MECS Modern Energy Cooking Services

IESR Institute for Essential Services Reform

Yayasan Humanis dan Inovasi Sosial

Affiliated with Hivos people unlimited

Overview of the Electric Cooking Landscape in Indonesia

Funded by: Loughborough University, ESMAP Energy Sector Management Assistance Program, UKaid from the British people

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This material has been funded by UKAid from the UK government; however the views expressed do not necessarily reflect the UK government's official policies.

About MECS

Modern Energy Cooking Services (MECS) is a five-year programme funded by UK Aid (FCDO). By integrating modern energy cooking services into the planning for electricity access, quality, reliability and sustainability, MECS hopes to leverage investments in (both grid and off-grid) renewable energies to address the clean cooking challenge. MECS is implementing a strategy focused on including the cooking needs of households in the investment into and action on 'access to affordable, reliable, sustainable modern energy for all'.

About IESR

The Institute for Essential Services Reform (IESR) is a think-tank in the field of energy and environment. IESR encourages transformation into a low carbon energy system by advocating a public policy that rests on data-driven and scientific studies, conducting capacity development assistance, and establishing strategic partnerships with non-governmental actors.

About Yayasan Humanis dan Inovasi Sosial (Hivos)

The Humanist and Social Innovation Foundation (hereinafter: Yayasan Hivos) is an Indonesian organization, born out of an active collaboration between Netherlands based Hivos and several like-minded Indonesian academics and civil society leaders. We promote humanistic values, amplify and connect voices that promote social and environmental justice and challenge power imbalances. We particularly empower marginalized rightsholders to raise their voice and demand freedom of choice. We support the development of alternative solutions to deep-seated problems in the economic and social sphere so that individuals and communities can make responsible and equitable choices within political and economic systems that serve their needs and preserve the planet. We connect people and organizations offering alternatives to those looking for solutions in their fight for social, economic and environmental justice.

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Acknowledgements
Yayasan Hivos and IESR would like to thank the following organizations for their contributions that were made through online or written interview:
Directorate of Energy Conservation, Ministry of Energy and Mineral Resources; Center for Research and Development of Electricity, New Renewable Energy and Energy Conservation Technology; Directorate of Electronics and Telematics, Ministry of Industry; State Electricity Company (PLN); Trisakti School of Tourism (culinary expert).

List of Content

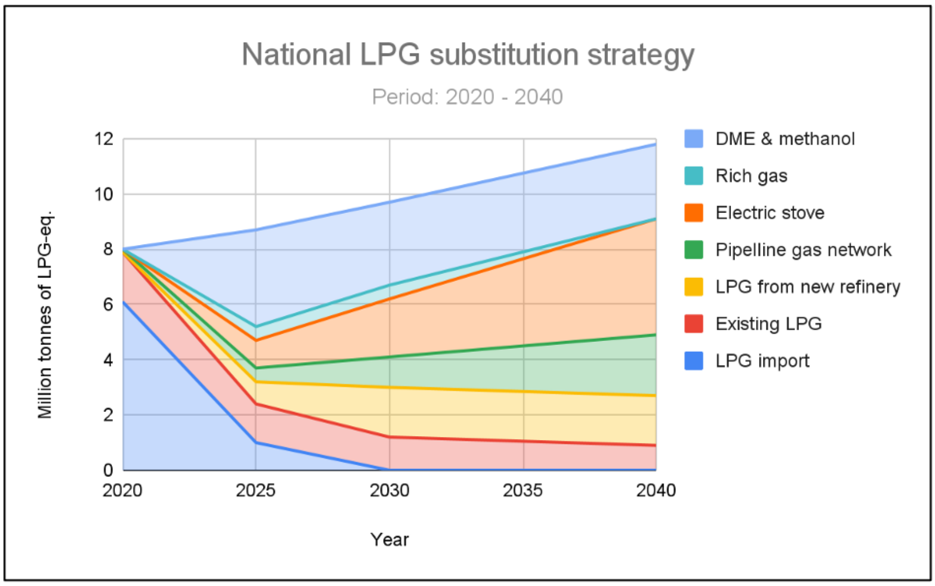
Acronyms and Abbreviations

BAR-HAP	: Benefits of Action to Reduce Household Air Pollution
BAU	: Business As Usual
CMEA	: Coordinating Ministry of Economic Affairs
CMMIA	: Coordinating Ministry of Maritime and Investment Affairs
CO	: Carbon Monoxide
DEN	: Dewan Energi Nasional or National Energy Council
DG	: Directorate General
DME	: Dimethyl Ether
EBTKE	: Energi Baru Terbarukan dan Konservasi Energi or New Renewable Energy and Energy Conservation
FGD	: Focus Group Discussions
GHG	: GreenHouse Gas
GSEN	: National Energy Grand Strategy
IDR	: Indonesian Rupiah
LPG	: Liquefied Petroleum Gas
MEMR	: Ministry of Energy and Mineral Resources
MEPS	: Minimum Energy Performance Standards
MOPH	: Ministry of Public Works and Housing
MoF	: Ministry of Finance
NOx	: Nitrogen Oxides
PM 2.5	: Particulate Matter 2.5
PLN	: Perusahaan Listrik Negara or State Electricity Company
RE	: Renewable Energy
SAIDI	: System Average Interruption Duration Index
SAIFI	: System Average Interruption Frequency Index
SNI	: Standar Nasional Indonesia or Indonesian National Standards
SOE	: State-owned Enterprises
USD	: United States Dollar
VA	: Volt Ampere

Excecutive Summary

Since the introduction of the kerosene-to-LPG conversion program in 2007, Indonesia's LPG consumption has massively increased. As domestic LPG production has been stagnant, about 75% of the LPG demand in 2020 needs to be imported. LPG import soared from only 1 million tonnes in 2009 to 6.4 million tonnes in 2020. In addition, the LPG subsidy provided for the 3 kg canisters has also increased and burdened the government budget. This situation has motivated the government to initiate another conversion program: from LPG to induction stove.

Through the National Energy Council (DEN), the government, set a strategy to reduce LPG import and subsidy, which includes converting to induction stoves. The plan targets 22% of cooking energy demand in 2030 to come from electricity. To support the conversion program, the government is set to spend a subsidy of IDR 1 million (USD 70) per household in 2022, targeting 8.3 million households. Other than that, PLN, the state electricity company, has also provided several incentives under its one million induction stoves program, such as free induction stoves distribution, connection upgrade discounts for existing consumers, free connection upgrades for new residential buildings equipped with induction stoves, and integration of induction stoves in subsidized housing credit programs.



National LPG substitution strategy set by DEN
Source: DEN, 2021

The responsibilities for the transition to induction stoves are distributed to various stakeholders. PLN is currently the main actor driving the conversion through its one million induction stoves program. Other main stakeholders are the Directorate General of Electricity of the Ministry of Energy and Mineral Resources (MEMR) that oversees the energy provision and the Ministry of Public Works and Housing (MOPH) that provides a large market for induction stoves through the public housing program. However, it is unclear who is actually responsible for coordinating and overseeing the whole conversion program.

From a societal perspective, conversion to induction stove provides more benefits than costs. The main benefit comes from health improvement due to less indoor air pollution. On the other hand, the main cost comes from increased GHG emissions, mainly due to the high share of coal in the current power generation. The renewable share in power generation needs to increase to about 80%, or the grid emission factor needs to decrease to 250gCO2e/kWh to avoid an increase in GHG emissions. This will be achieved around 2040-2045 according to Indonesia's Long Term Strategy for Low Carbon and Climate Resilience.

The purchase of induction stoves and iron-based cooking utensils costs almost twice as much as LPG stove sets (including the utensils, LPG cylinder, hose, and regulator). However, conversion to induction stoves also reduces the overall cooking fuel spending, including the government spending for LPG subsidy. From a households' perspective, conversion will also result in reduced cooking energy spending, unless household switch from 3kg-subsidized LPG to unsubsidized electricity. The higher purchase cost will be a major barrier for lower income households, while the increased energy spending will be a barrier for middle income households that use subsidized LPG but are not entitled to electricity subsidy. In addition, the current electricity subsidy scheme based on connection power would hold back low income households from upgrading their electricity connection at the expense of losing subsidy.

For the consumers, the majority are interested in converting from LPG stoves to induction stoves because the value proposition offered by induction stoves is higher than the value proposition of LPG stoves, such as improved safety features and cooking functions, ease to clean, or luxury appearance. However, some prefer to also keep LPG as backup and for cooking specific foods where they were accustomed using a specific wok. Also, their intention to adopt the induction stove is often limited by their household electricity connection power limit. For more than 90% of the population, the electricity power limit is 1,300 VA or lower, which is insufficient for induction stoves. Some are also concerned about the unreliability of the electricity supply, high purchase price of the stoves and cookwares, and increased electricity bills.

While Indonesian cooking is generally suitable with an induction stove (with minimal adaptation), some consumers are also concerned with the unsuitability of an induction stove with their preferred cooking method or experience (e.g. preference for cooking with fire or using a convex wok).

As current demand for induction stoves is low, the domestic industry is currently not ready to cater for the potential demand, with only two manufacturers available with a total annual capacity of 317,000 units. Moreover, the electronic component industries are also underdeveloped. However, a national scale induction stove deployment program from the government could attract investors and existing domestic electronic appliances producers to build induction stove manufacturing lines.

Based on the findings of this study and learning from the previous kerosene-to-LPG conversion program, here are some recommendations that need to be implemented in order for the transition to the induction stove to be successful:

- The government needs to establish a supportive policy and regulatory framework which lays out a clear pathway of LPG replacement and induction stove deployment strategy, as well as a task force to coordinate and regulate the program implementation.
- LPG subsidy should be limited only for the low income households. Lifting the entire LPG subsidy or limiting LPG distribution could be considered when the whole population, especially the low income households, already has access to affordable induction stove cooking.
- Electricity subsidy based on connection capacity needs to be transformed to allow low income households to upgrade their connections without being exempted from subsidy. It is noteworthy that the additional electricity subsidy given for these households will be higher than the LPG subsidy saving.
- Electricity connection power increase is needed for more than 90% of the population and electricity supply needs to be more reliable, as these are major concerns for the consumers.
- The cost for connection upgrade will become a barrier for consumers wanting to convert, thus a discount or free upgrades will be helpful.
- Campaigns and promotion emphasized at improved performance and utility (e.g. safety, cleanliness, appearance, ease of use) of induction stoves could attract the high income households which face less financial barriers.
- Education on the health risks of LPG and health benefits of the induction stove is important as public awareness is currently very low, although a further study on the health impact of cooking equipment in Indonesia might be needed for this.

- Education and campaigns on reduced energy cost could attract those in low to middle income households that are more cost sensitive. These segments, however, would need support for the initial purchase of the stove sets. For low income households, the government could provide free induction stoves and basic cookware. For middle income households, consumer financing will help to lower the financial barrier.
- PLN could actively facilitate consumer financing, for example, by providing its consumer payment data with the financiers, or even by directly providing consumer credits if suitable with the national regulations and PLN's business model.
- Increased capacity of domestic manufacturing, at least for assembly, is needed to cater the future demand of the conversion program. This will also create additional demand for the electronic component industry to develop.
- Bulk procurement coordinated by the government/task force for the free distribution program could guarantee a sizable market that enables manufacturers to produce at lower cost.
- Establishment of national quality standards for the induction stove will help avoid a negative public perception due to low product quality or performance.

1. Background

Indonesia is the fourth largest country in the world, with over 265 million people in 2018. Under the Paris Agreement, Indonesia committed to reducing greenhouse gas (GHG) emissions by 29% below a business-as-usual (BAU) baseline by 2030, or by 41% below BAU by 2030 with international support. Specifically for the energy sector, the unconditional and conditional GHG emissions reduction is projected to be 11% and 15.5% of total BAU.

To integrate with the response to climate change, several recommendations made by the Government including encouraging the transition of energy use to renewable energy sources, increasing efficiency, and increasing the amount of biofuel use. The Ministry of Energy and Mineral Resources (MEMR), through its Directorate General of New Renewable Energy and Energy Conservation (EBTKE), aims to reduce national energy consumption across all sectors by 17% in 2025 relative to BAU through various policies, including energy efficiency standards and labeling for household electric appliances.

One of the sectors with the most significant amount of energy needs in Indonesia is the household sector. In 2019, the household sector contributed to 14% of national energy use with an average growth rate of 4% per year. Energy consumption in the household sector is currently dominated by electrical energy and is predicted to increase by 50% in 2050. The increasing need for electrical energy in the household sector cannot be separated from the increasing human needs for various electronic equipment such as air conditioners, refrigerators, water pumping machines, lighting, and various electronic devices. Moreover, the government will make efforts to replace LPG stoves with induction stoves, aimed to reduce LPG import and subsidy. This will further increase the electricity consumption in households sector.

Induction stoves are not widely known by consumers in Indonesia. Most widely used electric cooking equipment is rice cookers. The small number of induction stove users in Indonesia is understandable since there is still a lack of information about the use of electric stoves and subsidized LPG cost that is accessible to everybody. There are also limited domestic manufacturers for good quality induction stoves.

In addition, there are several barriers that seemingly hinder induction stove penetration. Most induction stoves with high performance comparable to LPG stoves consume a lot of power. From the consumer's interest and buying capacity, the conversion will also require additional investment not only changing the stoves but also the cooking utensils such as pots and pan, and requirement to increase the connection capacity of power.

This research aims to explore the potential adoption of induction stove in urban households, especially in the Java-Bali region, and to assess the requirements and implications of such adoption. At the end, this research will propose recommendations for the policymakers on how to accelerate the adoption of induction stoves in Indonesia. To achieve this objectives, the research is designed to answer the following questions:

1. How is the current enabling environment of induction stove adoption?
2. How ready is the domestic induction stove industry and supply chain?
3. What are the expectations from the potential users/consumers?
4. What lessons can be learned from the previous kerosene to LPG transition program and rice cooker adoption?

2. Research methodology

The study was carried out through a desk review of secondary sources as well as focus group discussions (FGD) and semi-structured interviews with stakeholders and experts. Due to the pandemic, all FGDs and interviews were performed online.

Desk review

Most of the quantitative data regarding the current state of clean cooking, electricity access, and induction stove are obtained from secondary sources, including academic references, gray literatures, and official statistical data. Data regarding inductions stoves prices are obtained from e-commerce platforms.

Consumer FGDs

Five sessions of online FGDs were conducted between 2-9 December 2021, with 1-1.5 hours per session. 16 individuals participated in the FGDs fit the sample household's criteria of minimum 900 VA electricity connection capacity and residing in Greater Jakarta, Bandung (West Java), and Bali. The FGD participants were obtained through the authors' networks. Detail of FGD participants demography is provided in Appendix C. The FGDs involved a limited number of respondents and a further study involving a survey with a wider audience is necessary to better understand the consumer preferences and behaviors.

Stakeholder and expert interviews

a) Semi-structured interviews were conducted between November 2021 and January 2022 with stakeholders and experts below.

Table 1. Key actors

No	Key Actors
1	Directorate of Energy Conservation, Ministry of Energy and Mineral Resources
2	Center for Research and Development of Electricity, New Renewable Energy and Energy Conservation Technologies
3	Directorate of Electronics and Telematics, Ministry of Industry
4	Lecturer in Trisakti School of Tourism (culinary expert)
5	Lecturer in Trisakti School of Tourism (culinary expert)

* The interview with PLN was conducted in written form

Data analysis

The analysis was performed by comparing and vetting the information and findings obtained from the desk review, interviews, and FGDs. In addition, a cost-benefit analysis was performed using WHO's Benefits of Action to Reduce Household Air Pollution (BAR-HAP) tool. This cost-benefit analysis includes the cost of equipment, energy, health, and environment (climate). The detailed method of the cost-benefit analysis is available in Appendix A.

3. Current state of clean cooking and electricity access in urban households

Current state of clean cooking in urban households

The majority of Indonesian households, either in rural or urban areas, have adopted LPG stove as their cooking appliances. In 2021, 83% of Indonesian households used LPG as their main cooking fuel. In 2007, 86% of Indonesian households used wood and kerosene as their primary cooking fuel. As kerosene subsidy became a burden to the state budget, the government decided to stop kerosene subsidy and diverted it into the LPG subsidy programme in 2007. As a result,people started to adopt LPG as their primary cooking fuel massively.

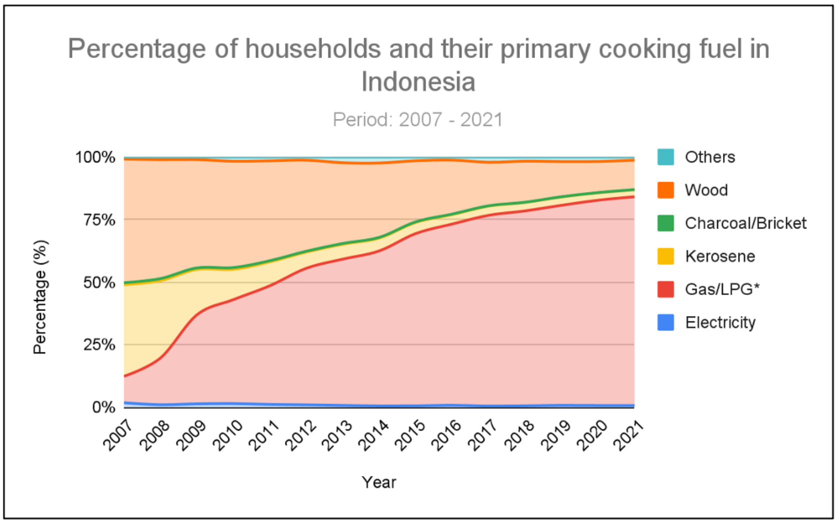


Figure 1. Energy mix of primary cooking fuel in Indonesia.
Source: BPS, 2017; BPS(a), 2017; BPS,2018; BPS, 2019, BPS, 2020; BPS, 2021

The majority of both urban and rural people have adopted LPG as their primary cooking fuel in 2021 (89% and 75%). The second largest primary fuel for cooking comes from firewood (urban: 4%, rural: 22%). The national electricity consumption for cooking activities has been stagnant below 1%.

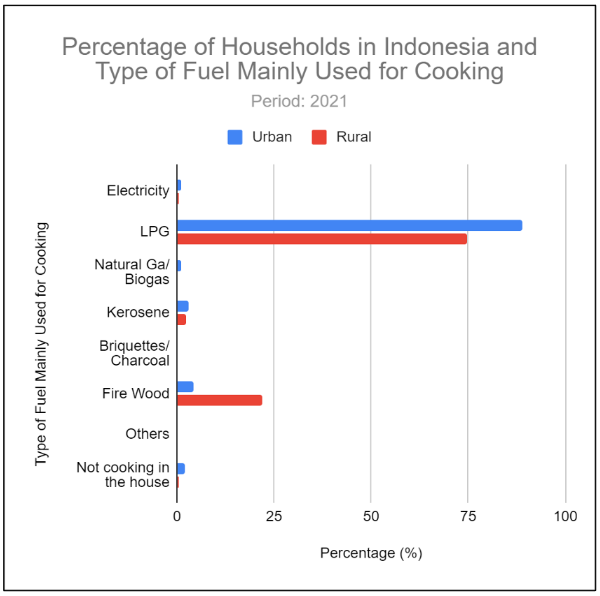


Figure 2. Percentage of households in Indonesia and type of fuel mainly used for cooking
Source: BPS, 2021

The situation in the Java-Bali region is quite similar to the national one, with LPG used as primary cooking fuel by the majority of people. The share of households using LPG as primary cooking fuel is also higher in urban than rural areas. The use of firewood is still prevalent in the rural areas, reaching over 30% in some provinces. In urban areas, more households do not cook at home, over 5% in some provinces. Utilization of electricity as main cooking fuel is generally low in most cities/regencies, lower than 5% of households, including in major cities in the Java-Bali region.

Meanwhile, the adoption of LPG is not as prevalent in the Eastern regions of Indonesia. In five provinces, i.e. Papua, West Papua, Maluku, North Maluku, and East Nusa Tenggara, only less than 6% of households use LPG as the primary source of cooking energy. The next lowest share of households using LPG as primary source of cooking energy is Sulawesi Tenggara at 64%.

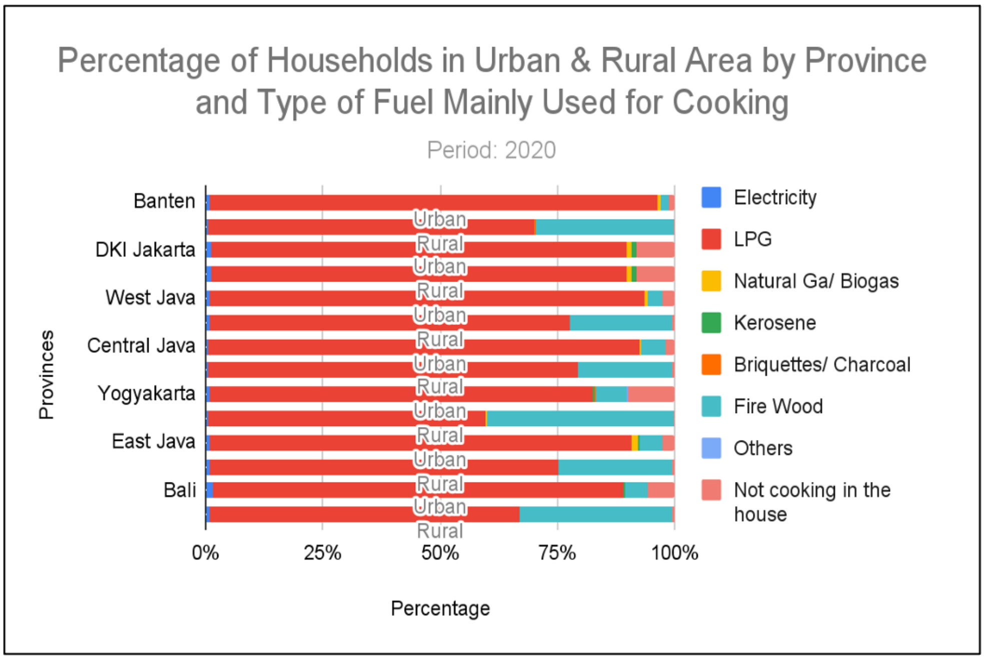


Figure 3. Percentage of households in urban and rural area and type of fuel mainly used for cooking
Source: BPS, 2021

The LPG for household use is available in the market in various sizes: 3 kg, 5.5 kg, 9 kg, 12 kg, and 14 kg. The 3 kg LPG is subsidized by the government, with the price set by each local government. Prices are officially set at IDR 16.000 per canister in Java island (USD 0.37 per kg), although often purchased by households at around USD 0.5 per kg from retailers. Meanwhile, the other sizes are sold at market price, at around IDR 140,000 per canister (USD 0.97 per kg).

The subsidized 3 kg LPG is intended for low income households, but has not been effectively distributed to those entitled. Middle- and high-income households (indicated by higher electricity connection[1]) also use the subsidized LPG, although to a lesser extent, as found by (Anggono et al., 2021).

Table 2. LPG consumption by household types. Source: Anggono et al., 2021

Electricity Customer category (VA)	450	900	900/M	1,300	2,200	3,500 - 5,500	> 6,600
LPG 3 kg	97.5%	86.3%	80.3%	70.2%	46.7%	31.6%	10.0%
LPG 5.5 kg	0.6%	2.3%	4.1%	5.9%	6.5%	-	-
LPG 9 kg	-	-	0.7%	-	-	-	-
LPG 12 kg	1.9%	11.5%	14.8%	23.9%	46.7%	68.4%	50.0%
LPG 14 kg	-	-	-	-	-	-	40.0%
Average LPG consumption (kg/ month)	8.6	10.5	10.0	11.0	12.7	16.1	32.7

Current state of electricity access in urban households

Indonesia's electricity access has improved over time. By 2021, the electrification ratio in most regions, including Java and Bali, has reached almost 100%. Only four provinces (Central Kalimantan, Papua, Maluku, and East Nusa Tenggara) have an electrification ratio lower than 98%. In terms of reliability, SAIDI and SAIFI levels are already in the Tier 5 (highest tier) of the Multi-Tier Framework of electricity supply. In 2020, SAIDI ranged 1.85 - 33.72 (national average 12.72) hours per consumer and SAIFI ranged 1.4 - 31.42 (national average 9.25) interruptions per consumer, depending on the region. In Java regions, average SAIDI and SAIFI is 10.95 hours and 7.46 interruptions per consumer, better than the national average (PLN, 2021b). The national SAIDI and SAIFI average has reduced substantially in 2021 to 6 hours per consumer per year and 4 interruptions per consumer per year respectively. No regional information is available yet. The historically poor quality of electricity supply plays a role in the consumers' anxiety to convert to induction stove, as will be explained in a later section.

1 Electricity tariff is subsidized for the low power connection (450 and 900 VA), thus low income households normally subscribe to these tariffs. More explanation will follow in the next section.

Table 3. SAIDI and SAIFI in Java-Bali regions[2] (2020). Source: PLN (2021)

Region	SAIDI (hours/consumer/year)	SAIFI (interruptions/consumer/year)
Jakarta	4.54	1.40
Banten	3.39	1.96
West Java	17.34	11.05
Central Java/Yogyakarta	13.56	9.99
East Java	5.21	4.49
Bali	1.85	1.94

The penetration of electronic appliances is quite high, with most households that have access to electricity own televisions (93%), cell-phone (78%), electric iron (70%), rice cooker (69%), refrigerator (69%), and electric fan (64%). The use of other devices is less common, such as blender (27%), dispenser (20%), air conditioner (5%), electric oven (1%), and microwave (0.5%) (CLASP & Ipsos, 2020a). The penetration in Java urban areas is likely to be higher, as an earlier study conducted in Bandung/Yogyakarta showed rice cooker, refrigerator, and microwave oven ownership reached 95%/85%, 81%/88%, and 19%/6% respectively (Wijaya & Tezuka, 2013).

The electricity generation capacity has increased faster than demand growth, especially in the Java-Bali region. The recent pandemic has hampered the electricity demand and exacerbated the oversupply situation. The reserve margin in the Java-Bali grid was 40% in 2020 and expected to increase to 59% in 2021. PLN plans to gradually reduce the reserve margin to 48% in 2025 and 37% in 2030 (PLN, 2021a).

The majority of Indonesia's electricity mix comes from fossil fuels. In 2021, 87% of electricity comes from fossil fuels including coal, natural gas, and oil (66%, 18%, and 4%). The rest of the electricity mix (13%) comes from renewable energy sources including hydropower, geothermal, and other REs (6.7%, 5.6%, and 0.4%) in 2021. Since 2015, renewable energy shares remain stagnant below 15%.

2 The SAIDI and SAIFI numbers are averaged over the population in the specified provinces. It is possible that the interruptions in certain areas occur more than in other areas in a province. This phenomenon is not captured in the presented SAIDI/SAIFI numbers.

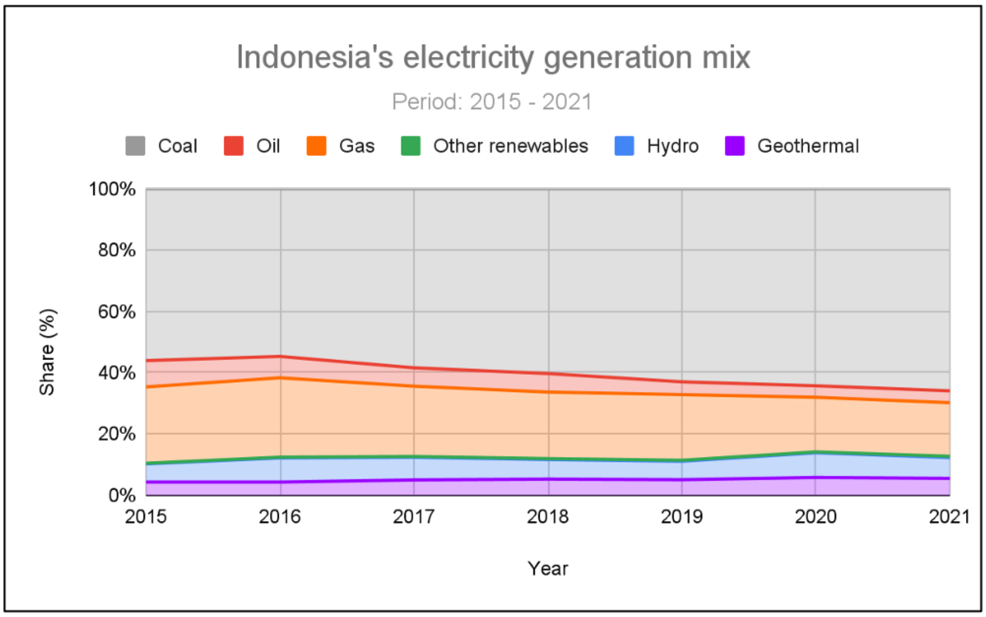


Figure 4. Indonesia's electricity generation mix
Source: MEMR, 2021

Based on MEMR Decree No. 28/2016, the household electricity tariff is classified into various categories according to connection capacity as presented in Table 4. The tariffs are subject to quarterly adjustment, except for the subsidized ones. However, for the past 5 years, the unsubsidized tariff has been flat.

Table 4. Household electricity tariff and numbers of users in each category in Java-Bali region (per December 2021).
Source: PLN, 2021.

Household types	Capacity	Tariff (USD/ kWh)	Number of users in Java-Bali	% of users in Java-Bali
Small households (R-1)	450 VA	2.90 cents*	17,337,171	38.85%
	900 VA	4.24 cents*	3,852,809	8.63%
	900 VA-RTM	9.46 cents*	13,172,328	29.52%
	1300 VA	10.11 cents	6,941,072	15.56%
	2200 VA	10.11 cents	2,130,024	4.77%
Medium households (R-2)	3500-5500 VA	10.11 cents	969,330	2.17%
Large households (R-3)	>=6600 VA	10.11 cents	220,002	0.49%
			44,622,736	100.00%

*These are subsidized tariff. During pandemic, there are additional tariff discounts for these users.

Less than 10% of the Java-Bali households have a connection of 2200 VA or above, which could reasonably use a high-performance induction stove over 1000 W power requirement without connection upgrade. The remaining households will require connection upgrades to be able to use a high performance induction stove, or will need to resort to the lower performance ones if they maintain the existing connection. Other electric cooking appliances with lower power requirements such as rice cookers could be used by these households. Rice cookers, in particular, are very common in Indonesian households. Almost 80% of the rice cookers used in Indonesian households have a power consumption under 450 W. About 90% of the rice cookers in the households use electric resistance technology rather than induction heating or induction pressure, as they are cheaper and available in lower power consumption (CLASP & Ipsos, 2020b).

In addition, 47% of the grid connected households in Java-Bali region get a subsidized tariff, as shown in Table 4. These consumer segments are unlikely to upgrade to higher connections since the existing subsidy schemes are based on the connection capacity. If they upgrade to a higher connection, they will not be entitled to the subsidy anymore. A change to the electricity subsidy scheme that allows these consumers to increase their connection power without losing access to subsidy would be necessary if the government wants to target them for the conversion to induction stove. Recently, the Directorate General of Electricity of MEMR stated that the electricity subsidy scheme will be modified into a direct subsidy scheme, in which the low income households still pay full electricity tariff but receive a cash transfer (Sugiharto, 2022).

4. Impacts of transitioning to induction stove

In general, an induction stove has multiple benefits, such as improved energy efficiency, lower energy cost, shorter cooking time, less harmful emissions, less vitamin losses, and better safety (Martínez-Gómez et al., 2016). In this section, several costs and benefits of the induction stove are discussed and put into comparison. The discussion focuses primarily on the economic and energy aspects.

Reduced indoor pollution and health improvement

The induction stove emits substantially less indoor pollutants compared to the LPG stove, including particulate matter (PM2.5), nitrogen oxides (NOx), carbon monoxide (CO), and formaldehyde, especially when ventilation is lacking. While cooking the food itself generates air pollutants, the electric stove itself emits close to zero additional pollutants (Seals & Krasner, 2020). These pollutants are known to be harmful for human health.

The analysis using BAR-HAP found that replacing LPG stoves with electric stoves in a million households by 2025 will reduce mortality and morbidity rates by over 800 lives/year and over 13,000 cases/year respectively. This translates to economic benefits of over USD 300 million per year.

Energy efficiency

The electric induction stove has the highest efficiency compared to the LPG stove and the conventional electric stove (Tiandho et al., 2021). The high power induction stove (2000 W) could be almost twice as efficient as an LPG stove, as shown by Anggono et al. (2021). Hakam et al. (2021) also showed that the efficiency of an induction stove tends to decrease at lower power. In addition, the high power (1800-2000W) induction stoves can cook faster than LPG stoves, although the lower power ones tend to cook significantly slower.

Table 5. Comparison of the performance of stove by types. Source: Tiandho et al., 2021

Dish	LPG stove				Conventional Electric Stove				Induction Stove			
	Ti (°C)	Tt (°C)	Time (s)	Energy (kWh)	Ti (°C)	Tt (°C)	Time (s)	Energy (kWh)	Ti (°C)	Tt (°C)	Time (s)	Energy (kWh)
Hard-Boiled Eggs	15	94	1,125	0.456	15	94	3,000	0.298	15	94	542	0.169
Grilled Chicken	15	72	510	0.427	15	72	1,575	0.281	15	72	425	0.233
Steamed Fish	15	75	620	0.439	15	92	1,525	0.250	15	92	365	0.214
Water (350 cc)	-	-	-	-	25	50	304	0.034	25	30	152	0.012

Deployment of one million induction stoves is estimated to add about 0.7 TWh per year (assuming the users only use induction stoves for 80% of their cooking energy). This is only 0.5% of the total electricity sold in Java-Bali in 2020.

LPG import reduction

The government's main reason for induction stove deployment is to reduce LPG import. As households shifted from kerosene to LPG for their cooking fuel, demand for LPG increased rapidly and exceeded national production. As a result, LPG imports soared from less than 1 million tonnes in 2009 to 6.4 million tonnes in 2020. With domestic production remaining around 2 million tonnes per year, around 75% of national LPG needs in 2020 was imported.

Replacing the LPG stove with the induction stove in a million households could reduce annual LPG demand by almost 70 thousand tonnes (at 50% fuel stacking) to 110 thousand tonnes (at 20% fuel stacking[3]).

Cooking cost reduction

Energy cost for cooking with an induction stove is generally lower than the cost for the unsubsidized LPG stove, but higher than for the subsidized one. Anggono et al. (2021) estimated that the energy cost for cooking in a household will increase by about 40%-50% when switching from 3 kg LPG to the induction stove at unsubsidized electricity tariff. On the other hand, when switching from unsubsidized LPG, the energy cost will decrease by about 20-25%. Meanwhile, for households with subsidized electricity tariff, switching from 3 kg LPG to the induction stove could reduce energy cost by 37% - 57%, although at the expense of increased subsidy budget from the government. Table 6 shows the energy cost in a household at different LPG prices and electricity tariff categories.

3 20% fuel stacking is defined as 20% LPG and 80% electricity use in households' cooking fuel.

Table 6. Comparison of the costs and benefits of the stove by customer categories. Source: Anggono et al., 2021

Parameter	LPG stove		Induction stove			
	3 kg	12 kg	450 VA	900 VA	900 VA/M	1,300 VA & higher
LPG consumption (kg/ month)	11.4	11.4	-	-	-	-
Electricity consumption (kWh/ month)	-	-	82	82	82	82
Energy cost for cooking (USD/ month)	5.6	10.4	2.4	3.5	7.8	8.3
Energy subsidy (USD/ month)	4.6	-	5.9	4.9	0.5	-

Based on BAR-HAP analysis, converting one million households from 3 kg LPG to induction stove at unsubsidized electricity tariff by 2025 would result in additional household energy spending of USD 16 million per year at 50% fuel stacking or USD 26 million per year at 20% fuel stacking. On the other hand, converting one million households from unsubsidized LPG to induction stove would result in USD 18 million per year less fuel cost for the households.

LPG subsidy reduction

Besides burdening the national trade balance, the increased national LPG consumption also burdens the state budget due to subsidy programmes. In 2018, the LPG subsidy programme used IDR 58.14 trillion (USD 4 million) from the state budget.

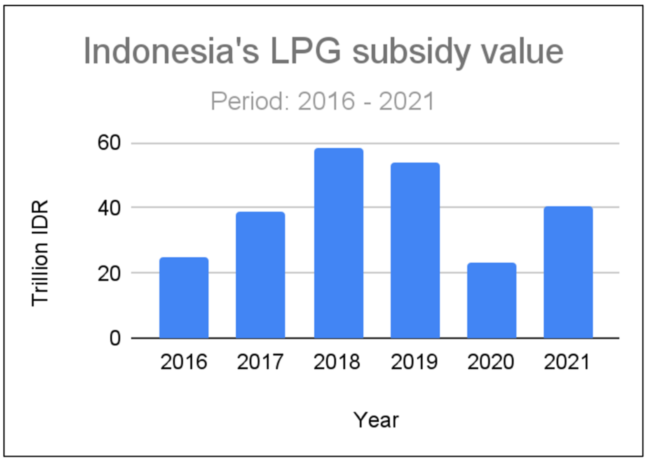


Figure 5. Indonesia's LPG subsidy value
Source: Transisi Energi, 2021

Anggono et al. (2021) estimated that shifting from LPG stove to induction stove could increase or decrease the energy subsidy, depending on the consumers' electricity tariff categories. Subsidy per customer could increase from USD 4.6/month to USD 4.9/month for the subsidized 900 VA customers to 5.9/month for the 450 VA customers. However, almost half of the subsidized LPG customers do not get electricity subsidy, thus reducing the overall subsidy amount. If a million of such households switch to induction stoves (at 20% fuel stacking), it is estimated that USD 48 million of subsidy could be avoided per year.

Greenhouse Gas Emission

The GHG emission of induction stoves depends on the electricity generation mix. Under the existing generation mix, shifting from LPG to the induction stove will result in even more GHG emissions. BAR-HAP analysis indicated that if one million households shift from LPG stoves to induction stoves, using the electricity from the grid, the GHG emission will increase by about 6.5 million tonnes CO2e (at 20% fuel stacking). Even increasing the renewables share in power generation to 60% (with the remaining 40% from coal) will still result in additional emissions of 2.5 million tonnes CO2e. To reach parity with LPG stove's GHG emissions, the electricity emission factor needs to decline from currently 892 gCO2e/kWh (2021) to about 250 gCO2e/kWh, or equal to about 78% of renewables. This negative impact to the climate could be mitigated if the induction stove users utilize cleaner electricity sources such as rooftop solar PV, although this would mean additional cost for the households.

Overall cost benefit analysis

Using the BAR-HAP tools, several induction stove transition scenarios were assessed. The simplified results are shown in table 7 (more detailed results are available in Appendix A). There are 6 scenarios simulated, covering various LPG to induction stove factors, including conversion rate, fuel stacking, LPG subsidy, and power generation mix. The cost-benefit calculation includes cost and benefit for the households transitioning and government. However, due to the nature of the model, the cost-benefit calculation does not include LPG subsidy savings. The LPG subsidy saving potential is presented as additional information.

Overall, the transition would result in a net benefit for the country. Benefits are gained mainly from health improvement while climate impact shows the biggest loss. At a higher share of renewables in the power generation, the cost to climate reduces, which improves the overall benefit. The fuel cost borne by households is higher after transition if the LPG replaced is subsidized, but lower if the LPG replaced is unsubsidized. However, when the reduction of LPG subsidy cost to the government is considered, the conversion to induction stove results in lower fuel cost. Figure 6 gives the illustration for two scenarios.

Table 7. Costs and benefits of transition to induction stove. Red indicates cost, green indicates benefit.

Scenario	1a	1b	1c	1d	1e	2
Conversion rate	1 million by 2025					10 million by 2030
Fuel stacking	50%	20%	20%	20%	20%	20%
LPG subsidy	Yes	Yes	Yes	Yes	No	Yes
Share of renewables in power generation	12%	12%	24%	60%	60%	60%
Net cost/benefit (NPV)	206,355,106	166,006,553	195,631,989	234,497,955	278,608,352	2,458,977,197
Stove purchase	-15,102,058	-15,102,058	-15,102,058	-15,102,058	-15,102,058	-42,608,171
Fuel cost (household)	-16,312,833	-26,100,532	-26,100,532	-26,100,532	18,009,865	-112,158,819
Administration cost	-9,182,888	-9,182,888	-9,182,888	-9,182,888	-9,182,888	-21,590,943
Health cost	315,907,727	326,719,779	326,719,779	326,719,779	326,719,779	2,815,345,274
GHG emissions	-68,954,842	-110,327,748	-80,702,312	-41,836,346	-41,836,346	-180,010,144
LPG Subsidy (undiscounted)	30,022,765	48,036,424	48,036,424	48,036,424	0	480,364,235

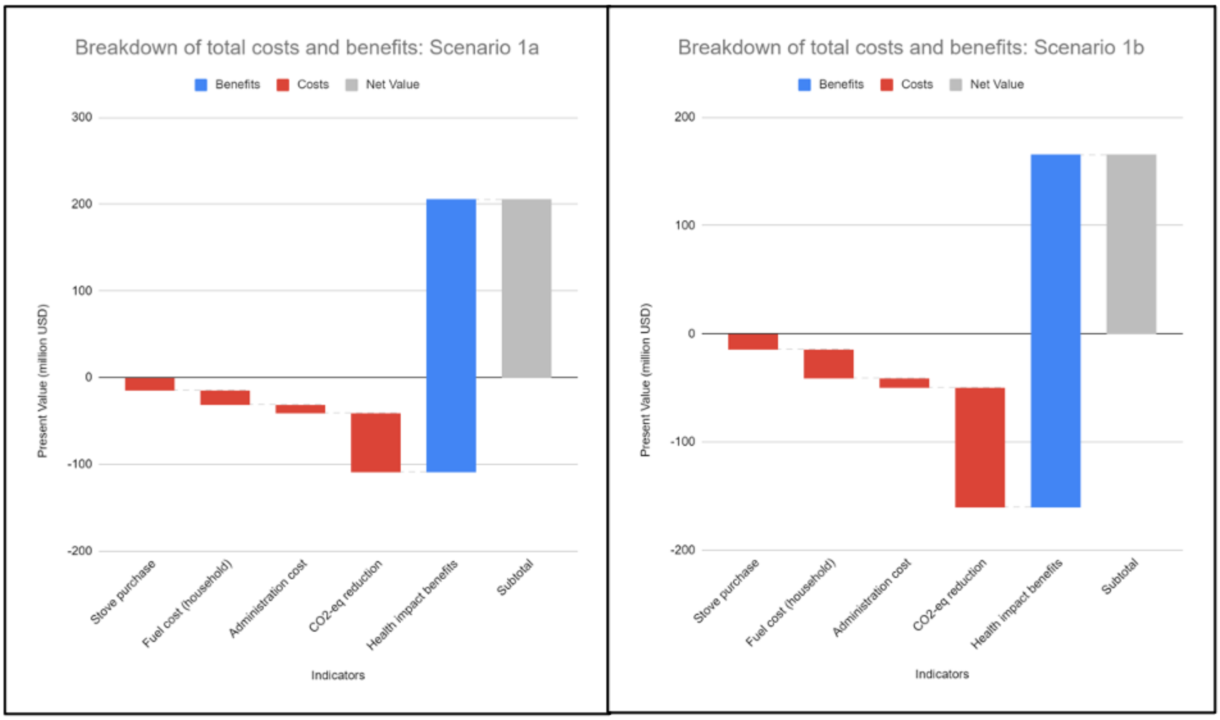


Figure 6.(a) Breakdown of total costs and benefits: Scenario 1a, (b) Breakdown of total costs and benefits: Scenario 1b. Scenarios are described in Table 7.

5. Enabling Environment

a. Policy on induction stove deployment

• Targets

The government's objective in induction stove deployment is mainly related to reducing LPG import and subsidy. The induction/electric stove is one of the alternatives to LPG that is planned by the government. Through the National Energy Grand Strategy (GSEN), the National Energy Council (DEN[4]) set up an LPG substitution programme by utilizing various alternative cooking energy sources, i.e. dimethyl ether (DME[5]), natural gas network, and electric stove, on top of increasing the LPG production capacity. As shown in Figure 7, the strategy is expected to eliminate LPG import by 2030 while electricity will later be the main cooking energy source. Under the strategy, electric stoves are expected to contribute to 11%, 22% and 35% of the cooking energy consumption in 2025, 2030, and 2040 respectively. This scenario is projected to save USD 3.3 billion annually in 2021 - 2040. However, by the end of 2021, the GSEN has not been officially legislated. There is no target of induction stove users available in the GSEN, but PLN estimated that 19 million users could be achieved by 2030.

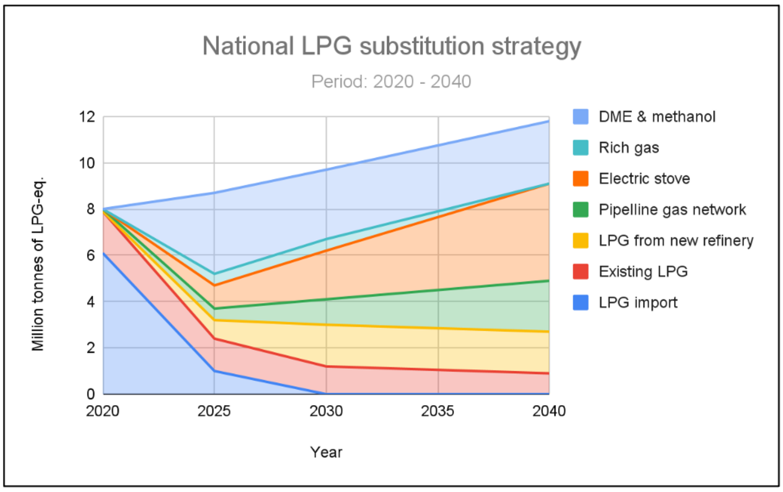


Figure 7. National LPG substitution strategy set by DEN
Source: DEN, 2021

• Standards

There is no SNI (Indonesian National Standards) for induction electric stoves yet because the market share for induction stoves is still small (it is still a new market). The government intends to stipulate SNI for induction electric stoves with the aim of providing quality and safety assurance, and giving Indonesian pride to this electric stove product. In addition, the Energy Conservation Directorate of MEMR is also planning to establish minimum energy performance standards (MEPS) for induction stoves, following other more widely used electronic devices such as air conditioners, fans, refrigerators, and rice stoves. However, there is no clear timeline yet for the establishment of both the SNI and MEPS for induction stove as it has not yet been used by many households.

[4] DEN is a government body responsible for designing national energy policy plans and monitoring its cross-sectoral implementation. Its membership consists of related ministers and selected stakeholders as representatives from academia, industry, consumers, technology, and environment.

[5] DME is a product of coal gasification that can be used as LPG replacement. Its energy content per mass basis is about 0.7 of the LPG's.

SNI is particularly important to ensure that the products available in the market are standardized and the product information is available to consumers, especially related to safety and performance. Otherwise, low quality stoves in the market could taint the reputation and limit the utilization of induction stoves. For example, an FGD participant decided to only use her induction stove for simple tasks since she felt that it cooked slower than LPG stoves.

• Existing programs, incentives, and policy supports

In October 2020, PLN launched a program to deploy 1 million induction stoves. As of December 2021, PLN claimed that 126 thousands consumers have converted to induction stoves (Sugiharto, 2021). To support the program, several incentives have been provided:

1. Providing discounts for connection upgrades (only IDR 150,000 / USD 10.5) through the Nyaman Kompor Induksi program). The default upgrade cost ranges from IDR 380,000/ USD 26 to millions, depending on the capacity addition.
2. Providing free connection upgrades for new residentials equipped with induction stove, which are built by the developers partnering with PLN (through the Ekstra Daya program)
3. Distributing free induction stoves to several urban neighborhoods and villages, within and outside Java island, under the Kampung Listrik program. It is most likely to be funded by corporate CSR funds.
4. PLN distributes one million free induction stoves to new residentials.
5. Partnering with BTN bank to install induction stoves in houses under a subsidized housing credit (KPR) program.

To support the 1 million induction stove program, PLN and DEN proposed to allocate IDR 1 trillion (USD 70 million) in the 2022 state budget to distribute 1 million induction stoves for free.

By the end of 2021, there was no incentive or policy support directly provided by the government for induction stove deployment. Only in February 2022, the government mentioned a plan to allocate IDR 1 million (USD 70) per household to purchase an induction stove and the suitable utensils. The government will also increase the subsidized 450 VA and 900 VA households to upgrade to 2,200 VA while keeping their subsidy tariff (Fajrian, 2022).

b. Key actors creating the enabling environment in which eCooking can scale

There are three main actors identified in the electric induction stove implementation.

1. PLN currently acts as the main actor driving the implementation of stove conversion. It is the main electricity provider in Indonesia. It provides incentives for users switching to induction stoves.

2. Ministry of Energy and Mineral Resources. Its interest is to reduce the rising LPG imports and subsidy. There are three directorate generals (DG) related with the induction stove conversion program: DG Electricity, DG New and Renewable Energy and Energy Conservation, and DG Oil and Gas.
3. Ministry of Public Works and Housing, which creates a large market for induction stoves through incorporation of induction stoves in its public housing program.

Other than that, there are other government agencies involved to a lesser extent such as the Ministry of Industry for developing the supply chain, the Ministry of Finance for state budget allocation, and the Ministry of State-owned Enterprises for coordinating a joint programme between the state-owned enterprises. However, from the interviews with these stakeholders, it is unclear who is responsible for coordinating and leading the implementation of the stove conversion program.

c. Key barriers and drivers

The drivers for induction stove implementation:

1. Reducing LPG import is the main objective for the government to implement the LPG to induction stove conversion program. Induction stove deployment is adopted in the GSEN as one of the alternatives to LPG.
2. Additional benefits expected by the stakeholders from the conversion include reduced GHG emissions, increased electricity consumption, fuel cost saving, and improved performance for the users. However, in the existing generation mix, the GHG emissions of the induction stove is actually higher than that of the LPG stove. Also, the increase of electricity consumption from induction stove usage will be insignificant to the total power demand. On the other hand, the importance of health impact benefits have been overlooked by the stakeholders.

The barriers of induction stove implementation, include:

1. LPG 3kg becomes the main constraint for transition since it is cheaper than the unsubsidized electricity tariff. Currently, this subsidized LPG is sold openly, meaning that everyone could purchase. This is different from the subsidy given for electricity, which can only be accessed by certain households that fit the criteria.
2. The current electricity subsidy scheme based on connection capacity will prevent the poor households from using induction stoves. Under the existing scheme, subsidy is only received by households with 450 VA and 900 VA connections. If they decide to upgrade the connection to be able to use an induction stove, they will automatically lose the subsidy allocation. Thus it is unlikely that these households will use an induction stove.

3. Transition programmes from the government to implement induction stoves are not attractive for households that have already installed LPG stoves in their kitchen. The cost incurred in converting from LPG to induction stove is substantial (to purchase the stove and cooking tools) but there are currently no incentives to reduce this cost, except the sparse distribution of free stoves by PLN.
4. The 1 million stove programme will be feasible if the household voltage limit is also increased since the current induction stove needs high voltage capacity (> 1000 VA for single burner).
5. There is no clear leadership between the government agencies. It is unclear who is currently leading/coordinating the implementation of the program. The intricacy occurs as the main objective of the program is to reduce LPG import, which benefits the directorate general of oil and gas in MEMR and ministry of trade. On the other hand, the departments tasked with the program implementation are from different agencies, i.e. directorate general of electricity, directorate of energy conservation, ministry of public works and housing, and ministry of industry.

6. Consumer Demand

The purpose of this paragraph is to map the community's perspective on induction stoves. Primary data was collected from the community directly by conducting focus group discussions (FGD). In addition, interviews with culinary experts were conducted to dig deeper into the suitability of the induction stove for the Indonesian cooking culture.

Types of typical menu

Based on an interview with the culinary expert, the various ethnic backgrounds and the assimilation of family marriages make Indonesian home cooking diverse and difficult to generalize. The most basic thing that Indonesians have in common in food is rice as their carbohydrate intake. Almost all Indonesian people cook rice every day at home. In addition, they add various side dishes to their dishes (breakfast, lunch and dinner). Their side dishes adjust to the menu they set for the day. The set menu per day in question is rice uduk, kecombrang rice, mixed rice with Javanese menu, gudeg rice, rice with Padang menu, rice with Chinese dishes, pecel rice, and others. The choice of the set menu per day will determine the dishes to be cooked that day. Typical Indonesian set menus can be seen in Figure 8.

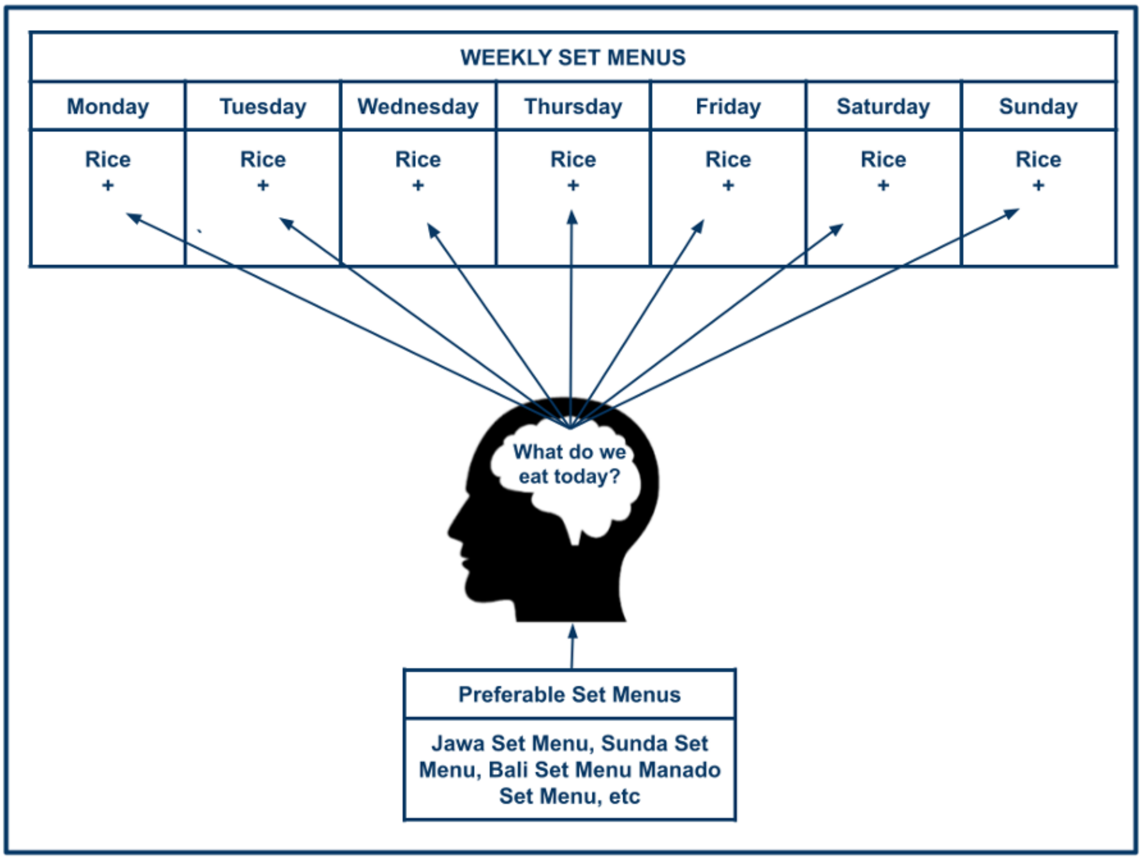


Figure 8. Typical Indonesian weekly set menus

For example, the set menu that was chosen that day was rice with Javanese menu. The menu that will be cooked that day is rice, balado eggs, tempeh and tofu with bacem seasoning, stir-fried vegetables (kangkung, beans, cabbage, etc.), chicken with coconut milk, beef skin with coconut milk, and others. If the set menu option chosen on that day is Sundanese menu, then the cooked menu is rice, fried meat (chicken/duck/catfish), fried tofu or tempeh, sambal ulek, lodeh soup, and others. Likewise, there were differences in menu in the choice of set menus that were cooked on that day.

The types of Indonesian food are very diverse and develop along with cultural assimilation, both at home and abroad. In general, Indonesian people cook with LPG stoves at this time. Almost all Indonesian dishes can be cooked using an LPG stove with suitable cooking utensils. The transition from LPG stoves to electric stoves can actually be done when viewed from the Indonesian cooking method. However, there are obstacles to human behavior factors such as cooking some Indonesian dishes using current cooking utensils (LPG stoves and aluminum cooking utensils). The suitability of the induction stove for the types of Indonesian menus in detail can be seen in the points below:

a. Indonesian Carbohydrate Menus

The main type of carbohydrate intake that is most often consumed by Indonesian people is rice. The second most frequently consumed carbohydrate intake is noodles. In addition, some Indonesians sometimes replace their carbohydrate intake with potatoes and bread. There is something unique in eastern Indonesia because not everyone eats rice as their main carbohydrate source, but some people eat *papeda* and tubers as their main carbohydrate source, especially those who live outside the big cities in Papua.

Figure 9. Indonesian carbohydrate menus

Kitchen utensils that are commonly used to cook carbohydrates are rice stoves and LPG stoves. Rice is cooked using a rice cooker, while other types of carbohydrates use an LPG stove. Noodles and papeda are cooked using a stove with a boiling technique. Potatoes are cooked by frying technique on medium heat. Meanwhile, sweet potatoes are cooked by steaming technique. This cooking technique can be done on an induction stove. Therefore, the conversion of LPG stoves into induction stoves for carbohydrate foods can be done.

b. Indonesian Slow Cook Menus

Some Indonesian dishes have a long cooking duration, there are even dishes that require a cooking duration of up to 2 days. One of the famous Indonesian foods is rendang. Rendang takes about two days to get the meat perfectly seasoned. In addition, gudeg requires a cooking duration of up to one night to dry the water content in it. Ayam betutu also takes about 3 hours to burn. *Ketupat*, a type of carbohydrate that is only available in the month of Ramadan, also requires a long steaming process.

Figure 10. Indonesian slow cook menus

The disadvantages of cooking food that requires a long time can be answered by using induction stoves. The efficiency offered by the induction compound can answer the wasted energy due to the length of the cooking process. Cooking processes that require baking, such as chicken betutu, can be replaced using an electric oven. Moreover, the presto technique can be used in slow cooked foods to reduce the duration of time to only minutes or hours. Therefore, switching to electronic cookware, such as induction stoves and ovens, is not a problem for this type of food.

c. Indonesian Fried Menus

Another common type of menu cooked by Indonesians is fried food. Fried dishes are divided into five frying techniques, namely shallow frying, deep frying, pan frying, sautéing, and stir-frying. An example of shallow frying is fish fry. An example of deep frying is french fries. An example of pan frying is fried bacon. An example of a sautéing dish is stir-fried kale. An example of stir-frying is *capcay*.

The five types of frying techniques are based on differences in oil and use of fire. Broadly speaking, frying techniques can be done with an induction stove. The difference in the use of the type of fire on the LPG stove can be accommodated by the choice of the degree of heat on the induction stove. However, one of the barriers to adoption is the habit of using round wok to cook some dishes, such as capcay. Although there are flat woks that can be applied to induction stoves, people prefer round woks because their cooking habits discourage them from adopting induction stoves.

Figure 12. Indonesian fried menus

The wok ring technology can be used to transfer heat from the induction process to the wok through the wok ring. However, the use of fire when cooking becomes a cooking experience that is rather difficult to replace also by cooking with the induction process. This is because some dishes require burning with the flambe technique to create a distinctive taste. However, the flambe technique can be done on an induction stove, it just requires a spark from the lighter.

d. Indonesian grilled menu

Figure 11. Indonesian grilled menus

Indonesian grilled dishes are not an everyday menu item in the household. There are several Indonesian households that sometimes make grilled dishes in their homes. However, most households buy baked goods as a side dish. Some typical Indonesian grilled dishes, namely satay with various spices, roasted chicken with *taliwang* seasoning, grilled fish with dabu-dabu seasoning, grilled pork with karo seasoning, and others.

Usually typical Indonesian grilled dishes are cooked using charcoal or coconut fiber. Currently, electric ovens are widely used to cook grilled menus. The use of a grill pan can be done on an induction stove. However, roasting using electric ovens and induction stoves does not have a carbon taste to food. The preference for carbon aromas in cooking for some people makes some people stick to traditional combustion (charcoal or coconut husk). Actually, there is liquid carbon that can be used in the cooking process to add a safe carbon aroma from carcinogenic substances. As for some barbeque spices, it has been equipped with liquid carbon content. Therefore, this type of menu can be cooked using an electric oven or induction stove. The obstacle is the limited information for the public to use ingredients such as liquid carbon to add a distinctive aroma to dishes.

e. Indonesian Boiled Menus

Boiled menu (soup) is one of the common dishes cooked by Indonesian people. Examples of this type of menu are yellow soup, meatball noodles, goat curry, and others. The process of cooking gravy uses the boiling technique (using high heat (boiling point) constantly). As for some soup dishes using low or medium heat after the water boils at the beginning of cooking. Different uses of fire are intended to soften different foodstuffs (meat and vegetables).

Figure 13. Indonesian boiled menus

Cooking boiled menus with an induction stove has a better efficiency of cooking water compared to an LPG stove. There is no difference between cookware and induction hobs in this dish, except for the need to use ingredients that can be used in induction compote. Therefore, cooking gravy can be done using an induction electric stove.

f. Indonesian Steam Menus

Steamed food is one of the foods that are often cooked by Indonesians. Usually Indonesian steamed dishes use banana leaves as food packaging. Examples of Indonesian steamed dishes are Pepes, Garang Asem, and steamed milkfish with basil. There are steamed foods that are cooked using only a stainless steel bowl, such as steamed chicken rice.

Figure 14. Indonesian steam menus

The technique of steaming Indonesian dishes is not much different from each other. This type of cooking requires high heat to boil the water until the evaporation process occurs. Then, the food is cooked using steam from a relatively medium fire when steaming. Cooking utensils for this type of menu can also be applied to induction stoves, especially induction materials. Therefore, this type of food can be cooked using an induction stove.

g. Indonesian Salad Menus

Figure 15. Indonesian salad menus

Indonesian salad dishes include food cooked with simple techniques. This type of food only needs to be cooked by boiling and steaming techniques. Vegetables in some Indonesian salad menus are still raw, such as karedok and raw vegetables. Some rujak are boiled first, such as fresh vegetables, lotek, pecel vegetables, and ketoprak. Lontong and eggs as a complement are usually cooked by steaming technique. The spices used in Indonesian salads are usually made using a traditional blender or grinder.

Induction stoves are not a problem for this type of food because the cooking process on the LPG stove can be replaced by the cooking process on an electric stove.

h. Indonesian Dessert Menus

Figure 16. Indonesian dessert menus

Broadly speaking, typical Indonesian desserts are divided into two, namely salty dessert and sweet dessert. Salty desserts are usually cooked using a frying technique, such as fried foods, pastels, risoles, and others. The sweet dessert is cooked using several techniques. First, a sweet dessert cooked by steaming technique, such as steamed sponge cake. Second, sweet desserts cooked with boiling techniques, such as Ramadhan compote. As for sweet desserts that do not require a cooking process, they only need to be mixed, such as fruit soup. Desserts with several cooking techniques can still be made even if the LPG stove is converted into an induction stove because all the cooking techniques used can be done on an induction stove.

Consumers insights from key market segments

Data on consumer insights on electric stoves were obtained by holding several FGD sessions. 16 participants joined in the FGD sessions that were conducted. The demographics of FGD participants can be seen in Figure 17. The insights of potential target consumers for stoves are analyzed more deeply into three points, namely benefits, financial considerations for transitioning, and compatibility with cooking behavior.

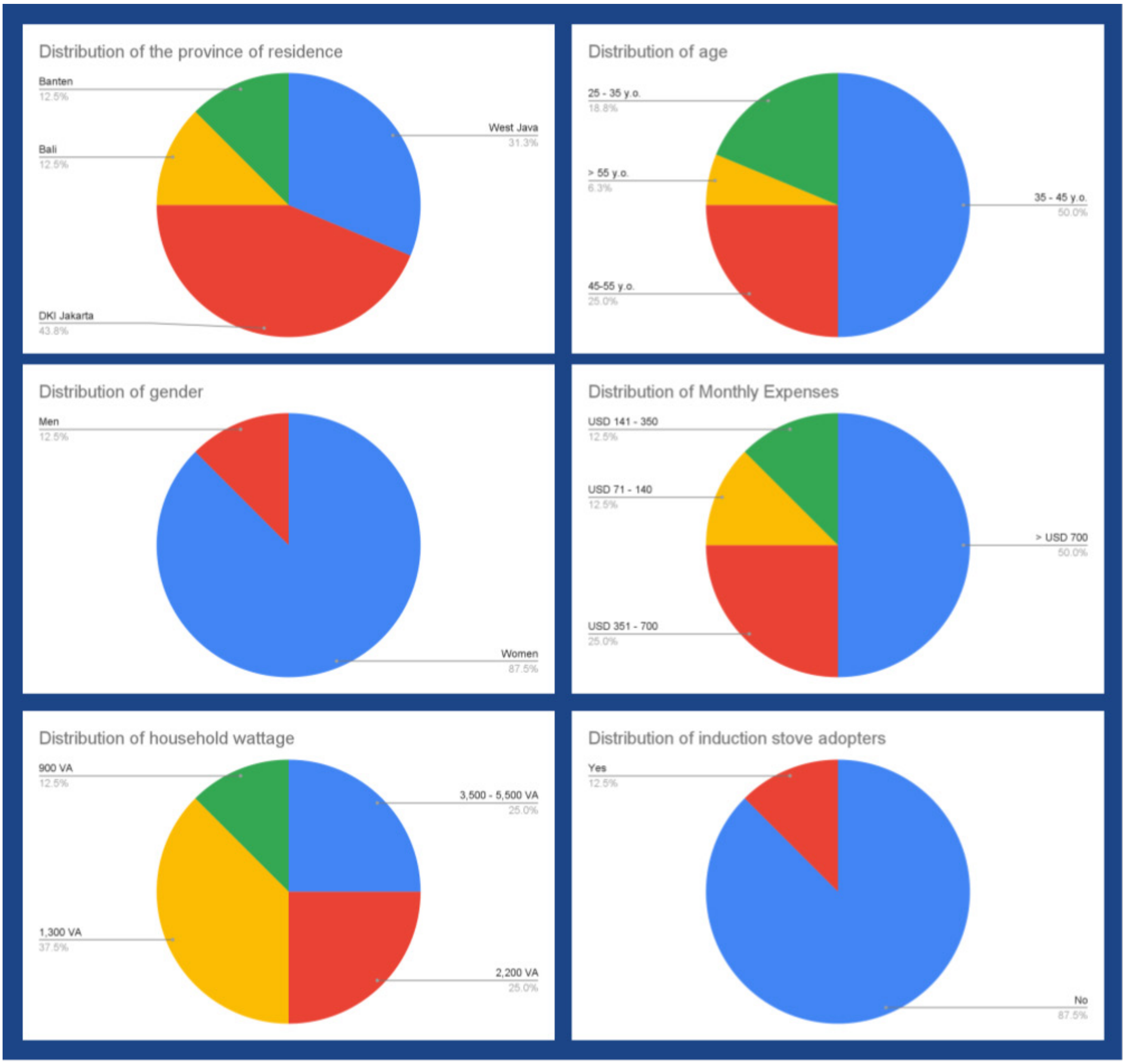


Figure 17. Demography of FGD's participants

Furthermore, the user's journey of converting LPG stoves to induction stoves are mapped using a user journey map. User journey map is a map that can be used to map user interactions/ behaviors towards an activity. User journey map is used in this study to map user behavior in cooking and user behavior in buying cooking utensils.

a. Benefits

Historically, the transition from wood to induction stove gives many benefits for the people. Firstly, people cook using a wood stove. This kind of cooking affects human health since it emits burning smoke which is full of dangerous pollutants. Second, people cook using a kerosene stove. The pollution of the kerosene stove is less than the wood stove, however, it gives a kerosene aroma after taste.

Third, people cook using LPG stoves. This kind of cooking is not safe at all since it is risky to burn. Finally, people cook using an electric or induction stove. This kind of cooking gives a safe and clean cooking experience. Also, cooking using an induction stove is better for cooking appliances since the fire combustion gives black stain, which is not found using the induction stove. The cooking process on the induction stove also produces lower indoor emissions compared to other cooking processes.

b. Compatibility with cooking behavior

Based on the results of the FGDs conducted, Indonesian cooking behavior is influenced by background, daily behavior, and interest in cooking. The type of food they cook is also influenced by their cooking behavior. Therefore, the FGD conducted in this study identified four types of personas based on their cooking behavior, see Figure 18. The ones who are in charge of cooking within the Indonesian family are commonly the women. Some men are in charge of work basically, and the rest are also involved in the cooking process.

Below are the results of the cooking journey of Indonesian people based on 4 types of persona:

1. Full-time worker

   This type of persona usually works full time on weekdays. This type also has limited time to cook, even though they have an interest in cooking. Usually, they cook simple food for breakfast, such as pasta (spaghetti), potatoes and sausages, etc. During the day, they order food from caterers, canteens, or online delivery. At night, they cook with the help of their families. On weekends, they have a habit of baking bread and cakes.

   This type of persona has a high enough interest in switching to electric stoves. In addition to their high economic capacity, they want to switch from LPG stoves to induction stoves because there are sophisticated features offered by electric stoves. The time efficiency offered by electric stoves can also be an answer to their limited time available for cooking.

2. Those who live in boarding houses

   This type of persona usually lives in a boarding house due to job demanding for migrating to a city. Those who like to cook can cook in the soup kitchen or their room. In the morning, they prepare simple food for breakfast, such as instant noodles or several types of simple dishes. If there is an excess of food when they cook in the morning, they bring the leftover food to eat during the day at their workplace. There are also those who cook simple meals for lunch, if they work from home (WFH). At night, they cook simple meals or eat more. On weekends, they usually eat out, ranging from street food to restaurants.

This type of persona has a neutral affinity for induction cooktops. They love the features that induction stoves offer. Although the size of the induction stove is suitable for the limited space they have, the availability of an LPG stove in the shared kitchen makes them discouraged from having an induction stove in their room. Interest in cooking is the main driver to adopt the induction stove in this type of persona.

3. Housewife type 1

   This type of housewife has a job in addition to doing household chores. Usually, this type of persona prefers to cook in large quantities in the morning before doing other work. During the day and night, this type of persona warms up leftovers to serve again. They also fry gorengan as a complementary food during the day and night. Their interest in induction stoves is quite high. The things that make them interested are the appearance of the electric stove which is more elegant than the LPG stove. However, there is one obstacle to conversion, namely that they are used to cooking using a convex pan (wok), especially for stir-fried dishes. If they buy an induction stove for cooking, they still use an LPG stove to cook certain foods. The availability of a convex pan substitute can indeed be replaced with a flat pan. However, users say that they prefer to have two types of stoves. This is because they anticipate power outages that sometimes occur.

4. Housewife type 2

   This type of persona is usually a full-time housewife. This type of persona has a lot of time to cook. They cook different meals for morning, noon, and night. As for heating leftover food for the next meal, it is also common for this type of persona to do this. As a dessert, they usually prefer to snack on sweet desserts or instant snacks. The persona interest of this type of electric stove is neutral. They like the elegant impression found in electric stoves. The obstacle that occurs is the same as the type of persona 3, namely their habit of cooking using a convex stove is difficult to replace. This type of persona has the desire to convert from an LPG stove to an induction stove, but they have had enough with the current state of the induction stove.

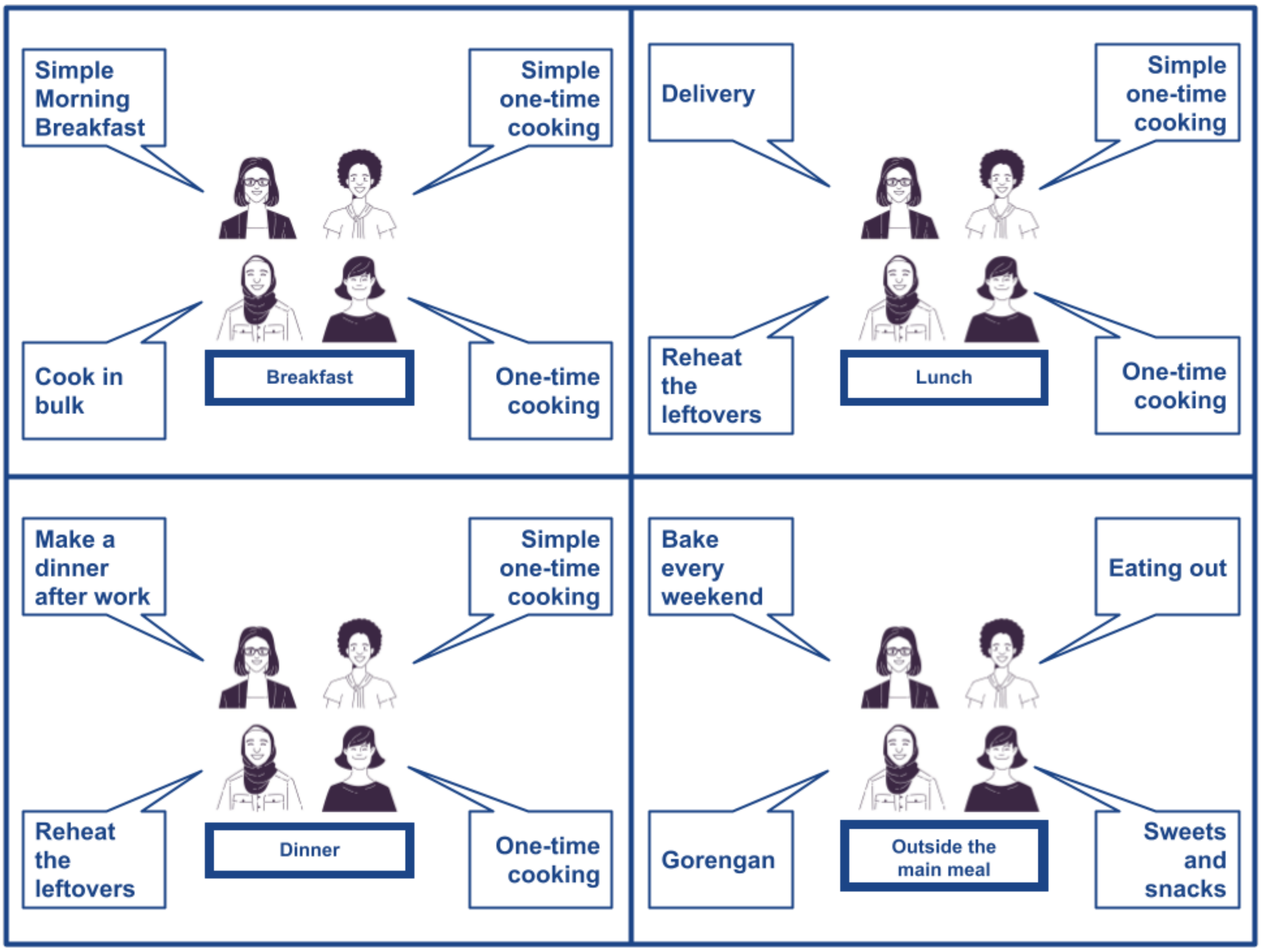


Figure 18. Common Indonesian Cooking Behavior

These four personas have similarities and differences. The common cooking behavior that almost all personas have in common is that they cook rice (as a carbohydrate food) in large quantities in the morning. They cook rice with a measure for one day using a rice cooker. During the day and at night, they warm the rice using a steamer on an LPG stove. These four personas also think they are willing to move to electric stoves. However, they still haven't moved from LPG stoves to induction stoves because they feel it's not the time to switch. They are also worried about the conversion of stoves causing their old cooking utensils to not be reused. This concern was shared by the majority of FGD participants because they had invested quite a lot in cooking utensils that can only be used on LPG stoves.

Meanwhile, the factor that makes a difference in cooking behavior is the user's background. Background, especially work background, affects the user's cooking schedule and type of cooking. Those who work have less time to cook and vice versa. The type of food is also getting simpler if they have a more complicated job. Likewise in the case of conversion of LPG stoves to electric stoves. If they have little time to cook, they have an affinity for conversion due to the efficiency of induction stoves in time. If they have enough or too much time, they have an interest in conversion because of the value proposition offered, such as an elegant appearance, safer, smaller, and others.

c. Financial considerations for transitioning

Indonesians have the behavior of asking for their family's opinion when buying an item, especially for people who live in the same house as their family. In cooking utensils, women usually have greater purchasing power. This is because Indonesian women are the main actors in the kitchen. Meanwhile, men have greater budget-determination power than women. The process of purchasing kitchen items can be seen in Figure 19.

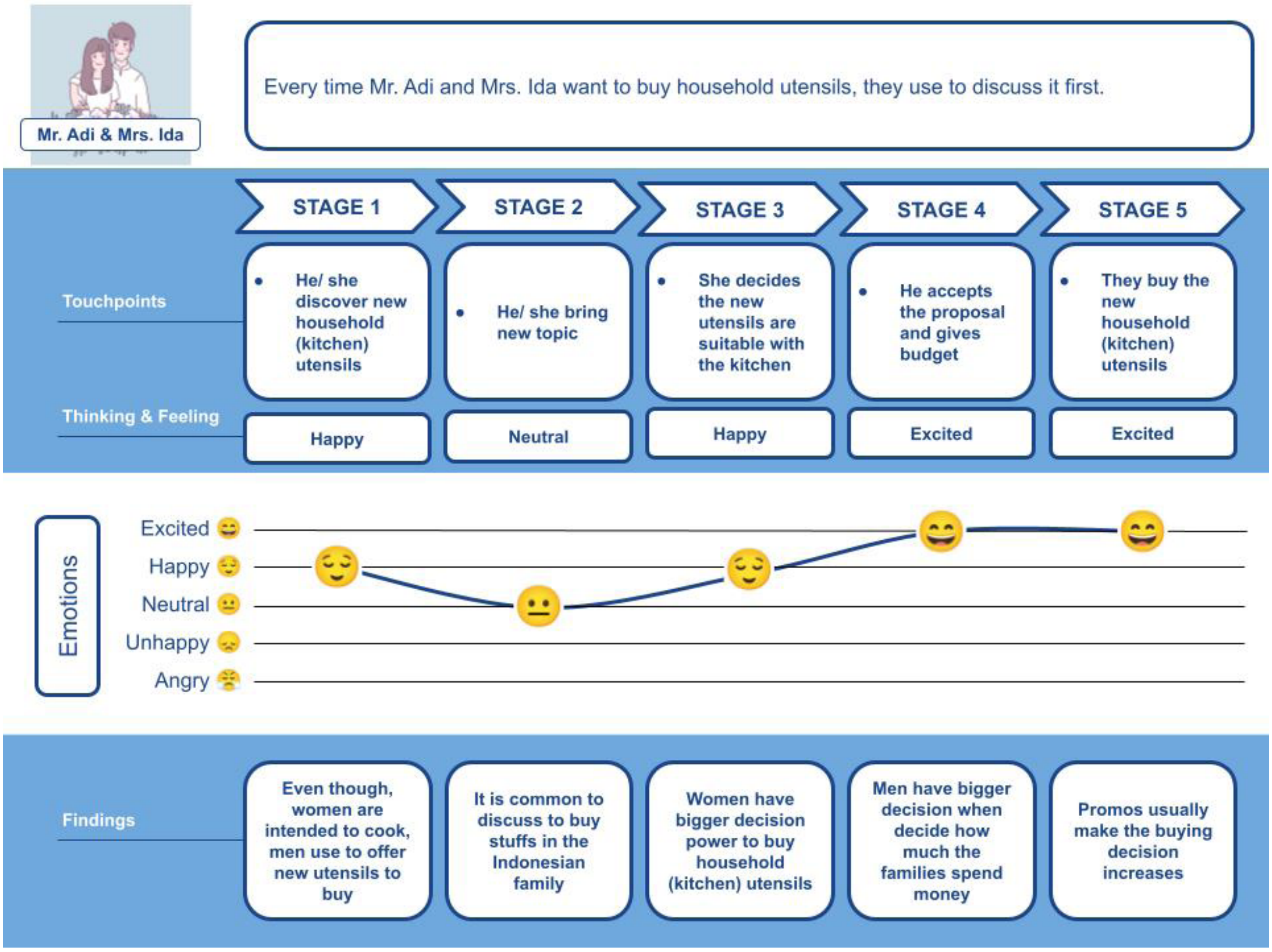


Figure 19. Indonesian cooking journey map

The main issue of the transition to induction stove is the conversion cost. The conversion cost is relatively not affordable for some classes. The initial cost of an induction stove is much more expensive than an LPG stove. However, the variable cost of the combustion process is also not affordable since it uses large amounts of electricity. An induction stove is not as affordable as an LPG stove. In the market, a single burner induction stove (min: USD 50.49; max: USD 335.04) is almost two times more expensive than a single burner LPG stove (min: USD 31.85; max: USD 171.76). Secondly, an induction stove needs specific cooking appliances. Generally, Indonesians tend to use aluminum-based appliances due to affordability. Unfortunately, aluminum-based appliances cannot be used in the induction stove since the induction does not work. Besides, the variable cost for the cooking process for Indonesian menus takes more money since it needs a longer time than any other menus. This becomes an issue when the electricity cost is more expensive than the LPG cost.

Key adoptions

Based on the FGDs and interviews conducted, this research found barriers or drivers from the consumer demand side. This stage maps the adoption factors in terms of consumer demand using context mapping. Supporting or inhibiting factors are used as a reference for recommendations in this research. Based on FGDs and interviews, the adoption of induction stoves has influenced factors from various contexts, see Figure 20.

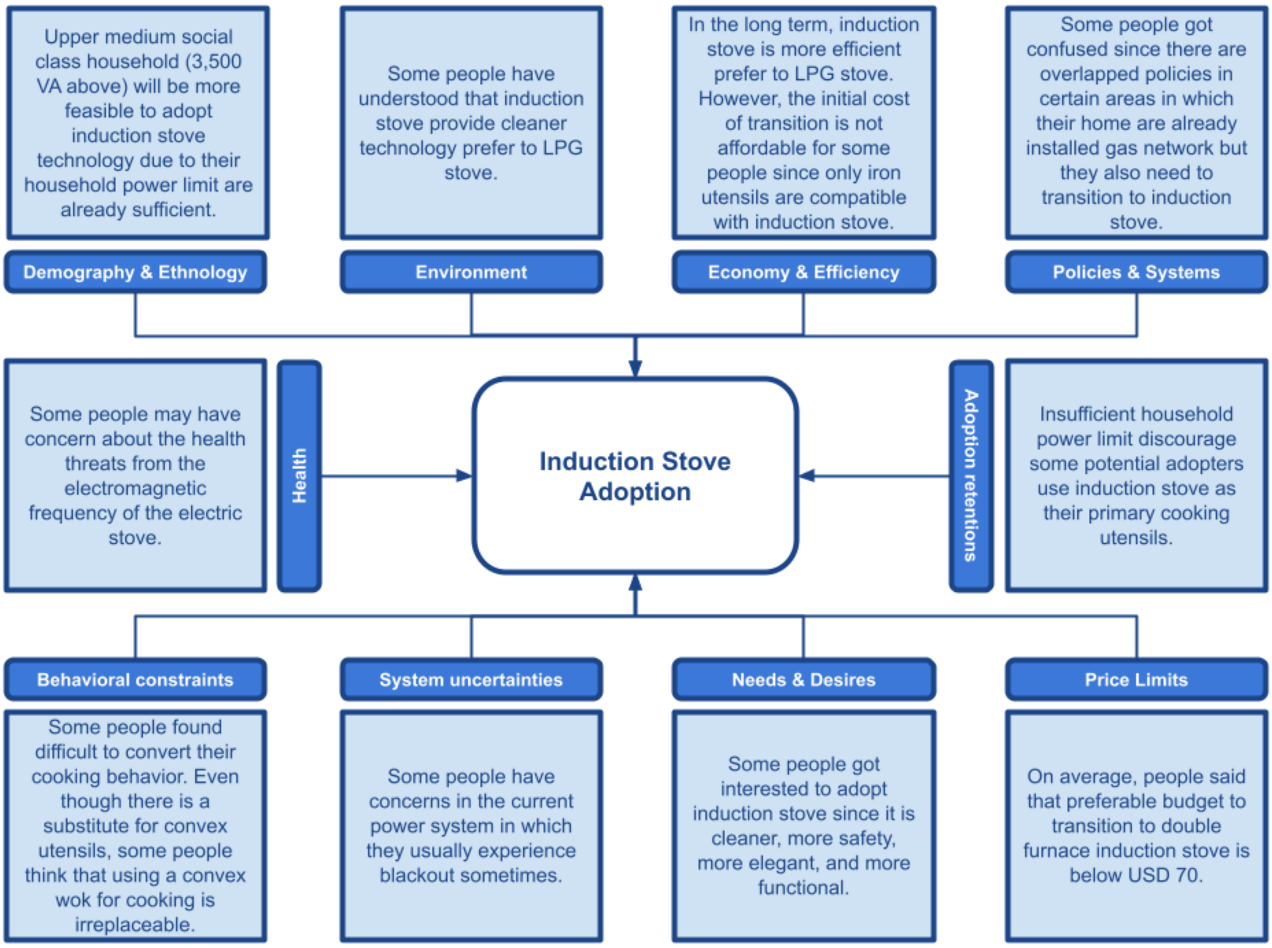


Figure 20. Context map of Indonesian adoption factors of induction stove

The context map also serves to synthesize the findings obtained in FGDs and interviews. The factor that is quite influential in increasing the adoption of induction stoves is that induction stoves can answer the shortcomings that are not found in LPG stoves. The health factor is a side driver for the adoption of electric stoves because not everyone understands that induction stoves produce less indoor pollution than LPG stoves. However, some people have the perception that the induction stove has the risk of electromagnetic hazards. People are also willing to shell out USD 70 and under for a conversion from an LPG stove to a two-burner induction stove. In addition, almost all Indonesian dishes cooked using an LPG stove can be cooked using an induction stove. The people's habit of using a convex skillet is an insignificant inhibiting factor because the dish can still be cooked using a flat pan.

However, the positive intentions of the community to adopt the induction stove are limited by significant inhibiting factors. The main factor that becomes a problem is the insufficient household power limit. Most people who are economically sufficient to buy an induction stove still use the household power limit of 1,300 VA. This resulted in people being discouraged from adopting the induction stove. In addition, their home's electricity transmission is sometimes affected by blackouts. The uncertainty of this energy source also makes it possible for them to still use LPG stoves as their backup stoves as an anticipatory measure. Some people were also discouraged from adopting an induction stove because their house had just been equippeded with natural gas lines. The public's understanding of the rising monthly electricity costs will discourage them, even though they can save money when using induction stoves over time.

Based on the FGDs conducted, this research found the pains and gains felt by the FGD participants, see Figure 21. Pains are feelings of loss experienced by the FGD participants. Gains are the feeling of benefit experienced by the FGD participants.

The FGD participants stated that they felt that the conversion of LPG stoves to induction stoves provided many benefits for them. They feel that induction stoves are safer than LPG stoves because the combustion process is replaced by an induction process to produce heat. They also feel that the induction stove gives an elegant impression to their kitchen. For those who have small children, the users feel that the induction stove provides a sense of security when operating it because some electric stoves have a children's lock feature. They are also facilitated with additional features, such as timers, automatic heat settings, etc.

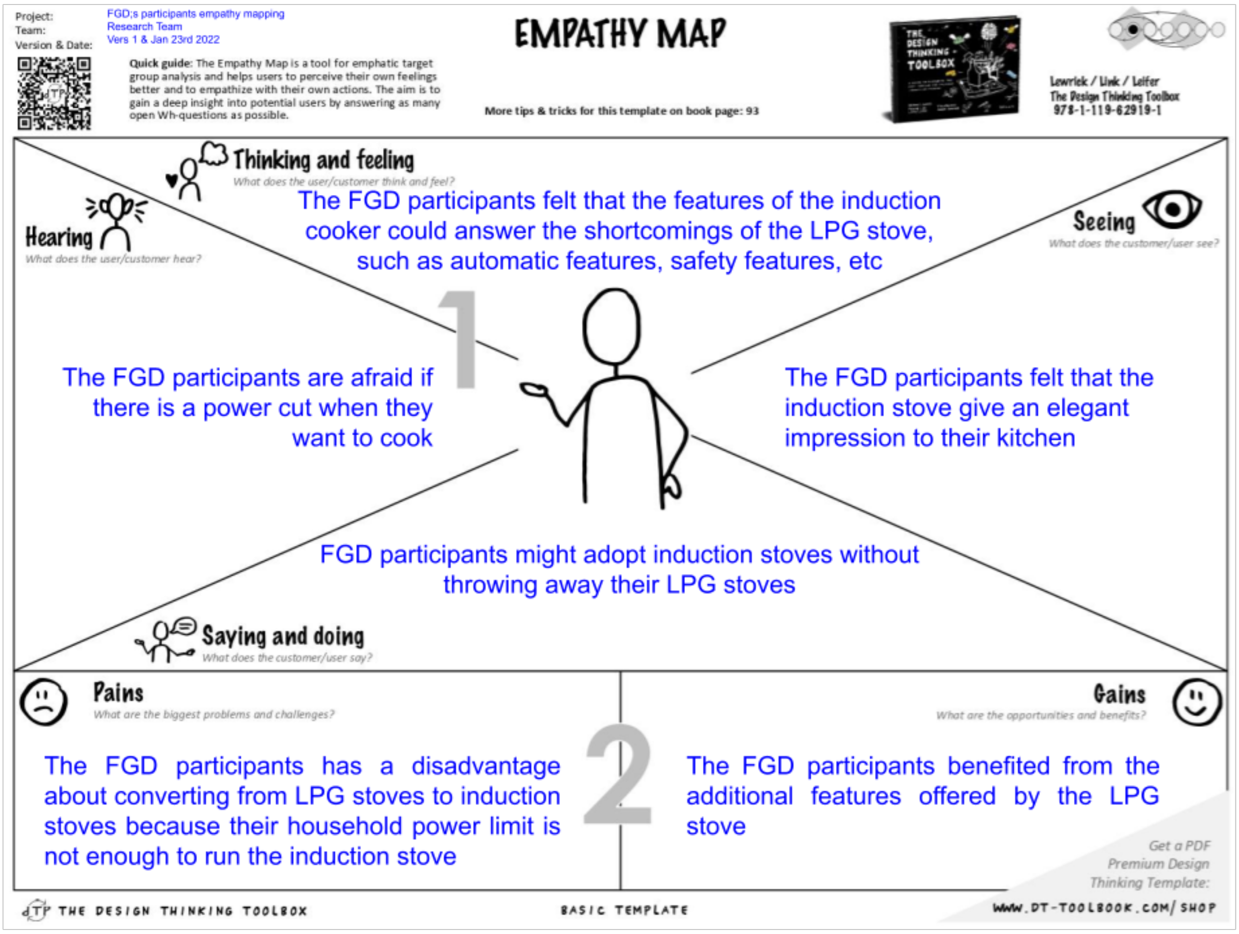


Figure 21. Empathy map of FGD's participants

In addition, they also feel a loss if they convert from an LPG stove to an induction stove. The most obvious thing is that those who use the 1,300 VA power limit feel that induction stoves cannot be applied to their homes. As for the users of the 2,200 VA power limit, they do not necessarily want to switch from an LPG stove to a stove because they need to turn off some of their household electronic equipment. This is because they are used to using two stoves and this causes the power used to exceed the power limit of their household. For example, one burner needs 1,000 - 1,500 VA to start. Anggono et al. (2021) and even found that only stoves with 2,000 VA power perform as well as LPG stoves. Households with 1,300-2,200 VA connections will find difficulty using induction stoves as their connection capacity is insufficient to power the induction stoves and their other household appliances. Likewise, they feel at a loss. They need to throw away their old cooking utensils because some cannot be used on induction stoves.

They think they would like to switch to an induction stove but it comes with a few caveats. Firstly, they need household power limits to be raised at a low cost. Secondly, they need an exchange program for their old cookware with equipment that is compatible with induction stoves. If there is a trade-in program, they think that the conversion intensity from LPG stoves to induction stoves will increase since they would get an incentive to reduce their initial outlay to replace all of their old cookware.

Based on an interview with a culinary expert, the behavior of cooking is the main barrier for people to convert their LPG stove into an induction stove. Basically, the way of family cooking is inherited from old generations to the next generation. Furthermore, not only did they inherit the recipes, but they also inherited the cooking appliances for the next generation. Thus, the experience of buying new cooking appliances rarely happens for some families in Indonesia. On the other hand, Indonesians rarely use induction stove-compatible appliances such as flat pans. Indonesians tend to use a convex frying pan since the cooking process is easier to use for deep fry and stir fry. Furthermore, the taste is not the barrier to the transition since the taste will be the same either using an induction stove or an LPG stove. The eating experience using different stoves tends to give anomaly suggestions in which taste, texture, and aroma of the dishes are the same.

Key barrier

Based on the consumers' point of view, the main barrier they have for conversion from LPG stoves to induction stoves is the problem of readiness of electric stove infrastructure in their households. First, their household power limit is not ideally sufficient to power an induction stove. Second, frequent power outages give users a high sense of worry to adopt electric stoves. Both of these matters discourage users to adopt induction stoves. Ease of access to additional household power and certainty of household electricity supply need to be upgraded to increase their adoption rate.

In addition, there is a unique belief system adopted in the habit of equipping kitchen utensils in Indonesian households. Some of their cooking utensils are usually inherited from their parents. Even if they don't get the inheritance of cooking utensils, they duplicate their parents' kitchen utensils. The phenomenon of duplication of kitchens occurs because they adjust the needs of cooking utensils similar to those of their parents. Purchasing kitchen utensils is also a long-term investment for some people. Converting LPG stoves to induction stoves is a constraint for some people because they think their cooking equipment is still suitable for use. Some people feel disadvantaged if they have to replace their cooking utensils at this time.

Key driver

Based on the consumers' point of view, the main driver for their conversion from LPG stoves to induction stoves is the value proposition offered by induction stoves. The community already has a sufficient understanding of the advantages of the induction stoves over LPG stoves. However, this community's sufficient understanding has not been able to increase theintention of purchasing induction stoves. Market creation strategies or programs to distribute induction cooktops for free can be considered to increase the level of adoption of the use of induction stoves among the community.

7. Supply Chain

a. Key domestic eCooking appliance manufacturers

The supply chain for induction stoves in Indonesia is currently lacking. The majority of induction stoves in the market are imported products. According to the Ministry of Industry, there are only two domestic induction stove manufacturers with manufacturing capacity of 300,000 units and 17,000 units per year. Moreover, many electrical components used in the induction stoves are imported as there is no domestic production. There is no data available on the local content of these domestically produced induction stoves.

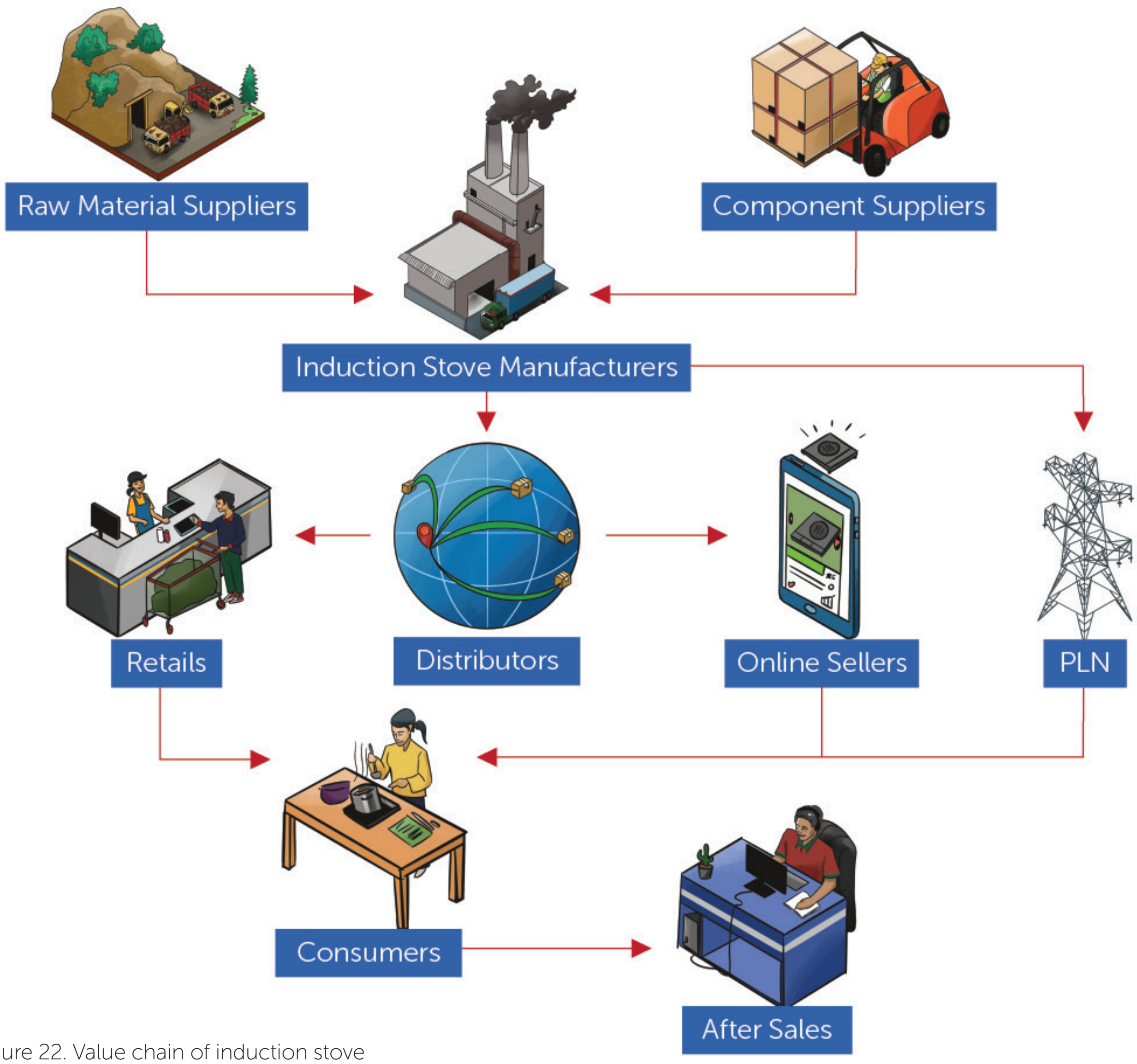


Figure 22. Value chain of induction stove

Currently, PLN also plays an important role in the induction stove distribution with its one million induction stoves program. Under the program, PLN arranges free stove distribution to households and installation by property developers.

b. Price of induction stoves vs LPG stoves in various market segments

LPG stove prices do not vary as much as those of induction stoves. The majority of differences in LPG stove prices comes from the different number of burners. The more burners on an LPG stove, the higher the price. The additional materials/features affect the price of LPG stoves. Meanwhile, induction stoves are priced according to the features offered by the product. For example, more expensive induction stoves have more advanced heat setting features and use anti-slip and non-stick material. Additional features such as timer, child lock, etc. are often found on induction stoves priced above IDR 1 million (USD 70).

Table 8. Differences between induction stove and LPG stove

<table>
<tr><th rowspan="2">Price Range</th><th colspan="2">Features</th></tr>
<tr><th>Induction Stoves</th><th>LPG Stoves</th></tr>
<tr><td>IDR 100,000 - IDR 200,000
USD 7 - USD 14</td><td>• One burner
• Auto switch off (Safety measure)
• Touch screen
• Timer
• Anti slip base.</td><td>• One burner
• No special features</td></tr>
<tr><td>IDR 201,000 - IDR 300,000
USD 14 - USD 21</td><td>• One burner
• Auto switch off
• Digital display
• Timer
• Touch screen
• Cooking temperature power control</td><td rowspan="2">• Two burners
• No special features</td></tr>
<tr><td>IDR 301,000 - IDR 500,000
USD 21 - USD 35</td><td>• One burner
• Waterproof
• Auto switch off
• Digital display
• Timer
• Touch screen
• Cooking temperature power control</td></tr>
</table>

<table>
<tr><td>IDR 501,000 - IDR 750,000
USD 35 - USD 52.5</td><td>• One burner
• Overheat protection system
• Waterproof
• Auto switch off
• Digital display
• Timer
• Touch screen
• Cooking temperature power control</td><td rowspan="2">• Two burners
• Tempered glass surface</td></tr>
<tr><td>IDR 751,000 - IDR 1,000,000
USD 52.5 - USD 70</td><td>• Same features like above
• 2 mix burner (1 infrared, 1 induction)</td></tr>
<tr><td>IDR 1,000,000 - IDR 1,500,000
USD 70 - USD 105</td><td rowspan="2">• 2 mix burners (1 infrared, 1 induction)
• Safety feature (child lock)
• More levels of heating options</td><td>• Two burners
• Tempered glass surface
• Several brands already offer infrared burners features that can save 43% gas and use anti-rust technology on the pan.</td></tr>
<tr><td>IDR 1,501,000 - IDR 2,000,000
USD 105 - USD 140</td><td>• 4 burners
• Same features like above</td></tr>
</table>

In addition, households who convert to induction stoves require additional costs for buying new cookwares such as pans and pots. The new purchase is required because the cookwares for induction stoves need to come from iron materials while most households in Indonesia use cheaper aluminum cookwares for their LPG stoves. Table 8 presents the price comparison of equipment needed for induction stoves and LPG stoves. Based on the calculation, the upfront cost needed for an induction stove with a basic set of cookwares is about IDR 726,000 (USD 50) for the low-end system to IDR 4,698,000 (USD 324) for a high-end system. The upfront cost for LPG stoves is about 50-60% of the induction's.

Table 9. Cost comparison of induction stoves and LPG stoves (Conversion: USD 1 = IDR 14,380.21)

Compo-nents	Induction stoves			LPG stoves		
		Cost (IDR)	Cost (USD)	Use	Cost	Cost (USD)
Gas cylin-der	No			Yes	Low: IDR 150,000 (3kg) High: IDR 280,000 (12 kg)	Low: USD 10.43 High: USD 19.47
Regulator and Hose	No			Yes	Low: IDR 50,000 High: IDR 150,000	Low: USD 3.48 High: USD 10.43
Stove	Yes	Low: IDR 188,000 High: IDR 2,000,000	Low: USD 13.07 High: USD 139.08	Yes	Low: IDR 75,000 High: IDR 500,000	Low: USD 5.22 High: USD 34.77
Frying Pan	Yes	Low: IDR 300,000 High: IDR 1,000,000	Low: USD 20.86 High: USD 69.54	Yes	Low: IDR 43,000 High: IDR 500,000	Low: USD 2.99 High: USD 34.77
Pot	Yes	Low: IDR 119,000 High: IDR 849,000	Low: USD 8.28 High: USD 59.04	Yes	Low: IDR 35,000 High: IDR 300,000	Low: USD 2.43 High: USD 20.86
Other Pan	Yes	Low: IDR 119,000 High: IDR 849,000	Low: USD 8.28 High: USD 59.04	Yes	Low: IDR 35,000 High: IDR 300,000	Low: USD 2.43 High: USD 20.86
Spatula	Yes	Low: IDR 20,000 High: IDR 120,000	Low: USD 1.39 High: USD 8.34	Yes	Low: IDR 20,000 High: IDR 120,000	Low: USD 1.39 High: USD 8.34
Wok Adaptor	No			Yes	Low: IDR 50,000 High: IDR 320,000	Low: USD 3.48 High: USD 22.25
TOTAL		Min: IDR 726,000 Max: IDR 4,818,000	Min: USD 50.49 Max: USD 335.04		Min: IDR 458,000 Max: IDR 2,470,000	Min: USD 31.85 Max: USD 171.76

c. Key supply side barriers/drivers

The barriers and drivers of induction stove implementation include:

1. The domestic induction stove industry and supply chain have not been well established. Most induction stoves currently available in the market are imported. Moreover, even the domestically manufactured induction stoves still need to use many imported electrical components as the electronics industry in Indonesia is not well developed.
2. The domestic electronic or kitchen appliances manufacturers have not been able to develop induction stove manufacturing because the market demand has not yet been established.
3. The upfront cost of converting to induction stoves is high, especially since most households need to buy iron cookware to replace their aluminum cookware which are incompatible with induction stoves.

8. Lessons learned from previous transitions program

The escalation of global oil prices in 2005 and 2006 overburdened the government budget. The substitution program of kerosene into LPG was expected to save about USD 2 billion per year (Budya & Yasir Arofat, 2011). It was reported that the total subsidy saving between 2006-2016 period reached USD 16.2 billion while the kerosene-to-LPG conversion of 57 million packages cost only USD 1.02 billion (Quinn et al., 2018).

These were the enabling conditions (Astuti et al., 2019):

- Arrangements and involvement of institutions were well-prepared: the Vice president as the coordinator, Pertamina as implementer, MEMR as regulator, MoF as the subsidy provider, and provincial and municipal governments supporting implementation.
- Regulatory instruments: the implementation of kerosene-to-LPG conversion was legally enforced through Presidential Decree No. 104/2007, in accordance with a higher regulatory framework (Oil and gas laws No. 22/2001 and Energy law No. 30/2007).
- Financial support from MoF for the subsidy, and from Pertamina and private investors for investment in the LPG infrastructure.
- Infrastructure preparedness: Along with the government, Pertamina developed the infrastructure for LPG.

There were several classifications of LPG adopters (Astuti et al., 2019), including people who fully adopt LPG, partial adopters of LPG under some circumstances, and the ones who resist moving on to LPG (using firewood or already using electricity for cooking). The main drivers of people adopting the LPG stove were:

- Affordability and accessibility of 3-kg LPG due to the subsidy provided by the government.
- Affordability and accessibility of the new system, i.e. the government distributed free stove and LPG canisters to target households.
- Market creation through market lock-in, i.e. the government pulled kerosene from the market so that people have no choice to remain using it.
- Social trust to the government or authorities.
- Environment (e.g. communities, friends, families, neighbours) influence.
- Information controlling through promotion and communication.
- Better value proposition than kerosene i.e. ease of use and energy efficiency.
- Cleaner fuel.
- Suitable kitchen architecture (there is no dirty kitchen in the house).

There are also other factors that act as the barriers to people adopting LPG:

- Unaffordability and inaccessibility of 12-kg LPG in the earlier phase failed to attract people to convert to LPG.
- Inaccessibility of 3-kg LPG in certain regions (especially in Eastern Indonesia) due to lack of infrastructure keeps the use of LPG low (only 11% in 2019).
- Safety risk posed by LPG use, as cases of LPG explosions were quite prevalent.
- Behavior and lifestyle became constraints, certain dishes require a specific type of heat that the LPG stove cannot provide, perception that fuel type influences the food taste.

There are other issues that arose from the conversion program, such as the raising LPG subsidy which has become a burden to the government budget, posing the same problem it was initially intended to solve. Also, the availability of free firewood or crop residues for rural households resulted in high fuel stacking as they combine the use of LPG and a biomass stove (Thoday et al., 2018).

The lessons learned can be classified using the PESTLE analysis, as shown in Table 10. The reason for the success of the conversion program lies in political and economic factors. The government took the step of converting kerosene to LPG to counter the national balance deficit due to the import of kerosene. The government also takes appropriate policies and strategies to regulate conversion, availability of substitutes, and actively educate the public.

Table 10. Lessons learned by PESTLE factors

No.	Factors	Lessons learned
1	Political	• The government has the intention to reduce the trade balance deficit due to soaring oil prices in 2005 and 2006. • The success of the conversion program for kerosene stoves to LPG stoves is due to the centralized program carried out by the government through Pertamina. • The government appointed the vice president, Jusuf Kalla, to oversee this conversion program.
2	Economic	• LPG becomes a cheaper cooking energy than kerosene because there is a shift in subsidies from kerosene to LPG. • Pertamina still gets cash inflows (sales of kerosene to sales of LPG) while implementing the program. • The community is greatly helped by the 50 million free stove program (the affordability of the new technology is not an issue because they get it for free). • LPG has high affordability compared to kerosene (even for rural areas). • Some investors contribute to the financial aspects of the success of this stove conversion program.

3	Sociological	• The behavior of using kerosene and the behavior of using LPG in the cooking process (from purchasing to the cooking process) did not have a big difference. • People turn to LPG because access to kerosene is increasingly scarce and LPG is easy to find in the market. • The government has provided adequate infrastructure (even in households by providing stoves) for people to move easily. • The government controls information by educational and promotional activities on the benefits of LPG stoves.
4	Technological	• LPG stoves offer technology that can answer the pains (dirty kitchen, poor health, poor safety, etc.) of the public when using kerosene stoves. • People who still use kerosene stoves are threatened because the fuel is getting less accessible in the market.
5	Legal	• The government issues a synergistic policy to support the success of the stove conversion program (regulatory instruments and SOP regulation).
6	Environmental	• Conversion from kerosene stoves to LPG stoves provides direct benefits to the users such as through reduced indoor emissions and cleaner kitchen from kerosene vapor. • The indirect impact for the community is that LPG stoves have a good impact on reducing carbon emissions.

9. Conclusion and recommendations

Conclusion

The ever increasing LPG import and subsidy is the main driver for the government to push for conversion to induction stove. From a societal perspective, the benefits of transitioning from LPG to induction stoves outweigh the costs. Main benefits come from health improvement (due to less air pollution) and reduced overall fuel spending (including LPG subsidy). The costs come from increased GHG emissions and additional expenses for stove and cookware purchase. From the consumer's perspective, the attraction of an induction stove comes from its value proposition, including improved safety and more advanced features.

The existing LPG subsidy policy, however, poses a major barrier for the transition. Conversion to an induction stove will increase the cooking cost for those using subsidized LPG. On the other hand, 90% of Indonesian households have relatively low power connections of 1,300 VA or lower, which is unsuitable for induction stove use. Moreover, the existing electricity subsidy scheme based on connection power capacity will prevent low income households from upgrading their connection as they will lose their access to subsidized tariff. In addition, the consumers are also concerned about power outages, high upfront cost of the stove and associated utensils, and unsuitability with their cooking behavior. The low demand for the induction stove resulted in a lack of domestic manufacturing capacity. Quality standards are also not yet developed by the regulator.

Looking at the success of the previous kerosene-to-LPG conversion program, there are several enabling conditions identified: the roles of institutions were well-defined and there was a clear leadership role, there were supporting regulatory frameworks, financial support was available, and the infrastructure was ready. Factors acting as barriers to the adoption of LPG stoves were also similar to the induction stove, such as unaffordability and inaccessibility of the system in earlier phases and cooking behavior unsuitability. Looking at this information could provide insights on how to overcome the barriers and accomplish a successful LPG to induction stove conversion program.

Recommendations

Enabling environment

- The government needs to establish the policy and regulation to support the conversion to induction stove. Looking at the previous kerosene-to-LPG transition, the President issued a decree which provides the legal framework to push the stakeholders to act. The regulation or decree should cover crucial aspects such as the deployment targets, mechanism of supply and distribution of the induction stoves, and reform of LPG and electricity subsidy schemes. There needs to be a clear pathway for the LPG replacement strategy, whether to focus on electric cooking, natural gas network, or DME, so that the consumers and private investors could act accordingly.

- Limiting access to subsidized LPG is important to create financial benefit of conversion. With access to subsidized LPG being closed for the middle and high income households, converting to induction stove will result in reduced cooking energy spending. Lifting the subsidy or limiting LPG availability in the market could be considered in the long term to reduce fuel stacking after the deployment of the induction stove covers the whole population.
- The current electricity subsidy scheme for lower income households that is based on power capacity, needs to change, to allow the subsidized households to upgrade their connection power capacity. The subsidy scheme could be based on the poverty data from the National Team for the Acceleration of Poverty Reduction that has been used to determine the 900 VA households entitled to subsidy. However, it should be noted that the additional electricity subsidy given for these households will be higher than the LPG subsidy saving.
- The government needs to create an integrated and centralized task force to oversee and regulate the conversion to induction stove. The Coordinating Ministry of Maritime and Investment Affairs (CMMIA) or the Coordinating Ministry of Economic Affairs (CMEA) could lead the conversion program from roadmap making to program implementation since they coordinate the relevant Ministries involved in the program, i.e. energy, environment, and public housing are under CMMIA, while finance, industry, trade, and state-owned enterprise are under CMEA.
- The power capacity compatible with induction stove is at least 2,200 VA, considering that stoves with 1000 W or lower cook significantly slower than LPG stoves (about twice as long). Thus, increasing the power capacity of electric connection is required for more than 90% of the population.

Consumer demand

- The success of widespread adoption of the rice cooker by Indonesian households was driven mainly by the improved utility compared to cooking with a gas stove. Similarly, the FGD respondents are mostly attracted by induction stoves' improved performance/utility compared to LPG stoves, such as safety, functionality, appearance, lifestyle, cleanliness, and ease of use. To attract consumers to switch, education, campaigns and promotions could emphasize these advantages that concern the consumers. This is especially important to motivate conversion in the high income households who have less concern toward the financial aspects.
- Another benefit that could be highlighted is the potential cost saving for the consumers of unsubsidized LPG. No FGD respondents mentioned cost saving as an attractive point of an induction stove; some even expected their energy cost to increase when using induction stoves. This could be caused by a lack of awareness or a lack of concern on the financial aspects by the respondents.

- An induction stove campaign should also address the largest benefit of health improvement that is not yet recognized by the consumers. As LPG is viewed as a clean cooking fuel, most people might not realize about the harmful pollutants emitted during cooking. None of the FGD participants mentioned the health impact of LPG as expected benefit. Further research on the household air pollution impact of LPG in Indonesia could provide the evidence to make a stronger case.
- For low income households, the government can distribute free induction stoves and basic cookwares to remove the transition cost barrier. The cost could easily be covered by the savings from LPG subsidy reduction.
- Consumer financing will be needed, especially for the middle income households. These households are concerned with the high upfront cost of conversion (induction stoves, cookwares, and connection upgrades), but are not entitled to subsidy. This could be initiated by state-owned banks. Once the consumer demand for induction stove increases, private financing will enter the market. There are significant existing consumer financing companies with digital platforms available in Indonesia that offer credits for home appliances such as televisions, handphones, furniture, etc.
- PLN could utilize its vast amount of consumer data and participate in the consumer financing through utility-enabled financing, where utility companies actively facilitate consumers' appliances financing at various degrees of involvement (Waldron & Hacker, 2020). For example, PLN could opt for a less involved approach such as sharing consumers' payment data with financiers or a more involved approach such as directly providing consumers credit. Further assessment is needed to check the suitability of the approach with national regulatory frameworks and PLN's business model.

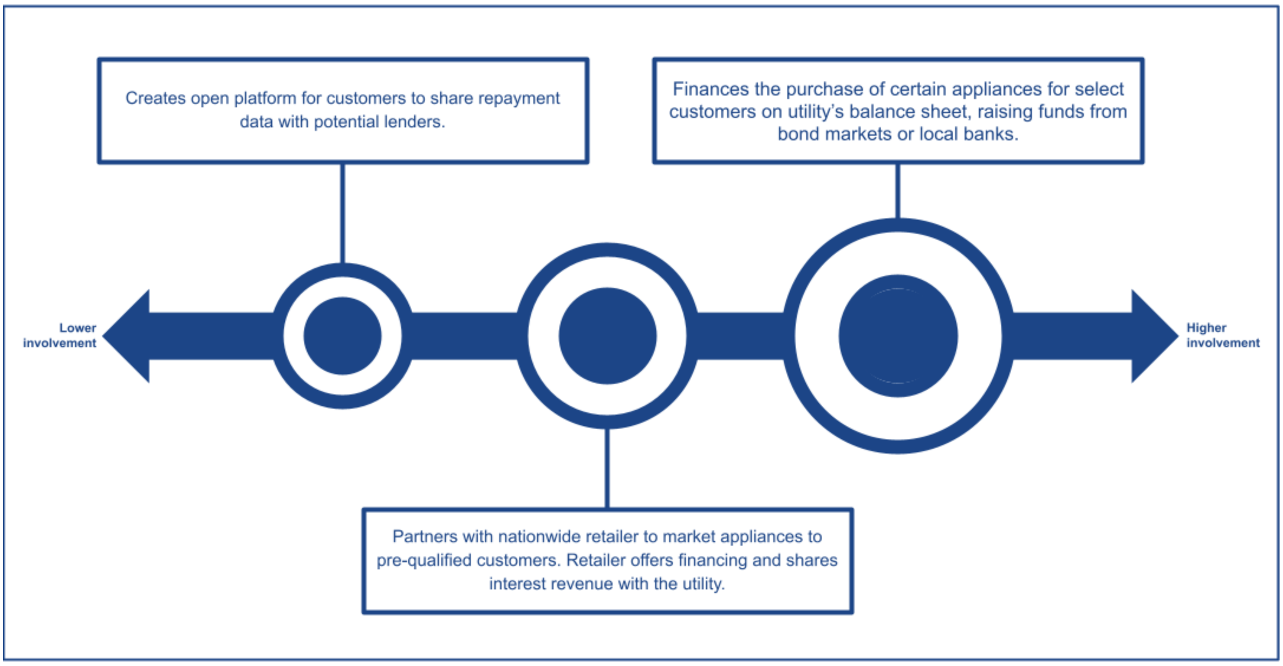


Figure 23. Various degrees of involvement in utility-enabled consumer financing.
Reproduced from Waldron & Hacker, 2020.

- Since there is currently a limited amount of studies on the Indonesian consumer preferences, further research with larger numbers of respondents will be beneficial to better understand the needs of different consumer segments and formulate the campaign and promotion materials.
- Poor reliability of the electricity supply should be resolved by PLN. In addition, manufacturers could innovate by providing small energy storage systems for back-up during electricity shortages, especially in areas with frequent and long interruptions such as West Java and Yogyakarta.

Supply chain

- Domestic manufacturing of induction stoves needs to be fostered soon, at least at the downstream level (assembling). To achieve PLN's estimate of 19 million users in 2030, at least 2 million units should be produced per year, while current production capacity is only 317,000 units. There are several domestic electronic appliances manufacturers in Indonesia that should have the capability to manufacture induction stoves.
- Increasing domestic induction stove manufacturing capacity will create additional demand for electronic components, which could support the development of the upstream electronic components industry. This is especially relevant for government programs that usually have a local content requirement. However, the local content requirement should not be set too high at the initial phase to avoid it becoming a barrier.
- For the initial phase, the free distribution program could use a low-cost imported stove, if domestic manufacturers are not yet able to produce at similar cost. Later, bulk procurement of standardized low-end induction stoves coordinated by the government for subsidized/free deployment to low-income households could guarantee the market for manufacturers and enable them to produce at lower cost.
- Poor quality or poor performance products in the market could hamper the public perception towards theinduction stove. Establishment of national standards (such as SNI and MEPS) could help mitigate that potential problem. Such standards are important since the induction stove is relatively new and the consumers' knowledge of the product is currently limited.
- Widespread availability of after-sales service for induction stoves could help increase the utilization rate of the purchased induction stoves. Indonesians normally call or go to independent electricity technicians to solve their problems with electronic appliances. However, since the induction stove is not yet widely used, these technicians might not be familiar with the technology. Training from manufacturers for these independent technicians could help provide the easily accessible repair services.

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Appendix A - Impact analysis using BAR-HAP tools.

MECS Modern Energy Cooking Services

eCooking Market Assessment for Indonesia: Impact analysis

eCooking Market Assessment for Indonesia: Impact analysis

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20th December 2021

This material has been funded by UKAid from the UK government; however the views expressed do not necessarily reflect the UK government's official policies.

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1 Introduction

MECS as commissioned an assessment of the market opportunities for electric cooking in Indonesia. As part of this work, we want to estimate the impacts that will occur if electric cooking is implemented at scale, compared to continued use of current cooking appliances and fuels. Impacts include costs and changes in subsidies (to the consumer, to government and to other funders etc); health benefits; climate and other environmental impacts; reduction in use of non-renewable biomass; and reductions in time spent gathering fuel.

This requires (a) defining one or more scenarios for level of uptake of eCooking in the country and (b) methods to calculate associated impacts.

The World Health Organisation (WHO) released a revised version of their "Benefits of Action to Reduce Household Air Pollution" (BAR-HAP) tool in July 2021[1], as part of their Clean Household Energy Solutions Toolkit (CHEST). Initial testing suggested the BAR-HAP tool offers an excellent platform for the impact assessments needed. The tool was applied for the individual countries in the market assessments or GIZ.

The BAR-HAP tool includes databases of demographics, population health, current cooking methods and national energy systems for all low- and middle-income countries, and technical assumptions for all of the traditional cooking appliances and fuels and for clean cooking options including LPG and electricity. Electric cooking is given as a single option, without any detail on devices such as EPC. We have made some additions to the original tool with respect to electric cooking in particular.

The tool could be applied without any input from the teams undertaking the country assessments, if we adopted some generic scenario for scale-up of eCooking. However some of the data built-in to the tool may not be as detailed as MECS would wish, and/or may not represent the segments of a country's population that we are focused on. Many of the data are also from 2018, and where more recent evidence was available, this was used instead.

This note provides an overview of the BAR-HAP tool, describes how it has been used for the scale-up analysis in Indonesia and then reports the results. Key data specific to the country are given in other parts of the market assessment, but this note provides an overview of the types of additional data added to the original tool.

2 Overview of BAR-HAP

The tool was developed by Dr. Marc Jeuland and Dr. Ipsita Das at Duke University, with support from various others. Quoting from WHO[1]: "BAR-HAP tool is a planning tool for assessing the costs and benefits of different interventions that aim to reduce cooking-related household air pollution. The tool includes 16 different cleaner cooking transitions from more polluting stoves and fuels to cleaner options, including both transitional options (that offer some health benefits) and clean options (that meet emissions levels in the WHO Guidelines for indoor air quality: household fuel combustion). For each cooking transition, users can also select a policy intervention that will be applied, such as stove or fuel subsidy, financing, intensive behaviour change campaign, or a technology ban." Figure 1 illustrates the range of options at each stage.

The BAR-HAP tool is a static model and its treatment of changes over time is not sophisticated. Many parameters are fixed values: eg emission factors for grid electricity are single fixed values so you can't include a scenario for decarbonisation of electricity supply. But you can change the emission factors, so we can implement our own assumption for 2030 grid mix by country. It is not based on a life-cycle approach to impacts, but focused on the

[1] https://www.who.int/tools/benefits-of-action-to-reduce-household-air-pollution-tool

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effects of the emissions associated with direct combustion of the fuel for cooking or for generation of the electricity used.

The tool does not attempt to report how things change over time for a scenario: a transition is effected by choosing from a defined set of policy measures, and there are in-built (but adjustable) factors that define the uptake rates depending on the policy. You can specify the number of years over which a transition takes place, and some values for initial setup delays, but the actual uptake of clean cooking per year as the policy measure takes hold is not shown. The results are in terms of total present value over the full period, or impact per year for just one year. It is not possible to define a specific uptake level for eCook by, say 2030, but we will be able to do trial-and-error tinkering with the policy drivers until we get the sort of uptake level we want for our scale-up scenario.

The tool is implemented in a large spreadsheet, with clear instructions and suggested workflow. Default values are included for all parameters, many of them country-specific, but most can also be adjusted. A journal paper is available that describes the tool in detail, although this is the original version, not the July 2021 update[2]. The models calculating the different impacts are mostly replicated from those described in an earlier publication from some of the same team[3]. A user manual is available, alongside the spreadsheet tool[4].

MECS added a front-end to the original model, facilitating entry of data for the key parameters mentioned below, and adding a bespoke table and chart for the results we are most interested in. A few minor errors were found in the publicly available version of the BARHAP model, and these were conveyed to the model's authors. Corrections for those are built into the version developed for the GIZ market assessments.

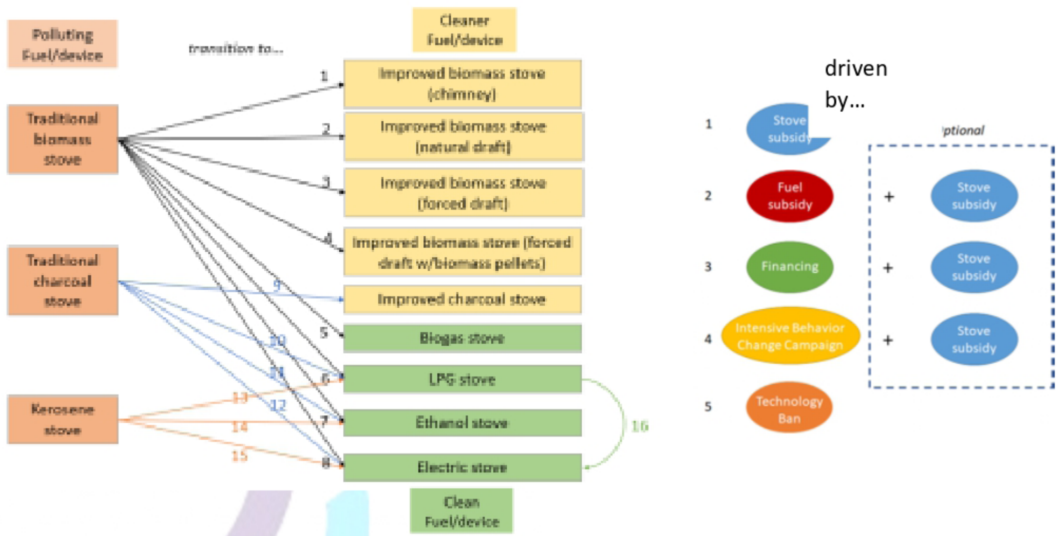

Figure 1 BAR-HAP tool schematic

Source: Adapted from WHO (2021)

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[3] Jeuland M, Soo JS, Shindell D. The need for policies to reduce the costs of cleaner cooking in low income settings: Implications from systematic analysis of costs and benefits. Energy policy. 2018 Oct. 1;121:275–85. https://doi.org/10.1016/j.enpol.2018.06.031

[4] WHO (2021). Benefits of Action to Reduce Household Air Pollution (BAR-HAP) Tool. Version 2. Geneva, World Health Organization. https://www.who.int/publications/m/item/manual-for-benefits-of-action-to-reduce-household-air-pollution-(bar-hap)-tool-(version-2-july-2021)

3

3 Assumptions and data needed for eCook impact analysis

3.1 Scenarios for scale-up

Two main scenarios were explored:

(1) uptake of an induction cookstove as the primary means of cooking by one million households[5] in Java/Bali, by 2025; and

(2) uptake of ten million induction cookstoves by 2030, consistent with the National Grand Energy Strategy (GSEN) plans for 20% of cooking to be electric[6]. In both cases, the transitions considered are from current use of LPG to induction.

For scenario 1, for 1 million induction stoves, a series of scenario variants are also implemented, to test out the sensitivity of results to some key assumptions. The assumptions explored are:

- the influence of fuel stacking, ranging from 50% induction and 50% LPG (scenario 1.a), to 80% induction and residual of 20% LPG (1.b)
- the effect on greenhouse gas emissions of the power generation mix, from the current mix with 12% renewable share of generation output (1.b), 24% share (1.c) and then 60% share (1.d). The higher shares reflect scenarios for 2030 in the UN's SDG7 Roadmap for Indonesia[7].
- the effect on cooking energy costs to households and to Government of the current LPG price subsidy, with the subsidy at present levels (approx. 54%) (1.d) or for households who do not receive an LPG subsidy (1.e).

Scenario 2, for 10 million induction stoves, is run for just one set of assumptions, which include 20% LPG stacking, 60% renewables share and subsidised LPG. This provides a view of the opportunities for eCook within a major programme, and with parallel efforts at decarbonising the economy.

There are almost 42 million households in the Java and Bali regions[8], some 58% of the national total. There are approximately 3.9 people per household, and the combined region has 160 million inhabitants. Almost all households in the region are connected to the electricity grid, and LPG is the primary cooking fuel for 80%[9]. as such the first scenario represents a transition of around 3% of the current LPG-using households to induction cooking, and the second scenario would be around 30%.

3.2 Country-level data

The BAR-HAP Tool can be used without any additional country-specific data/information; however, the user has the option to amend the country-specific data/information.. Detail of the tool and all its data can be found in the links earlier to the tool itself, its manual and the article by its authors. Below are key parameters that were

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[5] https://en.antaranews.com/news/199337/govt-promotes-induction-stoves-as-cheaper-cleaner-cooking-options

[6] https://setkab.go.id/en/govt-to-optimize-national-energy-utilization/

[7] https://www.unescap.org/resources/energy-transition-pathways-2030-agenda-sdg7-roadmap-indonesia

[8] https://banten.bps.go.id/linkTableDinamis/view/id/42

[9] https://www.bps.go.id/statictable/2014/09/10/1364/persentase-rumah-tangga-menurut-provinsi-dan-bahan-bakar-utama-untuk-memasak-tahun-2001-2007-2016.html

considered specifically for the country assessments, and for which updates to defaults were made in some cases to better reflect the local situation. Wider context for the assumptions made can be found in the rest of the market assessment report.

All costs are reported here in US dollars, using a conversion rate of 0.00007 $/Rs[10]

3.2.1 Stove data

The assumption is that transitioning households are fuel stacking, with 20% to 50% of cooking still delivered using LPG.

An induction stove is assumed to cost $40.25, compared to an LPG burner which costs $8.75 (source: https://review.bukalapak.com/techno/mengenal-3-tipe-kompor-listrik-54786). It is assumed that some additional cooking pans are required to be compatible with induction cooking, at a cost of $38. This takes the total cost of the new cooking equipment to $78 (Rs110,000). Efficiencies are 80% for induction and 40% for LPG (measured as MJ input to MJ useful heat output) (source: PLN).

BAR-HAP includes calculations of the time saved by household members, both in terms of avoided time collecting traditional fuels, and quicker cooking on some modern devices. For this analysis, the former is not relevant, as the focus is on current use of LPG only: there might be some avoidance of time for refilling or replacing LPG cylinders, but this is likely to be negligible. It is assumed that cooking times are identical for LPG and an induction stove.

3.2.2 Fuel and electricity data

LPG consumption per household is taken from Anggono et al (2021), at 136 kg/year per household. Fuel prices were obtained from Tiandho et al (2021)[11]. The current subsidised price paid by households for LPG is given as $0.373 per kg. The unsubsidised cost is estimated as £0.811 per kg, with an effective subsidy rate of 54%.
Electricity tariffs are taken from PLN[12]. For households with an electrical connection with capacity of 1,300 VA or higher, this is $0.101 per kWh. Households with a connection of only 900 VA pay a slightly lower tariff of $0.095/kWh. This 6% reduction will have negligible effect on the overall results, and we have limited information on the prevalence of this lower power connection, of of plans for upgrades, and so the higher tariff was used throughout.

The national electricity generation mix now, and how it might change during the period of the cooking transition, will influence the greenhouse gas and other emissions associated with the electricity uses. BAR-HAP does not use generation mix directly, but includes emission factors for all fuels, including electricity. The electricity emission factors are country-specific for the three main GHGs (CO2, CH_4, N_2O), and while values are missing for some countries, they are included for Indonesia. However these are just for one snapshot period, and the tool does not facilitate changing variable values over time. As such, a series of scenarios were run for changes in the generation mix, with assumptions about how those would alter the greenhouse gas emission factors.

Two scenarios were explored for generation mix change, the first from the UN's analysis of the national developments needed to meet Indonesia's Nationally Determined Contribution and second from the changes needed to meet wider SDGs[7]. The former suggests that the share of renewables in the generation mix needs to increase from its current 12% to 24%; the latter requires an increase to some 60% (assumed to be a mix of mainly geothermal and hydropower, with some wind power and some solar PV). In the absence of a calculation

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[10] www.xe.com, 14/12/2021

[11] https://iopscience.iop.org/article/10.1088/1757-899X/1034/1/012068/pdf

[12] https://web.pln.co.id/pelanggan/tarif-tenaga-listrik/tariff-adjustment

methodology to convert from these generation mixes to GHG emission factors, proxies were selected from the electricity consumption-based tables of emission factors by country in Ecometrica (2011)[13]. Data on the generation mix by country and by year[14] were used to find locations with generation mixes similar to the two scenarios above, and the emission factors for those places were adopted.

3.2.3 Policy options

BAR-HAP supports several different policy instruments, including subsidies on purchase costs for cooking equipment, subsidies on fuel costs, low cost financing, bans on certain fuel types and behaviour change campaigns. The effects of subsidy- and financing-based policies are to apportion costs between different stakeholders; the fuel ban and behaviour change policies have associated implementation costs and varying degrees of effectiveness in motivating households to transition.

For this analysis, the device subsidy option is used, with the full costs of the new induction stoves assumed to be paid for by the Government. This is not necessarily a likely scenario, but it is a convenient simplification as it separates out the costs of devices (paid by government) and the change in fuel costs (paid by households). BAR-HAP sums all the costs and benefits to show the overall net social benefit of a scenario, and these overall results are not affected by the assumption on how costs are shared out.

4 Scale-up cost-benefit analysis for Indonesia

This section explores the expected costs and benefits for the set of illustrative scenarios of scale-up of eCooking in the Java/Bali regions of Indonesia.

Figure 2 shows the scenarios and the results. The upper part of the table shows parameter values that differentiate the scenarios; coloured shading is used to indicate the change in parameter value from one scenario to the next. With four parameters being changed, a set of scenarios to show every combination would be extensive. However the intention here is to illustrate the influence of each parameter, not to provide specific results for every option, so a reduce set of combinations is shown.

The lower part of the table shows the results of BAR-HAP for the modelled scenarios. Results in rows labelled (a) come from BAR-HAP directly, and show a mixture of physical impacts and the monetisation of those. The rows labelled (b) provide some additional results calculated outside the model.

Overall, the results show that a transition from LPG to induction cooking should lead to net positive social benefits in all cases. The impact on GHG emissions is negative in all cases and the financial impacts (private plus public) appear to be negative in the first 4 scenarios: however these are both outweighed by large health benefits. However, the final row, (b-2) must be factored in too: these are the savings to government in avoided LPG subsidies for the households that transition. If these benefits were added to the financial costs, the overall financial impact would be approximately neutral. However, the effect on LPG subsidies has been kept separate here because the BAR-HAP model is not being used to calculate them (to avoid confusing these with a fuel subsidy policy instrument). The offline calculation for LPG subsidy savings is just a snapshot of the saving that would accrue in one example year, and unlike the monetary values in section (a) of the results, they are not subject to discounted summation across the transition period. So the LPG savings cannot be compared directly to the other costs; but they are clearly a similar level, as expected, since subsidy saving arises from corresponding

[13] https://ecometrica.com/assets/Electricity-specific-emission-factors-for-grid-electricity.pdf

[14] https://ourworldindata.org/grapher/share-elec-by-source

change in use of subsidised LPG by households. The LPG subsidy saving for scenario 2a in particular should not be compared to the discounted costs of results in section (a), as with the ten year programme period for this scenario, the effect of discounting is significant.

Physical impacts multiply by a factor of ten between scenarios 1 and 2, reflecting ten times greater uptake of induction stoves. However, the financial values of section (a) increase less than this: the financial figures are mostly calculated using discounting for the future value of money, and scenario 2 runs over ten years rather than the 4 years for scenario 1, and thus the effects in later year are more heavily discounted from a present value perspective..

Scenarios modelled		1. One million induction stoves, by 2025					2. 20% cooking is electric, by 2030
Scenario details (shading indicates key change from one scenario to next)		1.a	1.b	1.c	1.d	1.e	2.a
Households transitioning to induction stoves		1 million	1 million	1 million	1 million	1 million	10 million
Fuel stacking (% use of LPG)	%	50	20	20	20	20	20
LPG subsidised		Yes	Yes	Yes	Yes	No	Yes
Power generation mix	Share of Renewables	2021 12%	2021 12%	2030 24%	2030 60%	2030 60%	2030 60%
Results (costs are -ve, benefits are +ve)							
(a) Total present value (ie net social benefits of the transition)	**$/yr**	206,355,106	166,006,554	195,631,990	234,497,956	278,608,353	2,458,977,198
(a-1) Financial costs of transition, government+private	**$/yr**	-40,597,778	-50,385,478	-50,385,478	-50,385,478	-6,275,081	-176,357,932
Private cost to housholds: total	**$/yr**	-14,822,008	-24,609,707	-24,609,707	-24,609,707	19,500,690	-103,188,677
Stove purchases	*$/yr*	1,490,825	1,490,825	1,490,825	1,490,825	1,490,825	8,970,141
Fuel purchases	*$/yr*	-16,312,833	-26,100,532	-26,100,532	-26,100,532	18,009,865	-112,158,819
Maintenance	*$/yr*	0	0	0	0	0	0
Costs to government: total	**$/yr**	-25,775,771	-25,775,771	-25,775,771	-25,775,771	-25,775,771	-73,169,255
Stove purchase subsidy	*$/yr*	-16,592,883	-16,592,883	-16,592,883	-16,592,883	-16,592,883	-51,578,312
Electricity tariff subsidy	*$/yr*	0	0	0	0	0	0
Admin+Programme cost	*$/yr*	-9,182,888	-9,182,888	-9,182,888	-9,182,888	-9,182,888	-21,590,943
(a-2) Health, Time, and Environmental Benefits: total	**$/yr**	246,952,884	216,392,032	246,017,468	284,883,434	284,883,434	2,635,335,130
Health impact benefits total	$/yr	315,907,727	326,719,779	326,719,779	326,719,779	326,719,779	2,815,345,274
	DALYs/Yr	12,751	13,195	13,195	13,195	13,195	131,951
Mortality reduction	*YLL/Yr*	9,532	9,854	9,854	9,854	9,854	98,541
Mortality reduction	*Lives/yr*	813	840	840	840	840	8,400
Morbidity reduction	*YLD/yr*	3,219	3,341	3,341	3,341	3,341	33,410
Morbidity reduction	***Cases/yr***	13,192	13,684	13,684	13,684	13,684	136,843
Time savings	**$/yr**	0	0	0	0	0	0
Time savings	*Hours/HH*	0	0	0	0	0	0
CO2-eq reduction (CO2,CH4,N2O)	**$/yr**	-68,954,842	-110,327,748	-80,702,312	-41,836,346	-41,836,346	-180,010,144
	Tonnes/yr	-4,074,405	-6,519,048	-4,768,540	-2,472,027	-2,472,027	-24,720,268
(b) Other indicators							
(b-1) Additional electricity use	**MWh/yr**	428,593	685,749	685,749	685,749	685,749	6,857,487
Reduction in LPG use	**kg/yr**	68,574,872	109,719,795	109,719,795	109,719,795	109,719,795	1,097,197,951
(b-2) LPG subsidy savings for government (for transitioning HHs)	**$/yr (no discounting)**	30,022,765	48,036,424	48,036,424	48,036,424	0	480,364,235
Note: costs in (a) are discounted across programme period. Costs/year are total NPV divided by the length of the programme for each scenario							
Values in (b) are undiscounted, in final programme year							

Figure 2 Annual Costs and benefits by scenario for Indonesia

The charts in Figure 3 and Figure 4 show the costs and benefits summed cross the full transition (4 years, to 2025 in these cases) for the first two scenarios. The difference between the two charts is simply one of scale in most of the elements of cost, as the greater use of eCooking in scenario 1b (80% use rather than 50% per household) leads to larger impacts. The charts for all six scenarios look similar, and so are not all shown.

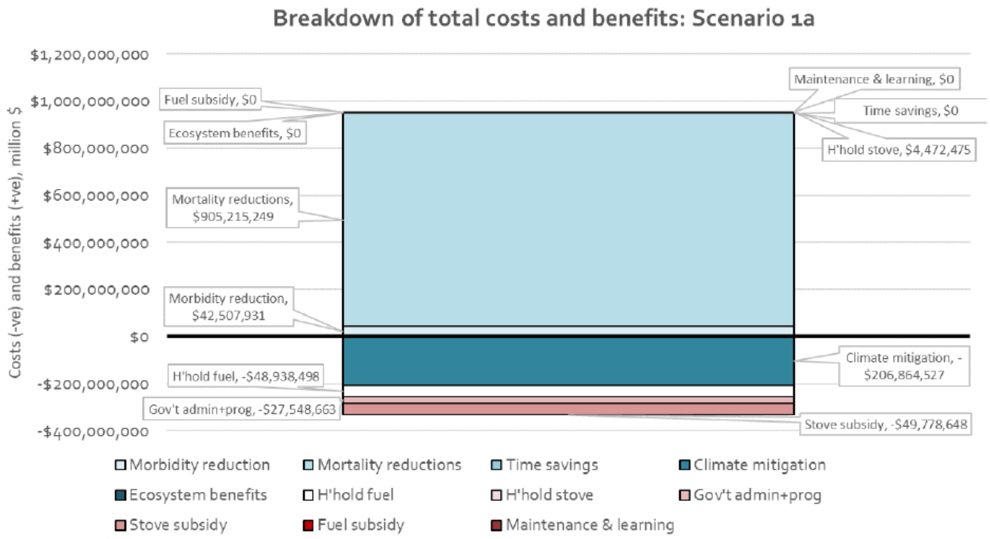

Figure 3 Scenario 1a total costs and benefits

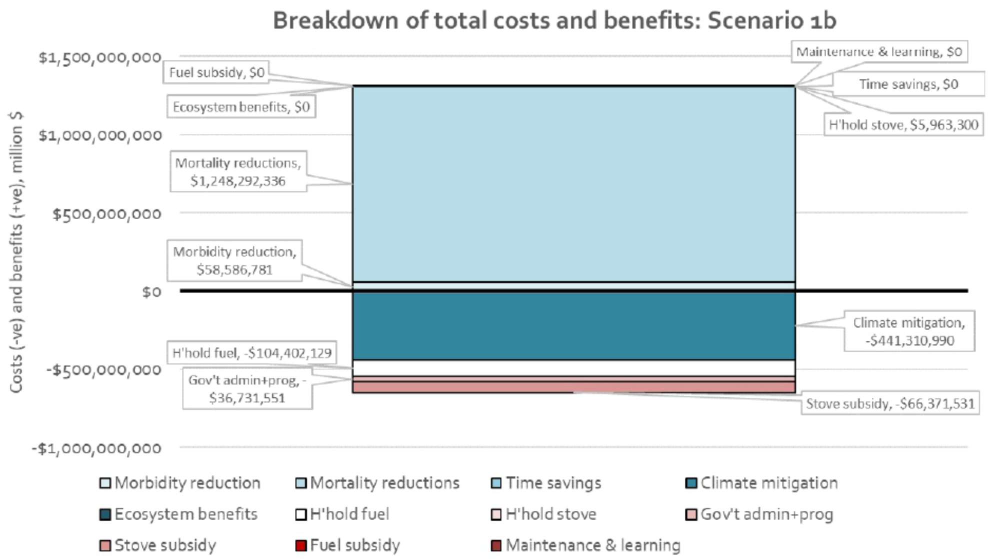

Figure 4 Scenario 1b total costs and benefits

Comments on the sensitivity of the results to each of the key parameters:

- Fuel stacking: moving from 50% electricity use to 80% between scenarios 1a and 1b leads to an increase in the fuel purchase costs for households. This highlights that the cost of electricity for induction cooking is higher than the cost of cooking with subsidised LPG. However the change from scenario 1d to 1e, which is a scenario showing the impacts of a move from LPG to eCooking for households that pay the full, unsubsidised price for LPG, shows that eCooking is cheaper than cooking with unsubsidised LPG. The benefit from eCooking is partly in the higher efficiency of induction cooking compared to cooking with LPG.

- Power generation mix: the GHG emissions increase in all scenarios, illustrating that even though LPG is a fossil fuel, cooking with electricity derived from fossil fuel sources will result in even greater emissions. The increase in emissions does reduce through scenarios 1b, 1c and 1d, as the share of renewables increases, with matching reduction in GHG emission factors. The most extreme scenario modelled here has 60% share of renewables, so 40% of the electricity is from coal or oil fired generation, which might have generation efficiency of only 40%. Even with the assumption that cooking on an induction stove is twice as efficient as using an LPG stove, with these values cooking with electricity is 25% more carbon intensive than using LPG.
- LPG price subsidy: if households are paying subsidised prices for LPG, then their purchase costs of energy for cooking will rise if they move to electricity, as seen by scenarios 1a, 1b, 1c and 1d: for unsubsidised users, eCooking is cheaper for the household than using unsubsidised LPG, as per scenario 1e.

Looking at the different perspectives:

- From an overall societal perspective, eCooking is always preferable. This is partly driven by strong health benefits, with even removal of 50% of LPG use in scenario 1a saving lives and avoiding ill-health.
- For households paying for unsubsidised LPG, moving to electric cooking offers clear financial benefits.
- For users receiving subsidised LPG, eCooking will increase the monthly energy bill, even with Government providing the induction stoves for free. However Government will save considerable sums in avoided LPG subsidy, and a portion of these could be used for transitional relief over a number of years, eg to leave the households at a similar cost of cooking. A crude analysis of, say, scenario 1b shows that household costs rise by $24 M/yr, direct costs to government increase by $25M, but there are (approximately) $48M of LPG subsidies avoided. Government could therefore cover the costs of providing the induction stove and pans through avoided subsidy payments, and provide additional incentives to households to overcome the barrier of higher energy bills.
- The public health benefits of shifting from LPG to electric cooking are large; they are monetized here using the WHO's recommended values for morbidity and mortality, and if factored in to Government's cost-benefit analysis would make electric cooking an attractive option.
- From a climate perspective, emissions will increase with all scenarios tested, for the next ten years. In the longer term, deeper decarbonisation of the power supply, eg beyond 60% of very low carbon generation in the mix, would see eCooking emissions fall below those of LPG.

In terms of overall conclusions:

- This is an impact analysis for a set of simple scenarios for the future of cooking in Indonesia.
- The scenarios have overall economic benefits to society, based on the WHO's physical impact and impact monetisation methodologies.
- Costs of the transition will fall variously on different parties, but policy could be set such that all parties see financial benefit, alongside considerable health benefits.

- In the longer term, climate benefit could be realised, but in the short to medium term, a switch to eCooking will increase GHG emissions.

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