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The Analysis of Residential Rooftop PV in Indonesia's Electricity Market

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Abstract: This study aimed to examine the customer interest in using rooftop PV considering the economic background and customer profile in Indonesia's electricity market using primary survey data with potential and existing (households and industries) respondents. This research uses logit model regression to analyze the impact of the demographic background of respondents and uses exploratory factor analysis (EFA) to understand the reasons why the existing users utilize rooftop PV at their homes. The results show that education, residence location, and income can positively and significantly affect the probability of using rooftop PV as the source of electricity. Then, there are several factors that influence the use of rooftop PV, such as easily finding it in their area, having concern for the environment, following trends, and loyalty. Some disadvantages of installing rooftop PV are felt by users, such as relatively high installation cost and frequent overheating during usage. Regarding customer satisfaction, most of the respondents from both households and industries answered that they were satisfied with their rooftop's PV. Consumers say that the benefits they obtain are comparable to the required installation costs, and the majority of consumers also said that the rooftop PV worked well and did not need many repairs every month, so consumers did not need to spend significant money on it.

Keywords: rooftop PV; Indonesia's electricity market; linear regression; residential

JEL Classification: D10; Q20; Q42

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1. Introduction

Climate change has become a concern of the global community, and the Paris agreement gathers nations to reduce global greenhouse gas emissions in the effort to limit global temperature rise below 2 degrees Celsius or further 1.5 degrees Celsius (UN website). One of the prominent ways to achieve this target is to reduce the use of fossil fuel and utilize a low emissions source in energy sectors, as emissions from this sector are projected to contribute more than any other land-based sectors in 2030 (Hidayatno et al. 2020). This effort looks promising as, in 2020, renewables accounted for more than 80% of power capacity addition, of which more than 90% of that capacity is for wind and solar energy including rooftop solar PV (IRENA 2019).

Rooftop solar PV is expected to play an important role in reducing greenhouse emissions from energy sectors in the future especially with sufficient policies and supportive measures (IRENA 2019). While, in developed countries, rooftop solar has significant capacity contribution in their electricity system (i.e., Australia with 14.7 GW rooftop PV compared to 32 GW peak load), developing countries such as Indonesia still have low rooftop solar capacity compared to their peak electricity load. Nevertheless, the progress on rooftop PV adoption in Indonesia looks promising, and the installation number jumped by more than 700% from 2018 to late 2020, as shown in Figure 1.

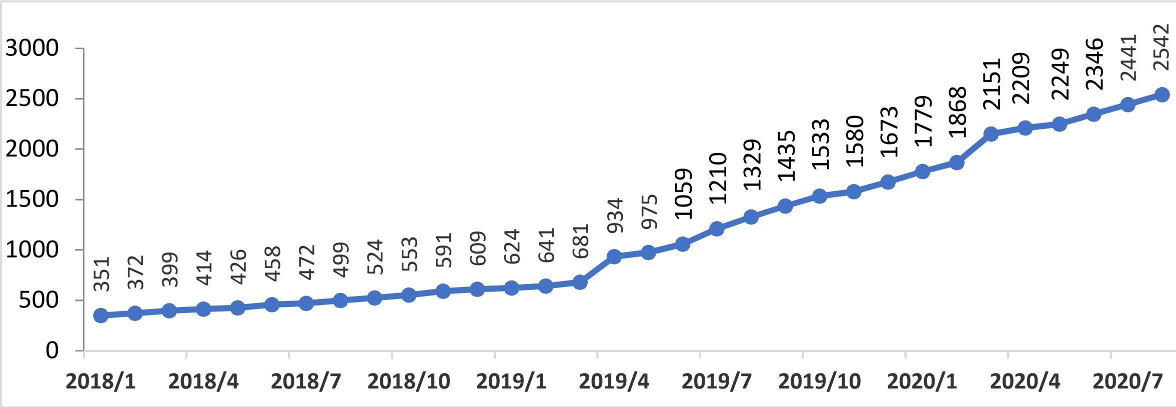

Figure 1. The number of rooftop PV customers in Indonesia per August 2020 (PLN 2020).

In general, high uptakes of residential rooftop PV are mainly supported by government support such as subsidies, as suggested by Chaianong and Pharino (2015). In addition to that, several factors also affect people installing rooftop PV, such as expanded awareness of energy use (Truffer et al. 2001), bill thrift (Herring et al. 2007), perceivability of the home exterior as a societal position symbol (Archer et al. 1987), and environmental advantages of diminishing nearby contamination (Luque 2001; Pearce 2002). One interesting finding in Sri Lanka suggests that middle-aged inhabitants who are educated as well as retirees also have the tendency to install rooftop PV at their households (Jayaweera et al. 2018).

On the opposite side, there are also barriers that make people reluctant to install rooftop PV, such as high real and perceived initial costs incurred to install and the quality of the PV system (Karakaya and Sriwannawit 2015; Margolis and Zuboy 2006); inconsistency of policy, which may cause uncertainty for electricity bills (Borenstein 2017); lack of knowledge about PV technologies and risks associated with the technology (Karakaya and Sriwannawit 2015; Margolis and Zuboy 2006); and a poor view of the aesthetic on the rooftop for certain house types (Faiers and Neame 2006). In addition, the trust issue and inadequate nature of the contractor worker labor force also discourage homeowners from purchasing a solar PV rooftop (Knudsen 2002).

In the light of supporting rooftop PV uptakes in Indonesia as one of the ways to achieve the Indonesian renewable energy target of 23% in 2025, several studies have been carried out regarding rooftop PV, including calculation of grid parity for rooftop PV (Haryadi et al. 2019), the effects of PV penetrations on the electricity grid (Tambunan et al. 2020), and evaluation of current policies and the suggestion to increase PV adoption in Indonesia (Hidayatno et al. 2020; Tarigan 2018). However, it is still hard to find research that specifically describes rooftop PV customers' background, and reasons for Indonesian customers to adopt or not to adopt rooftop PV.

This study aims to examine how interested Indonesian customers are in installing rooftop PV together with the background of the interested customers. Reasons for installing and not installing rooftop PV are also examined to evaluate the determinant factor of PV installation for Indonesian customers. This paper is organized as follows: Section 1 provides the background and importance of the study, Section 2 explains the data collected and research methods, Section 3 provides the results of data analysis together with the associated discussions, and finally, Section 4 offers the conclusions.

2. Data and Research Method

2.1. Data

We used primary data through conducting a survey of the existing and potential rooftop PV users in 2020 in Jakarta, Banten, West Java, East Java, and Bali provinces. We performed a survey on those areas because, based on data recorded by PLN (2020), around 92.64% or 2355 out of 2542 rooftop PV users in Indonesia are in those areas. Specifically, there are 755 users in Jakarta, 673 users in West Java, 632 users in Banten, 199 users in East Java, and 96 users in Bali. Using a 95% significance level and a 6% margin error from 117 million people in those areas, we obtained a recommended sample size of 267. However, we obtained potential users in order to analyze the impact of demographic background on the probability of respondents that are interested in installing rooftop PV in their homes. Meanwhile, using the 95% significance level and 10% margin error from 2355 rooftop PV users, the sample size recommended was 93, and we obtained 121 respondents of rooftop PV users in order to know the reasons for using rooftop PV.

2.2. Research Method

This research uses quantitative approaches, i.e., logit model, factor analysis, and descriptive statistics. The logit model is utilized to analyze the impact of the demographic background of respondents on the probability of utilizing rooftop PV at their homes. The exploratory factor analysis (EFA) is used to understand the reasons why the existing users utilize rooftop PV at their homes. Meanwhile, we used descriptive statistics to understand the demographic background and the existing users' satisfaction in installing rooftop PV.

Logistic regression is helpful to predict the likelihood that an event will happen using data or characteristics that are believed to be identified with or impact such events (Tolles and Meurer 2016). Logistic regression can show which of the different factors being assessed has the strongest association with a result and gives a measure of the magnitude of the potential impact and also has the ability to "adjust" for confounding factors, i.e., factors that are associated with both other indicator variables and the result, so the proportion of the influence of the predictor of interest is not distorted by the impact of the confounder (Tolles and Meurer 2016). In this study, respondents interested in using rooftop PV have a value of 1, and respondents who are not interested in rooftop PV have 0.

Logit represents the percentage of log-odds change or odds ratio for increasing x variables or independent variables. Generally, if we take the antilog of the independent variables slope coefficient, deduct 1 from it, and multiply the outcome by 100, we will obtain the percent change in the odds for a unit increase in the regressor (Gujarati and Porter 2009, p. 560). Furthermore, in order to compute the probability of installing the rooftop PV through its marginal effect, logit equations are as follows:

$$L_i = \ln\left(\frac{P_i}{1-P_i}\right) = \beta_1 + \beta_2 Age_i + \beta_3 Gender_i + \beta_4 Educ_i + \beta_5 Loc_i + \beta_6 House_i + \beta_7 Electric_i + \beta_8 Occup_i + \beta_9 LnIncome_i + \mu_i, \quad (1)$$

On the equations above, the dependent variables show public interest in using rooftop PV. In contrast, independent variables are *Age*, *Gender*, educational levels (*Educ*), location (*Loc*), size of house (*House*), electrical power (*Electric*), occupation (*Occup*), and income (in natural logarithm).

Furthermore, in order to investigate the reasons why the existing users use rooftop PV, we utilize EFA. According to Field (2013) and Mulaik (2009), EFA is utilized to identify the component of the underlying factors. In terms of the factor extraction method, we used principal component analysis (PCA) with varimax rotation. This is because it can optimize the combination of indicators on one factor, so the explanation about the component of the factor becomes clear. We also used the scree cut-off points in determining the total factor according to Cattell (1966) and extracting the eigenvalue of the factors that are more than 1 (one) according to the Kaiser rule (Kaiser 1960). Moreover, the Kaiser–Meyer–Olkin (KMO) test was also utilized to determine the appropriateness of data for analysis (Kaiser 1970).

We asked 23 questions to the existing users regarding the reasons for using rooftop PV. They answered according to the Likert scale from 1 (strongly disagree) to 4 (strongly agree). The motive statements included (1) wanting to reduce the air pollution, (2) wanting to contribute to conserving non-renewable fossil energy, (3) wanting to save the foreign exchange reserve, (4) wanting to implement Green Energy, (5) because solar power is a sustainable source of energy, (6) still using rooftop PV even though they know it is expensive, (7) still using rooftop PV even though they know it is currently still imported from abroad, (8) wanting to be the person/industry who started the movement for the use of rooftop PV in Indonesia, (9) wanting to give an example to their community of the benefits of rooftop PV, (10) wanting to influence their community to be interested in installing rooftop PV, (11) wanting to follow the current trend, (12) because it is easy to find it in their area, (13) because it is in accordance with modern society, (14) because it reflects the culture in their neighborhood, (15) because it is considered the technology that is popular today, (16) because the surrounding society is used to using it, (17) due to the influence of friends/other industries, (18) because it is influenced by their role and status in society, (19) because of adjusting the budget, (20) because it adapts to the economic situation, (21) because it reflects self-identity, (22) because it is practical and easy to find, and (23) because of the perception of advertising.

3. Empirical Results

3.1. The Preference of Potential Respondents in Installing Rooftop PV

Table 1 shows the descriptive statistics of the potential users of rooftop PV. There were 100 respondents from Bali, 98 from Jakarta, 77 from East Java, and 6 from Banten. From those 281 respondents, the average age is 38.52, with the lowest age being 17 years and the highest age being 72 years. The gender variable has an average value of 0.63, which means that the number of male respondents is more than female. The educational variables are categorical, namely, 0 = others; 1 = graduated from Junior High School; 2 = graduated from Senior High School; and 3 = graduated from Higher Education. The average education of respondents is 2.50, meaning that most respondents have a high level of education.

Table 1. The descriptive statistics of the potential users of rooftop PV.

Variables	N	Mean	Std. Dev	Min	Max
Age	281	38.52	12.19	17	72
Gender	281	0.630	0.484	0	1
Education	281	2.509	0.655	0	3
Location	281	0.128	0.335	0	1
House area	281	1.302	1.197	0	4
Electrical capacity limit	281	0.214	0.475	0	2
Occupation	281	1.854	1.596	0	4
Dummy interest using rooftop PV (1 = interest)	281	0.783	0.413	0	1
Natural logarithm of income	281	15.55	0.840	13.12	18.42

Other variables, such as the location of residence, are dummy variables, which are 0 when they live in the city center and suburbs and 1 when they live outside the city. Similarly, the variable of interest in using rooftop PV, a dummy variable, is worth 1 when interested in rooftop PV and 0 when not interested in using rooftop PV. The house area variable is also categorical, namely 0 = less than 100 m^2; 1 = 100–200 m^2; 2 = 201–300 m^2; 3 = 301–400 m^2; and 4 = more than 400 m^2. The average size of the house is 1.30, which means that the average size of the respondent's house is in the category of more than 100–200 m^2. The electrical capacity of respondents is divided into three categories, namely 0 = 450 volt-ampere (VA) up to 2200 VA (R-1); 1 = 3500 VA up to 5500 VA (R-2); and 3 = 6600 VA and above (R-3). That classification is because, in Indonesia, we use VA as the unit of electrical capacity of the house installed. The average power capacity limit of the respondents is 0.21, meaning that the average electric power used is more than 2200 VA (R-1). Respondents' occupations were also divided into several categories, including: 1 = private employee; 2 = civil servants/police/army; 3 = state-owned enterprises; 4 = entrepreneurs; and 0 = others. The job variable has an average value of 1.85 with a standard deviation of 1.59. On the other hand, the natural logarithm of the gross monthly income variable has an average value of 15.55 with a minimum value of 13.12 and a maximum value of 18.42.

Furthermore, in order to analyze factors influencing the potential customers' preference in installing rooftop PV, we used the logit estimation method. The logit estimate shows the effect of the independent variable on the dependent variable, although the coefficient cannot be interpreted directly (Ajija et al. 2021). The impact of independent variables on dependent variables can be analyzed from the odds ratio indicating two opportunies, i.e., interested in using rooftop PV or not.

The regression results as can be seen in Table 2 emphasize that only three variables, i.e., education, residence location, and income, affect the interest in using rooftop PV. The education variable has a positive effect on interest in using rooftop PV. Furthermore, from the interpretation of the odds ratio, we can assert that, for a unit increase in the level of education, the odds in favor of installing rooftop PV increase by 3.365 or about 236.5%. From the marginal effect result, we know that an increase of one level of education will raise the probability of installing rooftop PV by 0.155 points.

Table 2. The logit estimation, odds ratio, and marginal effect.

Variable Dependent	**Variable Independent (1 = Interest Using Rooftop PV)**		
	Logit	**Odds Ratio**	**Marginal Effect**
Constant	−13.90 ***	9.20×10^{-7} ***	-
	−3.992	-3.67×10^{-6}	-
Age	0.00905	1.009	0.0011
	−0.0138	−0.0139	−0.0017
Gender (1 = Male)	0.514	1.672	0.065
	−0.355	−0.593	−0.045
Education	1.213 ***	3.365 ***	0.155 ***
	−0.273	−0.918	−0.037
Location	2.430 **	11.36 **	0.311 ***
	−1.049	−11.91	−0.118
House size	0.0489	1.05	0.006
	−0.168	−0.176	−0.021
Electrical capacity limit	−0.0869	0.917	−0.0111
	−0.515	−0.472	−0.065
Occupation	−0.13	0.878	−0.0166
	−0.107	−0.0943	−0.0137
Ln income	0.758 ***	2.135 ***	0.097 ***
	−0.258	−0.55	−0.032
Observations	281	281	281
Prob > chi^2	0.0000	0.0000	-
Pseudo R^2	0.2084	0.2084	-

Note: ***, ** are significant at 1%, 5%, and 10% respectively.

The location variable also has a positive effect on interest in using rooftop PV. It means that if the respondent lives on the city's outskirts, then his chances of installing rooftop PV in his house are greater. For individuals who live outside the city, the odds in favor of installing rooftop PV increase by 11.36 or about 1036%. From the marginal effect result, we know that when the respondents begin living on the city's outskirts, the probability of installing rooftop PV increases by 0.311 points.

In addition, if income increases by one percent, then the odds in favor of installing rooftop PV increase by 2.135 or about 113.5%. From the marginal effect result, we know that for a 1% increase in income, the probability of installing rooftop PV will increase by 0.097 points, or a 100% increase in income increases the probability of installing rooftop PV by 9.7 points. It makes sense because the price of roof PV in Indonesia is categorized as a luxury good. Thus, the higher the income of the respondents, the greater the probability of installing rooftop PV at their homes.

3.2. The Preference of Existing Respondents for Installing Rooftop PV

In analyzing the preference of rooftop PV's installation, we also asked the existing users. There were 121 existing customers, consisting of 89 respondents from households and 32 respondents from industries. Most of these users were from Bali (49.6%), Jakarta and Banten (38.8%), and East Java (11.6%). Around 70.2% of respondents were male and 29.8% were female. According to their age, 30.6% of respondents were 20–30 years old, 23.1% were 30–40 years old, 31.4% were 40–50 years old, 12.4% were 50–60 years old, and 3.3% were more than 60 years old. Most respondents lived in suburban and rural areas, i.e., 57.9%, and the rests were in urban areas.

We used EFA to analyze the reasons for installing rooftop PV. The first step on the EFA analysis is calculating the number of factors using scree cut points by Cattell (1966) and the Kaiser rule through extracting the factors for which the eigenvalue is more than one (Kaiser 1960). Using KMO analysis, Kaiser (1970) recommended 0.5 as the cut-off value and 0.8 or more for factors that can continue to the next steps. In this research, the KMO value was 0.790, which is more than the cut-off value. Therefore, we can continue to the Barlett test for analyzing the correlation among indicators. The results indicate that the *p*-value was less than 0.001, indicating a strong correlation among indicators (Bartlett 1954). Overall, the outcomes fulfill the KMO criteria and Barlett test; thus, the sample was appropriate to conduct the factor analysis.

The exploratory analysis showed the seven factors representing the reasons for using rooftop PV in Indonesia. Nevertheless, there were five factors that had less than three indicators, i.e., wanting to save the foreign exchange reserve (Q3), wanting to give an example to their community of the benefits of rooftop PV (Q9), wanting to influence their community to be interested in installing rooftop PV (Q10), because of adjusting their budget (Q19), and because it adapts to the economic situation (Q20). Therefore, we dropped those questions, and the EFA resulted in four reasons for installing rooftop PV; hence, we can name the factors according to the grouping of indicators indicated by the loading factors from the step indicators. Those four factors were named (1) cultural, (2) environment awareness, (3) technological knowledge, and (4) loyalty, as explained in Table 3.

Table 3. The factors and items of the reasons for using rooftop PV.

Factors	Items
Factor 1: Cultural	Because it is easy to find it in their area (Q12), because it is in accordance with modern society (Q13), because it reflects the culture in their neighborhood (Q14), because the surrounding society is used to using it (Q16), because it is influenced by their role and status in society (Q18), because it is practical and easy to find (Q22)
Factor 2: Environmental Awareness	Wanting to reduce the air pollution (Q1), wanting to contribute to conserving non-renewable fossil energy (Q2), wanting to implement Green Energy (Q4), because solar power is a sustainable source of energy (Q5), wanting to be the person/industry who started the movement for the use of rooftop PV in Indonesia (Q8)
Factor 3: Technological Knowledge	Wanting to follow the current trend (Q11), because it is considered the technology that is popular today (Q15), because it reflects self-identity (Q21), because of the perception of advertising (Q23)
Factor 4: Loyalty	Still using rooftop PV even though they know it is expensive (Q6), still using rooftop PV even though they know it is currently still imported from abroad (Q7), due to the influence of friends/other industries (Q17)

Factor 1 was the culture and surrounding environment encouraging someone to use rooftop PV. In this factor, the reason that has the highest loading value is that rooftop PV is easily found in residences or industrial locations, and the surrounding environment already uses rooftop PV. The lifestyle of rooftop PV that develops in the surrounding environment seems to influence a person's behavior to also follow using rooftop PV. The second factor illustrates the reasons for concern and environmental awareness that one wants to contribute to a better environment, such as reducing air pollution, saving fossil energy, green energy, and sustainable energy. Some of these things are the reasons for respondents using rooftop PV. This is reinforced by the mean of each question, which is 3.2. The third factor illustrates the knowledge of current emerging technological trends as a reason for the use of rooftop PV. The fourth factor is loyalty, which is that respondents generally choose to keep using rooftop PV even though the price is still relatively expensive.

As well as asking their reasons, we also questioned the weaknesses of installing rooftop PV. Overall, both the household and industrial respondents answered that the main weakness of installing rooftop PV is that the price of the rooftop PV installation is relatively costly. Rooftop PV is considered expensive by the customers because of two main reasons, i.e., the limited availability of supporting materials and the maintenance of rooftop PV. Rooftop PV service providers have to import the PV materials from abroad, such as China and Germany. Additionally, they also stated that the participants did not intend to adopt due to its dependency and its frequent overheating during usage.

Furthermore, we also asked several questions to understand the customers' satisfaction with rooftop PV in Indonesia both from household and industrial respondents. First, we asked about how long it takes to obtain their payback time when they had used rooftop PV. From the household costumers, the results showed that most respondents (40%) obtained it within 6 to 10 years of the return period, 38% of them answered 1 to 5 years, and the longest period was 11 to 20 years after installing the rooftop PV (from 8% respondents). Similar results were also indicated by the industrial respondents, which were 6 to 10 years for 33% of respondents, 1 to 5 years for 30%, 10 to 20 years for 22%, and more than 20 years for 15%. Therefore, generally, the return period of installing rooftop PV in Indonesia was around 6 to 10 years. This is in line with the respondents' answers regarding the rooftop PV's economic life. Most household respondents, or 50%, answered that their rooftop PV's economic life was 10 to 20 years, and even 24% said it was more than 20 years. In industrial respondents, 30% answered around 10 to 20 years, although 22% said less than 10 years.

Second, we asked about the comparison between the benefit and cost analysis of using rooftop PV. From the household and industrial respondents, most of them (77% and 63%, respectively) said that the benefits received and the costs incurred of installing rooftop PV were proportional and quite comparable. Specifically, they stated that the benefits of installing rooftop PV were cost savings. A total of 69% of households and 55% of industrial respondents claimed to be more efficient after installing rooftop PV. Another benefit was the anticipation or backup of electrical energy if using rooftop PV. In addition, a small percentage answered that rooftop PV is able to accommodate large loads and investments, is environmentally friendly, and so on. From the benefits that have been spelled out, we can provide the view that using rooftop PV is able to reduce the cost of electricity in the long run.

Third, we questioned respondents about the quality of rooftop PV they have installed. From the household and industrial respondents, 77% of them said that their rooftop PV worked well, 3% said it worked very well, and 10% said it worked quite well. According to the frequency of reparations, they said that it was less than three times a month. From the existing duration-making choices, the majority of respondents chose the smallest option. This means that there is not much need for improvement every month, and it can be said that rooftop PV treatment is easy to do. This is strengthened by the cost that must be incurred by respondents every month for rooftop PV. Most respondents, or 44%, said that repair costs that must be incurred by rooftop PV users were less than IDR 300,000 or USD 21.16 out of the options used.

Finally, we also confirmed the overall satisfaction with installing rooftop PV. Most of the respondents both from household and industry answered that they were satisfied with their rooftop PV (77% were satisfied and 17% were very satisfied). Therefore, the respondents were interested and happy with rooftop PV instead of complaining about its weaknesses.

4. Conclusions and Recommendations

This study aims to determine the profile of existing and potential customers of rooftop PV in Indonesia's electricity market and analyze the determinants of rooftop PV installation by the customers. The result reveals that the higher the level of education, the higher the probability of installing rooftop PV. These things can happen because when a person's level of education is higher, their awareness or concern for the environment will be more heightened. Then, location can also influence the decision to install rooftop PV. When they are on the outskirts of the city, the possibility to install rooftop PV as a source of electricity will be even greater. In addition, when their income is high, they are more likely to be interested in using rooftop PV. It makes sense because the price of roof PV in Indonesia is categorized as luxury goods.

There are several factors that influence the use of rooftop PV. Some of them were (1) rooftop PV being easily found in residences or industrial locations and the surrounding environment already using rooftop PV, (2) concern and environmental awareness, (3) knowledge of current emerging technological trends, And (4) loyalty, which is when respondents generally choose to keep using rooftop PV even though the price is still relatively expensive.

Based on the determinant analysis, rooftop PV is considered more economical and environmentally friendly compared to the electricity from the PLN power grid. However, these customers believe that rooftop PV has disadvantages. Overall, both the household and industrial respondents answered that the main weaknesses of installing rooftop PV were the expensive price, the dependence on the weather, the need for a large installation area, the materials that are less environmentally friendly (difficult to recycle), and the frequent overheating of the device.

Regarding customer satisfaction with rooftop PV, most of the respondents from both households and industries answered that they were satisfied with their rooftop PV. Consumers say that the benefits they obtain are comparable to the required installation costs, and generally, the return period of installing rooftop PV in Indonesia was around 6 to 10 years. The majority of consumers also said that the rooftop PV worked well and did not require many repairs every month, so consumers did not need to spend a lot of money on it.

Strengthening policy connectivity and coordination between energy and the rest of the economy will draw maximum systemic benefits from the energy transformation. There are several policy recommendations that can be applied based on the analysis results: (1) reducing the cost of installing PV rooftops, as decreasing the price of rooftop PV per year and government subsidies on rooftop PV prices has an impact on the increasing rate of adoption of rooftop PV; (2) providing education to increase awareness and concern for the environment; and (3) providing long-term stability of policy instruments. Policymaking needs to minimize swings fromstrong supportive measures to aggressivecurbs.

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Abbreviations

kWh	kilo watt-hour
LCA	life cycle assessment
PLN	Perusahaan Listrik Negara
PV	photovoltaics
USD	United States Dollar
VA	electrical power unit used for the apparent power in an electrical circuit
WTP	willingness to pay

References

Ajija, Shochrul Rohmatul, Muhamad Abduh, Wasiaturrahma Wasiaturrahma, and Ahmad Hudaifah. 2021. Ethnicity and Household Savings in Indonesia. In *Research Anthology on Personal Finance and Improving Financial Literacy*. Hershey: IGI Global, pp. 138–50.

Archer, Dane, Pettigrew Thomas Fe, Costanzo Mark, Iritani Bonita, Walker Iain, and White Lawrence Te. 1987. Energy conservation and public policy: The mediation of individual behavior. *Energy Efficiency: Perspectives on Individual Behavior* 1987: 69–92.

Bartlett, Maurice S. 1954. A Note on the Multiplying Factors for Various $\chi 2$ Approximations. *Journal of the Royal Statistical Society. Series B Methodological* 16: 296–98. [CrossRef]

Borenstein, Severin. 2017. Private Net Benefits of Residential Solar PV: The Role of Electricity Tariffs, Tax Incentives, and Rebates. *Journal of the Association of Environmental and Resource Economists* 4: S85–S122. [CrossRef]

Cattell, Raymond B. 1966. The scree test for the number of factors. *Multivariate Behavioral Research* 1: 245–76. [CrossRef] [PubMed]

Chaianong, Aksornchan, and Chanathip Pharino. 2015. Outlook and challenges for promoting solar photovoltaic rooftops in Thailand. *Renewable and Sustainable Energy Reviews* 48: 356–72. [CrossRef]

Faiers, Adam, and Charles Neame. 2006. Consumer attitudes towards domestic solar power systems. *Energy Policy* 34: 1797–806. [CrossRef]

Field, Andy. 2013. *Discovering Statistics Using IBM SPSS Statistics*. Sussex: Sage.

Gujarati, Damodar N., and Damodar C. Porter. 2009. *Basic Econometric*, 5th ed. New York: McGraw-Hill/Irwin.

Haryadi, Fajar Nurrohman, Muhammad Ali Imron, Harry Indrawan, and Meiri Triani. 2019. Predicting Rooftop Photovoltaic Adoption in the Residential Consumers of PLN Using Agent-Based Modeling. Paper presented at 2019 International Conference on Technologies and Policies in Electric Power Energy, Yogyakarta, Indonesia, October 21–22; pp. 1–5. [CrossRef]

Herring, Horace, Sally Caird, and Robin Roy. 2007. Can consumers save energy? Results from surveys of consumer adoption and use of low and zero carbon technologies. *Proceedings European Council for an Energy Efficient Economy Summer Study* 4: 188595.

Hidayatno, Akhmad, Andri Setiawan, I. Made Wikananda Supartha, Armand O. Moeis, Irvanu Rahman, and Eddie Widiono. 2020. Investigating policies on improving household rooftop photovoltaics adoption in Indonesia. *Renewable Energy* 156: 731–42. [CrossRef]

IRENA. 2019. *Future of Photovoltaic: Deployment, Investment, Technology, Grid Integration and Socio-Economic Aspects*. Abu Dhabi: International Renewable Energy Agency. Available online: https://www.irena.org/publications/2019/Nov/Future-of-Solar-Photovoltaic (accessed on 15 November 2019).

Jayaweera, Nadeeka, Chathuri L. Jayasinghe, and Sandaru N. Weerasinghe. 2018. Local factors affecting the spatial diffusion of residential photovoltaic adoption in Sri Lanka. *Energy Policy* 119: 59–67. [CrossRef]

Kaiser, Henry F. 1960. The application of electronic computers to factor analysis. *Educational and Psychological Measurement* 20: 141–51. [CrossRef]

Kaiser, Henry F. 1970. A second generation little jiffy. *Psychometrika* 35: 401–15. [CrossRef]

Karakaya, Emrah, and Pranpreya Sriwannawit. 2015. Barriers to the adoption of photovoltaic systems: The state of the art. *Renewable and Sustainable Energy Reviews* 49: 60–66. [CrossRef]

Knudsen, Sø. 2002. Consumers' influence on the thermal performance of small SDHW systems—Theoretical investigations. *Solar Energy* 73: 33–42. [CrossRef]

Luque, Antonio. 2001. Photovoltaic market and costs forecast based on a demand elasticity model. *Progress in Photovoltaics: Research and Applications* 9: 303–12. [CrossRef]

Margolis, Robert, and Jarett Zuboy. 2006. Nontechnical Barriers to Solar Energy Use: Review of Recent Literature. Available online: http://www.osti.gov/bridge (accessed on 15 November 2019).

Mulaik, Stanley A. 2009. *Foundations of Factor Analysis*. Boca Raton: CRC Press.

Pearce, Joshua M. 2002. Photovoltaics—A path to sustainable futures. *Futures* 34: 663–74. [CrossRef]

PLN. 2020. *Rooftop PV Customers Report*. Jakarta: PLN.

Tambunan, Handrea Bernando, Dzikri Firmansyah Hakam, Iswan Prahastono, Anita Pharmatrisanti, Andreas Putro Purnomoadi, Siti Aisyah, Yonny Wicaksono, and I. Gede Ryan Sandy. 2020. The Challenges and Opportunities of Renewable Energy Source (RES) Penetration in Indonesia: Case Study of Java-Bali Power System. *Energies* 13: 5903. [CrossRef]

Tarigan, Elieser. 2018. Simulation and feasibility studies of rooftop PV system for university campus buildings in Surabaya, Indonesia. *International Journal of Renewable Energy Research* 8: 895–908.

Tolles, Juliana, and William J. Meurer. 2016. Logistic Regression Relating Patient Characteristics to Outcomes JAMA Guide to Statistics and Methods. *JAMA* 316: 533.

Truffer, Bernhard, Jochen Markard, and Rolf Wüstenhagen. 2001. Eco-labeling of electricity—Strategies and tradeoffs in the definition of environmental standards. *Energy Policy* 29: 885–97. [CrossRef]