TRANSFORMATION OF FOSSIL ENERGY SUBSTITUTION TO NEW AND RENEWABLE ENERGY IN THE EMERGING ECONOMY

Bintoro Ariyanto *, Bambang Agus Pramuka **, Abdul Aziz Ahmad **

* *Corresponding author*, Faculty of Economics and Business, Jenderal Soedirman University, Purwokerto, Indonesia;
Bhakti Pembangunan School of Management, Jakarta, Indonesia
Contact details: Bhakti Pembangunan School of Management, Jakarta 12270, Indonesia
** Faculty of Economics and Business, Jenderal Soedirman University, Purwokerto, Indonesia

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Abstract

Fossil energy is getting less and less and this study aims to determine the effect of the substitution of fossil energy with new and renewable energy on the monetary value of electricity subsidies in Indonesia. Rezki (2012) stated that the level of gross domestic product (GDP) per capita in a country in Southeast Asia had a positive relationship with the level of energy consumption. Indonesia is a relatively small electricity user per capita, with consumption only equivalent to a quarter of the world average (Davis, 2013). The data used is time series data from 2011–2019 with a multiple linear regression analysis method. The regression results three of the four independent variables which include tariffs, cost of supply (CS), and electricity sales volume have a significant influence and have a positive correlation with the subsidy, while the margin variable has no significant effect against subsidies. Based on the F-test, all independent variables have a significant effect on the monetary value of subsidies. This simulation shows a positive relationship between CS and the monetary value of subsidies, it means that the substitution of fossil energy, including coal with new and renewable energy, which is environmentally friendly but is still relatively expensive, will result in an increase in energy subsidies. Thus, the implementation of the energy transition policy from fossil energy to new and renewable energy (NRE) in Indonesia must be carried out conservatively by taking into account the dynamics of the right time.

Keywords: Subsidy, Rates, Cost of Supply, Electricity Sales Volume, Margin

Authors' individual contribution: Conceptualization — B.A., B.A.P., and A.A.A.; Formal Analysis — B.A.; Writing — Original Draft — B.A.; Writing — Review & Editing — B.A., B.A.P., and A.A.; Supervision — B.A.P. and A.A.A.; Funding Acquisition — B.A.

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1. INTRODUCTION

Electricity is one of the energy sources whose benefits are needed by the community both for commercial and non-commercial purposes. The chain of social and economic activities cannot run without the availability of electrical energy. The supply-demand of basic necessities, transportation, production, and other economic sector activities depend on the smoothness and availability of electrical energy. Without electricity, special economic zones, tourism, health, and other economic nodes cannot function properly. Therefore, it can be said that a reliable and inexpensive electricity system is an important requirement in supporting national economic growth.

In Indonesia, the availability of abundant natural resources of electrical energy makes the electricity rates for household customers Rp 1100, business Rp 836–Rp 1100, and industry Rp 747–Rp 836 per kilowatt-hour (kWh) considered quite expensive. The high cost of electricity supply is an obstacle to the formation of cheap electricity rates and the reduction of electricity subsidies (Badan Pusat Statistik [BPS], 2019a).

The electricity of cost of supply (CS) tends to increase and its value is above the electricity rates for household customers, except in 2009 and in 2010. The reason is the use of fossil energy for power generation dominant. The government needs to be serious to reduce the electricity CS by transforming and diversifying the use of fossil energy. One of them is to reduce the use of diesel power plants using high-speed diesel (HSD) fuel which is very expensive. The CS for the diesel power plant is Rp 2,50–Rp 03,000 per kWh (Perusahaan Listrik Negara [PLN], 2020). So, reducing the number of diesel power plant operations to a minimum level will certainly suppress CS and encourage a reduction in electricity rates. Another way is to apply dual firing to power plants by implementing an energy mix policy based on marine fuel oil (MFO), coal, natural gas, and new and renewable energy (NRE).

Assuming there is no COVID-19 pandemic, PLN predicts that a 1% increase in economic growth is equivalent to a 1% increase in electricity demand (RUPTL 2019–2028). For this reason, it can be said that electricity is energy that has a strategic role in the economic development of a country.

Demand for electrical energy in the future can certainly continue to increase due to high economic and business activities, technological innovation sector which is very dynamic requires adequate electricity supply. The Ministry of Energy and Mineral Resources (MoEMR) estimates that the number of electric vehicles such as electric cars and electric motorcycles in Indonesia in 2021 will be around 125 thousand units and 1.34 million units, respectively. To fulfill this need, 572 units and 3,000 units of public electric vehicle charging stations (*stasiun pengisian kendaraan listrik umum* — SPKLU) and public electric vehicle battery exchange stations (*stasiun penukaran baterai kendaraan listrik umum* — SPBKLU) are needed. The projected increase in electricity demand in the coming year is linear with the increase in electricity consumption per capita from 2015–2019.

In 2018, Indonesia's electricity consumption per capita was 1.064 megawatt hours (MWh) (BPS) while in 2019, it was 1.084 MWh (MoEMR). This consumption increased by 2.26% compared to the previous year. Meanwhile, in 2020, the electricity consumption target is 1.14 MWh per capita. The target was certainly not achieved due to the COVID-19 pandemic factor.

When compared to countries in the Asian region, in 2015–2019, Indonesia's electricity consumption per capita is very small, for example, Thailand 2.7, China 4.3, Malaysia 4.9, Hong Kong 6.0 are far behind Brunei 10.1 and Singapore 8.7 MWh per capita. Meanwhile, the electricity consumption per capita of South Korea and Taiwan as newly industrialized countries are 11.0 and 10.9 MWh, respectively.

In line with this, Kurniawati stated that in 2014, Indonesia was the 21st largest electricity consumer in the world. In terms of consumption, Indonesia is a relatively small electricity user per capita, with consumption only equivalent to a quarter of the world average (as cited in Davis, 2013).

The low consumption of electricity per capita in Indonesia is influenced by several factors, including the occurrence of technological innovations in the electronics industry to produce energy-efficient household electronic products. In addition, it is influenced by people's purchasing power and per capita income. The results of a study conducted by Rezki (2012) stated that the level of gross domestic product (GDP) per capita in a country in Southeast Asia had a positive relationship with the level of energy consumption. An increase of 1% of the GDP per capita of a country in the Southeast Asia region will increase energy consumption by 1.05%. Based on this correlation, it can be said that the level of electricity consumption per capita is also influenced by per capita income.

The average economic growth for the 2015–2019 period is in the range of 5% per year, which has a positive effect on increasing per capita income. However, structurally it has not been able to significantly positively influence the demand and volume of electricity sales. This can be seen from the production side of GDP in 2019 for the electricity sector which only grew by 5.5% (BPS, 2019a).

Analogous to this condition in the RUPTL, in 2026, PLN revised the electricity demand from 483 terawatt-hours (TWh) to 407 TWh or decreased by 15.7% (PLN, 2018a). Correction of electricity demand target due to growth in electricity sales beyond expectations. This is in line with the difficulty of the Government in achieving the economic growth target become 6% in the 2020–2024 period. This is because, until the first quarter (Q1) of 2021, the handling of the COVID-19 pandemic is still far from successful. In contrast, the results of a study conducted by Price Waterhouse Cooper (PwC, 2018) stated that in 2016, Indonesia's GDP was in the position of eighth in the world after China, the USA, India, Japan, Germany, Russia, and Brazil. Meanwhile, in 2050, Indonesia is projected to become the country with the fourth largest economy after China, the USA, and India. The results of this linear projection provide a challenge for the government to prepare as early as possible the continuity of the availability of electricity supply and infrastructure to anticipate the possibility of high electricity demand for household, industrial and business customers.

However, the GDP projection carried out by PwC (2018) was predicted to change because the projection does not take into account the COVID-19 shock pandemic that occurred in 2020 (PLN, 2018a). In 2020, Indonesia's economic growth is minus 2.07% (BPS, 2021). This figure was far off the mark with the 2020 State Budget assumption which projected economic growth of 5.1%.

In order to maintain the continuity of the supply of electrical energy in the long term, it is necessary to carry out a policy of transforming primary energy from fossil energy (coal) to NRE which is cheap and environmentally friendly. The use of coal as energy for power generation encourages the creation of air pollution and environmental pollution. Therefore, the transformation of fossil energy into clean energy to support the creation of a green economy is a necessary condition to do.

Another argument is that Indonesia is one of the countries that participated in ratifying the United Nations Convention on Climate Change (Paris Agreement), that is by issuing Law No. 16 of 2016 concerning the Ratification of the Paris Agreement to The United Nations Framework Convention on Climate Change, that the Government of Indonesia is committed to reducing greenhouse gas emissions by 29% in 2030 with a target threshold for increasing the earth's temperature below 2 degrees Celsius.

As a follow-up to the Paris Agreement, the Government targets the use of NRE by 23% in the energy mix by 2025. This is stated in Government Regulation No. 79 of 2014 concerning the National Energy Policy. Another commitment is to reduce CO_2 emissions in accordance with Law No. 16 of 2016 concerning the Ratification of the Paris Agreement to the UNFCCC and Presidential Decree No. 16 of 2021 concerning the National Action Plan for Reducing Greenhouse Gas Emissions (RAN-GRK).

Essop (2020) stated that overall the electricity sector in G20 countries was the largest contributor to CO_2 emissions, reaching 35.5% of total emissions. However, in 2018, CO_2 emissions produced by the electricity sector decreased by 2.5% and in 2019 became 2.4%. On the other hand, Indonesia and China increased in electricity sector emissions, namely 7.6% that was in 2018 and 5.6% that was in 2019, while China 6.5% in 2018 and 2% in 2019 (Essop, 2020). During the 2014–2019 period, there was a decrease in CO_2 emissions such as South Africa, India, Saudi Arabia, and Australia. On the other hand, Indonesia had an increase due to the policy of increasing the capacity of coal-fired power plants from 26,800 megawatts (MW) in 2018 to 27,100 gigawatts (GW) in 2019. In line with this, Burke and Kurniawati (2018) stated that Indonesia was the 11th largest emitter of CO_2 in the world from steam power plants. Therefore, the Government of Indonesia continues to strive to reduce CO_2 emissions to reach 54.8 million tons of CO_2 in 2019 while in 2014 the emission reduction was only 23.38 million tons of CO_2.

To reduce emissions, MoEMR (2020) planned to replace around 11 GW of fossil fuel power plants with renewable energy including 23 coal-fired power plants that are over 20 years old with a total capacity of 5,700 MW. In line with this, after the current 35,000 MW expansion program is completed all new capacity will become renewable energy to meet the target of 23% renewable energy by 2025 (Government of Indonesia, 2014).

The electricity sector's dependence on fossil energy such as HSD and coal as a source of energy for power generation can create a financing burden in the form of energy subsidies, considering that Indonesia is a net importer of petroleum. The decrease in the portion of the use of fossil energy for power generation can be substituted by NRE in the 2014–2019 period by 8% (Essop, 2020). In the same period, when compared with the existing potential, the utilization of NRE for power generation reached 14.7% from 10.5 GW to 441.7 GW.

The plan to implement a carbon tax as a logical consequence of the ratification of the Paris Agreement, in the long term optimizing the use of NRE as primary energy for power plants is predicted to be able to increase the competitiveness and efficiency of PLN as a natural monopolist in the electricity sector. However, as explained before, the obstacle to implementing NRE in the electricity sector is the relatively high price of NRE compared to the price of fossil energy in general, such as natural gas and coal. This means that in the short term, the efficiency of rates with the CS instrument for electric power by substituting fossil energy into NRE in theory cannot be implemented optimally considering that the structure of the electricity business in Indonesia is still a natural monopoly. For this reason, it is necessary to amend Law No. 30 of 2009 concerning Electricity, thus opening the door to competition in the electricity sector.

Limited competition in the electricity sector is expected to stimulate the entry of private investment in the downstream oil and gas sector. With a limited competition pattern, the Government continues to prioritize PLN as a state-owned enterprise, but on the other hand, there is a reduction in electricity rates, especially for non-subsidized customers, industries, and businesses. Thus, there will be opportunities for efficiency in the injection of subsidies that PLN can use to develop a healthier electricity business in the future.

Future challenges in NRE development: First, there is an increase in government subsidies and support for fossil energy in G20 member countries including Indonesia (Organisation for Economic Co-operation and Development [OECD], 2020; International Energy Agency [IEA], 2020b) so it is estimated that energy consumption in the coming year will experience sufficient achievement compared to 2022. High government support for energy causes low investor interest in NRE development (Institute for Essential Services Reform [IESR], 2019). This results from regulations that create high economic costs in developing NRE. For example, solar panels assembled domestically are relatively more expensive than in China due to domestic content level regulations (Brown, 2020; IESR, 2019). Second, increasing government support for fossil energy and regulations requiring investors to accommodate domestic content levels are one of the factors that increase the cost and price of NRE. This gap causes the transformation of fossil energy into NRE to be constrained.

Sen et al. (2020) state that the integration of renewable energy in the presence of subsidies can challenge the implementation of market-based reforms as the former often requires intervention, and the efficiency of the latter involves price signals that reflect costs and competition. Meanwhile, the electricity system in Indonesia is still a natural monopoly that does not conflict with the concept of market competition. This condition is a dilemma for the Government which has committed to reducing carbon emissions. However, on the other hand, the electricity system is still a natural monopoly so it is far from efficient.

As explained before, one of the reasons for the high price of electricity in Indonesia is the inefficiency of using fossil energy, especially HSD in diesel power plants. The expensive price of HSD causes the CS for electricity to be high, so to reduce electricity rates, the Government allocates subsidies to close the gap between the economic price and the set price. One way to solve the problem of electricity prices is that diesel power plant operations throughout Indonesia must be reduced so that HSD consumption automatically decreases and is replaced with cheaper energy fuels and the choices are coal, natural gas, and NRE. Coal and natural gas are part of non-renewable fossil energy so their sustainability is limited. The logical choice in line with the Government's commitment to reduce pollution and move towards green energy is NRE. So, the purpose of this study is to analyze the policy of energy transformation from fossil energy to NRE in the electricity sector using a linear model approach.

The remainder of this study is structured as follows. Section 2 presents a literature review on electrification and subsidies. Section 3 provides the research methodology. Section 4 reveals results in the form of output from data processing. Section 5 discusses the transformation of fossil energy to new renewable energy. Section 6 concludes the paper.

2. LITERATURE REVIEW

The management of electricity in Indonesia is carried out in a natural monopoly with a vertically integrated model from upstream to downstream. Such an integrated management model was carried out by the USA in 1990 (Burke & Kurniawati, 2018). To facilitate the management, the electricity system in Indonesia is divided into several regions, namely Sumatra, Java-Bali and Nusa Tenggara, Kalimantan, Sulawesi, and Maluku-Papua. All of these systems are managed in a monopoly by PLN.

The development of information technology and the flexibility of market characteristics in a modern economy that demands transparency, distortion of information, and equality in business is a factor in reducing monopoly business management. The birth of Law No. 30 of 2009 concerning electricity allows private parties (independent power producers — IPPs) to participate in the construction of power plants is momentum for competition in the upstream electricity sector. But when the final consumer uses it, electricity requires transmission.

Indonesia's geographical location in the form of an archipelago that stretches from Sabang to Merauke makes investment in transmission network construction uneconomical because the risk is high. In addition, it requires a high sunk cost and a long payback period. Under these conditions, the electrical products produced by the independent power producer still have to be sold to PLN as the only company that has a transmission network throughout Indonesia. Thus, investment in the electricity sector becomes less attractive to the private sector because of the inefficiency due to distribution to end users having to go through PLN.

The implication of natural monopoly management is the supply of electricity only comes from one company so it is vulnerable to blackouts easily. The policy of rotating blackouts has been carried out by PLN considering the electricity supply has experienced a deficit. This is because the electrical system does not have an adequate reserve margin.

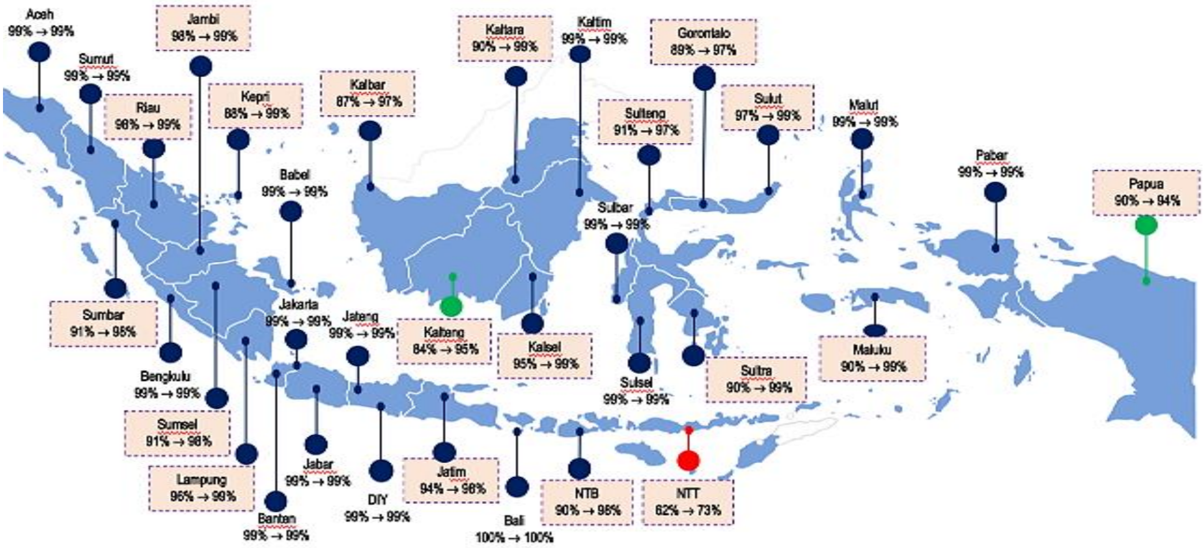
In 2019, electricity conditions were in an imbalance since the Java-Bali region's electricity system was in excess supply. This was due to the non-fulfillment of expectations of the national economic growth rate of 5.5%. While the realization was only 5.02% (BPS, 2019a), as a result, a lot of electricity was not absorbed by the industrial sector, resulting in excess supply. On the other hand, the Eastern Indonesia region was experiencing a power deficit.

Excess electricity condition does not necessarily indicate the reliability of electricity in Indonesia because the disconnection from one region to another will impact in uneven distribution of electricity. For this reason, in the future PLN investments prioritize transmission and distribution networks over power plants (MoEMR, 2020). Although in the 2019–2028 RUPTL, it is stated that to increase the reliability of the national electricity system in the next ten years, PLN still needs an additional installed capacity of 56.4 GW.

The Energy International Agency stated that the electricity system could be reliable if it had a reserve margin of 25–30% of the total installed capacity. While other regions' reserve margin was still below 30%. In line with this, a study conducted by Essential Services Reform, Monash University, and Agora Energiewende stated that the Java-Bali power plant system had the potential to be the smoothest asset due to an excess capacity of 13.3 GW compared to other regions.

Electrification ratio. The success of equitable distribution of electricity in the community is seen from the electrification ratio, which is the comparison of the number of household customers whose source of lighting is either from the State Electricity Company (PLN) or non-PLN electricity with the number of households (BPS, 2019b). From year to year, the electrification ratio continues to increase. In 2013, the national electrification ratio of 78% meant that there were still 22% of households that have not enjoyed electricity. In 2019, the electrification ratio reached 98.9% and in 2020, it was 99.9%. Meanwhile, the electrification ratio per province is shown in the following graph.

Figure 1. Electrification ratio in 2019



The increase in the electrification ratio from 2013 to 2020 is quite significant. This means that there is an increase in the connection of household customers and the expansion of distribution and transmission network construction. There are three approaches taken by the Government to improve electricity services, namely: first, expansion or expansion of the electricity network through rural electricity programs, especially for household customers who are near the electricity system. Second, for customers who live in remote areas, and are scattered and far from PLN electricity installations, energy-saving solar lamps (*lampu tenaga surya hemat energi* — LTSHE) are used. Third, for customers who live far from electrical installations, this is done by developing off-grid micro-grids according to the Minister of Energy and Mineral Resources Regulation No. 38 of 2016 (Government of Indonesia, 2014).

The supply of electricity in the border area with neighboring Malaysia is carried out by importing electricity from Sarawak through 275 kilovolts (kV) interconnection transmission with a power of 230 MW. In 2019, electricity imports were recorded at 1,697 GWh and in 2020, it was 1,553 GWh (RUPTL 2019–2028). Meanwhile, for customers who live in undeveloped, remote, outermost, or border villages, it is carried out by regional-owned enterprises, private companies, and cooperatives which are given separate business permits by the Government by prioritizing the use of new and renewable energy sources. This policy is in line with the second phase of the 10,000 MW program (Fast Track Program II) in the era of President Susilo Bambang Yudhoyono.

New and renewable energy. In the long term, the condition of higher dependence on petroleum fuels, solid biomass, and natural gas as fuel for power generation will impact the energy crisis. For this reason, a gradual reduction will continue to be carried out to achieve the energy mix target in accordance with *Peraturan Pemerintah* (PP) No. 79 of 2014 concerning National Energy Policy. In 2014, the proportion of fuel as energy for diesel power plants was 11.8% and then continued to decline to 4.03% in 2019. However, the proportion of coal use was still high at 60.15%. The rest is gas 23.11% and NRE 12.36% (MoEMR, 2020).

The policy about the usage of new and renewable energy for the supply of electricity is based on the Minister of Energy and Mineral Resources Regulation No. 50 (ESDM, 2020). One of the important components of this policy is that the price of new and renewable energy is determined by referring to the basic cost of the supply of electricity. However, in the implementation of this regulation, it cannot run optimally so the dominant factor affecting the CS for electric power is the price of fuel. The electricity rates using NRE energy become less attractive to investors because the price refers to the Indonesia crude price, which is very vulnerable to geopolitics and other shocks so it becomes a high-cost economy. The high risk and the absence of optimal support from the Government have resulted in obstacles to the development of new and renewable energy in the electricity sector.

Nationally, the power plants of CS are at the level of US$7.86 cents per kWh or Rp 1,119 per kWh. Meanwhile, the purchase price of electricity for NRE plants is lower than the feed-in tariff system. The core scheme is in the form of a fixed rate calculated from the investor's fee plus the difference in profits.

Table 1. Use of NRE in power generation (MW)

Generator	*2015*	*2016*	*2017*	*2018*	*2019*	*2020*
Hybrid	4,0	4,0	4,0	4,0	4,0	4,0
Wind	1,5	1,5	1,5	143,5	154,3	154,3
Surya	33,4	43,1	50,9	60,2	97,4	231,9
Biomass	1741,7	1783,1	1856,8	1882,8	1884,6	2131,5
Geothermal	1438,3	1533,3	1808,3	1948,3	2130,6	2270,7
Hydro	5227,5	5620,9	5657,9	5742,1	5885,5	6050,7

Electricity rates. In Indonesia, electricity rates are divided into two, namely subsidized and non-subsidized. Subsidized electricity rates are for 450 volt-amperes (VA) and 900 VA including poor/ non-RTM (*rumah tangga mampu*, "able households") or poor household customers. Another part of the 900 VA customers is called "well-off households" (RTM) and belongs to non-subsidized rates. The proportion of non-RTM and RTM customers is 43% and 57% (TNP2K). The mechanism for subsidized electricity rates is determined by the government with parliamentary approval (administered price). Meanwhile, electricity rates for industrial and business customers for medium and high scale are subject to non-subsidized rates with the amount following the market mechanism. The table below shows an overview of electricity rates in Indonesia and other ASEAN countries in 2018.

Table 2. Electricity rates in ASEAN (IDR/KWh)

Description	*Indonesia*	*Malaysia*	*Singapore*	*Thailand*	*Philippines*	*Vietnam*
Household	1.100	1.000	1.878	1.351	2.109	1.279
Avg. business-low voltage	1.100	1.358	1.321	1.135	1.262	1.596
Major business-med. voltage	836	960	1.293	1.114	1.229	1.468
Avg. industry-med. voltage	836	829	1.205	1.270	1.196	948
Major industry-high. voltage	747	776	1.175	1.270	1.188	901

In general, in either Indonesia or other ASEAN countries, the price of electricity for household customers is higher than for businesses and industries. This policy proportionally reflects the partiality of the small community as consumers of subsidized electricity while at the same time encouraging the development of industry and business because cheap electricity makes the structure of production costs lower so as to produce competitive products.

When compared to other ASEAN countries, electricity prices in Indonesia are relatively competitive. This is due to the abundance of natural resources as primary energy for power generation. Singapore is an example of a country that does not have primary energy natural resources for power generation. Singapore's policy is to import primary energy so that the electricity price is relatively more expensive than other ASEAN countries.

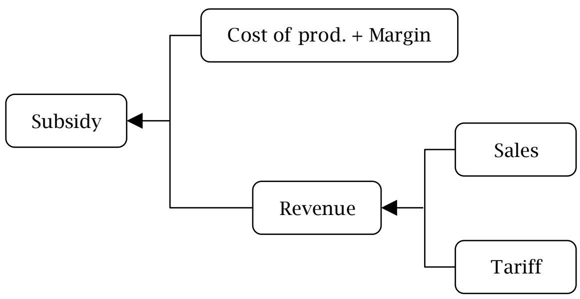
In Indonesia, electricity rates for household customers are higher than for business and industrial customers. One of the causes is the policy of purchasing electricity by PLN at the IPP where the price of electricity per kWh is quite high. According to the Regulation of the Minister of Energy and Mineral Resources No. 17 of 2014 about the purchase of electricity from geothermal, if the selling price to PLN is US$09 cents per Kwh, then assuming the exchange rate of the rupiah against the US$ is Rp 14,000, so the purchase price of electricity will reach Rp 1,2150 per kWh. Meanwhile, the selling price of non-subsidized electricity for business and industrial customers is Rp 836 and Rp 747 per kWh. To reduce potential losses, PLN allocates electricity to household customers (PLN, 2020).

Substantially, electricity rates are one of the factors that affect the number of electricity subsidies. The determination of subsidized and non-subsidized electricity rates is carried out based on the Minister of Energy and Mineral Resources No. 3 of 2020 about Electricity Rates (ESDM, 2020). Article 6 paragraph 3 states that the rate adjustment for non-subsidized electricity is carried out by considering the exchange rate, Indonesia crude price, inflation, and coal benchmark price.

By using new and renewable energy sources in power generation, electricity rates can be reduced to even lower prices. The implications of industrial production and transportation costs are lower and more competitive than in the global market as well as savings in subsidies.

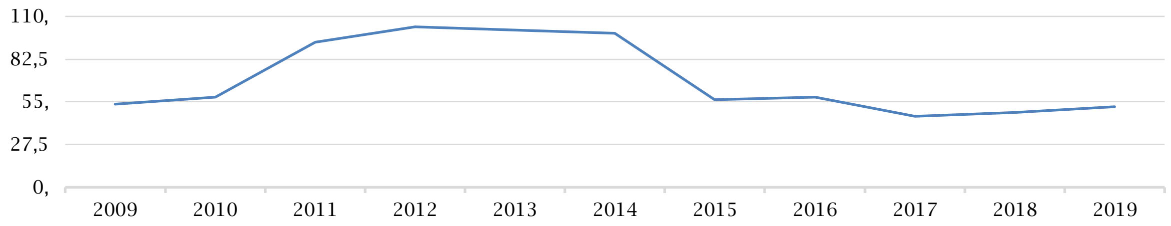
Subsidy. Substantially, the amount of electricity subsidy is the difference between PLN revenue and electricity supply cost and margin. Electricity CS is synonymous with production costs in an economic context. Thus, the factors that affect electricity subsidies are production components such as electricity production costs and the energy mix, namely the proportion of NRE use in power generation and sales and losses, which can be shown using a simple economic model. The determinants of electricity subsidies are illustrated in the following chart:

Figure 2. The determinant of the electricity subsidy



The current year's budget allocation for electricity subsidies in the state revenue and expenditure budget (*anggaran pendapatan belanja negara* — APBN) is increasing. In APBN-P 2009, the amount for electricity subsidies is Rp 55.1 trillion and continues to increase up to Rp 101.8 (29.8% of the total energy subsidy of Rp 341.8 billion). In 2019, electricity subsidies amounted to Rp 49.7 billion or 36.7% of the total energy subsidy of Rp 135.4 billion (MoEMR, 2020). The following graph shows the trend of electricity subsidies for 2009–2019.

Figure 3. Electricity subsidy 2009–2019 (Rp billion)



3. RESEARCH METHODOLOGY

This study used the ordinary least square (OLS) method. The OLS method has been widely used to perform quantitative analysis to explain the effect of the explanatory variable on the response variable. In the OLS model, the regression coefficient value and also the confidence interval for parameter *b* will be obtained which will be useful for identifying how to fit the resulting model (Hutcheson, 2011). This statistical regression technique has the advantage of optimizing the algorithm which will provide a robust solution. The model can also be implemented easily, effectively, and efficiently and can produce the nature of the relationship between the dependent and independent variables (Iqbal, 2020). This statistical method will be useful for finding quantitative relationships between variables, building mathematical models, and used for predictions based on changes in existing data (Kang & Zao, 2020).

The methodology of least square begins with the selection of paired variable data (x_1, y_1), (x_2, y_2), … (x_n, y_n), where it is assumed that the function of the effect of x_i on y_i will produce the equation:

$$y = \beta_0 + \beta_1 x \quad (1)$$

Formally, the equation that will be generated is:

$$y_i = \beta_0 + \beta_1 x_i + \varepsilon_i \quad (2)$$

The least square method with a larger number of independent variables *x* will produce the equation:

$$y_i = \beta_0 + \beta_1 x_i + \beta_2 x_2 + \beta_3 x_3 + \dots + \varepsilon_i \quad (3)$$

Testing the fit of the OLS model, in general, requires t-statistics.

The data used in this paper is secondary data with an annual time series time horizon from 2011 to 2019. To find out the effect of the substitution of fossil energy with NRE on the number of electricity subsidies, in the simulation it is assumed that a decrease in the cost of supplying electric power represents the replacement of fossil energy with NRE.

One of the variables that influence the formation of electricity rates is the cost of fuel for power plants. If the fuel used is fossil energy fuel (HSD), which is expensive, the cost of providing electricity will be high, and conversely, if the fuel used for power generation is a mixture of coal, natural gas, or NRE, which is cheaper, then the basic supply of electricity to be low.

Multiple linear regression model is presented in equations (4) and (5).

Model 1

$$S = f(Tarif, CS, Margin, Volume) \quad (4)$$

$$Ln\_S = ln\_C + b_1\, ln\_Tarif + b_2\, ln\_CS + b_3\, ln\_Margin + b_4\, \ln\_Volume \quad (5)$$

where,
ln_S: Subsidy;
ln_Tarif: Electricity tariffs for subsidized electricity customers;
ln_CS: Cost of supply;
ln_Margin: Operating margin;
ln_Volume: Sales volume;
ln_C: Constant;
ε: Error term.

4. RESULTS

The regression carried out in this study used a secondary time series database by classifying the data into three parts, namely subsidized and non-subsidized electricity customers consisting of industrial customers and business customers. The results of linear regression showed that the value of R^2 was quite large, namely 0.980 with an adjusted R^2 value of 0.960 below R^2. This showed that the selection of independent and dependent variables used in this model was acceptable because theoretically 98% of the variables used were representative enough so that the model used in this study can be said to be quite valid for treatment.

After treatment, the regression model is obtained as follows:

$$\underset{(12,263)}{S = 55{,}21} + \underset{(3,325)}{0{,}986\, Tarif} + \underset{(5,486)}{3{,}481\, CS} - \underset{(-1,628)}{1{,}222\, Margin} - \underset{(-7,567)}{3{,}577\, Volume} + \varepsilon \quad (6)$$

The regression results showed that by using α of 5%, all variables such as rates, CS, and electricity sales volume had a significant effect on the amount of subsidy except for the margin variable whose effect was not significant. Because the margin, which in fact, is the Government's injection of funds to PLN as the sole operator, did not have a direct effect on the subsidy but through the basic cost of providing electricity. In other words, substantially the influence of the margin has been covered in the components of the basic cost of electricity supply. In addition, the purpose of margin injection, the amount of which was a proportion of the total electricity sales volume, was aimed at improving PLN's financial performance. As a result, the balance sheet was positive and profitable, so it attracted investors to invest in the electricity sector. The positive correlation between the electricity rates (administered price) and the amount of the subsidy was theoretically quite reasonable because these two variables are the domain of the Government. The increase in electricity rates (administered price) was solely to support and reduce the burden on PLN as the sole operator appointed by the Government to distribute electricity in the territory of the Republic of Indonesia. It was analogous to the basic cost of providing electricity in that the increase in production costs was positively correlated with the amount of the subsidy. This was in line with the theory that an increase in production costs had an impact on an increase in rates. However, because the electricity rates are regulated by the Government, an increase in the basic cost of providing electricity would impact in an increase the number of electricity subsidies. The results of this regression were quite in line with the hypothesis that an increase in the basic cost of providing electricity had a large enough effect on subsidies. Based on this hypothesis, the variable cost of electricity supply was used as a decision variable in the simulation to determine its impact on increasing or decreasing electricity subsidies (Brown, 2020; Burke & Abayasekara, 2017; Coady et al., 2017).

Another variable is the volume of electricity sales, which correlated with the number of electricity subsidies inversely. This is in line with the theory that with an increase in sales volume, the probability of obtaining revenue became greater, and in the end, the company's ability to cover production costs due to the gap between commercial prices and subsidized prices would be smaller (Omer, 2011). Therefore, in the short term, this condition would have a positive effect.

To prove the hypothesis that the reduction in the cost of supplying electricity was done by increasing the use of NRE or by substituting fossil fuel HSD used in diesel power plants with NRE, a simulation was carried out using the variable for reducing the cost of supply of electricity as the decision variable. The regression results of the 10% reduction in the cost of electricity supply are shown in the equation below:

$$\begin{aligned} S = \ & 55{,}21 + 0{,}986\,Tarif + 3{,}872\,CS - 1{,}222\,Margin - 3{,}577\,Volume + \varepsilon \\ & (12{,}263)\ \ (3{,}325)\qquad (5{,}486)\qquad (-1{,}628)\qquad (-7{,}567) \end{aligned} \tag{7}$$

The coefficient of the basic cost of electricity supply in equation (7) was greater than in equation (6). This meant that the substitution of HSD in diesel power plants with NRE would actually increase the number of subsidies. This was because the proportion of the number of diesel power plant operating in Indonesia is getting smaller since diesel power plant is only operated in remote areas and is emergency.

The simulation results were consistent with the empirical conditions and facts that the current implementation of the energy transformation policy from fossil energy to NRE requires very large economic costs. One of the contributing factors is the implementation of the 35,000 MW program, all of which were based on coal fuel which incidentally was part of fossil energy. If the policy of transforming energy to NRE was forced to be implemented without waiting for the right time, it could be imagined how big the potential loss to the state would be. There would be tens or even hundreds of steam-electric power stations that have been operating and would stop operating, at least for technology adjustments to be made to suit NRE fuels. Another risk was that there will be many blackouts during the overhaul for technology adjustments (Mulyana, 2018).

Another loss that is clearly visible is the financial loss that will be borne by PLN as a BUMN (*badan usaha milik negara*, "state-owned enterprises"). PLN as the executor of the mandate to build the 35,000 MW steam-electric power station program will bear the economic and financial burden. This is because PLN must terminate all existing and ongoing steam-electric power station construction contracts and change the technology of the steam-electric power station that is already operating. In fact, all the steam-electric power station development processes carried out by PLN are government mandates (PLN, 2019).

In addition, there is a potential risk of civil lawsuits from various contractors due to unilateral contract cancellations. Other risks are layoffs, and increased unemployment, and what is more worrying is the lack of legal certainty in investing, uncertainty, and trust from investors due to changing policies. Keep in mind that PLN's current balance sheet is already red due to a very large debt burden and has the potential to go bankrupt.

To avoid blackouts throughout Indonesia and save PLN from bankruptcy due to the implementation of the policy of transforming fossil energy to NRE which is more expensive, hasty, without careful calculations and only follows the wishes and external pressures of developed countries, it is estimated that the Government should inject trillions of subsidy funds to PLN. If this is the choice, fiscal sustainability will be threatened.

5. DISCUSSION

Theoretically, the positive relationship between the variable electricity tariffs regulated by the Government (administered price), specifically the tariff for household customers of 450 VA and 900 VA non-RTM (not well-off households) with the amount of subsidy as shown in equations (6) and (7) is not logical based on microeconomic theory. Subsidies are basically the opposite of taxes (negative taxes). In this case, subsidies are costs incurred by the Government to cover the difference between the economic price (market price) and the set price. Therefore, when the administered price of electricity tariff (450 VA household customers and 900 VA non-RTM) is increased, the number of subsidies issued by the government should decrease. Thus, there is a theory relationship. The factor that causes the theory relationship is the use of HSD as fossil fuel for power plants where the percentage of diesel power plants is estimated to be quite high, especially for the island and remote areas (Elavarasan, 2020).

To reduce the role of fossil energy, including the use of HSD and commitment to climate change, the Government of Indonesia is planning a program to transform fossil energy into NRE.

From the simulation results by comparing the variable coefficient of CS in equations (6) and (7) it can be said that the substitution of fossil energy in diesel power plant with NRE will actually increase the amount of subsidies. It is because the price of NRE is much more expensive than the price of HSD. This means that this simulation is in line with the structure of the cost of producing renewable energy in Indonesia, which is still high when compared to the cost of producing fossil energy.

This condition theoretically illustrates that Indonesia's plan to implement a policy of energy transformation from fossil energy to NRE, which is planned to start in 2030, is quite difficult to implement, considering the infrastructure facilities are not adequate yet. Therefore, this condition encourages fragmentation between NRE sources and the market, resulting in high NRE prices (Melnyk et al., 2020).

To implement this transformation policy, it is not necessary to wait for the right time because tens or even hundreds of steam-electric power stations that have been operating will stop operating, at least for technology adjustments to be made to suit NRE fuels. Another risk is that there will be many blackouts during the overhaul for technology adjustments.

In addition, there is a potential risk of civil lawsuits from various contractors due to unilateral contract cancellations caused by the cancellation of the use of the steam-electric power station. Other risks are layoffs, and rising unemployment and the worst risk is the lack of legal certainty in investing, uncertainty, and trust from investors due to changing policies. It should be emphasized that PLN's current balance sheet is already red due to a very large debt burden and has the potential to go bankrupt (Khezri et al., 2022; Nguyen et al., 2021; Sequeira, 2018; Xu et al., 2019).

6. CONCLUSION

The results of linear regression showed that the value of R^2 was quite large, namely 0.980, which meant that theoretically, 98% of all variables used in the model in this paper were quite representative. Variable electricity rates (administered price) and subsidies were positively correlated. This was theoretically quite reasonable because to maintain the financial performance of PLN as the only company mandated to manage and distribute electricity, the increase in subsidized electricity tariffs would directly increase the injection of subsidized funds to PLN.

It is analogous to the basic cost of providing electricity in that the increase in production costs was positively correlated with the amount of the subsidy. This was in line with the theory that an increase in production costs would have an impact on an increase in tariffs. However, because the electricity rates were regulated by the Government, an increase in the basic cost of providing electricity would result in an increase in the number of electricity subsidies.

Another variable was the volume of electricity sales whose correlation was the opposite of the number of electricity subsidies. This was in line with the theory because, with an increase in sales volume, the probability of obtaining revenue becomes greater and in the end, the company's ability to cover production costs due to the gap between commercial prices and subsidized prices becomes smaller. This condition will have a positive effect on reducing the number of electricity subsidies.

The simulation results using the variable cost of electricity supply showed a linear trend where a 10% decrease in CS which was assumed to substitute HSD with more expensive NRE would have an impact on an 11.2% increase in the number of subsidies.

This simulation showed a linear relationship between CS and the amount of subsidy. This meant that the implementation of the policy of transformation or substitution of fossil energy with new and renewable energy that was environmentally friendly but more expensive so it currently needs to be reviewed because it has the potential to cause economic losses with the potential for layoffs and an increase in unemployment in the electricity sector, the threat of the balance sheet of PLN as a BUMN which carried out electricity management, investment law uncertainty, civil lawsuits by contractors due to unilateral contract terminations, the steam-electric power station construction and one thing which is more worrying is the large increase in electricity subsidies that will threaten fiscal sustainability.

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