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Predicting Residential Photovoltaic Adoption Intention of Potential Prosumers in Thailand: A Theory of Planned Behavior Model

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Abstract: The current study investigates economic expectations and socio-psychological factors influencing individuals' residential photovoltaic (RPV) adoption intentions in Thailand. The theory of planned behavior (TPB) and the diffusion of innovation theory provide a framework for our predictor selection. We obtained the data from a nationwide survey on electricity prosumer infrastructure. RPV non-users (N = 760) were asked to rate their RPV knowledge, attitudes, perceived behavioral controls (PBCs), norms, and innovativeness. They then read scenarios describing the current RPV installation cost and payback rate. They rated their adoption intention and specified their intended system capacity, affordable installation cost, and desirable payback period. The gaps between the actual and desired installation costs and the internal rate of return were calculated. These economic expectation gaps, attitudes based on financial benefits, PBC based on perceived financial barriers, social norms, and innovativeness significantly predicted the adoption intention. On the other hand, perceived knowledge, attitudes based on environmental and image benefits, and PBC based on anticipated troubles and inconveniences failed to predict intention. The implications of the TPB model for RPV adoption were discussed.

Keywords: residential solar photovoltaics; RPV adoption; prosumer; renewable energy; theory of planned behavior; TPB; intention; diffusion of innovations; innovativeness; Thailand

Citation: Huansuriya, T.; Ariyabuddhiphongs, K. Predicting Residential Photovoltaic Adoption Intention of Potential Prosumers in Thailand: A Theory of Planned Behavior Model. *Energies* **2023**, *16*, 6337. https://doi.org/10.3390/en16176337

Academic Editors: Kittisak Jermsittiparsert and Thanaporn Sriyakul

Received: 30 July 2023
Revised: 28 August 2023
Accepted: 29 August 2023
Published: 31 August 2023

1. Introduction

The electricity industry in Thailand is shifting towards energy sustainability. According to the country's Power Development Plan [1], Thailand aims to reduce its reliance on non-renewable energy (i.e., coal and lignite, natural gas, diesel, and fuel oil) and decrease carbon emissions per kWh of electricity generated from 0.437 $kgCO_2$/kWh by 2017 down to 0.283 $kgCO_2$/kWh by 2037. The electricity generated from renewable energy is projected to reach 18,176 MWh, accounting for 23.6 percent of the total generating capacity. Solar photovoltaic (PV) is expected to take a significant share in this category (10,000 MWh). The plan also indicated that ten percent of this capacity (1000 MWh) should come from residential PV (RPV) prosumers—consumers who also produce electricity with a PV system for their own use or sell it back to the grid or other users. Specifically, the government expects more RPV prosumers to contribute an additional 100 MWh to the grid each year over the next ten years. As such, RPV prosumers' total installed generating capacity will reach the 1000 MWh goal by 2028.

However, the People's Solar Power Campaign, rolled out in 2019, with a target feed-in electricity of 100 MWh in the first year, failed drastically. Households participating in this campaign contributed only approximately 3 MWh of installed generating capacity [2]. The trend was similarly disappointing in 2020 [3]. According to most analysts, the main reason for low participation in the program was the low feed-in tariff (1.68 Baht or ~$0.05 per unit), rendering the payback period too long for the investment to be attractive [2,3].

It should be noted, however, that economic factors such as feed-in tariffs, electricity prices, PV system cost per watt, payback period, and internal rate of return are relatively constant for every household under the same policy and market conditions. However, some households joined the program and became prosumers, while most did not. How the information about these economic factors is presented to and understood by each person may vary [4]. The persons' knowledge about PV systems and their household situational constraints might also differ, creating differences in perceived barriers and perceived economic values of RPV adoption. Moreover, other behavioral and socio-psychological factors might influence the decision to become RPV prosumers.

Existing RPV adoption studies in Thailand primarily focused on the influences of economic factors such as payback periods, installation costs, and feed-in tariffs [5–8]. Therefore, this study aims to contribute to understanding RPV adoption decisions by examining the influences of knowledge, expectations, perceptions, and other socio-psychological factors that support or hinder households' intention to adopt RPV. Such an understanding would provide a broader model to understand and predict RPV adoption.

The following section reviews previous research on drivers and barriers to RPV adoption. We also describe the theory of planned behaviors and the diffusion of innovation theory as the framework to identify behavioral and socio-psychological drivers and barriers in this study. Section 2 describes the dataset we used in the current study. Section 3 reports a hierarchical linear regression analysis that examined the predictive power of four sets of predictors. Finally, Section 4 discusses the potential implications and applications of the findings.

Previous research identified various drivers and barriers to RPV adoption, ranging from underlying national conditions, energy policy, and technological advances to economic, socio-psychological, and behavioral factors [9–13]. Some macro-level factors, such as the underlying national conditions, technology, management, and policy, are constants for every household. They are also relatively far removed from the potential RPV prosumer decision-making process. These factors may influence a household's intention to become an RPV prosumer only after being translated into more proximal economic matrices that interact with behavioral and socio-psychological factors [14]. Therefore, the current study focused on these latter types of factors.

1.1. Economic Expectations

RPV adoption's economic factors include, for example, the system installation cost, retail electricity prices, feed-in tariff rate, and payback period. These factors may boil down to two major factors in laypeople's decision-making process: (1) the cost they need to pay up-front and (2) the financial return they would reap over time. Previous research demonstrated the influence of these economic factors on RPV adoption. For example, the system cost was negatively associated with RPV growth [11,15–17]. The feed-in tariffs and other government financial support brought down the payback period, improved the internal rate of return (IRR), and predicted RPV adoption [11,17,18].

However, these economic factors are generally constant for everyone under the same policy and market conditions. They may be necessary but insufficient to explain an individual household's decision to adopt RPV. For example, Jager [19] reported that the Dutch government announced in 2002 that it would cover 90% of the RPV system's cost. This policy cut the payback period to three years; however, only 0.5 percent of Dutch homeowners participated in the program. This example suggests that information about economic drivers may not be presented and delivered to every household equally well [4] or may be subject to different interpretations and evaluations by those with different expectations and constraints.

Therefore, the gap between these economic matrices and each household's constraints or expectations should be considered to better predict households' RPV adoption intentions. Specifically, the gap between the maximum price per watt (PPW) that a household can and is willing to pay and the current PPW of the PV system at the time the data were collected (Max PPW − Current PPW = Gap PPW) tells us whether that household can afford a PV system at the current price point. On the other hand, the gap between the current IRR of the PV system and a household's expected IRR (Current IRR − Expected IRR = Gap IRR) indicates whether the current financial return is attractive to that household. We thus hypothesized that:

Hypothesis 1: *Heads of households with a positive or less negative Gap PPW and Gap IRR would report a greater RPV adoption intention.*

1.2. Perceived Knowledge

Knowledge is another factor influencing RPV prosumer growth [10]. Studies showed that a lack of knowledge and information about PV technology, maintenance, and trustworthy installers was a barrier to RPV adoption. Such problems surfaced in high-income countries [11,15,20] and low-income countries, especially in rural communities [16,21]. Inadequate knowledge and information could hinder homeowners' and contractors' involvement in planning and installing a building-integrated PV system [22]. Moreover, without an adequate understanding of the RPV system, adopters in China experienced difficulties in system maintenance, resulting in negative word-of-mouth, discouraging other potential consumers who also lack knowledge from adopting the RPV system [23]. Therefore, to the extent that the potential prosumers think they have adequate and accurate information, they should have a lower perceived risk and uncertainty associated with the PV system installation, which could foster a positive inclination towards adoption. Specifically, the current study hypothesized that:

Hypothesis 2: *Heads of households with higher perceived knowledge about the RPV system would report greater RPV adoption intentions. The perceived knowledge about RPV would explain additional variance in the RPV adoption intention above and beyond economic expectations (Gap PPW and Gap IRR).*

1.3. Behavioral and Socio-Psychological Factors

In addition to perceived knowledge and economic expectations, RPV adoption is also influenced by behavioral and socio-psychological factors. Such factors have been used to study various sustainability-related behaviors (e.g., preferences for hybrid vehicles [24,25], participation in renewable energy communities [26], and acceptance of home energy management services [27]), providing steps to an integrated framework for studying RPV adoption [13,28]. This section reviews two theories and previous research that would serve as a framework for identifying and understanding the influence of these factors on RPV adoption.

1.3.1. Theory of Planned Behavior

The theory of planned behavior (TPB) [29] assumes that humans are rational beings. We deliberately choose to engage in behavior based on our intention. An intention is determined by many factors that can be subsumed under three broad categories—attitudes toward the target behavior—norms regarding the target behavior—and perceived behavioral controls (PBC). Attitudes are formed upon assessing the likelihood that the target behavior will bring desirable or undesirable outcomes. Norms are the perceived approval of others (subjective norms) as well as the awareness of how most people behave (descriptive norms) [30]. PBCs are perceptions of the presence and strength of factors that could hinder or facilitate the target behavior (See Figure 1).

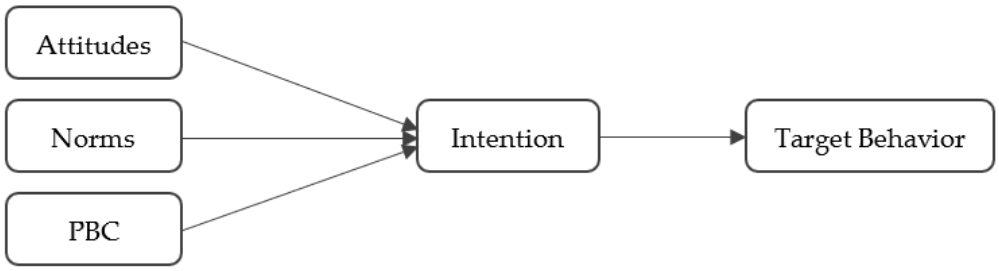

Figure 1. Schematic model of the theory of planned behavior.

Research showed that these TPB constructs significantly predicted intention and actual RPV adoption [13,31–34]. However, the beliefs and perceptions that formed attitudes, norms, and PBCs vary from one study to another. Attitudes towards RPV adoption were based on different perceived benefits of RPV. Most studies focused on perceived financial benefits such as saving on electricity bills and extra income from feed-in tariffs [11,12,32]. Some studies, especially those from relatively high-income countries, discussed environmental benefits as the basis for attitudes toward RPV adoption [13,15,32,35–37]. The autarky benefit—the ability to control one's own energy production and be independent of the grid—was mentioned primarily in research on PV adoption in European countries [32,35]. Some studies also identified symbolic or social status benefits as motivators [38,39].

How norms were operationally defined also varied among studies. Most studies found that subjective norms significantly predicted intention and actual adoption [13,32]. Some studies also used descriptive norms [31], and some found descriptive norms to be a stronger predictor than subjective norms [33]. In addition to the types of norms, the sources of these social influences also varied. Palm [40] reported that the influence of close friends was more substantial than that of neighbors.

Finally, the most frequently discussed PBC in previous research were financial barriers. The slow adoption rate was associated with homeowners' perceptions that the investment and maintenance costs were too high and that the payback period was too long [11,12,14,15,17,18,22,33]. Other barriers to RPV adoption, such as the perceived inconvenience of obtaining, installing, and maintaining the RPV system, the challenge of finding trusted information and installers, and homeowners' trust in the PV technology, were also identified in different studies [11–13].

Therefore, the present study used the TPB framework to identify socio-psychological factors relevant to households' intention to become RPV prosumers. These variables were expected to predict the strength of households' intentions to adopt RPV. Specifically, we hypothesized that:

Hypothesis 3: *Heads of households with more positive attitudes, more supportive norms, and less prohibitive PBCs would report a greater RPV adoption intention. These TPB constructs would explain additional variance in the RPV adoption intention above and beyond economic expectations (Gap PPW and Gap IRR) and perceived knowledge.*

1.3.2. Diffusion of Innovation and Consumer Innovativeness

Research showed that homeowners' dispositional interest in technology and innovation also influences their decision to become RPV prosumers [37,41]. According to the diffusion of innovation theory [42], consumer innovativeness determines how soon they will adopt an innovation (See Figure 2). The *innovators* are approximately 2.5% of the population who are highly enthusiastic about new ideas. They usually venture out of their local communities to seek innovative ideas, products, or technologies. They tend to have substantial financial resources, so they are less price-sensitive, willing to take risks, and may adopt an innovation even before it proves successful.

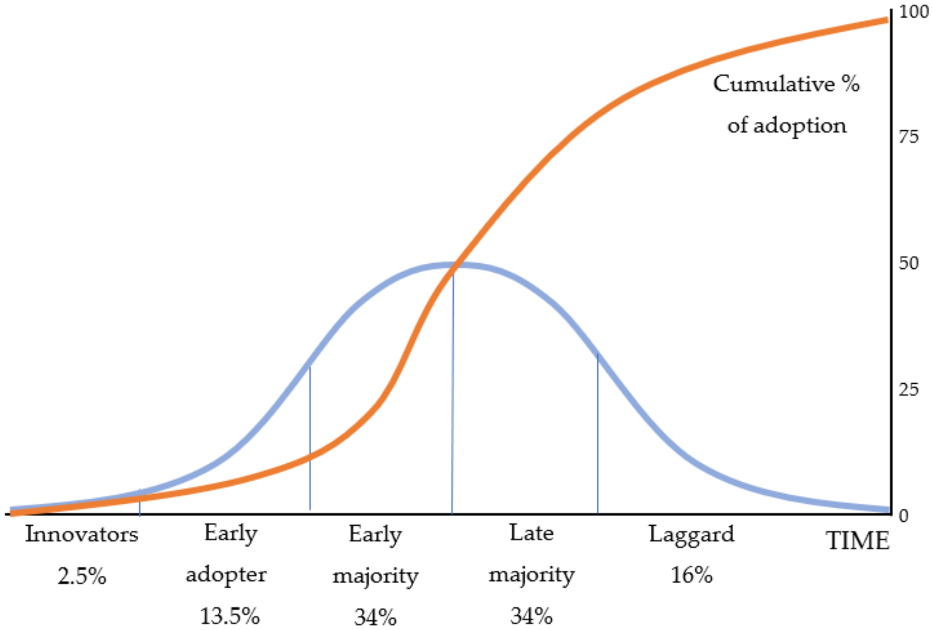

Figure 2. Categories and distribution of innovation adopters according to the diffusion of innovation theory. The blue line represents an approximate distribution of each innovation adopter category. The orange line represents an approximate cumulative distribution of adoption over time.

The *early adopters* are the next group of approximately 13.5%, who also adopt new products very early on. They usually assume the role of opinion leaders who disseminate information and advice regarding the innovations they have adopted to others in their social circles.

The next roughly 34% of the population to adopt an innovation are the *early majority*. They usually wait to learn about the effectiveness of new products or technologies before deciding to adopt them. This group is critical for the successful diffusion of innovation as they bridge the gap between early adopters and the other half of the population.

The *late majority* are the next roughly 34% of the population, who are usually skeptical about new ideas or products. They would adopt an innovation out of necessity and only after it proved successful with most people.

Finally, the *laggards* are the last 16% of the population to adopt innovations. They usually have low financial resources and are thus conservative decision-makers. They are also skeptical about the innovations and the opinion leaders who try to convince them.

The concept of consumer innovativeness based on the diffusion of innovation theory has been used to study the adoption of many technologies, including RPV. For example, Schelly [41] found that RPV early adopters in Wisconsin share an interest in the energy system's technical innovation, which they identified as motivating factors for adoption. Faiers and Neame [36] compared the early adopters to the potential "early majority" adopters of RPV and found that the early majority needed more convincing that RPV was visually attractive, affordable, easy to install, and maintenance-free. For later adopters, seeing or talking to others who adopted a PV system in their neighborhood increased the likelihood of considering an RPV adoption [20,43]. Moreover, Ramirez and Goldsmith [44] argued that consumers with high innovativeness are generally willing to pay more for innovative products (e.g., clothing [45], organic food [46], online shopping [47], and smart toys [48]). Early RPV adopters who became opinion leaders were also willing to pay more for an RVP system than regular respondents [49]. Therefore, we proposed self-identified innovativeness as another predictor of intention to become an RPV prosumer. Specifically, we hypothesized that:

Hypothesis 4: *Heads of households who identified themselves as being more innovative would report a greater RPV adoption intention. The innovativeness level of the household decision maker would explain additional variance in the RPV adoption intention above and beyond economic expectations (Gap PPW and Gap IRR), perceived knowledge, and TPB constructs.*

Figure 3 summarizes the conceptual model of this study and the four hypotheses described above. We planned to test the four proposed hypotheses using least-squares hierarchical regression analysis. In Step 1, we would regress RPV adoption intention on two economic expectations, i.e., Gap PPW and Gap IRR. Perceived knowledge would be added as another predictor in Step 2. In Step 3, TPB constructs, i.e., attitudes, perceived behavioral controls, and norms, would be added to the predictive model. Finally, innovativeness would be added as the last predictor in Step 4. The overall squared multiple correlation (R^2) of each model, as well as the change in R^2 at each step (ΔR^2), will be calculated to examine whether the predictors added in each step help explain extra variance in RPV adoption intention above and beyond the predictors already in the model in the previous step.

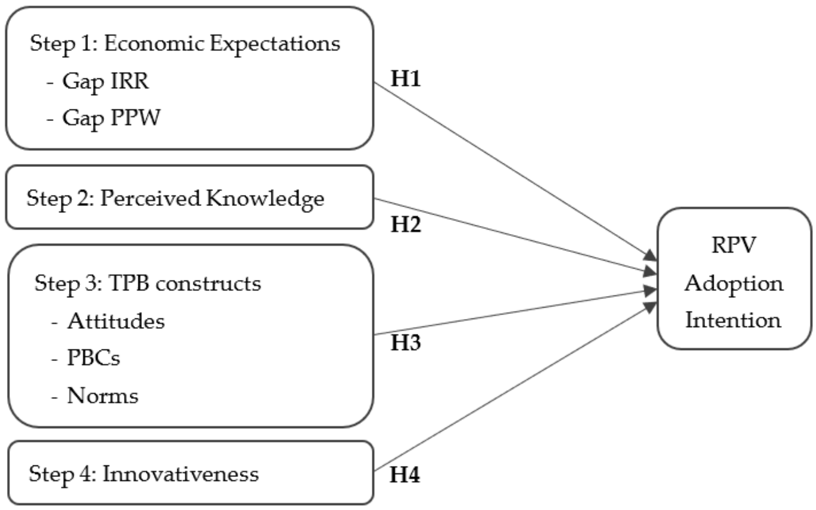

Figure 3. The proposed hierarchical regression model predicts the RPV adoption intentions of household decision-makers.

2. Materials and Methods

2.1. Participants

Participants were 760 Thai heads of household (or household decision-makers) who had not installed a PV system. We retrieved a dataset from one section of a more extensive study on Thailand's electricity supply infrastructure enhancement to support prosumer penetration, commissioned by the Energy Policy and Planning Office (EPPO) in 2019 [50]. EPPOs original study utilized stratified quota sampling to reflect the proportion of electricity consumer groups within Thai regions. First, sample sizes were set for the five service regions of Thailand: Metropolitan, North, South, Central, and Northeastern. The metropolitan area contributed about half of the total sample, as the original study focused on drawing inferences regarding metropolitan consumers versus the four provincial regions.

The consumers in each service region were further sorted into five categories: (a) small- and (b) medium-sized households; and (c) small-, (d) medium-, and (e) large-sized businesses. The sample size of each category was stratified according to the proportion of consumer groups in each regional population.

Nine counties in the metropolitan area and two cities in each of the four provincial regions were randomly selected as data collection sites. The data collection commenced in January 2019 and continued until all the quotas were filled in April 2019. The small- and medium-sized households comprised 87% of the total sample. We selected only the households that had yet to install a PV system. After removing responses with missing data and outliers, the remaining 760 samples were used for the present analysis. The demographic information of the participants is shown in Table 1.

Table 1. Demographic information of participants (*N* = 760).

	n	%
Gender		
Female	464	61.05
Male	288	37.89
Unspecified	6	0.79
Missing	2	0.26
Electricity User Tier		
Below 150 unit/month	203	26.71
Above 150 unit/month	557	73.29
Region		
Bangkok and metropolitan area	379	49.87
Central	89	11.71
South	96	12.63
North	97	12.76
Northeastern	99	13.03
Self-identified Innovativeness		
1 Innovators	50	6.58
2 Early adopters	92	12.11
3 Early Majority	299	39.34
4 Late Majority	184	24.21
5 Laggards	135	17.76

2.2. Materials

The questionnaire used in the EPPOs study was developed under the framework of the theory of planned behavior, the diffusion of innovation theory, and the themes that emerged from the interview with 12 Thai PV adopters in the EPPO preliminary study.

Demographic information. Participants reported their gender and age and verified that they are decision-makers in a small- (load $\leq$ 150 MWh/month) or medium-sized (load > 150 MWh/month) household. Because the EPPOs study was interested in the sample's decision to adopt a PV system, only individuals who could make an adoption decision were eligible for this study.

Perceived knowledge. Ten items were used to measure perceived knowledge about RPV prosumer. Participants rated how much they knew or understood the information listed in each item on a scale of 0 (*not at all*) to 4 (*complete knowledge or understanding*). The scale's reliability, measured by Cronbach's α was 0.96, indicating satisfactory internal consistency among the scale's items. Cronbach's α values above 0.70 are generally acceptable [51]. See Table 2 for the full list of items.

TPB constructs. According to the EPPO study report, the questionnaires were originally designed to fit the definition of the three TPB constructs, i.e., attitudes, PBCs, and norms. The details of each construct's measures are as follows (See Table 3).

Attitudes. Eight items measuring attitudes towards becoming an RPV prosumer were derived from the literature and the interview with 12 PV adopters in the EPPOs preliminary study. Participants rated each item from 0 (*strongly disagree*) to 4 (*strongly agree*). We conducted an Exploratory factor analysis (EFA) with principal component extraction and direct oblimin rotation with Kaiser Normalization on IBM SPSS Statistics (Version 29.0). A three-factor solution was enforced following the EPPO study's conception of the attitudinal aspects of RPV. The results revealed aspects of attitude towards PV adoption, namely, perceived financial benefits (four items, Cronbach's α = 0.80), perceived environmental benefits (three items, Cronbach's α = 0.87), and perceived image benefits (one item). The first two subscales demonstrated satisfactory reliability. However, for the last aspect, Cronbach's α cannot be calculated for a single item. See Table 3 for the full list of attitude items and their factor loadings.

PBCs. Seven items were used to measure the perceived behavioral control or barriers to becoming an RPV prosumer. Participants rated each item from 0 (*strongly disagree*) to 4 (*strongly agree*). The same EFA procedure with a three-factor solution revealed that the seven items clustered into troubles (two items, Cronbach's α = 0.72), cost (two items, Cronbach's α = 0.77), and inconvenience (three items, Cronbach's α = 0.77). All three subscales demonstrated acceptable reliability. See Table 3 for the full list of the PBC items and their factor loadings.

Norms. Participants reported (1) whether any of their relatives, friends, or other significant persons adopted a PV system; (2) whether their close relatives or friends recommended that they adopt a PV system; and (3) whether any of their neighbors adopted a PV system. Participants were given one point for a positive response to each question. The norm score was calculated by summing up these three items. Thus, the value represents a combination of subjective and descriptive norms. The possible values ranged from 0 (no supporting norms) to 3 (high supporting norms).

Innovativeness. Participants chose a description from five categories of innovation adopters that best described themselves, namely, (1) innovators, (2) early adopters, (3) early majority, (4) late majority, and (5) laggards [42]. The innovativeness variable is then treated as a continuous variable in the analysis, i.e., the lower score indicated that participants identified themselves as highly acceptable to the adoption of new technology, whereas the higher value indicated that participants identified themselves as less likely to adopt new technology. See Table 4 for the full description of each category.

RPV investment and payback scenarios. Since the RPV non-users generally have very limited knowledge about the RPV system, we provided them with the necessary information on the financial cost and return of the investment before asking them to report their intention to become an RPV prosumer. After participants completed the perceived knowledge, attitudes, norms, PBCs, and innovativeness scales, they read scenarios that laid out the current (at the time of the EPPOs study, i.e., 2019) financial cost and return of a PV system investment at different installed generating capacities (3 kW, 5 kW, 10 kW, and 20 kW). The installation cost was based on the average RPV system installation price of 30 Baht per Watt (~$1/Watt) at the time of the study. For example, if participants choose the installed generating capacity of 10 kWh, they would pay 300,000 Baht (~$10,000) for the RPV system. The payback period was estimated to be around 8–9 years.

Table 2. Items measuring perceived knowledge.

Perceived Knowledge (Cronbach's α = 0.96)	Items
0 = *Not at all* 1 = *Limited* 2 = *Moderate* 3 = *Advanced* 4 = *Complete knowledge or understanding*	How much do you know or understand the following information? 1. Equipment in the PV system and the length of its operable lifetime. 2. Procedure and documents required for a permit application. 3. System size that is appropriate for your household or business 4. Initial installation cost for a system of the size that is appropriate for your household or business 5. Factors effecting the amount of actual electricity production 6. Payback period and factors effecting its length 7. Maintenance procedure to run the system efficiently 8. System and steps of selling electricity back to the grid or other users. 9. Policies and supports from the government 10. Impact to the grid by the production and sales of electricity produced by prosumers.

Table 3. Items measuring TPB constructs.

TPB Constructs and Response Options	Dimensions and Items	EFA Factor Loadings
Attitudes 0 = *strongly disagree* 1 = *disagree* 2 = *neutral* 3 = *agree* 4 = *strongly agree*	To me, RPV …Perceived Financial benefits (Cronbach's α = 0.80)	
	• generates a satisfactory income.	0.936
	• saves a satisfactory amount of electricity bill.	0.589
	• is a profitable long-term investment.	0.624
	• is a low-risk investment.	0.589
	Perceived Environmental benefits (Cronbach's α = 0.87)	
	• reduces the overall fossil fuel use for electricity generation.	0.845
	• helps conserve the environment.	0.916
	• demonstrates your care for the environment.	0.804
	Perceived Image benefit	
	• makes me look modern and innovative.	−0.727
PBCs 0 = *strongly disagree* 1 = *disagree* 2 = *neutral* 3 = *agree* 4 = *strongly agree*	Perceived Troubles (Cronbach's α = 0.72)	
	• There may be some danger during the installation and usage.	0.941
	• The maintenance is difficult or troublesome.	0.757
	Perceived Cost (Cronbach's α = 0.77)	
	• The initial investment of a PV system is too expensive for me.	−0.888
	• The payback period is too long for me.	−0.851
	Perceived Inconvenience (Cronbach's α = 0.77)	
	• It is hard to find a reliable installation service.	0.752
	• Information regarding the installation is not readily available and difficult to understand.	0.899
	• The process of an installation permit request is troublesome.	0.824
Social Norms 0 = *no* 1 = *yes*	Social norms	
	• Do any of your friends or relatives adopt a solar PV system?	- *
	• Do households in your neighborhood adopt a solar PV system?	- *
	• Did any of your friends or relatives recommend adopting a solar PV system?	- *

* Social norms measurement was not subjected to EFA.

Table 4. Innovativeness categories.

Categories	Descriptions
1 = innovators	Actively follow news on technological advances and are usually among the first to adopt the most cutting-edge technology.
2 = early adopters	Are among the first group to adopt a new technology when it becomes available on the market.
3 = early majority	Adopt a new technology when a growing number of people are using it
4 = late majority	Adopt a new technology only when it is proven effective by most people.
5 = laggards	Are not interested in new technology. Prefer old and familiar technology.

The financial return in the scenarios depended on three parameters. The first parameter was the estimated amount of electricity produced each month. This value was conservatively calculated at 80% of the installed generating capacity at the maximum insolation, which was estimated to last 3.6 h a day. The second parameter was the savings on electricity bills from on-site usage at the current retail electricity price (approximately 4 Baht or $0.13 per unit in 2019). Third, the feed-in tariff was projected by the Ministry of Energy at a fixed rate of 2.40 Baht (~$0.08) per unit, which was equal to the wholesale electricity price at the time of data collection [52].

At each installed generating capacity, three payback scenarios were calculated to give participants general ideas of the monthly and yearly financial return if they were to install a PV system. Specifically, the payback was calculated in cases where the electricity generated was (1) 100% used on-site, (2) 100% sold back to the grid, and (3) 50% used on-site and 50% sold back to the grid. Because the feed-in tariff was lower than the retail electricity price, the higher the on-site consumption, the higher the return. Participants also read that the PV system generates electricity during the day when most residents are not home. Hence, most PV adopters had to sell back to the grid to a certain extent. For example, a 10 kWh system was estimated to produce 864 monthly electricity units. According to the third payback scenario, in which there was an equal split between on-site use and feed-in tariff, the overall financial return would be 2851 Baht per month or 34,212 Baht per year (~$1140 per year).

RPV adoption intention. After reading the scenarios, participants indicated their intention to install a PV system and become an RPV prosumer on a scale of 0 (*definitely not*) to 4 (*definitely going to*).

Gap PPW. Participants also hypothetically indicated their preferred generating capacity and the maximum price they could and were willing to pay if they adopted a PV system. We took the maximum amount they would pay (in Baht). We divided it by the chosen generating capacity (in watts) to calculate the maximum acceptable price per watt (max PPW). The Max PPW was then subtracted by 30 Baht (i.e., the current PPW in 2019), yielding the gap between the maximum acceptable price and the current price (Gap PPW). We expected participants whose Max PPW was higher than or not lower than the current price per Watt would report a higher adoption intention. The linear transformation from Max PPW to Gap PPW did not change the nature of the relationship between the predictor and the outcome. However, we did so to aid in the interpretation of the variable.

Gap IRR. We derived the participants' expected IRR from their preferred payback period and installation cost. To calculate the IRR, we first established each respondent's expected yearly income generated by the PV system. We calculated this yearly expected cash flow by taking the maximum installation price they were willing to pay and dividing it by their preferred payback period. That is, the amount of annual income generated by the PV system is implied by the chosen payback period and the installation cost. Second, the expected amount of cash flow was projected to be constant over 25 years (i.e., the expected lifetime of a PV system). The IRR over the lifetime of the system was calculated. We then subtracted the expected IRR from the current average IRR in the market (i.e., 8.1% in 2019), resulting in a Gap IRR. A positive or less negative gap in IRR should boost adoption intentions.

3. Results

A correlation matrix and descriptive statistics of the predictors and the outcome variable are shown in Table 5. On average, household intention to adopt an RPV was moderate ($M = 1.85$, $SD = 1.04$). The Gap PPW ($M = -10.92$, $SD = 12.84$) and Gap IRR ($M = -21.45$, $SD = 25.72$) were both negative, suggesting that most households could not afford the RPV system at the market price and that the rate of return was much lower than their expectations. The mean perceived knowledge was close to zero ($M = 0.81$, $SD = 0.92$), indicating that most respondents knew very little about the RPV system and the prosumer concept. The intention to adopt an RPV had the strongest correlations with innovativeness ($r = -0.30$, $p < 0.01$), attitudes based on perceived financial benefits ($r = -0.28$, $p < 0.01$), and Gap PPW ($r = -0.24$, $p < 0.01$).

Table 5. Descriptive statistics and correlation coefficients among predictor and outcome variables ($N = 760$).

Variable	M	SD	1	2	3	4	5	6	7	8	9	10	11
1. RPV Adoption Intention	1.85	1.04											
2. Gap IRR	−21.45	25.72	0.17 **										
3. Gap PPW	−10.92	12.84	0.24 **	0.24 **									
4. Perceived Knowledge	0.81	0.92	0.06	0.02	0.11 **								
5. Perceived Financial Benefits	2.51	0.85	0.28 **	0.11 **	0.12 **	0.16 **							
6. Perceived Environmental Benefits	3.10	0.90	0.19 **	0.13 **	0.08 *	0.08 *	0.66 **						
7. Perceived Image Benefit	2.66	1.11	0.12 **	0.06	0.05	0.14 **	0.41 **	0.51 **					
8. Perceived Troubles	1.90	0.98	−0.04	−0.07	−0.06	0.11 **	0.04	0.08 *	0.16 **				
9. Perceived Cost	2.45	0.98	−0.11 **	−0.04	−0.09 *	0.11 **	0.21 **	0.25 **	0.23 **	0.39 **			
10. Perceived Inconvenience	2.49	1.13	−0.00	−0.06	−0.08 *	−0.00	0.24 **	0.27 **	0.22 **	0.35 **	0.49 **		
11. Social Norm	0.29	0.64	0.19 **	0.09 *	0.14 **	0.16 **	0.16 **	0.18 **	0.05	−0.14 **	−0.02	−0.01	
12. Innovative-ness	3.34	1.10	−0.30 **	−0.05	−0.18 **	−0.19 **	−0.18 **	−0.09 *	−0.06	0.00	−0.01	−0.00	−0.17 **

* $p < 0.05$. ** $p < 0.01$.

We explored four hierarchical regression models predicting RPV adoption intention to test the unique contribution of economic expectations, perceived knowledge, TPB variables, and innovativeness. None of the predictors in the model had a variance inflation factor (VIF) above 2.5, suggesting that the strength of the correlations among predictors is not too high, and thus the multicollinearity assumption was not violated. Table 6 shows the results of the hierarchical regression analysis.

First, we tested how much economic expectations influenced adoption intentions. The first model with Gap IRR and Gap PPW as predictors significantly explained the variance in RPV adoption intention ($R^2 = 0.07$, $p < 0.01$). Both economic expectations were positively related to intention (β = 0.12 and β = 0.21, respectively), supporting Hypothesis 1. The model in this step could be described as follows:

$$\text{RPV adoption} = b_0 + b_1 \text{ Gap IRR} + b_2 \text{ Gap PPW} + e_1, \tag{1}$$

where b_0 is the model intercept, b_k is the regression coefficient for each predictor, and e_i is the error term associated with each model.

Second, we hypothesized that respondents knowledgeable about an RPV would be more likely to adopt the system. Inconsistent with Hypothesis 2, the perceived knowledge added in Model 2 did not significantly explain additional variance in intention ($R^2 = 0.071$, $\Delta R^2 = 0.001$, $p = 0.323$). The model was as follows:

$$\text{RPV adoption} = b_0 + b_1 \text{ Gap IRR} + b_2 \text{ Gap PPW} + b_3 \text{ Perceived Knowledge} + e_2. \tag{2}$$

In Model 3, seven TPB socio-psychological variables suggested by the theory, research, and interviews with adopters were added as predictors. The TPB constructs explain the variance in intention above and beyond Model 2, $R^2 = 0.166$, $\Delta R^2 = 0.095$, $p < 0.01$. Therefore, Hypothesis 3 was supported. Among the TPB predictors, attitude based on financial benefits (β = 0.24), PBC based on cost (β = −0.18), and social norm (β = 0.12) were significantly related to adoption intention. The third model was as follows:

$$\begin{aligned} \text{RPV adoption} = \; & b_0 + b_1 \text{ Gap IRR} + b_2 \text{ Gap PPW} + b_3 \text{ Perceived Knowledge} + \\ & b_4 \text{ Financial Attitude} + b_5 \text{ Environmental Attitude} + \\ & b_6 \text{ Image Attitude} + b_7 \text{ Perceived Troubles} + \\ & b_8 \text{ Perceived Cost} + b_9 \text{ Perceived Inconvenience} + \\ & b_{10} \text{ Social Norm} + e_3. \end{aligned} \tag{3}$$

Finally, we explored the notion that the innovators and early adopters were more likely to adopt an RPV system than the laggards. Model 4 treated self-identified innovativeness as another linear predictor. It significantly explained an additional variance in intention to become an RPV prosumer (β = −0.22, R^2 = 0.21, ΔR^2 = 0.048, $p < 0.01$), suggesting that earlier innovation adopters were more inclined to become an RPV prosumer. The fourth model was described as follows:

$$\begin{aligned}\text{RPV adoption} = \; & b_0 + b_1 \text{ Gap IRR} + b_2 \text{ Gap PPW} + b_3 \text{ Perceived Knowledge} + \\ & b_4 \text{ Financial Attitude} + b_5 \text{ Environmental Attitude} + \\ & b_6 \text{ Image Attitude} + b_7 \text{ Perceived Troubles} + \\ & b_8 \text{ Perceived Cost} + b_9 \text{ Perceived Inconvenience} + \\ & b_{10} \text{ Social Norm} + b_{11} \text{ Innovativeness } + e_4.\end{aligned} \tag{4}$$

Table 6. Hierarchical regression models predicting RPV adoption intention (*N* = 760).

Variable	***b***	**95% CI for *b***		**β**	**95% CI for β**		***R*²**	**Δ*R*²**
		LL	***UL***		***LL***	***UL***		
Step 1							0.07	
(Intercept)	2.14 **	2.04	2.24					
Gap IRR	0.005 **	0.002	0.008	0.12	0.05	0.19		
Gap PPW	0.02 **	0.01	0.02	0.21	0.14	0.28		
Step 2							0.071	0.001
(Intercept)	2.11 **	1.98	2.23					
Gap IRR	0.005 **	0.002	0.008	0.12	0.05	0.19		
Gap PPW	0.02 **	0.01	0.02	0.21	0.13	0.28		
Perceived Knowledge	0.04	−0.04	0.11	0.03	−0.04	0.1		
Step 3							0.166	0.095 **
(Intercept)	1.50 **	1.2	1.81					
Gap IRR	0.003 *	0.001	0.006	0.09	0.02	0.15		
Gap PPW	0.01 **	0.01	0.02	0.16	0.09	0.23		
Perceived Knowledge	−0.01	−0.09	0.07	−0.01	−0.08	0.06		
Financial Attitude	0.30 **	0.19	0.41	0.24	0.15	0.33		
Environmental Attitude	0.005	−0.11	0.11	0.004	−0.09	0.1		
Image Attitude	0.03	−0.04	0.11	0.03	−0.04	0.11		
Perceived Troubles	0.04	−0.04	0.12	0.04	−0.03	0.11		
Perceived Cost	−0.19 **	−0.27	−0.11	−0.18	−0.26	−0.10		
Perceived Inconvenience	0.02	−0.05	0.09	0.02	−0.06	0.1		
Social Norm	0.20 **	0.09	0.32	0.12	0.06	0.19		
Step 4							0.214	0.048 **
(Intercept)	2.30 **	1.92	2.68					
Gap IRR	0.004 *	0.001	0.006	0.09	0.02	0.15		
Gap PPW	0.01 **	0.005	0.02	0.13	0.06	0.19		
Perceived Knowledge	−0.05	−0.12	0.03	−0.04	−0.11	0.03		
Financial Attitude	0.25 **	0.15	0.36	0.21	0.12	0.29		
Environmental Attitude	0.02	−0.09	0.12	0.01	−0.08	0.11		
Image Attitude	0.04	−0.03	0.11	0.04	−0.04	0.12		
Perceived Troubles	0.04	−0.04	0.12	0.04	−0.04	0.11		
Perceived Cost	−0.19 **	−0.27	−0.10	−0.18	−0.25	−0.10		
Perceived Inconvenience	0.02	−0.05	0.09	0.02	−0.05	0.1		
Social Norm	0.16 **	0.05	0.27	0.1	0.03	0.17		
Innovativeness	−0.22 **	−0.28	−0.15	−0.23	−0.30	−0.16		

Note. *b* = unstandardized regression weights. β = standardized regression weights. *LL* and *UL* = the lower and upper limits of a confidence interval, respectively. * $p < 0.05$. ** $p < 0.01$.

4. Discussion

4.1. Interpretation of the Findings

Overall, the results highlighted the importance of economic, behavioral, and socio-psychological factors determining Thai consumers' RPV adoption intentions. Our model accounted for 21.4% of the variance (R^2 = 0.214) in RPV adoption intention. This number is not too far from a recent meta-analytic study showing that benefits and perceived behavioral control predicted adoption intention (R^2 = 0.280) [34]. Consistent with previous research [9,10,12,53], four out of six variables that significantly predicted RPV adoption intention were related to financial cost and return. The first two were the economic factors relative to each household's constraints and expectations, specifically, Gap PPW and Gap IRR. The households that could afford the system at the market price and had a more realistic expectation of the financial return from RPV investment were more likely to become interested in RPV adoption. In general, the respondents reported that they could not afford an RPV system at the 2019 market price (roughly 30 Baht or $1 per Watt) and, on average, wanted to pay approximately 36% less ($M_{\text{Gap PPW}} = -10.92$ Baht or −$0.36). They also implied that the IRR was significantly below their expected rate of return ($M_{\text{Gap IRR}} = -21.45\%$).

We suspect two potential sources of such a discrepancy. First, on average, Thai households earned 312,221.04 Baht/year (~$10,407.37/year) with 248,905.44 Baht or ~$8296.85 yearly expense per household in 2019 [54]. With the financial condition of most households in Thailand, a significant long-term investment such as RPV systems is unaffordable. For example, a 5 kW RPV system would cost $5000, roughly half of the yearly earnings and more than double the annual cash reserve of an average Thai household.

The second explanation for such huge gaps could be a lack of knowledge regarding the RPV system's investments. While the current IRR in 2019 was 8.1%, the expected IRR implied by the respondents' preferred payback period and expected cash flow was 29.55%, leaving a considerable gap of −21.45%. This discrepancy suggested that Thai households expected a much shorter payback period than was plausible with the current feed-in tariff, electricity price, and system cost at the time of the data collection. Thai residents indicated that they did not have sufficient knowledge about RPV systems. The lack of knowledge could lead to unrealistic expectations and, thus, enormous gaps between what the market could offer and what individuals wanted.

The other two financial-related factors that significantly contributed to an intention to become RPV prosumers were attitude based on perceived financial benefits and PBC based on perceived cost. The result supported previous research showing that such socio-psychological factors predicted RPV intention and adoption [13,31–33,53]. Although the two variables seem to overlap with the two economic factors discussed earlier, the fact that they capture unique variance in the adoption intention when entered in the same model suggests that homeowners made further subjective evaluations of the actual values of the economic factors. For example, two households might report that they could afford an RPV at the current price; however, it might seem reasonable to one but expensive to another.

Social norm was another socio-psychological factor significantly predicting Thai households' intention to adopt RPV. In the current study, the social norm was a combination of an observation that peers, relatives, and neighbors possess an RPV system and a suggestion to install one. Such exposure could create awareness and stimulate interest in RPV among respondents. Peers or relatives who adopted RPV could also be a trustworthy source of information, which could help reduce uncertainty about the profitability and potential risks associated with RPV adoption. In support of these speculations, our data showed that social norms were positively associated with knowledge, perceived financial benefits, and perceived environmental benefits while being negatively associated with perceived risk (See Table 5).

In addition to the perception of these external factors, we also found that the heads of household's differences in innovativeness also contributed to the intention to become RPV prosumers. Respondents who identified themselves as highly innovative consumers (e.g., innovators and early adopters) were more interested in installing an RPV system than those who identified themselves as later adopters (e.g., late majority and laggards). This can be explained by the earlier adopters' nature, which tended to be drawn to new technology, ideas, and innovations [41,42,49]. In contrast, later adopters were likely to wait and see until the technology spread more widely in their communities [20,42,43]. However, one could argue that innovators tended to have higher financial resources and were thus more ready to adopt RPV. Our model controlled for a Gap PPW that reflected the monetary constraints of our respondents. Therefore, the unique variance explained by the innovativeness level would reflect a behavioral or personality factor contributing to the adoption intention.

The diffusion of innovation theory also suggests that earlier adopters are less influenced by the prevalence of technology adoption in the market. On the other hand, the later adopters tend to wait until the technology becomes standard. In other words, the later adopters would be more sensitive to the social norm. We explored this notion by calculating the regression slopes of the social norm for each of the five innovativeness levels (see Table 7). The overall statistical test of a linear trend of the slopes across the five innovativeness levels was not significant ($t = 1.19$, $p = 0.237$). However, an increasing trend, albeit nonsignificant, was noticeable in the unstandardized regression coefficients across innovativeness levels. The relationship between norm and RPV adoption intention seems stronger in the later adopters than in the earlier adopters.

Table 7. Slopes of the social norm by innovativeness levels.

Innovativeness Levels	***b***	**95% CI**	
		LL	***UL***
1 = innovators	0.10	−0.27	0.47
2 = early adopters	0.11	−0.13	0.36
3 = early majority	0.14	−0.01	0.30
4 = late majority	0.14	−0.11	0.40
5 = laggards	0.43	0.03	0.82

On the other hand, several variables did not perform as expected. Although previous research has shown that a lack of knowledge is a barrier to RPV adoption [10,12,15,16,21], we did not find a significant relationship between knowledge and intention when controlling for other variables in the regression model. However, we suspect that knowledge might indirectly influence intention via the TPBs socio-psychological constructs. The significant zero-order correlations between knowledge and most of the socio-psychological variables hinted at the role of knowledge as a basis for subjective evaluation of the benefits and perceived barriers of RPV adoption. The current data showed that, in 2019, Thai households lacked confidence in their knowledge regarding RPV ($M = 0.81$, $SD = 0.92$ on a 0 to 4 scale), leaving a huge knowledge gap to be filled. Increased knowledge regarding the RPV system could potentially enhance attitudes and perceived behavioral controls predicting RPV adoption intention. The lack of knowledge in Thai households also contrasts with the fact that Thailand had the second-largest installed capacity of solar PV in Southeast Asian countries in 2020 [55]. Commercial and industrial sectors dominated the rooftop PV system with 125.03 MW of installed capacity during 2020, while residential PV accounted for only 2.22 MW [56]. Our model has identified financial, behavioral, and socio-psychological factors that could be strategically used to realize the untapped potential of Thailand's RPV adoption.

Another interesting finding was the null result of attitudes based on perceived environmental benefits. Note that it was not that Thai households did not see the environmental benefits of the RPV system. Our result showed that they did to a relatively high degree ($M = 3.10$, $SD = 0.90$ on a 0 to 4 scale). Perceived environmental benefits also had a significant zero-order correlation with the intention to become an RPV prosumer. However, controlling for other factors in the regression model did not explain a substantial amount of the unique variance in intention to become an RPV consumer. This finding was consistent with studies that found the financial cost and gain to be the major determinants of PV adoption in developing countries, while other aspects, such as environmental attitudes, would become important only in developed countries, where there are lower financial constraints [13,15,35–37,53]. Therefore, attitudes based on environmental benefits and probably other nonsignificant predictors, namely, perceived image benefits, perceived risk, and perceived inconvenience, could play a role in determining Thai households' RPV adoption intention only when the financial barriers are lifted.

Notably, while previous research examined some combinations of financial, motivational, and social factors [11,12,18,19,32,40,49,53,57], only a few studies empirically tested an integrated model with economic, behavioral, and socio-psychological factors [13,34,58]. Our models are among a few that simultaneously examined financial expectation, TPB constructs, and consumer innovativeness, supporting the notion that each factor uniquely contributes to the prediction of RPV adoption intention.

4.2. Implications

Based on the findings, interventions to promote RPV prosumer growth should focus on making RPV investment more financially attractive through a combination of multiple strategies. First, the government could help bring down the upfront payment. Although a decline in solar panel costs would alleviate some economic pressure, it would only benefit households on the upper end of the income distribution. This strategy may be particularly effective in developing countries like Thailand, where average households do not have a financial reserve for significant and long-term investment and are unlikely to take full advantage of the declining price. Nonetheless, from a policymaker's standpoint, the declining panel price would make a subsidization program more feasible as it would put less pressure on the budget. Elimination of the upfront cost would help with the RPVs affordability and improve the perceived financial benefits, thus lifting financial barriers and raising a positive attitude toward the RPV at the same time.

Second, an intervention should focus on making financial benefits more attractive. In addition to the upfront cost, the cash flow generated via the feed-in tariff is a parameter that determines the return on RPV investment. Our data showed a significant IRR gap due to the low actual IRR and the unrealistically high expected IRR. A governmental intervention could allow for a higher feed-in tariff to improve the IRR. For example, depending on a country's economic policy, the government could either set a higher central rate for the entire grid or implement a microgrid system to allow grid members to trade electricity with neighbors with more price flexibility. A report by the EPPO [50], from which we retrieved the dataset, outlined the market structure and models for potential RPV prosumers, where the trading price would reflect market demand and supply and allow for a higher return with minimal intervention from the government.

Third, for such financial incentives and subsidies to effectively close the economic expectation gap, potential RPV prosumers' unrealistic expectations should be rectified with effective communication. The economic and financial structure of RPV investment is new and complicated for most potential prosumers. The campaign message should provide some reference points, such as the cost, payback period, and IRR of more common yet comparable investment forms (e.g., interest rates). Such a reference point would allow the potential prosumers to develop more realistic expectations and a more positive subjective evaluation of the RPV investment's financial benefits and costs.

Effective communication could also improve potential prosumers' knowledge. Although knowledge about RPV did not directly predict the intention to become an RPV prosumer, it is necessary for attitude and perceived behavioral control formation. We suggested that a campaign to promote the growth of RPV prosumers should educate people on RPVs financial benefits, its technical limitations, and key investment considerations. Attitude and perceived behavioral control, backed up by more accurate information, will be more potent and predictive of intention and actual behavior [59]. Instead of running such communication and education campaigns themselves, the government could also entrust private entities such as solar panel resellers to deliver necessary information to potential prosumers through their marketing efforts. The government may provide incentives (e.g., tax breaks or subsidization) to motivate solar panel resellers to promote RPV installation while regulating advertising to prevent misinformation.

Finally, our results highlighted the importance of social influence. Observing or being persuaded by adopters was associated with a greater intention to become RPV prosumers. According to the diffusion of innovation theory, innovators and early adopters are predisposed toward adopting new technology. They could be a target for the first phase of an RPV campaign. The campaign could successfully establish a significant user base by removing economic and financial constraints for these groups. The Theory of Planned Behavior suggests that social norms influence an individual's intention. By fostering a strong community of adopters, they could help spread the word to other potential adopters. Later phases of the campaign could leverage these users' positive attitudes and enthusiasm to gain momentum. A referral program and word-of-mouth would entice the early majority to consider becoming an RPV prosumer. Once the adoption rate reaches its critical point, the rest will eventually be drawn to the change.

4.3. Strength, Limitations, and Future Research

Typically, participants in RPV studies had to rely on their preconceived knowledge of the RPV market conditions when reporting their adoption intention [13,53,57,60]. One of the key features of the EPPOs survey was the use of investment payback scenarios. Since the non-adopters generally lacked knowledge about the RPV systems, asking them to report their intention to adopt an RPV system without the necessary information would have undermined the validity of the responses. The scenario provided essential information such as the system cost, projected financial return, and payback period, which were necessary for the non-adopters to make a more realistic judgment on their RPV adoption intention. This feature of the study design could benefit future RPV research in areas where residents are not familiar with the price and returns of an RPV system.

Another notable feature of this study was the selection of the predictors. First, the predictors were chosen based on the theory of planned behaviors, the diffusion of innovation theory, and the interview with PV adopters in the EPPOs original study to ensure comprehensiveness and relevancy. Second, using economic expectations (i.e., Gap IRR and Gap PPW) was an innovative attempt to test the effects of economic factors at the individual level. We did not use straightforward economic factors (e.g., IRR, payback period, and system cost), which were primarily constant for every household under the same policy, market, and economic conditions. Their effects were usually measured collectively, such as a county's or country's adoption rate. Instead, the Gap IRR and Gap PPW in the current study were the difference between the actual and potential prosumers' expected IRR and the PV system's price per watt. These calculated indices allow us to empirically test the impact of economic factors on individuals' decision-making.

Nonetheless, several limitations should be noted. The first classic limitation was that intention does not always translate into action. Households that intend to adopt RPV might fail to perform so due to unforeseen factors, such as a change in government regulations or their own economic status. A cross-sectional study that compares prosumers to non-prosumers would help identify predictors that can empirically discriminate between the two. However, such a design is not without limitations. In the case of existing prosumers, predictors such as knowledge and attitudes might be a result rather than a cause of their RPV adoption. A longitudinal design that tracks purchase behaviors over time, albeit costly to conduct, would provide a more apparent causal relationship.

Secondly, the social norm measure was crude, as it only summed up responses from three dichotomous questions that asked whether or not any of their peers or neighbors adopted RPV and recommended them to adopt one. The measure did not take the magnitude of the psychological impact of these social influences into account. This design was intended during the original survey by EPPO because it needed to accommodate respondents with minimal RPV experience and knowledge. If the scale were phrased as in a typical subjective norm measure (e.g., "People important to me think that I should install RPV"), the response could be artificial because most respondents might never have had an actual conversation on RPV with anyone before. Therefore, they would have had to imagine how much others would think they should adopt an RPV. This method could have potential pitfalls. Respondents' ratings might depend on their attitude towards RPV adoption. Specifically, if they think RPV is generally desirable, they might infer that everyone would support its adoption. Hence, the original survey was designed to prevent these potential issues by trading a finer rating scale for the measurement's generality.

5. Conclusions

Our results suggest that, to increase RPV adoption intention, the policy should initially focus on removing financial barriers on both economic and psychological aspects. The survey respondents weighed their decision on the initial investment cost, rate of return, perception of financial benefits, and financial barriers to the solar PV system. The concentration of financial-related factors seems to be particularly true in developing countries. In addition, we found that social and personality factors also played an important role in adoption intention. A campaign to promote RPV adoption should leverage the power of social influence by encouraging current adopters to be sustainability evangelists in their communities. By targeting the early innovation adopters and making them innovation leaders, we would have a better chance of building momentum for the widespread adoption of the solar PV system.

The combination of economic expectations, behavioral, and socio-psychological factors in the RPV adoption model could be applied to governmental policy intervention as well as other energy initiatives, especially in the region of Southeast Asia, where economic and cultural contexts are similar to Thailand's. Moreover, our results were also aligned with research from other regions at different economic development statuses, suggesting the practicality and generality of the TPB model and the use of socio-psychological factors in studying energy-related behavior.

Author Contributions: Conceptualization, T.H. and K.A.; methodology, T.H. and K.A.; formal analysis, K.A.; investigation, T.H. and K.A.; resources, T.H.; data curation, K.A.; writing—original draft preparation, T.H.; writing—review and editing, T.H. and K.A.; visualization, T.H. and K.A.; supervision, T.H.; project administration, T.H. and K.A. All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding.

Data Availability Statement: The data presented in this study are available on request from the corresponding author. The data are not publicly available due to privacy restrictions.

Conflicts of Interest: The authors declare no conflict of interest.

Nomenclature

b	Regression coefficient
CI	Confidence interval
Cronbach's α	Internal consistency reliability index
Current IRR	Current market internal rate of return of a PV system at the time of the study
Current PPW	Current market price per Watt of a PV system at the time of the study
EFA	Exploratory factor analysis
EPPO	Energy Policy and Planning Office of Thailand
Expected IRR	Internal rate of return of a PV system implied by respondent's expected yearly income generated by a PV system.

Gap IRR	Current IRR − Expected IRR
Gap PPW	Max PPW − Current PPW
IRR	Internal rate of return.
LL	Lower limit of a confidence interval
M	Mean
Max PPW	Maximum price per Watt of a PV system that a household could afford
N	Total sample size
p	Probability value (*p*-value)
PCB	Perceived behavioral control
PPW	Price per Watt.
PV	Photovoltaic.
r	Person's correlation coefficient
R^2	Coefficient of determination; proportion of variance in the dependent variable explained by the model
RPV	Residential photovoltaic.
SD	Standard deviation
t	Student's *t*-test
TPB	Theory of Planned Behavior
UL	Upper limit of a confidence interval
ΔR^2	Change in R^2 between regression models.

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