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Influence of Socioeconomic, Demographics, and Prices Factors on Cooking Fuel Choice of Indonesian Households

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Abstract
There are differences in the choice of cooking fuel in Indonesian households. Some households still not yet used clean fuel for daily cooking, even though clean energy is crucial and included in the Sustainable Development Goals (SDGs). This study examines the influence of several factors on household's cooking fuel choice using SUSENAS data. This study is based on conceptual framework and theory on several determinant factors, including income, education level of the household head, and energy prices. The testing of the hypothesis used the probit methods. In the estimation results obtained, socioeconomic and demographic factors, namely income, education level of the household head, location of the household in urban areas, positively and significantly impacts the decision to choose clean fuel for cooking. Meanwhile, the price of clean fuel types such as LPG and city gas negatively and significantly impacts the decision to choose clean fuels for cooking in Indonesian households.

Keywords: Demographic Factors; Socioeconomics Factors, Energy Prices; Cooking Fuel Choice, Probit

Pengaruh Faktor Sosioekonomi, Demografi, dan Harga pada Pilihan Bahan Bakar Memasak Rumah Tangga Indonesia

Abstrak
Terdapat perbedaan pada keputusan pilihan bahan bakar untuk memasak di rumah tangga Indonesia. Terdapat rumah tangga yang masih belum menggunakan bahan bakar bersih untuk aktivitas memasak sehari-hari, padahal jenis energi tersebut penting dan termasuk dalam Tujuan Pembangunan Berkelanjutan (TPB). Penelitian ini mengkaji pengaruh beberapa faktor pada keputusan rumah tangga memilih bahan bakar memasak dengan menggunakan data SUSENAS. Penelitian ini didasarkan pada kerangka konseptual dan teori pada beberapa faktor determinan yaitu pendapatan, tingkat pendidikan kepala rumah tangga, dan harga energi. Pengujian hipotesis diestimasikan menggunakan metode probit. Dalam hasil estimasi yang diperoleh, faktor sosioekonomi dan demografi yaitu pendapatan, tingkat pendidikan kepala rumah tangga, serta lokasi rumah tangga di perkotaan berpengaruh positif dan signifikan terhadap keputusan pilihan bahan bakar bersih untuk memasak. Sedangkan harga jenis energi yang bersih seperti LPG dan gas kota berpengaruh negatif dan signifikan terhadap keputusan pilihan bahan bakar bersih untuk memasak di rumah tangga Indonesia.

Kata kunci: Faktor Demografi; Faktor Sosioekonomi; Harga Energi; Pilihan Bahan Bakar Untuk Memasak; Probit

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INTRODUCTION

Energy is a vital commodity needed in every household, although it is generally not classified as a basic need. With energy, some housework, such as cooking, lighting the house at night, or moving motorized vehicles for transportation, can be carried out. As a vital commodity that is needed, energy is also discussed in the Sustainable Development Goals (SDGs) program, which is a worldwide goal in coordination with the United Nations (UN) in 2015 until the target in 2030 a follow-up to the Millennium Development Goals (MDGs). The discussion of the energy sector is clearly explained in the sentence, "Ensure access to affordable, reliable, sustainable and modern energy for all." Among the various types of energy and their uses to achieve SDGs, one that needs to be discussed is the fuel used in household cooking activities.

There are still differences in the use of fuel for cooking among households. Some households still need help to using clean fuel for daily cooking activities. Even though clean fuel for cooking is crucial, it has some influences/impacts on health. Stoves used for cooking with wood/biomass fuel produce pollution that is not good for health. Apart from that, for housewives using traditional fuel, it takes longer to collect the fuel, and some efficiency will loss during cooking (Lewis & Pattanayak, 2012).

Clean fuel used for cooking consists of several types, including electricity, liquified petroleum gas (LPG), and city gas. These three types of fuel are classified as good fuels because they support the economy by increasing the productivity of both labor and capital. Clean fuel technology provides higher quality services such as low environmental impact at low costs. It frees up household time, especially for mothers and children, so it can be used more for other productive purposes (International Energy Agency (IEA), 2006).

Based on global/regional data, this clean fuel usage level is not yet universal. Around 32% of the Indonesian population still had no access to clean fuel for cooking purposes in 2015 (IEA, 2017). Compared with other ASEAN countries, Indonesia is also behind Singapore, Brunei, Malaysia, and Thailand. Households in Singapore, Brunei, and Malaysia fully have access to clean fuel for cooking purposes. Meanwhile, in Thailand, the number who do not yet have access is smaller, namely 26% of the population. However, Indonesia has challenges due to its unique geographical conditions as it is an archipelagic country.

As a developing country with the fourth largest population in the world, Indonesia is also trying to support the targets set globally by ratifying the SDGs in Presidential Decree No. 59 of 2017. Besides, the choice of fuel used for cooking by the community has begun to transform through a conversion program provided by the government through the state-owned company Pertamina since 2007. This program is also aimed at improving the quality of cooking fuel for households in terms of cleanliness and the environment, as well as reducing the tremendous subsidies from the government for kerosene fuel that had occurred previously (Budya & Arofat, 2011). To date, fewer people use firewood or kerosene, while others use LPG, as shown in Figure 1.

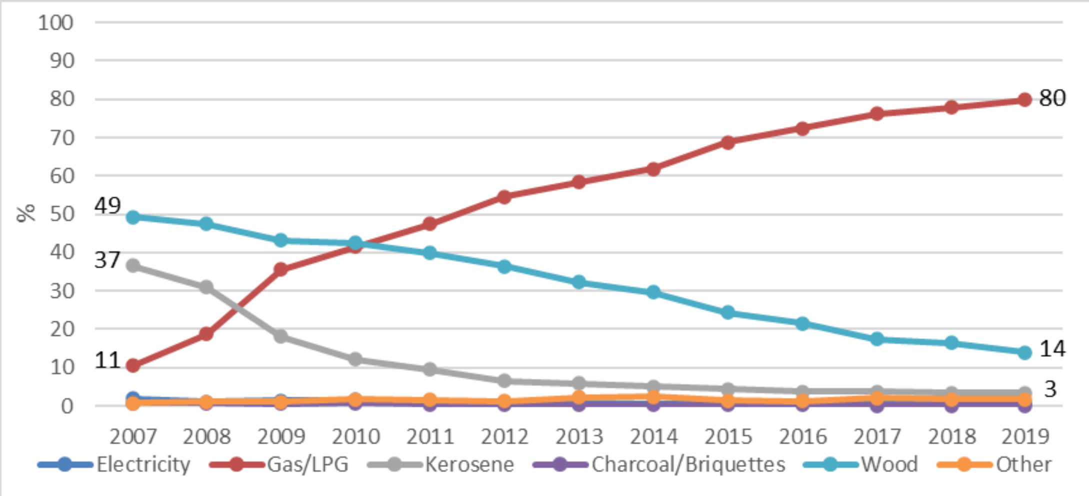

Figure 1. Percentage of Households according to primary fuel for cooking (BPS, 2021, processed)

Data from MEMR (2019) also show more generally that the type of energy consumed by Indonesian households has been quite transformational, where the most energy used in Indonesian households was biomass (including briquettes, charcoal, and firewood) in 2009. However, LPG and electricity led in 2019, although those data do not specifically refer to use for cooking.

The data on fuel use for cooking purposes shows that many households still need clean fuel in Indonesia. Even if they use clean fuel, sometimes households do not choose it as the primary fuel for cooking purposes. This condition follows what is stated in the fuel stacking theory, which explains the use of fuel not singly and allows households to use fuel in combination. This aspect is possible for several reasons, including frequent shortages of clean fuel, the high cost of equipment that uses clean fuel, fluctuations in commercial fuel prices, and household preferences.

So, it is necessary to carry out various programs and policies based on science and actual data to come up with a solution so that households can use clean fuel as the primary fuel for cooking. It is necessary to determine to what extent each household's socioeconomic and demographic conditions are associated with the household's choice decisions.

Previous research in Indonesia generally focused on types of energy for various activities, such as electrical energy at regional and national levels. These studies generally use an approach to the level/amount of consumption of each type of energy, including electricity consumption in Malang (Karisma et al., 2016), electricity consumption in Medan (Nababan, 2015), and the conversion program to LPG, especially in the area Semarang and Salatiga (Kities et al., 2014). So far, only two studies cover a national scale, namely research on household factors that influence household energy consumption expenditure (Nazer & Handra, 2017) and changes in household energy demand (Chen & Pitt, 2017) in Indonesia. Therefore, this research focuses on decision indicators in the choice of fuel for cooking in Indonesian households, represented by the types of electricity, gas/LPG, and city gas.

In analyzing the determinants of choosing clean fuel for cooking in households, the main factors will be researched as income and other household characteristics/preferences, whether they are associated determinants or not. These household characteristics/preferences include socioeconomic and demographic conditions, which, based on several theories, influence a household's fuel amount or choice. From the many studies abroad, the details of these factors are still debated whether they significantly influence household energy consumption decisions (Muller & Yan, 2018).

There are many factors associated with and influence households in making decisions. Therefore, this research will use a conceptual framework built to describe the decision-making environment for cooking fuel choices in households according to Figure 2 and based on various theories and literature studies, which will be discussed later.

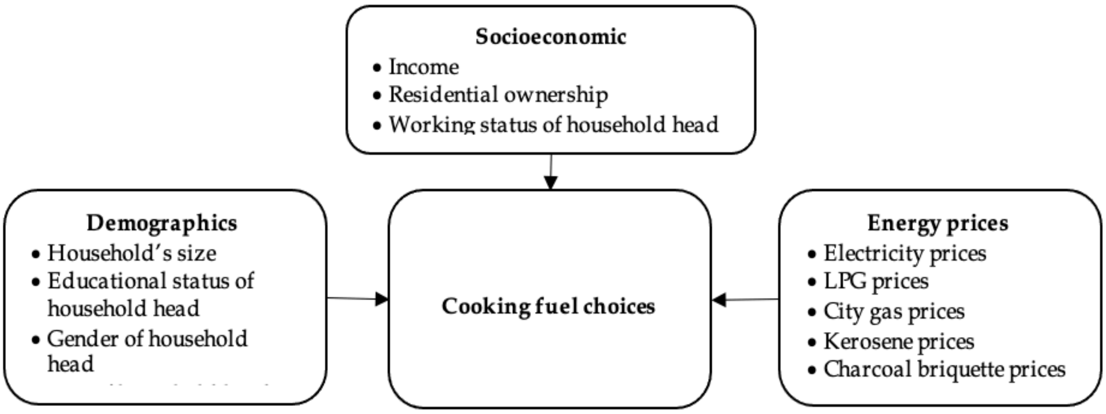

Figure 2. Conceptual framework explaining household fuel choice decision factors, extracted from several studies (Kowsari & Zerriffi, 2011; Muller & Yan, 2018).

This conceptual framework illustrates that decision-making, especially fuel choice, in households depends on three categories of determinant factors, namely: (i) internal socioeconomics of the household, (ii) household demographics, and (iii) energy prices. In the internal economic category of the household, the focus is on the income level, area of residence, and working status of the head of the household. The demographic category focuses on household size, especially adult household members, educational status of the head of the household, gender of the head, and age of the head. As for the household price category, electricity, LPG, city gas, kerosene, and charcoal briquettes prices are used.

These various household characteristics/preferences have different influences on household consumption of clean energy. Several other determinant factors, mainly in the form of socioeconomic and demographic conditions (Kowsari & Zerriffi, 2011; Muller & Yan, 2018), are explained in the following literature review of fuel choice decision factors in households:

1. Income

Income influences individual decisions in consumption. One of the theories on household energy consumption is the energy ladder theory, which is generally used in developing countries. It explains that the increasing income of a household will influence the process of changing from dirty traditional fuel choices (firewood) to alternative fuels, medium fuel (kerosene), and then clean/modern fuels (gas, electricity) which are cleaner and more efficient (van der Kroon et al., 2013). This theory is also demonstrated by Hosier & Dowd (1987) and Leach (1992). Hosier & Dowd (1987) showed a relationship based on Zimbabwean data, while Leach (1992) showed empirical data from several previous studies.

Besides, following consumer behavior theory, income influences individual consumption decisions. In more detail, consumption decisions based on income adjust to the classification of consumer goods, whether they are classified as luxuries, necessities, or inferior goods, as seen from the level of elasticity described by the Engel Curve.

Most of previous studies use income data with a household expenditure approach because household expenditure data is generally easier to obtain, and the validation can be trusted. Meanwhile, some authors use household income data directly or wealth data as alternative proxies. Hosier & Dowd (1987) showed a positive relationship between increasing household income and the effect of fuel transition from the choice of firewood to using kerosene and electricity based on data from urban Zimbabwean households.

Apart from this research, various studies have been carried out, proving the existence of the energy ladder theory in various countries. These studies include case studies in Afghanistan (Paudel et al., 2018), West Africa (Rahut et al., 2016), Burkina Faso (Ouedraogo, 2006), Nigeria (Baiyegunhi & Hassan, 2014), India (Gupta & Köhlin, 2006; Saxena & Bhattacharya, 2018), Ghana (Martey, 2019), Kenya (Lay et al., 2013), and rural China (Démurger & Fournier, 2011; Liao et al., 2019). Lee (2013) also shows evidence that Uganda's consumption and choice of energy fuels follow this theory using OLS, tobit, multinomial logit, and logistic estimation models.

Another research results indicate that clean fuels are more part of a fuel combination than a complete substitute for traditional fuels (Heltberg, 2004; Heltberg, 2005). Several studies have also produced income elasticities, which show that LPG and electricity are necessities goods (Akpalu et al., 2011; Lee, 2013; Macauley et al., 1989).

Research results in Indonesia also show a positive influence of income on modern/clean fuels. However, some results positively influence traditional fuels (Nazer & Handra, 2017), which differs from overseas case studies research.

2. Level of education

The level of education, in general, negatively influences traditional energy consumption, increases the opportunity cost of collecting fuel, and increases income. A higher level of education will provide knowledge of the negative impacts on the health of traditional energy consumption and the efficiency advantages of modern/clean energy. Apart from that, increasing education increases the opportunity cost of collecting traditional fuel and increases the opportunity to work with a higher income.

This aspect is evidenced by the shift of households from using traditional energy to modern/clean energy in research in Nigeria (Baiyegunhi & Hassan, 2014), India (Farsi et al., 2018; Gupta & Köhlin, 2006), Ethiopia (Abebaw, 2007; Gebreegziabher et al., 2012), and Kenya (Lay et al., 2013).

3. Prices

Prices influence the capabilities of households with limited income. In accordance with what has been written previously, households will try to meet needs and maximize utility/satisfaction within their budget constraints (Marshallian) and minimize expenditure at a certain utility level (Hicksian). However, most previous studies did not use price variables due to data limitations (Alem et al., 2016). Of the several studies that use price variables, some use market prices for fuel. However, some studies use costs as a proxy for fuel collection time multiplied by the opportunity cost of time. Most studies prove the results of a significant negative influence of own-price on the amount of fuel consumed and the probability of choosing that fuel, including increasing LPG prices in India (Farsi et al., 2018) and China (Jingchao & Kotani, 2012). However, the magnitude of the effect varies between fuel types, years, and locations.

However, there are some differences in the results for the cross-price effect, which shows that the substitute/complement effect is related to the income effect that needs to be controlled. This aspect is demonstrated by research in China (Peng et al., 2010) and Guatemala (Heltberg, 2005). Apart from that, the prices of consumer and other production goods also greatly influence energy consumption. Thus, the precautionary principle is crucial in interpreting the results of estimating direct and cross-price effects on prices. Alem et al. (2016) stated that price is one of the factors that plays an essential role in the decision to choose the type of energy in households based on Ethiopian data, as well as expenditure which represents income and education level.

METHOD

This research focuses on analyzing the influence of socioeconomic, demographics, and energy prices factors on cooking fuel choice decisions using econometric estimates. The influence of determinant factors was calculated using household cross-section data as a comparison in 2014.

Choosing fuel for cooking in a household is a qualitative response and a discrete result of behavioral choices. In analyzing it, it cannot be estimated consistently using the linear regression method, adopting several models that have been carried out in case studies in Malawi (Jumbe & Angelsen, 2011), India (Gupta & Kohlin, 2006), and several researches in other countries, using probit model for cooking fuel choice in this study.

In this probit model, the decision to choose clean fuel for cooking is analyzed using the $CleanFuel_i$ variable, which results from binary categorization using data on consumptions of electricity, LPG, or city gas as the primary fuel for cooking. $CleanFuel_i$ is categorized as having a value of 1 (one) if the household chooses clean fuel for cooking, namely using electricity, LPG, or city gas, and a value of 0 (zero) if otherwise/other types of fuel such as kerosene, charcoal, briquettes or wood. The types of electricity, LPG, or city gas represent the clean fuels chosen as cooking fuel in households.

So, the analysis of the determinant factors for the decision to choose cooking fuel in Indonesia was carried out using a probit specification model regression referring at least to the case studies of Malawi (Jumbe & Angelsen, 2011) and India (Gupta & Kohlin, 2006), as follows:

$$Prob\ (CleanFuel_i) = \alpha + \beta_1\, income_i + \beta_2\, educ_i + \beta_3\, P_i + \beta_n\, Z_i + \varepsilon_i$$

with:

$CleanFuel_i$ = probability 1/0 categorization for the decision to choose clean fuel as the primary cooking fuel;

$income_i$ = household income level (household expenditure proxy);

$educ_i$ = education of the head of household (a proxy for the number of years of study based on the highest level of education ever/currently occupied);

P_i = energy prices (a proxy for average household energy expenditure per quantity);

Z_i = other independent variables as control variables, namely socioeconomic and demographic factors, including $urban_i$, $Java_i$, $adults_i$, $homestat_i$, age_i, $gender_i$, dan $workstat_i$;

ε_i = error term.

The data used is a micro-level dataset, namely the household level in 2014 through data from the National Socioeconomic Survey (Susenas), both the KOR RT Module and the Food/Non-Food Consumption Expenditure and Household Income/Receipts Module conducted by the BPS - Statistics Indonesia (BPS). These data are the result of a survey of 285,400 samples representing 65,627,400 households throughout Indonesia. The choice of data from 2014 is due to a more balanced distribution of fuel choices, not too heavy on one type of fuel (in this case compared to the choice of LPG as the primary cooking fuel in the 2019 data).

A summary and discussion of each variable used is explained in Table 1, which is displayed in the appendix section.

FINDING AND DISCUSSION

The model's dependent variable in this research is the choice of clean fuel as the primary fuel for cooking in households. Based on processed BPS data (2014), households that choose clean fuel reach 62.50% of all Indonesian households. Meanwhile, looking at the distribution, the differences can be seen, where in 2014 there were 79.67% in urban areas who chose clean fuel as the primary fuel for cooking, while in rural areas it was only 45.44%. Likewise, on the island of Java, 70.41% chose clean fuel, while in non-Java, it was only 51.10%. Details are shown in Table 2.

Table 2. *Data on households (hh) deciding to choose clean fuel as the main fuel for cooking (BPS, 2014, processed)*

Household Fuel	National	Urban	Rural	Java	Non-Java
Clean Fuel	37.50%	20.33%	54.56%	29.59%	48.90%
Dirty / traditional fuel	62.50%	79.67%	45.44%	70.41%	51.10%
Total hh sample	65,627,400	32,708,768	32,918,632	38,752,949	26,874,451

Meanwhile, looking in more detail at the data for each province, there is inequality as shown on the map of Indonesia in Figure 3. In 2014, Maluku Province had the least number of people choosing clean fuel as the primary fuel for cooking, namely only 0, 4% of its households. DKI Jakarta Province has the most people choosing clean fuel as the primary fuel for cooking, namely around 88% of households.

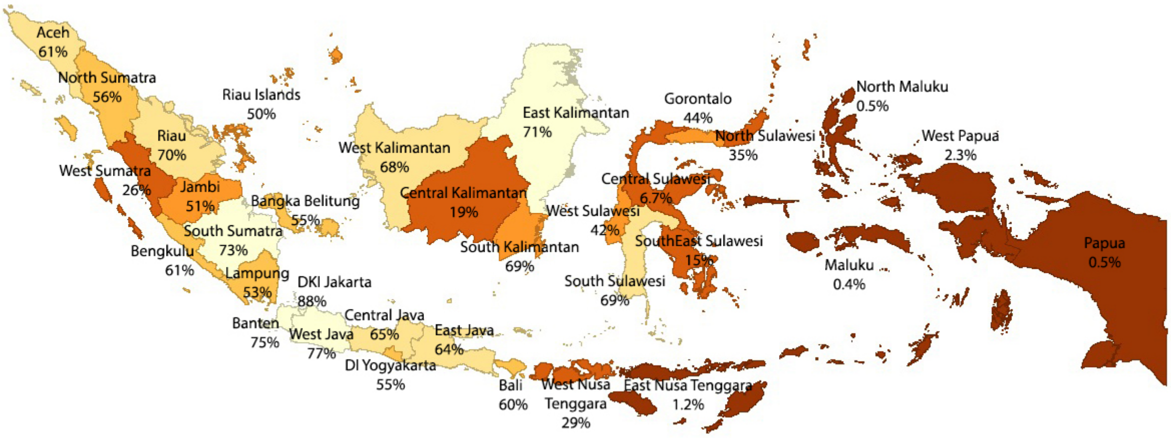

Figure 3. Data on households that choose clean fuel as the primary fuel for cooking by province (BPS, 2014, processed)

An overview of the independent variables in this research model is shown in Table 3. Most variables have average values close to each other for households located in urban, rural, Java, non-Java, and at the national level. There are several exceptions, namely the average values of the income and education (education of the head of the household) variables, which are pretty different, especially between urban and rural. In 2014, the average household income in rural was around 2.28 million rupiah; in urban, it reached 3.7 million rupiah. The level/length of education of household heads in rural reaches 6.62 years while in urban it reaches 9.47 years.

Table 3. *Data on the average value of each variable (BPS, 2014, processed)*

Variables	National	Urban	Rural	Java	Non-Java
income	2.88	3.70	2.28	2.76	2.95
adults	3.12	3.16	3.09	2.99	3.18
homestat	0.90	0.83	0.95	0.92	0.89
age	48.08	48.08	48.07	50.12	47.09
gender	0.85	0.84	0.86	0.84	0.86
workstat	0.85	0.81	0.88	0.83	0.87
educ	7.84	9.47	6.62	7.64	7.93
Total hh sample	65,627,400	32,708,768	32,918,632	38,752,949	26,874,451

As for the other independent variable, namely prices, according to what was previously stated, the value is obtained from calculating the average household expenditure on energy per quantity of energy consumed by the household (average price). The price unit is rupiah/unit of each type of energy, namely kWh for electricity, kg for LPG, m^3 for city gas, liters for kerosene, and kg for charcoal/coal/briquettes. With these varying values, the average price in each province is used for calculations in the estimation model. This condition is also related to data observations; this study found that not all households used every type of energy, which resulted in data gaps for certain types of energy in some households. For few provinces, there also cases which no households use certain types of energy based on the Susenas sample.

From these data, descriptive analysis can also be carried out by looking at the distribution of clean fuel choice data for the distribution of certain dependent variables, for example in the particular income (*income*) group and in the particular education of the head of a household (*educ*) group.

The distribution of fuel choices is obtained by dividing household data into five income groups, as shown in Figure 4 below. Grouping is carried out based on each percentile of 20% of the household sample. So, there was Group 1 with an income (expenditure proxy) of less than 1.28 million rupiah; Group 2 with an income range of between 1.28-1.83 million rupiah; Group 3 with an income range of between 1.83-2.51 million rupiah; group 4 with an income range of between 2.51-3.77 million rupiah; and group 5 with an income range of more than 3.77 million rupiah.

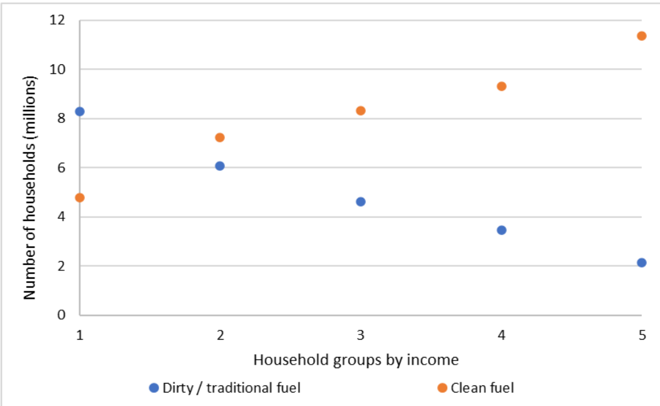

Figure 4. Tabulation of households based on income groups and their choice of fuel for cooking (Central Statistics Agency, 2014, processed)

It can be seen that the energy ladder theory also occurs in Indonesian households. More household groups with high incomes use clean fuel than dirty/traditional fuel. The higher the household group based on income, the greater the percentage of households choosing clean fuel for cooking, where in group 1, it is only 36.6%; group 2 was 54.4%; group 3 was 64.3%; group 4 was 72.9%; up to group 5 of 84.1%.

The same condition can be observed by looking at the education level of the head of the household to obtain the distribution of fuel choices, as shown in Figure 5 below. Household groups with higher education (more years of education) tend to use clean fuel compared to dirty or traditional fuel.

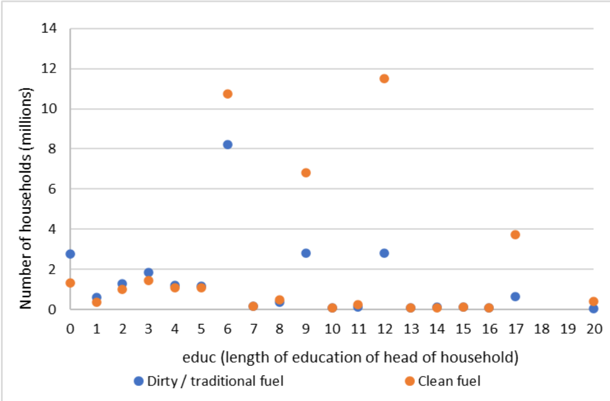

Figure 5. Tabulation of households based on income groups and their choice of fuel for cooking (BPS Susenas 2014, processed)

It can be seen that households with household heads having less than 6 years of education (less than primary school level) have a higher percentage of dirty or traditional fuel choices. Meanwhile, on the other hand, households with household heads having completed more than or equal to 6 years of education (more than elementary school level) have a higher percentage of clean fuel choices.

Probit model estimation results – clean fuel.

In this research model, the choice of clean cooking fuel is analyzed using the $CleanFuel_i$ variable, which is the result of binary categorization using data on electricity, LPG, or city gas as the primary fuel for cooking. $CleanFuel_i$ is categorized as having a value of 1 (one) if the household consumes modern/clean energy for cooking, namely using electricity, LPG, or city gas, and a value of 0 (zero) if otherwise/other types of fuel such as kerosene, charcoal, briquettes, or wood. Electrical energy, LPG, or city gas represent the clean fuels chosen as household cooking fuel.

Estimation results from regression models carried out on household data as a whole (Urban-Rural/Java-NonJava) or those located in rural areas (Rural), urban areas (Urban), Java Island provinces (Java), as well as outside the Island provinces Java (Non-Java) is shown in Table 4, displayed in the Supplement section. Based on the model estimation results shown in Table 4, most of the independent variables, namely determinant factors, are proven to be significant in influencing the dependent variable of clean fuel choice.

A positive association exists between increasing income (household expenditure) and choosing clean fuel. An increase in household income of 1 unit of log will increase by 14.56 - 34.17%, which points to the probability of choosing clean fuel. This 1 unit of log figure, when viewed from an income perspective, means that income multiplied by e (natural number) = 2.71828, thus showing an increase of 171.83% (Schechter, 2016). This positive association also proves that the energy ladder theory occurs in Indonesian households. Meanwhile, the influence of increasing income on choosing clean fuel is greater in rural areas than in cities and in Java than in non-Java islands. This result also proves that the energy ladder theory follows previous research (Hosier & Dowd, 1987; Ouedraogo, 2006;

Baiyegunhi & Hassan, 2014; Gupta & Köhlin, 2006; Saxena & Bhattacharya, 2018; Lay et al., 2013; Démurger & Fournier, 2011; Lee, 2013). When compared in magnitude, a study in Kolkata, India (Gupta & Köhlin, 2006) shows that an increase in household income of 1 unit of log will increase the probability of a decision to choose clean fuel by 30% points. So, the magnitude of the increase in probability points in Indonesia is almost the same as in Kolkata, India, from the influence of income perspective.

Positive association of the influence of increasing the education level of the head of the household: With a one-year increase in the length of education of the head of the household, it will increase by 1.11 - 2.61% points the probability of making a clean fuel. Meanwhile, the influence of increasing education levels on choosing clean fuel is greater in rural areas than in cities and in Java than in non-Java. This result follows previous research (Baiyegunhi & Hassan, 2014; Farsi et al., 2018; Gupta & Köhlin, 2006; Gebreegziabher et al., 2012; Lay et al., 2013). In terms of magnitude, a study in Kolkata, India (Gupta & Köhlin, 2006) shows that a one-year increase in the length of education of the head of the household increases the probability of a clean fuel choice decision by 2% points. So, the magnitude of the increase in probability points in Indonesia is almost the same as in Kolkata, India, from the influence of the education of the head of the household.

There is a negative association of increasing prices of clean energy, including LPG and city gas, on the decision to choose clean fuel. With an increase in LPG prices by 1 unit of log or 171.83%, will reduce 46.80 - 110.47% points in the probability of deciding to choose clean fuel. This result shows a reasonably significant LPG price association and follows demand theory, where demand will decrease as the price increases. Meanwhile, an increase in the price of city gas by 1 unit of log or 171.83%, will reduce the probability of a decision to choose clean fuel by 1.41 - 31.30%. The differences in changes in probability points show different levels of elasticity in urban and rural areas as well as Java and non-Java.

CONCLUSION

This research focuses on determining the influence of socioeconomic conditions, demographics, and energy prices on household decisions to use fuel for cooking. Based on the results of the research conducted, factors in the form of socioeconomic and demographic conditions of households, as well as energy prices, have various associations with the decision to choose clean fuel among households in Indonesia. This research found that household income level (based on a proxy for household expenditure) positively affects the decision to choose clean fuel for cooking. This result proves that the energy ladder theory also occurs in Indonesian households. Another factor, namely the education level of the head of the household (based on the number of years of study of the head of the household), also has a positive association with the decision to choose clean fuel for cooking.

Meanwhile, prices for clean types of energy or own-price, namely LPG and city gas, have been proven to have a negative association with choosing clean fuel for cooking. Meanwhile, several other types of clean energy, namely electricity, show different results depending on where the household lives. Prices for dirty/traditional types of energy or cross-price, namely kerosene, have been proven to affect the decision to choose clean fuel for cooking positively. Meanwhile, charcoal briquettes are another traditional/dirty energy, which shows different results depending on where the household lives. The difference in the magnitude of changes in the probability of choice outcomes shows different levels of elasticity in urban and rural areas as well as Java and non-Java.

Based on the results of this research, the advice that can be given is that, in order to implement the choice of clean fuel for cooking evenly across all households in Indonesia, policies are needed to address the socioeconomic variables of the household. The urban dummy determinant variable is one of the household's socioeconomic conditions, which is proven to influence the household's decision to choose clean fuel as the primary fuel for cooking. Apart from that, the income level and level/length of education of the head of the household and the price of clean energy, especially LPG and city gas, are also proven to influence the household's decision to choose clean fuel.
So, policies are needed to overcome the decision to choose clean fuel for cooking, especially in rural areas and outside Java, in terms of socioeconomic conditions, household demographics, and the price of clean energy. For example, through efforts to increase education levels and provide knowledge and information regarding the advantages of using clean energy as fuel for cooking in rural households and outside Java.

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REFERENCES

Abebaw, D. (2007). Household determinants of fuelwood choice in urban Ethiopia: a case study of Jimma Town. *J. Dev. Areas* 41 (1), 117–126.

Akpalu, W., Dasmani, I., & Aglobitse, P. B. (2011). Demand for cooking fuels in a developing country: To what extent do taste and preferences matter? *Energy Policy*, 39(10), 6525–6531. https://doi.org/10.1016/j.enpol.2011.07.054

Alem, Y., Beyene, A. D., Köhlin, G., & Mekonnen, A. (2016). Modeling household cooking fuel choice: A panel multinomial logit approach. Energy Economics, 59, 129–137. https://doi.org/10.1016/j.eneco.2016.06.025

BPS-Statistics Indonesia. (2014). Survei Sosial Ekonomi Nasional.

BPS-Statistics Indonesia. (2019). Survei Sosial Ekonomi Nasional.

BPS-Statistics Indonesia. (2021). Persentase Rumah Tangga Menurut Provinsi dan Bahan Bakar Utama untuk Memasak Tahun 2001, 2007-2021. Accessed on https://www.bps.go.id/statictable/2014/09/10/1364/persentase-rumah-tangga-menurut-provinsi-dan-bahan-bakar-utama-untuk-memasak-tahun-2001-2007-2021.html

Baiyegunhi, L. J. S., & Hassan, M. B. (2014). Rural household fuel energy transition: evidence from Giwa LGA Kaduna State, Nigeria. *Energy for sustainable development*, *20*, 30-35.

Budya, H., & Arofat, M. Y. (2011). Providing cleaner energy access in Indonesia through the megaproject of kerosene conversion to LPG. *Energy Policy*, 39(12), 7575–7586. https://doi.org/10.1016/j.enpol.2011.02.061

Chen, J. J., & Pitt, M. M. (2017). Sources of change in the demand for energy by Indonesian households: 1980 – 2002. *Energy Economics*, 61, 147–161. https://doi.org/10.1016/j.eneco.2016.10.025

Démurger, S., & Fournier, M. (2011). Poverty and firewood consumption: A case study of rural households in northern China. *China Economic Review*, 22(4), 512–523. https://doi.org/10.1016/j.chieco.2010.09.009

Farsi, M., Filippini, M., & Pachauri, S. (2018). Fuel choices in urban Indian households. *Environment and Development Economics*, 12(May), 757–774. https://doi.org/10.1017/S1355770X07003932

Gebreegziabher, Z., Mekonnen, A., Kassie, M., & Köhlin, G. (2012). Urban energy transition and technology adoption: The case of Tigrai, northern Ethiopia. *Energy Economics*, 34(2), 410–418. https://doi.org/10.1016/j.eneco.2011.07.017

Gupta, G., & Kohlin, G. (2006). Preferences for domestic fuel: Analysis with socio-economic factors and rankings in Kolkata, India. Ecological Economics, 57, 107–121. https://doi.org/10.1016/j.ecolecon.2005.03.010

Heltberg, R. (2004). Fuel switching: evidence from eight developing countries. Energy economics, 26(5), 869-887. https://doi.org/10.1016/j.eneco.2004.04.018

Heltberg, R. (2005). Factors determining household fuel choice in Guatemala. Environment and development economics, 10(3), 337-361. https://doi.org/10.1017/S1355770X04001858

Hosier, R. H., & Dowd, J. (1987). Household fuel choice in Zimbabwe. *Resources and Energy*, 9, 347–361. https://doi.org/10.1016/0165-0572(87)90003-X

International Energy Agency (IEA). (2006) World Energy Outlook. Energy for cooking in developing countries. Paris: International Energy Agency.

International Energy Agency (IEA). (2017). Energy Access Outlook 2017. Paris: International Energy Agency.

Jingchao, Z., & Kotani, K. (2012). The determinants of household energy demand in rural Beijing: Can environmentally friendly technologies be effective? *Energy Economics*, 34(2), 381–388. https://doi.org/10.1016/j.eneco.2011.12.011

Jumbe, C. B. L., & Angelsen, A. (2011). Modeling choice of fuelwood source among rural households in Malawi: A multinomial probit analysis. *Energy Economics*, 33(5), 732–738. https://doi.org/10.1016/j.eneco.2010.12.011

Karisma, K. A., Maski, G., & Noor, I. (2016). Analysis of Electricity Consumption Behaviour: Case Study of Non-Business and Business Household in Malang. *International Journal of Social and Local Economic Governance (IJLEG)*, 2(2), 168–176.

Kities, R., Mulder, P., & Rietveld, P. (2014). Energy poverty reduction by fuel switching. Impact evaluation of the LPG conversion program in Indonesia. *Energy Policy*, 66, 436–449. https://doi.org/10.1016/j.enpol.2013.11.021

Kowsari, R., & Zerriffi, H. (2011). Three-dimensional energy profile: A conceptual framework for assessing household energy use. *Energy Policy*, 39(12), 7505–7517. https://doi.org/10.1016/j.enpol.2011.06.030

Lay, J., Ondraczek, J., & Stoever, J. (2013). Renewables in the energy transition: Evidence on solar home systems and lighting fuel choice in Kenya. *Energy Economics*, 40, 350–359. https://doi.org/10.1016/j.eneco.2013.07.024

Leach, G. (1992). The energy transitions. *Energy Policy*, *20*(2), 116-123. https://doi.org/10.1016/0301-4215(92)90105-B

Lee, L. Y. (2013). Household energy mix in Uganda. *Energy Economics*, 39, 252–261. https://doi.org/10.1016/j.eneco.2013.05.010

Lewis, J. J., & Pattanayak, S. K. (2012). Who Adopts Improved Fuels and Cookstoves? A Systematic Review. Environmental Health Perspective, 120(5), 637–645. https://doi.org/10.1289%2Fehp.1104194

Liao, H., Chen, T., Tang, X., & Wu, J. (2019). Fuel choices for cooking in China: Analysis based on multinomial logit model. Journal of Cleaner Production, 225, 104–111. https://doi.org/10.1016/j.jclepro.2019.03.302

Macauley, M., Naimuddin, M., Agarwal, P. C., & Dunkerley, J. (1989). Fuelwood use in urban areas: a case study of Raipur, India. The Energy Journal, 10(3). DOI: 10.5547/ISSN0195-6574-EJ-Vol10-No3-10

Martey, E. (2019). Tenancy and energy choice for lighting and cooking: Evidence from Ghana. *Energy Economics*, 80, 570–581. https://doi.org/10.1016/j.eneco.2019.02.008

Ministry of Energy and Mineral Resources (MEMR). (2019). Handbook of Energy & Economic Statistics of Indonesia (HEESI). Jakarta: Ministry of Energy and Mineral Resources

Muller, C., & Yan, H. (2018). Household fuel use in developing countries: Review of theory and evidence. *Energy Economics*, 70, 429–439. https://doi.org/10.1016/j.eneco.2018.01.024

Nababan, T. S. (2015). Karakteristik Rumah Tangga yang Mempengaruhi Permintaan Energi Listrik Rumah Tangga Sederhana. *Jurnal Ekonomi Pembangunan*, 16(1), 61–74.

Nazer, M., & Handra, H. (2017). Analisis Konsumsi Energi Rumah Tangga Perkotaan di Indonesia: Periode Tahun 2008 dan 2011. *Jurnal Ekonomi Dan Pembangunan Indonesia*, 16(2), 141–153.

Ouedraogo, B. (2006). Household energy preferences for cooking in urban Ouagadougou, Burkina Faso. *Energy Policy*, 34, 3787–3795. https://doi.org/10.1016/j.enpol.2005.09.006

Paudel, U., Khatri, U., & Prasad, K. (2018). Understanding the determinants of household cooking fuel choice in Afghanistan: A multinomial logit estimation. Energy, 156, 55–62. https://doi.org/10.1016/j.energy.2018.05.085

Peng, W., Hisham, Z., & Pan, J. (2010). Household level fuel switching in rural Hubei. *Energy for sustainable development*, *14*(3), 238-244.

Presidential Decree Number 59 of 2017 on Implementation of the Achievement of Sustainable Development Goals

Rahut, D. B., Behera, B., & Ali, A. (2016). Patterns and determinants of household use of fuels for cooking: Empirical evidence from sub-Saharan Africa. *Energy*, 117, 93–104. https://doi.org/10.1016/j.energy.2016.10.055

Saxena, V., & Bhattacharya, P. C. (2018). Inequalities in LPG and electricity consumption in India: The role of caste, tribe, and religion. *Energy for Sustainable Development*, 42, 44–53. https://doi.org/10.1016/j.esd.2017.09.009

Schechter, C. (2016). Answer on: Marginal Effects in Probit model for a Log-Transformed Variable. Statalist: The Stata Forum. https://www.statalist.org/forums/forum/general-stata-discussion/general/950118-marginal-effects-in-probit-model-for-a-log-transformed-variable

van der Kroon, B., Brouwer, R., & van Beukering, P. J. H. (2013). The energy ladder: Theoretical myth or empirical truth? Results from a meta-analysis. Renewable and *Sustainable Energy Reviews*, 20, 504–513. https://doi.org/10.1016/j.rser.2012.11.045

APPENDIX

Table 1. *Variables used in the research*

No	Variables	Symbols	Unit	Description
Dependent variables				
1	Binary variable: clean fuel	$CleanFuel_i$	0/1	0: when using kerosene, charcoal, briquettes, wood, or others as the main fuel for cooking. 1: when using electricity, LPG, or city gas as the main fuel for cooking.
Main independent variables				
1	Income	$income_i$	million rupiah	Taken through a total household expenditure approach.
2	Household's head educational level	$educ_i$	years	Taken using the number of years of study approach based on the highest level of education ever/currently occupied.
3	Energy price	$P_{energytype}$	rupiah / unit of energy	Calculated using the approach of average expenditure per quantity of electricity, LPG, city gas, kerosene, and charcoal briquettes in households for each province. Some provinces with no households data with certain types of energy use the national average price.
Independent/control variables				
1	Location of the house in urban/rural	$urban_i$	0/1	0: if the house is located in rural. 1: if the house is located in urban.
2	Location of the house in Java / non-Java	$Java_i$	0/1	0: if the house's location is in Java Island's provinces. 1: if the house's location is outside Java Island's provinces.

3	Number of adults	*adults*$_i$	person	Number of household members over 10 years old.
4	Residential ownership status	*homestat*$_i$	0/1	0: if the house is a contract, rented, rent-free house owned by someone else, official/company house, or other. 1: if the house is owned or rent-free by the family.
5	Household head's age	*age*$_i$	years	
6	Household head's gender	*gender*$_i$	0/1	0: if the household head is female 1: if the household head is male
7	Household head's working status	*workstat*$_i$	0/1	0: if the household head has not carried out work activities during the last week or three months. 1: if the household head carried out work activities during that time.

Table 4. *Probit model estimation results – clean fuel (italics indicate a standard error)*

Independent/control variables	**Marginal Effect (dF/dx)**											
	Urban-Rural		**Urban**		**Rural**		**Java-NonJava**		**Java**		**NonJava**	
ln *income*	0.2667	***	0.1456	***	0.3417	***	0.2978	***	0.2464	***	0.3013	***
	0.0001		*0.0001*		*0.0002*		*0.0001*		*0.0002*		*0.0002*	
educ	0.0196	***	0.0111	***	0.0261	***	0.0255	***	0.0260	***	0.0220	***
	0.0000		*0.0000*		*0.0000*		*0.0000*		*0.0000*		*0.0000*	
ln $P_{electricity}$	0.0643	***	0.0972	***	0.0239	***	0.0857	***	-0.0577	***	0.0785	***
	0.0003		*0.0003*		*0.0004*		*0.0003*		*0.0007*		*0.0006*	
ln P_{LPG}	-0.6046	***	-0.4680	***	-0.6188	***	-0.7312	***	-1.1047	***	-0.7583	***
	0.0004		*0.0004*		*0.0006*		*0.0006*		*0.0059*		*0.0008*	
ln $P_{city\ gas}$	-0.2090	***	-0.1473	***	-0.2053	***	-0.2283	***	-0.0141	***	-0.3130	***
	0.0003		*0.0002*		*0.0004*		*0.0003*		*0.0007*		*0.0004*	
ln $P_{kerosene}$	0.4444	***	0.2986	***	0.4488	***	0.4902	***	1.0269	***	0.4782	***
	0.0004		*0.0004*		*0.0006*		*0.0005*		*0.0039*		*0.0006*	
ln $P_{charc\text{-}briquett}$	-0.0247	***	-0.0263	***	-0.0235	***	-0.0078	***	-0.1585	***	0.0129	***
	0.0002		*0.0002*		*0.0002*		*0.0002*		*0.0007*		*0.0002*	
urban	0.2287	***										
	0.0001											
Java							-0.0263	***				
							0.0002					
adults	-0.0125	***	0.0096	***	-0.0423	***	-0.0137	***	-0.0048	***	-0.0240	***
	0.0001		*0.0001*		*0.0001*		*0.0001*		*0.0001*		*0.0001*	
homestat	0.1076	***	0.0927	***	-0.1057	***	0.0199	***	0.0974	***	-0.0392	***
	0.0002		*0.0002*		*0.0005*		*0.0002*		*0.0003*		*0.0003*	
age	-0.0006	***	0.0001	***	-0.0014	***	0.0002	***	0.0000		0.0009	***
	0.0000		*0.0000*		*0.0000*		*0.0000*		*0.0000*		*0.0000*	
gender	-0.0296	***	0.0031	***	-0.0848	***	-0.0495	***	-0.0548	***	-0.0286	***
	0.0002		*0.0002*		*0.0003*		*0.0002*		*0.0002*		*0.0003*	
workstat	0.0185	***	0.0408	***	-0.0458	***	-0.0065	***	-0.0046	***	-0.0068	***
	0.0002		*0.0002*		*0.0003*		*0.0002*		*0.0002*		*0.0003*	
Pseudo R^2	0.1521		0.0688		0.0747		0.1421		0.1652		0.0775	

LR test (chi^2)	1.30E+07	2.30E+06	3.40E+06	1.20E+07	7.80E+06	2.90E+06
Number of observation	65,627,400	32,708,768	32,918,632	65,627,400	38,752,949	26,874,451

* significant at the 10% level; ** significant at the 5% level; *** significant at the 1% level