,949 participants, overall water savings conservatively estimated to be 6.5%, which equated to 156,000 kL of water saved [9,10]. The regional towns BCP was completed in 2013, with 7305 households participating across 12 towns, and water savings was conservatively estimated to be 6.3%, which equated to 142,000 kL.

These programs demonstrate that a number of CBSM techniques are effective when applied across different regions as long as site-specific research and planning are undertaken beforehand. The techniques can be deployed in behavioural change programs to reduce energy consumption and shift or reduce peak loads:

a) Identifying the barriers to engaging sustainable behaviours through focus groups, online discussion boards and surveys;
b) Designing a strategic approach that integrates behaviour change tools, appropriate messaging and graphics;
c) Launch of media advertising, promotions, announcement letter and first registration and survey call to homes in the target suburbs;
d) Delivery of educational materials requested in the first of a series of eco-coaching calls;
e) Regular meter reads supplemented by self-reads in willing households (or use of real-time feedback from IHDs or online dashboards);
f) Feedback/progress letters followed by coaching phone calls each round by trained eco-coaches;
g) Final thank you letter and scorecard;
h) Evaluation and reporting to the client (e.g. network operator).

Increasingly, Photovoltaic (PV) systems are being grid connected by 'prosumers' for the promise of a feed-in tariff provided by network operators. Acting of their own volition and encouraged by rebates offered through government initiatives, consumers are turning to PV for subsidization of power consumption, adopting behaviours that maximise the feed-in of generated electricity (and thus the feed-in tariff accrued) [11]. To a lesser degree, it is anticipated that some portion of grid connected PV systems subsidize an increase in 'prosumer' consumption, a consequence known as the rebound effect. The result of these behaviours is a small but growing perturbation in the usual peak [11]. This paper will explain how to leverage a large urban electricity meter replacement program to achieve a reduction in peak demand and overall energy consumption through the use of advanced metering infrastructure (AMI or 'smart meters') coupled with CBSM. In order to measure success it is necessary to meet the following targets:

- Peak demand reduction (peak lopping) of 20% in BCP participating households.
- Peak demand shifting (load shifting) to reduce energy consumption during 'super peak' by 10% in BCP participating households.
- Average total energy use reduction of 10% in BCP participating households.

The energy efficiency actions discussed with householders during eco coaching are identified by utilising the information regarding barriers and benefits from phase one. These actions can include referral to other initiatives such as the provision of reduced cost solar PV power systems, direct load control devices for domestic air-conditioners, the time-of-use pricing product, the provision of IHDs and other devices necessary for development of a 'smart grid'.

Over 16,000 households have participated in the Perth Solar City program since commencing in 2009. During this program Western Power, the network provider on Western Australia's South Western Interconnected System (SWIS), installed 9269 smart meters, with 2551 households receiving smart meter enabled in-home displays (IHDs). As of the 30th of September, 2012 the trial has completed. During this trial an energy audit (eco-consultation) was conducted on 3515 homes and behaviour change programs (eco-coaching) were delivered to 6300 over 12 months. In addition, 746 households that participated in a time of use tariff trial, 700 homes were installed with a PV system and 1100 homes were installed with a solar hot water system [11].

Over $1 million was saved on power bills by participating households in 2012 [11]. A summary of results at conclusion of the smart grid trial is shown in Fig. 1 [11].

2. Methods

McKenzie-Mohr [6] and others [7] identified that an un-integrated intensive approach towards changing individual's behaviour, such as provision of information and economic self-interest are not successful. Instead CBSM has shown to be very effective at inducing behavioural change due to its pragmatic approach. In particular, it is important to introduce goal-setting [7], a sense of community ("your neighbours are doing it") and inspire concern for the environment [9] as better motivators for change. Accordingly, the H2ome Smart programs by Water Corporation and ENV [9] have undertaken the following methodological development:

Firstly, a conceptual framework of CBSM has been refined with the main actions developed into an ongoing feedback loop as shown in Fig. 2.

Secondly, community engagement strategies have been incorporated that connect people with their community interests and raise awareness on the drying climate. After recruitment, this is followed by application of coaching with facilitative conversations that help customers set targets for themselves. The CBSM methods deployed across these towns during 2010 and 2011 included [9]: