Indonesia Induction Stoves Conversion Program: Technology Adoption and Behavior

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Abstract. The 7th objective of the Sustainable Development Goals (SDG) aims to ensure access to affordable, reliable, sustainable, and modern energy. In alignment with this global agenda, the Indonesian government initiated a pilot project through the National State Electricity Company (PT PLN) in 2022 to transition from LPG gas stoves to induction stoves. Benefiting from its existing electrical infrastructure, Surakarta was one of the cities selected for this program. The pilot project targeted 1,000 households with electrical capacities of 450 or 900 VA. To fulfill the increased electrical demand, PT PLN provided free power up to 2200 VA at a subsidized tariff rate. Additionally, each household received a 2-burner induction stove with 1800 VA power, specialized cooking utensils, and an installation package. This research sought to scrutinize the adoption process of induction stoves, focusing on behavioral shifts and the accompanying complexities among residents, especially for those from lower socioeconomic strata. Employing quantitative (statistical descriptive survey) and qualitative methodologies (observations, in-depth interviews, and focus group discussions), the study yielded a comprehensive analysis. The findings are of significant value to scholars, decision-makers, and policymakers in the fields of energy and technology management, especially in developing nations.

Keywords: Behavioral Change, Energy Conversion, Technology Acceptance

1 Introduction

The reduction of carbon emissions to create a cleaner environment has emerged as a central focus for numerous countries worldwide, which is consistent with the aspirations of fulfilling SDG 7 [1-7], including Indonesia [8, 9]. According to the Sustainable Development Report 2022, Indonesia has successfully achieved 69.16% of all SDGs targets, ranking 82nd among 163 countries. Regarding achieving goal 7, Indonesia is actively implementing its national energy policy program to transition its energy needs to renewable energy and reduce its dependence on fossil fuels [9].

Indonesia has developed a roadmap and energy transition policies to facilitate transition from conventional technologies to environmental friendly ones. This includes

adopting electric technologies in sectors such as transportation, agriculture, fisheries, and livestock. These measures are projected to decrease carbon emissions by 29% to 40% [8, 9]. Specifically, in 2022, Indonesia targeted the transition from LPG gas to induction stoves in two cities, Surakarta in Central Java and Denpasar in Bali, as part of its pilot project.

This program aligns with initiatives in other developing countries like India [10-12], Ecuador [13-15], Ghana [16, 17], and Nepal [1, 18]. Similar to these countries, Indonesia has piloted its induction stove transition program among lower-to-middle income communities with electricity capacities of 450 VA and 900 VA. The objective is to explore whether people in this demographic, primarily relying on government-subsidized LPG gas could adopt induction stove technology for daily cooking. Through the state electricity company (PT PLN), the Indonesian government supported the increase of electricity capacity up to 2200 VA to facilitate the implementation of the Indonesian induction stove program.

Technological transformation in developing countries encounters multiple challenges, [19-22], not only related to infrastructure but also user behavior, which is influenced by education level, income, and sociocultural aspects [23-26]. Therefore, assessing a technology transition program is essential and intriguing, especially for developing nations [27-30].

The transition from LPG gas stoves to induction stoves has been underexplored in comparison with that to electric vehicles. Besides, existing research has typically employed only either qualitative [16, 31] or quantitative methods [18, 32], so that has not comprehensively examining induction stove transformation programs. The integration of these two approaches is essential because technology adoption is influenced by technical as well as social contexts that require examination through deeply qualitative observations. The integration of these two approaches is essential because technology adoption is influenced by technical as well as social contexts that require examination through deeply qualitative observations [33, 34].

To address this gap, the present study conducts a comprehensive analysis of Indonesia's transition to induction stoves, integrating both quantitative survey and qualitative observations. This approach aims to provide a nuanced understanding of the program's implementation within the specific sociocultural context of the Indonesian society. The results are anticipated to offer valuable insights for researchers, decision-makers, and policymakers in the domain of electric energy-based technological transformations, especially in developing countries.

2 Method

2.1 Case Description

In 2022, Indonesia initiated a pilot project in Surakarta to transition households from 3 kg LPG gas stoves to induction stoves. Conducted in partnership with the PT PLN, this study assesses the adoption and implementation of the conversion program. The project engaged 1,000 households across five sub-districts, primarily targeting the lower-middle economic group utilizing electricity capacities of 450 VA and 900 VA.

These households were chosen based on stratified random sampling in the five sub-districts based on socio-economic conditions as assessed by their use of electrical power.

These households had been reliant on stoves fueled by subsidized 3 kg gas cylinders. PT PLN facilitated the transition by offering a comprehensive package, including a free increase in electricity capacity up to 2200 VA, specialized tariffs for induction stoves, as well as the provision and installation of the stoves and specialized cooking utensils.

2.2 Data Collection

Surveys served as a primary methodological approach for this research, aimed at collecting valid data for analysis [35, 36]. This method enabled the collection of community opinions and feedback on the adoption of induction stoves for daily cooking.

The study employed a sampling strategy that combined purposive sampling as the most efficient and effective data collection mechanism [37-39]. This non-probability method targets specific respondents who satisfy certain criteria, thereby enhancing research precision and data reliability [38, 39]. However, this non-probability sampling method has potential bias, which may affect the generalizability of the results. To anticipated, this research uses a combination method to explore data, including cross-checking questionnaires with in-depth interviews, observations, and periodic visits by the research team to respondents. With these various methods, consistency of data collection can be guaranteed.

In this research, purposive sampling was indispensable for obtaining an in-depth, social understanding of induction stove adoption. The target population as respondents is 1000 people. Based on the Slovin formula, with a 95% confidence level (5% error), a minimum sample size of 289 respondents is required to significantly represent the population. To anticipate data deficiencies (missing values and outliers), this research approached 400 program participant households with the final result being 389 households expressed their desire to partake as respondents. This number meets the adequacy of targeted sampling data to represent the population. Sufficient sampling strengthens the validity of this research.

The survey team acquired data through questionnaires and observational visits to the respondents' homes, with interviews exploring the adoption of induction stove technology. The respondents completed the questionnaires with the assistance of the surveyor. During this process, the survey team also conducted in-depth interviews regarding the respondent's usage of induction stoves. The procedure of questionnaire completion, discussions, and observations for each respondent spanned from 45 to 60 min. The questionnaire has been tested statistically. Validity test uses Pearson product moment with alpha 5% and showed all item have t value above 0.05, which indicates the questionnaire valid. The reliability test with Cronbach's alpha produced a value of 0.83, which can be interpreted as all questionnaire items being reliable. These questionnaires and additional tools available in a repository and can be obtained upon request from the corresponding author.

The analytical approach of this research includes deriving descriptive statistics from processed questionnaires, elaborated with observations and interview outcomes. The analyzed factors of technology adoption include cooking behavior, induction stove usage, 3 kg LPG cylinder consumption, participants' interest in transitioning from LPG gas stoves to induction stoves, and their willingness to use induction stoves for daily cooking activities. The research analysis framework is illustrated in Fig.1.

3 Result and Discussion

Data from elaborated questionnaires, interviews, and observations indicated shifts in household cooking behavior following the transition from 3 kg LPG gas stoves to induction stoves.

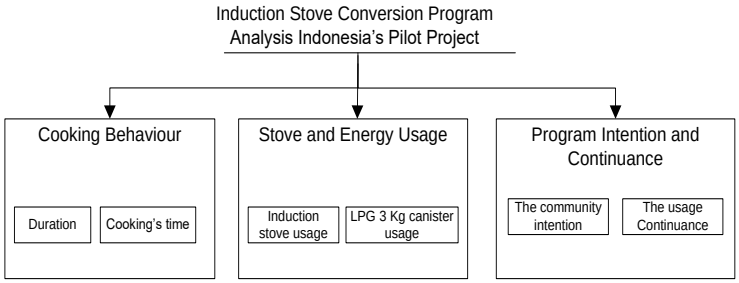

Fig. 1. Framework of Analysis of Induction Stove Conversion Program in Indonesia

3.1 Cooking Behavior

The duration of cooking sessions increase notably after the conversion program. Prior to using induction stove, the majority of the respondents (47%) were engaged in cooking activities for less than an hour per day. Subsequent to adopting induction stoves, 54 % of respondents reported spending more than two hours daily on cooking, reflecting an increase in one hour of cooking duration.

Further investigation and in-depth analysis reveal that the increase in cooking duration is partly attributable to respondents' need for additional preparatory activities when using induction stoves. These activities involve recalling operational instructions and focusing on initial setup procedures, such as navigating through menus, accurate placement of cooking utensils on the stove, and temperature adjustments.

Respondents acknowledged a necessity for greater attention while operating induction stoves. In case of any cooking-related complications, participants expressed feelings of inadequacy in identifying the underlying issues and executing remedial measures. Therefore, the participants in the induction stove conversion program in Surakarta lack familiarity with troubleshooting induction stove technology and cannot independently address such issues. The usage of induction stove by conversion program participant is shown in Fig.2.

Fig. 2. The usage of induction stove by conversion participant program

This phenomenon is commonly observed during the early adoption phase of new technological products [22, 40, 41], which is similar to the induction stove program currently ongoing for three months in Indonesia. This initial phase marks a critical point during the introduction of an innovation or a new technology, wherein a slow penetration strategy is employed, utilizing a low-cost scheme that includes free induction stoves, subsidized rates, free-installations, and other incentives. This strategy aims to gain substantial acceptance from the market, especially for capturing the community acceptance of induction stoves [42-45].

In several case, behavior can be altered through increased product awareness and knowledge [46, 47], which has been effectively achieved with accompaniment [48, 49] and training [33, 50]. Regarding the induction stove program, adequate mentoring, and training activities should be implemented to enhance the community's knowledge and experience in using induction stoves. This knowledge and experience will encourage households to prefer induction stoves over gas stoves.

Regardless of the variations in cooking duration, the timing and frequency of cooking remained largely consistent. A significant proportion of respondents cooked once a day (77%), i.e., during morning hours, specifically between 04:00 and 09:00 AM (81%) (see Fig.3). This routine morning cooking is aligned with the longstanding cultural norms in Indonesia, where the majority of the daily needs is prepared during the initial hours of the day [51, 52]. Despite the adoption of induction stoves, this behavior persisted among the respondents.

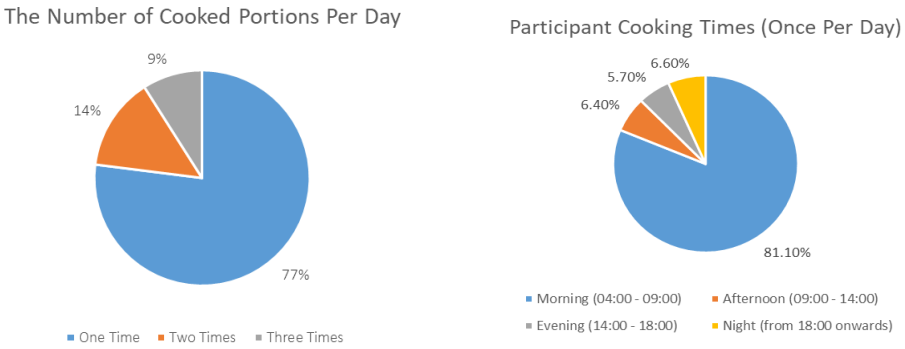

Fig. 3. The Respondents Cooking Duration and Frequency in Using Induction Stoves

Several hindrances have been identified due to the existing behavioral patterns. Respondents conveyed that the cooking utensils supplied as part of the program package possess limited capacity, rendering them inadequate for large-quantity cooking. Consequently, the necessity for multiple cooking sessions extends the overall cooking duration.

3.2 Stove and Energy Usage

Data accumulated over a three-month period unveil the respondent usage patterns for induction stoves. A significant proportion of participants in the conversion program (80.7%) reported using both induction and gas stoves interchangeably, a pattern termed as "hybrid" usage (see Fig. 4). Although induction stoves were primarily suitable for cooking the majority of daily dishes, the respondents maintained their gas stoves due to the possession of specialized cooking utensils such as aluminum pots, curved woks, and clay pots, which are incompatible with induction stoves. Similar challenges have been noted in countries like India, China, and Mexico, where traditional cooking utensils are prevalent [12, 31, 53, 54].

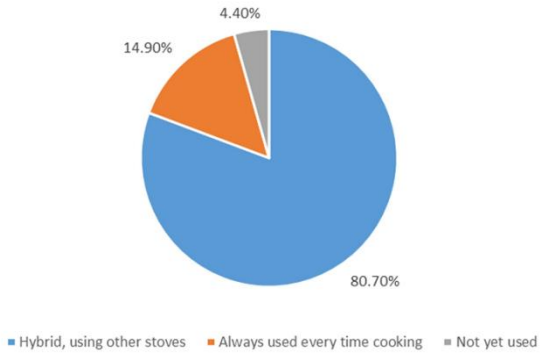

Fig. 4. Respondent's Behavior for Using an Induction Stove

Observational findings indicate that the gas cylinder usage decreased among 66% of the respondents upon entering the conversion program, with an average monthly reduction of 1.5–2 units of 3 kg gas cylinders (see Fig. 5). Throughout the three months of implementation, the research team examined the average usage of induction stoves based on the KWH meter readings. The upward trajectory observed in household electric consumption is depicted in Fig.6. In the first month of usage, the average consumption per household was 1.02 KWH, followed by an increase to an average of 5.98 KWH in the second month and reaching up to 15.29 KWH in the third month.

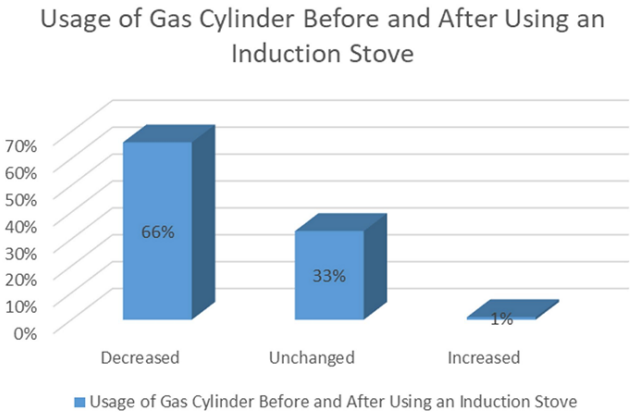

Fig. 5. The 3 Kg Gas Cylinders Usage

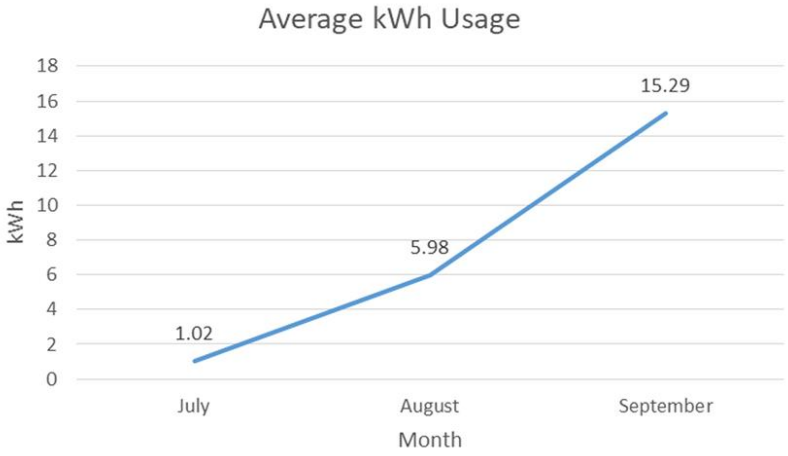

Fig. 6. Average KWh Using Induction Stoves in Surakarta

This reflects that respondents gradually continued to use induction stoves, despite various challenges such as adjusting to the technological features, limitations of cooking utensils, and concerns regarding the program's sustainability. Essentially, this condition indicates a positive acceptance response from the targeted community toward a new technology, signifying the participants' willingness to actively engage and adopt the program [55, 56]. The incorporation of contemporary social media strategies could serve as an efficacious mechanism for program stakeholders to amplify community engagement and promote confidence in adopting this novel technology [57-59].

3.3 Program Intention and Continuance

Over three months of using induction stoves, the program assessed the participants' readiness and acceptance toward using induction stove technology. The preparedness for technology acceptance was measured using the Technology Readiness Index and registered a score of 3.33, indicating a moderate level of readiness [60]. Given the cultural disposition of the target community in Surakarta, Central Java, which is characterized by a "slow" attitude toward change and a "non-aggressive" stance toward innovation, this score can be interpreted as relatively positive [61, 62].

Upon program initiation, 90% of respondents reported a positive experience while cooking with induction stoves. However, respondents expressed unfamiliarity with the broader range of the available menu options for cooking. A majority (81%) felt amenable to adapting to the new culinary process enabled by induction stoves, although they acknowledged a need for extended period for setup preparation. Approximately 78.6% of respondents noted beneficial changes such as simplified stove maintenance and increased child participation in cooking and menu exploration.

Although these respondents accept and are willing to use induction stoves, approximately 26% of households are still uncertain regarding the sustainability of the program and perceive electricity costs/tariffs as a limiting constraint. Almost 35% of respondents are not completely prepared to transition from LPG gas to induction stoves. The remaining 39% displayed continued interest in participating in the program till the current policies prevail (*special). The induction stoves supplied to the program participants were mostly approved to be continued in use (even in a hybrid manner) until the government policies are amended. In total, approximately 89.5% of the respondents commonly express this sentiment. However, altering the policy aspects is anticipated to raise concerns, resulting in a 7.8% decrease in the respondents' interest and sustainability in using induction stoves. This outcome is expected because implementing new technology in a country requires policy and regulatory certainty [26-29].

3.4 Finding and Implication

The comprehensive data collected through questionnaires, interviews, and community observations provided valuable insights. These findings served as a foundation for focus group discussions (FGDs) involving the research team, the PLN team as the program's custodians, and Indonesian government representatives. These discussions aimed to develop strategies for expanding the pilot project to additional regions within Indonesia. The FGD outcomes are summarized in Table 1, listing both short- and long-term strategies to ensure the sustainability of the induction stove conversion program based on the results of the pilot project conducted in Surakarta.

Table 1. Findings and Strategy Implications Based on the Pilot Project

Condition	Potential Causes	Solution Strategy	
		Short-term	**Long-term**
Participants cook for a longer duration.	- Participants are still unfamiliar with the technology and features of induction cookers. - Participants have limited cooking tools for induction stoves.	- The PLN project team, as the program owner, provides regular mentoring and training to the community. - The government establishes an induction stove information center and call center to address challenges faced by the public for using induction stoves. - Organizing events and activities by regional stakeholders (local government) related to induction stoves, including rewards of specialized cooking utensils.	- The government, through the Ministry of Communication and Information, establishes regulations for the promotion and official advertisement for using induction stoves. - Through the Ministry of Education, the government guides instructional material on leveraging induction stove technology at the elementary to high school levels. - Through the Ministry of Industry, the government provides direction for regulations concerning the production of affordable induction-cooking appliances.
The community is enthusiastic, receptive, and gradually adopting induction stoves. Nonetheless, they are hesitant about the program's sustainability and are not yet fully willing to completely transition to induction	Government policies and regulations still within the scope of a pilot project (not yet on a national scale).	- The PLN project team, as the program owner, provides regular support and socialization to the community. - The government establishes an information and induction stove call center to address user doubts.	The government, through the Ministry of Energy and the Ministry of Finance, issues national regulations and policies that ensure the tariff of the induction stove program.

Condition	Potential Causes	Solution Strategy	
		Short-term	**Long-term**
stoves.			
The patterns, types, and frequency of cooking with induction stoves remain unchanged from 3 kg LPG gas stoves; however, the community is still reluctant to enact a 100% substitution from gas stoves to induction stoves.	Government policies and regulations are currently within the scope of a pilot project (not yet implemented on a national scale).	- The PLN project team, as the program owner, provides regular support and socialization to the community. - The government establishes an information and induction stove call center to address user doubts.	The Ministry of Energy and the Ministry of Finance issue national regulations and policies that guarantee the tariff for the induction stove program.
The community prefers using hybrids as it is more energy-efficient, reducing the consumption of 3 kg LPG gas and electricity (under special induction stove tariffs).	The limitation of induction stove-specific cooking appliances and prevalence of owing general cooking equipment	- Organizing events and activity agendas by regional stakeholders (local government) related to induction stoves that offer special prizes for dedicated induction-cooking appliances.	Through the Ministry of Industry, the government guides regulations for producing affordable induction-cooking appliances.

4 Conclusion

This research has provided a comprehensive analysis of induction stove technology adoption in Indonesia, with particular emphasis on the community's social behavior approach. Utilizing descriptive statistical analysis, the study effectively outlined the profile of the Indonesian society over a three-month period subsequent to the induction stove conversion program. In-depth interviews and observations further enriched

the inquiry into the assimilation of this technology. The synthesized findings yield salient insights, highlighting underlying issues that inform both short- and long-term strategic planning for key stakeholders, specifically PT PLN as the program proprietor and the Indonesian government.

Nonetheless, the study possesses certain limitations, primarily its temporal scope, which is confined to a three-month period following the program's inception. This restricted timeframe does not allow for a holistic view of the program's evolution. For future study, ongoing community observations must be carried out in Indonesia to gain a deeper and more comprehensive understanding of the technological transition, thereby enabling the formulation of more nuanced and targeted strategies. The longitudinal study approach can be applied for further research which can be complement with correlation analysis of supporting and inhibiting factors the adoption also sustained use of induction stoves in Indonesia.

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