

Investigation on Consumers' Behaviour towards Energy Saving through Utilisation of Virtual SED (Smart Energy Displays) in Residential Building

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Abstract. The study is conducted by gathering data from interviews and an in-home experiment, to examine the impacts of both virtual and physical SED toward user engagement. Business opportunity and benefits of virtual SED for stakeholders are also discussed in this study. The research was conducted by interviewing method to respondents in Nottingham, UK. By comparing consumers' energy saving behaviour from physical and virtual SED users, virtual SED shows similar level of effectiveness as physical SED, but there is no evidence that the virtual versions are better than the physical ones in terms of reducing energy consumption. Nevertheless, virtual SED can be more beneficial for consumers who can get easier access. They also help educating users to be more concerned about energy issues. Energy suppliers get benefits by having virtual versions of SED, in which they can reduce production and distribution costs, as well as diminishing waste from physical SED.

1. Introduction

The UK government has officially stated a framework contained the target to reduce 80% of the greenhouse gases (GHG) emissions by 2050 in every sector, including residential sector. In 2014, the residential sector accounted for 12% of the GHG emissions, which made it the fourth-highest GHG contributor to the environment [1], as shown in Figure 1.

Carbon dioxide was recorded to be the dominant substance in the emissions. In particular, heating played a significant role in the energy consumption, which reached 85% of the total consumption for this sector, including space heating, water heating, and cooking [2].

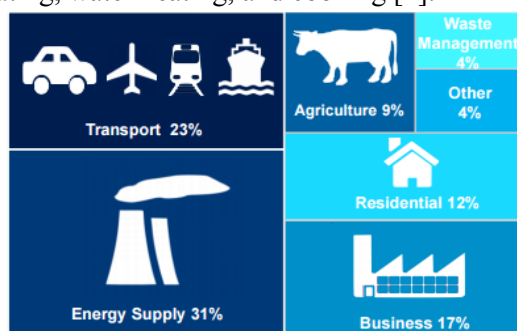


Figure 1. UK GHG Emissions by Sector in 2014

Source: DECC UK, 2016



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One reason why residential sector consumed high amount of energy was because of the intangibility of energy itself. The form of energy, which was abstract, made people hard to visualise how much energy they spent every time. In this case, smart meters played role as devices that can record energy consumption regularly.

Smart meters are developed versions from conventional gas and electricity meters. The ‘smart’ devices collect consumption data and transmit the data to energy suppliers and home owners in near real-time. This makes manual recording no longer required. Besides providing energy consumption data, smart meters also give more accurate energy bills for consumers based on actual usage rather than estimated use [3].

The UK government has started 53 million of smart meter roll-out programme for residential and small businesses that should be completed by 2020 [2]. The programme is conducted through major energy suppliers in the UK, such as E.ON, British Gas, and SSE. Consumers are welcome to get free smart meter installation from the energy suppliers.

By having smart meters, home owners can monitor their energy consumption and improve their consumption behaviour. The improvement may result in annual savings, especially in electricity and gas, that is predicted to reach GBP 24 by 2020 per household and GBP 39 in 2030 [2].

Each smart meter will be accompanied by an in-home display, a device that allows users to monitor and access the information sent by the smart meter with ease. In-home display will also help users to visualise their energy consumption, so that they can change their paradigm about energy into a more dynamic, transparent, and controlled matter [4][5].

Smart Energy Displays (SED) are one of physical in-home displays developed by E.ON for its customers. Consumers can monitor their energy consumption in currency (Poundsterling), kWh, or the amount of CO₂ emission through the device.

Unfortunately, SED will be ‘abandoned’ gradually along with the users’ routine activity due to lack of motivations in accessing the devices. This issue triggered further development of SED to be more accessible, attractive, and interactive in the form of virtual versions, such as mobile application and website. This innovation has great potential to be implemented worldwide, including in Indonesia, if virtual SED can be used effectively.

The study is conducted to assess the effectiveness of virtual SED, the benefits for E.ON as energy supplier, for consumers, for the UK government, and the impact of virtual SED on people’s energy conservation behaviour, and to compare this with the effectiveness of physical SED. Potential of long term engagement between virtual SED and users are assessed as well..

2. Literature Review

2.1. Review on SED Technology and the Application

Currently, both physical and virtual in-home displays/SED products are widely available in the market. Some of these are developed by private companies, such as Owl, Current Cost, and Efergy, while others are distributed through energy supplier companies, which have become major players in the utility sector. Figure 2 shows eight examples of in-home displays products that are used in this study.

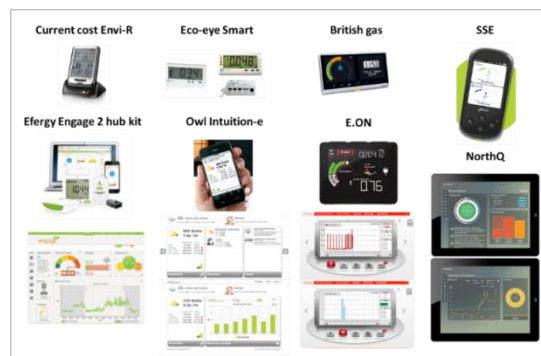


Figure 2. Examples of In-Home Displays Products

Four of the products come in physical devices, while the rest of them are complemented with virtual versions. Each product offers diverse sets of features.

Based on findings from Nguyen [6] and Dr. Lewis et al.[7], it has been proven that SED can reduce energy consumption from 5% to 15%, with an average reduction of 9%, within Europe and Great Britain. The savings are highly influenced by what is featured in SED. In Great Britain itself, the minimum typical saving for households is £147 over three years. It has been determined that having additional features meeting consumers' need increases the likelihood of reducing their energy bills.

2.2. Related Research

Several studies have found that there are four main elements to encourage users to use mobile applications or websites as virtual SED; namely, eco-visualisation, comparison, gamification, and social media. Intangible information such as energy consumption can be understood through eco-visualisation, which uses animations to illustrate levels of consumption, as non-numeric information is more likely to captivate users [8][9]. Meanwhile, the ability to compare levels of consumption and savings with those of other users can encourage further energy reduction [10][9]. Such comparison can provide a benchmark for users' success in decreasing consumption [11]. Users' consumption and savings can also be compared against those of similar household types, in order to obtain more validation [12]. Gamification, a term used for integrating game elements into a non-game aspect, combined with social media, can allow users to collaborate and socialise in order to accomplish their goals [13][14].

3. Methodology

In-home experiment for 10 days was conducted toward participants that had been selected randomly by installing a prototype of virtual SED, called NorthQ Home Manager starter kit, onto their electricity meter. The kit consisted of a Q-stick as the gateway and a Q-Power that received and transmitted information about energy consumption. The kit works when it is installed and connected to a network as illustrated in Figure 3. The data collected from the device could be accessed through a mobile application and website.



Figure 3. How NorthQ Electricity Starter Kit Works

Source: NorthQ Home Manager, 2016

The experiment was held to examine the amount of their energy consumption and their savings compared to their previous consumption (without virtual SED). Furthermore, interviews with the participants were held to gather feedback about user interface, SED visualisation, and SED contents.

2 sets of groups were involved in data collection through an in-home experiment. Group 1 was a group of small family (3 persons, age 25-34 years old and 0-5 years old) and Group 2 was consisted of students (4 persons, age 18-24 years old) that never used any form of SED before.

Several methods are used to analyse the results, those are comparative analysis as well as cause and effect analysis. Comparative analysis is used to compare the benefit, impact, and effectiveness between physical and virtual SED. Cause and effect analysis as well as SWOT analysis are conducted to get a better understanding of what works well and what needs to be improved.

4. Result and Discussion

Information regarding the impacts of mobile application usage, the intensity of interaction, and user preference are obtained from the experiment involving both groups of participants.

4.1. The Experiment of Virtual SED Towards Energy Saving Behaviour

Some findings have been found based on 10 days experiment toward the groups. They had been interviewed before and after the experiment conducted to gather information about their perception about virtual SED.

Before the test, both groups admitted that they not really paid attention how much energy they consumed. However, they argued that they had applied energy saving behaviour in daily life, such as optimising household appliances, adjusting their schedule based on energy tariff, and shutting down appliance when it was not used.

The family group felt optimistic they would be more motivated to save energy in longer term with the help of virtual SED. On the other hand, the student participants thought that virtual SED would indeed help increasing their energy awareness, but the device would not play a significant role in reducing energy consumption. The reason behind their skeptical thought was because energy, especially electricity, was primary needs and it was difficult to replace, so it would be hard to conserve the energy.

Final interview was held after 10 days of experiment. The features and performance of NorthQ Home Manager as virtual SED device were evaluated by both groups of participants. In general, both groups agreed that it took around 1-2 days to access and operate the application proficiently. The information was presented clearly through graphs and diagrams, so it could be understood easily. The visualisation was displayed quite attractive to motivate them accessing the application.

After using the virtual SED, all participants became more aware about how much energy they consumed which could be monitored regularly through its mobile application and website. However, there was no significant change towards their energy saving behaviour and their consumption reduction compared to the previous situation without SED.

The family group felt that it was extremely important to have a virtual SED device, so that they could make an effective strategy to get further savings. The same response was provided by the students group who thought that they could understand their consumption with the support of the device.

The Daily Consumption overview in the menu was the most attractive feature for the family participant. The feature showed electricity consumption overview for today, yesterday, as well as average electricity usage in kWh or Poundsterling. By looking at the information displayed in graphs, the participant could analyse what activities consumed most energy. Meanwhile, the students group preferred the compare feature as well as the historical data view. The features allowed them to monitor and compare their consumption in more detail and for specific times. Based on the comparison, they would be pleased if they managed to consume less energy compared to yesterday and would try to reduce the consumption if it appeared higher than yesterday. Those features are presented in Figure 4.

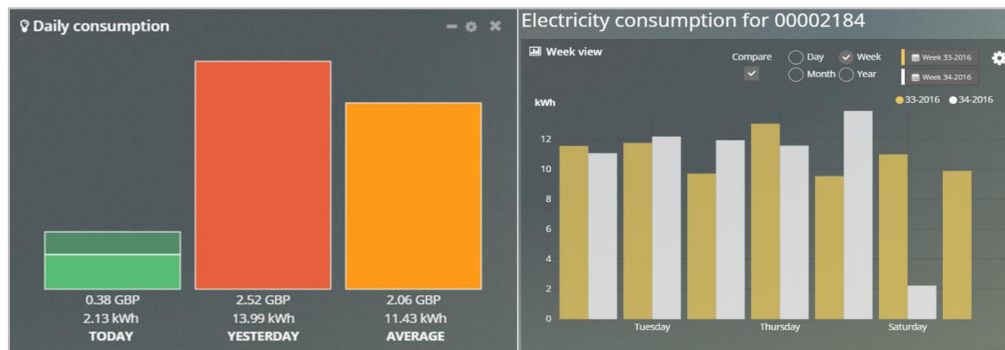


Figure 4. Daily Consumption Feature (left) and Compare Feature (right) of NorthQ Home Manager Apps

Reducing energy bills became the main reason for all the participants to use the SED. Because of this reason, they tended to see the consumption in currency rather than kWh, so they could easily imagine how much they spent on electricity. The device was able to attract all the participants to interact with it regularly by having favourable layout composition and colour schemes. Nevertheless, the students group felt that it took users' initiative to check the application and it would be good if there was an alert feature to notify users. This issue would affect participants' willingness to use the application in long term. If there was no update and improvement of the product, they might stop using the device gradually when their objectives were achieved and they managed to reduce a considerable amount of energy. Moreover, all participants agreed that virtual SED would be more beneficial if it provides additional information about energy consumed by household appliances. They also thought that physical SED would be useful to complement mobile application or website when their cell phones were in used.

5. Business Opportunity

According to a survey [15], 56% of mobile leaders testified that it takes at least 7 months to develop an application, while 18% of them said that it costs approximately \$500,000 to more than \$1,000,000 per application as shown in Figure 5.

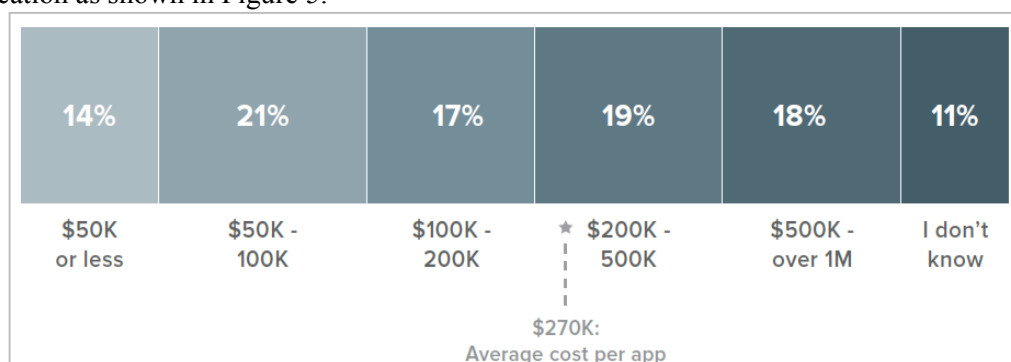


Figure 5. Costs of a Mobile Application Development (Formotus, 2016)

Since smart meters should be installed in around 53 million homes and small businesses by 2020 and the market share of E.ON is 14%, it is estimated that the company should deploy smart meters to around 8.15 million customers.

If it is assumed that a moderate physical SED will have £35 of production cost, E.ON should spend approximately £285 million to produce similar physical SED. Compared to an application, its

development costs an average of \$270,000 or around £206,000 for mid-range applications. This will be huge savings for E.ON as a company.

Not only it can give financial savings, virtual SED have more benefits. For example, the ease of products distribution, less production of waste, large market potential, and the growing trend of smart home technology will support the product development.

On the other hand, energy suppliers must be responsive in addressing the shortcomings of existing products and problems that may arise in the future, such as the accuracy of products in displaying information and competition that will arise with companies engaged in smart home technology.

Wide market segmentation may become an obstacle, in which virtual SED should be easily accessed and accepted by society from various background

6. Conclusion

Currently, most of the energy suppliers in the UK have developed their SED products to comply with the government target, which is to finish the installation of over 53 million smart meters and SED in the UK by 2020. Not only energy suppliers, but several other companies engaged in the business of smart home technology have manufactured their products that makes the competition tougher.

Moreover, the motivation of using an SED is decreased after a certain amount of time due to the lack of user interest. However, more attractive visualisation, a favourable user interface, comparison feature, and additional features increase the engagement on SED utilisation. This will lead to higher energy savings.

In addition, in terms of the energy awareness and energy consumption reduction, virtual SED may be as effective as physical SED, but there is no evidence shown that virtual SED is better compared with the physical versions. Overall, every respondent, agree that their energy awareness and energy saving behaviour may be improved by utilising the device. Some participants argued that the improvement was mainly influenced by the real-time energy overview feature, which can assist them to understand their energy usage.

Despite that, virtual SED offer more benefits, such as ease of access and more thorough information can be presented in a single view, as well as the virtual versions may eliminate the waste that comes from physical SED. Furthermore, virtual SED development will also benefit companies from savings in production and distribution costs. The cost can be reduced further by developing an application, rather than manufacturing the physical products. For the government, smart meters and SED installation will help to stabilize the national energy security.

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