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Economic Simulation of Indonesia's Clean Energy Policy: Shifting from LPG to Induction Stove

Dzikri Firmansyah Hakam[1,2,*], Meiri Triani[1], I Putu Wirasangka[1], and Siti Aisyah[1]
PT. PLN (Persero) Research Institute, Jakarta, - INDONESIA
School of Business and Management, Institut Teknologi Bandung (ITB), Bandung - INDONESIA
[*] Corresponding author e-mail: dzikri@pln.co.id

Abstract

Indonesian government is facing the burden increase of state budget from the energy subsidy, especially

Liquefied Petroleum Gas (LPG) subsidy. According to state budget plan of Indonesia (RAPBN) year 2019, the LPG subsidy (3 kg tube) year 2019 was estimated more than 70 Billion Rupiah. The subsidy nominal for LPG 3 kg tube is fluctuated because influenced by the uncertainty of world crude oil price where the LPG is the refinery product of crude oil. The increase of crude oil price in the global market could significantly increase the LPG subsidy of Indonesia's government. In the other hand, PLN as Indonesia's state-owned electricity company currently constructing new power plant approximately 35,000 MW that lead to the increasing of reserve margin in the power system that should be absorbed by the consumers. Recently, induction stove emerges by the Indonesia's government as a solution for those two issues above. However, the literature review regarding the economics and policy of the development of induction stove in Indonesia's electricity market is still limited. This research provides the economic valuation of induction stove compared to the utilization of LPG stove for each electricity and LPG tariff, i.e. subsidy and non-subsidy tariff. This research could serve as an academic reference for energy sector stakeholders in Indonesia in objective to implementing the clean energy policy to shift cooking technology from LPG stove to induction stove.

Keywords: Induction stove, LPG, energy subsidy, economic valuation, clean energy policy

1. Introduction

Indonesian government is facing the burden increase of state budget from the energy subsidy, especially Liquefied Petroleum Gas (LPG) subsidy. According to state budget plan of Indonesia (RAPBN) year 2019, the LPG subsidy (3 kg tube) year 2019 was estimated more than 70 Billion Rupiah. The subsidy nominal for LPG 3 kg tube is fluctuated because influenced by the uncertainty of world crude oil price where the LPG is the refinery product of crude oil. The increase of crude oil price in the global market could significantly increase the LPG subsidy of Indonesia's government. In the other hand, PLN as Indonesia's state-owned electricity company currently constructing new power plant approximately 35,000 MW that lead to the increasing of reserve margin in the power system that should be absorbed by the consumers.

Recently, induction stove emerges by the Indonesia's government as a solution for those two issues above. Induction stove program increases the household access to clean energy source, increases the public health, has an adverse effect of climate change compared to the CO2 emission from LPG stove, increases energy efficiency and security (Brown et al. 2017; Quinn et al. 2018). However, the literature review regarding the economics and policy of the development of induction stove in Indonesia's electricity market is still limited. This study determines the economics of induction stove compared to LPG stove for each electricity and LPG tariff, i.e. subsidy and non-subsidy tariff. This research could serve as an academic reference for energy sector stakeholders in Indonesia in objective to implementing the clean energy policy to shift cooking technology from LPG stove to induction stove. Therefore, this research contributes to the academic literature review of clean energy policy in Indonesia.

This study provides economic valuation, strategy, and policy implementation for induction stove development in Indonesia. This research focuses in the utilization of induction stove for household consumer that comprises of electricity tariff 450-900 VA and > 1,300 VA. The structure of this paper is as follows: The first section provides the introduction, research gap, research objective, research structure, and research novelty of the study. The second section shows the research methodology of economic valuation of induction stove compared to LPG stove. The third chapter is the economic simulation and analysis of induction stove for each electricity tariff. Chapter four is the conclusion of the study.

2. Research methodology

This research has an objective to determine the economic valuation and policy implication of induction stove compared to LPG stove for each electricity tariff. To address research objective above, this study applied descriptive analysis and economic valuation methodology. Economic simulation was performed by comparing the cost of cooking of induction stove and LPG stove to determine the cooking cost saving. The efficiency assumption of induction stove in this simulation is based on the reference from (PLN Puslitbang, 2017) where PLN Research Institute performed efficiency study and cooking time experiment using different type kind of stove, i.e. LPG stove, electricity stove, and induction stove. There are three types of electricity tariff applied in (Puslitbang, 2017):

- Electricity tariff with subsidy of 605 Rp/kWh for 450 VA and 900 VA household
- Electricity tariff non-subsidy of 1,352 Rp/kWh for 900 VA household
- Electricity tariff non-subsidy of 1,467 Rp/kWh for 1,300 VA and 2,200 VA

This study using LPG price assumption of 6,666 Rp/kg for LPG price with subsidy and 12,083 Rp/kg for LPG price with non-subsidy based on (PLN Puslitbang, 2017).

The result of efficiency and cooking time comparison for each type of stove could be seen in Table 11. According to Table 11, the LPG stove 1,800 Watt has the highest efficiency of 81.78% and the lowest cooking time of 3.6 %. The greater the power from the induction cooker, the higher the resulting efficiency, and the shorter the cooking time. For the 2,200 VA electric power tariff group, the lowest cooking cost (Rp 152) was generated by a 1,800 Watt induction stove. Due to the power installation limitation for households with 900 VA electricity tariff rates, the lowest cooking costs generated by the 500-Watt induction stove was Rp 166. For the 450 VA electric power tariff group, the lowest cooking cost (Rp 74) generated by 300-Watt induction stove. When compared to LPG stoves, LPG stoves have cooking costs of Rp. 161 for the price of non-subsidized LPG and Rp. 89 for the price of subsidized LPG.

The economic simulation in this study applies three types of subsidized LPG (3 kg) prices based on the delivery point, namely:

- The delivery point at LPG agent with LPG price Rp 4,250 / kg or Rp 12,750 / tube
- The retail delivery point is based on the Highest Retail Price (HET) of Rp. 17,900 / tube
- The retail delivery point for households is IDR 22,000 / kg

It is important to note that the retail sale price of households for 3 kg LPG can vary according to the LPG scarcity in each province, where the selling value of subsidized LPG to the consumers can reach Rp 40,000 / kg.

3. Economic Simulation of Induction stove

The economic simulation in this study is divided into 4 scenarios. The first scenario calculates cooking cost savings made by households by comparing the cost of cooking using induction stoves subsidized tariffs (605 Rp / kWh) with LPG stove subsidized tariff (Rp 4,250 / kg at LPG agent). In this scenario, it is assumed that the induction stove used is of low efficiency, i.e. 300-Watt induction cooker. Based on table 1, the energy utilization of 1 kg LPG on an LPG stove is equivalent to 10.7 kWh on a 300-Watt induction stove. Based on the financial calculations in table 2, there was a savings in cooking costs per month amounting to Rp 10,344 per month for the 12 kg LPG/ month usage pattern. If there is a scarcity of LPG cylinders in the field, the price of 3 kg LPG could

rises to Rp 40,000 per tube, then the savings in cooking costs also increase up to Rp 82,344 per month. The electricity tariff group assumption in this scenario applies 605 Rp / kWh tariff with the consideration that this scenario can be done by low-income households, with subsidized electricity tariff groups of 450 VA and 900 VA, who make the cooking behavior transition from 3 kg LPG stove to induction stove without having to make changes in the electrical installation of the household. Things to consider from this scenario are the availability and manufacturing of 300-watt scale induction stoves where induction stoves usually have relatively larger power nominal than 300-watt.

Table 1: Volume and power equivalents between LPG and induction cookers

Type of Stove	Nominal	Cost	Volume		Equivalency	
Induction stove	300 Watt	210.3	0.14333	kwh	10.696	kwh
	500 Watt	180.51	0.12302	kwh	9.181	kwh
	1000 Watt	165.75	0.11296	kwh	8.430	kwh
	1400 Watt	159.11	0.10844	kwh	8.093	kwh
	1800 Watt	152.3	0.1038	kwh	7.746	kwh
LPG Stove	LPG 3 kg	89.33	0.0134	kg	1	kg
	LPG 12 kg	161.92	0.0134	kg	1	kg

The second scenario calculates cooking cost saving made by household by comparing the cost of cooking induction stove subsidized tariff (500 Watts stove at electricity tariff of 605 Rp / kWh) with LPG stove subsidized tariff (Rp 4,250 / kg at an agent) with. Unlike the first scenario, this second scenario can only be done by household group of 900-watt subsidized electricity tariff rate. Based on table 1, the energy utilization of 1 kg LPG is equivalent to 9.18 kWh on a 500-Watt induction stove. Based on the calculations in table 3, there was a saving in cooking cost per month of Rp 21,344 per month for the 12 kg LPG / month usage pattern. If there is a scarcity of LPG cylinders in the field, the price of 3 kg LPG could rise to Rp 40,000 per tube, therefore the cooking cost savings will also increase to Rp 93,344 per month. It can be compared with the first scenario, that with the increase in induction stove power from 300 Watt to 500 Watt, the cooking cost saving has doubled. In line with the first scenario, this second scenario can be done if the household gets access to a 500-Watt induction cooker.

The third scenario is carried out with the assumption that household subsidized electricity tariffs received a facilities access to increase the electricity installation capacity so that the household can use the high-efficiency induction stoves such as the 1,800-Watt induction stove. Based on the conversion energy in the table 1, 1 kg of LPG is equivalent to 7.74 kWh of 1,800-Watt induction stove. Based on the cost saving calculation in table 4, there is a saving in cooking cost per month of Rp 31,761 per month for the 12 kg LPG/month usage pattern. If there is a scarcity of LPG cylinders in the field and the price of 3 kg LPG rises to Rp 40,000 per tube, the saving in cooking cost also increase up to Rp 103,761 per month. This third scenario has an economic saving that is more than three times greater than the saving in the first scenario. This scenario is specifically intended for low-income households because the electricity tariff applied is the subsidized electricity tariff (605 Rp/kWh). Therefore, it should be remembered that this scenario needs to consider the investment costs that need to be undertaken by the government / PLN to increase the low voltage electricity installations so that the low-income households can use induction cookers and other power tools with high efficiency.

The fourth scenario calculates the cooking cost saving that can be made for middle and high-income households by comparing the cost of cooking of non-subsidized LPG stoves (1,800-Watt) induction stove with induction stove with non-subsidized electricity tariffs. Similar with the subsidized LPG tariff, the price of nonsubsidized LPG also varies depending on the delivery point. At the agent delivery point, LPG has a price of Rp 156,000 / 12 kg while at the retail delivery point, the LPG has a price of Rp 180,000/ 12 kg. Based on the calculation in table 5, there is an economic saving in cooking costs per month in the amount of Rp 43,606 per month for the 12 kg LPG/month usage pattern. From all the scenarios carried out, it can be analyzed that the biggest cooking cost savings occur in the middle and high-income households who change their cooking behavior and migrate the cooking technology from non-subsidized LPG stove to high-efficiency induction stove with nonsubsidized electricity tariffs.

Tables 2-5 shows the evaluation results based on simulation.

Table 2: Scenario 1 Economic simulation of LPG stove with subsidized LPG tariff and 300-Watt induction stove with 605 Rp / kWh electricity tariff

	LPG						Induction stove			
Consumption (per Household)	1 gas tube/ 7 days	1 gas tube/ 10 days	1 gas tube/ 7 days	1 gas tube/ 10 days	1 gas tube/ 7 days	1 gas tube/ 10 days	32.09	kwh / 7 days	32.09	kwh / 10 days
Consumption (per household per month)	4 gas tube = 12 kg	3 gas tube = 9 kg	4 gas tube = 12 kg	3 gas tube = 9 kg	4 gas tube = 12 kg	3 gas tube = 9 kg	128.36	kwh / month	96.27	kwh / month
Delivery point	Agen		Retail (HET)		Household retail		Lov voltage network			
Price	12,750	Rp/tube	17,900	Rp/tube	22,000	Rp/tube	605	Rp/kwh	605	Rp/kwh
Cost per household per month	51,000	38,250	71,600	53,700	88,000	66,000	77,655.87	Rp	58,241.90	Rp
Energy saving per household per month							10,344.13	Rp	7,758.10	Rp
Energy saving per household per month on scarcity							82,344.13	Rp	61,758.10	Rp

Table 3: Scenario 2 Economic simulation of LPG stove with subsidized LPG tariff and 500-Watt induction stove with 605 Rp / kWh electricity tariff

	LPG						Induction stove			
Consumption (per Household)	1 gas tube/ 7 days	1 gas tube/ 10 days	1 gas tube/ 7 days	1 gas tube/ 10 days	1 gas tube/ 7 days	1 gas tube/ 10 days	27.54	kwh / 7 days	27.54	kwh / 10 days
Consumption (per household per month)	4 gas tube = 12 kg	3 gas tube = 9 kg	4 gas tube = 12 kg	3 gas tube = 9 kg	4 gas tube = 12 kg	3 gas tube = 9 kg	110.17	kwh / month	82.63	kwh / month
Delivery point	Agen		Retail (HET)		Household retail		Lov voltage network			
Price	12,750	Rp/tube	17,900	Rp/tube	22,000	Rp/tube	605	Rp/kwh	605	Rp/kwh
Cost per household per month	51,000	38,250	71,600	53,700	88,000	66,000	66,655.55	Rp	49,991.66	Rp
Energy saving per household per month							21,344.45	Rp	16,008.34	Rp
Energy saving per household per month on scarcity							93,344.45	Rp	70,008.34	Rp

Table 4: Scenario 3 Economic simulation of LPG stove with subsidized LPG tariff and 1,800-Watt induction stove with 605 Rp / kWh electricity tariff

Consumption (per Household)	1 gas tube/ 7 days	1 gas tube/ 10 days	1 gas tube/ 7 days	1 gas tube/ 10 days	1 gas tube/ 7 days	1 gas tube/ 10 days	23.24	kwh / 7 days	23.24	kwh / 10 days
Consumption (per household per month)	4 gas tube = 12 kg	3 gas tube = 9 kg	4 gas tube = 12 kg	3 gas tube = 9 kg	4 gas tube = 12 kg	3 gas tube = 9 kg	92.96	kwh / month	69.72	kwh / month
Delivery point	Agen		Retail (HET)		Household retail		Lov voltage network			
Price	12,750	Rp/tube	17,900	Rp/tube	22,000	Rp/tube	605	Rp/kwh	605	Rp/kwh
Cost per household per month	51,000	38,250	71,600	53,700	88,000	66,000	56,238.66	Rp	42,178.99	Rp
Energy saving per household per month							31,761.34	Rp	23,821.01	Rp
Energy saving per household per month on scarcity							103,761.34	Rp	77,821.01	Rp

Table 5: Scenario 3 Economic simulation of LPG stove with non-subsidized LPG tariff and 1,800-Watt induction stove with 1,467 Rp / kWh electricity tariff

	LPG				Induction stove			
Consumption (per Household)	1 gas tube/ 7 days	1 gas tube/ 10 days	1 gas tube/ 7 days	1 gas tube/ 10 days	23.24	kwh / 7 days	23.24	kwh / 10 days
Consumption (per household per month)	4 gas tube = 12 kg	3 gas tube = 9 kg	4 gas tube = 12 kg	3 gas tube = 9 kg	92.96	kwh / month	69.72	kwh / month
Delivery point	Agent		Household retail		Lov voltage network			

Price	39,000	Rp/gas tube	45,000	Rp/gas tube	1,467	Rp/kwh	1467	Rp/kwh
Cost per household per month	156,000	117,000	180,000	135,000	136,393	Rp	102,295	Rp
Energy saving per household per month					43,606.85	Rp	32,705.14	Rp

4. Conclusion

This study has conducted the economic simulations of induction stoves compared to LPG stoves under various scenarios. The simulations carried out in this study consider various possibilities that can occur in the field.

- For various possible economic scenarios conducted in this study, the application of induction stoves for cooking are more economical when compared to LPG stoves.
- In the existing condition (without electrical installation uprating) for low-income households, the transition of cooking behavior from LPG (subsidized) stove to 300-Watt induction stove provides monthly cooking savings per household of Rp 10,344. The application of 500-Watt induction stove provides savings in cooking costs of Rp. 21,344 per month per household. These scenarios needs to consider the availability of low power induction stoves, in this case the induction stove with the scale of 300 Watt and 500 Watt.
- In the existing conditions for the middle- and high-income household group, the cooking cost savings obtained will be even greater of Rp 43,606 per month per household. This economic scenario is carried out by considering the use of an 1,800 Watt high-efficiency induction stove.
- If the electrical installation rating for a low-income household is upgraded so that the household can apply a high-efficiency induction cooker (1,800 Watt), the cooking cost saving gained will increase significantly of Rp. 31,761 per month per household.
- The economic saving for low-income households will increase significantly if there are a scarcity of 3 kg LPG tubes in the field.

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