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# The state of energy poverty in Indonesia and its impact on welfare

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ABSTRACT

Indonesia has committed to ensure universal energy access by 2030. However, there is a lack of framework to identify who are the energy poor and to what extent providing energy access can improve people's welfare. We evaluated energy poor into three situations: (i) energy spending more than 10% of total spending; (ii) no access to electricity; and (iii) electricity consumption below 32.4 kWh per month per household. We analysed household and village surveys. The study showed three important findings. First, the range of energy poverty based on expenditure criteria was about 53% and, based on electricity consumption, was about 22% of total households. Non-energy-poor households spend more on food (16.2%) and non-food (24.3%) than energy-poor families. Finally, access to electricity and modern cooking fuel reduced the rate of malnutrition in the village. We suggest that government provides more support to improve energy access to people who do not have access to it and to subsidise public transport. Finally, productivity and efficiency in energy use need to be improved amongst the poor.

## 1. Introduction

During the 2002 World Summit on Sustainable Development in Johannesburg, South Africa, global leaders emphasised the importance of energy for sustainable development. In April 2010, the Secretary-General's Advisory Group on Energy and Climate Change asked for commitment from United Nations (UN) member states to ensure universal access to modern energy services by 2030. The Sustainable Development Goal for energy (SDG7) highlights three objectives for 2030: (i) ensure universal access to modern energy services; (ii) double the share of renewable energy in the global energy mix; and (iii) double the global rate of improvement in energy efficiency. Global leaders believe that access to modern energy can help alleviate poverty.

Energy poverty has become a major problem in the world's development. According to the International Energy Agency (IEA) (2017), about 1.06 million people worldwide do not have electricity access. In Africa, about 588 million people do not have electricity; in the developing countries of Asia, the number is about 439 million. Amongst developing Asian countries, India has the highest number of people while in ASEAN, Indonesia contributes about 5.2% of total electricity poverty in developing Asia (IEA, 2017). This implies that if Indonesia can effectively develop electricity access, the country can significantly contribute to reducing electricity poverty in the region and in the world.

Providing energy access in Indonesia is a challenging task with its 16,056 islands, as confirmed by the Ministry of Home Affairs. Many people also live in remote areas. The Indonesian government has acknowledged the importance of energy access, as contained in Indonesia's Energy Law No 30/2007:

> 'Improve accessibility to energy for the people who are less wealthy and/or who live in remote areas to bring about just and equal welfare and prosperity for the people by: (1) providing assistance to increase the availability of energy for less wealthy people; and (2) building energy infrastructures in under-developed regions in order to reduce disparities among regions.' (Article 3 point f)

In the medium-term development plan 2014–2019, the government aims to promote energy security, and one of the policies is to improve energy access (Bappenas, 2014). In 2017, the ratio of electrification in Indonesia (number of residential customers to the total number of residential) reached 95.35%, more than the target of 92.75% (ESDM, 2018). According to the World Bank, the access to electricity (% of population) in 2016 was about 97.6%.

The condition of electrification ratio is diverse across provinces. Papua and East Nusa Tenggara provinces have electrification ratios of about 61.4% and 59.8%, respectively. This implies that promoting electricity or energy infrastructure in those provinces needs to be prioritised. Further, in Indonesia, many small islands do not have electricity access. As a result, government has promoted decentralised and off-grid systems such as solar home system. Based on Presidential

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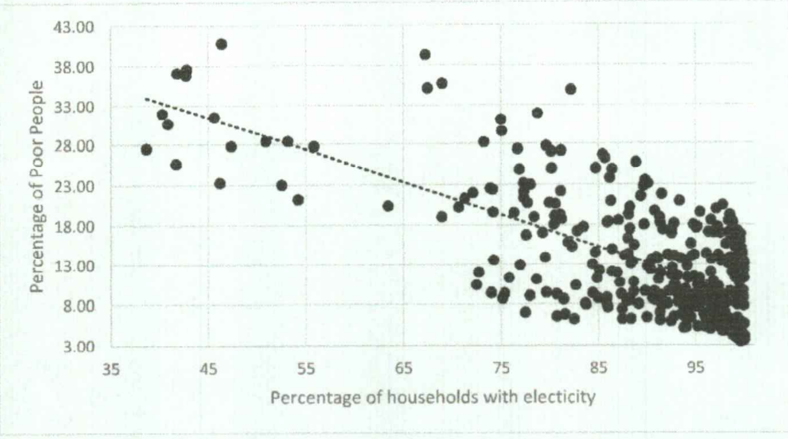


**Fig. 1.** Correlation between Poor People and Electricity Access at the Provincial Level (2007–2017) Source: BPS (last update 14 November 2017).

Regulation of Republic Indonesia, No. 47 Year 2017 on Providing Solar Home Lighting for People without Electricity Access (*Penyediaan Lampu Tenaga Surya Hemat Energi/LTSE bagi Masyarakat yang Belum Mendapatkan Akses Listrik*). Government plans to distribute 95.729 packages with total cost of about IDR332.8 billion or about IDR3.4 million per unit. The package includes a solar panel with capacity 20-W peak, 4 LEDs (light emitting diodes), battery, instalment cost, and after-sales service for 3 years. Government determined several locations that can access this programme, such as cross-border zones with other countries, underdeveloped regions, isolated regions, and outer islands that cannot be reached by the PLN (a state-owned company in the electricity sector). Priority is given to regions without electricity.

According to the National Team for the Acceleration of Poverty Reduction (*Tim Nasional Percepatan Penangulangan Kemiskinan*/TNP2K), one priority programme to improve people's access to basic services is to provide electricity under a cheap and power-saving programme (*listrik murah dan hemat*). This programme allows selected poor households to have grid and installation connections for free. By providing better access to electricity, government has a better chance of reducing poverty. Fig. 1 shows a negative correlation between percentage of households with electricity and percentage of poor people. Provinces with a high percentage of poor people have a low level of electricity access. This also implies that, in terms of expenditure, poor people are also more likely poor in terms of energy access or vice versa. However, improving accessibility to energy has become one of the basic rights for a quality life.

Developing energy access needs investment, and government has allocated a budget to expand energy access. There are several channels of the state budget from which to increase energy access. This may bring new challenge on programme coordination. In 2011, government allocated the special allocation fund (*Dana Alokasi Khusus*, DAK) to support rural electrification programme. Basically, the programme implemented before 2011 was part of basic infrastructure development in rural areas. In 2011, government allocated IDR150 billion and increased it to about IDR190.64 billion in 2012. In 2017, the special allocation fund for constructing and maintaining the small and medium scale of power plant was about IDR502.3 billion. This programme covered broad energy projects in rural areas. Further, in 2017, government allocated about IDR60 trillion to 74,954 villages or about IDR800 million per village on average. This village fund can be used to develop energy infrastructure, thus implying that rural governments have more financial capacity to develop modern energy access.

However, the amount of resources to increase energy access is less than the amount of energy subsidies provided as subsidy for commodities. In 2017, government allocated a subsidy of about IDR52 trillion for electricity and about IDR51 trillion for gasoline and 3-kg LPG cylinder. It seems that government provides more subsidy to people that have energy access than to those without. Thus, energy subsidy should be allocated to promote energy infrastructure and benefit most people with traditional energy access. Reallocation of energy subsidy to the poor and improving local capacity to manage modern energy services with sustainable ways are two important agendas for improving energy access.

This paper analysed the status of energy poverty in Indonesia by using the most recent socio-economic survey and village data. The situation of energy access in Indonesia is not well understood with comparison of international's standard. Even, evaluation on the impact of electricity access on people's welfare are understudied in Indonesia. Then we used econometric techniques to measure the impact of electricity access on people's welfare and rural development. The two parts are interconnected in strengthening the motivation for tackling energy poverty. Further, the study has strong policy implications especially in providing insight on the importance of allocating energy subsidy to targeted households for strengthening energy justice.

## 2. Review of literature on energy access and poverty

The (IEA) describes energy poverty in two dimensions, namely, lack of access to electricity and clean cooking. Further, it also said that energy poverty is indicated by three situations: lack of access to modern energy services, lack of reliability of services, and affordability of access (IEA, 2017). Holdren and Smith (2000), as cited by Savacool (2015), argued that energy poverty is related to the energy ladder. The energy ladder is a situation in which energy efficiency increases due to a transformation in energy caused by a shift from traditional fuel to modern fuel, such as from firewood to kerosene or from kerosene to liquefied petroleum gas (LPG). Zhang et al. (2019) defined households that used solid fuel for cooking are in energy poor. According to the Advisory Group on Energy and Climate Change as cited by Savacool (2015), the level of energy consumption is divided into three parts: basic human needs, productive uses, and modern needs (Table 1). Energy consumption has two components: electricity consumption and energy for cooking. The IEA also measures energy poverty when energy spending is more than 10% of income. In developed countries, about 15% of 200 million people are energy poor (IEA, 2017). By this definition, energy poverty is also a challenge for rich countries.

Basically, access to modern energy can help attain eight goals of sustainable development: (i) no poverty; (ii) no hunger; (iii) good health and well-being; (iv) quality education; (v) gender quality; (vi) decent work and economic growth; (vii) industry, innovation, and

**Table 1**
Energy services and access levels.
Source: UNDP (2010).

| Level | Electricity (kWh/person/year) | Modern Fuel/Person/Year (kg of oil equivalent) |
|---|---|---|
| Basic human needs | 50–100 | 50–100 |
| Productive uses | 500–1000 | 150 |
| Modern society needs | 2000 | 250–450 |

infrastructure; and (viii) sustainable cities and communities (IEA, 2017). This implies that modern energy services can create new opportunities to increase human capability and resilience. In the case of Indonesia, Patunru (2013) argued that non-income poverty is a more serious problem than income poverty. This implies that government must develop basic infrastructures such as on education, health, access to clean water, sanitation, road, and electricity. Further, Hausmann et al. (2005) also mentioned that poor infrastructure brings low social return, and this implies low returns to economic activity. Finally, this can bring in low levels of private investment and entrepreneurship. Thus, income and non-income poverty indicators (basic infrastructure access) are interconnected and both can lead to a vicious circle, without any affirmative policy. Similarly, Sambodo et al. (2016a) also highlighted that energy access can strengthen social mobility and social capital.

The connection between access to electricity and welfare is a complex mechanism (Khandker et al., 2013). As seen in Fig. 2, access to electricity directly impacts on increasing demand for electronic devices such as lamps, followed by radio, television, iron, fan, refrigerator, kettle, rice cooker, air conditioner, and electric machines such as sewing machines, lathe, and milling paddy. All electronic devices are important to support night activities and to improve food quality, efficiency in cooking, and productivity and quality of work. With electricity access, the community can extend study hours, activities, economic opportunities; improve good health; and enhance economic efficiency. Khandker et al. (2013) argued that it is difficult to measure direction and magnitude of an electrification programme with regard to selected outcomes due to the complex relationship between electricity equipment, output, and intermediate outcome. They further said that final products from electricity access can be monitored from better indicators in education, income, and people's health, and there are interactions amongst indicators (Khandker et al., 2013).

Studies also showed that a connection between electricity access and people welfare (Munasinghe, 1988; Reiche et al., 2000; Peng and Pan, 2006; Al Mohtad, 2006; Kanagawa and Nakata, 2008). Reiche et al. (2000) investigated the social impact of rural electrification programmes on increasing standard of living, declining traditional energy consumption such as firewood leading to better health conditions and quality of environment, increasing job opportunities, and in causing improvement in business productivity. Kanagawa and Nakata (2008) studied electricity access in a poor region in India and showed that electricity access directly and indirectly impacts on poverty indicators such as health, education, income, and environment.

According to Barnes et al. (2010), access to electricity can reduce energy spending. When the relative price of energy decreases, and non-food expenditure is more likely energy intensive, then due to electricity access, non-food expenditure will increase compared to food expenditure. Barnes et al. (2010) also said that it is possible for both food and non-food expenditure to increase due to electricity access. Electricity access will also increase productivity and income (Barnes et al., 2010). Sola et al. (2016) studied the connection between energy access and food security. They argued that poor energy access for cooking can lead to reallocation of household resources from food production and preparation to fuel procurement. They also said that lack of energy access can encourage switching to inferior energy forms, thus, reducing agricultural productivity. However, Sola et al. (2016) argued that evidence connecting energy access and food security is still lacking.

Electricity access is not the only cause of poverty. Based on the multidimensional poverty index (MPI), poverty covers three dimensions: education, health, and living standard. The elements of education are years of schooling and child school attendance; the elements of health are child mortality and nutrition; and the elements of living standard are electricity, improved sanitation, safe drinking water, flooring, cooking fuel, and assets. Thus, poverty alleviation needs comprehensive strategies. Providing better access to electricity also requires expanding capacity in education, health, etc. This implies that electricity access can elevate capacity and capability to improve well-being.

Alkire and Robles (2017) showed that in Indonesia, electricity access has the lowest contribution compared to other indicators on deprivations to overall poverty. Table 2 indicates that child mortality contributes the highest share of poverty. Thus, providing better health services needs to be a top priority agenda in poverty alleviation. However, regarding standard of living, summation of electricity access

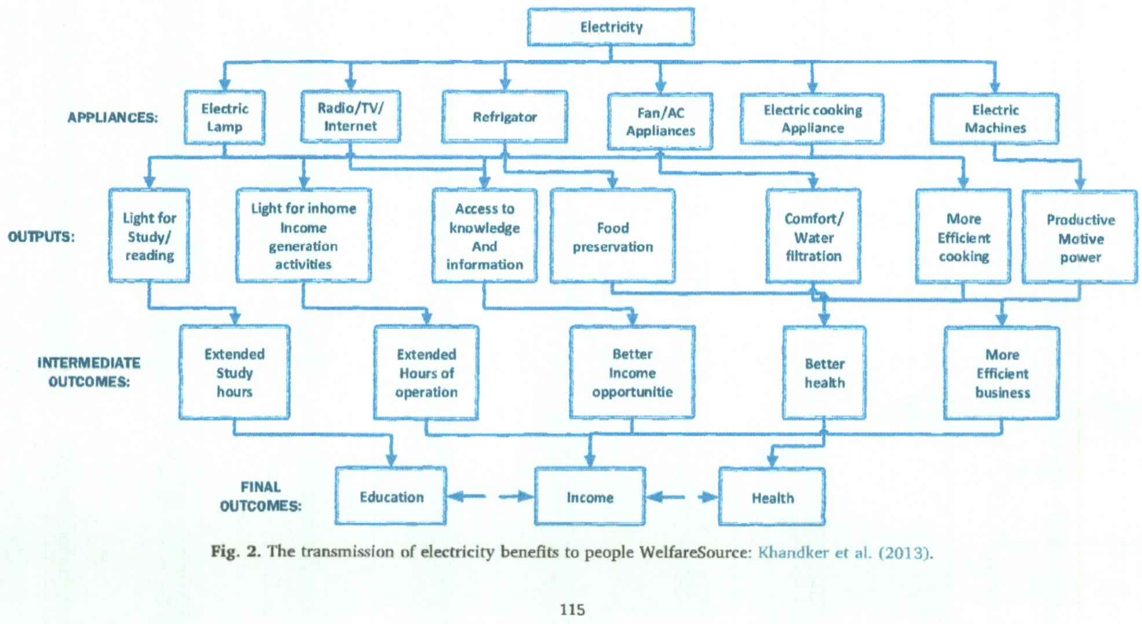


**Fig. 2.** The transmission of electricity benefits to people WelfareSource: Khandker et al. (2013).

**Table 2**
Contribution of deprivations of each indicator to overall poverty.
Source: Alkire and Kanagaratnam (2018).

| Indicators | Percentage |
|---|---|
| Years of schooling | 6.2 |
| Child school attendance | 6.4 |
| Mortality (any age) | 60.7 |
| Nutrition | NA |
| Electricity | 1.5 |
| Improved sanitation | 6.7 |
| Drinking water | 5.1 |
| Flooring | 1.9 |
| Cooking fuel | 8.0 |
| Asset ownership | 3.5 |

and cooking fuel has the highest contribution. Access to cooking fuel is one important indicator of standard of living. With access to clean cooking oil, rural women can reduce time in collecting firewood. Thus, they can devote more time to other productive activities. Access to modern energy cooking can also reduce the health risks from mosquito bites and other predatory animals because people do not have to go to the jungle or forest to get fuelwood.

In summary, to support basic human needs, energy is a necessary element both for electricity and cooking. There are several definitions of energy poverty, absolute and relative. Energy access is clearly not only related to income generation but also to social justice. Energy access can improve human capability to perform better – in creating income and achieving good health and education. But this is a complex process. Although electricity access is not the most important factor in explaining the deprivation of poverty, greater access to electricity can provide poor households better opportunities to improve their quality of life and move above the poverty line.

## 3. Methodology

### 3.1. Data

The study focused on two key factors driving modern energy services, namely, electricity and energy for cooking. In Indonesia, electricity supply is provided by the state electricity company (PLN) and others (non-PLN), such as private companies, cooperatives, local government, and the community. However, for simplicity, we divided electricity access into two sources: PLN and non-PLN. There are also many families or villages without electricity access. In terms of energy for cooking, major sources are city gas, liquefied natural gas (LPG), kerosene, firewood, and others. Many families combine energy for cooking such as kerosene and firewood.

We conducted two levels of analyses. We explored the National Social Economic Survey (Susenas) based on March 2016 data that covered more than 68.2 million households. We used descriptive analysis to understand and describe energy poverty in Indonesia. Then we analysed village level data using PODES (village data base) for 2011 and 2014. Data for 2014 is the latest data that the government published, while that for 2011 was selected because PODES data is issued every 3 years. The year 2011 was also the launch of the special allocation fund for the rural electrification programme so we can analyse the impact of this programme. However, because of the expanded number of villages between 2011 and 2014, we need to deal with the complexity of merging the data. Thus, we limited the scope of analysis to the villages in Java and Sumatera island only.

Indonesia does not have a clear definition of energy poverty. For the government, energy poverty is defined when households do not have electricity at all or they depend on kerosene lamp. Nowadays, some people said that pre-electrification is a situation when access to electricity can only cover lighting and mobile charging needs. Thus, we identified energy-poor household by applying two criteria. First, we developed benchmarking for pre-electrified by considering the level of electricity consumption. In 2017, government issued Presidential Decree No 47 Year 2017. The decree regulated solar panel lighting for households that do not have access to electricity. Thus, energy-poor households obtained a set of solar panels with 20-W peak and four light emitting diodes. This capacity is equal to 32.4 kWh per month per household.[1]

By converting the UNDP's standard of 50–100 kWh per person per year, to about 16.7–33.3 kWh per month per household (at four family members per household), electricity consumption under this range is considered as being energy poor. Thus, we defined households that consume electricity below 32.4 kWh per month as energy poor. Second, we analysed energy spending to total spending and defined energy poverty of households that consume more than 10% of their total expenditure for energy (IEA, 2017).

### 3.2. Estimation strategies

We developed two strategies of analysis to measure how electricity access affects the welfare of households and villages. At the household level, we evaluated the impact of energy poverty on household expenditure for food and non-food items and, thus, developed two equations. Because the error terms in the regression equations are correlated, we applied Seemingly Unrelated Regression (SUR), or allowed the error terms of two equations to correlate. We applied the SUR estimate for the Susenas data as follows (Sambodo et al., 2016b):

$$Y_i = \beta_0 + \sum_{i=1}^{n} \beta_i x_i + \varepsilon_i \tag{1}$$

| Dependent Variable | Independent Variables |
|---|---|
| -Log food expenditure (equation (1)) -Log non-food expenditure (equation (2)), excluding energy spending | -Non-energy-poor (dummy variable: 1 if electricity consumption > 32.4 kWh/month; 0 if otherwise<br>-Village dummy (dummy variable: 1 village; 0 city)<br>-Area of house (Log area of house)<br>-Number of family members<br>-Access to clean water (dummy variable: 1 if has access to clean water; 0 if otherwise)<br>-Educational level of household head |

For the village level, we modified the model of Khandker et al. (2013). Basically the model aims to test causality of electricity access and number of malnourished people. We argued that there are two mechanisms why having access to energy can reduce the incident number of people with malnutrition. First, energy is needed for preparing food. Lack in modern energy access can reduce capability to prepared food (in term of quality). Poor of food quality will affect health condition.

Second, Sola et al. (2016), mentioned the possibility of 'reallocation of spending' between food and energy spending. The two components are complementary. Generally speaking, modern energy access is more efficient and relatively cheaper than traditional energy. In Indonesia, government provide more energy subsidy for poor households with modern energy access. Similarly, Sambodo et al. (2016a), showed that electricity access can reduce about 30% of kerosene spending. This

[1] For 20-W peak, we assume optimal heat from the sun 4.5 h per day, thus 20 wp x 4.5 h = 90 W-hours per day. If the solar panel can be used for 12 h a day, in 30 days, the total kWh per month is about 32.4 (90 W-hour x 12 h × 30 days).

implies that people can have more money to spend on food an non-food expenditure.

We formulated the output of electricity access as follows:

$$Y_{it} = \beta_0 + \beta_1 Acce.\ Elect_{it} + \beta_2 NHH_{it} + \beta_3 Ener.\ Cook_{it} + \beta_4 NationalGrid_{it} + \varepsilon_{it} \quad (2)$$

where *i* indicates village, and *t* indicates time index (years 2011 and 2014); $Y_{it}$ represents output (number of malnourished people in the village stricken with diseases such as marasmus and kwashiorkor for the last 3 years); *Acce.Elect* is village electricity access (1 if village has electricity access, 0, if otherwise); *Ener.Cook* is energy for cooking (1 if majority of the households in the village use modern energy such as kerosene, LPG, and city gas; 0 wirefood); *NHH* is the number of households in the village; *NationalGrid* is availability of national grid (1 if the village is passed by the national grid; 0, if otherwise) and $\varepsilon_{it}$is a non-systematic error.

We then modified equation (2) into the fixed effect model. This strategy can eliminate the unobserved heterogeneity. Then equation (3) will result in an unbiased estimate if the time-invariant heterogeneity assumption is fulfilled.

$$(Y_{i1} - Y_{i0}) = \beta_1 (Acce.\ Elect_{i1} - Acce.\ Elect_{i0}) + \beta_2 (NHH_{i1} - NHH_{i0}) + \beta_3 (Ener.\ Cook_{i1} - Ener.\ Cook_{i0}) + \beta_4 (NationalGrid_{i1} - NationalGrid_{i0}) + (\varepsilon_{i1} - \varepsilon_{i0}) \quad (3)$$

Further unobserved heterogeneity and the initial village characteristics are correlated. The initial village characteristics will affect the village's electricity access. Equation (3) can thus be rewritten as follows:

$$\Delta Y_{it} = \beta_0 + \beta_1 \Delta Acce.\ Elect_{it} + \beta_2 \Delta NHH_{it} + \beta_3 \Delta Eber.\ Cook_{it} + \beta_4 \Delta NationalGrid_{it} + \beta_5 Acce.\ Elect_{i0} + \beta_6 NHH_{i0} + \beta_7 NationalGrid_{i0} + \Delta\varepsilon_{it} \quad (4)$$

In conclusion, equation (4) will result in an unbiased estimate.

Generally speaking, the existence of national grid can represent the condition of remoteness of the village. Usually, development of national grid is promoted after roads ware developed. This is because the national grids usually construct follow the roads. Thus, we can infer that village with the national grid connection, will have better basic infrastructures. This can expand economic opportunity and welfare. However, the existence of national grid, is not necessary houses or villages have access to electricity. Other power infrastructures such as medium and low grid transmission, and transformers are needed. Further, Sambodo et al. (...) also showed that many households could not have access on electricity due to high connection fee.

## 4. Results

### 4.1. Energy poverty in Indonesia

The condition of the energy-poor depends on the definition of energy poverty. Based on the average 32.4 kWh/month consumption, about 17.9% of surveyed households were energy poor (Table 3). Decile 1 households had the highest percentage of energy poor (48.4%) but the share gradually decreased. Surprisingly, there are still energy-poor households amongst the top rich. This indicates that electricity access has become a problem not only for the poor but also for the rich.

However, by defining energy poverty as share of energy spending to total expenditure with the cut-off point of 10%, we obtained a completely different condition (Table 4). On average, about 53% of surveyed households were energy poor. In the case of China, Zhang et al. (2019) said that in terms of accessibility and affordability in 2016, around 48.98% of household are in energy poverty. We had a higher number because the information on energy spending was not divided between input for production and consumption. In Indonesia, many households are mostly involved in micro, small, and medium-sized enterprises. Further, energy spending covers electricity, gas, and gasoline. Interestingly, Table 4 indicates that deciles 2, 3, and 10 relatively spend more on energy compared to other groups. This implies that both poor and rich people are concerned with energy cost because more than half of their expenditure is allocated to energy.

**Table 3**
Distribution of Energy Poor by Decil (based on 32.4 kWh/month, 2016).

| Decil Household | Energy-Poor Households | Non-Energy-Poor Households | Share of Energy-Poor Households to Total Households |
|---|---|---|---|
| 1 | 3,300,953 | 3,520,168 | 48.4 |
| 2 | 2,110,570 | 4,710,413 | 30.9 |
| 3 | 1,632,397 | 5,188,833 | 23.9 |
| 4 | 1,324,795 | 5,496,117 | 19.4 |
| 5 | 1,143,838 | 5,677,079 | 16.8 |
| 6 | 935,065 | 5,886,263 | 13.7 |
| 7 | 721,623 | 6,099,093 | 10.6 |
| 8 | 547,563 | 6,273,617 | 8.0 |
| 9 | 354,633 | 6,466,312 | 5.2 |
| 10 | 143,209 | 6,677,730 | 2.1 |
| **Total** | **12,214,646** | **55,995,625** | 17.9 |

Source: Calculated from Susenas.

**Table 4**
Distribution of energy poor by decile (based on 10% of Expenditure, 2016). Source: calculated from Susenas.

| Decil Household | Energy-Poor Households | Non-energy-Poor Households | Share of Energy-Poor households to Total Households |
|---|---|---|---|
| 1 | 2,395,681 | 4,425,440 | 54.1 |
| 2 | 2,641,939 | 4,179,044 | 63.2 |
| 3 | 2,593,321 | 4,227,909 | 61.3 |
| 4 | 2,491,083 | 4,329,829 | 57.5 |
| 5 | 2,384,375 | 4,436,542 | 53.7 |
| 6 | 2,377,173 | 4,444,155 | 53.5 |
| 7 | 2,178,599 | 4,642,117 | 46.9 |
| 8 | 2,091,418 | 4,729,762 | 44.2 |
| 9 | 2,109,988 | 4,710,957 | 44.8 |
| 10 | 2,458,360 | 4,362,579 | 56.4 |
| **Total** | **23,721,937** | **44,488,334** | 53.3* |

Note: *average share.

In the case of developed countries, about a quarter of the population is energy poor (IEA, 2017). This is an issue on the effectiveness of energy pricing policy in Indonesia because despite government subsidies on energy, households still incur substantial energy expenditure. If government does not subsidise energy, the number of energy-poor households may increase. Government needs to provide compensation to protect the lowest income group. However, providing energy subsidy to the targeted group is not enough. The government then needs to develop energy infrastructure especially in remote areas. Developing connectivity in transportation system will also promote goods mobility with least costs. Similarly, in the case of Malaysia, Li et al. (2017) suggested that government can use saving from subsidy to reduce budget deficit, and provide more spending on education, health, and other services sectors.

In October 2016, the government implemented the one-price policy on gasoline in all regions in Indonesia. This implies that government needs to provide more support in covering the shipping cost of energy and building energy storage facilities in remote areas. Strengthening connectivity across the islands and simplifying the distribution of gasoline are keys to success in creating a one-price policy. If the programme succeeds, Indonesia can reduce the number of energy-poor households based on energy expenditure. Monitoring and evaluation on

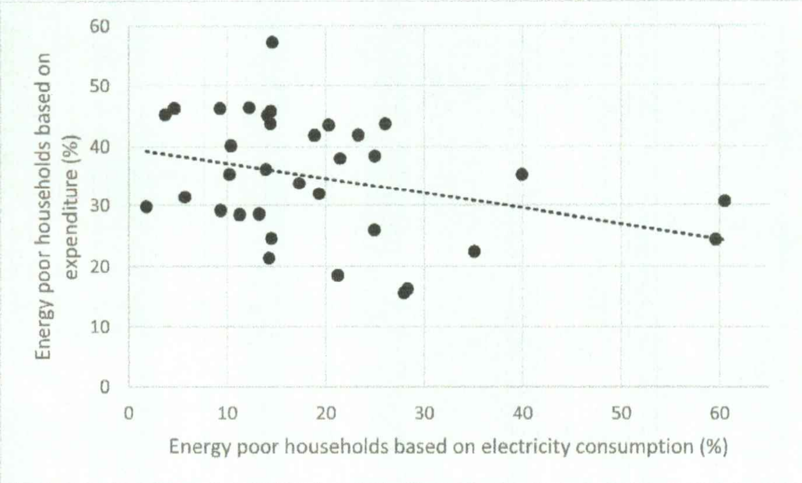


**Fig. 3.** Correlation between Household Energy Poor based on Expenditure and Electricity Consumption at the Provincial LevelSource: Calculated from Susenas.

this policy need to be controlled by local and central government.

Energy-poor households, based on the expenditure and electricity consumption approach, was provided at the province level. The correlation between the two indicators showed that as energy-poor households based on electricity consumption in the province increase, those based on the expenditure approach tend to decrease (Fig. 3). We noticed that low electricity consumption mostly happens in remote areas with poor road access and lack in transportation facilities. This lead high transportation cost and make commute intensity relatively low. We notice that transportation cost has substantial amount of expenditure compare to other energy expenditure. Thus, energy poor household in remote areas, will relatively have less energy expenditure compare to household who live in less remote areas.

According to Tsun et al. (2018), inequality of electricity consumption may due to in regional income. This situation is driven by level of industrialization and urbanization for each region (Tsun et al., 2018). There are two provinces whose share of household electricity poverty is above 50% are Papua (60.5%) and East Nusa Tenggara (59.6%). Based on expenditure, there are 13 provinces whose share of electricity poverty is above 40%. Three provinces – East Java, Central Java, and West Java – dominate energy poverty at the national level. This implies that energy poverty is still a problem even in Java island, which is more advanced economically than other islands.

By decomposing poverty line and energy poverty, we obtained the same pattern, especially for households below the poverty line, with energy poor (we defined it as 'chronic' poverty). As seen from Table 5, the share of chronic poverty is between 3% and 3.5%. Government needs to provide social assistance and energy subsidy as special support to this group. Households with energy access and above the poverty line or having an access problem was about 14.4% for electricity and 31.6% for energy. This group has effective demand but has low access to energy. Better electricity or energy access and affordable price to this group can stimulate economic growth or improve welfare. Further, many households were below the poverty line but they were not energy poor. Improving productivity and energy efficiency to this group of households is important.

We decomposed energy spending into four components such as electricity, generator, vehicle or transportation, and cooking. Spending on vehicle or transportation had the highest proportion (Table 6). Spending on transport covered only fuel spending and we dropped spending on lubricating oil and services. This implies that any policies to enhance efficiency, connectivity, and competition are important to reduce transport costs. The rapid growth of online transportation such as Grab, Gojek, and Uber in many cities in Indonesia has become an alternative in helping people's mobility with effective cost. Basically, government needs to provide more support or subsidy to public transportation. This can reduce transportation costs and enhance people mobility. Currently, most energy subsidies go to cooking and electricity, and a very small portion to the transport sector or less than 10% (Ministry of Finance, 2018).

In general, energy poverty in Indonesia is not only amongst poor households but also amongst the rich. Because spending on transportation has the highest share in energy spending, enhancing connectivity for people's mobility at the least cost is important. Direct subsidy to the users of public transport is more important than providing energy subsidy to energy commodities because the latter can bring more problems in pursuing energy justice.

**Table 5**
Decomposing poverty line energy poor in 2016.
Source: Calculated from Susenas

| Based on 32.4 kWh/month | | | |
|---|---|---|---|
| Poverty Line[a] | Energy-Poor Households, % | Non-energy-Poor Households, % | Total, % |
| Below poverty line | 3.51 | 5.64 | 9.15 |
| Above poverty line | 14.40 | 76.45 | 90.85 |
| **Total** | 17.91 | 82.09 | 100.00 |
| **Based on 10% expenditure** | | | |
| **Poverty Line** | **Energy-Poor Households, %** | **Non-energy-Poor Households, %** | **Total, %** |
| Below poverty line | 3.19 | 5.96 | 9.15 |
| Above poverty line | 31.59 | 59.26 | 90.85 |
| **Total** | 34.78 | 65.22 | 100.00 |

[a] The poverty line is different across provinces in Indonesia, similarly between urban and rural areas. We adjusted the poverty line by province.

**Table 6**
Decomposition of poor and non-poor based on spending in each sector.
Source: Calculated from Susenas

| Decile | Electricity | | Generator | | Vehicle/Transportation | | Cooking | |
|---|---|---|---|---|---|---|---|---|
| | Poor | Non-poor | Poor | Non-poor | Poor | Non-poor | Poor | Non-poor |
| 1 | 66,389 | 6,754,732 | 4614 | 6,816,507 | 242,660 | 6,578,461 | 534,600 | 6,286,521 |
| 2 | 41,697 | 6,779,286 | 5704 | 6,815,279 | 505,360 | 6,315,623 | 194,341 | 6,626,642 |
| 3 | 36,916 | 6,784,314 | 7887 | 6,813,343 | 582,956 | 6,238,274 | 111,479 | 6,709,751 |
| 4 | 35,066 | 6,785,846 | 8291 | 6,812,621 | 585,886 | 6,235,026 | 82,653 | 6,738,259 |
| 5 | 44,234 | 6,776,683 | 13,251 | 6,807,666 | 539,077 | 6,281,840 | 71,748 | 6,749,169 |
| 6 | 46,233 | 6,775,095 | 15,866 | 6,805,462 | 542,713 | 6,278,615 | 48,015 | 6,773,313 |
| 7 | 55,723 | 6,764,993 | 14,205 | 6,806,511 | 553,262 | 6,267,454 | 40,569 | 6,780,147 |
| 8 | 77,273 | 6,743,907 | 15,964 | 6,805,216 | 632,039 | 6,189,141 | 34,062 | 6,787,118 |
| 9 | 105,954 | 6,714,991 | 14,868 | 6,806,077 | 627,115 | 6,193,830 | 15,845 | 6,805,100 |
| 10 | 135,095 | 6,685,844 | 12,253 | 6,808,686 | 890,219 | 5,930,720 | 3519 | 6,817,420 |
| Total | 644,580 | 67,565,691 | 112,903 | 68,097,368 | 5,701,287 | 62,508,984 | 1,136,831 | 67,073,440 |

Note: We assumed energy poverty by sector, if spending in respective sector is higher than 10% of total spending.

### 4.2. Energy poverty and people welfare

The previous section analysed the conditions or characteristics of energy poverty in Indonesia. This section explored the impact of energy poverty on people's welfare by analysing household survey data. In Indonesia, household expenditure is the basis for calculating the poverty line. Expenditure can be divided into food and non-food. Food expenditure has the highest weight in determining the poverty line. As seen from Table 7, food and non-food expenditure increased by 16% and 22%, respectively, for a non-energy-poor family compared to an energy-poor one (other things being equal). Further, the magnitude of non-food expenditure is higher or is more sensitive than food expenditure. This also implies that non-food expenditure obtains the higher share for a non-energy-poor household. The model also indicates that living in a village decreases food and non-food expenses compared to a household living in the city. Having access to clean water also increases food and non-food expenditure compared to families who do not have access to clean water. Further, using firewood for cooking decreases both food and non-food expenditure, compared to families who cook using modern energy sources. The level of education of the household head significantly increases both food and non-food spending. Because energy spending is a broader expenditure than electricity consumption, we expect a lower parameter estimate for food and non-food spending from energy spending.

As seen from Table 8, a non-energy-poor household spends more on food and non-food items by 10% and 11.5%, respectively, compared to an energy-poor household (other things being equal). Further, households without access to modern for cooking spend lesser on food and

**Table 7**
SUR Result based on Electricity Consumption.
Source: author's calculation

| Equation | Obs | Parms | RMSE | R-sq | chi2 | P |
|---|---|---|---|---|---|---|
| Log food | 291,414 | 11 | 0.5054562 | 0.3877 | 184523.21 | 0 |
| Log non-food | 291,414 | 11 | 0.6929403 | 0.4256 | 215924.33 | 0 |
| | Coef. | Std. Err. | z | P > z | [95% Conf. | Interval] |
| Log food | | | | | | |
| Non-energy-poor household | 0.1621293 | 0.0025928 | 62.53 | 0 | 0.1570476 | 0.167211 |
| Village | −0.0108967 | 0.0021629 | −5.04 | 0 | −0.0151358 | −0.0066576 |
| Log area of house | 0.0925565 | 0.001603 | 57.74 | 0 | 0.0894148 | 0.0956983 |
| Number of household member | 0.1684732 | 0.0005697 | 295.75 | 0 | 0.1673567 | 0.1695897 |
| Clean water | 0.00978 | 0.002381 | 4.11 | 0 | 0.0051134 | 0.0144466 |
| Education level head of household | | | | | | |
| Incomplete primary school | 0.0950993 | 0.0049307 | 19.29 | 0 | 0.0854354 | 0.1047633 |
| Primary school | 0.2097424 | 0.0047174 | 44.46 | 0 | 0.2004965 | 0.2189883 |
| Junior high school | 0.2474002 | 0.0058456 | 42.32 | 0 | 0.2359431 | 0.2588573 |
| Senior high school | 0.369618 | 0.0049531 | 74.62 | 0 | 0.3599102 | 0.3793258 |
| Higher education/University | 0.5922651 | 0.0056971 | 103.96 | 0 | 0.5810989 | 0.6034312 |
| Firewood for cooking | −0.2174806 | 0.0025221 | −86.23 | 0 | −0.2224238 | −0.2125374 |
| Constant | 12.84042 | 0.0086444 | 1485.4 | 0 | 12.82348 | 12.85736 |
| Log non-food | | | | | | |
| Non-energy-poor household | 0.2171558 | 0.0035545 | 61.09 | 0 | 0.2101891 | 0.2241224 |
| Village | −0.2501834 | 0.0029651 | −84.38 | 0 | −0.2559949 | −0.2443719 |
| Log area of house | 0.3078473 | 0.0021975 | 140.09 | 0 | 0.3035402 | 0.3121544 |
| Number of household member | 0.1076227 | 0.0007809 | 137.81 | 0 | 0.106092 | 0.1091533 |
| Clean water | 0.0773181 | 0.0032641 | 23.69 | 0 | 0.0709206 | 0.0837157 |
| Education level head of household | | | | | | |
| Incomplete primary school | 0.1263878 | 0.0067596 | 18.7 | 0 | 0.1131393 | 0.1396363 |
| Primary school | 0.3135549 | 0.0064672 | 48.48 | 0 | 0.3008795 | 0.3262304 |
| Junior high school | 0.3701344 | 0.0080138 | 46.19 | 0 | 0.3544276 | 0.3858412 |
| Senior high school | 0.6157718 | 0.0067902 | 90.68 | 0 | 0.6024631 | 0.6290804 |
| Higher education/University | 1.154024 | 0.0078103 | 147.76 | 0 | 1.138716 | 1.169332 |
| Firewood for cooking | −0.3065062 | 0.0034576 | −88.65 | 0 | −0.3132829 | −0.2997294 |
| Constant | 11.85978 | 0.0118508 | 1000.76 | 0 | 11.83656 | 11.88301 |

**Table 8**
SUR results based on energy spending.
Source: author's calculation

| Equation | Obs | Parms | RMSE | R-sq | chi2 | P |
|---|---|---|---|---|---|---|
| Log food | 291,414 | 11 | 0.5066425 | 0.3848 | 182296.87 | 0 |
| Log non-food | 291,414 | 11 | 0.6952445 | 0.4218 | 212566.99 | 0 |
| | Coef. | Std. Err. | z | P > z | [95% Conf. | Interval] |
| Log food | | | | | | |
| Non-energy-poor household | 0.1002704 | 0.001994 | 50.29 | 0 | 0.0963623 | 0.1041786 |
| Village | −0.0125452 | 0.002168 | −5.79 | 0 | −0.0167944 | −0.008296 |
| Log area of house | 0.1175894 | 0.0015907 | 73.92 | 0 | 0.1144716 | 0.1207072 |
| Number of household member | 0.1688919 | 0.0005711 | 295.71 | 0 | 0.1677725 | 0.1700114 |
| Clean water | 0.0245411 | 0.0023717 | 10.35 | 0 | 0.0198927 | 0.0291896 |
| Education level head of household | | | | | | |
| Incomplete primary school | 0.1085657 | 0.0049376 | 21.99 | 0 | 0.0988881 | 0.1182433 |
| Primary school | 0.2334363 | 0.0047185 | 49.47 | 0 | 0.2241883 | 0.2426844 |
| Junior high school | 0.2736723 | 0.0058492 | 46.79 | 0 | 0.2622081 | 0.2851365 |
| Senior high school | 0.3965058 | 0.0049521 | 80.07 | 0 | 0.3868 | 0.4062117 |
| Higher education/University | 0.6234054 | 0.005702 | 109.33 | 0 | 0.6122296 | 0.6345811 |
| Firewood for cooking | −0.2574129 | 0.0024533 | −104.92 | 0 | −0.2622213 | −0.2526044 |
| Constant | 12.77966 | 0.0088746 | 1440.02 | 0 | 12.76227 | 12.79705 |
| Log non-food | | | | | | |
| Non-energy-poor household | 0.1154204 | 0.0027363 | 42.18 | 0 | 0.1100574 | 0.1207833 |
| Village | −0.2537265 | 0.0029751 | −85.28 | 0 | −0.2595575 | −0.2478955 |
| Log area of house | 0.3398932 | 0.0021829 | 155.71 | 0 | 0.3356148 | 0.3441716 |
| Number of household member | 0.1086066 | 0.0007837 | 138.57 | 0 | 0.1070705 | 0.1101428 |
| Clean water | 0.0974683 | 0.0032546 | 29.95 | 0 | 0.0910895 | 0.1038472 |
| Education level head of household | | | | | | |
| Incomplete primary school | 0.1443982 | 0.0067757 | 21.31 | 0 | 0.131118 | 0.1576783 |
| Primary school | 0.3445526 | 0.006475 | 53.21 | 0 | 0.3318619 | 0.3572433 |
| Junior high school | 0.4045319 | 0.0080266 | 50.4 | 0 | 0.3888001 | 0.4202638 |
| Senior high school | 0.6509922 | 0.0067955 | 95.8 | 0 | 0.6376732 | 0.6643111 |
| Higher education/University | 1.194068 | 0.0078246 | 152.6 | 0 | 1.178732 | 1.209404 |
| Firewood for cooking | −0.3596487 | 0.0033666 | −106.83 | 0 | −0.3662472 | −0.3530502 |
| Constant | 11.79763 | 0.0121783 | 968.74 | 0 | 11.77376 | 11.8215 |

non-food goods.

The previous section analysed household data while this section developed analyses at the village level. The number of malnourished people decreased if the number of households in the village have more access to electricity (Table 9). Precisely, if the number of households with electricity access increases by one household, the number of people with malnutrition, such as marasmus and kwashiorkor, since the last 3 years decreased by seven people (other things being equal). Further, initial condition of a household with electricity access tends to lowered the number of malnutrition by five persons (other things being equal). The initial condition of existence of the national grid lowered the number of malnourished people to about five. However, extending the national grid tended to increase the number of malnutrition cases but it is not statistically significant. We can argue that passing through the national grid connection does not automatically mean access to electricity. Several months are needed to connect from a high-voltage transmission to a low-voltage one. Further, connecting from a low-voltage grid to the house needs installation; for many families, it is very costly.

### 4.3. Conclusions and policy implications

Indonesia has committed to reduce the number of energy-poor people globally and nationally. However, the country does not have a benchmark in defining energy poverty. This paper adopted two definitions of energy poverty that reflect international standards and national policies. By international standards, we found that about 53% of households are energy poor. Spending on transportation has dominated energy spending. A relatively high spending on transportation can hamper people's mobility. We found that non-poor-energy households (in terms of electricity consumption and energy spending) spend more on food and non-food goods than energy-poor households. Further, we found that non-energy-poor families have more elastic spending on non-food than food items. This implies that access to energy can create more demand for non-food goods. Further, villages with access to electricity and modern energy (for cooking) had a lesser number of

**Table 9**
Impact of electricity access at the village level.
Source: author's calculation

| Malnutrition | Coef. | Std. Err. | t | P > t | [95% Conf. | Interval] |
|---|---|---|---|---|---|---|
| Village with electricity | −6.932799 | 3.271623 | −2.12 | 0.034 | −13.34522 | −0.5203733 |
| Number of households in the village | −0.0144339 | 0.0037637 | −3.84 | 0 | −0.0218108 | −0.0070571 |
| Modern energy for cooking | −0.9070762 | 0.4902967 | −1.85 | 0.064 | −1.868064 | 0.0539119 |
| National grid | 3.488738 | 2.107775 | 1.66 | 0.098 | −0.6425302 | 7.620006 |
| Initial condition village with electricity | −5.241748 | 1.126436 | −4.65 | 0 | −7.449579 | −3.033917 |
| Initial condition number of households in the village | 0.0138609 | 0.0019789 | 7 | 0 | 0.0099822 | 0.0177396 |
| Initial condition modern energy for cooking | 1.484411 | 1.191374 | 1.25 | 0.213 | −0.8506996 | 3.819521 |
| Initial condition national grid | −5.480363 | 2.224455 | −2.46 | 0.014 | −9.840325 | −1.120402 |
| Constant | 2.846031 | 3.252839 | 0.87 | 0.382 | −3.529577 | 9.221639 |

Number of observations = 47,808; F(8, 47799) = 48.32; Probability > F = 0; R-squared = 0.0768; Root MSE = 78.717.

malnourished people.

Our study implied four policy options. First, based on income or expenditure criteria, more than half of household are energy poor. Government needs to improve efficiency in the electricity and transportation sector. Public private partnership on developing energy infrastructure and public transport need to be enhanced. Government also needs to provide more incentives in using public transport. In the case of the electricity sector, the government can develop utilisation of renewable energy based on local resources. Rapid decline in generating cost of renewable energy will have substantial impact in terms of utilisation and reduce dependency on fossil fuel. Second, government still provide energy subsidy (products based). It is necessary to provide energy subsidy first to households below the poverty line and without access to modern energy. Government also can reallocate energy subsidies for promoting energy infrastructure such as public transport. Third, because many non-energy-poor households lie below the poverty line, government should enhance energy efficiency and improve appropriate skills to boost the productivity in the way energy is used. Community empowerment programs can focus on this group of household. Finally, many households still consume electricity below 32.4 kWh/month, and many of them are not poor. This implies that demand for electricity can be expanded without raising energy poverty. Utilisation of electric stove, electric bike or even electric car can be promoted in many regions that have excess power.

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## Appendix A. Supplementary data

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