Identifying Household Residential Electricity Un-subscribers under Two Electricity Subsidy Regimes in Indonesia

Mohammad Herman SULISTIYO
Graduate Student
Graduate School for International Development and Cooperation
Hiroshima University
1-5-1 Kagamiyama Higashi-Hiroshima, 739-8529 Japan
E-mail: herman_sulistiyo@yahoo.com

Latdaphone BANCHONGPHANITH
Researcher
Graduate School for International Development and Cooperation
Hiroshima University
1-5-1 Kagamiyama Higashi-Hiroshima, 739-8529 Japan
E-mail: linglatda@hiroshima-u.ac.jp

Shinji KANEKO
Professor
Graduate School for International Development and Cooperation
Hiroshima University
1-5-1 Kagamiyama Higashi-Hiroshima, 739-8529 Japan
E-mail: kshinji@hiroshima-u.ac.jp

Abstract

The use of electricity without a contract with a utility company is a form of electricity theft in Indonesia. The problem of illegal connection to the grid is neither widely acknowledged nor is discussed in detail in the recent literature. To enable deep discussions regarding issues of electricity fraud in Indonesia, this study aims to firstly identify the electricity un-subscribers, and then classify the un-subscribers by different tariff blocks based on the SUSENAS survey data. By comparing the un-subscriber structure over two electricity subsidy regimes, the results suggest that although with a regressive trend, the un-subscribers still make up a dominant proportion to the total electrified households. Furthermore, evidence from the classification of un-subscribers by tariff block tells that despite the number of the un-subscribers largely shrank among the low tariff blocks, it surged among the high tariff blocks. In summary, being able to identify the un-subscribers and classify them by tariff block paves the foundation for more in-depth studies on social and economic impacts of the un-subscribers in the future.

1. Introduction

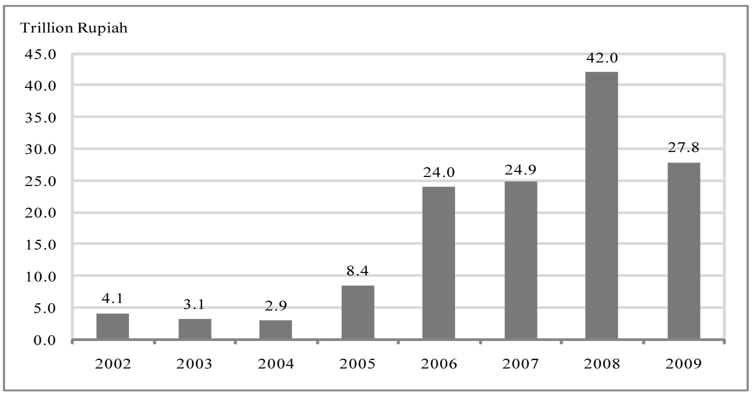
The Republic of Indonesia is the most populous country in Southeast Asia. Rapid economic development and population growth have posed increasing demand for energy supply. The pressure on energy demand comes not only from industrial sector, but also from households (World Bank, 2009a). Conventionally, household energy consumption in Indonesia relies mainly on electricity, fire-wood, kerosene, and LPG. Fire-wood is dominated in rural areas while kerosene is dominated in urban, mainly for cooking and lighting. In recent days, electricity has become the most important energy source and the foundation for much of the way of life rather than just for cooking and lighting. Thus, pricing of electricity could affect the welfare of households at different income classes to a large extent.

According to the International Energy Agency (IEA) data, at present, half of the country's electricity generation is dependent on coal and one fourth generated electric power remains dependent on oil. As a consequence, the country is struggling to increase oil production, which has been declining since 2001, amid soaring international oil prices and rising domestic demand. However, against increasing demand for electricity and oil products, Indonesia has unavoidably become a net oil importer since 2004. It caused the local oil product markets to be very sensitive to the global oil prices; very often the local oil product prices have fluctuated along the imported oil prices. Accordingly, the costs of electricity production (using oil fuel) also varied in line with the changes in the oil prices.

The State Owned Electricity Company or Perusahaan Listrik Negara (PLN) is the major player in Indonesia's power sector in the generation, transmission and distribution of electricity (Pintz & Korn, 2005). It is also by far, the predominant electric power supplier for households. As oil prices increase, the electricity company could hardly survive without increasing the electricity prices. To eliminate the burden of rising electricity prices to the poor, the government of Indonesia has been giving subsidies for different types of fuels for a long time, especially for kerosene which accounts for approximately half of the total oil subsidies, and gasoline and diesel each represents roughly one quarter of the total oil subsidies (Mourougane, 2010). That includes the oil subsidies to the PLN for generating electricity. Meanwhile, alike oil subsidies, the government also has been giving direct electricity subsidies to the residential electric power consumers, so that the poor can have more equal chances to access to electricity. Hence, the electricity subsidies are comprised of the direct subsidy to the PLN, and the indirect subsidy through the provision of oil products at subsidized prices. In general, a per unit electricity subsidy is measured as the difference between the regulated unit retail price and the unit production cost based on a price-gap method.

To-date, Indonesia has experienced three electricity subsidy mechanisms; up to 2001, the government issued the lifeline subsidy scheme which was provided to all customers with a consumption level below a minimum threshold considered necessary for meeting basic needs. This is based on the common knowledge that households with less electricity consumption are likely to be poor, and some intervention is warranted to enable them to meet their basic needs at an affordable cost. From 2002 to 2004, the government started implementing the targeted subsidy (TS) scheme to ensure the poor benefit the most from the electricity subsidy. Then in 2005, the government again shifted the subsidy scheme from the TS to the public service obligation (PSO) scheme by providing electricity to all customer categories with regulated tariffs. The PSO subsidy scheme aims at promoting equality and poverty alleviation with a high cost by the government budget. Throughout these periods, the government indirectly subsidized the PLN for purchasing oil fuels at lower than market prices. According to the World Bank, subsidies to the electricity sector accounted for 28 percent of the total subsidies disbursed by the Indonesian government in 2006 (World Bank, 2008). Nevertheless, from 2008 the government no longer provided the indirect oil subsidy to the PLN. As a result, the PLN started to purchase the oil fuels from the oil company at market prices. In other words, instead of getting oil subsidies, the PLN receives the direct subsidy based on the difference between the sales revenue and the electricity generation cost.

As shown in Figure 1 that electricity subsidy in real price has apparently become a heavy fiscal burden as it has increased significantly from merely 2.9 trillion rupiah in 2004 to 42.0 trillion rupiah in 2008. Due to drastic international oil price increase, the production cost of electricity has surged dramatically for the power generation still largely relied on oil fuel. In addition, given the fact that the tariffs are regulated as uniformed throughout the country by the government, and rising tariffs has always been a sensitive and controversial issue in Indonesian society; therefore, against the increasing production costs, the



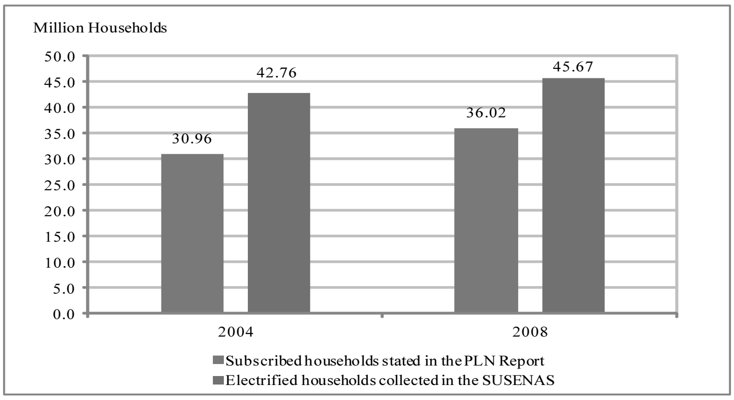
Source: State Owned Electricity Company (PLN) Report 2009.
Note: The total electricity subsidy includes subsidies to residents and other economic sectors.

Figure 1. Total electricity subsidy from 2002 to 2009 (2002 prices =100)

latest regulated electricity tariffs have remained unchanged since 2003 until 2010. Furthermore, existing electricity fraud problems further worsen the financial status of the PLN. Amid those dilemmas the PLN has become the biggest loss-making state owned enterprise and also the biggest subsidy receiver in Indonesia (World Bank, 2008). The long term and large electricity subsidy affects not only on the performance of the electric power sector, but also on general socio-economic performance as well. First, it is not yet fully understood that to what extent the subsidy benefits the poor in general. Second, the cost of the subsidy needs to be covered in some way, either by consumers, or by reduced spending and losses.

By mentioning the possibility that the subsidy to be covered by the electricity utility itself, the PLN can help the government reduces such heavy subsidy through minimizing its losses on electricity sales, or in short, through managing its income loss. Smith (2004) mentioned that the income loss of an electric utility could be caused by several channels. First, it covers the losses caused by inefficiency in the electric power systems from the aspects of loss in system use, loss due to technical transmission and distribution loss, and from gratis (electricity provided without charges to certain people and organization). Second, it also includes the losses caused by electricity theft, which can be in the forms of fraud (meter tampering), stealing (illegal connections), billing irregularities, and unpaid bills. However, there is another type of electricity fraud that is not yet discussed much in the literatures, which is fraud on meter rental charge (or capacity charge). In this study we regard households committed to meter rental charge fraud as the un-subscribers. An un-subscriber is a household accesses to the grid by sharing same electricity meter with a legal subscriber of the PLN. The un-subscriber normally does not pay the meter rental fee but only shares the energy charges with the owner of the meter. This situation happens commonly with the housing condition of which multi-families living under the same roof, or as cluster of families living near to each other within a close distance.

So far, it is difficult to measure the losses caused by the un-subscribers and it is even more difficult to identify which households are un-subscribers without detailed investigation report from the PLN. In Indonesia, there are two main sources of information on household electricity consumption. One is from the PLN annual report, and the other is from the National Socio-economic Survey (or SUSENAS). On one hand, the PLN annual report provides the number of households registered with the PLN on an annual basis, and the by-tariff-block electricity sales to all registered households (electricity loss due to electricity theft is not accounted). However, the PLN report does not reveal the information on its losses linked with electricity theft, as well as the losses due to unpaid capacity charges. On the other hand, the SUSENAS household data set, of which is collected by sampling with weight, although contains economic and demographic information of both electrified and non-electrified households, it does not distinguish whether or not the interviewed households who claim to pay electricity bills, are legally subscribed to the PLN. Nevertheless, by comparing the number of households registered as customers of the PLN stated in the PLN report and the number of households claimed to have electricity access from the SUSENAS, we observe that the number of households claimed to have access to electricity and pay electricity bills in the SUSENAS is greater than the number of households registered with the PLN (Figure 2). We therefore assume the difference of these two sources of data as the number of the un-subscribed households.



Source: The State Owned Electricity Company (PLN) Report 2005 and 2009, the SUSENAS Core 2004 and the SUSENAS Module 2008.

Figure 2. Comparing the data on the subscribed households from the PLN report and the electrified households from the SUSENAS

However, without knowing which households are supposed to be the un-subscribers and which tariff block the un-subscribers locate in, it is difficult to estimate the potential losses that those un-subscribers are responsible for. As can be seen in Table 1, the PLN provides six electricity tariff blocks for subscription options. The lowest tariff block of 450VA capacity only allows for low-intensity electricity use (e.g. only for lighting). In Indonesia, the poorest households fall predominantly in the 450VA capacity group and the electricity subsidy to this tariff block, which accounts for more than half of all electricity subsidies to residents, is progressive (World Bank, 2008). The electricity tariff consists of two types of charges. One is the meter rental fee (capacity charge), progressive along the subscribed capacity service; the other charge is the energy charge, also progressive with the amount of electricity consumption. The legal subscribers pay both the capacity charge and the energy charge on a monthly basis, whereas the un-subscribers only pay the energy charge at the price associate with the electric capacity level they connect with. Their unpaid capacity charges comprise the losses to the PLN.

Table 1. Electricity tariff structure based on the presidential decree 2003

Tariff Block	Capacity (VA)	Meter Rental Fee (Capacity Charge) (Rp/KVA/month)	Energy Charge (Rp/KWH)
R-1/450	450	11,000	Block 1: 0 until 30 KWH = 169 Block 2: 31 until 60 KWH = 360 Block 3: > 60 KWH = 495
R-1/900	900	22,000	Block 1: 0 until 30 KWH = 275 Block 2: 31 until 60 KWH = 445 Block 3: > 60 KWH = 495
R-1/1350	1350	30,100	Block 1: 0 until 30 KWH = 390 Block 2: 31 until 60 KWH = 445 Block 3: > 60 KWH = 495
R-1/2200	2200	30,200	Block 1: 0 until 30 KWH = 390 Block 2: 31 until 60 KWH = 445 Block 3: > 60 KWH = 495
R2/2200-6600	2200-6600	30,400	560
R3/>6600	>6600	34,600	621

Source: The State Owned Electricity Company (PLN) Report 2009.

The acknowledgement of the potential losses due to unpaid capacity charges could provide evidence for the PLN to further improve its service management in terms of households' grid connection monitoring. However, as mentioned above, neither the SUSENAS nor the PLN annual report contains the information regarding identification of the un-subscribers and the detailed information of electricity capacity to which each un-subscribed household connects. This has made the public not be able to raise the awareness of the existence of the un-subscribers and it also has created a great barrier to conduct scientific studies on the characteristics, and factors motivating the meter rental fee fraud (illegal electric connections), as well as the economic and social impacts brought by the un-subscribers. In order to fill this information gap and pave the foundation for further studies on the economic and social impacts responsible by the un-subscribers, this study aims to (1) identify the un-subscribers among the households claimed to have access to the electricity grid base on the household survey data from the SUSENAS; (2) identify the tariff block each un-subscribed household is supposed to connect with; and (3) compare the changes in number of un-subscribers in total and by tariff block between two electricity subsidy regimes. It is expected that upon the successful identification of the un-subscribers, further studies related to the economic impacts such as estimation of potential revenue loss to the PLN and related social impacts become possible in the future.

The rest of this paper is constructed into three sections as follows. The second section will provide detailed information on data used for this study and methodology employed for identifying and classifying the un-subscribers. The third section will discuss on the results yield from the analysis and the last section will wrap up the paper with conclusions and discussions.

2. Data and the un-subscriber identification method

2.1 Data

On electricity consumption data side, we use data from the National Socio-economic Survey (SUSENAS) conducted by the Central Bureau of Statistics (BPS) of Indonesia to identify the un-subscribers. The SUSENAS is a series of large-scale multi-purpose socio-economic surveys initiated in 1963-1964 and fielded every year or two since then. Since 1993, the SUSENAS surveys cover a nationally representative sample typically composed of 200,000 households. Each survey contains a core questionnaire which consists of a household roster listing the sex, age, marital status, and educational attainment of all household members, supplemented by modules covering about 60,000 households that are rotated over time to collect additional information such as health care and nutrition, household income and expenditure, and labor force experience. The data collection from selected households is given certain weight representing a specific number of households sharing similar characteristics. With those weight data, one can enlarge the SUSENAS household survey data set to cover all households in Indonesia.

In order to study the changes in number of the un-subscribers as well as the losses they are supposed to be accountable to, particularly during the period when there were changes in electricity subsidy regimes, we selected two time periods covering two electricity subsidy schemes (the TS and the PSO). We were able to obtain two SUSENAS data sets, the SUSENAS Core 2004 (covering approximately 42.76 million electrified households, enlarged with weights) and SUSENAS Module 2008 (covering approximately 45.67 million electrified households, enlarged with weights) from the BPS. There are several major differences between these two SUSENAS data as displayed in Table 3. Despite their different purposes and natures, both SUSENAS household data sets contain information on electricity expenditure, while the information on electricity consumption of all electrified households is noted in the SUSENAS Core 2004 only. It means that the electricity consumption in physical units in 2008 need to be estimated based on the electricity expenditure.

Table 2. The SUSENAS Core 2004 and the SUSENAS Module 2008

Type of Information	SUSENAS Core 2004	SUSENAS Module 2008
Coverage information	Only cover core questions related to welfare	Module 1: consumption (income & expenditure) Module 2: welfare, social culture, criminality and tourism Module 3: health, nutrition, education, & home environment
Periods of survey	Every year	Each module rotates yearly
Sample size	Around 240 thousand households	Around 67 thousand households
Data on electricity expenditure	Available	Available
Data on electricity consumption	Available	Not available

2.2 Convert electricity expenditure to electricity consumption

As mentioned above, the SUSENAS Module (consumption) 2008 only provides information on electricity expenditure. To estimate the electrified households' electricity consumption in 2008, the following formula is adopted:

$$ec_i^{sub} = \frac{ex_i^{sub} - mtf_{VA\,i}}{tariff_{VA\,i}} \quad \cdots\cdots (1)$$

where ec_i^{sub} is the amount of electricity consumption of the subscribed household i, ex_i^{sub} is electricity expenditure of the subscribed household i, mtf_{VAi} is the capacity charge (meter rental fee) paid by household i corresponding to the tariff block subscribed, and $tariff_{VAi}$ is the energy charge corresponding to the tariff block subscribed.

For the un-subscribed households, electricity consumption can be obtained without considering capacity charge as follow:

$$ec_i^{unsub} = \frac{ex_e^{unsub}}{tariff_{VA\,i}} \quad \cdots\cdots (2)$$

where ec_i^{unsub} is the amount of electricity consumption of the un-subscribed household i, and ex_i^{unsub} is electricity expenditure of the un-subscribed household i.

2.3 Identify the un-subscribers

To identify the un-subscribers, we developed a demand function of the household electricity consumption associated with various socio-economic aspects of all electrified households. Those socio-economic statuses include expenditure level (as proxy of income), living floor space, living location differed by urban and rural areas, age and education level of the head of household, family size, and the geographical location of the households. This is inspired by several previous studies in assessing electricity or energy demand models, although the focus of this research is not to estimate demand, but to differentiate between the subscribers and the un-subscribers and their respective electricity consumption.

Pitt (1985) and Fillippi and Pachauri (2004) developed the electricity demand function depending on prices of alternative energies, household expenditure as proxy of income, and geographical and demographic characteristics. In addition, Tiwari (2000) confirmed that electricity consumption can also be estimated by regressing income, price of electricity and other household characteristics. In line with their demand models and results, Pachauri (2004) estimated per capita demand for energy consumption in India using micro survey data. Her model includes three groups of key variables such as economic variables represented by per capita expenditure (proxy of income); demographic variables covering household rural/urban location, and number of household members; and the last variable group is dwelling attributes that include floor space of dwelling and type of dwelling.

Based on those preceded studies and refer to Pacharuri (2004)'s model, we developed the Indonesian household demand model and employed the early mentioned SUSENAS household survey data to regress the monthly per capita electricity expenditure (as proxy of household electricity demand) with variables such as per capita household expenditure (as proxy of income), living floor space, and dummies represent the household's dwelling type and demographic characteristics The model is presented as following:

$$\begin{aligned}\ln V_{el} = \alpha + \beta_1\ \ln Y\ + \beta_2 \ln fs + \beta_3\ Durru + +\beta_4\ Dmhh5 + \beta_5\ Dmhh6 + \beta_6\ Dmhh7 \\ + \beta_7\ Dmhhex7 + \beta_8\ Dwall2 + \beta_9\ Dwall3 + \beta_{10}\ Dah60\ + \beta_{11}\ Dahex60 \\ + \beta_{12}\ Dedh + \beta_{13}\ Dsm + \beta_{14}\ Dsl + \beta_{15}\ Dkl \\ + e \quad \cdots\cdots \quad (3)\end{aligned}$$

where, V_{el} is monthly per capita electricity expenditure;
Y is monthly per capita household expenditure (rupiah);
fs is living floor space (m^2);
Durru is dummy variable equals *1* if the household lives in an urban area and *0* otherwise;
Dmhh5 is dummy variable equals *1* for household has 5 members and *0* otherwise;
Dmhh6 is dummy variable equals *1* for household has 6 members and *0* otherwise;
Dmhh7 is dummy variable equals *1* for household has 7 members and *0* otherwise;
Dmhhex7 is dummy variable equals *1* for household has more than 7 members and *0* otherwise;
Dwall2 is dummy variable equals *1* for the household living in house with wooden walls and *0* otherwise;
Dwall3 is dummy variable equals *1* for household living in house with bamboo walls and *0* otherwise;
Dah60 is dummy variable equals *1* for the head of household aged between 45-60 years old and *0* otherwise;
Dahex60 is dummy variable equals *1* for the head of household aged over 60 years old and *0* otherwise;
Dedh is dummy variable equals *1* for the head of household having 12 or more years of education and *0* otherwise;
Dsm is dummy variable equals *1* if the household is located in Sumatera Island and *0* otherwise;
Dsl is dummy variable equals *1* if household is located in Sulawesi Island and *0* otherwise; and
Dkl is dummy variable equals *1* if household is located in Kalimantan island and *0* otherwise.

There are two steps of identifying the un-subscribers. First, the households with monthly electricity expenditure less than the capacity charge of the lowest tariff block were directly regarded as the un-subscribers. Then the remaining households were enlarged with their corresponding weights to get the population of all households in the country that are subjected to be distinguished weather they are the subscribers or the un-subscribers. In the second step, the enlarged population households were tested with ratio between their actual electricity expenditure and their predicted electricity expenditure using the specified demand model. (*re* = actual electricity expenditure/predicted electricity expenditure of each household remained from the first step selection). A household is more likely to be the un-subscriber if the household's actual expenditure is lesser than its predicted electricity expenditure (the ratio *re* is lesser than 1). After estimating the *re* ratio of each remaining household, all remaining households were then ranged in descending order based on their *re* ratios.

In further identifying the potential un-subscribers, we cross refer to the additional information provided in the PLN report 2004 and 2008. In the mentioned reports, the total number of subscribed households was 30,957,160 and 36,022,177 households in 2004 and 2008, respectively (the PLN Report 2005 & the PLN Report 2009). According to this information, by counting the remaining households from the second step of screening in descending order (based on *re* value), in 2004, 30,957,160 households ranging from the highest *re* ratios were hence regarded as the subscribers and the rest were regarded as the un-subscribers. Likewise, in 2008, 36,022,177 households ranging from the highest *re* ratios were spotted as the subscribers and the remaining were eventually classified as the un-subscribers. In addition, the *re* ratios corresponding to the 30,957,160th household in 2004 and the 36,022,177th household in 2008 were therefore regarded as the thresholds for identifying the un-subscribers in those years. In other words, the households with *re* ratio below the threshold were automatically identified as the un-subscribers.

2.4 Classify the un-subscribers by tariff block

Upon knowing the total number of both the subscribers and the un-subscribers, we further classified them by tariff block. The first step was to classify the subscribers. Following the common knowledge that poor households have high potential to fall into the lower tariff blocks for they are expected to have low-intensity electricity use, all the subscribers ranged in descending order according to their *re* ratios were allocated to six tariff blocks ranging from high to low tariff differentiation. Each newly classified group contains the same number of households as it was stated in the PLN report. In each tariff block, the difference between the total electricity expenditure of all the newly classified subscribers (regarded as revenue to the PLN) and the total revenue stated in the PLN was therefore regarded as the revenue that collected from the un-subscribers. Base on this revenue difference, we further proceeded to classify the un-subscribers.

In classifying the un-subscribers, household attributes such as the level of electricity expenditure, and floor space of the dwelling were used to produce the index for each household. Each un-subscriber was indexed with its multiplicative value of those two attribute values. Then, all the un-subscribers were ranged according to their index values. Based on the similar assumption used in classifying the subscribers, households with higher index values were classified to higher tariff blocks, and likewise, those with lower index values were automatically classified to lower tariff blocks. Be reminded that here we consider the revenue gap between the total revenue stated in the PLN and the collective electricity expenditure of the newly classified subscribers as the revenue that the PLN collected from the un-subscribers; therefore, the total electricity expenditure of all un-subscribers classified to a particular tariff block should be very close to the revenue gap appears to that tariff block. By following this principle, which un-subscribed household and how many of those households to be classified to each tariff block can be decided. Figure 3 shows the flow chart to allocate the un-subscribers in each tariff block.

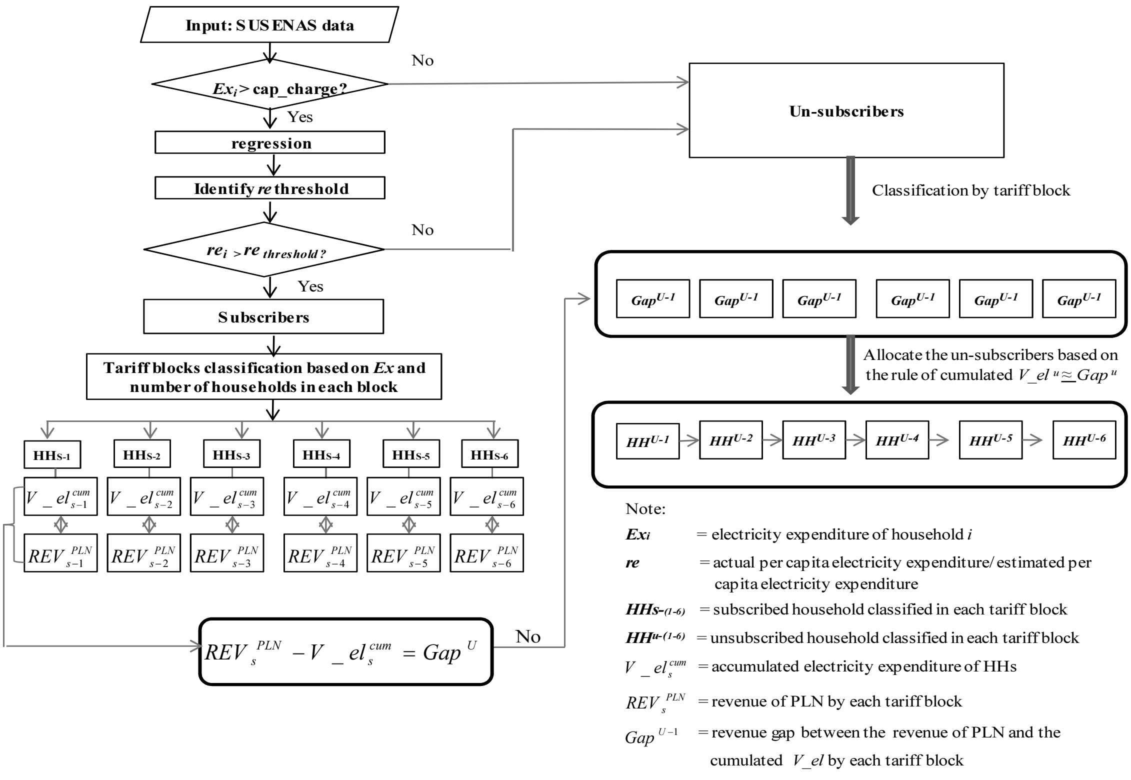


Figure 3. The subscribers and the un-subscribers classification

As shown in Figure 3, after we successfully allocated the subscribers in each tariff blocks (displayed as $HH_{S-(1-6)}$). There is a gap between the accumulated electricity expenditure of the subscribers and the revenue collected by the PLN in each tariff block. The gap in each block was hence filled out by the un-subscribers' electricity expenditure. Same as classifying the subscribers, the principle used to allocate the un-subscribers is started from allocating the un-subscribers with low indices (the multiplicative value of electricity expenditure and floor space of the dwelling of each un-subscriber) to the low tariff block. The number of how many un-subscribers will be allocated to a particular tariff block is decided based on the rule that their accumulated electricity expenditure should be equal or close to the gap between the revenue stated in the PLN report and the accumulated electricity expenditure of the subscribers in that tariff block (see Figure 3). After the lowest tariff block was located with enough un-subscribers, the same procedure was repeated in the next higher tariff block consecutively until all un-subscribers were allocated.

3. Results

After screening the observations (households) with electricity expenditure less than the least capacity charge threshold, 177,721 and 51,437 remaining observations in 2004 and 2008, respectively, were left and used in the regression electricity demand model. The first round OLS regression results suggest the existence of heteroscedasticity in data. In order to overcome heteroscedasticity problems, we estimated parameters using weighted least squares. The easiest approach to conduct weighted least squares regression is to use weights in the equation of the generalized least squares (GLS) estimator. The GLS estimator is then calculated by regressing the transformed response variable against the transformed explanatory variables. Table 3 and 4 present the results of before and after solving the heteroscedasticity problems for 2004 and 2008. The root of mean squared error and the coefficient variance are greatly improved after implemented the weighted least squares regression.

In 2004 and 2008, it appeared that income level, size of floor space and status of living in urban areas has positively significant effect on electricity demand. It is also interesting to find that the more family members a household has, the lesser per capita demand for electricity will occur. Meanwhile, households with middle aged or senior head of households tend to have more demand for electricity; especially those households with head of households, aged over 60 years old, have a tendency to have larger demand for electricity consumption than those of between 45-60 years old likely to do. Regarding the relationship between the types of dwelling with demand for electricity, the regression results imply that households living in shabby houses tend to have negative demand for electricity. The results also present that the households with higher educated head of household are likely to have more demand for electricity use. However, in terms of the effect of geographical location, the analysis results show inconsistent results in two different periods. The common similarity is that households located in Sumatera Island constantly had less demand for electricity as compared to those living in Sulawesi and Kalimantan Island.

Table 3. Household electricity expenditure by various factors in 2004

	OLS (Ordinary Least Squares)			WLS (Weighted Least Squares)		
Variable	parameter	Std error	t-value	parameter	Std error	t-value
Constant	−1.464***	0.037	−39.6	−0.993***	0.041	−24.0
ln Y	0.776***	0.003	255.7	0.745***	0.003	216.3
ln fs	0.193***	0.002	77.4	0.173***	0.003	64.2
Durru	0.266***	0.003	83.8	0.266***	0.003	82.0
Dmhh5	−0.153***	0.004	−39.1	−0.164***	0.004	−43.0
Dmhh6	−0.234***	0.005	−46.9	−0.245***	0.005	−53.7
Dmhh7	−0.321***	0.007	−46.9	−0.341***	0.006	−58.3
Dmhhex7	−0.407***	0.008	−54.0	−0.426***	0.006	−69.5
Dwall2	−0.160***	0.004	−44.0	−0.159***	0.003	−46.4
Dwall3	−0.196***	0.006	−31.2	−0.200***	0.005	−38.6
Dah60	0.059***	0.003	18.0	0.051***	0.003	15.7
Dahex60	0.150***	0.005	32.1	0.138***	0.005	28.0
Dedh	0.089***	0.004	23.7	0.078***	0.004	22.3
Dsm	0.051***	0.004	14.2	0.059***	0.004	16.0
Dsl	−0.109***	0.005	−22.7	−0.101***	0.004	−23.0
Dkl	0.123***	0.005	23.3	0.121***	0.006	21.9
Root MSE	0.59			0.01		
R^2	0.50			0.44		
Adj- R^2	0.50			0.44		
Coeff Var	6.66			0.09		
Observations	177,721					

Note: *, **, and *** indicate significance at 10%, 5%, and 1% level, respectively.

Table 4. Household electricity expenditure by various factors in 2008

	OLS (Ordinary Least Squares)			WLS (Weighted Least Squares)		
Variable	parameter	Std error	t-value	parameter	Std error	t-value
Constant	−2.262***	0.063	−35.6	−1.700***	0.071	−24.0
ln Y	0.823***	0.005	162.6	0.789***	0.006	138.8
ln fs	0.165***	0.004	39.6	0.136***	0.004	30.4
Durru	0.275***	0.006	47.3	0.258***	0.006	43.7
Dmhh5	−0.168***	0.007	−24.0	−0.180***	0.007	−27.2
Dmhh6	−0.264***	0.009	−28.8	−0.280***	0.008	−34.7
Dmhh7	−0.342***	0.013	−26.5	−0.363***	0.011	−34.0
Dmhhex7	−0.420***	0.015	−28.8	−0.458***	0.012	−39.6
Dwall2	−0.133***	0.007	−19.2	−0.118***	0.006	−18.9
Dwall3	−0.098***	0.011	−9.1	−0.088***	0.009	−10.3
Dah60	0.056***	0.006	9.6	0.050***	0.006	8.8
Dahex60	0.174***	0.008	21.9	0.153***	0.008	19.1
Dedh	0.098***	0.006	15.6	0.103***	0.007	15.1
Dsm	0.007	0.007	1.0	0.001	0.007	0.2
Dsl	−0.169***	0.009	−18.2	−0.171***	0.008	−21.3
Dkl	0.004	0.010	0.4	−0.024**	0.010	−2.4
Root MSE	0.57			0.01		
R^2	0.58			0.51		
Adj- R^2	0.58			0.51		
Coeff Var	6.37			0.08		
Observations	51,437					

Note: *, **, and *** indicate significance at 10%, 5%, and 1% level, respectively.

Based on the regression results, the estimation of the *re* ratio of each enlarged population households (enlarged with the weight of each observation in the SUSENAS) was made. First, we calculated each household's estimated electricity expenditure by using the specified demand model. Then the ratio was calculated by comparing the actual electricity expenditure and the estimated electricity expenditure. To identify the un-subscribers, the households were ranged according to their re ratios in descending order from the highest to the lowest. We found that in 2004, the *re* value corresponding to the 30,957,160th household was 0.96168; and in 2008, the *re* value corresponding to the 36,022,177th household was 0.94793. The households with their *re* values lower than the mentioned threshold values are consequently identified as the un-subscribers.

Figures 4 and 5 display the distribution of the *re* value of electrified households in 2004 and 2008, respectively. Along the horizontal axis, the *re* values are distributed in ascending order from the left to the right. Counting from the right hand side of the plot figure, households fall in the accumulated gap that is identical with the number of the subscribers stated in the PLN report will be regarded as subscribers; the rest households lay in the left hand side of the plot, whose *re* values are relatively smaller, will therefore be considered as un-subscribers.

Tables 5 and 6 present the results of the classification of the subscribers and the un-subscribers in 2004 and 2008. From 2004 to 2008 the subsidy regime had shifted from the TS scheme to the PSO scheme, which the government had been giving more subsidies to the residential consumers in a hope to ensure the low income families were able to meet basic needs in terms of electricity use. As a result, the number of households accessed to electricity relatively increased from 42.76 million in 2004 to 45.67 million in 2008.

The increase of the subscribers can be noticed across all tariff blocks from 2004 to 2008. Major increments in 2008 are spotted in low tariff blocks. For instance, there were approximately 3 million more new subscribers to the tariff block of R-900VA and approximately 1 million each to the tariff blocks of R-450VA and R-1350VA. In addition, the increase in the number of the subscribers caused the total electricity expenditure (considered as the revenue of the PLN) of all subscribers to increase from 18,526 billion rupiah in 2004 to 22, 661 billion rupiah in 2008, which made up to approximately 90 percent of the total revenue to the PLN. As there were more than half of the subscribers were lying in the lowest capacity block, so that their contribution to the PLN revenue was significant. The electricity expenditure by the subscribers connected to tariff blocks of R-450VA and R-900VA summed up to 12.1 billion rupiah and 13.6 billion rupiah, which made up 65.6 percent and 60.2 percent to the total revenue from subscribers in 2004 and 2008, respectively.

Meanwhile, the number of the un-subscribers had been reduced to a certain extend. Approximately 11.8 million and 9.6 million households were identified as the un-subscribers for 2004 and 2008, respectively. In general, the un-subscribers made up 28 percent and 21 percent of the total electrified households in 2004 and 2008, respectively. As shown in Tables 5 and 6, by 2008, significant decrease in the number of the un-subscribers can be observed from the tariff blocks of R-450VA and R-1350VA, which collectively decreased by 3.9 million households. In contrast with that, there was an increase of the un-subscribers in the tariff blocks of R-900VA, R-2200VA, and R>6600VA. It is worth mentioning that the increment of the un-subscribers in the tariff blocks of R-900VA and R>6600VA were relatively large, which was 794 thousand and 693 thousand households, respectively.

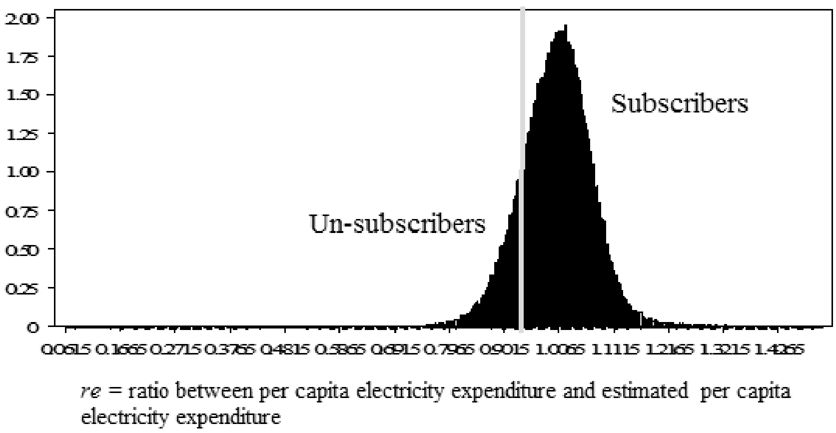


Figure 4. Distribution of *re* ratios between the actual household electricity expenditure and the predicted electricity expenditure in 2004

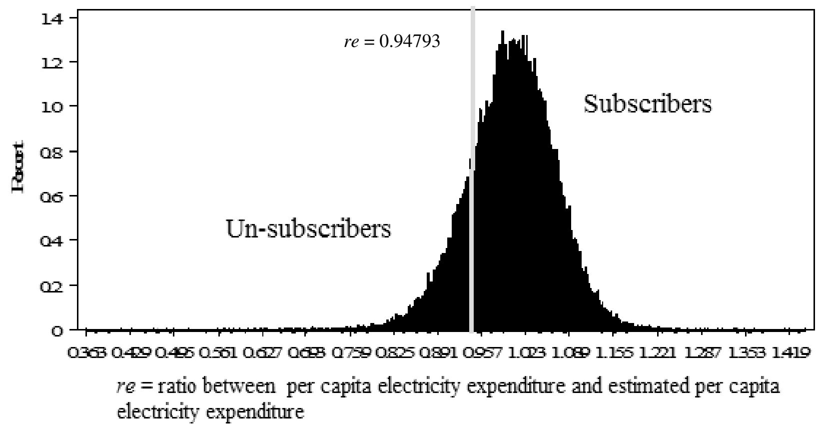


Figure 5. Distribution of *re* ratios between the actual household electricity expenditure and the predicted electricity expenditure in 2008

In terms of electricity use, generally the un-subscribers have relatively less electricity use as compared to that of the subscribers located in the same tariff block. The total electricity use of the un-subscribers had a declining trend along with the decrease in the number of the un-subscribers. A couple of exceptions are that the use increased largely in the tariff block of R-900VA and in the highest tariff block of R>6600VA. For instance, in 2008 the electricity use of the un-subscribers in the highest tariff block was 1461 KWh, eventually greater than that of the subscribers subscribed to this tariff block (1044 KWh). Nevertheless, the falling number of the un-subscribers had led to a shrinking share of the revenue from the un-subscribers to the total PLN revenue. In 2004 the un-subscribers' electricity bill payment comprised approximately 11 percent of the PLN's total revenue and then the share plunged to 7 percent in 2008.

Table 5. Results of the subscriber and the un-subscriber classification in 2004

Tariff Blocks	Subscribers			Un-subscribers			All electrified households		
	Number of HH	Total Electricity Consumption (GWH)	Electricity Expenditure (billion Rp)	Number of HH	Total Electricity Consumption (GWH)	Electricity Expenditure (billion Rp)	Number of HH	Total Electricity Consumption (GWH)	Electricity Expenditure (billion Rp)
R-450	18,661,655	15,333	5,778	3,869,009	701	347	22,530,664	16,034	6,125
R-900	8,719,223	10,016	6,360	341,717	83	41	9,060,940	10,099	6,401
R-1350	2,327,292	4,074	2,992	1,772,205	491	243	4,099,497	4,565	3,235
R-2200	868,121	2,212	1,745	2,637,589	997	494	3,505,710	3,210	2,238
R-2200-6600	318,936	1,384	1,159	2,003,698	1,018	529	2,322,634	2,402	1,688
R>6600	61,933	523	493	1,179,816	917	569	1,241,749	1,440	1,062
All	30,957,160	33,542	18,526	11,804,034	4,207	2,224	42,761,194	37,749	20,750

Table 6. Results of the subscriber and the un-subscriber classification in 2008

Tariff Blocks	Subscribers			Un-subscribers			All Electrified Households		
	Number of HH	Total Electricity Consumption (GWH)	Electricity Expenditure (billion Rp)	Number of HH	Total Electricity Consumption (GWH)	Electricity Expenditure (billion Rp)	Number of HH	Total Electricity Consumption (GWH)	Electricity Expenditure (billion Rp)
R-450	19,211,592	15,225	5,757	1,534,141	173	86	20,745,733	15,398	5,843
R-900	11,793,229	11,878	7,843	1,135,138	212	105	12,928,367	12,090	7,948
R-1350	3,314,668	5,565	4,149	197,656	41	20	3,512,324	5,606	4,169
R-2200	1,163,217	2,770	2,240	3,041,949	813	402	4,205,166	3,583	2,642
R-2200-6600	450,497	2,216	1,783	1,860,874	742	367	2,311,371	2,957	2,150
R>6600	88,974	1,044	890	1,873,510	1,461	723	1,962,484	2,505	1,613
All	36,022,177	38,698	22,661	9,643,268	3,442	1,704	45,665,445	42,140	24,365

4. Discussion and conclusion

Despite the un-subscribers make fraud on avoiding capacity charges and that produces revenue loss to the PLN, the information on the un-subscribers and their electricity consumption remain unknown to the public. Thus, this study tries to identify the un-subscribers in two periods when there were electricity subsidy scheme changes in Indonesia. Moreover, this study also makes afford to classify the un-subscribers by tariff block. The results suggest that in comparison to 2004 the number of the un-subscribers eventually shrank while that of the subscribers swelled in 2008. It is also worth mentioning that the increased subscriptions are largely associated with the low income group households as the evidence tells that the subscriptions in the lowest tariff blocks rose drastically as compared to the higher tariff blocks. This result implies that after the subsidy scheme shift (from the TS to the PSO regime) the electrification among the poor, in particular, had been improved greatly.

Another significant contribution of this study is that it paves the path for further analyses on efficiency of electricity distribution management of the PLN by proposing a unique method to identify the households that are potentially to be the un-subscribers as well as to estimate their electricity consumption by using the PLN report and the SUSENAS data. The results suggest a notable shrink in the total number of the un-subscribers by 2008. Meanwhile, the structure of the un-subscribers under each tariff block also had remarkable changes. Although there was a momentous decrease in the number of illegal electric connections among low tariff blocks (R-450VA and R-1350VA), we observe a significant growth in the illegal electric connections and the electricity use by the un-subscribers in the tariff block of R-900VA and the highest tariff block R>6600VA. This finding suggests an increasing household demand for electricity in Indonesia as a whole, and the illegal connection preference had been shifting from low tariff blocks to higher tariff blocks.

The results on the classification of the un-subscribers present that in 2008 the un-subscribers had shifted their demand from the lower tariff block to the block one level higher as compared to 2004. This implies that the lowest electricity capacity supply at the tariff block of R-450VA was no longer attractive to the un-subscribers. Similarly, among the tariff blocks in the middle range, the concentration of the un-subscribers also shifted towards higher tariff block (from R-1350VA to R-2200VA). Likewise, among the high tariff blocks (R-2200-6600VA and R>6600VA), the illegal connection preference also tended to shift towards the highest tariff block of R>6600VA. In summary, in 2008, the un-subscribers appeared to have a tendency to choose higher tariff block for higher electricity demand driven by improved income and the living conditions.

Highlighted by the findings, we have to admit that capacity charge fraud problem is impossible to stop or decrease rapidly in a short period. The study reveals that over the four-year time horizon, although the government had been giving large amount of electricity subsidy to enable the poor to benefit from the electrification, the number of the un-subscribers still remain significantly high. Moreover, the illegal electric power connection occurred in all income classes, and in all tariff blocks. Even worse, the increasing un-subscribers who are non-poor families among middle and high tariff blocks had played a big part in causing revenue loss to the PLN.

In searching for approaches to reduce the illegal electric power connection, many existing researches related to the electricity theft problem criticize that the electricity utility companies are responsible for having loose electricity law enforcements, electricity corruption, and inefficient service management (Mimmi and Ecer, 2010; World Bank 2009b). In addition, those studies also point out that the popularization of the electricity fraud is partly due to little public awareness on legal, economic and even safety consequences of electricity theft. Regarding those criticisms, the authors hope that the results from this study would be useful in providing reference on the un-subscriber identification and classification to the PLN to further improve its electricity law enforcement and its residential connection services for reducing the potential income loss caused by the illegal power connection behaviors.

Lastly, this study is the first attempt ever to make contribution in providing methodology for identifying the hidden un-subscribers and proposing their potential connected tariff blocks. It is recommended that ones who use the SUSENAS data to estimate the demand for electricity have to consider the existence of a large number of the un-subscribers in their analysis. Although the validity of the results from this study could be limited by the accuracy of the information on electricity consumption and electricity expenditure collected in the SUSENAS households survey data and even the indexing method, the authors still believe that the results of the un-subscriber identification could be useful and they provide opportunity for further challenges on studying the un-subscriber related issues in Indonesia. Those challenges may include in-depth analyses on the characteristics of the un-subscribers associate with various socio-economic aspects such as income, demographic factors, dwelling condition, and geographical location. Furthermore, if substituting energy prices are available, the results from this study lay the preliminary frame to enable exploration on the factors driving the illegal electric power connections in different regions and in Indonesia as a whole.

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