

# A Proposed Study on the Use of ICT and Smart Meters to Influence Consumers' Behavior and Attitude towards Renewable Energy

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**Abstract**— Recently, use of Renewable Energy (RE) and development of RE technologies are being promoted by many countries. Policies have also been developed to facilitate and encourage consumers to adopt RE. However, the availability of technologies alone does not guarantee their widespread adoption. Numerous reports have identified the barriers are due to lack of knowledge and awareness towards the new technologies. This paper proposes a study and the development of an Information and Communication Technology (ICT) learning tool incorporating the use of smart meters in order to provide knowledge, increase awareness and to influence consumers' behavior and attitude in adopting RE. This proposed research is based on quantitative and qualitative approach and the study will be carried out among residents from a local council in Western Australia. It is expected that results from this study will provide insights and understanding to encourage RE adoption through the use of ICT and smart meters.

**Index Terms**— Renewable Energy Adoption, Consumer Adoption Attitude and Behavior, E-learning, ICT Educational and Training Tools, Information Technologies Design.

## I. INTRODUCTION

IN recent years, residents in many developed and developing countries are encouraged to adopt or switch to Renewable Energy (RE) in order to reduce the reliance on fossil fuel and to address the issue of climate change. It is particularly evidenced when President Barack Obama of the USA declared RE as a top agenda under his administration in 2009. Policies, technologies and trainings have been developed to facilitate and encourage the transition. This includes incentives and regulations developed by policy makers; development and adoption of advanced technologies to enable integration and accounting of energy generation and consumption; and, training of experts and workers in the RE sector [3],[4],[5],[6]. The objectives are to stimulate private investments, to implement integration between different entities in the power industry, and to spur the adoption of new technologies by all stakeholders.

However, the availability of RE technologies alone does not guarantee their widespread adoption by consumers. Although

plans, policies and technologies have been put in place to encourage adoption of RE, the take up rates are still underachieved [1], [2]. It is therefore important to understand the barriers and drivers that affect the rate of consumers' RE adoption and behaviour. These understanding will serve as an insight to the stakeholders and subsequently it could provide solutions to overcome the obstacles as well as promoting the drivers to further motivate wider adoption of RE as an alternative energy.

Numerous researches have identified barriers to consumers' adoption of RE being a lack of awareness, fear of switching and technology, pricing premium, lack of knowledge regarding environmental impact, cynicism about making a difference, high initial investment, and a lack of trusted installers, are hurdles (barriers) towards RE adoption from the perspective of consumers [10], [11]. Among them, some are myths while others are simply misconceptions. In summary, these barriers indicate that consumers are generally lack of knowledge and awareness towards adoption of RE.

Adopting RE involves a shift of the mindset, life style changes, in addition to investment in RE technologies; which are the major decisions to be made by the consumers. Fishbein and Ajzen [12] published that knowledge arms consumers with choices and it is critical in influencing consumers' adoption attitude. Thus, knowledge is an important component in consumers' decision-making process; inevitably, a vital causes that influences consumers' RE adoption behaviour.

Knowledge and awareness are generally acquired through educational programs. Therefore consumer education is an essential part of the process towards mainstream adoption of RE, as education help to minimize and overcome the (adoption) barriers. Correspondingly, consumer education programs enable consumers to be aware of the benefits of conserving energy, and to acquire information on emerging RE products, services, investment planning, polices and schemes. This requires effective communication media to achieve the desirable results.

The role and importance of Information Technology in education and learning are growing and developing at a rapid pace. In particular, multimedia design tools have been widely adopted for educational and communication applications. It is largely due to their user-friendly and interactivity features. The interactivity features of multimedia design tools involve

users' participation while the visual and audio elements are able to engage and retain users' concentration.

Effectiveness on deploying multimedia design tools has been broadly researched in various learning paradigms. Among which, Hess, Fuller and Mathew [13], established that multimedia design tools increase involvement and influence decision-making. In addition, Rose [14] found investment decisions are influenced by affective responses to financial data, and multimedia design tools are known to facilitate the development of applications, which create affective responses from the users. These two findings support that multimedia design tools are effective learning tools and are able to influence investment decision. Hence, forms the theoretical foundation and assumption of this research - in developing an Information and Communication Technology (ICT) learning tool aims to provide knowledge, increase awareness of RE and to influence consumers' RE adoption behaviour ultimately.

## II. AIMS AND SCHOLARLY CONTRIBUTIONS

This research comprises proposal, development and validation of an ICT education & training tool, termed "Renewable Energy Intelligence System (REIS)", which aims to provide knowledge, increase awareness, and influence investment decision on RE. In addition, REIS will also include the use of Smart Meters to provide information and decisions concerning energy consumption. Smart meters will empower customers to make choices on their energy consumption. Information on forecast of energy demand at different times of the day, will assist consumers in life-styles changes centered upon the adoption of RE. Similarly, suppliers will have accurate real-time information on energy used at the consumer's sites. REIS consequently will assist to influence consumers' RE adoption attitude and behavior. Validity of REIS will be measured by conducting a number of surveys. Details of the survey are outlined in the next section. In addition to the development of REIS, this study also aims to achieve the followings, which form the basis and groundwork of REIS:

1. Identify barriers and drivers of consumers' adoption behavior by reviewing data from secondary sources, and collecting primary data through a survey from samples of population in the City of Melville, Western Australia.
2. Identify and apply appropriate design theories and principles of multimedia design in respect to the development of REIS.
3. Research and incorporate in REIS, the applicable theories and principles of consumers' adoption behavior, process of decision-making and significant factors of investment decisions.

This research will contribute to scholarly knowledge with the followings:

1. Effectiveness of ICT tools (REIS) in providing knowledge; increasing awareness, influencing investment decision-making & consumers' RE adoption behavior.

2. Obtaining measurements of the different groups of consumers in relations to improve knowledge, to increase awareness and to influence adoption behaviour by using REIS (Consumer variables includes gender, age, education backgrounds, cultural backgrounds and social economic background).
3. Data collected and information gathered from the survey will provide invaluable insight to using of ICT to influence consumers' RE adoption behavior. Consequently, recommendations will be made to stakeholders – policy makers, educationists and utility providers – to improve consumers' adoption rate.

## III. RESEARCH METHODOLOGY

Two surveys will be carried out during the course of this research. The first survey, Consumer Renewable Energy Behavior Survey 1 (CREBS1), will be conducted prior developing REIS; intended for identifying consumers' barriers and drivers of RE adoption. Data and information collected from the first survey and secondary sources will be incorporated, forming part of the REIS content. That is, REIS will address and assist consumers to overcome these barriers whilst promoting the drivers. Following the first survey, REIS will be proposed and developed. Second survey, Consumer Renewable Energy Behavior Survey 2 (CREBS2) will be conducted after the implementation of REIS. Residents from the Melville Council will be invited to use REIS for measuring the effectiveness of REIS in: providing knowledge, increasing awareness and influencing consumers' adoption behaviour on RE.

Melville Council in Western Australia is an ideal collaboration partner in this project. Members of the management team are enthusiastic supporters for this study. It is a committed council with keen interest to increase uptake on RE for its residences and Murdoch University has a long history of collaboration with the council. This research will be in lined with Melville Council's "Ecology and Sustainability" planning strategy, in which promoting Consumer RE adoption is among their priorities [15]. Besides that, the Melville Council has had previous successful collaborations with Murdoch University on RE researches and projects and the relationship will ensure the achievement of the common goals and objectives.

### A. Research Questions

The primary research questions of this research are:

*Q1: Does the use of ICT tools improve the participants' knowledge on Renewable Energy?*

*Q2: Does the use of ICT tools increase the participants' awareness on Renewable Energy?*

*Q3: Does the use of ICT tools influence the participants' investment decision on Renewable Energy?*

*Q4: Does the use of ICT tools influence the participants' adoption behaviour on Renewable Energy?*

Results from the second survey (CREBS2) will be used to answer the above research questions thereby determines the

effectiveness of the ICT tools to influence consumers' behavior.

### *B. Research and Survey Approach*

The two research surveys namely CREBS1 and CREBS2 will be carried out based on both quantitative and qualitative approaches. Participants will be invited by advertisements on newspapers and via emails. Completion of the questionnaire will be voluntarily and all responses will be anonymous. Approval from the Research Ethics Committee will be sought prior to the execution of the following activities.

#### *1) First Survey, Consumer Renewable Energy Behavior Survey 1 (CREBS1), (To be conducted prior development of REIS)*

The first survey, Consumer Renewable Energy Behavior Survey 1 (CREBS1), will be carrying out by quantitative approach. It will utilize a self-administered questionnaire that will be distributed via email as well as make available online on Melville Council district's website for completion by participants, electronically. The questionnaire will take approximately 10 minutes to complete. CREBS1 will be largely based on the followings elements [9]:

1. Pricing: (Affordable after grant/special offer)
2. Likely fuel savings not worth cost
3. Difficulty finding a reputable installer
4. New technology with uncertain performance and reliability
5. System not likely to last long enough to payback
6. Incompatibility with current heating system (heating/hot water systems)
7. Difficulty finding suitable location for installation of unit/meter box
8. Expected disruption in Home
9. Difficulty getting planning permission
10. Difficulty finding suitable location for unit
11. Noise/vibration
12. Unattractive visual appearance
13. Difficulty controlling heat output
14. Lack of knowledge and education
15. Lack of financing options
16. Lack of policy incentives

Reporting on the findings of CREBS1 will be tabulated in accordance to the barriers and or drivers of "Consumer's Renewable Energy Adoption Factor" table, with detail analysis and discussions. Data collected from the first survey will be incorporated into the content of REIS aims to educate consumers, 'break' the barriers while assisting consumer to adopt Renewable Energy.

#### *2) Second survey, Consumer Renewable Energy Behavior Survey 2 (CREBS2) (To be conducted after implementation of REIS)*

A second survey (CREBS2) will be carried out to validate and establish the effectiveness of REIS by applying both

quantitative and qualitative approaches. The questionnaire will take approximately 30 minutes to complete. The survey will comprise a number of different sections relating to participants' personal information and demographics, a range of questions relating to RE adoption behaviour and feedback on using REIS. No personal or private information from the participants will be disclosed and released, results will not include any information, which could toward identification of individuals.

The questionnaire will consist of four main sections. The first section will ask questions about the participants and their previous training and experience with computers and Internet. The second section will ask questions about the participants' perceptions of RE adoption, their satisfaction with it, and its role in their life style changes. The third section will ask questions from both the Questionnaire for User Interface Satisfaction (QUIS) and the Technology Acceptance Model (TAM) for evaluating the effectiveness of REIS [16], [17]. The fourth section is the 'Have your say' section, which will deploy the qualitative techniques. It allows participants to provide any other feedback and/or suggestions on REIS.

Participants will be invited via email and through advertisements on local newspapers. They will meet at the Piney Lake Environment Education Centre (PLEEC), which belongs to Melville City District. PLEEC is the educational and training center for Sustainable Energy, showcasing latest RE technologies to the residence of Melville City District. There will be 10 sessions, 50 participants in each session, in order to achieve at least four hundred sounding samples.

In each session, participants will be separated into two groups randomly. First being the treatment group while the second group will be the non-treatment group. Treatment group will be using REIS for 20 minutes then answer questionnaire for another 10 minutes. Where as the non-treatment will be reading the brochure given which has the same content as REIS for 20 minutes, after which questionnaire will be administered for another 10 minutes. The total duration will be 30 minutes for each session. Results obtained will be used to compare the level of RE knowledge, awareness and intended RE investment, between the treatment and the non-treatment group.

Results and findings from the second survey (CREBS2) will be analyzed and published in relation between demographic (age, genders, educational and social economic background) and adoption behaviour with detail analysis and discussions.

### C. Variables

#### 1) First survey (CREBS1)

Independent Variables: *Age, Gender, Educational and Social Economic Background*

Output: *Drivers and barriers of consumers' RE adoption*

#### 2) Second Survey (CREBS2)

Independent Variables: *Age, Gender, Role in the family (if applicable), Educational and Social Economic Background*

Dependent Variables: *Knowledge, Awareness, Adoption Behavior, Investment Behavior, Decision Making*

### D. Data Analysis

Correlation test will be performed on the statistical package, SPSS. This tool will be used to provide an extensive statistical analysis and presentation of the results will be shown in tables and charts for data analysis and interpretation purposes. Correlation tables will be produced for analyzing the relationships between the independent variables, age and computer experience, with RE impact on lifestyle changes. Results on the Ease of use in RE in relation to users' adoption behaviour: user satisfaction, attitude to using and impact will also be derived from the correlation table.

## IV. CONCLUSION

This proposed study will comprise two surveys to investigate and examine REIS's influential intensity on the community's attitude and behavior towards adoption of RE, respectively. The surveys will be conducted with the collaboration of Melville Council, Western Australia. Incorporating results from first survey, principles and theories of consumer adoption behavior and effectiveness of ICT educational tools, REIS will be developed, aiming to provide knowledge, increase awareness and to influence investment decision on RE. In addition, REIS will also feature the utilization of smart meters providing consumers and suppliers with real time information on energy consumption. Subsequently, the analysis from the second survey will be shown and explained on the effectiveness of the proposed system, as well as correlation of consumers' demographic to adoption behavior and attitudes. These findings will serve as an invaluable insight to stakeholders, to further improve RE technologies, enhance policies and schemes, for increasing consumers' RE uptake rate.

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## VI. BIOGRAPHIES

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