PUBLIC KNOWLEDGE OF NUCLEAR TECHNOLOGY AND ITS EFFECT ON THE INTENTION TO USE ELECTRICITY FROM NUCLEAR POWER PLANTS IN THAILAND

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Abstract: This paper reveals the new perspectives about the structure of factors that influenced the public's intention to use electricity from nuclear power plants (NPPs) in Thailand. The public's knowledge of nuclear technology could be a key issue for nuclear power utilization. Hence, this paper mainly focuses on the impact of knowledge on public attitudes and social influence. Structural equation modeling was applied to examine the relationship between the above factors. Probability sampling method was used in the form of stratified random sampling with 400 electricity household users across regions in Thailand. Results showed that the public's knowledge of nuclear technology and nuclear power has a direct positive influence on public attitudes toward NPPs and a direct positive impact on social influence. In addition, the public's knowledge transmits an indirect influence on attitudes and social influence to include another factor: the intention to use electricity from NPPs. Consequently, in order to put forward the nuclear power program, the Thai government should educate the public on nuclear technology as a precondition.

Keywords: Nuclear power plant, Public, Electricity, Knowledge, Thailand

I. INTRODUCTION

In the 21st century, many countries across the globe have been concerned about the future of the energy policy for sustainable energy as well as trying to reduce the environmental impact of the electricity production process and consumption. The energy generation could be a major source of greenhouse gas which, eventually, releases into the atmosphere and produces adverse consequences surrounding climate change. Hence, the energy policy is a critical tool to lead the direction of energy consumption and later on to delay the serious climate change situation.

The role of nuclear power in protecting energy supplies has been raised since the OPEC oil crisis in the 1970s [1]. Besides the worry about climate change, the inconsistency in fossil fuel price drives concern about the insecurity of energy supply.

Unfortunately, since the major accidents at Three Mile Island, Chernobyl, and Fukushima, public health and safety are the greatest challenges for the new nuclear power plant. The consequences lead to freezing any growth in the nuclear power industry. The new generation of nuclear power was designed based on the philosophy that the public is aware mainly of its safety and low operation costs. The advances in the new technology reactor might release the nuclear industry out of its deadlock which eventually could provide great benefits to society by reducing greenhouse gas emissions [2].

However, public knowledge has been a key factor affecting the public attitudes [3–5], besides awareness of the real benefit gains from nuclear technology, the nuclear safety, and the disposal of radioactive wastes. The study of the nuclear establishment reveals the risk in public perception which should be managed in an efficient and credible way regarding gaining the public's support [6].

Thailand plans to operate its nuclear power plants in the year 2030 [7]. The government, therefore, authorized government agencies to handle the nuclear-related topics and they provided nuclear technology knowledge through public acceptance campaigns for the proposed nuclear power plant's nominated sites. The campaigns aimed to provide adequate and appropriate nuclear knowledge and information. However, it did not gain a sufficiently high level of positive feedback to help the government to make a clear decision on nuclear power establishment.

Subsequently, the purpose of this study is to establish a model to illustrate the structure of public acceptance toward nuclear power plants (NPPs) in Thailand.

The research methodology was developed by using a comprehensive empirical survey of Thai public attitudes towards future nuclear power energy in Thailand, revealing the difficulties in identifying and interpreting public opinion to improve public acceptance.

II. NUCLEAR POWER SITUATION

Nuclear power's share the worldwide electricity production rose from less than 1 percent in 1960 to 16 percent in 1986, and that percentage has held essentially constant since 1986. In 2006, nuclear power's share dropped to 15 percent, and in 2007 it dropped another percentage point to 14 percent [8]. In 2014, there were 436 NPPs in 29 countries, which contributed 11.5% of the world's electricity production [9]. Recently, 48 countries have proposed to operate 322 NPPs within 15 years [10] which will

contribute 15–20% of the world's electricity production [9].

The Thai government has initiated the Thailand Power Development Plan (PDP) according to the three areas of consideration: energy security, maintaining economic growth and environmental impact.The recent power plan (PDP 2015) showed that the government tried to reduce the fossil fuel production and increase renewable energy and nuclear power. Accordingly, the two NPPs are being considered: a.1,000MWe plant is supposed to be operated in the year 2035 and another 1,000 MWe in the year 2036.

III. LITERATURE REVIEW AND THEORETICAL BACKGROUND

3.1 Knowledge and related studies

Knowledge is a set of information that supports individuals to have attitudes toward a thing. Cappurro [11] and Glassey [12] pointed out that the body of knowledge contains three major components: empirical knowledge, scientific knowledge and practical knowledge. Previously, most of the volume of studies in the areas of public knowledge, public opinion and public acceptance of nuclear technology and NPPs were mostly in the area of psychology [3, 13–14]. Recently, these topics have gained more obvious interest in other areas of discipline. Nevertheless, the positive relationship between public knowledge of nuclear technology and public attitudes towards NPPs has been found in limited research literature [15–16].

Siegrist and Cvetkovich [17] found that the body of knowledge influenced not only the individual perception, but also the people surrounding them. They pointed out that this influence significantly increases when the topic moves to the hazardous technology. Based on the literature, the research was hypothesized as follows:

H1: Public knowledge of nuclear technology and power has a positive effect on the public attitudes toward NPPs.

H2: Public knowledge of nuclear technology and power has a positive effect on social influence.

3.2 The studies related to public attitudes

Fishbein and Ajzen [18] gave the definition of attitudes as a latent disposition or tendency to respond with some degree of favorableness or unfavorableness to a psychological object. Rosenberg et al. [19] stated that attitudes contain three major components: cognitive component, affective component and behavior component. Duff [20] found a relationship between the attitudes and the intention to use electricity from NPPs. Feng [21] studied the structural equation modeling of the parameters that influence the decision to use renewal energy by the people of Taiwan and found that the public attitudes has positive influence on the intention to use electricity from renewal energy. Claudy et al. [22] studied the factors that affect the decision-making of American people in order to utilize renewable energy. Their studies revealed that public attitudes have a significantly positive impact on the intention to use renewable energy. Park and Ohm [13] studied the attitudes of people in Korea toward renewable energy after the Fukushima incident. They found a positive impact between the public attitudes and the intention to use renewable energy.

Previous studies could confirm the relationship between factors in the Technology Acceptance Model (TAM). Hence, the researcher formulated the third hypothesis as below:

H3: The public attitudes toward NPPs has a positive impact on the intention to use electricity from NPPs.

3.3 Social influence and related studies

Social influence signifies the impact of external factors that affect the individual decisional behavior which makes social influences a significant element in the Theory of Reason Action (TRA) model [23]. Some literature has examined the relationship of the social influence toward the intention to use new technology. Hobman and Ashworth [24] found that social influence has a positive impact on the utilization of nuclear technology in electricity production in Australia. Feng [21] concluded that social influence has a positive influence on the intention to use renewable energy in Taiwan. Similarly, Yun and Lee [25] found a comparable impact in America. Read et al. [26] pointed out that social influence has a positive impact on the intention to use wind energy in Australia. Nonetheless, Yazdanpanah et al. [27] did not find any relationship between social influence and intention to use alternative energy in Iran.

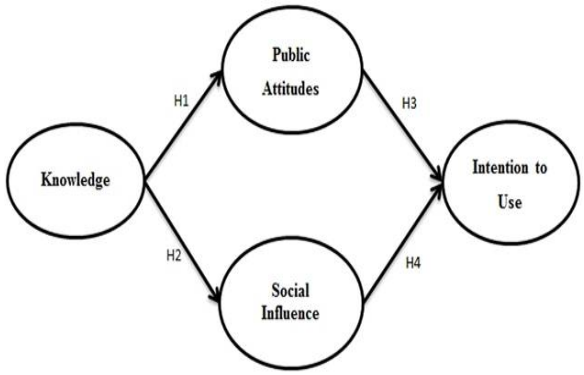
Therefore, the researcher formulated the fourth hypothesis as below:

H4: Social influence has a positive impact on the intention to use electricity from NPPs.

3.4Research Framework

The research framework constructed by the literature review. The model is shown in Fig. 1.

Fig. 1 Research Framework



IV. METHODOLOGY

4.1 Population and Sample

The study used the 20,452,075 households of Thai electricity users [28] as its population. The Yamane technique [29] was used to identify 400 households as the sample size. The researcher conducted the sampling by probability sampling and stratified random sampling. As a result, the sample size was distributed by electricity user ratio to 77 provinces around the country.

The data collection was conducted between May to July 2016. The researcher used an online questionnaire by a Google Doc program as the data collecting method. To ensure that the target group would be aware of the project and could access the questionnaire, the researcher promoted the project and questionnaire details at all of the Provincial Electricity Authority (PEA) and the Metropolitan Electricity Authority (MEA) branch offices as well as posted the same information on their Facebook page.

4.2 The measures development

The questionnaire used as a data collection tool was developed from previous nuclear and renewal energy research. The questionnaire aimed to measure the value of the four factors extracted from the research framework: they are knowledge factor, public attitudes factor, social influence factor and intention to use electricity from NPPs factor. The observed variables were used to design the questions. The questions, later on, were analysed and measured the four latent variables. The respondents answered each item by rating their answer from a seven points Likert scale which varied from 1= strongly disagree to 7= strongly agree.

The questionnaire contains four parts: nuclear technology knowledge, public attitudes, social influence, and the intention to use electricity from NPPs. The questions in the knowledge in nuclear power and technology parts were developed according to Kim et al. [4], Park and Ohm [13] and Stoutenborough et al. [16]. The questions in the public attitudes part were established from Kim et al. [4], and Bhanthumnavin and Bhanthumnavin [30]. The questions in the social influence part were taken from Hobman and Ashworth [24], Yun and Lee [25] and Römer et al. [31]. The latent variables, the intention to use electricity from NPPs, were adapted from Kim et al. [4], Park and Ohm [13] and Feng [21].

The questionnaire was tested for its validity and reliability. The validity test was conducted by the context validity and construct validity. Five nuclear experts were invited to examine the questionnaire. The index of Item Objective Congruence (IOC) was calculated. The researcher selected only the items that achieved an IOC value more than 0.5 [32] to develop the pilot test and process the reliability testing. Thirty electricity users in Bangkok were randomly selected, participated and answered the pilot questionnaire. Subsequently, Cronbach's alpha was used to measure the questionnaire's internal consistency. Eventually, all items could maintain a Cronbach's alpha value of more than 0.7 (Cronbach [33]). As a result, the pilot questionnaire was accepted.

After collected the samples, the researcher tested each latent variable's validity and reliability. All variables could maintain an item reliability between 0.61-0.91, which is higher than the acceptable level at 0.5 [34] and achieved a Cronbach's alpha value of between 0.71-0.96, which is higher than the acceptable level at 0.7 [33]. According Bagozzi and Yi's suggestion [35], the composite reliability values are between 0.66-0.83, which is higher than the acceptable value at 0.6. Consequently, it could be concluded that the items and variables have reliability. The results are shown in Table 1.

Variable	Item	Item reliability	Cronbach's alpha	Composite reliability	Average variance extracted
Knowledge	K1	0.61	0.78	0.66	0.56
	K2	0.72			
	K3	0.63			
Public attitudes	A1	0.65	0.71	0.67	0.52
	A2	0.71			
	A3	0.62			
Social influence	S1	0.65	0.79	0.69	0.52
	S2	0.79			
	S3	0.69			
Intention to use	I1	0.90	0.96	0.83	0.62
	I2	0.91			
	I3	0.91			

Table 1. Validity and reliability test.

V. RESULTS

5.1 Descriptive statistics

The basic information of respondents was measured in four categories: sex, age, highest education, and average monthly income Female was the majority (58%) while the biggest portion of the participants' age was recorded at 26 - 40 years (49%). Most of the respondents gain the Bachelor's degree or equivalent as their highest education (38%) and earn average income at 10,001-20,000 THB (41%). Descriptive statistic of sample characteristics can be seen in Table 2.

Table 3 displays the general data of the samples and the observed variables. Each observed variable reveals its Mean and Standard Deviation, and eventually all of them reflect the latent variables. The results show that knowledge performs worst when compared to other factors: it gains its mean value in below medium level while other latent variables gain their mean value in medium level.

Measure	Items	Frequency	Percent
Gender	Male	167	42
	Female	233	58
Age	Below25 years old	67	17
	26 – 40 years old	198	49
	Above 41 years old	138	34
Educational level	Primary school or equivalent	28	7
	Junior high school or equivalent	50	13
	High school or equivalent	82	20
	Diploma	48	12
	Bachelor degree	150	38
	Master degree or above	42	10
Average income	Below10,000 THB	65	21
	10,001 - 20,000 THB	126	41
	20,001 - 30,000 THB	69	22
	30,001 - 50,000 THB	38	12
	50,001 - 100,000 THB	10	3
	Above100,001 THB	3	1

Table 2. Basic information of the sample**.**

Variables	Items		Mean	S.D.
Knowledge	K1	I think the technology and fuel used in NPPs to generate the electricity are similar to other kinds of power plants.	2.96	1.38
	K2	I think the electricity generating processed by NPPs is similar to other electricity generating processes.	3.42	1.44
	K3	I know the benefit of nuclear power in order to produce electricity.	3.23	1.57
Public attitudes	A1	I understand the benefits and hazards involved in NPPs	3.80	1.32
	A2	I think it is a good idea to produce electricity by nuclear technology in Thailand.	3.18	1.51
	A3	I will fully support the setting up of NPPs in Thailand?	3.55	1.18
Social influence	S1	I think the organization which will be responsible for generating nuclear electricity in Thailand is trustable and reliable.	3.21	1.48
	S2	I think the public will support the usage of electricity from NPPs.	3.20	1.49
	S3	My family could influence my decision to use electricity from nuclear technology.	2.98	1.56
Intention to use	I1	I will immediately use nuclear electricity when it starts to be generated in Thailand.	3.31	1.75
	I2	I think my community has to use electricity from nuclear technology in the near future.	3.41	1.72
	I3	If I have free choice to choose the source of energy, Iwill choose electricity from nuclear power.	3.27	1.73

Table 3.Descriptive statistics (mean and S.D.).

5.2 The analytical for assessing the model

Structural Equation Modelling (SEM) was conducted by measuring the model to test the hypotheses and verify the inter-relationship between the variables. At the early stage, each component of latent variables was analyzed to confirm its quality by using first order confirmatory analysis. After each component was confirmed, the designed model was verified by using the AMOS (version 21) program.

This study used seven major criteria to test the goodness of fit. They are: χ^2/df, goodness-of-fit index(GFI), adjusted GFI (AGFI), normalized fit index (NFI), an incremental fit index of improved NFI (CFI), root-mean-square error of approximation (RMSEA) and standardized root mean square residual (SRMR). The acceptable level for concluding the fitness of the model is where the χ^2/df value should be below 3, the GFI and AGFI should be above 0.8, the NFI and CFI should be above 0.9 and RMSEA and SRMR value should be below 0.08. As shown in Table4, the results gained from the structural equation model could maintain all the criteria. Therefore, it could be concluded that the model has an overall goodness of fit.

Fit index	Recommended criteria	Results	Suggested by authors
χ^2/df	< 3	2.84	Bentler and Bonett [37]
GFI	> 0.8	0.95	Seyal et al. [38]
AGFI	> 0.8	0.91	Scott [39]
NFI	> 0.9	0.97	Bentler and Bonett [37]
CFI	> 0.9	0.98	Bentler and Bonett [37]
RMSEA	< 0.08	0.07	Hair et al. [34]
SRMR	< 0.08	0.04	Hu and Bentler [40]

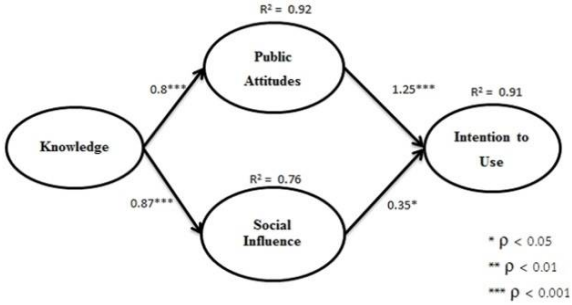
Table 4. Overall fits of models.

5.3 Test of the structural model

The researcher developed the structural equation model to test the research hypotheses. The model has an overall goodness of fit as has been proven in section 5.2. Then, the researcher tests the latent varibles' coefficients. The findings reveal that nuclear technology knowledge has a significant positive impact on public attitudes toward NPPs ($\beta = 0.8$, $\rho < 0.001$) and social influence ($\beta = 0.87$, $\rho < 0.001$). As a result, the H1 and H2 were accepted.

The factors in the nuclear technology knowledge part could explain 92% of public attitudes and could explain 76% of social influence. Additionally, the results found that public attitudes and social influence have a significantlypositive impact on the intention to use electricity from NPPs ($\beta = 1.25$, $\rho < 0.001$ and $\beta = 0.35$, $\rho < 0.05$) and three variables can explain the intention to use electricity from NPPs stood at 91%. Therefore, the H3 and H4 were accepted.

Fig. 2 Result of structural modelling analysis



CONCLUSION

6.1 Implication for practices

The findings unfold several implications for the policy makers as follows:

Firstly, nuclear technology knowledge is the crucial factor that highly influences creating a positive public attitude toward NPPs. It also has impacts on social influence which generates social acceptance. Eventually, all of those stimuli drive public intention to use electricity from NPPs.

Thus, it is necessary for the policymakers to constantly educate society strategically with relevant knowledge, such as the essentials of nuclear power, the nuclear electricity generating process, and the benefits to be gained from nuclear electricity. The active knowledge should be delivered to all levels of people, especially in the primary and secondary schools. As well as educational institutes, self-learning materials should be developed and be made easy to access. All related organizations should work collaboratively in order to expand a broader knowledge of nuclear technology and power through the media and advertisements which could be an efficient way to maximize their knowledge-spreading capacity to a larger group of the public.

Secondly, social influence is another critical factor to create social awareness of using nuclear electricity. Therefore, besides providing public knowledge, the related organizations should make the nuclear industry in Thailand more acceptable. The idea could be concretized by providing the right information about the compulsory nuclear knowledge, cultivate the good image of the Thai nuclear operation organizations and promote the transparency of the NPPs. These strategies could be a driving force to gain the public's intention to use NPPs which ultimately could back-up the nuclear power establishment program in Thailand.

Finally, although the Thai government will be an initial investor and operator in the first NPP, this research found that the Thai people intend to use nuclear electricity. For that reason, it is possible that in the future when people have a higher level of nuclear technology knowledge, the privately own companies could be NPP investors and operators as other power plant.

6.2Research Limitations

Nuclear power is still a new agenda for Thailand and this study was the first research focusing on the public attitudes and opinions on nuclear technology and power. Due to this, the factors that were introduced in the study were limited. Thus, future research should expand its scope of factors by introducing external factors or factors from Technology Acceptance Model (TAM) or The Unified Theory of Acceptance and Use of Technology (UTAUT). Additionally, this model has a high potential for future research in order to verify the model in other countries in both the nuclear power existing and embarking realms. The results could be used to compare, develop and adjust the model and perhaps it could be used internationally.

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