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# Multiple Regression Analysis on Influence Factors of Household Cooking Fuels in Indonesia

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## Abstract

*One of the causes of the energy crisis is that the number of people is positively correlated with increased consumption of energy, especially fuel and electricity. The need for energy sources, especially for household purposes such as cooking, can be fulfilled by using LPG gas and firewood, as is well known, the LPG and firewood have been used by households in Indonesia since a long time. The variables that affect the use of LPG and firewood by households are "per capita GRDP", poor population, total area, number of islands, forests, and waters. By using multiple linear regression analysis, the prediction of the effect of these variables on the use of LPG and firewood can be obtained. Accuracy results obtained are 64% for both types of fuel. Meanwhile, the completeness of the data and the addition of other variables can improve the results of prediction accuracy.*

**Keywords:** *multiple regression, cooking fuels, liquid petroleum gas, firewood.*

## 1. Introduction

Energy has important roles for human life, one of them is the source of social, economic and environmental achievement in order to carry out sustainable development and encouraging economic activities. Two forms of energy that are very important and also most widely used today are heat and electricity. Heat is usually used for household heating, while it is also used in industry as an important component in the production process, for example for drying (in a dryer). Given that energy security is an important indicator that ensures a country as a big country or a strong country so it should be noted that energy can be generated from sources available or provided by nature, ie conventional energy (non-renewable energy) and non-conventional energy (renewable energy). In particular, the energy that can be used as household fuel is divided into two; "Modern" fuels and traditional fuels.

In Indonesia, modern fuels used in households, for example, gas and kerosene have been categorized as fuels from petroleum products, and firewood was considered as the traditional fuels [1]. The total population of Indonesia has reached 205 million in 2000 and has increased to more than 254 million in 2013. On average, population growth in the period of 2000-2013 is 1.66% per year. GDP per capita, (current price) increased from 6.78 million

rupiahs per capita in 2000 to 36.52 million rupiahs per capita in 2013. GDP per capita, in dollar terms, decreased from 3,469 dollars per capita in 2012 to 2,997 dollars per capita in 2013. This decrease was due to the rise in the dollar exchange rate against the rupiah from 9,670 rupiah per dollar in 2012 to 12,189 rupiah per dollar in 2013. Based on World Bank criteria, Indonesia in 2013 includes lower middle-income countries.

In 2013 the largest share of energy use was in the industrial sector (37.17%) followed by the household sector (29.43%), transportation (28.10%), commercial (3.24%), and others (2, 04%). In the period of 2000-2013, transportation sector experienced the greatest growth from energy use which reached 6.71% per year, followed by commercial sector (4.65%), and industrial sector (3.35%). As for growth in the household sector only amounted to 1.03%, and other sectors decreased by 1.65%. The household sector has low energy consumption growth due to the more efficient use of equipment and technologies such as the use of LPG and electricity [2].

The energy generated from LPG, firewood, and charcoal does not come from the fuel itself but comes from the technological processing procedures associated with the manufacture of fuel. Modern fuel can be known from its efficiency, safety, health, and the influence on the surrounding environment. However, in its development, firewood can be a very efficient and clean renewable energy source. In terms of energy density, combustion efficiency, heat transfer efficiency and heat control characteristics, LPG occupies the top position in terms of its energy transfer. This is despite the fact that LPG uses non-renewable fossil energy, however, LPG can be burned very efficiently; 1kg of LPG gas has an energy value of 11,254.61 kcal/kg.

The amount of firewood needed to produce energy equivalent to 1kg of LPG gas is 2.8kg, with the need for charcoal of 1.6kg. The use of charcoal for cooking is one of the alternatives of LPG or firewood. As is well known, the carbonization of fuelwood (charcoal) is referred to as a transitional fuel that can at any time replace LPG or firewood. In its implementation, wood charcoal is not widely used by households, but is the main choice for restaurant owners, as it is believed to make food more delicious.

According to the specifications, LPG is divided into three types: mixture, propane, and butane. The specifications of each LPG types are listed in the decision of the Director General of Oil and Gas Number: 25K / 36 / DDJM / 1990. Meanwhile, LPG marketed by Pertamina is LPG with mixed type.

This reseach aims to understand the factors influence the energy consumption, and to identify the cause of inefficiency on energy use. In energy source consumption process would accompanied by the cultural values or spesific behaviours. The existence of energy source is very important for local wisdom preservatio, and lead to its sustainability. The development of adequate infrastructure will provide opportunities for the development of gas, LPG and electricity stoves that have been used. LPG and natural gas will grow by 1% each, while firewood has decreased by 2.2%. Firewood is used more in

areas that still have considerable timber resources, remote villages, villages close to forests and far from urban areas. [3].

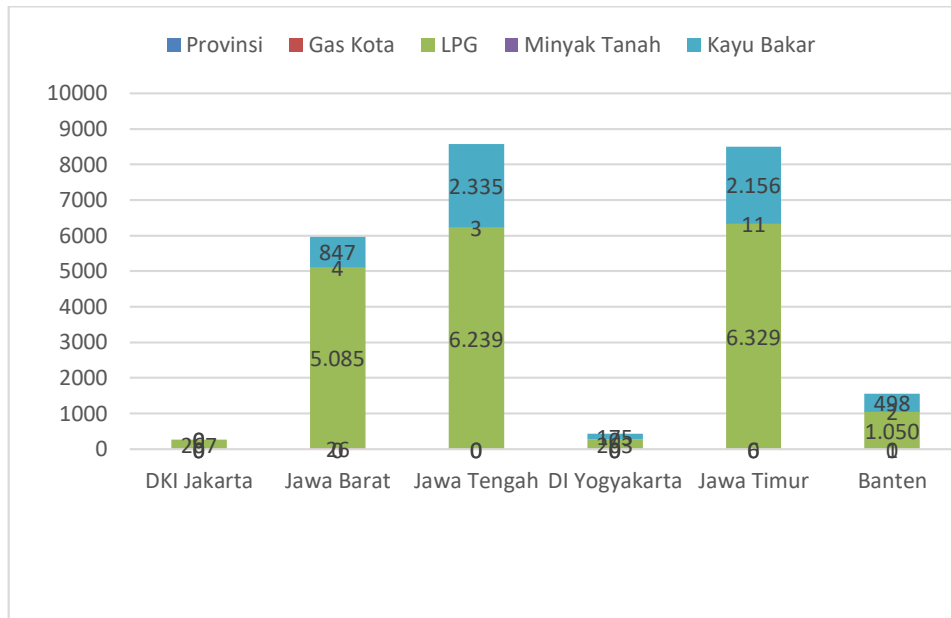


Figure 1. Histogram of cooking fuel used in the village / kelurahan of Java island [3]

Figure 1 shows that the use of LPG in Java Island in the village / kelurahan has reached a total of 19,233 and the use of firewood has reached as many as 6,011 villages / kelurahan. LPG gas users around its 30% (highest) are located in East Java and 1.3% (lowest) users are located in D.I Yogyakarta. The research will be obtained by using multiple linear regression analysis to measure the effect of several variables from the use of LPG and firewood. Then this research will find the clusters and correlations of energy use as a cooking fuel in Indonesia; between LPG as fossil energy and firewood as part of the biomass, which will then be compared to the map of the LPG plant in Indonesia. This research is also expected to help mapping efforts of biomass potentials in Indonesia so that the community can empower the potential for energy security.

## 2. Materials and Methods

The research will be conducted on a dataset consisting of seven independent variables; GRDP per capita, poor population, total area and number of islands by province, total forest area and then water area. The

dependent variable is the number of LPG users and users of firewood throughout Indonesia. In this research, there is a dataset with dimensions 4 x 34, where each sequence in question is the number of variables multiplied by the number of provinces in Indonesia. Multiple regression analysis methods will be used to determine the influence of one or several variables on one variable. This research is done simultaneously to the measurement result to then will be seen how far the independent variable's influence on output (dependent variable).

Independet Variables	Dependent Variables
1. GRDP per capita 2. The number of poor people 3. Area and number of islands by province, 4. The amount of forest and water area	1. Number of LPG and firewood users

Table 2. List of Independent and Dependent Variables

### 3. Results and Discussion

Multiple linear regression is a useful statistical method for finding the relationship between each of the predictor (independent) variables with the response variable (dependent) which is linear.

$$y = b_0 + b_1X_1 + b_2X_2 + b_3X_3 + \dots + b_xX_y \quad (3.1)$$

Equation (3.1) above, is used to find the relationship of predictor variable with the response variable. In this research, two experiments were conducted to determine the results of the research:

First experiment:

$$\begin{aligned}
 & \text{Number of LPG users} \\
 &= \text{GRDP per Capita} + \text{Poor People} \\
 &+ \text{Area and Number of Islands by Province} \\
 &+ \text{Number of Forest and Water Area}
 \end{aligned}$$

Second experiment:

$$\begin{aligned}
 & \text{Number of firewood users} \\
 &= \text{GRDP per Capita} + \text{Poor People} \\
 &+ \text{Area and Number of Islands by Province} \\
 &+ \text{Number of Forest and Water Area}
 \end{aligned}$$

#### 3.1. Multiple Regression Analysis "amount of LPG users in Indonesia"

Result from the first Experiment

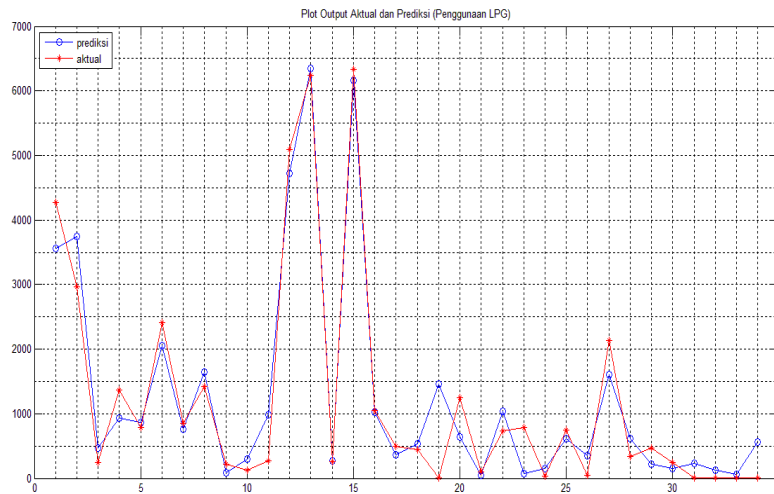


Figure 2. Comparison between actual graph (red) and predictions (blue) of LPG users in Indonesia

Figure 2 shows actual and predictive graphs that are almost significant in shaping the same pattern. Meanwhile, Table 3 will show how much difference between the actual value based on data source obtained from the Central Bureau of Statistics (BPS), and the predicted value of the results of the experiment using multiple linear regression.

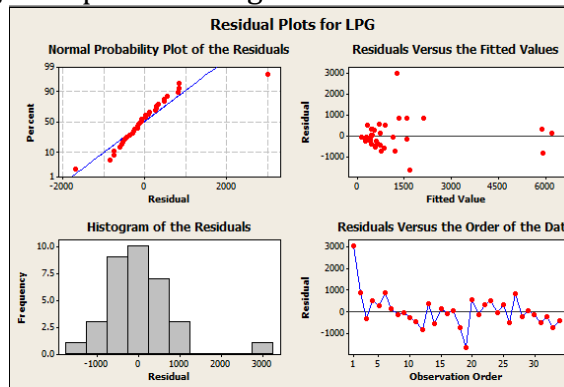


Figure 3. Residual Plots on Multiple Linier Regression of LPG

The result of multiple regression from equation 3.1 is as follows:  
 $LPG = 165 + 0.00055 \text{ from PDRB per Capita} + 0.001227 \text{ from Poor Population} + 0.00192 \text{ from Area and Number of Islands by Province} - 0.0290 \text{ from Number of Forest and Water Area}$ .  
 $S = 805,654$   $R\text{-Sq} = 81.5\%$   $R\text{-Sq (adj)} = 78.9\%$

NO	PROVINSI	AKTUAL	PREDIKSI	AKURASI PER PROVINSI	AKURASI MENURUT
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					<b>ZONA PULAU</b>
1	Aceh	4274	3560	83%	72%
2	Sumatera Utara	2967	3738	79%	
3	Sumatera Barat	248	471	53%	
4	Riau	1366	928	68%	
5	Jambi	788	868	91%	
6	Sumatera Selatan	2416	2054	85%	
7	Bengkulu	858	754	88%	
8	Lampung	1414	1647	86%	
9	Kepulauan Bangka Belitung	220	88	40%	
10	Kepulauan Riau	131	296	44%	
11	DKI Jakarta	267	987	27%	83%
12	Jawa Barat	5085	4720	93%	
13	Jawa Tengah	6239	6340	98%	
14	DI Yogyakarta	263	275	95%	
15	Jawa Timur	6329	6165	97%	
16	Banten	1050	1025	98%	
17	Bali	494	364	74%	
18	Nusa Tenggara Barat	446	529	84%	
19	Nusa Tenggara Timur	N/A	1457	-	
20	Kalimantan Barat	1248	639	51%	41%
21	Kalimantan Tengah	104	52	50%	
22	Kalimantan Selatan	737	1043	71%	
23	Kalimantan Timur	781	78.4	10%	
24	Kalimantan Utara	37	147	25%	
25	Sulawesi Utara	748	620	83%	56%
26	Sulawesi Tengah	47	348	13%	

27	Sulawesi Selatan	2134	1605	75%	
28	Sulawesi Tenggara	337	610	55%	
29	Gorontalo	464	211	46%	
30	Sulawesi Barat	245	157	64%	
31	Maluku	N/A	232	-	2%
32	Maluku Utara	N/A	126	-	
33	Papua Barat	N/A	55	-	
34	Papua	10	556	2%	
	<b>The accuracy average of LPG use in Indonesia</b>			64%	

Table 3. Accuracy by province and island zones in Indonesia (LPG)

Table 3 is a comparison between the actual data and the predicted results. Table 3 shows that the use of data such as; GRDP per Capita, Poor Population, Area, and Total of Islands based on Province and Data of Total Forest and Aquatic Area, can produce 64% prediction accuracy for LPG use in Indonesia. If judging from the accuracy point of view based on the island zone, Java island has an excellent data accuracy of 83%, while the worst is the Maluku and Papua island of 2%. This is due to the absence of significant actual data from these provinces, ie how many LPG users are in the provinces, or written with N/A (Not Addressing) code.

### 3.2. Multiple Regression Analysis “amount of firewood users in Indonesia”

#### Results of the second experiment

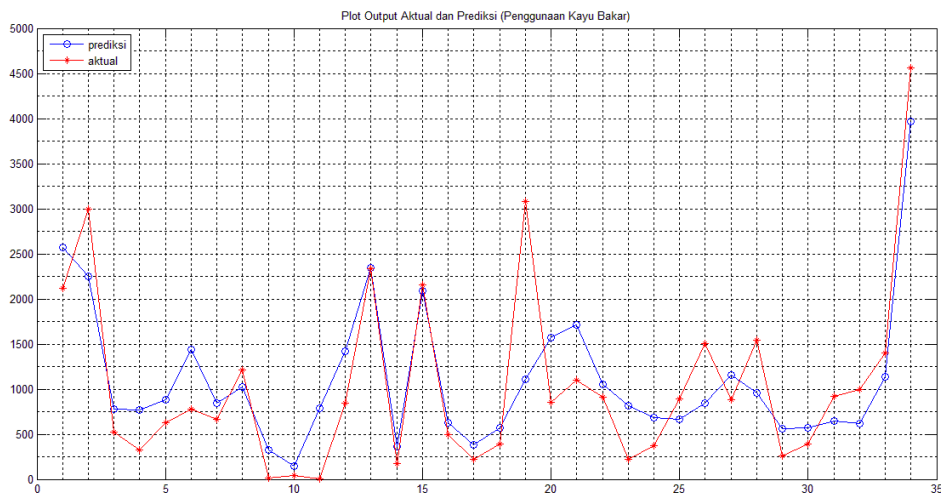


Figure 4. Comparison between actual graph (red) and prediction (blue) of firewood users in Indonesia

In Figure 4, the actual graph and the prediction show the pattern, which is almost linear. If the above results are then paired with the results of multiple linear analysis, it is discovered that the independent variables have a significant influence on the dependent variable. Figure 5 below will show the residual plots of multiple linear regression of firewood users in Indonesia.

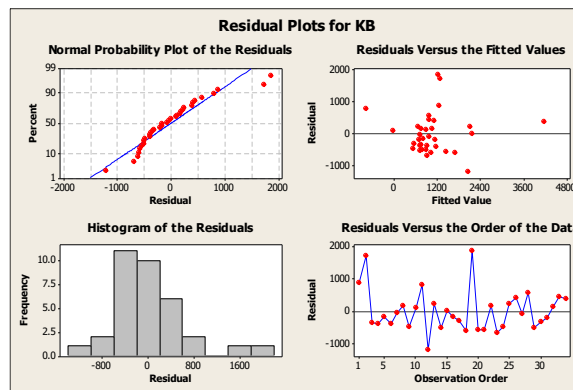


Figure 5. Residual Plots Multiple Linear Regression of Firewood

Results of a linear regression of the use of firewood as follows:  
 Firewood = 848- 0.00917 of GDP per Capita + 0.000326 of Poor Population - 0.00150 of Area and Number of Islands by Province + 0.0974 of Number of Forest and Water Area.  
 S = 687.457 R-Sq = 59.5% R-Sq (adj) = 53.9%.

NO	PROVINSI	AKTUAL	PREDIKSI	AKURASI PER PROVINSI	AKURASI MENURUT ZONA PULAU
1	Aceh	2119	2567	83%	59%
2	Sumatera Utara	2997	2251	75%	
3	Sumatera Barat	527	781	67%	
4	Riau	326	773	42%	
5	Jambi	630	879	72%	
6	Sumatera Selatan	777	1437	54%	
7	Bengkulu	667	845	79%	
8	Lampung	1216	1024	84%	



9	Kepulauan Bangka Belitung	16	322	5%	68%
10	Kepulauan Riau	38	147	26%	
11	DKI Jakarta	N/A	784	-	
12	Jawa Barat	847	1418	60%	
13	Jawa Tengah	2335	2343	99.7%	
14	DI Yogyakarta	175	362	48%	
15	Jawa Timur	2156	2094	97%	
16	Banten	498	629	79%	
17	Bali	222	384	58%	
18	Nusa Tenggara Barat	394	569	69%	
19	Nusa Tenggara Timur	3081	1108	36%	57%
20	Kalimantan Barat	855	1573	54%	
21	Kalimantan Tengah	1099	1709	64%	
22	Kalimantan Selatan	907	1050	86%	
23	Kalimantan Timur	222	819	27%	
24	Kalimantan Utara	371	685	54%	64%
25	Sulawesi Utara	889	665	75%	
26	Sulawesi Tengah	1509	846	56%	
27	Sulawesi Selatan	879	1159	76%	
28	Sulawesi Tenggara	1539	955	62%	
29	Gorontalo	255	558	46%	
30	Sulawesi Barat	394	573	69%	75%
31	Maluku	923	646	70%	
32	Maluku Utara	1000	614	61%	
33	Papua Barat	1404	1141	81%	
34	Papua	4564	3969	87%	
	<b>The accuracy average of</b>			64%	

<b>using the firewood in Indonesia</b>				
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Table 4. Accuracy based on data by province and island zone in Indonesia (Firewood)

The accuracy of data obtained from the eastern Indonesian island zones, including Maluku, North Maluku, West Papua and Papua, overall show the best accuracy against the comparison of actual and predicted results, with an average of 75%. Table 4 also shows the comparison between the actual results and the predicted results in Central Java province has an accuracy of 99.7%. Overall, the independent variables used can predict the use of firewood as domestic fuel in Indonesia by 64%.

**4. Conclusion**

One of the causes of the energy crisis is that the number of people is positively correlated with increased consumption of energy, especially fuel and electricity. Aside of LPG, firewood as the material obtained directly from nature is one of biomass type that can be used as a cooking fuel and can also be electrical energy source through engineering with simple technology. Meanwhile, the largest use of LPG in Indonesia is found in Java and Bali with total usage of 20173 Households, as for the use of firewood as a cooking fuel is the most widely used in Papua which is an area with forest and water area of 37124 meters per facet.

The use of multiple linear regression methods is appropriate to predict the use of LPG and firewood in Indonesia. This is indicated by the percentage accuracy of the similarity between the actual data and the overall prediction, then both LPG and firewood have an average accuracy of 64%. The accuracy of this model could be better if the data released by the National BPS are available and recorded. For example, there are no data from firewood users in Jakarta, as well as LPG user data in NTT, Maluku, North Maluku and West Papua.

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