THE IMPLEMENTATION OF BUILDING-INTEGRATED PHOTOVOLTAICS IN THAILAND: FACTORS AFFECT ON USERS AND INVESTORS INTENTION

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ABSTRACT

The purpose of this research is to find out the prospect of implementing Building-Integrated Photovoltaics in Thailand and figure out how the factors will affect end users' usage intention and investors' investment intention of the product. Within this research, the researcher used Unified Theory of Acceptance and Use of Technology model to study the BIPV's potential market drivers and barricade in Thailand. 400 questionnaires were distributed and liner regression analysis was applied to prove that theory. The result of research showed that BIPV's product facilitating condition, social influence, performance expectancy and security have a significant positive impact on end users' usage intention and investors' investment intention.

Keywords: BIPV, facilitating condition, social influence, performance expectancy, security, intention

INTRODUCTION

Due to the reason that more power generation ways should be adopted except for the traditional way of generation by fuel, Ministry of Energy of Thailand has announced the new Alternative Energy Development Plan (AEDP) policy to increase the proportion of renewable energy to 30 percent of whole energy generation. In this plan the capacity of solar energy could achieve 10,000 megawatts by year of 2037 (PDP, 2018).

According to the report of International Renewable Energy Agency (IRENA) two major Photovoltaics' (PV) modules application scenarios in Thailand are ground solar farm and solar rooftop. Regards to the solar PV application places, Bangkok metropolitan area still has great potential for solar PV deployment with more engagement from MEA and PEA if they can solve the current challenges and problems contractor will face with. (IRENA, 2017).

Building-integrated photovoltaic (BIPV) is a new solar PV technology product in recent years and it has a lot of potential advantages to customers such as: (1) Positive effect to property value to which choose to use BIPV product; (2) Grow R & D capacities for technology; (3) Possibility to achieve government incentive; (4) Possibility to attract investors and customers' attention; (5) Efficient thermal insulation; and (6) Good noise and weather protection.

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However, there are also disadvantages when it comes to compare with conventional PV product including: (1) Higher cost but lower efficiency due to technology limitation; (2) Difficulty to use on existing buildings; (3) Difficult to install and higher skill labor forces are needed; and (4) Higher designing difficulty. The priority value of conventional PV and BIPV is electricity revenues, but BIPV products concentrate more on higher status, better market images and replacing building materials.

So far there is not any BIPV product existing in Thailand solar market even this market is estimated to boom in next decade. For manufacturer party, most manufacturers have limited knowledge of Thailand current standards and building codes, government possible incentive policy and social response to BIPV application scenarios. For user and investors party, both the investors and end users are unfamiliar with this new technology and have performance concerning and security concerning as well. This research aims to study the potential customers and investors' acceptance and investment intention of BIPV product and forecast whether it is good time for BIPV to enter Thailand solar market, and whether this new technology product could survive in Thailand market or even take place of conventional solar PV in the future or not.

LITERATURE REVIEW

This research will adopt Venkatesh et al. (2003) Unified Theory of Acceptance and Use of Technology model to study the BIPV's potential market drivers and barricade in Thailand and how these factors affect customers' and investors' intention.The UTAUT model adopts four core factors include facilitating conditions, social influence, effort expectancy, and performance expectancy to determine users' behavioral intentions. Gender, age, experience, and voluntariness of use could be considered as moderating variables which act as the catalyst of the four core factors.

Facilitating condition is defined as "the degree to which an individual believes that an organizational and technical infrastructure exists to support the use of the system" (Venkatesh et al., 2003). When it comes to the promotion of BIPV products in Thailand it could be defined as the degree to which Thai customers and investors believe that Thai government provide incentives to support the use of BIPV system. Chien-wen Shen et al. (2019) ever studied how to use the facilitating condition affect the behavior intention of using new technology of virtual reality in learning. Social influence refers to "the degree to which an individual perceives that important others believe he or she should use the new system" (Venkatesh et al., 2003). Xiao-liang Shen et al. (2011) studied how social influence affects intention to use instant messaging and concluded that social influence could be the driver for people's intention to use new tools instead of old communication ways. Performance expectancy is defined as "the degree of ease associated with the use of the system" (Venkatesh et al., 2003). Regards to the BIPV product, Performance could be the degree of ease associated with power generation or building construction. Oechslein et al. (2014) had a research on social recommender system and assumed that performance expectancy had a positive effect on people's system adopting behavior. Although Unified Theory of Acceptance and Use of Technology (UTAUT) model, which is already considered as one of the most meaningful mode investigating the determinants that affect the technology adoption decision, the mode would become more accurate if some new modifications are added to set up the new research direction. Feras Fares Al Mashagba and Mohammad Othman Nassar (2012) had ever added security in the model of Unified Theory of Acceptance and Use of Technology when they did research of factors effecting the adoption of mobile banking. So, this research will also add security as the supplement variable of Unified

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Theory of Acceptance and Use of Technology (UTAUT) model to identify how security affect the behavior intention. The definition of behavioral intention is the degree to which a person has formulated conscious plans to perform or not perform some specified future behavior (Warshaw & Davis, 1985). Many researchers set up intention as dependent variable and study that how other independent variables affect the people's intention. In the study of rural households' renewable energy usage in Iran, Rezaei et al. (2018) developed a new UTAUT model which evolve from original Unified Theory of Acceptance and Use of Technology (UTAUT), the components of the developed UTUAT model include behavioral intention as the most important determinant of actual behavior.

RESEARCH METHODOLOGY

Conceptual Framework

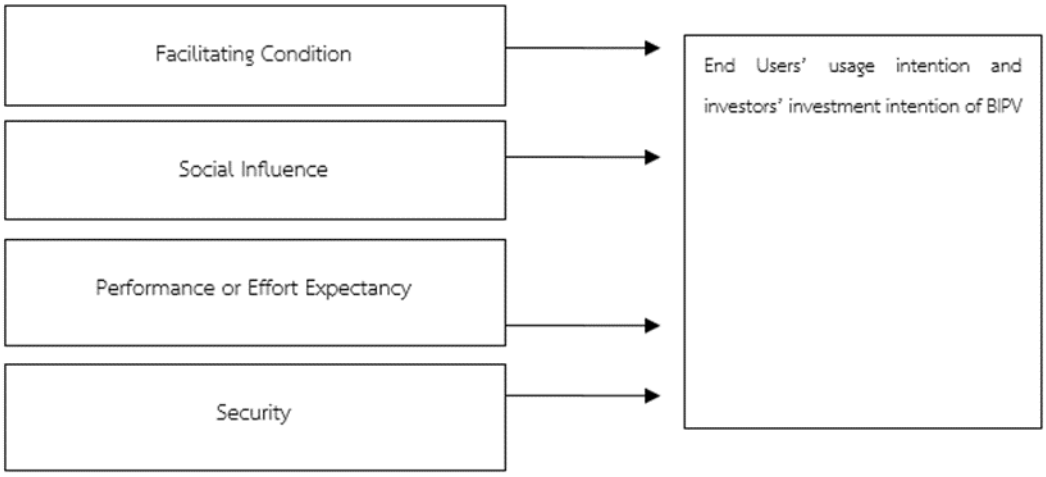

Figure 1: The Conceptual Framework of users and investors intention making.

Hypotheses

Hypothesis 1**:** BIPV's facilitating condition has positive impact on user's usage intention and investor's investment intention in Thailand.

Hypothesis 2: BIPV's social influence has positive impact on user's usage intention and investor's investment intention in Thailand.

Hypothesis 3: BIPV's performance expectancy has positive impact on user's usage intention and investor's investment intention in Thailand.

Hypothesis 4: BIPV's product security has positive impact on user's usage intention and investor's investment intention in Thailand.

Data Collection

Population of this research are governor officers of energy department, investors and potential end users in Thailand who are interested in adoption of renewable energy. The population amount in this case is hard to define, so the nonprobability purposive sampling method is chosen for this research. The purposive sampling technique, also called judgment sampling, is choosing a participant deliberately according to the qualities and characteristics the participant owns. It is a nonrandom technique that does not need underlying theories or a set number of

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participants. On contrary, the researchers themselves could decide what needs to be known and set the regulations to find out people who can and are willing to provide the information by virtue of knowledge or experience (Bernad, H.R., 2002). Researcher will select certain groups of respondents to be the sample which include 1). Staff in investing companies which have experience of solar energy 2). Owners and management staff of industrial and commercial building 3). Officers of local electricity authorities 4). BIPV manufactures as the research participants. Totally 400 participants will be selected to attend the questionnaire survey.

Measurement

To investigate how usage or investment intention of BIPV product will be affected by different variables, a questionnaire survey is used in this study. First of all, all the possible drivers and barricades should be identified when it comes to the study of BIPV products' promotion in Thailand market.

Lu, Y. et al. (2019) have studied the drivers and barricades selling BIPV in Singapore, they conducted the literature review and identified totally 12 drivers and 21 barriers from all the related literatures. After that they organized group discussion to finally pick up 12 drivers and 18 barriers which are fit for Singapore market. The result is shown below:

Drivers for BIPV.

Code	List of Drivers
D1	Positive impact on the property value
D2	Enhance green image for better marketing
D3	Generation of renewable energy which brings economic benefits
D4	Improve the performance of the building envelope
D5	Obtain governmental incentive
D6	Achieve Green Mark certification
D7	Reduce CO_2 emission
D8	Reduce dependency on fossil fuels
D9	Demonstrate green image and sustainable development to public
D10	Encourage the occupants to adopt pro-environmental behaviour
D11	To be partially independent of the grid
D12	Grow industrial R&D capacities for technology

Figure 2: BIPV marketing drivers in Singapore
Source: Lu, Y. et al. (2019), The implementation of building-integrated photovoltaics in Singapore

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Barriers to BIPV.

Code	List of Barriers
B1	Difficulties in obtaining governmental approvals (e.g. from different agencies)
B2	Lack of BIPV specific design standards and codes
B3	Uncertainties in BIPV policies (e.g. the source and stability of subsidy funds)
B4	Lack of R&D support covering the entire industry chain of BIPV
B5	Projects awarded to lower price tendering
B6	Few choices for BIPV products
B7	High upfront capital costs of BIPV
B8	The long-term payback period of BIPV
B9	Low electricity tariff from conventional sources (i.e. natural gas)
B10	The low energy conversion efficiency of BIPV systems
B11	Difficulty in integrating BIPV into the grid
B12	Fluctuating energy generation due to weather
B13	Unclear maintenance procedures (e.g. replacement of BIPV modules)
B14	Few numbers of competent contractors and installers
B15	Lack of successful BIPV demonstration
B16	Lack of BIPV knowledge for professionals
B17	Additional time and efforts to collaborate with stakeholders (e.g. communications between engineers and designers)
B18	Lack of public awareness of BIPV

Figure 3: BIPV marketing barriers in Singapore
Source: Lu, Y. et al. (2019), The implementation of building-integrated photovoltaics in Singapore

In this research, the drivers and barricades identified in Singapore will be used as the source. The factors influence the Thai customers and investors' intention will be selected from the source and be concluded and separated into 4 groups as the independent variables to form a more detailed theoretical framework structure. The questionnaire is designed according to the detailed theoretical framework structure:

This research employs quantitative research approach with questionnaire survey to collect all the necessary data. Positivism will be used as philosophical paradigm associated to this research design. The nonprobability purposive sampling method is chosen for this research. The questionnaire is created by Microsoft Office and would be sent to relevant firms by emails and linked in messages in a period of one month start from July 31st, 2020.

Statistics analysis software is used in this research to do the data analysis. In the questionnaire, participants are asked to evaluate each factor's important level from extremely agree to not agree. The evaluation standard follows 5 = extremely agree, 4 = very agree, 3 = moderately agree, 2 = slightly agree, and 1 = disagree. Each independent variable is combined with 5 factors.

At the first stage of data analysis, Cronbach's alpha is applied to examine the reliability ratings of four independent variable separately and determine the result is acceptable or not. Based on most other social science research, if the reliability coefficient is equal with or above 0.70 (Bruin, J., 2006), the result is considered as acceptable. After that, statistics of mean, mode and median is used to check data central tendency of each independent variable, statistics of standard deviation and variance is used to check data dispersion of each independent variable. Finally, regression analysis will be applied to confirm the hypotheses.

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Instrument Pretest

Firstly, researcher will find professional interpreter to interpret the questionnaire from English language to Thai language in case the participants take part in the test are not good at English skills.

Secondly, the questionnaire is sent to 40 participants who are experts take part in BIPV product R & D research and marketing development research from different companies and departments at the beginning to check the instrument's reliability and validity. The result is shown as below:

Validity

3 professors from national electricity bureau and Board of Foreign Investment was selected to check the content of the questionnaire before the pretest. The Index of Item-Objective Congruence (IOC) was applied to confirm the content validity. The score range of the Index of Item-Objective Congruence (IOC) for each questions was from -1 to 1.

Congruent=1

Uncertain=0

Incongruent=-1

The questions which score are lower than 0.5 should be revised and the questions which score are higher than 0.5 should be reserved.

Reliability

The reliability pretest is conducted to make sure all the data collected from instrument is reliable and consistent. The 40 respondents will be chosen to answer the questionnaire first and their result will be analyzed by using Cronbach's alpha to see whether the reliability coefficient is equal with or above 0.70 (Bruin, J., 2006).

After all the pretest is done and data is collected and analyzed by the statistical analysis software, the results of reliability pretest are as follows:

Facilitating Condition	0.825
Social Influence	0.873
Performance Expectancy	0.872
Security	0.852
Intention	0.830
Total	0.953

All the variables' Cronbach alpha is more than 0.8, the data shows that the questionnaire is very trustworthy.

Data Collection Procedure

Researchers prepare both English language and Thai language questionnaire in Microsoft Word file and send the electronic file to the carefully selected participants by emails or linked in messages.

Totally 400 respondents are selected for data collection, who are from the area of invest companies, PV manufactures, government departments of energy and local factories. All of them will answer the questions about BIPV development in Thailand and their answers will be used for the analysis for correctness of hypotheses in this article.

DATA ANALYSIS

Statistics analysis software is used in this research to do the data analysis. At the first stage of data analysis, Cronbach's alpha is applied to examine the reliability ratings of four

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independent variable separately and determine the result is acceptable or not. Based on most other social science research, if the reliability coefficient is equal with or above 0.70 (Bruin, J., 2006), the result is considered as acceptable. According to the result all the variables' Cronbach alpha is more than 0.8, the data shows that the questionnaire is very trustworthy.

The researcher distributed the questionnaires to 400 participants. Finally, the researcher analyses data by using Linear regression analysis.

The demographic data in this research questionnaire include respondents' age, education level, occupation, position level, annual salary level, interested product category, interested material type, interested brand and relevant experience.

After finish collecting the respondents' questionnaires and the data, the data will be put into the statistical analysis software. An analysis of the biology information frequency focuses on age, education level, occupation, position level, annual salary level, interested product category, interested material type, interested brand and relevant experience. The result is showed as below:

First of all, there are 346 male respondents, which take 86.5% of all respondents. The other 54 female respondents take the balance 13.5% of all respondents.

Secondly, 314 respondents' age is between 25 years old to 40 years old, which takes 78.5% of all respondents. The number of respondents whose age is between 41 years old to 55years old is 64, which ranks No.2 and take 16% of all respondents. 13 respondents' age is below 25 years old and 9 respondents' age is above 55 years old, which take last 3.3% and 2.2% separately.

Thirdly, most respondents are holding a bachelor's degree, which takes nearly 70.5% (N=282) among the 400 respondents. Meanwhile, the people who are holding master's degree take 27.8% (N=111) and the people who are holding doctor's degree take 1.8% (N=7). The result shows the respondents' lowest level of education is bachelor's degree and the highest level is doctor's degree.

Fourthly, 36.5% (N=146) respondents are PV manufactures, 20.5% (N=82) respondents are government employees, 19.3% (N=77) respondents are investment company employees and 15.3% (N=61) respondents are factory employees. Only 8.5% (N=34) respondents are from designing company.

Fifthly, 36.5% (N=146) respondents are PV manufactures, 47% (N=188) respondents are junior management level, 35.8% (N=143) respondents are officer level and 15.5% (N=63) respondents are senior management level. Only 1.5% (N=6) respondents are company directors.

Sixthly, most respondents' annual salary level is 240,000-600,000 THB, which take 81.8% (N=327) of all respondents. 16.8% (N=67) respondents' annual salary level is 600,001-960,000 THB. Only 1.5% (N=6) respondents' annual salary is above 960,000 THB. The result shows that no respondent's annual salary is below 240,000 THB.

Seventhly, 44.5% (N=178) respondents are interested in commercial rooftop, 37.3% (N=149) respondents are interested in commercial façade and 10.5% (N=42) respondents are interested in residential rooftop. Only 7.8% (N=31) respondents are interested in residential facade.

Eighthly, 75.3% (N=301) respondents are interested in mono, 17.3% (N=69) respondents are interested in thin film and 7.2% (N=29) respondents are interested in poly. Only 1 respondent of 400 consider the material of dye sensitize cell.

Ninthly, most popular brand is LONGi Solar, 35.8% (N=143) of respondents will choose this brand. Second popular brand is Jinko Solar, which 25.3% (N=101) respondents would like to choose. The third and last popular brand are Canadian Solar and GCL, which take 22% (N=88) and 17% (N=68) of respondents.

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Finally, because BIPV is a quite new product in market, only 6% (N=24) respondents have mono crystalline project experience before, all the other respondents don't have relevant BIPV project experience previously.

Figure 4: Demographic frequency analysis

Frequency Table

gender

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	male	346	86.5	86.5	86.5
	female	54	13.5	13.5	100.0
	Total	400	100.0	100.0	

age

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	below 25 years	13	3.3	3.3	3.3
	25years-40years	314	78.5	78.5	81.8
	41years-55years	64	16.0	16.0	97.8
	above 55 years	9	2.3	2.3	100.0
	Total	400	100.0	100.0	

education

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	bachelor's degree	282	70.5	70.5	70.5
	master's degree	111	27.8	27.8	98.3
	doctor's degree	7	1.8	1.8	100.0
	Total	400	100.0	100.0	

occupation

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	investment company employees	77	19.3	19.3	19.3
	government employees	82	20.5	20.5	39.8
	factory employees	61	15.3	15.3	55.0
	PV manufactures	146	36.5	36.5	91.5
	building designers	34	8.5	8.5	100.0
	Total	400	100.0	100.0	

position

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	director	6	1.5	1.5	1.5
	senior management	63	15.8	15.8	17.3
	junior management	188	47.0	47.0	64.3
	officer	143	35.8	35.8	100.0
	Total	400	100.0	100.0	

annualsalary

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	240000THB-600000THB	327	81.8	81.8	81.8
	600001THB-960000THB	67	16.8	16.8	98.5
	above 960000THB	6	1.5	1.5	100.0
	Total	400	100.0	100.0	

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product

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	residential building facade	31	7.8	7.8	7.8
	residential building rooftop	42	10.5	10.5	18.3
	commercial building rooftop	178	44.5	44.5	62.7
	commercial building façade	149	37.3	37.3	100.0
	Total	400	100.0	100.0	

material

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	mono crystalline cell	301	75.3	75.3	75.3
	poly crystalline cell	29	7.2	7.2	82.5
	Thin film	69	17.3	17.3	99.8
	Dye Sensitized cell	1	.3	.3	100.0
	Total	400	100.0	100.0	

brand

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Jinko Solar	101	25.3	25.3	25.3
	LONGi Solar	143	35.8	35.8	61.0
	GCL System Integration	68	17.0	17.0	78.0
	Canadian Solar	88	22.0	22.0	100.0
	Total	400	100.0	100.0	

experience

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Mono crystalline cell	24	6.0	6.0	6.0
	others	376	94.0	94.0	100.0
	Total	400	100.0	100.0	

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Regression Result

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.870[a]	.756	.754	.199

a. Predictors: (Constant), security, facilitating condition, performance expectancy, social influence

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	48.316	4	12.079	306.260	.000[b]
	Residual	15.579	395	.039		
	Total	63.894	399			

a. Dependent Variable: intention

b. Predictors: (Constant), security , facilitating condition, performance expectancy , social influence

Coefficients[a]

Model		Unstandardized Coefficients B	Unstandardized Coefficients Std. Error	Standardized Coefficients Beta	t	Sig.
1	(Constant)	-1.514	.161		-9.423	.000
	performance expectancy	.348	.025	.367	13.697	.000
	social influence	.391	.031	.345	12.788	.000
	facilitating condition	.352	.022	.392	15.639	.000
	security	.291	.026	.298	11.248	.000

a. Dependent Variable: intention

Table 1: Regression analysis

Analysis and Result

From the model summary, it shows that R^2=0.756, which means the 4 independent variables explain 75.6% of variation for the dependent variable of intention.

Then ANOVA test is employed to check the statistical significance of the variables. In the test F=306.260 and P＜0.001, proves that there is statistical correlation between the dependent variables and independent variable.

Finally, coefficient shows the correlation between each independent variables with dependent variable:

The coefficient between facilitating condition and intention is 0.392 which proves the hypothesis 1. The coefficient between social influence and intention is 0.345 which proves the hypothesis 2. The coefficient between performance expectancy and intention is 0.367, which proves the hypothesis 3. The coefficient between security and intention is 0.298 which proves the hypothesis 4.

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DISCUSSION AND RECOMMENDATION

By using linear regression analysis, researcher find out all the factors include in facilitating condition, social influence, performance expectancy, and security will influence the users' usage intention and investors' investment intention of BIPV product in Thailand.

As the manufacturers of BIPV product, they must pay attention to BIPV product's performance expectancy and security. Continue R & D is necessary for manufactures because the improvement of 7 factors in performance expectancy and 7 factors in security will have significant positive effect on users and investors' intention.

On condition that the objectives of research were well conducted and the UTUAT theoretical structure were proven by quantitative analysis the research will have a significantly implication for investors in Thailand. The investors will have a deeper understanding of BIPV's future application prospect and make a judgement whether it is good time to invest BIPV in Thailand solar market. By the research of facilitating condition, social influence, performance expectancy and security, the users could realize whether using BIPV is a smart choice to replace their traditional building materials. The manufactures should know how product performance expectancy and product security effect user's usage intention and investor's investment intention and improve their BIPV product according to users and investors' reaction and feedback.

FUTURE RESEARCH

Even the research was well conducted and the UTUAT theoretical structure were proven by quantitative analysis, it still has improved spaces as follow:

Firstly, the drivers and barricades identified in Singapore is used as the source and separated into 4 groups as the independent variables to form a more detailed theoretical framework structure. The questionnaire based on this source may have the limitation to explain the market in Thailand. For the future study, the researcher suggests gathering more kinds of factors could affect Thailand market.

Secondly, due to the BIPV product still not commercial used in Thailand, a lot participants of the research are only familiar with tradition photovoltaic but lack of experience in BIPV product, so some answers of the questionnaire could not be very reliable. For the future study, the researcher suggests to guarantee most participants have related BIPV product experiences to make sure the questionnaire be more reliable. The researcher believes that as time pass by, it will become easier to find the people with BIPV knowledge in Thailand

Thirdly, as for the research has been conducted in a quantitative way, so that it lacks deep insights on the effects of user's usage intention and investor's investment intention. For the future study, the researcher suggests using both quantitative and qualitative methodology together to get more details and insight opinions for deeper understanding the relationship between facilitating condition, performance expectancy, social influence, security with user's usage intention and investor's investment intention.

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