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KEY FACTORS INFLUENCING USERS' INTENTIONS OF ADOPTING RENEWABLE ENERGY TECHNOLOGIES

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ABSTRACT

In last 30 years, the usage of Power had grown highly in developed and developing countries. The storage of petroleum has decreased in recent years. OPEC (Organization of Petroleum Exporting Countries) estimated the storage of oil will be used out in the end of century, In addition, the globe warming erode constantly. How to make good use of Renewable Energy is an urgent issue. The purpose of this research is to analyze the key factors that affect users' intentions of adopting renewable energy technologies. The research was based on TRA, TAM and Roger's Diffusion of Innovation. It helps us to figure out acceptance model and influencing factors. The result of the research could be used not only for promoting the adoption of renewable energy technologies, but also for providing insights to government institution. This study interviews 273 persons to comprehend their attitude and behavior about renewable energy technologies. These results reinforce some of the past findings of technology diffusion, renewable energy implementation, and partner relationship literatures. Therefore, to ensure effective renewable energy technology diffusion, technology promoter and policy maker need to ensure not only that appropriate technology is considered and adopted, but also that the person's attitude and new environmental changes.

Keywords: Renewable energy technologies, Behavioral intention to use, Diffusion of innovation, Structural equation modeling

INTRODUCTION

Over the century natural resources have been the key factor that dominates all the developments in human society. Especially in the last three decades, the consumption of natural resources has increased massively whether in developed or developing countries. And the discovery of fossil energy storage is slowing down. OPEC estimated that the storage of fossil oil and natural gas would be completely used up within this century. Even the storage of coal is dropped down to another 170 years. Besides, fossil energy fastens the production of carbon dioxide and indirectly causes the rise of temperature on the surface of earth as well as the continuance of global warming. Therefore, no matter viewing from the angles of natural resources, economy and environment, the search for various kinds of sustainable, economical and clean resource in the future is an urgent mission for the mankind.

Starting from the nineties, due to the pass of "Rio Declaration" and "Framework Convention on Climate Convention, FCCC" under the circumstances of global environments, the continuing development and appliance of energies has set up a brand new model. And the act of applying solar

power well has been widely encouraged and the appliance of solar power has also been tightly connected to international environments protection.

The Johannesburg World Summit on Sustainable Development convened between August 26 and September 4, 2002. The Summit constitutes a high-level forum designed to promote policies integrating economic, environmental and social considerations. Sustainable development integrates the principles of dynamic economic development with the protection of the environment and natural resources, alongside the creation of a stable and egalitarian society. The Summit demanded all the countries participated to transfer scientific results to acts of production collaboratively in order to develop the industries of solar power and vastly facilitate the sufficient supply of solar power. And this is one of the motivations of this research.

Over the past four years the average growing rate of solar power batteries has reached 35.8% and the growing of solar power generation system has also reached more than 30% (Lin, 2004). The annual output value of solar power batteries was 1.3 billion US dollars and analysts predicted it the reach 4.23 billion US dollars in 2010 and 48.85 billion US dollars in 2020. The global output value will multiply. Judging from the consecutive over 30% growth rate at global photonics market in the past five years, there's an indefinite potential of development in this industry. Among all the developments, lots are the results of government financing. Lin presumes that the major motivation of these developments is the rise of environmental protection concepts. The encouragement and financing of solar power generation system from the countries around the globe and the applications of renewable energy related laws have resulted in the increasing needs for solar power batteries.

This study hopes to have a deeper understanding of the key factors in terms of how person around the world use the Renewable Energy Technologies (RET), to conclude the possible hinders when promoting solar energy, and to make suggestions to the expanding of RET and its appliance, to benefit designing relating measures in promoting RET, and offer another way of thinking and choice to all the governments and corporation policies in the world.

This study regards the RET as an advanced technology and to explore person's acceptance towards the system. The major goals are as follows: to explore person's acceptance towards the RET and to compare different features (including individual attribute, behavior characteristic and cognition degree) according to the connection of person's behavioral intention to use RET.

THEORETICAL BACKGROUND

Theory of Reasoned Action (TRA)

The Theory of Reasoned Action (TRA) (Ajzen & Fishbein, 1980; Fishbein & Ajzen, 1975) originated in the field of social psychology and explains how and why attitudes affect behavior. TRA asserts that an individual's behavior is determined by his attitude toward the outcome of that behavior and by the opinions of others within his social environment. Ajzen and Fishbein (1980) proposed that an individual's intention to perform leads to a specific behavior. Behavior is the transition of intention into action. Intention to behave is a function of an individual's attitude toward the behavior and his subjective norms. TRA is designed to enable generalizations regarding behavior, since individuals make conscious choices based on: (1) How strongly they perceive the benefits leading to a positive outcome; and, (2) the social norms, risks, and rewards they associate with that choice.

Based on the TRA, a person's intention is a function of two basic determinants, one "personal" in nature and the other reflecting "social influence." The personal factor is the individual's positive or negative evaluation of performing the behavior, which is called "attitude toward the behavior" and refers to attitudinal factors. The second determinant of intention is the person's perception of the social pressure put on him/her to perform or not to perform the behavior in question. This factor is termed "subjective norm"—which deals with perceived prescriptions and relates to the normative considerations (Ajzen & Fishbein, 1980).

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Technology Acceptance Model (TAM)

Originally based on Ajzen and Fishbein's (1980) Theory of Reasoned Action (TRA), the Technology Acceptance Model was first proposed by Davis (1986). The TAM model is one of the dominant theories used to explain the process of user acceptance of high-tech products, mainly from intrinsic perception factors, rather than extrinsic environmental factors. Within the TAM school of thought, 'perceived ease of use', will simultaneously affect 'perceived usefulness' and 'attitude towards use'. Perceived usefulness will in turn affect both attitude towards usage and 'intention to use'. Ultimately, attitude towards usage will affect intention to use, which will in turn affect the 'actual use' of high-tech products. Other academics also introduced extrinsic environmental factors such as extra-organizational factors (e.g. Igbaria and Zinatelli, 1997) and product characteristics (Hong et al., 2002) to expand the application of the TAM model.

The TAM model has been examined in a variety of high-tech products, services and environments, including personal computers, email systems, the World Wide Web (WWW), and online shopping and eCommerce (see, among others, Webster, 1992; Chin and Gopal, 1995; Szajna, 1996; Gefen and Straub, 1997; Igbaria and Zinatelli, 1997; Lederer et al., 2000; Moon and Kim, 2001; Gefen, 2003; Zhang and Prybutok, 2004). The above empirical results have revealed the applicability of the theoretical TAM for evaluating the use of high-tech products. Nevertheless, to the best of the authors' knowledge, few TAM studies have assessed its applicability to the perspective of the acceptability of online channel functions.

Adoption, Innovation and Diffusion Theory

Everett M. Rogers(1962) pioneered the effort to understand diffusion of innovations in his seminal book of the same title. Subsequently, hundreds of scholars have applied and expanded Rogers' principles of early adopters, early majority, laggards, and others whose labels have become standard terminology. Scholars in a variety of fields—including organizational theory (Damanpour 1992; Granovetter and Soong 1983; Kanter 1988; Mahajan and Peterson 1985; Van de Ven et al. 1999; Wejnert 2002), education (Napierkowski and Parsons 1995), business and management (Burns and Wholey 1993; O'Neill, Pouder, and Buchholtz 2002; Ravichandra 2000)—have contributed to the understanding of this phenomenon called diffusion of innovation.

Rogers' (2003) DOI Model contends that innovation characteristics are primary determinants in the innovation adoption process. His five attributes include: relative advantage, compatibility, complexity, observability, and triability. Empirical and non-empirical studies have used successfully the five attributes in predicting innovation diffusion and adoption. According to Rogers (2003), 49 to 87 percent of variance of the rate of the adoption is explained by these five attributes.

Rogers identifies five critical attributes that greatly influence the rate of adoption. It has tried to adapt them to key factors that are required for the success of a new technology or product in the enterprise network market:

(1) Relative Advantage— New technologies that make up communication networks need to improve some aspect of the network. Many of the performance and cost advantages of an innovation are justified as problem avoidance. Interestingly, Rogers points out that preventative innovations that are justified by avoiding a problem (e.g., not contracting AIDS by adopting "safe sex") are particularly slow in adoption because individuals have difficulties in perceiving the relative advantage.

(2) Compatibility— Compatibility is the degree to which an innovation is perceived as consistent with the existing values, past experiences and needs of potential adopters. This is an area where Rogers shows how strongly individuals operating within a social structure govern the adoption process.

(3) Complexity— Complexity is the degree to which an innovation is perceived as difficult to understand and use. Of course, the level of perceived complexity is inversely proportional to the rate of adoption.

(4) Trialability— Trialibility is the degree to which an innovation can be experimented with on a limited basis. There is good news in this area. In the early days, connecting LANs and offices required defining architecture, specifying many details, and spending a lot of money in order to build enough of a network for the result to be understood, evaluated and ultimately justified. Many performance techniques can be applied to a very narrow subset of users, locations, applications and even portions of an application or content. The effect can be monitored to support decisions for gradual expansion of the innovation.

(5) Observability— Observability is the degree to which the results of an innovation are visible to others. There are two key terms in that sentence: visible and others.

Again, as we move to innovations with more subtle performance and cost improvements, measuring the change may be difficult. The more general benefits statements offered by the vendor earlier in the process are not sufficient at this stage. The enterprise must be able to directly observe (measure and document) the beneficial effect on its particular applications, users or infrastructure. And these advantages arc often realized over time. The longer it takes to make the case for an innovation, the longer it will take to be adopted even in an enterprise that is already trying it.

Rogers' key contribution to the study of diffusion of innovations was the innovation/adoption cycle (Collins 1996). In this cycle, a new product or innovation of any kind only initially appeals to a few individuals. These early adopters subsequently influence a larger group called the early majority, who in turn influence the late majority, and soon only a few laggards remain. In this article, we address one such innovation.

RESEARCH MODEL AND HYPOTHESIS DEVELOPMENT

Research Model

This research wishes to understand person's behavioral intention to use the RET. Due to the many external variables that cannot be completely taken into consideration, this research adopts TRA, TAM and DOI as its theory base. These theories have been proved and studied, applied by many experts and scholars, who all consider that " Behavioral Intention to Use" can be used as prediction indexes for future use (Mathieson, 1991; Szajna, 1996;Jackson et al., 1997; Hu et al., 1999). Therefore, judging from the documentations above, person's behavioral intention to use the RET can be effectively predicted. And that's the reason why this research focuses on exploring this.

The infrastructure of this research is shown as Figure 1. The external variables that this research model takes into consideration include gender, marriage, age, occupation, education, and income. And this research model hypothesizes that these factors affect not only the attitude toward to use (perceived usefulness, perceived ease of use and compatibility), but also the acceptance of innovation and subjective norm can affect person's behavioral intention to use the RET.

Research Hypothesis

Attitudes are formed through learning, but they are affected by gender, age, social classes, personalities, ways of lives, values, families, relatives, social and economic factors (Walter, 1978). Zhou's research on people's behavior of using electronic communication technology has made a discovery that on the differences of cognition degree among different groups, there's a significant difference of perceived usefulness and perceived ease of use between users and non-users. And there are some slight differences on personality variables i.e. the interviewees from different population statistics. Among them highly educated and younger age groups have better understanding on perceived usefulness and perceived ease of use (Zhou, 1993). Yu's research discovered that people

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who have received college education or above can absorb information of new energy rapidly and can accept solar power technology (Yu, 2004). Conclude all other research results above, this study draws further hypothesis as follows:

H1: External variables will affect person's attitude toward to use the RET.

H2: External variables will affect person's acceptance of innovation.

H3: Attitude toward to use will affect person's behavioral intention to use the RET.

H4: Acceptance of innovation will positively affect person's behavioral intention to use the RET.

H5: Subjective norm will positively affect person's intention of using the RET.

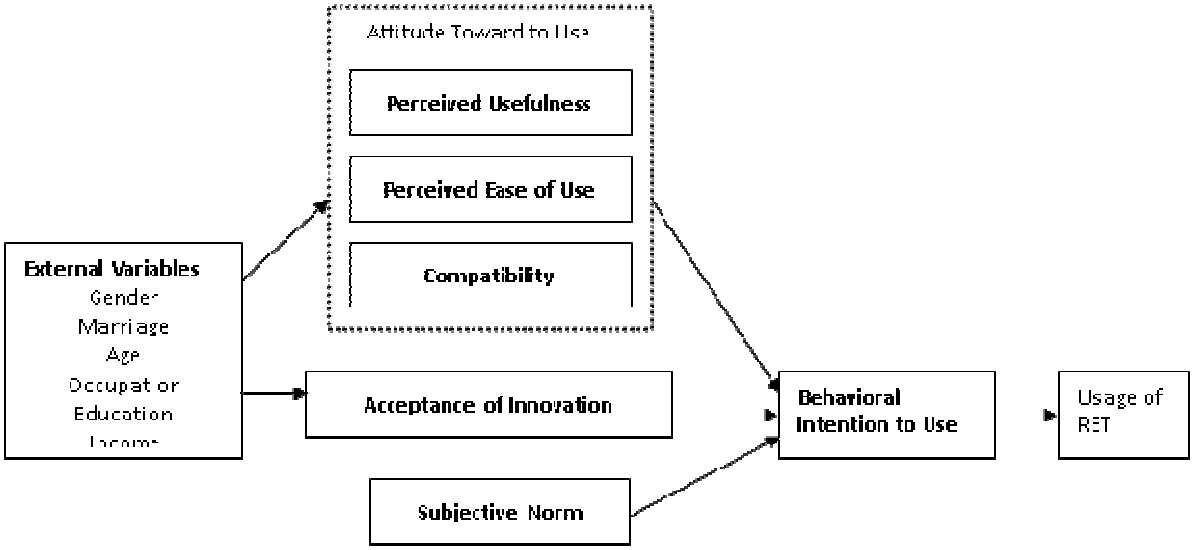

Figure 1: The research model

METHODOLOGY

In Taiwan, the energy resources are deficient, 97% of it needs to rely on the import, therefore develops the non-pollution new energy, then, uses it effectively, is a urgently work. In 2010, Taiwan's national energy conference, it was pointed out that the climatic changing is the global question, affects various countries' economy and the environment. Same year in February, the Kyoto protocol is to become effective. It will be the important issue in international environmental protection and the energy in the future. In addition, the time of high price in the petroleum is coming. The consciousness of environmental protection is increasing in the domestic. It will become major to influence the development of industry and energy resources using. For this pressure and the tendency, "the green energy develops and how to raises the energy use efficiency" is becoming the key character in the energy effective using and continually growing economic of our country.

Survey Administration

The objects of research questionnaires were staff, local residents, and tourist from these seven demonstration systems in Kaohsiung and Pingtung area. Questionnaires were collected immediately after finished. The purpose was to survey the possibility of acceptance and the intention to use RET. Altogether 300 questionnaires were provided, excluding questionnaires that were obviously not meeting the reality, the validate questionnaire is 273, the returns-ratio accounts for 91%.

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Table 1: Participants demographics

Item	Characteristics	Percentage (%)
Gender	Male	63.0
	Female	37.0
Marriage	Married	71.4
	Unmarried	28.6
Age	Less than 21	2.9
	Between 21 and 30	24.9
	Between 31 and 40	44.0
	Between 41 and 50	15.7
	Above 50	12.5

The material analysis is by counts software SPSS for the Windows version to take the statistical analysis tool. The questionnaire material and passes through first carries on the Cronbach's α validation test, in "Perceived Usefulness", "Perceived Ease of Use", "Compatibility", "Acceptance of Innovation", "Subjective Norm" and "Behavioral Intention to Use", α value is bigger than 0.7; And the overall reliability also achieves 0.9126.

Reliability analysis confirms the reliability and validity of variables adopted in this study. The reliability of all instruments assessed by the Cronbach'α reliability coefficient are above the conventional level of 0.7 as shown in Table 2.

Table 2: Reliability test

Variable	Cronbach'α	Number of items
Perceived Usefulness	0.9170	5
Perceived Ease of Use	0.9020	4
Compatibility	0.7218	2
Subjective Norm	0.7062	3
Acceptance of Innovation	0.8394	9
Intention to Use	0.9192	6

Measurement Development

Measurement items used in this study were adapted from previously validated measure or were developed on the basis of a literature review. The questionnaires were tested previously. The items were slightly modified to suit the context of RET. Our scale items for perceived usefulness, perceived ease of use, compatibility, Acceptance of Innovation, Subjective Norm, and behavioral intention to RET were from above literatures. Each item was measured on a five-point Likert scale, ranging from "disagree strongly"(1) to "agree strongly"(5).

The proposed model was evaluated using structural equation modeling, which is a powerful second-generation multivariate technique for analyzing causal models with an estimation of the two components of a causal model: measurement and structural models. The measurement model is estimated using confirmatory factor analysis (CFA) to test whether the constructs possess sufficient validation and reliability. The structural model is used to investigate the strength and direction of the relationship between the theoretical constructs. Such analyzed technique has been widely applied in recent years.

Using CFA, the results in Table 3 indicate that the composite reliability of all scales exceeds the 0.5 thresholds for acceptable reliability. The convergent validity was established if all indicator loadings were statistically significant and greater than 0.5. For the current CFA model, all factor loadings were above the 0.5 thresholds. Since the values of reliability were above the recommended thresholds, the scales for evaluating the constructs were deemed to exhibit convergence reliability.

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Table 3: Summary of measurement scales

	Constructs/Measures	Factor Loading
Perceived Usefulness (PU), composite reliability = 0.729		
PU1	Using RET economically causes me to be more convenient	0.881
PU2	Using RET is safe	0.897
PU3	RET is clean and for health	0.888
PU4	RET service life is long	0.763
PU5	The whole says, the usability of RET is very high	0.884
Perceived Ease of Use(PEU), composite reliability = 0.752		
PEU1	Study to use RET is easy	0.839
PEU2	Maintains of RET is easy matter	0.839
PEU3	Using RET is not easy to make a mistake	0.871
PEU4	The whole says, RET is very easy to use	0.858
Compatibility(COM), composite reliability = 0.750		
COM1	Using solar-powered water heater and RET has been dissimilar	0.855
COM2	Using RET and tradition generating system has been dissimilar	0.855
Subjective Norm(SN), composite reliability = 0.81		
SN1	My friends can encourage and supports me to use RET.	0.848
SN2	My colleagues can encourage and supports me to use RET.	0.931
SN3	My families can encourage and supports me to use RET.	0.819
Acceptance of Innovation(AI), composite reliability = 0.537		
AI1	I like attempting each novel idea.	0.78
AI2	I am a person which comparatively first has the new product.	0.68
AI3	I usually the pattern that to the past experiences handle the matter.	0.54
AI4	I thought myself has the original in the thinking and the behavior ability.	0.75
AI5	I am very easy to accept the new idea.	0.78
AI6	I am glad accept the new thing the challenge, even if it needs to spend the very much time and the energy.	0.82
AI7	I am cope with shifting events by sticking to a fundamental principle or policy to new thing can.	0.65
AI8	The relative or friend usually is by my opinion primarily.	0.52
AI9	Accepts item of new idea or in front of a new thing in the decision I will collect related information.	0.71
Intention to Use(IU), composite reliability = 0.757		
IU1	It has the solar-powered water heater in my house.	0.843
IU2	I know solar-powered water heater this item of product.	0.867
IU3	I am interested to the solar-powered water heater.	0.865
IU4	I knew the relatives and friends to use the solar-powered water heater.	0.731
IU5	I would consider the use solar-powered water heater.	0.865
IU6	I would want to use the RET substitution tradition generating system.	0.912

ANALYSIS AND RESULTS

Descriptive Statistics

Descriptive statistics were calculated and shown in Table 4. These show that, on average, our sample responded positively to Renewable Energy Technologies (RET). The averages of all constructs were greater than 3 out of 5. In addition, we use the t-test examination External Variables for the Attitude Toward to Use and the Acceptance of Innovation. It shows no statistically significant difference between Income (External Variables) and Attitude Toward to Use, no matter the Perceived Usefulness, Perceived Ease of Use and Compatibility. It also shows no statistically significant difference between Income Variable and Acceptance of Innovation. The Gender External Variable is no statistically significant for Compatibility. Other External Variables show statistically significant.

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Table 4: Descriptive statistics

n = 273	Means
Perceived Usefulness	3.58
Perceived Ease of Use	3.50
Compatibility	3.19
Subjective Norm	3.59
Acceptance of Innovation	3.42
Intention to Use	3.50

The Structural Model Assessment

The fitness measures for the measurement models are provided suitable. These fit statistics, GFI(0.90), AFGI(0.87), RMR(0.049), NFI(0.91), NNFI(0.93), CFI(0.94) were all indicative of good fit. And, this study examined the structural equation model by testing the hypothesized relationships among the research variables; see Fig 2. The results show that attitude toward to use (included perceived usefulness, perceived ease of use and compatibility) had significant effects on the behavioral intention to use (β= 0.276, $p < 0.001$; β = 0.159, $p < 0.001$; β = 0.201, $p < 0.001$); and acceptance of innovation and subjective norm had significant effects on the behavioral intention to use, too (β= 0.106, $p < 0.01$; β = 0.180, $p < 0.001$). Together, these paths accounted for 51.2% of the variance in behavioral intent to use.

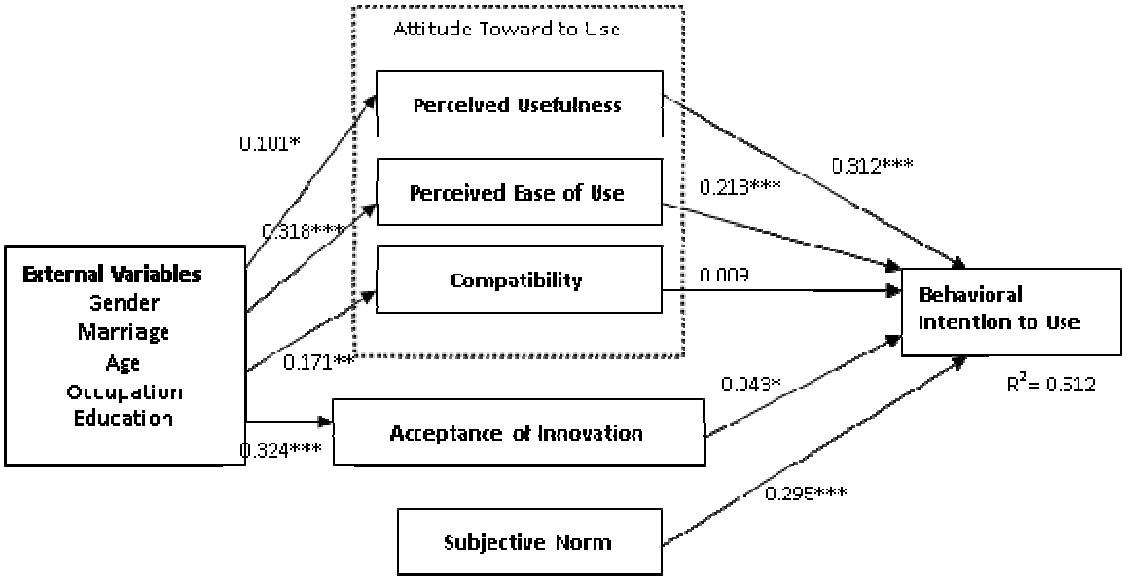

Figure 2: Path coefficients for the research model

RESULTS OF HYPOTHESES TESTING

As the below table 5, H1 express that external variables do not completely influence person's attitude toward use. And H2, external variables do not completely influence person's acceptance of innovation. Since person's income doesn't influence his attitude toward to use the RET and his acceptance of innovation. H3 result show that attitude toward to use will affect person's behavioral intention to use the RET. Hypothesis 4 and 5 have the same result, show that acceptance of innovation and subject norm will affect person's behavioral intention of using the RET.

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Table 5: Results of hypotheses tests

Hypotheses	Result
H1: External variables will affect person's attitude toward to use the RET.	Partly supported
H2: External variables will affect person's acceptance of innovation.	Partly supported
H3: Attitude toward to use will affect person's behavioral intention to use the RET.	Partly supported
H4: Acceptance of innovation will positively affect person's behavioral intention to use the RET.	Supported
H5: Subjective norm will positively affect person's intention of using the RET.	Supported

CONCLUSION

This research using the theory of reasoned action (TRA), the technology acceptance model (TAM), and the diffusion of Innovation (DOI), the result showed that in the behavior pattern of accepting the application of the RET, the person who is perceived usefulness to RET has the most significant influence on behavioral intention to use (β=0.276). Next importance factor will be the compatibility of system (β= 0.201), and the last factor is the acceptance of innovation (β= 0.106).

The external variables of the person whose attitude toward to use the RET are significant effect. The result of this research has found that the income isn't the significant variables. Also, it won't have to affect the attitude toward to use the RET. In addition, the variables for gender manner, the male thinks the RET is more usability than feminine. So, the way to operate is same with person's self-custom. While the person understands more about the RET, whom he/she will believe the system is most practical and easy to operate.

According to the past research, individual or family's income is critical factor that affect adoption of technology or innovation. This research supposed that income will be critical influential factor to use RET, but the result deliver income is weakly influential factors. This atmosphere can be explained that environmental protection and energy shortage issues are more thought important than it used to by most people all over the world. Meanwhile, environmental protection is accepted and identified by majority of people in developed and developing countries.

The following will base on the result of research to center up on how to develop practical methods of management or marketing strategies. It's also to provide the following suggestions to help the local government to reference the policy of the RET. When a salesman wants to promote the RET, he has to consider the market characteristic, not only to aware the person's external characteristics, the behavior special characteristic and the innovation acceptable. But also try to have appropriate marketing strategy on those groups who have lower intention to use. These research results and our suggestions:

(1) Perceived usefulness is the major key factor to influence people to use the RET. Whether the system is better than previous used, the economic benefit to gain, the bring convenience, satisfaction and impression are all affect the people will use or not. Therefore the suggestion is to have a RET in the community first, combine art with technology. It will help the technology more pretty. Such as, inviting artist to design, beautifying the absorber, it will make them to become one vision with the natural and let the art integrate into the technology. So, it will enhance the agreement of image of the RET to the people; raise the degree of the convenience of the system and satisfaction to the people.

(2) Subjective norm is also a factor to influence the person's behavior to use the RET application. Therefore, the suggestion is to encourage the person who is in the community, to have activities for the community and display the success case of the application of the RET. It will raise the utilization ratio of the system.

(3) The compatibility is about the past experiences of a person, and the present demand. It also one of factor of influence his behavior. Therefore, the suggestion is to hold some relative teaching activities

in local area, it teaches the people how to operate first. Try to motivate by asking question and offer prizes for correct answers. This is to strengthen the understanding and agreement to the RET.

(4) Perceived ease of use is also one factor of influencing the people to use the RET. Therefore, the suggestion may have some conferences to show the introduction of the RET, which will be able to educate the people, increases the people utilization ratio and the convenience. It will reach the goal to increase the satisfaction to the system and reduce the environmental pollution in the area.

These results reinforce some of the past findings of technology diffusion, RET implementation, and partner relationship literatures. Therefore, to ensure effective renewable energy technology diffusion, technology promoter and policy maker need to ensure not only that appropriate technology is considered and adopted, but also that the person's attitude and new environmental changes.

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