Chapter 5

Measuring Public Acceptance Value of Rural Biogas Development through Logistic Regression and Willingness to Pay

Christia Meidiana, Zuqnia Gita Ramadhani and Dian Dinanti

Additional information is available at the end of the chapter

http://dx.doi.org/10.5772/intechopen.69191

Abstract

The development of renewable energy technologies (RETs) in rural areas requires acceptance of technical solutions by key stakeholders, such as consumers and decision-makers, as well as energy providers. This study aims to identify the current status of public acceptance of RETs, especially biogas technology, the associated influencing factors, and the villager's preference of role to biogas management. Questionnaires were distributed to the respondents in Bendosari village to collect the required data for logistic regression and measurement of willingness to pay (WTP). Bidding game format was used to assess the WTP of three different groups, that is, biogas farmer, non-biogas farmers, and non-farmers. Three regression models were generated from the analysis, describing the factors influencing the public acceptance of each group toward biogas technology. The determinants of one group differed from the other group, reflecting the customer behavior in deciding toward certain goods which is biogas technology in this case. Measurement of public acceptance in percentage indicates the high acceptance and low acceptance of biogas technology for biogas farmers and for other two groups, respectively. This is affirmed by the result of the WTP-ATP comparison where WTP is lower than ATP and indicates that biogas technology has no important value for most non-biogas farmers and non-farmers. Furthermore, the preference of role as a consumer in biogas technology development is higher than as provider or co-provider. Biogas technology in rural areas is more sustainable when most farmers have roles as a co-provider.

Keywords: social acceptance, logistic regression, willingness to pay, rural biogas

1. Introduction

In Outlook Energy Indonesia 2013, it is estimated that the average growth of national energy demand is 4.7% per year from 2011 to 2030, indicating that the energy demand in 2030 will be 2.4 times higher than that in 2011. If this condition is not anticipated properly, the energy security may be influenced, leading to energy crisis. Therefore, the Government of Indonesia (GoI) is working on a solution for declining fossil fuel dependents and promoting utilization of renewable energy (RE) resources such as wind, sun, geothermal, biogas, and water [1]. Related regulations were endorsed in national and regional as well as public level to support the development of RE. In national level, regulation no. 79/2014 on National Energy Policy was enacted to target increase of RE share in final energy consumption up to 23% by 2025. Currently, the share of RE is only 5%. The policy is in line with the National Action Plan on greenhouse gases (GHGs) emission reduction which is targeting 26% emission reduction by 2020.

Renewable energy (RE) development is promoted as a promising method to solve problems of rural energy provision and to improve the rural household life because it can reach the remote areas far from the grid network. GoI realizes that many advantages can be achieved from RE utilization. GHGs emission reduction, fossil fuel dependency reduction, and energy security reinforcement are the benefits of RE [2]. In the regional level, provincial government ratified Regional Action Plan on GHGs in 2012 as a derivation of the higher Action Plan, while at the municipality public level, Government of Malang introduced some policies and programs on RE, especially biogas, since it has high potentials. The government is encouraging the renewable energy development, especially in rural areas where the renewable energy sources are relatively adequate. One of the REs, which is potential to be developed in Malang Regency, is biogas, especially from manure waste. In Malang Regency, there are 315,326 cows raised by the farmers who used it for biogas production. There are approximately 60,000 anaerobic digesters (ADs) constructed in the region (Veterinary Board of Malang Regency, 2016). It is targeted that 10.81% final energy consumption will be from biomass including its derivation (biogas) by 2020. Biogas development shows increasing trends in Indonesia since it has public, economic, and environmental benefits [3]. Community awareness, increase of green energy, promotion of sustainable development of village, acceleration of environmentally friendly agriculture, rural household savings improvement, and rural energy equity as well as the quality of rural life increase [4–7]. This condition is supported by some factors such as shift of final energy consumption from conventional energy dependence to public renewable energy empowerment to save energy and environment protection initiatives [8, 9]. However, the development of renewable energy in rural areas is relatively slow because it involves high initial cost spending mostly on energy generation, research and development, and implementation [10–13]. Therefore, an integrated rural biogas planning is needed to solve the rural energy provision problems.

Rural biogas development was initiated in 2013 in Bendosari village as a pilot project of rural biogas development in Malang Regency to support the national target of GHG reduction and public program of self-sufficient energy village (SSEV) as well as target of Village Midterm Planning 2013–2019. It is targeted that 1051 households will be provided by 200 communal units of anaerobic digesters (ADs) by the end of 2016. However, there are currently 77 ADs (39%), which are constructed. According to a preliminary survey in 2015, the reasons for slow biogas development in Bendosari village are lack of knowledge and farmer's perception of high cost and low level of service of biogas technology.

In this study, farmers' perception refers to the term people's perception as proposed by Ajezen (1991). People's perception of the ease or difficulty of performing the behavior [14]. This perception may influence the response, which is actualized through certain behaviors. In this context, behavior refers to the behavior of the respondents, namely farmers and non-farmers. Biogas and non-biogas farmers are producers and consumers for AD, while non-farmers are consumer for biogas. Consumer's buyer behavior may influence many factors such as cultural, sociodemographic, and psychological backgrounds. Sociodemographic factors such as age, gender, and income may influence consumer behavior and public acceptance. For example, Refs. [15, 16] affirmed that such factors are important in the case of congestion charge. Meanwhile, psychological background comprises perception, knowledge, motivation, beliefs, and attitudes.

Public acceptance is important in renewable energy development. Liu et al. [17] explained that gap between public acceptance and renewable energy quota increases target, which could be a hindrance in the government's target achievement. Low public acceptance leads to failure of renewable energy development. Schweizer Reis [18] affirmed that public acceptance may be described in two different ways, which are passive or active response. Passive response is expressed by state of agreement, while active response is stated by state of involvement. Both definitions are used as reference to measure public acceptance to use or to buy biogas as renewable energy. Willingness to use or to buy may be viewed as active public acceptance for rural biogas development in which the community involve actively through payment for biogas usage or contribution for anaerobic digester (AD) construction. Stren [19] stated that willingness to pay (WTP) may be described as behavior of pro-environment of an individual person in order to improve the environmental condition. According to Ref. [20], an individual's behavior is determined by the individual's behavioral intention. It defines the intention to engage in the behavior, which is called behavioral intention to consume biogas as a renewable energy. The intention is set by certain reasons. Therefore, it is called as reasoned action. Hansen et al. [21] have proposed initially this theory, which is extended by Ajzen [22] as described in **Figure 1**.

The contingent valuation method (CVM) was applied in this study to elicit people's willingness to pay (WTP) for biogas technology. CVM is one of the two common approaches that can be applied to estimate WTP. It is a direct approach [23], while the other is an indirect approach in which WTP can be estimated by observing the behavior of consumer. Dichotomous choice CVM was employed to estimate the WTP of the respondents to accept the biogas technology.

Generally, the value of WTP for renewable energy (RE) reflects individual's preferences to use the RE [24]. Some previous studies have attempted to measure the value of WTP and to determine the influencing factors of public acceptance. Hansla et al. [25] showed that value of WTP for green electricity is proportional to a positive response toward green electricity. The

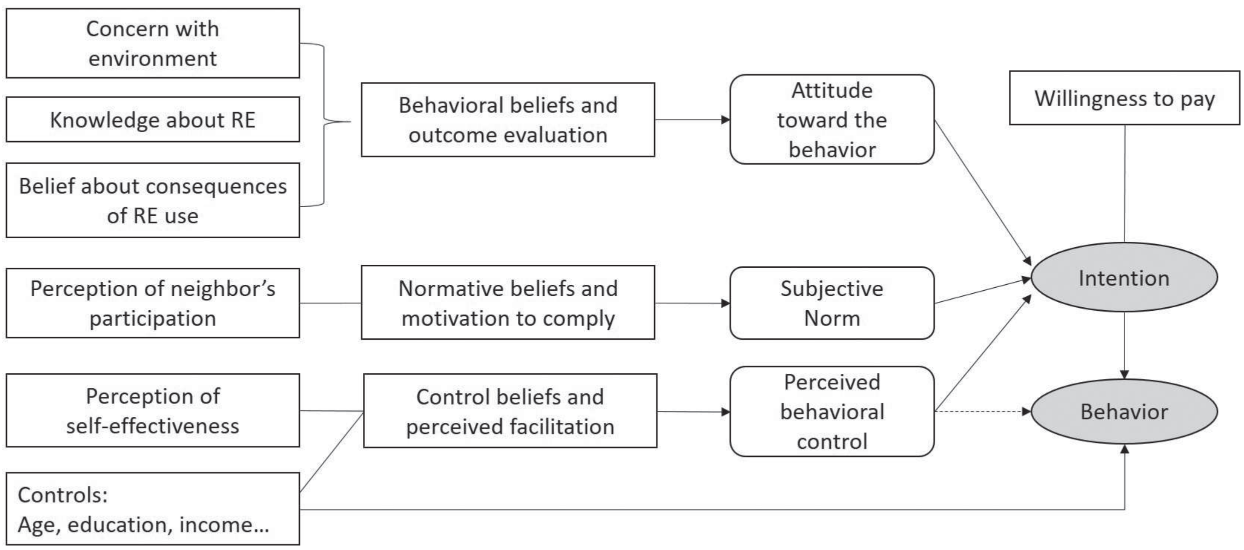

Figure 1. An analytical framework based on the theory of planned behavior [21].

response reflects the relative good awareness of consequences of environmental problems. The determinants for RE public acceptance are public conditions such as individual factors [26] including sociodemographic conditions [27, 28], economic characteristics, ways of living [29], income, household size [30], and personal experience [31]. Knowledge and people's perception play an important role also in public acceptance. These factors are observed in this study by conducting a survey of households. This survey, having potentials in supporting the biogas development in rural areas focusing on public acceptance, would provide sufficient data to understand how biogas as a new renewable energy is perceived at the public level, as done with the research presented in this chapter. Therefore, the objective of this chapter is (a) to observe public acceptance of rural biogas, (b) to examine households' preferences of role for biogas management, and (c) to find out determinants of biogas development in rural areas.

Public acceptance is measured based on current involvement of rural biogas actors in Bendosari village, that is, biogas farmer, non-biogas farmer, and non-farmer. It is expected that biogas farmer's acceptance will maintain the sustainability and non-biogas farmer has higher acceptance to increase the biogas utilization since this group has potentials. Meanwhile, non-farmers are expected to use biogas as energy sources. These rural biogas users are categorized as (a) producers because they only produce biogas without consuming only; (b) co-producers because they produce and use biogas for domestic use; and (c) consumers because they use biogas without producing it. The two first categories could be biogas or non-biogas farmers.

The chapter is structured as follows. The next section outlines the methodology applied in the chapter. This is followed by sections on the design survey for village identification and data collection including questionnaire survey as well as data analysis. This section is followed by willingness-to-pay (WTP) results for households expecting to choose their role in biogas management. The last section has conclusions drawn about the value of WTP, the public acceptance of biogas management and the determinant factors, and the preference of role in biogas management.

http://dx.doi.org/10.5772/intechopen.69191

2. Methodology

2.1. Area of the study

Bendosari village was selected as a pilot project for biogas development program in Malang Regency in 2005 due to the fact that it has livestock potentials. The geographical setting, which is a hilly landscape and the mild climate condition in Bendosari village, is appropriate for developing agricultural sector, especially husbandry. The village is located about 32 km west from Malang city and covers an area of 269.23 ha, comprising five smaller units called Dusun as described in **Table 1**. Furthermore, **Table 2** presents the social and economic conditions on the village. The farmer is the main source of livelihood in the village, having an income ranging between Rp 600,000 and Rp 3,500,000 per month. The average expense for fossil fuel (gas) is Rp 35,000 per month, and cow ownership is 3.6 cows/household (HH). However, the number of anaerobic digesters decreases gradually as many of them were damaged. Currently, biogas utilization rate is only 10.84%, indicating that only 77 of 710 farmers have used manure waste as feedstock for AD to produce biogas. Biogas is utilized only for cooking. Some farmers spread fresh manure over the field for fertilizer, but most farmers dispose manure waste to the ditches or streams, leading to water pollution and odor. The anaerobic digestion process in Bendosari village is illustrated in **Figure 1**. All biogas farmers (77 farmers) use fixed dome type with the various capacities ranging between 4 and 8 m^3. Bendosari village is located adjacent to the forest. Therefore, some households search for wood in the forest for cooking. The number of illegal tree cuttings by the villagers increases since 2012 as the fuel price increases. Therefore, the public government promotes biogas management in the village to decrease the number of illegal logging cases.

2.2. Description of the manure waste

The characteristic of manure waste determines the biogas production. **Table 3** describes the manure waste characteristic in Bendosari village. Production of manure waste is 25.8 kg/head/day, resulting in total manure production of 63,855 kg/day. This manure is mixed with

No.	Dusun	Number of		
		Biogas farmers	Non-biogas farmers	Non-farmers
1.	Dusun Cukal	39	231	215
2.	Dusun Dadapan Wetan	12	90	22
3.	Dusun Dadapan Kulon	20	207	135
4.	Dusun Ngeprih	1	28	31
5.	Dusun Tretes	5	77	72
	Total	77	633	475

Table 1. Population in Bendosari village.

Parameters	Unit of measurement	Value
Average household size	Number of persons	4.3
Average cattle herd size owned	Number of animals	3.6
Average cooking energy demand (LPG)	Kg/hh	5.3
Average number of cooking times/household/day	Frequency	2.4
Monthly income	Rp/hh	600,000–3,500,000
Monthly LPG cost for cooking purposes	Rp/hh	35,000
Monthly savings	Rp/hh	50,000–1,500,000

Table 2. Socioeconomic and demographic conditions.

certain amount of water to attain a slurry concentration enabling stirring and flowing to AD. It is assumed that adding water decreases the dry matter content from 85 to 9.5%. This value is adopted from the previous study [32]. Totally, 2475 cows are raised by 710 households (HH). This number determines the biogas production, which is 278 m^3/t ODM with methane concentration of 52%.

A typical AD in the Bendosari village is a fixed dome type with the capacity ranging from 4 to 10 m^3. The price of AD is proportional to the AD capacity (**Table 4**).

2.3. Data collection

Data were collected during primary survey through observations, interviews, and questionnaires and secondary survey by collecting official information from related planning documents to technical reports. **Table 5** shows the data collection method for getting primary data.

2.3.1. Population

Outlining of population is important to determine the sample, especially if there are more than one population. In this study, population is stratified into different groups based on the

Parameters	Unit of measurements	Values
Average manure production	kg/d	25.8
Total manure	kg/d	63,855
Input manure for existing AD	kg/d	7946.4
Dry matter	%	9.2
Organic dry matter (ODM)	%	85
Biogas yield	m^3/t ODM	278
Methane concentration	%	52

Table 3. Manure waste description.

AD size (m^3)	Required number of cow (head)	Manure mass for feedstock (kg)	Price (Rp)
4	3–4	20–40	4500.000
6	5–6	40–60	6000.000
8	7–8	60–80	8000.000
10	9–10	80–100	11000.000

Table 4. Size of anaerobic digester in Bendosari village.

Method	Data	Remarks
Observation	**a.** Village characteristic **b.** Location of farmer **c.** Location of AD	Data collection through rapid rural appraisal (RRA)
Interview	Biogas management • Number of cows • Pasture system • Biogas production method • Household characteristic • Economic condition • Public condition • Demographic	Data source: • Village initiatives (household biogas/BIRU) • Village cooperative *SAE Pujon* • *Village administrator* • *Community*
Questionnaire	**a.** Perspective on individual behavior • Environmental concerns • Knowledge about biogas • Beliefs about benefits of biogas • Beliefs about cost biogas **b.** Willingness to pay (WTP) **c.** Questionnaire for *Elicitation Methods* using *Bidding Game Format* **d.** Preference of role in biogas development	Respondents are provided with questions to be answered related to their willingness to pay some amounts starting with the least up to the most amount. Yes/no questions must be answered beforehand. Only respondents with the yes answer are asked for the willingness to pay

Table 5. Methods for data collection.

status of biogas management, which are the biogas farmer, non-biogas farmer, and non-farmer (**Figure 2**). This stratification aims to divide a heterogeneous population (villager of Bendosari) into homogenous sub-population. Homogenous population avoids biased data collection [33].

2.3.2. Sampling technique

A questionnaire survey was conducted in August 2016 in Bendosari village. The questionnaires are designed, referring to the analytical framework presented in **Figure 3**. A stratified random sampling was used in the study. The number of samples were determined using

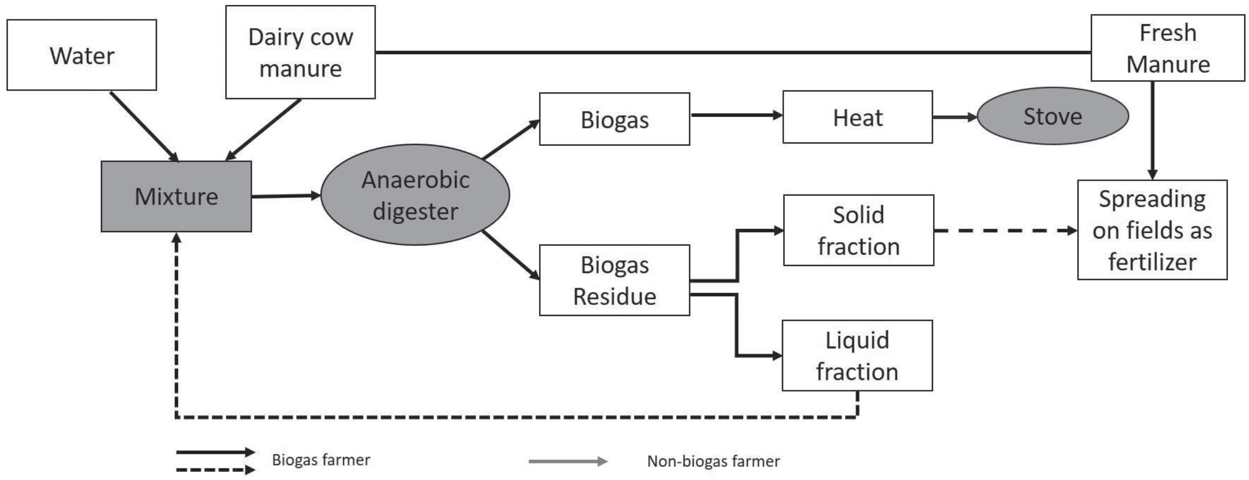

Figure 2. Biogas production system in Bendosari village.

Eq. (1), referring to each group of population discussed above. The stratified random sampling is the probability sampling method, enabling that every member in the population has the same opportunity to be chosen as a sample

$$n_i = \frac{N_i}{1 + N_i \alpha^2} \tag{1}$$

where n_i is the number of sample i, N_i is the number of population i, and α is the marginal error (10%).

The bidding game format was used to assess the WTP of biogas and non-biogas farmers as well as non-farmers. Nine independent variables were introduced in the equation and analyzed through a number of tests in multiple regression. The model resulting from the regression is used to calculate the probability of the respondents' preference of their role in rural biogas

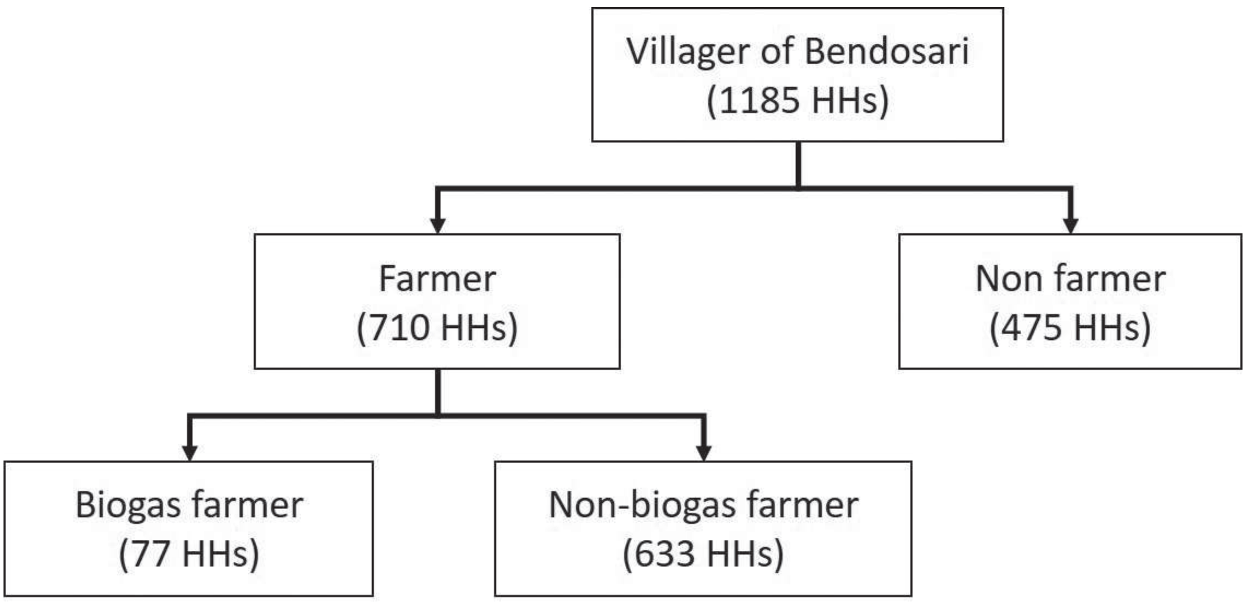

Figure 3. Stratification of population in Bendosari village.

development. The possible three roles are as provider, co-provider, or consumer. The value of probability indicates the public acceptance toward rural biogas development in Bendosari village. Eq. (2) is used to construct the regression model, while Eq. (3) is applied to calculate public acceptance

$$Z = \beta_O + \sum_{i=1}^{n} \beta_i x_i + \varepsilon_i \tag{2}$$

$$P_i = \frac{1}{1 + e^{-z}} \tag{3}$$

where P is the probability, β is the vector of estimated parameters, x is an independent variable, and i is assumed normally distributed.

2.2.3. Questionnaires

In all, 213 questionnaires were distributed to public households (farmers and non-farmers), where 44, 86, and 83 are required for biogas farmers, non-biogas farmers, and non-farmers, respectively. They are provided by questionnaires comprising three sections. The first section included questions relating to respondents' socioeconomic characteristics. The second part included a description of the current situation regarding biogas technology implementation, existing problems, and stakes of the current biogas management in the village. The third part included questions relating to the perception, attitudes, and awareness of the respondents toward biogas management in general. The data are required for measuring the willingness to pay (WTP) and determining the factors in rural biogas development using logistic regression. The respondents distributed among *dusuns* are proportional to the ratio of the number of households in *dusun* and in the village as shown in **Table 6**.

2.2.3.1. Willingness to pay

Initially, all respondents were asked for their willingness to pay. The respondents who were not willing to pay were asked a follow-up question to establish their reasons for not wanting to pay. Respondents with 'yes' answer were asked furthermore for bidding. **Figure 4** describes the procedures for getting the information about the WTP.

No.	Respondent category	Number of samples					Total
		Dusun Cukal	Dusun Dadapan Wetan	Dusun Dadapan Kulon	Dusun Ngeprih	Dusun Tretes	
1.	Biogas farmer	22	7	11	1	3	44
2.	Non-biogas farmer	32	12	28	4	10	86
3.	Non-farmer	37	4	23	5	14	83
Total							**212**

Table 6. Number of samples.

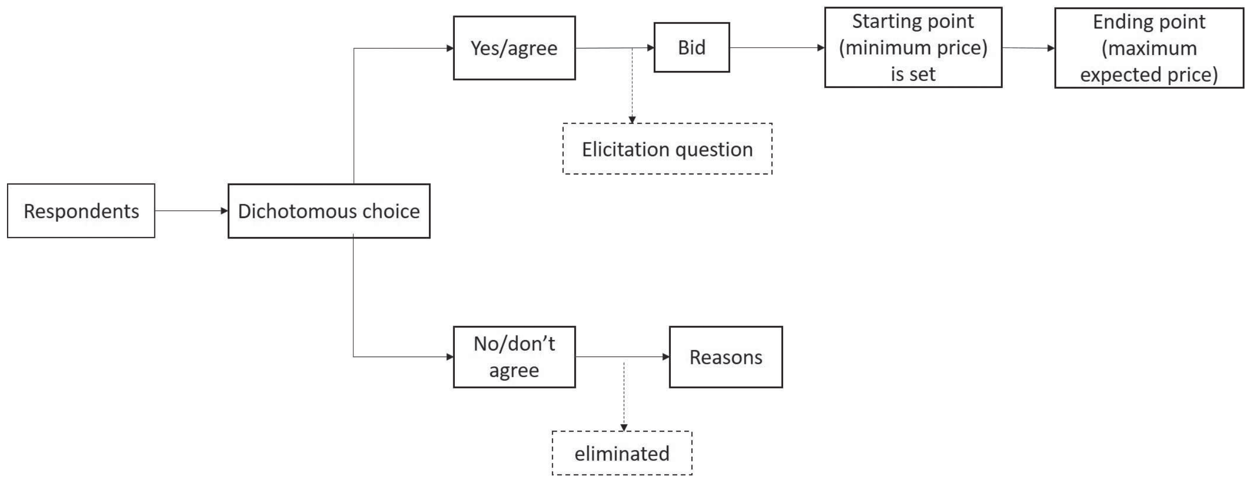

Figure 4. The structure of the question for WTP.

Three categories of respondents determine the amount of the first bid. Biogas farmers have already paid for the biogas technology. Hence, they were asked whether they were willing to pay more for better biogas technology. In contrast, non-biogas farmers have not used biogas technology and have not paid for it. Hence, they were asked whether they would be willing to pay for biogas technology. Non-farmers have the same situation as the non-biogas farmers. This group was asked whether they would be willing to pay for biogas distribution from the first and the second groups. The bid level is much lower than the other two groups since it refers to the conventional fuel expenses on a monthly basis. The cost for anaerobic digester construction and its regular maintenance are excluded from the amount that has to be paid.

2.2.3.2. Logistic regression

Logistic regression analysis was used to predict the preference of the role of each group (biogas farmer, non-biogas farmer, and non-farmers) using nine independent variables which are age, education level, income, concerns on environment, knowledge about biogas, perception about biogas benefit, perception about biogas cost, neighbor's interest on biogas, and self-perception about influence on people. These independent variables will be evaluated to measure the dependent variable, which is community acceptance on biogas. Variables are set as a dummy variable assigned with the value '0' and '1'. The criteria for values '0' and '1' are contextual with the questions given to the respondents. For example, for dependent variable, a value '1' is given if the answer is 'agree' and '0' is given if the answer is 'disagree.' Meanwhile, a value '1' is given if the answer is 'available' and '0' is given if the answer is 'not available' for the question of knowledge about biogas. Especially for sociodemographic data, that is, age, income, and education level, we set a certain value as a limit to group the data into two categories that can be valued as '0' and '1'.

2.2.4. Variables

Some variables have been chosen to answer the research objectives. The details of the variables are described in **Table 7**.

Criteria for determining the value of variables are explained in **Table 8**.

No.	Research objectives	Variable	Sub-variable	Method	Source
1.	Identifying public acceptance in Bendosari village based on community's perception on biogas development	• Sociodemographic	• Age • Education level • Income	Binary Logistic Regression	Ek [27]
		• Perspective on individual behavior	• Concern about environment • Knowledge about biogas • Beliefs about biogas benefit • Beliefs about biogas • cost • Perception of neighbor's participation • Perception of self-effectiveness		Modified from Liu et al. (2012)
2.	Identifying the value of *willingness to pay* and *ability to pay*	• Range of nominal price of AD construction and biogas distribution fee		Elicitation method (bidding game format)	Simanjuntak, Gusty Elfa M., (2009)
		• Gross income • Expenses			Handayani (2013)
3.	Identifying the role of villager on manure waste utilization for rural biogas development	• Preference of role on biogas development • WTP value • Distribution fee			Liu et al. (2012)

Table 7. Variables for the analysis.

Variable	Group	Value	Remarks	Criteria	Variable
1.	Community acceptance on biogas (Y)	Biogas farmers	0	Not will to pay	
			1	Will to pay	
		Non-biogas farmers	0	Not will to pay	
			1	Will to pay	
		Non-farmers	0	Not will to pay	
			1	Will to pay	

Variable	Group	Value	Remarks	Criteria	Variable
2.	Age (X1)	Biogas farmers	0	Non-productive	<15 years and >64 years
			1	Productive	15–64 years
		Non-biogas farmers	0	Non-productive	<15 years and >64 years
			1	Productive	15–64 years
		Non-farmers	0	Non-productive	<15 years and >64 years
			1	Productive	15–64 years
3.	Education level (X2)	Biogas farmers	0	Having basic education	≤Junior high school
			1	Having more than basic education	>Junior high school
		Non-biogas farmers	0	Having basic education	≤Junior high school
			1	Having more than basic education	>Junior high school
		Non-farmers	0	Having basic education	≤Junior high school
			1	Having more than basic education	>Junior high school
4.	Income (X3)	Biogas farmers	0	Income/month	<Rp 2,000,000,00
			1	Income/month	≥Rp 2,000,000,00
		Non-biogas farmers	0	Income/month	<Rp 2,000,000,00
			1	Income/month	≥Rp 2.000.000,00
		Non-farmers	0	Income/month	<Rp 2,000,000,00
			1	Income/month	≥Rp 2,000,000,00
5.	Concern about environment (X4)	Biogas farmers	0	Without concern	
			1	With concern	
		Non-biogas farmers	0	Without concern	
			1	With concern	
		Non-farmers	0	Without concern	
			1	With concern	
6.	Knowledge about biogas (X5)	Biogas farmers	0	Without knowledge	
			1	With knowledge	
		Non-biogas farmers	0	Without knowledge	
			1	With knowledge	
		Non-farmers	0	Without knowledge	
			1	With knowledge	

http://dx.doi.org/10.5772/intechopen.69191

Variable	Group	Value	Remarks	Criteria	Variable
7.	Beliefs about Biogas benefit (X6)	Biogas farmers	0	Without knowledge about biogas benefit	<3
			1	With knowledge about biogas benefit	≥3
		Non-biogas farmers	0	Without knowledge about biogas benefit	<5
			1	With knowledge about biogas benefit	≥5
		Non-farmers	0	Without knowledge about biogas benefit	<4
			1	With knowledge about biogas benefit	≥4
8.	Beliefs about Biogas cost (X7)	Biogas farmers	0	Affordable	<2
			1	Not affordable	≥2
		Non-biogas farmers	0	Affordable	<1
			1	Not affordable	≥1
		Non-farmers	0	Affordable	<2
			1	Not affordable	≥2
9.	Perception of neighbor's participation (X8)	Biogas farmers	0	Not having influence	
			1	Having influence	
		Non-biogas farmers	0	Not having influence	
			1	Having influence	
		Non-farmers	0	Not having influence	
			1	Having influence	
10.	Perception of self-effectiveness (X9)	Biogas farmers	0	Not having influence	
			1	Having influence	
		Non-biogas farmers	0	Not having influence	
			1	Having influence	
		Non-farmers	0	Not having influence	
			1	Having influence	

Table 8. Criteria for dependent and independent variables.

3. Results and discussion

3.1. Public acceptance on biogas technology

Based on the survey, sociodemographic conditions are presented in **Table 9**. Most farmers (biogas and non-biogas) are 66–70 years old, and most non-farmers are 36–40 years old. Education level is mostly more than junior high school, indicating that approximately, community ability

Parameter	Unit/measurement	Group		
		Biogas farmers	Non-biogas farmers	Non-farmers
Age	Years	66–70 years	66–70 years	36–40 years
Education level	Years of education	12 years	12 years	12 years
Income	Rp/month	>Rp 1,000,000–Rp 1,500,000	>Rp 1,000,000–Rp 1,500,000	>Rp 1,000,000–Rp 1,500,000

Table 9. Sociodemographic of respondents.

to accept information as well as to support biogas development is relative high. Mostly, household income for biogas farmers, non-biogas farmers, and non-farmers is low, ranging between Rp 1,000,000.00 and Rp 1,500,000.00. Low income may affect the ability to pay (ATP) for AD.

The result from regression analysis shows that there are two variables influencing the decision of biogas farmers to pay, that is, perception on biogas cost and perception of self-influence on other biogas users. Furthermore, five variables influencing the decision of non-biogas farmers to pay biogas, that is knowledge about biogas, perception on biogas benefit and cost, neighbor's interest toward biogas utilization of people, and perception of self-influence toward other users. For non-farmers, variables of knowledge about biogas, perception on benefit, and cost are determinant factors in decision-making to pay biogas technology (**Table 10**).

Group	Individual self-perception	B	Sig.	Exp(B)
Biogas farmers	Cost	2.803	0.026	16.496
	Self-perception	2.830	0.016	16.943
	Constant	−5.309	0.009	0.005
Non-biogas farmers	Knowledge	1.637	0.033	5.142
	Benefit	1.604	0.036	4.971
	Cost	1.616	0.025	5.032
	Neighbor's perception	1.629	0.028	5.101
	Self-perception	1.659	0.021	5.256
	Constant	−6.849	0.000	0.001
Non-farmers	Knowledge	4.493	0.045	89.346
	Benefit	5.345	0.010	209.524
	Cost	4.226	0.004	68.449
	Constant	−13.664	0.002	0.000

Table 10. Determinants of public acceptance toward biogas technology.

The results from regression analysis are presented as follows:

1. Regression model for biogas farmer:

   $Z = 5787 - 2832 \times 7 - 3255 \times 9$

2. Regression model for non-biogas farmer:

   $Z = 3752 - 1724 \times 3 - 1847 \times 5 - 1489 \times 6 - 1698 \times 7 - 1299 \times 9$

3. Regression model for non-farmer:

   $Z = 5750 - 4493 \times 5 - 5345 \times 6 - 4226 \times 7$

The model is applied to calculate the probability of public acceptance toward biogas technology for each group using Eq. (2). Public acceptance is reflected by willingness or unwillingness to pay. The result shows that public acceptance toward biogas technology is relative low since the percentage of farmers who is willing to pay biogas technology is only 39, 12, and 33% for the biogas farmer, non-biogas farmer, and non-farmer, respectively (**Table 11**). The acceptance of biogas farmer is higher than other groups (non-biogas farmers and non-farmer). However, all percentages are relative low that all groups have low interest in supporting the biogas development. Samples unwilling to pay for biogas technology are excluded, and only samples agreeing to pay for are asked for their value of WTP. Based on the questionnaires, low WTP of biogas farmers is caused by their perception that biogas cost (AD construction cost) is higher than benefit, while low WTP of non-biogas farmers and non-farmers is caused by lack of knowledge about biogas, unaffordability, neighbor's interest, and perception of self-influence toward others. Value of WTP is required to identify because this value is compared to the ability to pay (ATP). If WTP is lower than ATP, it indicates that the product (biogas technology in this case) has no importance value for samples and vice versa.

3.2. Willingness to pay

Farmers' WTP of biogas technology is related to the minimum and maximum AD construction cost accepted as affordable which are zero and Rp 10.1 million, respectively. HIVOS, a

Group	Prediction	Prediction
	Willing to pay	**Willing to pay**
Biogas farmers	39%	39%
Non-biogas farmers	12%	12%
Non-farmers	33%	33%

Table 11. Prediction of public acceptance through willingness to pay.

Dutch NGO, gives financial support of Rp 2.0 million for each AD as shown in **Table 12**. WTP value varies with different incomes where WTP of farmers ranges between Rp 3.0 million and Rp 6.0 million and Rp 0.9 million and Rp 3.0 million for biogas farmers and non-biogas farmers, respectively, while WTP of non-farmers for biogas distribution fee ranges between Rp 20,833 and Rp 66,670. However, biogas farmers' WTP is higher than non-biogas farmers' WTP because they have got benefits of biogas technology. Based on the interview, biogas farmers can reduce fuel expenses for cooking up to 100% (**Table 13**).

According to [34], ability to pay (ATP) refers to net income calculated by subtracting expenses from gross income. **Table 14** shows that most WTP values are higher than ATP values. It means that biogas technology, as a product, has an important value that samples are willing to pay for it. During interviews, respondents are asked for their preference to play a role in biogas development in Bendosari village. There are three types of roles that can be chosen, that is, as a producer, co-provider, or consumer. Producer is a farmer producing biogas and using only for his family, co-provider is a farmer producing and distributing biogas for both his family and his neighbors, and consumer is a farmer or non-farmer only buying biogas for his domestic use.

No.	AD capacity (m^3)	Construction cost (Rp Mio)	Financial support from NGO (Rp Mio)	Cost paid by user (Rp Mio)
1.	4	6.3	2	4.3
2.	6	7.9	2	5.9
3.	8	8.8	2	6.8
4.	10	10.1	2	8.1
5.	12	11	2	9.0

Table 12. Cost for anaerobic digester construction.

Class	Income	Value of willingness to pay (Rp)	Class	Income
		Biogas farmers	**Non-biogas farmers**	**Non-farmers**
1	6,000,000–1,325,000	3,000,000–5,500,000	900,000–2,500,000	20,833–54,170
2	>1,325,000–2,050,000	2,400,000–5,000,000	600,000–2,000,000	33,000–63,340
3	>2,050,000–2,775,000	2,000,000–4,000,000	1,500,000–3,000,000	25,834–50,000
4	>2,775,000–3,500,000	3,000,000–6,000,000		25,000–66,670

Table 13. Willingness to pay by respondents.

Group	Income class	Ability to pay (ATP)	Willingness to pay (WTP)	Comparison	Preference of role
Biogas farmer	1	Rp 480,000	Rp 3,000,000–Rp 5,500,000	ATP < WTP	Producer
		Rp 540,000	Rp 3,000,000–Rp 5,500,000	ATP < WTP	Producer
		Rp 720,000	Rp 3,000,000–Rp 5,500,000	ATP < WTP	Co-provider
		Rp 735,000	Rp 3,000,000–Rp 5,500,000	ATP < WTP	Producer
	2	Rp 900,000	Rp 2,400,000–Rp 5,000,000	ATP < WTP	Co-provider
		Rp 900,000	Rp 2,400,000–Rp 5,000,000	ATP < WTP	Producer
		Rp 1,050,000	Rp 2,400,000–Rp 5,000,000	ATP < WTP	Co-provider
		Rp 1,200,000	Rp 2,400,000–Rp 5,000,000	ATP < WTP	Consumer
		Rp 1,200,000	Rp 2,400,000–Rp 5,000,000	ATP < WTP	Co-Provider
		Rp 1,200,000	Rp 2,400,000–Rp 5,000,000	ATP < WTP	Producer
	3	Rp 1,500,000	Rp 2,000,000–Rp 4,000,000	ATP < WTP	Producer
		Rp 1,200,000	Rp 2,000.000–Rp 4,000,000	ATP < WTP	Co-Provider
		Rp 1,800,000	Rp 2,000,000–Rp 4,000,000	ATP < WTP	Co-provider
Non-biogas farmer	1	Rp0	Rp 900,000–Rp 2,500,000	ATP < WTP	Co-provider
		Rp 50,000	Rp 900,000–Rp 2,500,000	ATP < WTP	Co-provider
		Rp 50,000	Rp 900,000–Rp 2,500,000	ATP < WTP	Consumer
	2	Rp 200,000	Rp 600,000–Rp 2,000,000	ATP < WTP	Consumer
		Rp 800,000	Rp 600,000–Rp 2,000,000	ATP = WTP	Producer
		Rp 900,000	Rp 600,000–Rp 2,000,000	ATP = WTP	Producer
	3	Rp 100,000	Rp 1,500,000–Rp 3,000,000	ATP < WTP	Co-provider
		Rp 250,000	Rp 1,500,000–Rp 3,000,000	ATP < WTP	Producer
		Rp 250,000	Rp 1,500,000–Rp 3,000,000	ATP < WTP	Co-provider

Group	Income class	Ability to pay (ATP)	Willingness to pay (WTP)	Comparison	Preference of role
Non-farmers	1	Rp 0	Rp 250,000–Rp 650,000	ATP < WTP	Consumer
		Rp 0	Rp 250,000–Rp 650,000	ATP < WTP	Producer
		Rp 150,000	Rp 250,000–Rp 650,000	ATP < WTP	Consumer
		Rp 300,000	Rp 250,000–Rp 650,000	ATP = WTP	Consumer
		Rp 350,000	Rp 250,000–Rp 650,000	ATP = WTP	Co-provider
	2	Rp 500,000	Rp 400,000–Rp 760,000	ATP = WTP	Consumer
		Rp 700,000	Rp 400,000–Rp 760,000	ATP = WTP	Consumer
		Rp 750,000	Rp 400,000–Rp 760,000	ATP = WTP	Consumer
		Rp 800,000	Rp 400,000–Rp 760,000	ATP > WTP	Consumer
		Rp 900,000	Rp 400,000-Rp 760,000	ATP > WTP	Consumer
		Rp 1,000,000	Rp 400,000–Rp 760,000	ATP > WTP	Consumer
		Rp1,000,000	Rp 400,000–Rp 760,000	ATP > WTP	Co-provider
		Rp1,050,000	Rp 400,000–Rp 760,000	ATP > WTP	Producer
		Rp 1,250,000	Rp 400,000–Rp 760,000	ATP > WTP	Consumer
	3	Rp 500,000	Rp 310,000–Rp 600,000	ATP = WTP	Consumer
		Rp 750,000	Rp 310,000–Rp 600,000	ATP > WTP	Consumer
		Rp 850,000	Rp 310,000–Rp 600,000	ATP > WTP	Consumer
		Rp 1,000,000	Rp 310,000–Rp 600,000	ATP > WTP	Producer
		Rp 1,200,000	Rp 310,000–Rp 600,000	ATP > WTP	Producer
		Rp 1,200,000	Rp 310,000–Rp 600,000	ATP > WTP	Consumer
	4	Rp 700,000	Rp 300,000–Rp 800,000	ATP = WTP	Consumer
		Rp 900,000	Rp 300,000–Rp 800,000	ATP > WTP	Consumer

Table 14. Classification of WTP and preference of role in biogas development.

4. Conclusion

Rural biogas development requires acceptance of the community which can be reflected through their involvement. Research objectives are set to find out the factors influencing the decision of involvement and to measure villager involvement in biogas development according to their preference of role in biogas development using regression analysis. There are three options of roles which are producer, co-provider, and consumer. The determinants for public acceptance toward biogas technology in one group differ from the other groups. Beliefs about cost of biogas and self-perception are important factors for biogas farmers, while knowledge, beliefs about cost and benefit of biogas, perception of neighbor's participation, and self-perception are the driving forces for non-biogas farmers. For non-farmers, knowledge and beliefs about the cost and benefit of biogas are the determinants.

The comparison between ATP and WTP comes to the result that all biogas farmers have ATP values higher than WTP where this condition describes that the product (biogas) has importance for consumer [35]. In this case, ATP is higher than WTP because biogas farmers have experienced the benefit of biogas and they want to sustain the technology although the price is unaffordable. Meanwhile, some non-biogas farmers (20%) have an ATP value which equals to WTP value, indicating that there is a balance between importance and cost. Eighty percentage of non-biogas farmers have ATP value lower than WTP value, indicating that biogas is important for them. Furthermore, three conditions exist in the non-farmer group where 44% have an ATP value higher than WTP value, 37% have ATP value equal to WTP value, and 19% have ATP value lower than WTP value. The percentage shows that the majority of non-farmers have ATP higher than WTP, indicating the low importance of biogas. The lack of knowledge about biogas is the main factor for this.

A preference of the role in biogas technology varies among the three groups. The percentage of the role for biogas farmers is 41, 53, and 6% as a producer, co-provider, and consumer, respectively. The percentage of the role for non-biogas farmers is 34, 44, and 22% as a producer, co-provider, and consumer, respectively. Meanwhile, the percentage of the role for non-farmers is 10, 81, and 1% as a producer, co-provider, and consumer, respectively.

Author details

Christia Meidiana*, Zuqnia Gita Ramadhani and Dian Dinanti

*Address all correspondence to: c_meideiana@ub.ac.id

Faculty of Engineering, Brawijaya University, Kota Malang, Jawa Timur, Indonesia

References

[1] Mulyono D. Pemanfaatan kotoran ternak sebagai sumber energi alternatif dan peningkatan sanitasi lingkungan. Teknologi Lingkungan. 2000;**1**(1):27-32

[2] Čucek L, Droběz R, Pahor B, Kravanja Z. Sustainable synthesis of biogas processes using a novel concept of eco-profit. 2012

[3] Akella AK, Saini RP, Sharma MP. Social, economical and environmental impacts of renewable energy systems. Renewable Energy. 2009;**34**(2):390-396

[4] Chen R. Livestock-biogas-fruit systems in South China. Ecological Engineering. 1997;**8**: 19-29

[5] Chen Y, Yang G, Sweeney S, Feng Y. Household biogas use in rural China: A study of opportunities and constraints. Renewable Sustainable Energy Reviews. 2010;**14**:545-549

[6] Cheng S, Li Z, Shih J, Du X, Xing J. A field study on acceptability of 4-in-1 biogas systems in Liaoning province. China Energy Proceedings. 2011;**8**:1382-1387

[7] Zhang LX, Wang CB, Song B. Carbon emission reduction potential of a typical household biogas system in rural China. Journal of Cleaner Production. 2012;**47**:415-421

[8] Rao PV, Baral SS, Dey R, Mutnuri S. Biogas generation potential by anaerobic digestion for sustainable energy development in India. Renewable and Sustainable Energy Reviews. 2010;**14**:2086-2094

[9] Yu L, Yaoqiu K, Ningsheng H, Zhifeng W, Lianzhong X. Popularizing householdscale biogas digesters for rural sustainable energy development and greenhouse gas mitigation. Renewable Energy. 2008;**33**:2027-2035

[10] Anthony DO. Renewable energy: Externality costs as market barriers. Energy Policy. 2006;**34**(5):632-642

[11] Klaas VA, Huden SK, Marko PH. Policy measures to promote the widespread utilization of renewable energy technologies for electricity generation in the Maldives. Renewable and Sustainable Energy Reviews. 2008;**12**(7):1959-1973

[12] Pegels A. Renewable energy in South Africa: Potentials, barriers and options for support. Energy Policy. 2010;**38**(9):4945-4954

[13] Kobos PH, Erickson JD, Drennen TE. Technological learning and renewable energy costs: Implications for US renewable energy policy. Energy Policy. 2006;**34**(13):1645-1658

[14] Ajzen I. The theory of planned behavior. Organizational Behavior and Human Decision Processes. 1991;**50**:179-211

[15] Ben-Elia E, Ettema D. Rewarding rush-hour avoidance: A study of commuters' travel behavior. Transportation Research. 2011;**45**:567-582

[16] Eliasson J, Johnsson L. The unexpected "yes": Explanatory factors behind the positive attitudes to congestion charges in Stockholm. Transport Policy. 2011;**18**:636-647

[17] Liu W, Wanga C, Mol APJ. Rural public acceptance of renewable energy deployment: The case of Shandong in China. Applied Energy. 2013;**102**:1187-1196

[18] Schweizer Reis P. Energy sustainable communities. Environmental Psychological Investigations. 2008;**36**:4126-4135

[19] Stren PC. Toward a coherent theory of environmentally significant behaviour. Journal of Social Issues. 2000;**56**(3):407-424

[20] Fishbein M, Ajzen I. Belief, Attitude, Intention, and Behavior: An Introduction to Theory and Research. Boston: Addison Wesley; 1975

[21] Hansen T, Jensen JM, Solgaard HS. Predicting online grocery buying intention: A comparison of the theory of reasoned action and the theory of planned behavior. International Journal of Information Management. 2004;**24**:539-550.

[22] Ajzen I. From intentions to actions: A theory of planned behavior. In: Kuhland J, Beckman J, editors. Action-Control: From Cognitions to Behavior. Heidelberg: Springer; 1985. pp. 11-39

[23] Raje DV, Dhobe PS, Deshpande AW. Consumer's willingness to pay more for municipal supplied water: A case study. Ecological Economics. 2002;**42**(3):391-400

[24] Nomura N, Akai M. Willingness to pay for green electricity in Japan as estimated through contingent valuation method. Applied Energy. 2004;**78**(4):453-463

[25] Hansla A, Gamble A, Juliusson A, Gärling T. Psychological determinants of attitude towards and willingness to pay for green. Energy Policy. 2008;**36**:768-774

[26] Jobert A, Laborgne P, Mimler S. Local acceptance of wind energy: Factors of success identified in French and German case studies. Energy Policy. 2007;**35**:2751-2760

[27] Ek K. Public and private attitudes towards '''green'' electricity: The case of Swedish wind power. Energy Policy. 2005;**33**:1677-1689

[28] Batley SL, Colbourne D, Fleming PD, Urwin P. Citizen versus consumer: Challenges in the UK green power market. Energy Policy. 2001;**29**:479-487

[29] Tanner C, Kast SW. Promoting sustainable consumption: Determinants of green purchases by Swiss consumers. Psychology and Marketing. 2003;**20**:883-902

[30] Zografakis N, Sifaki E, Pagalou M, Nikitaki G, Psarakis V, Tsagarakis KP. Assessment of public acceptance and willingness to pay for renewable energy sources in Crete. Renewable Sustainable Energy Reviews. 2010;**14**:1088-1095

[31] Batley SL, Fleming PD, Urwin P. Willingness to pay for renewable energy: Implications for UK green tariff offerings. Indoor and Built Environment. 2000;**9**:157-170

[32] Akbulut A. Techno-economic analysis of electricity and heat generation from farm-scale biogas plant: Çiçekdagı case study. Energy. 2012;**44**:381-390

[33] Buesch D, Granacher U, editors. Routledge Handbook of Talent Identification and Development in Sport. 1st ed. New York: Routledge; 2017

[34] Handayani E, Gondodiputro S. Kemampuan membayar (Ability to Pay) masyarakat untuk iuran jaminan kesehatan. Bandung Indonesia: Universitas Padjajaran Press; 2012

[35] Tamin OZ. Evaluasi tarif angkutan umum dan analisis ability To Pay (ATP) dan Willingness To Pay (WTP) di DKI Jakarta. Bandung Indonesia: ITB Press; 1999