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Psychological and Social Determinants that Influence Interest in Residential Photovoltaic (RPV)

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Abstract

This study aims to assess the psychological and social determinants that influence interest towards RPV through an empirical investigation of a new survey-based dataset collected in Jakarta Metro, Indonesia. The theory of planned behaviour (TPB) framework was tested using survey data from 174 non-adopters, providing recommendations of potential intervention for policy makers and RPV installers in alleviating key barriers of RPV adoption. Overall, each of TPB components; attitudes, subjective norms and perceived behavioral control have significant direct and indirect impact towards interest. Individuals perceiving RPV personally and environmentally beneficial are more interested in RPV. Perception of RPV adoption will be supported by peers also increases interest. In contrast, belief of unsuitable house decreases interest. Notably, individuals seeing RPV as a complex technology are more interested to gain information about RPV.

ARTICLE INFO

Keywords: Theory of Planned Behaviour, TPB, Residential photovoltaics, RPV

Abstrak

Penelitian ini bertujuan untuk mengidentifikasi faktor psikologis dan sosial yang mempengaruhi ketertarikan seseorang terhadap fotovoltaik residensial (RPV) melalui sebuah investigasi empiris berdasarkan data yang diperoleh dari survei di Metropolitan Jakarta, Indonesia. Kerangka teori perilaku yang direncanakan (TPB) diuji melalui data survei dari 174 responden yang belum memasang RPV, memberikan rekomendasi intervensi yang potensial bagi pembuat kebijakan dan pemasang RPV untuk mengurangi hambatan utama dalam mengadopsi RPV. Secara umum, seluruh komponen TPB; sikap, norma subyektif, dan persepsi terhadap kontrol perilaku memiliki dampak signifikan secara langsung maupun tidak langsung terhadap ketertarikan. Individu yang menganggap RPV bermanfaat bagi diri sendiri maupun lingkungan lebih tertarik pada RPV. Persepsi bahwa mengadopsi RPV akan didukung oleh orang-orang terdekat juga meningkatkan ketertarikan. Sebaliknya, anggapan ketidakcocokan rumah akan menurunkan ketertarikan. Uniknya, individu yang menganggap RPV sebagai teknologi yang kompleks lebih tertarik untuk mencari informasi mengenai RPV.

Kata kunci: Teori perilaku yang direncanakan, fotovoltaik residensial

1. Introduction

Residential photovoltaic (RPV) is a solar photovoltaic (PV) system that has electricity-generating solar panels mounted on the rooftop of a residential building. It converts the sun's radiation into usable electricity. RPV has many advantages worth noting such as environmental benefit and personal economic benefit. Installing RPV helps combat greenhouse gas emissions and reduces collective dependence on fossil fuel such as coal and natural gas. Furthermore, RPV can reduce electricity bills since homeowners will be meeting their energy needs from the electricity generated by RPV.

Worldwide growth of residential photovoltaics has been exponential between 2007–2017 but varies strongly by country. In the U.S., cumulative installed capacity of RPV has grown from 380 megawatts in 2010 to 5,644 megawatts in 2016. Improvements in technology, drop in price per watt, regulatory incentives and innovative financing options have made the recent surge in U.S. possible (Barbose & Darghouth 2015).

However, hardly any private residential houses in Indonesia have installed RPV to date. Despite the recent raise in electricity tariffs and the introduction of a net metering system from the state utility provider, installation of RPV has not kicked off as it did in the U.S. and other leading countries (Hasan *et al.*, 2017). Understanding factors that influence interest in RPV might provide potential leverage points for RPV adoption to grow in Indonesia.

To the best of our knowledge, to date there has been no specific research on identifying factors that influence RPV adoption in Indonesia. Research regarding photovoltaics in Indonesia have largely focused around mapping of solar energy potentials (Rumbayan *et al*,. 2012) and economic feasibility of utility grade solar PVs (Said 2011). This research aims to fill the gap through an investigative survey. Specifically, we apply the theory of planned behavior (TPB) framework to investigate attitudes, subjective norms, and perceived behavioral control vis-a-vis RPV. Identifying the key psychological and social determinants that affects interest in RPV is necessary for designing successful interventions to foster RPV penetration. Establishing the degree to which attitudes, subjective norms and perceived behavioral control influence interest in RPV is informative as to decide which information will be most useful and effective in interventions intended to increase RPV adoption.

2. Literature Review and Hypotheses

Despite being an unusual one, RPV can still be considered as a consumer good. Thus, referring to theories that have proven helpful in understanding consumer decision making could be useful in identifying factors that influence interest in RPV adoption. The theory of planned behavior (TPB) has been used widely in analyzing various consumer behaviors. TPB asserts that the behavior of individuals is determined by the attitude toward the behavior, subjective norms, and perceived behavioral control (Ajzen 1991). An attitude toward a certain behavior is formed from beliefs about the likely positive or negative consequences of a behavior. Subjective norms are the perception of how a particular behavior will be viewed by others important to the subject. Perceived behavioral control measures a person’s perception of her/his ability to perform the behavior.

Wolske *et al.* (2017) recently provides evidence that TPB can be useful in explaining what drives and hinders interest in adopting RPV. The research tested the TPB framework using survey data from 904 non-adopter homeowners in 4 states of the U.S. It proposed a penultimate variable before interest: social curiosity about RPV, defined as how interested people would be in learning about the cost and benefits of RPV when a friend/family or neighbor installed RPV.

It was found that positive attitudes such as personal benefits and environmental benefits, along with positive subjective norms positively influence interest in adopting RPV through indirect path via social curiosity. The people were more likely to learn about RPV if they believed RPV would be personally beneficial, helping the environment and be supported by their peers.

In contrast, negative attitudes regarding concerns about cost directly reduced interest in adopting RPV. The people believing that RPV were too expensive would show less interest in going for RPV. Surprisingly, negative attitudes of perceived risk and unsuitability of home (personal behavioral control) positively influence interest via direct path. This finding may suggest that people would be interested in confirming whether or not their perception of RPV risks are true and their home are really unsuitable. Lastly, waiting for improvements and the people’s expectancy to move in the near future were found to have no significant influence to both interest and social curiosity.

Considering the recency and comprehensiveness of Wolske *et al*. (2017) model, we decided to use it as the basis of our proposed model, which incorporates: (1) personal benefit, (2) environmental benefit, (3) perceived risk, (4) concerns about cost, (5) waiting for improvement, (6) normative beliefs, (7) unsuitable home, (8) may move, and (9) social curiosity.

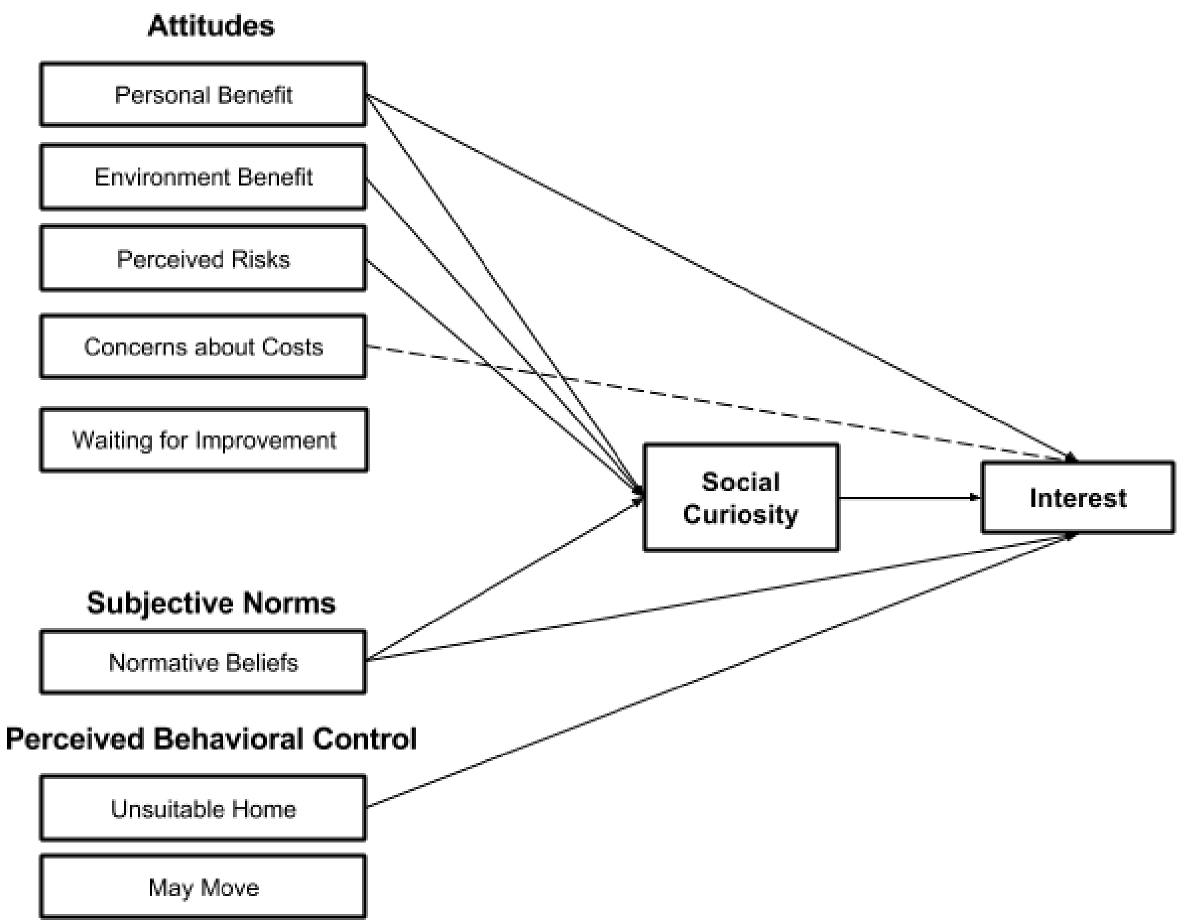

Fig 1. Wolske *et al.* (2017) Research Result. Statistically significant and positive relationship are indicated with a solid arrow while significant, negative relationship are marked with a dashed arrow.

Personal Benefit

Personal benefit is the degree which a specific behavior will be personally beneficial for someone. People will be more likely to have interest in RPV when they believe they could personally feel the benefits.

H1: The higher RPV is perceived to be personally beneficial, the higher the interest will be.

Environmental Benefit

Environmental benefit is the degree which a specific behavior will be beneficial for the environment as a whole. With rising concerns of environmental problems, RPV will be more likely adopted if people perceive it to pose high environmental benefit.

H2: The higher RPV is perceived to be environmentally beneficial, the higher the interest will be.

Perceived Risk

Perceived risk is the uncertainty someone believes that threatens when performing a specific behavior. New technology innovation such as RPV are subject to perceptions of high risks that could reduce the adoption rate.

H3: The higher RPV is perceived to be risky, the lower the interest will be.

Concern about Cost

Concern about cost is the reservation someone has based on the perceived monetary cost of adopting RPV. Despite steep price decline in recent years, RPV is still considered expensive even in the U.S. (Wolske *et al*., 2017). Thus it makes sense that RPV is perceived very expensive and unaffordable in Indonesia.

H4: The higher RPV is perceived to be costly, the lower the interest will be.

Waiting for Improvement

Waiting for improvement is the state where someone considers to postpone a behavior in search for better outputs in the future. As RPV technology keeps developing, its quality and cost-effectiveness also keeps improving. Most people will wait until the RPV technology could provide the best result before adopting it.

H5: The higher RPV is perceived to be better in the future, the lower the interest will be.

Normative Beliefs

Normative belief is the perceived social pressure to do a specific behavior.

H6: The higher the belief of gaining support from peers in adopting RPV, the higher the interest will be.

Unsuitable Home

Unsuitable home is the state of perceiving one's house to be unsuitable for RPV installation. Even if someone has a favorable attitude towards RPV, unsuitability of home can immediately offset those positive influences.

H7: The higher the belief of home unsuitability, the lower the interest will be.

May Move

May move is the belief of moving residence in the near future, hindering benefits of RPV to be felt.

H8: The higher the belief of moving in the near future, the lower the interest will be.

This research uses two measures to assess interest in adopting RPV. With the final variable of interest in adopting RPV, social curiosity is used as the mediating variable. Thus, it is essential to test whether social curiosity influence interest in adopting RPV.

Social Curiosity

Social curiosity is defined as how interested people would be in learning about the cost and benefits of RPV when a friend/family or neighbor installed RPV

H9: Social curiosity mediates the relationship among attitudes, subjective norms, and perceived behavioral control to interest

Wolske *et al.* (2017) further directed future research to find additional measures of attitudes towards RPV that might influence social curiosity and interest. Faiers (2006) in his research, measures consumer attitudes towards RPV using perceived characteristic of innovation based on the difussion of innovation (DOI) theory (Rogers 2003). DOI asserts that an innovation is an idea, practice or object that is perceived as new by an individual. There are five major perceived characteristics of innovation: (1) relative advantage, (2) complexity, (3) compatibility, (4) observability and (5) trialability.

Relative advantage

Relative advantage is the degree to which an innovation is perceived as better than the idea it supersedes. The principle is that the greater the perceived relative advantage of an innovation, the more rapid the rate of adoption will be. The relative advantage in the innovation of RPV has been portrayed in the personal benefit and environmental benefit that has been included in TPB, thus no additional variable will be added to include relative advantage.

Complexity

Complexity is the degree to which an innovation is perceived as difficult to understand and use. RPV as a new technology will be perceived as complex thus decreasing people's interest.

H10: Perception on higher complexity of RPV will show lower interest about RPV.

Compatibility

Compatibility is the degree to which an innovation is perceived as being consistent with the existing values, past experiences, and needs of potential adopters. The more compatible the innovation with existing technology, the easier the innovation could be adopted by people.

H11: Perception on higher compatibility of RPV will show higher interest about RPV.

Observability

Observability is the degree an innovation is perceived to be visible to others. The easier it is for individuals to see the results of an innovation, the more likely they are to adopt.

H12: Perception on higher observability of RPV will show higher interest about RPV.

Trialability

Trialability is the degree to which an innovation is perceived may be experimented before being adopted. Higher trialability of innovation means that people could easily try the innovation thus results in less uncertainty that increase the rate of adoption. Due to the nature of RPV that requires modification for installation and long lifetime, the degree of trialability of RPV is low. Thus different perceptions on trialability will be irrelevant and will not be included in the research.

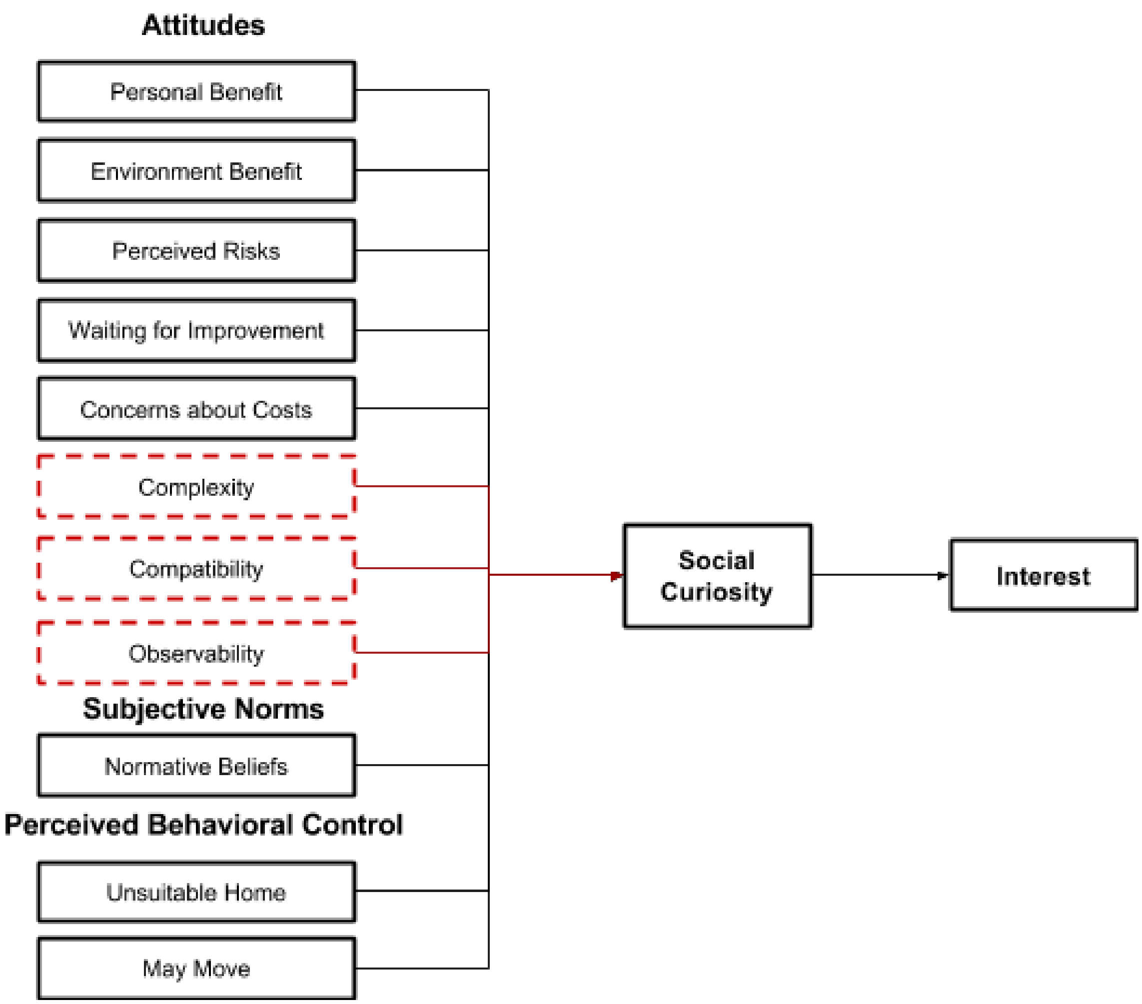

Fig 2. Proposed Research Model

3. Methodology

3.1 Data Collection and Sample

This research was conducted using a quantitative method through direct offline questionnaires for 174 respondents who are (1) aware of RPV, (2) non-adopters of RPV, (3) highly educated (minimum bachelor degree), (4) living in Jakarta Metropolitan Area. Respondents unaware of RPV are excluded from the data set due to no relevant perceptions on RPV. This research also focused on non-adopters of RPV to capture the insights on motivators and barriers affecting non-adopters that might be overlooked when studying RPV adopters. Considering RPV is a new technology in Indonesia, we believe participants with higher education possess higher and broader knowledge to form relevant perceptions about RPV. Jakarta Metropolitan Area was chosen due to higher education, higher disposable income, and greater population compared to other metro areas in Indonesia.

Table 1

Sample Profile

Age	Proportion	Home Square Footage	Proportion	Home Electric Load Capacity	Proportion
24-30 years	34.68%	<100 m2	13.29%	<1300 VA	11.76%
30-35 years	19.08%	100-150 m2	20.89%	2200 VA	42.48%
35-40 years	20.23%	150-200m2	22.15%	3300 VA	17.65%
40-45 years	10.98%	200-250 m2	10.13%	4400 VA	11.11%
45-50 years	8.09%	250-300 m2	11.39%	5500 VA	7.84%
50-55 years	4.05%	300-350 m2	9.49%	6000 VA	5.23%
>55 years	2.89%	>350 m2	12.66%	>6000 VA	3.92%

Monthly Household Expenditure	Proportion	Monthly Electricity Bill	Proportion
< Rp 5.000.000	15.03%	< Rp 350.000	6.67%
Rp 5.000.000 - 10.000.000	34.68%	Rp 350.000 - 650.000	20.00%
Rp 10.000.000 - 15.000.000	23.12%	Rp 650.000 -1.000.000	29.33%
Rp 15.000.000 - 20.000.000	11.56%	Rp 1.000.000 - 2.000.000	24.00%
Rp 20.000.000 - 25.000.000	4.05%	Rp 2.000.000 - 3.000.000	13.33%
Rp 25.000.000 - 30.000.000	5.20%	Rp 3.000.000 - 5.000.000	5.33%
> Rp 30.000.000	6.36%	> Rp 5.000.000	1.33%

3.2 Measures

The survey has been developed by referring to previous research measures that were translated into Bahasa Indonesia and adjusted for the sake of practical consideration and better local familiarization. The survey combines relevant social science theories and practical implementation of RPV in Indonesia. Some questions that have been validated in previous research will be addressed below while some other questions are developed to provide additional measures that may be useful for future research.

The survey instrument questions uses 7-point Likert scales from 1=*Strongly disagree* to 7=*Strongly agree* unless otherwise noted. Every question is accompanied with an option of *Don't Know* to avoid answers not reflecting the real perceptions.

Personal Benefit

Perceptions on personal benefit are reflected with seven items on the survey. Four items on the survey are adopted from previous research (Wolske *et al.*, 2017) such as whether RPV is a profitable investment, saves cost, minimizes the uncertainty of electricity tariffs, and increases the house's value. While additional three items on the survey are adjusted by researchers with prideful local culture such as whether RPV is a social status symbol; whether it improves the house's appearance; and whether it makes the owner proud.

Environmental Benefit

Perceptions on environmental benefit are tested using the same measurement as prior research (Wolske *et al.*, 2017) reflected with the questions such as the extent to which RPV helps to slow down climate change, improves environmental quality, and reduces environmental impact.

Perceived Risks

Perceived risks are captured with the extent of how people thought RPV is an unfamiliar experience, risky thing for a household, and damages the house as measured in prior research (Wolske *et al.*, 2017). Additional measurements such as 'RPV increases the risk of short circuit', 'RPV is an easily damaged device', and 'RPV does not produce electricity as it promised' are added to the questions.

Waiting for Improvement

Perceptions on how RPV will be cheaper and more advanced in the future rationalize why people rather wait for improvement than adopt RPV now. [Rewritten]
Questions on how people think RPV will be cheaper and more advanced in the future thus it is reasonable to delay the purchase reflect the perceptions on how people rather wait for improvement than adopt RPV now.

Concerns about Cost

People's perception on cost related to RPV are captured in four items, with three items from prior research (Wolske *et al.,* 2017) such as RPV is expensive, beyond the household's budget, and requires expensive maintenance fee. Researchers added one question to capture how long people think RPV investment pays back.

Complexity

Perspectives on RPV complexity are reflected through how people think RPV is a complex technology that is troublesome to be adopted. Four items on the survey such as how people think RPV is difficult to be used, understood, maintained, and required a lot of paperwork portrayed complexity.

Compatibility

RPV as a new technology requires several adjustment to the current technology used. The degree of changes necessary to convert to RPV is captured by how people think RPV needs electrical appliances adjustment, rooftop adjustment, electrical installation adjustment, and the parallelity with the grid.

Observability

One item on the survey based on prior research (Faiers 2006) and three items based on additional practical experience are used to reflect how observable the benefit of RPV, such as RPV is currently not widely known, RPV will be used widespreadly in the future, the benefit of installing RPV is easily seen, and benefit of RPV is easily explained to other people.

Normative Beliefs

Normative beliefs are represented by how people think that installing RPV will be supported by family members, important people, and society.

Unsuitable Home

Unsuitable home is portrayed by how people perceived their home unsuitable to be installed with RPV, such as the area is not sunny enough, too cloudy, and there is no place to put RPV.

May Move

For some people who plan to move in near future or often resettled have lower adoption rate. Three items from prior research (Wolske *et al.*, 2017) captured this may move perceptions.

3.3 Software

This study uses SmartPLS v 3.2.7 to evaluate the measurement model and visually examine the relationships that exist among variables. SmartPLS is one of the prominent software applications for Partial Least Squares Structural Equation Modeling (PLS-SEM). The software has gained popularity since its launch in 2005 not only because it is freely available to academics and researchers, but also because it has a friendly user interface and advanced reporting features.

4. Results

4.1 Measurement Model Evaluation

As a preliminary step in our analysis, a measurement model evaluation was employed aimed to evaluate the validity and consistency of the manifest variables. Validity of the variables was tested based on convergent and discriminant validity by calculating standardised outer loadings of the manifest variables. Manifest variables with outer loading 0.7 or higher were considered highly satisfactory (Litwin 1995) while loading value of 0.5-0.7 were regarded acceptable and manifest variables with loading value of less than 0.5 were dropped.

Consistency evaluation were tested through 2 measures: Cronback-Alpha and Composite Reliability of individual manifest and construct. Value of cronbach alpha should be higher than 0.7 and a composite reliability value of 0.7 is suggested as "modest" (Litwin 1995). As presented in Table 2, all constructs have cronbach's alpha and composite reliability above 0.7.

Table

Measures and Factor Loadings.

	Factor Loading	Mean	SD
Personal Benefit (α = 0.909, CR= 0.928)		4.85	1.56
Installing solar provides a great return on a family's investment	0.848		
Using solar would save me money	0.815		
Using solar will help protect my family from rising electricity prices in the furure	0.859		
Solar panels would increase my property value	0.804		
Solar panels would increase my house appearance	0.748		
Installing solar is a symbol of social status	0.712		
I will be proud for going solar	0.836		
Environmental Benefit (α = 0.960, CR= 0.974)		5.66	1.26
Having solar panels would be a good way to reduce my environmental impact	0.953		
If more households get solar panels, environmental quality will improve	0.976		
Solar panels help slow down climate change	0.959		
Perceived Risk (α = 0.776, CR= 0.974)		4.60	1.72
I would worry about having solar panels because it would be an unfamiliar experience	0.798		
Installing solar panels is a risky thing for a household to do	0.890		
I would worry my solar panel dose not generate electricity as it should be	0.793		
Expense Concerns (α = 0.826, CR= 0.885)		5.58	1.38
Solar panels are still very expensive	0.801		
I can't afford solar on my family budget	0.845		
Solar investment requires too long pay back period	0.858		
Maintaining solar panels is expensive	0.735		
Waiting for Improvement (α = 0.726, CR= 0.829)		5.00	1.52
The prices of solar keep going down, so it is wise to wait before deciding whether to install it	0.867		

Solar panel technology will only get better, so it doesn't make sense to get them now	0.904		
Compatibility (α = 0.765, CR= 0.807)		5.61	1.15
When going solar, I still can use my electric appliances as usual	0.823		
Solar power can operate in parallel with the grid without any problem	0.925		

Table 2 (*Continued*)

	Factor Loading	Mean	SD
Operating solar panels is a hassle	0.903		
Solar panels requires complex maintenance	0.903		
There is a lot of paperwork involved in installing solar	0.871		
Observability (α = 0.824, CR= 0.924)		5.25	1.47
Solar power will be more widespread in the future	0.880		
Benefit of going solar is easy to be observed by others	0.859		
I can easily tell the benefit of going solar to others	0.839		
Normative Belief (α = 0.852, CR= 0.931)		5.30	1.35
People who are important to me would be in favor of installing solar panels	0.932		
Most people who are important to me would support me if i decided to go solar	0.935		
May Move (α = 0.724, CR= 0.878)		2.39	1.86
I am planning to move in the near future	0.876		
I often move residences	0.894		
Unsuitable Home (α = 0.809, CR= 0.912)		2.90	1.85
Its not sunny enough in my area for solar panels to work well	0.928		
It'a too cloudy where I live for solar panels to be effective	0.904		
Social Curiosity (α = 0.973, CR= 0.980)		5.86	1.04
How interested are you in learning about the benefits of solar if a neighbor installed solar panel?	0.950		
How interested are you in learning about the benefits of solar if a friend or family member installed solar panel?	0.974		
How interested are you in learning about the costs of solar if a neighbor installed solar panel?	0.960		
How interested are you in learning about the costs of solar if a friend or family	0.964		

member installed solar panel?			
Interest (α = 0.954, CR= 0.967)		5.29	1.49
How interested are you in learning more about solar panels?	0.948		
How interested are you in finding out solar panel installers?	0.951		
How interested are you in talking to a solar installer?	0.935		
How interested are you in installing solar panel?	0.915		

Factor loadings and scale reliabilities based on initial sample, N = 200. Individuals who responded “Don’t Know” to all items in a factor were dropped from subsequent analyses (N = 26). Means are based on remaining sample, N = 174. All items were rated on a 7-point scale from 1 = Strongly disagree to 7 = Strongly agree.

4.2 A Structural Model

We conducted separate path analyses to assess the explanatory power of the variables derived from each constructs. Each path analysis involved regressing each variable in the causal chain on all of the variables that preceded it. Using the path modeling, we estimated both direct effects, net of other variables, and total effects, which include both the direct effects and indirect effects through other variables.

The structural model assesses relationship between exogenous and endogenous latent variables through evaluating R^2 value, that is, coefficient of determination and also β value, the path coefficients of the model. R^2 corresponds to the degree of explained variance of endogenous latent variables while β indicates the strength of an effect from variables to endogenous latent variables. The value of R^2 of endogenous latent variable should be more than 0.26 (Cohen 2003). The next step assessed the path coefficient of all latent variables (paths) by comparing β values among all the paths. The highest β value symbolizes the strongest effect of predictor (exogenous) latent variable towards the dependent (endogenous) latent variable. However, β value has to be tested for its significance level through *t*-value test. The test is achieved by performing nonparametric bootstrapping technique (Efron 1993).

A bootstrapping technique computes *t*-value by creating prespecified number of samples. Efron (1993) mentioned that acceptable *t*-values for a two-tailed test are 1.96 (5% significance level), 2.58 (1% significance level), and 3.29 (0.1% significance level). As presented in Table 3, social curiosity (0.832) and environmental benefit (0.224) have significant relationship towards interest even at 0.1% level. Personal benefit (0.184) and normative belief (0.149) have significant relationship towards interest at 1% level, while unsuitable home (-0.105) and complexity (0.109) have significant relationship towards interest at 5% level. The research results are presented in Figure 3.

Table 3

Direct and total effects for Social Curiosity and Interest in Adopting RPV (standardized coefficient)

Independent Variables	SC Direct		SC Total		IN Direct		IN Total		Hypothesis Supported
Social Curiosity (H9)					0.832	***	0.832	***	Yes
RPV-specific beliefs & attitudes									
Personal Benefit (H1)	0.128	**	0.128	**	0.153	**	0.184	**	Yes
Environmental Benefit (H2)	0.156	***	0.156	***	0.187	***	0.224	***	Yes
Perceived Risk (H3)	0.043		0.043		0.052		0.043		No
Expense Concern (H4)	-0.024		-0.024		-0.029		-0.024		No
Waiting for Improvement (H5)	-0.049		-0.049		-0.059		-0.049		No
Normative Belief (H6)	0.103	**	0.103	**	0.124	**	0.149	**	Yes
May Move (H7)	-0.059		-0.059		-0.071		-0.059		No
Unsuitable Home (H8)	-0.088	*	-0.088	*	-0.088	*	-0.105	*	Yes
Compatibility (H10)	0.004		0.004		0.005		0.004		No
Complexity (H11)	0.076	*	0.076	*	0.091	*	0.109	*	No
Observability (H12)	0.095		0.095		0.079		0.095		No
Household Constraints									
Age	-0.038		-0.038		-0.046		-0.046		
Household Expenditure	0.043		0.043		0.012		0.012		
Monthly Electricity Expenditure	0.046		0.046		0.056		0.056		
Home Square Footage	-0.035		-0.035		-0.042		-0.042		
Home Electric Load Capacity	0.006		0.006		0.007		0.007		
R Adj			0.805				0.69		

N = 174, *p < 0.05, ** p<0.01, ***p<0.001

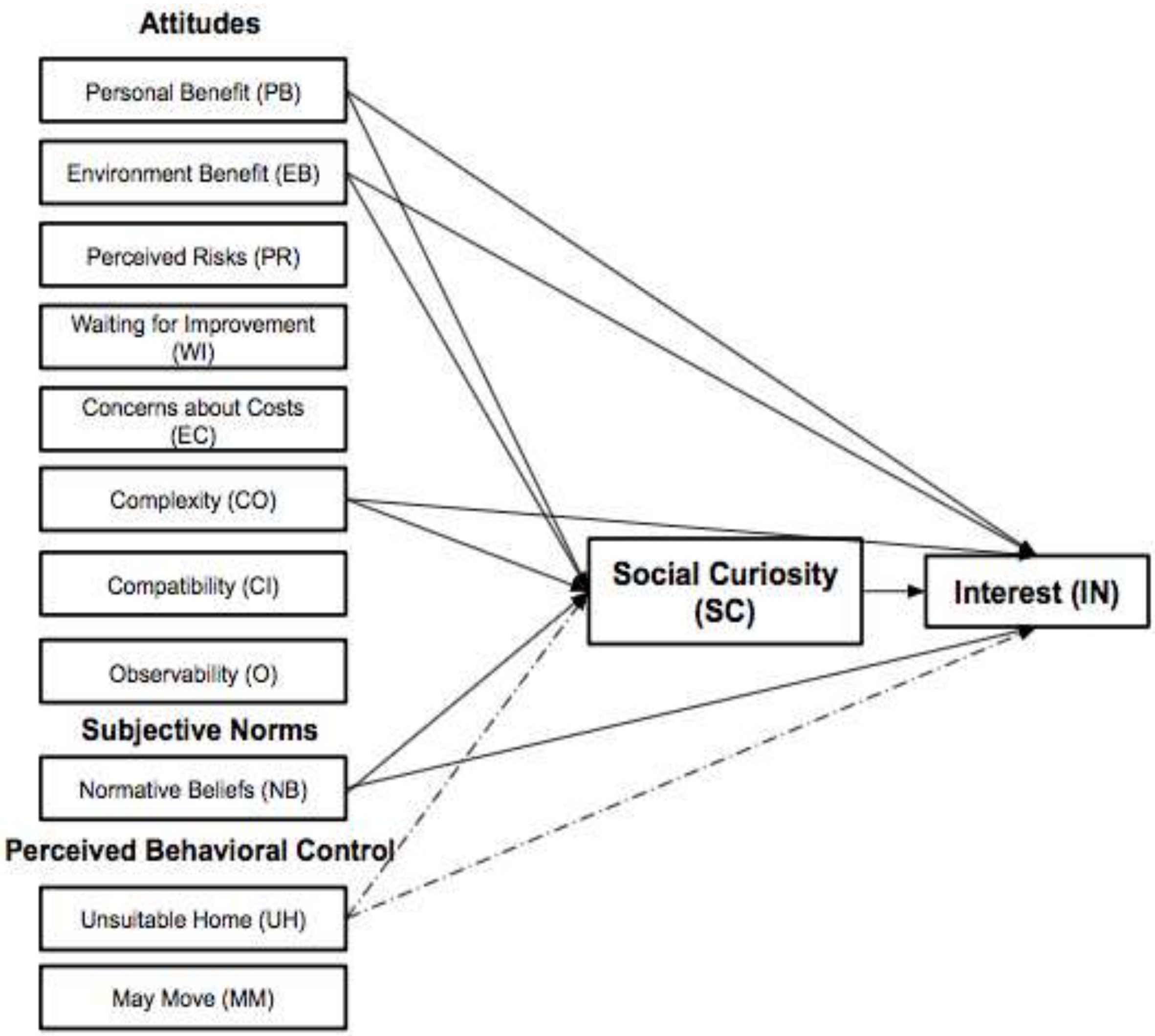

Fig 3. Significant pathways for each construct. See Table 2 for standardized coefficients.

5. Discussions

Congruent with Wolske *et al.* (2017), our study demonstrates that TPB can be useful in explaining what drives and hinders interest in adopting RPV. Each of TPB components (attitude, normative belief and perceived behavioral control) were proven to have significant influence on interest via social curiosity. This study finds positive attitudes such as personal benefits and environmental benefits, along with positive subjective norms positively influence interest in adopting RPV through both direct and indirect path via social curiosity. The result shows that people are more likely to learn about RPV if they believe RPV will be personally beneficial, helpful to the environment and supported by their peers. On the contrary, negative attitudes regarding unsuitability of home (personal behavioral control) negatively influence interest through both direct and indirect path via social curiosity. This finding shows that people will have less interest if they believe that their house is not suitable for RPV installation. All of these findings regarding attitudes, subjective norms and perceived behavioral control are in-line with TPB posits.

The result also shows our additional measures of attitude towards RPV represented in the form of complexity have significant direct and indirect impact on interest. However, which contradicts our hypothesis, complexity has positive influence towards interest. This finding may suggest that people would be interested in confirming whether or not their perception of RPV complexity is true. People would be interested in understanding how RPV works and how difficult is operated and maintained even if they have already perceived RPV difficult to be understood, operated and maintained.

Conclusion

This study tests the Theory of Planned Behavior (TPB) framework to explain consumer interest in residential photovoltaics (RPV). We find that each of TPB components (attitudes, normative beliefs, perceived behavioral control) has significant relationship towards interest, which provides further evidence that TPB can be useful in explaining what drives and hinders interest in adopting RPV. Additional measures of attitude towards RPV in the form of complexity are found to have significant influence towards interest.

The results of our study have several implication for both policymakers and RPV installers seeking to increase RPV adoption. Firstly, considering that perceived environmental benefit has the strongest effect on interest, our study suggests that RPV should be targeted to environmentally-conscious homeowners who feel morally obliged to contribute in reducing environmental impacts and slow down climate change. It would be advisory for RPV installers to emphasize how RPV can meet the homeowners' goals in fighting climate change.

Secondly, as personal benefit also poses a very strong effect on interest, RPV should also be targeted to homeowners seeking to reduce their electricity bills and minimizing impact from future electricity price uncertainty. Recently, the electricity tariff in Indonesia has risen after some period of controlled electricity price. It would be beneficial to capitalize upon this momentum by highlighting the monetary benefits of installing RPV. For policymakers, it would be good to implement financial incentives for installing RPV such as feed-in-tariff system or tax credits so that RPV personal benefits will be increased.

Finally, our study also points out the importance of social networks to promote RPV as curiosity from seeing RPV on other's house and social support are significant predictors of interest. This finding suggests installers to promote RPV through referral programs that is successful in promoting cable TV and internet providers in Indonesia.

Limitations and future research directions

As in most empirical studies, this study poses limitations that warrant acknowledgment. The limitations may lead to suggestions for future research. Our survey only sampled respondents in Jakarta Metro; therefore, the results may not be generalizable to other geographic regions in Indonesia, since level of education and disposable income differences may lead to different results. The results of this study ought to be interpreted with caution for intervention formulation in other regions. We recommend further research to test our framework in other regions of Indonesia to determine whether our results remain consistent in places outside Jakarta Metro.

Furthermore, this research was conducted at the early stage of RPV adoption in Indonesia. Consumer attitudes towards RPV may change as RPV become more widespread in the future. Hence, further research may be conducted during later stage of RPV adoption to test whether or not relationship among variables have changed.

Lastly, due to concerns regarding survey length, this research focuses only factors that influences interest towards RPV based on the TPB framework. We did not analyze the factors that shape consumer attitudes towards RPV that might provide useful information in building favorable consumer attitudes. Further research could enhance our framework and provide more insights for useful interventions by incorporating these factors, forming an integrated model.

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