An Exploratory Study of the Intention to Use Information Systems to Manage Electricity Consumption: A Theme Analysis of Influencing Factors

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Abstract

The value of timely feedback on energy consumption, especially with the use of information systems has been demonstrated by much research in this area. What's lacking in the research, as well as practice, is an understanding of why residents would accept (or reject) the use of IS to manage energy consumption. This paper presents results of an exploratory study, with the use of theme analysis, to understand influencing factors in the adoption of such an IS to manage electricity (the most common form of energy researched) consumption. This led to the conceptualization of a model, based on the Theory of Planned Behaviour that could facilitate further studies to understand the likelihood of intention to adopt an IS to manage electricity consumption. The result of such a study could be used for further empirical studies to explain low adoption rate (or even resistance) in mass implementation of such an IS.

Keywords

Residential energy, energy management systems, energy informatics, adoption intention, energy behaviour

INTRODUCTION

The objective of this study is to explore the development of constructs for a conceptual model through theme analysis, in order to gain insights into influencing factors leading to an intention to adopt an IS to manage residential electricity consumption. Initial inputs for this conceptual model are derived from related theories and models found from a literature search, with recurring ideas crystallized as themes via theme analysis of interview transcripts of the various stakeholder groups concerned with the use of IS in managing residential electricity consumption. We adopted theme analysis to analyse the interview transcripts, as it is an approach that is most useful in distilling common themes where various unrelated parties are interviewed [see for example (Strauss and Corbin 1990)].

Various research (Darby 2006; Fischer 2008; Hargreaves et al. 2010) had pointed to the importance of real-time feedback on energy consumption[1] to encourage conservation. In fact, feedback via IS is also deemed critical (Martinez 2006) for the success of demand response (DR) programs for residential energy consumption. Demand-side management (DSM) of energy is the ''systematic utility and government activities designed to change the amount and/or timing of customer's use'' (Charles Rivers Associates 2005), in which DR is DSM practised from a societal and end user perspective (York and Kushler 2005). Although the word energy is used in a generic sense, these research were primarily based on electricity (being the dominant form of residential energy used), which is also what we would focus on in our research. While there is consensus on the value of IS in managing residential electricity consumption, what has not stood out coherently is the functional affordance of such an IS, leading us to ask **research Question 1**: *What is the functional affordance for an IS to manage residential electricity consumption?*

Although research has shown that IS helps reduce electricity consumption, what still needs to be verified is that if such forms of IS has been widely adopted. Two major world-wide implementation of IS for residential electricity management by Microsoft (Hohm) and Google (Powermeter) in 2009 were subsequently withdrawn from the market (Google 2011; LaMonica 2011) after less than three years. Reasons cited by industry analysts vary but the main contention was lack of acceptance by consumers (LaMonica 2011). Withdrawal of these major

[1] Throughout this paper, a distinction is drawn here between energy consumption and energy use as defined in the ISO standard for energy management system: ISO 50001:2011. Energy use refers to the manner or kind of application of energy while energy consumption refers to the quantity of energy applied. This allows us to differentiate the quantification of energy consumed (consumption) from the energy related behaviour which translates to how energy is used.

implementations by two of the world's major technology companies begs the question of acceptance by users. Interestingly also, government mandated smart meter implementation in some Australian states, and other developed countries (such as Canada) have been met with resistance. Reasons cited were additional cost to consumers, health (due to wireless signal transmission), and invasion of privacy (Hess and Coley 2014). Hence we ask **research question 2:** *How likely are residents to accept an IS to manage residential electricity consumption?*

Notwithstanding the research mentioned earlier on feedback and use of IS for residential electricity management, a critical area of research needed is its adoption. As these research had also not focussed on the factors influencing the intention of residents to adopt such a complete IS, there is little empirical data to guide understanding of the adoption of such an IS based approach. Most research on adoption of a new technology are based on the Theory of Planned Behaviour (TPB) (Ajzen 1985). A prominently researched conceptual model of adoption of personal computers at homes (having similar premises which this research could leverage on) is the model of adoption of technology at home (MATH) (Venkatesh and Brown 2001). This conceptual model is based on three belief structures: attitudinal beliefs, normative beliefs and control beliefs that was derived from TPB's three core constructs of attitudes, subjective norms and perceived behavioural control. We would thus expect a conceptual model for similar adoptions of technologies (as in IS for residential electricity consumption) to be based on a structure of beliefs leading to **research question 3**: *What is the belief structure that affect intention to adopt an IS to manage residential electricity consumption?*

As with other TPB based models, in the MATH model the researchers proceeded to uncover the driving factors behind the three belief structures of attitudinal beliefs, normative beliefs and control beliefs. This allowed further empirical studies to be carried out on these factors and, ultimately, their relationship with intention to adopt via the belief structures. In order to derive a complete understanding of these factors, we ask the final **research question 4***: What are the factors that contribute to the formation of beliefs leading to adoption of an IS to manage residential electricity consumption?*

This paper adds to the emerging body of knowledge on energy informatics (EI) defined as "analysing, designing, and implementing information systems to increase the efficiency of energy demand and supply systems" (Watson et al. 2010). This sets it apart from the more generic Green IS (where EI is a subset of), which is defined as the use of IS to help organizations attain environmental sustainability through automating, informating and transforming products, business processes, business relationships and practices" (Chen et al. 2008). Our research also contributes to DSM/DR programs by governmental or residential energy generating/distribution or retailing entities, given the importance of ensuring adoption of such an IS on the part of the residential energy users.

The rest of the paper is organised as follows. Section two presents a background review of the functional affordance of such an IS and also the relevant theories and models for IS adoption in order to gain better insights into the adoption of these theories and models for our research. This is followed by an elaboration of our research method in section three. Section four describes how theme analysis was used on the results of interviews and how this led to the development of a number of propositions and our conceptual model. The paper concludes with a summary of our findings, the limitations to this research and suggestions for further research.

BACKGROUND

IS for Residential Energy Management

By and large, the studies on IS used for residential energy management had focused on the use of specific component technologies for residential energy management, but not the system as a whole. For instance, Darby (2006) reviewed sensitized objects in the form of smart meters as well as display technology, emphasizing the importance of these technologies in the quality and quantity of feedback to the energy user, leading to better energy management. However, a smart meter still requires an application (e.g. web application) utilising the metered consumption data. This is to help residents better manage electricity consumption, in order to constitute a full IS. Hargreaves et al. (2010) drew on qualitative evidence from interviews with fifteen UK householders trialling smart energy monitors focussing on how feedback has changed consumption behaviour. These are but parts of the whole picture (or a complete IS) which need to be rationalized and assimilated in order to realise a total understanding of the IS and its functional affordance.

Hartson (2003) defined functional affordance as a design feature that helps users accomplishes work (i.e. the usefulness of a system's function). In the context of this research, the work to be accomplished is managing residential electricity consumption. However, this could involve various aspects, representing the various functional affordances, namely:

a) *Monitoring electricity consumption*. Metering electricity consumption to allow for monitoring was deemed a baseline functional affordance of the IS (Darby 2010; Corbett 2013).
b) *Analysing electricity use*. In this aspect, various methodologies has been proposed and implemented, notably:
- Zeifman et al. (2013) – by recognizing the type of appliances or systems (e.g. lighting system) using energy based on the overall energy consumption data from the main meters.
- Chen et al. (2013) by processing data on household activity in conjunction with energy consumption data in order to establish a dynamic model of energy behaviour.

c) *Benchmarking or comparing electricity consumption*. Research has shown that residential electricity users "wanted to know more about how much energy other households in their area consumed in order that they could benchmark or judge their own consumption patterns" (Hargreaves et al. 2010).
d) *Learning of better ways to conserve[2] electricity or use electricity more efficiently*. Through feedback channelled via an IS, the users learnt areas which they could conserve electricity, or more efficient ways to use electricity (Froehlich 2009; Hargreaves et al. 2010).

This initial understanding of the possible functional affordances from the literature provided inputs for formulating the interview questions in our exploratory study.

Theories and Conceptual Model Relating to Adoption of IS

A major challenge to research in the adoption of an IS for residential electricity management is that it is not widely adopted in the first place; hence directly measuring adoption would not be easy. As adoption of a technology is subject to social-psychological theories, we turn to established models in this discipline. Several interrelated theoretical models, such as the MATH model (Venkatesh and Brown 2001) and Technology Acceptance Model (TAM) (Davis 1980) had been used to explain adoption of a new technology. Adoption of an IS is seen as a form of acceptance of technology, as defined in the TAM as well as the decision to make full use of it as an innovation (Rogers 1995). Most of the technology adoption models are centred on TPB which we selected as the basis for our conceptual model. These models predominantly posit that a behavior (such as adoption an IS) can be predicted by studying the behavioral intention (BI) to perform it. In TPB, a person's intention to perform (or not to perform) a behaviour under his or her volitional control is the immediate determinant of that action. The link between volitional behaviour and its intention was established from the theory of reasoned action (TRA) (Fishbein 1979). Adopting a new form of IS (seen as within a person's volitional control) can thus be predicted from measuring that person's intentions to do so. TPB was then established with its three belief driven constructs of attitude towards behavior (AT), subjective norm (SN), and perceived behavioral control (PBC) that determines intention to perform that behaviour. Models built on this theory assigned these three constructs as dependant variables and the factors influencing these beliefs as independent variables. The MATH model expanded on its three belief structures into (1) attitudinal beliefs (utilitarian, hedonic, and social outcomes), (2) normative beliefs (social influences and secondary sources), (3) control beliefs (lack of knowledge, difficulty of use, and high cost). As the same belief structure has been used in other TPB based research for adoption of technology (Davis 1980),we could then leverage on this same structure of beliefs as a framework for our intended conceptual model, with the exploratory study verifying the usability of this belief structure.

Key models of adoption of new technologies point to contributing factors from various sources and disciplines, which at first glance appear rather diverse. However, a closer look at these factors seems to suggest a possibility of clustering them for collective study. In the MATH model (Venkatesh and Brown 2001), the attitudinal, normative belief, and control belief structure was used to cluster influencing factors for these beliefs. Like-wise, TAM (Davis 1980) postulates that attitude towards using (a technology) is determined by perceived usefulness (PU) and perceived ease of use (PEOU). The determinants of PU and PEOU were later expanded on in TAM3 into individual differences, system characteristics, social influences and facilitating conditions (Venkatesh and Bala 2008). In a similar manner, our exploratory study would need to flesh out the influencing factors for the belief structure that drives intention to adopt an IS to manage residential electricity consumption, and then to cluster them for collective study.

RESEARCH METHODOLGY

This study follows an exploratory strategy with a primary intent to uncover and understand the factors influencing the belief structures determining intention to adopt an IS for residential electricity management. Such

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[2] While some literature equates energy efficiency with energy conservation, technically there is a fine difference. The level of energy service (e.g., the level of lighting in a room) is preserved under energy efficiency with a reduction in energy consumption. In energy conservation, the level of energy service might be reduced in order to meet the goal of reducing energy consumption.

research on adoption becomes more valuable in countries where use of IS for residential electricity management is in the early stages of diffusion. Singapore is in such a situation now as there is a master plan (Intelligent Energy System), launched in 2010. As the technology is in its early stages of diffusion in Singapore, and also given the value of such research for residential electricity conservation, it was deemed appropriate to conduct the study in Singapore.

In this study, semi-structured interviews (Annex 1) were used in order to solicit inputs on behavioural rationale related to intention to adopt an IS to manage residential electricity consumption. For a holistic understanding of the factors influencing intentions to adopt an IS for residential energy management, inputs from various stakeholders involved in the development, administration and use of such an IS were sought in our studies. A primary group, nevertheless, would be the residents who have used or have exposure to an IS for residential electricity management. Together with four types of organizations involved in the implementation of such an IS, the type of stakeholder groups and intended participants for the research is tabulated in table 1 below.

Table 1: Participant Groups and Input Areas

Stakeholder Group	Intended Participants	
1) Residents who have used or have exposure to an IS for residential electricity management	Adult (18 years old and above) user of such a system	5 Households
2) System developers for such an IS	System Development Manager, or Engineer	2 organizations 1 personnel each
3) Housing developers who see value in such an IS	Project Manager or project engineer	2 organizations 1 personnel each
4) Governmental departments responsible for residential electricity consumption	Officer / Manager in charge of residential electricity consumption programs	1 governmental department. 1 personnel
5) Residential electricity distributors or retailers	Program / Public Relations Manager or Executive	2 organizations 1 personnel each

Each participant was interviewed on their perspective on adopting an IS for managing residential electricity consumption. System developers, housing developers and residential electricity distributors/retailers were identified using snowballing sampling techniques based on contacts developed through attendance of seminars and conferences related to IS and energy management. Contacts in the governmental department were identified via the directory of governmental officers available online. Residents who have used or have exposure to an IS for residential electricity management were identified through referrals of the system developer contacts. Invitations were sent out directly to all the participants. All interviews were transcribed before the data were analysed.

Three system developers were invited for the interviews, of which two accepted the invitation. One was a local developer, and the other was a developer for a multi-national. As for housing developers, the dominant housing developer in Singapore (responsible for 82% of the housing) is the Housing Development Board (HDB) (a Singapore governmental body in charge of housing). They agreed to represent both the housing developer as well as the governmental department. The other (private) housing developer declined the invitation. Both the electricity retailers invited for the interviews declined the invitation for interview. In all three of the five residents (living in HDB apartments) invited for the interview participated in the interviews. All interviews were conducted between January 2013 and February 2013.

The empirical study for this exploratory research was based on data collected via face-to-face semi-structured interviews conducted during the first half of 2013. In this study, we have adopted theme analysis, an approach used to analyse interview transcripts from diverse views (from the various stakeholder groups) with the objective of sifting out common recurring themes (Strauss and Corbin 1990). Recognising recurring themes in the interview data requires the ability to recognise words and expressions that may be referring to a common idea, hence the need to have appropriate knowledge and experience of the research area. This paper limits the themes by identifying only those related to our research interests, in this case the research questions. This differs from some approaches to theme analysis where all emerging themes are identified in interview transcripts (in line with grounded theory) often as an initial stage in the formation of theories (Strauss and Corbin 1990). One method for identifying themes is based on a seven stage approach described by in Chessler (1987) in Ball (2011) Ball (2011). This approach allowed sequential analysis for development of theories or models with the seven steps listed as follows:

1. Identify key components of research questions
2. Repeated readings of interview transcripts
3. Identify emerging themes related to research question
4. Underline key comments related to research questions

5. Reduce comments and record in margin of text
6. Crease clusters using “constant comparison” as clusters are formed
7. Use clusters to confirm themes

The first three stages in this approach can be used to identify emerging themes related to specific research questions. The goal of steps 4 to 6 (which is independent of stages 1 to 3) is to produce a list of clusters, each of which contains paraphrased comments with the same focus related to the research interest. The clusters in Step 6 would also lead us to the influencing factors for an intention to use an IS to Manage Electricity Consumption. The confirmed themes (CTs) from step 7 are matched with the research questions, providing further insights to these questions.

FINDINGS AND DISCUSSIONS

The **first step** of identifying key components of the four research questions was carried out based on a review of the research questions and the outcome is tabulated below in table 2.

Table 2: Key Components of Research Questions

	Research Question	Key Component
1	What is the functional affordance for an IS to manage residential electricity consumption?	Functional affordance
2	How likely are residents to accept an IS to manage residential electricity consumption?	Likelihood of acceptance
3	What is the beliefs structure that affect intention to adopt an IS to manage residential electricity consumption?	Belief structure
4	What are the factors that contribute to the formation of beliefs leading to adoption of an IS to manage residential electricity consumption?	Factors contributing to the formation of beliefs.

Steps 2 and 3 led to a list of emerging themes (ETs) evident in the interview transcripts as listed below:

ET1) IS can be a useful tool for residential electricity conservation
ET2) Residential electricity user education on IS to manage electricity consumption is important
ET3) Residents not self-motivated to adopt IS to manage electricity consumption, preferring a wait and see approach
ET4) IS to manage residential electricity consumption needs to be user friendly
ET5) Cost of IS to manage residential electricity consumption and electricity price is important for adoption

The five ETs noted here appear diverse in nature as, at first glance, they relate to the range of factors. Organizing them are left to the end (after step 7) when they have been confirmed. In **steps 4 and 5** key comments related to the research questions were sifted out (step 4) and paraphrased into a summary (step 5), results from which are tabulated below in table 3.

Table 3: Results for Steps 4 and 5

	Step 4 – Highlighted interview comments related to research question	Step 5 – Paraphrased Comments
1	“Maybe that is the reason why this thing did not really take off. We tried for more than 1 year. Low take up rate. Then all the directors decide to low key it. Because sell about twenty or thirty units of this is like selling one unit of our other building energy system.” – System developer	Our product did not sell well so we put in on low priority.
2	“We think it is due to lack of understanding of this type of product and also what it can do for them. Nobody will straight away believe you if you tell them it’ll save them money and the environment. They want to see results first. They will also consult their friends about it first.” – System developer	There is lack of awareness of the benefits of IS for residential energy management.
3	“.. in terms of product features and functions, I think what they want is easy to use. For sure they can reduce electricity bill if they know where and how to cut down the over-consumption. But this is something we cannot guarantee because it is user controlled. Not our system control tahan (*last*) long long (*very long)*. For sure they can reduce electricity bill if they know where and how to cut down the over-consumption.” – System developer	Perceived ease of use is important. Electricity savings is within the control of the electricity user.
4	“Even if more people get to know this system, it might not guarantee more people convinced to buy. They need to consider many other factors. Like cost, easy to use, government support, free sample to try and so forth. So even having a very	Besides awareness other factors such as cost governmental support, and trialability are important in

	advanced product in the market doesn't guarantee good acceptance. All very bread and butter one. No see result first no talk." – Housing developer	adoption. Advanced product features are not the most important in adoption.
5	"Longer term yes But in the meantime, government or someone must step in to provide education. What such a system do. Why good to use. Is it the same with using any IT systems?" -- Residential electricity user	Governmental involvement is important. Usefulness of system. How different is it with other IT systems I've used?
6	"People are aware now. It is good. But does not want to know how they impact the country level. I just think that people always like that. Take care of themselves first. You know, if they can see how big the problem is they first want to know how to help themselves first." -- Housing developer	People tend to look first at the immediate issue and gains, not so much the wider picture of environmental sustainability.
7	".. it's not cheap. Then there is a limit on how much you can save. Basically it is only air cond. If the household don't use air-cond, then there is nothing you can save." -- Residential electricity users	IS to manage residential electricity consumption is not cheap and would not result in much cost savings for households.
8	" I resident, it always boils down to cost right?" -- Residential electricity user	It's all about cost.

The paraphrased comments were clustered in **step 6** as tabulated below in table 4. These clusters then allow us to identify the factors that influence the belief structure of ATT, SN, and PBC.

Table 4: Step 6 - Clusters and Paraphrased Comments

Paraphrased Comments	Cluster		Factors
• Besides awareness other factors such as cost, governmental support are important in adoption • People tend to look first at the immediate issue and gains, not so much the wider picture of environmental sustainability. • IS to manage residential electricity consumption is not cheap and would not result in much cost savings for households. • It's all about cost.	1	Cost/benefit of IS to manage residential electricity consumption and electricity price	• IS affordability • Electricity price
• Besides awareness other factors such as cost, governmental support, and trialability are important in adoption. • Governmental involvement is important	2	Governmental support	• Supportive policies • Sustainability advertisements[3]
• There is lack of awareness of the benefits of IS to manage residential electricity consumption. • People tend to look first at the immediate issue and gains, not so much the wider picture of environmental sustainability.	3	Awareness of IS to manage residential electricity consumption. This also infers lack of clarity on the functional affordance of such an IS.	• PU • Environmental altruism[3]
• Our product did not sell well so we put it on low priority. • How different is it with other IT systems I've used?	4	Acceptance of IS to manage residential electricity consumption	• PU • Compatibility[3]
• Perceived ease of use is important.	5	PEOU	• PEOU
• Electricity savings is within the control of the electricity user.	6	Perceived behavioural control	• Environmental altruism • Technology readiness
• Advanced product features are not the most important in adoption. • Usefulness of system • Besides awareness other factors such as cost, governmental support, and trialability are important in adoption.	7	Technological factors	• PU • Trialability

Seven clusters were identified from grouping the paraphrased comments. From these seven clusters, factors influencing the belief structure of AT, SN and PBC were deduced. "Compatibility", "Environmental altruism" and "sustainability advertising" are three factors deduced via literature search, which need further elaboration.

[3] The definitions of sustainability advertisements, environmental altruism, and compatibility are provided in the ensuing paragraph.

Rogers (1995) defined *compatibility* as the degree to which an innovation is perceived as consistent with the existing (1) values, (2) past experiences, and (3) needs of potential adopters. Stern (2000) defined *environmental altruism* from Schwartz (1973) whereby "altruistic (including pro-environmental) behavior occurs in response to personal moral norms that are activated in individuals who believe that particular conditions pose threats to others (awareness of adverse consequences,) and that actions they could initiate could avert those consequences (ascription of responsibility to self)". He also proposed that behavioural beliefs (Stern, Dietz et al. 1999, Stern 2000) drives environmental altruism. Rogers (1995) found that *secondary sources of information, such as TV and newspapers* are influential in the early adopters' decisions to adopt an innovation. At the same time, Venkatesh and Brown (2001) found that household PC adoption decisions were influenced by messages conveyed via mass media. Put together, these indicate a link between advertising of a technology and its adoption. Although the interest here is on advertising, the context here would therefore be sustainable advertising, which refers to advertising concerning environmental sustainability.

In the next **step (7),** the clusters are matched against the emerging themes (ET) from steps 1 to 3 in order to confirm these themes and the results are as tabulated below.

Table 5: Stage 7 - Matching of Clusters and Emerging Themes

Cluster	Emerging Themes
1 Cost/benefit of IS to manage residential electricity consumption	(ET5) Cost of IS to manage residential electricity consumption and electricity price is important for adoption
2 Governmental support	(ET3) Residents not self-motivated to adopt IS preferring a wait and see approach
3 Awareness of IS to manage residential electricity consumption	(ET2) Residential electricity user education on IS to manage electricity consumption is important
4 Acceptance of IS to manage residential electricity consumption	(ET1) IS can be a useful tool for residential electricity conservation (ET3) Residents not self-motivated to adopt IS to manage electricity consumption, preferring a wait and see approach
5 PEOU	(ET4) IS to manage residential electricity consumption needs to be user friendly
6 Perceived behavioral control	(ET3) Residents not self-motivated to adopt IS to manage electricity consumption, preferring a wait and see approach
7 Technological factors	(ET4) IS to manage residential electricity consumption needs to be user friendly

All the emerging themes (ETs) were matched against at least one cluster, thus confirming these themes as confirmed themes (CTs). The CTs were then matched against the three core TPB constructs of attitude towards AT, SN and PBC to determine if the TPB based belief structure holds for this research as follows:

CT1) IS can be a useful tool for residential electricity conservation (AT)
CT2) Residential electricity user education on IS to manage electricity consumption is important (PBC)
CT3) Residents not self-motivated to adopt IS to manage electricity consumption, preferring a wait and see approach (SN)
CT4) IS to manage residential electricity consumption needs to be user friendly (AT)
CT5) Cost of IS to manage residential electricity consumption and electricity price is important for adoption (PBC)

Although these CTs appear diverse, they are found to be representative of the three core TPB constructs of attitude towards behaviour (AT), subjective norms (SN) and perceived behavioural control (PBC). This affirms the applicability of the belief structure in TPB for our model. With this the five CTs were reviewed against the key components of the four research questions (RQ) as tabulated in table 6 below.

Table 6: Key Components of RQ and Confirmed Themes (CT)

Key Components of RQ	Confirmed Themes (CT)
1 Functional affordance	CT2
2 Likelihood of acceptance	CT1, CT3, CT4, CT5
3 Belief structure	CT1, CT2, CT3, CT4, CT5
4 Factors contributing to the formation of beliefs.	CT1, CT2, CT3, CT4, CT5

Although CT2 does not provide direct answers to RQ1 it affirms the importance of RQ1. I.e. the perceived need for education on such an IS implies a lack of understanding of its functional affordance. That residents preferred a wait and see approach (CT3) provides an understanding to the question of likelihood of adoption (RQ2). The belief structure of AT, SN and PBC (RQ3) can be linked to all the confirmed themes as each CT relates ultimately to a belief based on AT, SN and PBC as explained in the previous paragraph. Accepting the belief structure in RQ3 also helps answer RQ4 as all the confirmed themes are mapped to RQ4 and also relates to this belief structure as well. As a final step towards building a conceptual model, we reviewed the grouping of these factors into logical groups as tabulated in table 7 below.

Table 7: Grouping Factors into Logical Groups

Factor Grouping	Factors
Technological factors	• PU • PEOU • Trialability
Economic factors	• IS affordability • Electricity price
Consumer factors	• Environmental altruism • Technology readiness
Sustainability factors	• Supportive policies • Sustainability advertisements

It was found that the factors uncovered could be grouped logically into four factors, namely technological (T), economic (E), consumer (C), and sustainability (S), or collectively to be referred to as the TECS factors. Together with TPB's behavioural intention (BI) and the three constructs of AT, SN, and PCB, this allows us to deduce an initial conceptual model to study the adoption intention of IS to manage residential electricity consumption as illustrated in figure 1 below.

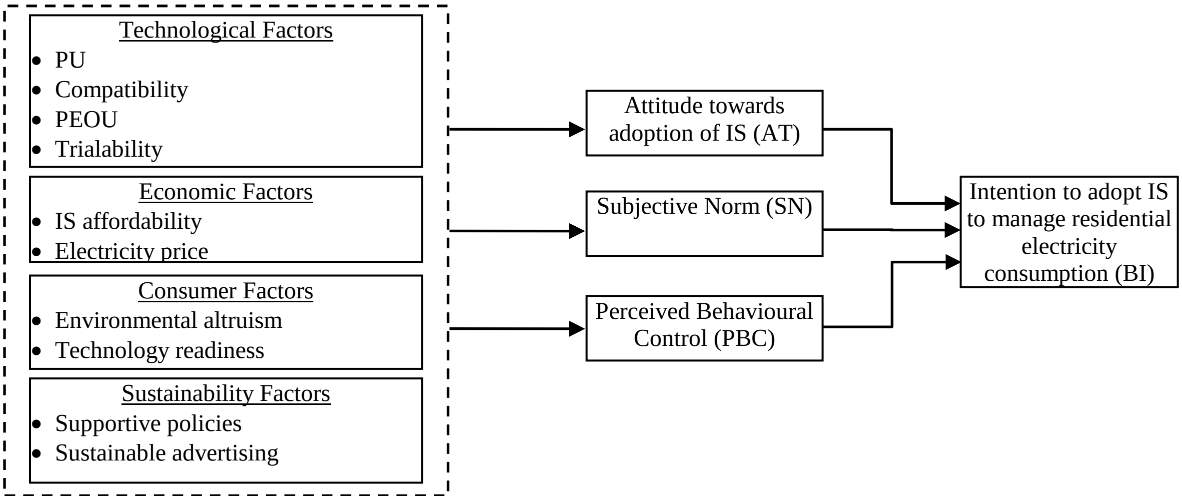

Figure 1: Conceptual Model of IS Adoption for Managing Residential Electricity Consumption

This initial conceptual model indicates that the TECS factors would represent independent variables influencing with the belief structure constructs of AT, SN, and PBC (dependant variables). The belief structure constructs would in turn determine BI.

CONCLUSION, LIMITATIONS AND FUTURE RESEARCH

In this research, we had successfully used theme analysis to identify can categorize factors that influence an intention to adopt an IS to manage residential electricity consumption. We had also gained insights into these factors which we collectively term as the TECS factors. From our literature search, we had proposed an appropriate belief structure based on the three constructs of TPB (AT, SN, and PBC) which we had found from the theme analysis to be influenced by the TECS factors. This led to the development of constructs for a conceptual model to further study the adoption intention of IS to manage residential electricity consumption.
A limitation of this research is the relatively low sample size of interviews.

Further work that needs to be done in this research would be validating the predictive capability of the model via a survey as a measuring instrument. This should also take into account the socio-demographic factors acting as moderators as they were not addressed directly in the interviews. Potential socio-demographic factors can be inferred by the similar study on home PC adoption in the MATH model by Brown and Venkatesh (2005) which includes family life cycle (deduced from age, marital status and children's age) as well as income. While we had found functional affordance to be important, it has not been fully determined in this study.

This research is one of the first studies on the adoption of IS to manage residential electricity consumption. It has a potential to contribute to knowledge in the following areas of gaps in IS research and practice:

- Further empirical research with use of a conceptual model to predict the likelihood that an IS to manage residential electricity management would be accepted and used.
- A working understanding of the factors influencing adoption of IS for managing residential electricity consumption which would help understand low adoption rate (or even resistance) in mass implementation of such an IS, especially from a DR perspective.

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ANNEX 1. INTERVIEW QUESTIONS

Interview questions for system developers / housing developers:

1. Why did your organization decided to develop/implement an information system (IS) for residential energy management?
2. How was the IS developed/implemented? Any estimation of the cost and effort involved?
3. Could you tell me the important design features and functions of the IS that your organization has developed/implemented and why you think these are important?
4. Let us discuss the aspects of your organization's IS that you think are important to households and the reasons for these. What does it helps households to do?
5. Have you collected feedback from users of the IS? If so, what do they tell you?
6. What is the current status and future prospects of the IS?
7. What are the wider community benefits from the wider diffusion of such an IS?
8. What do you think facilitate and/or inhibit the wider acceptance of this IS by residents?
9. What are your future plans for this IS?
10. How do you see the future for such kind of IS?

Interview questions for the residential electricity users:

1. What are your views towards electricity and electricity consumption?
2. Can you tell me about the IS that you are using in managing your electricity use? What does the IS enables you to do?
3. When did you adopt this IS?
4. Shall we discuss the factors that led you to adopt this IS?
5. What are some of the key benefits of using this IS?
6. What problems and issues did you encounter in using the IS?
7. Have you or would you encourage others to adopt such a system?
8. In your opinion, what contributes to convincing residents to form a positive belief and attitude towards adopting such an IS?

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