



Consumption Patterns of Rural Community Users of Micro-Hydro Power

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Abstract

One form of the environmentally friendly power plant is Micro Hydro Power (MHP). An area in East Java that uses MHP as a power source is Seloliman Village in Mojokerto. Although this village has the resources to produce electricity independently, not all residents are willing to use this energy for various reasons. This study aims to formulate consumption patterns of MHP users in rural areas based on socio-economic characteristics in development communication theory. To achieve this, quantitative research approaches and methods are used through the Near Ideal Linear Approximation Demand (LA/AIDS) system model using microdata from a survey that targets all residents in Seloliman Village up to fifty-three heads of families. Based on the results of previous studies, the researcher assumes that the consumption patterns of villagers are influenced by socioeconomic factors and the results show that in general socioeconomic characteristics play an important role in determining household energy consumption patterns.

Keywords: Consumption Pattern; Sustainable Energy; Micro-Hydro Power (MHP)

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Introduction

One potential source of renewable energy is water. The potential for water energy is large; however, its utilization has not been maximized. Therefore, it is appropriate to develop the potential of water energy to meet electricity needs in remote/rural areas, which can also be used as an interconnection system with the existing State Electricity Company/PLN network (Hanggara & Harvi, 2017).

The idea was motivated by data in figure 1. The chart shows a lot of renewable energy potential in SPP (Solar Power Plants) in 2019 according to data from the Institute for Essential Services Reform (IESR). However, SPP in Indonesia faces many challenges, both geographically and economically. A study result by (Frastuti, 2020) showed that there is a significant influence of economic factors on people's interest in using the rooftop solar power system. It means that economic factors are elements that can influence interest in using the rooftop power plant system. Community interest in using solar power, as much as 88.9%, is caused by economic factors; while the remaining 11.1% comes from outside the variables being studied, such as assumptions about the initial investment costs for installation, the installation,

or other thinking patterns (Frastuti, 2020).

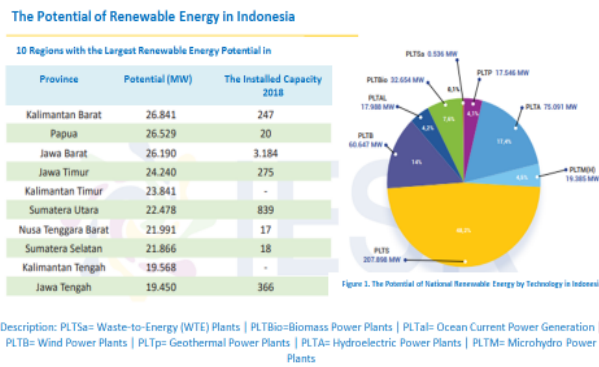


Figure 1. The Potential of National Renewable Energy by Technology in Indonesia
Source: IESR, 2019

In rainy season, SPP performance will not be optimal due to the lack of sunlight intensity (Susanto et al., 2018). Thus, water sources or Micro Hydro Power Plants (MHP) will become another promising energy source for that concern. In the province of Jawa Timur (East Java) alone, based on data in 2018, the potential for SPP producing electricity is 24,240 Megawatts (MW), while those already installed are 275 MW (IESR, 2019). Meanwhile, MHP in the East Java province is in the fourth position for the amount of potential, and plans for installation in 2019-2028 will be conducted at 55 potential points as shown in figure 2.



Figure 2. The Potential of Renewable Energy in East Java
Source: IESR, 2019

Previous studies related to MHP have been conducted and act as supporting studies. One study result stated that MHP potential in Ngantang Regency is quite large considering that the area is located in the highlands so that it can be developed more. This potential source of water energy is in the form of water sources from rivers that have a continuous discharge throughout the year (Hanggara & Harvi, 2017). People in Ngantang use MHP as a means of irrigation for their fields throughout the year so that they can avoid crop failure. The same thing happened in Kediri Regency through the Dusun Kelud empowerment program. The programs provided consist of goat farming, chili drying, and cultivation of Indigofera plants which require electrical energy to run the equipment; residents then use MHP as a water source in Dusun Laharpang that runs quite heavy in two seasons (Abdul, 2017). Likewise, in Bendosari Village, Malang Regency, which is located around a spring, the electricity generated by MHP is used for lighting and operating electric water pumps to increase the supply of clean water for residents (Utami et al., 2019).

The explanation above shows that the use of MHP can be an alternative to new and renewable energy replacing fossil energy. It will help to overcome the problem of high electricity consumption and the uneven supply of electrical energy, especially in rural areas, by utilizing the existing river flows. The use of MHP is in accordance with environmental conditions in Indonesia, which is hilly and has many rivers. Such geographical conditions can be utilized for the manufacture of MHP (Sugiharto, 2018).

Since the focus of this research is MHP in a rural area, the study is deliberately conducted in Seloliman Village, Mojokerto, East Java. This village has been using renewable energy since 1994 with the assistance of PPLH (Environmental Research Center) in collaboration with the German Embassy. By 2021, Seloliman Village has already had two MHP of large-scale (25kva) and a small scale (15kva). The two turbine housings are coordinated by the Paguyuban Kali Maron or PKM (Maron Creek Association). In addition, other hamlets (dusun) in Seloliman Village can also use the MHP. However, not all residents use this source of electrical energy because companies operating in the electricity sector or PLN have entered their hamlets first before the MHP was established. Apart from that, the electrical energy produced by the MHP is also limited as there is no potential to make another MHP.

Based on the explanation above, the potential to develop MHP as one of the alternative energy sources is quite promising. However, many supports are needed to help the realization of MHP in many other areas. More studies related to MHP are discussing the use of energy but lacking in the social aspects. Therefore, this study tries to identify the consumption pattern of the community that uses MHP. The understanding of consumption patterns is important to predict how certain groups of people have some preference toward energy, thus it can become a consideration before developing one source of renewable energy in an area. Besides, consumption patterns will help local government to create an effective campaign and community-based activities to encourage the community to use renewable energy. In this study, socio-economic characteristics have a big role in showing consumption patterns. Several studies related to consumption patterns have been carried out, but not the one related to renewable energy in Indonesia.

Research Method

This research took place at Seloliman Village, Mojokerto, Jawa Timur. It was chosen because it was one of the villages in Jawa Timur that used MHP as an energy producer and no one has ever conducted research in that place before. This research was carried out from January to June 2021. The primary data used in this study was cross-section data derived from survey results conducted to all residents of Seloliman Village through an analytical survey method that was processed using STATA 13 software. Meanwhile, the secondary data taken was the demographics of the residents and a general description of the research site. The population and sample in this study were 53 household heads in Seloliman Village; they represented the total of all existing residents. The researchers applied total sampling to the research respondents with consideration that the total population was less than 100. Each respondent filled out the questionnaire with assistance. The econometric approach is carried out using the Error Correction-Linear Approximation Almost Ideal Demand System (EC-LA/AIDS) model. The model is estimated using the Seemingly Unrelated Regression (SUR) method. To conform to the theory of development communication, adding-up restrictions, symmetry, and homogeneity are included in the model.

This model is used to study the consumption function by adding socio-economic variables, which are proxied from price, income, age of household head, gender of household head, education of household head, the main occupation of household head, regional typology, homeownership status, and household poverty status. The effect can be seen from the estimation results of the LA/AIDS equation system coefficient, simultaneous test, and partial test. Then, the variables included in the consumption pattern model are tested to find out whether they are stationary or not. If the data are integrated to the same degree, cointegration can be performed on all respondents in this study. The cointegration test is carried out by first forming the residual obtained by regressing the independent variable to the dependent variable. Firstly, the LA/AIDS and EC-LA/AIDS system models are estimated without using the unrestricted form of restriction. Next, the homogeneity and symmetry restrictions are inserted in the system separately and then combine to estimate the restricted model. The parameters in EC-LA/AIDS equation are used as a basis for calculating short-term elasticity, while the parameters in LA/AIDS are used as a basis for calculating long-term elasticity until consumption patterns are found and culminate in the proof of hypothesis proposed by the researchers.

Results and Discussion

The Effect of Price

Since they could not reach Seloliman village, PLN asked the Environmental Education Center (PPLH) of Seloliman to establish an MHP in Seloliman Village. PLN is not the only BUMN (state-owned enterprises) unit having constraints in approaching people in rural areas (geographical constraints);

other BUMN business units (Pertamina) also experience the same thing, the economic constraint for exact, in marketing fuel oil products. The results of a survey by WWF Indonesia and Nielsen in 2017 showed that as many as 63% of Indonesian consumers were willing to consume environmentally friendly products at higher prices. This indicates a significant increase in consumer awareness of the consumption of environmentally friendly products and indicates the readiness of the domestic market to absorb sustainably produced products. Consumers have become the main force to be reckoned with to achieve the goals of environmental protection and sustainable development. A fairly wide range of studies seeks a better understanding of the factors that determine the performance of environmentally responsible behavior. Environmental attitudes, environmental concerns, socio-demographic characteristics, personality, environmental knowledge, and the environment are some of the variables commonly used by researchers to explain nuances in environmental awareness. Environmentally conscious consumers are more likely to show a sense of protection for the environment. Therefore, they are willing to change their consumption behavior to minimize the negative impact on the environment (Chandra et al., n.d.). Although it has been 12 years since the previous research was conducted in 2005, similar results regarding the price effect factor were also delivered by a different follow-up researcher in 2017. The results show that the profitability of the surveyed companies is positively influenced by value-based pricing strategies and high price levels, and is negatively affected by a low price level (De Toni et al., 2017). These findings indicate that pricing policies affect organizational profitability, thus, to be more strategic in seeing the pricing process is an aspect that cannot be ignored by-product or service owners. Pricing strategy should be a major thing to approach target consumers. The same thing is also done by PLN to approach residents of Seloliman, where the first step is to disseminate information about the form of water-fueled energy. PPLH gathers all residents and specifically targets male residents in the age range of 41-50 years with the consideration that PPLH can use them as KOL (Key Opinion Leader) who will help PPLH carry out socialization to residents. One of the main points raised specifically in the socialization is the price or cost that will be charged to residents who use this energy. Therefore, price becomes one of the dimensions in this study to measure its effect on energy consumption decisions in Seloliman Village.

From previous research conducted by Raymond Li et al. in 2021, they predicted that fossil fuel prices in Europe would have a stronger impact on renewable energy consumption if fossil fuels take up a larger share of electricity generation. Thus, rather than estimating the impact of coal and natural gas prices on renewable energy consumption directly, prices are weighted based on the share of power generation from coal and natural gas. There are not many literature studies that analyze the price control of non-renewable energy sources that compete with renewable energy. Their findings on short-term and long-term causality from coal and natural gas prices to renewable energy consumption confirm the substitution between renewable and non-renewable energy. The fact that short-term causality is found shows that the price of fossil fuels can affect the cost of procuring and delivering electricity economically. These results show that apart from setting consumption targets for renewable energy that have been implemented in Europe, the government has other ways to promote the use of renewable energy through fossil fuel prices (Raymond et al., 2021). It shows that the government can make a price policy between renewable energy and fossil energy to encourage people to use renewable energy instead of fossil energy by raising the price of fossil energy to be more expensive than renewable energy prices. That way, people will gradually switch to using renewable energy, especially in rural areas where the price factor is one of the main factors in determining energy use.

Based on the results of the study, it was found that prices can influence energy consumption decisions. This dimension measures the price commensurate with the benefits and product, affordability, price comparison, and the suitability between price and quality. The indicators used in this study are very supportive for the consumption decisions of MHP users. Many of the respondents use price dimension as a consideration because they are in a community area with socio-economic characteristics. This is indicated by their main job as farm laborers so that expenditure items other than basic needs are really needed to be well thought of. The relatively low price strongly supports consumers to decide and buy energy from MHP. There were only a few previous studies related to the effect of prices on renewable energy consumption decisions in Indonesia. The results of previous studies were more about the effect of renewable energy consumption, energy prices, and trade on emissions in G7 countries which show that there was a negative effect of energy prices on CO2 emissions. The effects of renewable energy consumption and trade differ across countries. Granger Causality panel shows the one-way causality flowing from energy prices. Consumption of renewable energy has no causal relationship with CO2 emissions but indirectly affects CO2 emissions through

its direct effect on energy prices. Joint action in trade, energy prices, and country-specific renewable energy policies have implications for environmental sustainability and the achievement of the Sustainable Development Goals (SDGs) (Ike et al., 2020).

Other research on renewable energy shows that traditional energy sources fail to reflect their real costs of usage. Renewable energy does not consider the costs incurred to overcome environmental problems due to the greenhouse effect that causes increased gas emissions, thus triggering changes in the global climate system. Other researchers researched the effect of energy prices on renewable energy development in different economic growth rates of OECD (Organization for Economic Co-operation and Development) member countries. The results show that countries with high economic growth rates can respond to the impact of energy prices by changing the use of renewable energy. On the other hand, countries with low economic growth rates tend to be unresponsive to energy prices in their use of renewable energy (da Silva et al., 2018). Based on that research, it can be concluded that the level of economic growth can affect the decision to consume renewable energy, and one of the factors to be considered is the price set by the government. Meanwhile, in Seloliman Village, the cost calculation for determining the price of MHP renewable energy only includes management and production costs since the energy is managed independently. The determination of cost calculation as such is due to the fact that energy sources obtained from river flows have been provided naturally by nature so that costs are charged only to those two elements. In addition to creating energy independence in the region, with a demographic condition of 74% of residents working as farm laborers, residents are quite responsive to energy prices by continuing to consume the energy produced by their villages.

The Effect of Renewable Energy Consumption Decisions of Rural Residents on The Use of Micro Hydro Power Plant (MHP) Energy

The influence of MHP energy use decisions is obtained from the prices and services received by residents that make them decide to use this energy. 8 stages in the dimension of energy consumption decision show that consumers undergo these 8 stages seriously which take quite some time. Each stage involves external parties and internal parties, and the variety of information received creates more alternatives so that more time is needed to be able to make a decision. Not only that but the determination of renewable energy consumption decisions is also influenced by the policies made by the government. Specific public policies on Energy Systems Integration (ESI) have also emerged to regulate energy use and regulation. However, it turns out that this policy creates economic obstacles in Europe where policies related to ESI cannot increase the number of investors who invest in ESI (Cambini et al., 2020) The decision to consume renewable energy in Europe is different from that in Asia, especially Indonesia. Each region in Indonesia implements public policies based on a decentralized or devolved system and a centralized system.

The limited availability of non-renewable energy poses a challenge to the resilience energy of a country in achieving economic momentum so that currently, renewable energy is being intensified which can maintain economic momentum. Theoretical and empirical evidence shows that the use of energy plays a very important role in economic growth, but there is a shift in energy from fuel to high-quality energy. Currently, electricity is one of the energies that become a challenge faced by Indonesia in economic momentum. In addition to renewable energy, there is still much alternative energy or other renewable energy that greatly affect economic growth, such as micro-hydro energy, which has a significant relationship in the long term. Renewable electrical energy input in Indonesia does not seem to have a long-term relationship which is probably due to the low percentage of renewable energy-based electricity. In 1984-2018, the average input generated from renewable electrical energy was only about 16% of the total electricity result. Although previous research has not shown a significant effect on the use of renewable energy, the opportunity for a larger proportion of output from electrical energy based on renewable energy can increase economic growth (Derizal et al., 2021). For Seloliman village, public policies are made based on the principle of devolution so that the policies can facilitate all residents. This village has an MHP that is managed independently and is able to provide broad benefits for its residents. However, PLN through village officials cannot simply invite residents to switch to using MHP energy because residents need socialization on how to use this energy.

Research conducted by Ozgur in 2019 in rural areas of the European Union indicated that the population they surveyed expected renewable energy to be reliably supplied because rural areas experience longer blackouts in the event of bad weather and power lines cut off can disrupt the energy supply. Thus, they need renewable energy as alternative energy if this happens. Villagers see that

renewable energy that can supply their village to the maximum is crucial. They believe that local power plants can increase village independence. Those who consider an uninterrupted supply of renewable energy also important and they see that the reliability of the energy supply is identified as a bolster in the diffusion of renewable energy technologies (Ozgur et al., 2019).

The residents of Seloliman Village openly accept the socialization carried out by PPLH because they are enthusiastic about getting electricity in their village. However, after being asked to pay a certain amount of money to obtain the energy, they need additional information and time to decide. After receiving enough information, then they make a purchase and end up becoming loyal consumers and recommend alternative energy to relatives or other residents who have not used renewable energy as their main energy.

Similar to the price dimension, the dimension of renewable energy consumption decisions in Indonesia has not been widely carried out by researchers in Indonesia. Research on renewable energy consumption decisions by other researchers aims to provide a systematic decision support framework for policymakers based on Multi-Criteria Decision Making (MCDM) using Iran as an example. They combine Benefits, Opportunities, Costs, Risks Analysis (BOCR) with the Analytic Network Process (ANP) to integrate strategic planning and decision making. BOCR and ANP are used because they are proven to be able to create a hybrid model that can ultimately overcome regret that may arise from past purchases (Alizadeh et al., 2020). MCDM techniques are very popular in energy policymaking and sustainable energy management, including renewable energy planning and energy resource allocation (Kumar et al., 2017).

MCDM itself is considered capable of providing solutions to decision-making problems, including conflicting criteria and various objectives in energy planning decisions. However, in the process, consumers have gone through several external effects such as subjective opinions which can ultimately influence the final decision to use the energy or not (Alizadeh et al., 2020). MCDM often notices how changes in the weights of criteria and ratings can affect the impact of ranking on all alternatives arise. This can relate to conditions in the current study which show certain situations when respondents as consumers get an offer for several alternative uses of renewable energy.

The researchers use the concept of consumption decision as one of the dimensions to find out the consumption pattern of the community as MHP energy users by involving several factors to discover whether or not respondents make purchasing decisions. Similar to Alizadeh et al. in 2020 that used Iran as a research sample, the researchers also use Deso Seloliman in Mojokerto, an example of MHP's renewable energy consumption, as a sample. The results of the study show that this dimension is influenced by other dimensions such as price, which also exist in this study. In the consumption decision process, respondents go through at least 3 main stages before making a purchase decision, including identifying the problem, searching for information, and evaluating alternatives that appear after getting the information. After making a purchase decision for renewable energy products for the first time, respondents are then directed by managers to repeat purchases so that they can create loyalty to renewable energy products. To repeat purchases and become loyal consumers, respondents have to go through at least 3 advanced stages: using renewable energy based on its benefits (for example, the energy is used for daily energy needs), providing recommendations to other people or relatives who have not used renewable energy, and (sometimes) having post-purchase regret due to certain conditions. After going through these three stages, respondents can be labeled as respondents who have loyalty to renewable energy.

This consumption decision model is also applied in Alizadeh's research, which uses MCDM by combining Benefits, Opportunities, Costs, and Risks Analysis (BOCR) with Analytic Network Process (ANP). In the BOCR, respondents are in the initial 3 stages of purchasing decisions. They see that renewable energy offers more benefits after all this time they have to pay more to PLN for their energy needs. The information they receive regarding the benefits of renewable energy products offers them several alternatives to consume energy in other forms that are more environmentally friendly with more benefits. Here, respondents begin to get opportunities to rearrange the alternatives obtained after getting a lot of information from the manager. The collected alternatives are then sorted according to their priority level so that it is easy to make decisions. In the process, respondents involve external parties and internal parties and ask their opinions about alternatives they have. This priority level involves an element of cost that must be incurred to obtain the desired energy. In the case of Seloliman Village residents, the cost factor is the main issue they use in the level of alternative renewable energy.

They start to think about whether the costs they incur will be greater or less than the previous expenses, or if the costs incurred are greater, will they get a greater profit than before? Due to some of these considerations, respondents then involve the management to help them know and

understand the risks they may carry if they use renewable energy. This combination of BOCR is then combined with ANP to integrate strategic planning and decision making. ANP itself is used to compare alternatives that appear after respondents get information about renewable energy.

Consumption Pattern of MHP Energy Users

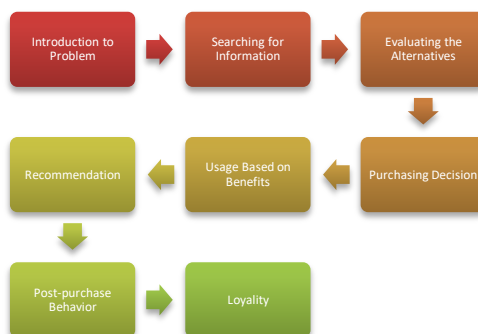


Figure 3. Flowchart of Micro Hydro Energy Consumption Pattern in Seloliman Village
 Source: Results of Research Process (2021)

Figure 3 describes consumption patterns based on the results of data processing in Seloliman Village. As previously explained, based on the distribution of consumption patterns, consumption patterns in the Seloliman Village area are high because they already use the energy produced by MHP and independently conduct campaigns or promotions to relatives in other areas or in nearby villages who have not used alternative energy. However, renewable energy sources and the resulting benefits are not well understood by consumers and local communities. Thus, renewable energy consumers in Indonesia need to get enlightened about the importance of the diffusion of innovations concept that is more in line with current conditions. This will have implications for policymakers, electricity suppliers, and future researchers. With the development of renewable energy, consumers will become more involved and have more of a central role in community systems in the energy-independent area (Febriani & Avicenna, 2021). The same thing happened to the residents of Seloliman Village. Even though the household head has made a purchase decision, there is still an unresponsive attitude from some other family members. Nevertheless, in general, this does not have a major impact on the use of renewable energy in this village. It can be seen that all 53 households use MHP renewable energy continuously.

Conclusions

The conclusion of this research based on the analysis that has been conducted is that the price dimension, in general, has a big role in determining the pattern of MHP energy consumption in East Java, especially in rural areas. This can be seen from the average value of the price dimension that is quite high and has an influence on energy consumption decisions. There are some findings of this research, which include PPLH as the main initiator of the use of MHP did not carry out further socialization to residents. PPLH only conducts socialization at the beginning before the use of MHP. Not only that, but PPLH must also convince users and prospective MHP users about the advantages of the products produced. Seloliman Village has great potential as an MHP, but PPLH or PKM have not been able to build a turbine housing again to produce new electrical energy. In addition, MHP in Seloliman Village is only prioritized for Sempur Hamlet. Thus, it can be concluded that residents in Seloliman Village do not fully believe in the existence of MHP, even though Seloliman Village as a whole has the potential to build turbine housing that can be used as MHP. The implication of the research that can be put forward is that seeing the high value of the price dimension, the increase in purchasing power of energy for the people in East Java can be carried out more effectively in terms of people's income, but price policy also needs to be controlled by the government and PPLH as an energy provider. The results of this study also found that MHP's renewable energy consumption pattern depends on price and environmental factors. Viewing data from this research, MCDM is a hybrid model that can be used to help formulate policies related to decision-making. In MCDM itself, there are possible problems and solutions for using energy products, recommendations given by respondents, forms of post-purchase behavior, and loyal attitudes towards energy products. Each has a different level and it is very interesting to do more complete research on this in the future.

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