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Drivers of the Sustainability Performance of Induction Stove Conversion Program in Indonesia

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ABSTRACT

In 2022, Indonesia initiated a pilot project to transition from liquid petroleum gas (LPG) stoves to induction stoves, targeting 8.2 million households by 2025. While LPG is considered a clean cooking fuel by the World Health Organization due to its low PM2.5 emissions, this program aims to further reduce CO2 emissions from cooking activities, aligning with Indonesia's clean energy transition and 2060 Net Zero Emission goals. Throughout the program, doubts and criticisms arose among various sectors of society, particularly concerning the sustainability of this program. This research aims to determine and analyze the driving factors that support the sustainability of the induction stove transition program. Five sustainability aspects, namely, economic, social, environmental, technical, and institutional, were analyzed. A total of 315 Indonesian citizens participated as respondents in this research survey. The Partial Least Squares - Structural Equation Model (PLS–SEM) method was utilized as the analytical approach for the study. The results revealed that nine factors significantly influenced program sustainability, with the strongest impacts from technology costs (path coefficient = 0.859), contextual factors (0.803), electrical infrastructure (0.792), and community perception (0.773). Economic sustainability was driven by technology costs and business opportunities (0.643), while environmental sustainability was strongly influenced by electrical infrastructure. Post-installation support (0.307) and financial management (0.391) significantly impacted technical and institutional sustainability respectively. These empirical findings improve previous research on the sustainability of an energy transition program, which provides insights for researchers and stakeholders in the energy management field, especially in developing countries, for policy determination and decision-making.

Keywords

Energy transition;
Electricity;
Clean energy;
Induction cooker;
Correlation model.

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1. Introduction

In the past two decades, countries worldwide have shifted their focus toward clean energy as part of sustainable development goals [1]. Not only developed nations but also developing countries [2], including Indonesia, are equally enthusiastic about achieving clean energy goals [3]. One of Indonesia's clean energy commitments, among others, is in the cooking technology area. Indonesia has begun to initiate the use of LPG stoves that are categorized as clean cooking technology [4] to replace kerosene stoves in 2007. By 2016, the program had achieved significant success; as of 2023, about 88% of Indonesian households use LPG as their main cooking fuel. This kerosene-to-LPG conversion program was a significant energy policy shift in Indonesia and is often cited as a successful large-scale fuel transition program [5].

However, it's worth noting that the success of this program has led to new challenges, particularly the

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increasing dependence on imported LPG, which is now motivating the government to consider transitioning to induction stoves. This motivation is also in the context of achieving Indonesia's Net Zero Emission target by 2060 [3] through a conversion program of LPG stoves to induction for 8.2 million households by 2025 [6].

Induction stoves are indeed increasingly being adopted in various countries as a more efficient and clean cooking technology. China leads in adoption, with over 150 million units by 2015 [7], while European countries like Germany, France, and Sweden have seen significant uptake, with 17–20% of households using induction stoves [8]. In Asia, Japan and South Korea have high adoption rates, with over 30% of households using induction stoves [9, 10]. The United States [11] and Australia [12] are seeing increasing interest, albeit at a slower pace. Even developing countries like India, Nepal, Myanmar, and some African nations are exploring induction cooking as part of their clean cooking strategies [13].

Indeed, implementation in developing countries still faces many challenges, ranging from infrastructure challenges to cultural resistance [13]. However, Indonesia is trying to initiate a program to convert LPG to induction stoves in order to achieve clean cooking energy targets and reduce LPG imports by running a pilot project program in 2022 [14]. The program was initiated by providing a set of induction stoves along with cooking utensils and free electrical installations with special electricity tariffs to 1,000 Indonesian households [14].

For this pilot project, all equipment, including induction hobs, was provided by the state electricity company to participating households at no cost, allowing for a comprehensive assessment of the program's feasibility and impact. During the pilot project, positive and negative feedback from the Indonesian public about this program emerged. Proponents viewed induction stoves as more efficient, safe, clean, and modern [15], also providing a solution to the market's scarcity of 3-kg LPG cylinders [14].

However, various negative responses arose from opponents, including concerns regarding the large electricity capacity requirement for households (minimum 2,200 VA), which could impact the tariffs. Doubts were also raised concerning the stability of electricity supply from the National Electricity Company (PLN) to households, the perceived mismatch between Indonesian cooking methods and modern stoves, and doubts about future benefits or sustainability for the community [16]. Public opinion, including from the general populace, industry, and parliament, questioned this program's long-term sustainability [17].

Generally, implementing new programs and technologies indeed requires critically examining their sustainability [18]. Sustainability is a concept that refers to the ability to meet the needs of the present without compromising the ability of future generations to meet their own needs [19, 20]. It involves maintaining a balance between economic growth, environmental protection, and social well-being over the long term. Recently, sustainability concepts in implementing new technologies have evolved, encompassing economic, social, and environmental elements as well as technical and institutional ones [21]. Sustainability indicators have also developed with recent concepts such as the circular economy, stakeholder engagement, and creative innovation [22].

Induction stoves are a relatively new cooking technology, particularly in developing countries. Sustainability analyses of induction stove conversion are still continuously explored by experts and researchers. Paudel et al. [23] recently examined the sustainability of implementing induction stoves from an economic perspective related to the public's willingness to pay in Nepal. Yudiartono et al. [24] analyzed electric vehicles and biofuels for transportation, induction stoves and urban gas networks for households based on the National Energy Policy. The result showed that primary energy supply projections need to optimized New Renewable Energy (NRE) power plant use and increase NRE's position in the national energy mix. A Low Emissions Analysis Platform (LEAP) utilized to examined economic sustainability related to energy supply and demand in Indonesia for the implementation of the induction stove program. From a technical perspective, Moraskar and Daigavane [25] evaluated the sustainability aspects of induction stove implementation in India. Others also explored the sustainability of induction stoves from technical, economic, social, and environmental perspectives [26, 27, 28]. However, mostly they focused on financial or economic aspects. To date, no identified model or framework comprehensively discusses all sustainability aspects of implementing induction stoves simultaneously. This study fills this gap by analyzing all aspects of sustainability (economic, social, environmental, technical, and institutional) and examining their interrelationships simultaneously in the implementation of the induction stove conversion program.

This research aims to investigate the factors that support the economic, social, environmental, technical, and institutional sustainability of the induction stove program from the public's perspective, with an empirical case in Indonesia. To identify and analyze the correlation of factors that drive the sustainability of the induction stove program, the Partial Least Squares - Structural Equation Modeling (PLS–SEM) method is applied. The PLS-SEM is a statistical method used for analyzing complex relationships between multiple variables. This method is a variance-based approach to structural equation modeling that is particularly useful for exploratory research [29]. This method is indeed widely applied to assess the readiness and acceptance of implementing new technologies, including in the field of electrification, for instance, in the context of electric vehicles [30, 31] also in the electric household technology [32] among them was induction stoves [14].

This research will contribute to both researchers and practitioners. The theoretical model results can enhance insights for researchers in the field of energy transition conversion, especially in developing countries. Practically, the research findings can serve as stakeholders' considerations to ensure the sustainability of the induction stove program.

2. Background and Implementation of Clean Cooking Technologies

To provide a comprehensive base for this study of Indonesia's induction stove program, it is essential to examine the broader landscape of clean cooking initiatives, with a specific focus on modern and clean cooking technology. This review of existing literature explores three interrelated topics: the concept of modern and clean cooking technologies; modern and clean cooking in Indonesia; and the induction stove transition program with a specific focus on developing nations.

2.1 The concept of modern and clean cooking technologies

Clean cooking technologies have been redefined over time. Initially, the World Health Organization (WHO) and International Organization for Standardization (ISO) defined them based on technical performance, specifically emissions of particulate matter (PM2.5) and carbon monoxide (CO). The WHO's 2014 guidelines set specific emission targets [4], while ISO 19867-3 established a tiered system for cook stove performance [33]. Fuels like solar, electricity, biogas, natural gas, LPG, and alcohol are considered clean, as are biomass stoves meeting specific emission standards [4].

In 2020, the Energy Sector Management Assistance Program (ESMAP) introduced a broader definition: Modern Energy Cooking Services (MECS) [13]. This approach uses a Multi-Tier Framework (MTF), considering six factors: convenience, fuel availability, safety, affordability, efficiency, and reduced exposure to pollutants. A household is categorized as having modern cooking technology if it meets or exceeds Tier 4 requirements in all six categories, with a transition category for those meeting at least Tier 2 standards but not all at Tier 4.

An ESMAP survey [13] across 71 developing countries, which represents 90% of lower and lower-middle-income countries' populations, found that only 24.5% of the 5.3 billion people sampled have access to MECS. Access rates vary significantly by region: Latin America and the Caribbean lead at 56%, followed by East Asia at 36%, while Sub-Saharan Africa lags at 10%. The definition from ESMAP combined with the MECS term provides a more comprehensive understanding of clean cooking, considering user experiences and local contexts beyond just technical specifications.

2.2 Modern and clean cooking technologies in Indonesia

"Indonesia's modern cooking program, termed the Kerosene-to-LPG Conversion Program, initiated in 2007, stands out as a significant example of a large-scale national fuel-switching initiative [5]. The program successfully converted approximately 57 million households (88% of total Indonesian households) from kerosene to LPG by 2016, demonstrating its remarkable scale and effectiveness in transforming national cooking practices [34]."

This ambitious effort significantly reduced the fiscal burden of heavy kerosene subsidies [35, 36]. The Indonesian government's approach involved substantial investments in LPG-specific infrastructure, which allowed for significant economies of scale in distribution and provision. However, despite its success, the program has faced challenges. It has not fully captured all segments of the population, particularly rural end users. Additionally, while switching the subsidy from kerosene to LPG has realized fiscal efficiencies, the subsidy cost continues to rise due to increasing energy demands. By 2020, about 75% of Indonesia's LPG demand had to be imported, burdening the state budget, especially for the 3 kg LPG canister, which is subsidized by the government [1, 35]. The subsidized 3 kg of LPG was intended for low-income households but has not been effectively distributed to those entitled. Middle- and high-income households also use the subsidized LPG, although to a lesser extent.

In order to continue using modern and clean cooking technologies, the Indonesian government aims to gradually reduce dependence on LPG through the promotion of alternative cooking methods, namely induction stoves [14]. This approach aims to reduce the financial burden on the government while also continuing to promote environmental and clean energy. One induction stove produces substantially fewer indoor pollutants than an LPG stove.

2.3 The Induction Stove Transition Program

Induction stove implementation is driven globally by environmental concerns, energy security, health issues, technological advancements, and electrification. Developed countries (e.g., USA, UK, South Korea, Japan) focus on energy efficiency and carbon footprint reduction, while developing nations prioritize clean cooking access, reducing indoor pollution, and decreasing LPG imports [8].

India leads among developing countries, introducing induction cooktops into its energy efficiency program in 2010 [37]. State-level pilot programs began in 2013, with ongoing plans for wider distribution. Nepal began promoting electric cooking around 2016, with significant national initiatives starting in 2018 with the goal of reducing LPG dependence [23].

African countries joined later: Ghana in 2018 [38], Kenya in 2019 [39], and Ethiopia in 2019-2020 [40] began exploring induction cooking, often collaborating with the MECS program. These countries focus on urban areas with reliable electricity and view electric cooking as part of a broader clean cooking strategy.

In Southeast Asia, implementation varies. Indonesia initiated national programs and pilot projects in 2020-2022 through its national state electricity company (PT PLN). Incentives include connection upgrade discounts, free upgrades for new homes with induction stoves, and free stove distribution in pilot areas [14, 41]. Other countries, like Singapore, Thailand, and Malaysia, have seen market-driven adoption [42].

Developing countries face challenges including infrastructure limitations, cultural barriers, economic constraints, competition from established technologies, and a lack of domestic manufacturing capabilities [23, 37, 43, 44]. Despite these challenges, induction stove programs remain attractive for their potential benefits. The complex implementation process requires addressing infrastructure, affordability, cultural factors, and policy integration simultaneously. This makes the analysis of these programs' sustainability an intriguing area for further exploration.

3. Conceptual Model and Hypotheses

Recently, the sustainability aspects are developing, which not only focus on the environmental, economic, and social but also technical and organizational institutions. This study adopted a research model by Poudel et al. [21], which was adjusted to the context of induction stove applications and strengthened with the relevant literature. Then, to formulate research hypotheses, the exploration results were employed.

3.1 Social Sustainability

Newly implemented technologies must have social impacts on society, including improving quality of life and education, enhancing public health (e.g., through reduced workload), and increasing job opportunities for residents [45]. In a past study, Poudel et al. [21] considered aspects directly related to social sustainability, such as contextual conditions comprising electricity tariff tax structure, subsidy factors, electricity access flexibility and ease, and electricity supply stability. These aspects are relevant to the induction stove study [35]. This description forms the basis for hypothesis formulation:

H1: Contextual factors positively influence social sustainability.

Poudel et al. [21] also consider the project team's knowledge to support social sustainability. The community's information and knowledge regarding new technology in a region are the foundation for long-term implementation success [46]. Communities require as much knowledge and support concerning the operationalization and maintenance of new technology, how to obtain it, the adequacy and stability of electricity supply needs, and program policies such as subsidies, tariffs, and promotions [47]. These aspects support the community's understanding of whether the program or new technology opportunities can continue to be employed to improve their social welfare [48]. Thus, knowledge from the program implementation team becomes crucial [49]. Past studies have proven that the implementation team's knowledge positively influences the program's social sustainability [21]. The previous literature exploration is closely related and relevant to this research; thus, the hypothesis formulation is as follows:

H2: The implementation team's knowledge has a positive impact on social sustainability.

User perceptions correlate with social sustainability [28]. These perceptions are closely related to social backgrounds, such as age, occupation, and income [50], as well as the influence of promotional advertisements [51].

Positive community perceptions are more likely to support community acceptance [52], as communities tend to accept the advantages and benefits of implementing new programs and technologies [53]. Communities are motivated to take advantage of opportunities that arise from the multiplier effect of technology implementation [54]. The literature exposition forms the following hypothesis:

H3: User perceptions of technology positively influence the social sustainability.

3.2 Economic Sustainability

Economic sustainability aspects of implementing electrical technology programs are related to productive electricity usage, access to local market products, and post-installation support that contributes to the growth of local businesses. Such growth ultimately increases electricity sales revenue [55].

Implementing new electricity-related technology considers cost and device efficiency during operationalization [56, 57]. These costs comprise the initial purchase, maintenance, and repairs [36]. Reasonable costs support the economic sustainability of implementing new technology programs [23]. This description provides a formulation for the following hypothesis:

H4: The cost of technology usage has a positive influence on economic sustainability.

Implementing new technology is expected to be advantageous for businesses and create new entrepreneurial opportunities [21, 45]. The existence of new business opportunities supports stakeholders' economic sustainability [45, 58].

In the context of induction stoves, these opportunities may arise, including in the electronics equipment business [58], induction cooker tools for households and restaurants [59], and related industries such as distribution, electronic materials/components, and food businesses [60]. This explanation provides the basis for the formulation of the following hypothesis:

H5: Business opportunities in technology implementation in the community positively influence economic sustainability.

3.3 Environment Sustainability

Environmental sustainability is related to energy efficiency and pollution reduction [61, 62]. The social lifestyle of the community may be associated with environmental sustainability [21]. Communities that understand the importance of saving fossil fuels and using environmentally friendly technology wisely can also maintain their environment, ultimately supporting long-term environmental sustainability [21, 23].

In the case of induction stoves, the technology is scientifically proven to be more efficient than kerosene stoves [63] and emits no carbon pollution during cooking [26]. The community's consistent use of induction cookers can save energy and reduce carbon pollution. Based on this description, the following hypothesis is formulated as follows:

H6: The lifestyle of technology usage in cooking positively influences environmental sustainability.

Users of environmentally friendly technology require stable energy supply support because it is related to operational use [64]. This means that pollution reduction and energy efficiency are achieved when the technology and energy sources are distributed stably and consistently so that the community is confident that the supply is adequate [64, 65].

This description is relevant to the implementation of induction stove technology because cooking activities are a daily routine for most households and food businesses. Ensuring a stable electrical energy distribution infrastructure for users can encourage the use of induction stoves for daily cooking continuity, which implies gradual and sustainable environmental sustainability. This description is the basis for the following hypothesis:

H7: Infrastructure for community electricity distribution has a positive impact on environmental sustainability.

3.4 Technical Sustainability

Technical sustainability relates to meeting technical needs, including reliability and maintenance, as well as the function and efficiency of local industry's capability to support technical issues of the technology [66, 67], procurement of materials, and handling of technology waste [68]. Some researchers have begun to emphasize technical sustainability's importance in complementing environmental, economic, and social sustainability, especially in implementing new technology [69, 70].

Previous studies have shown that the project team's competence in explaining technical matters to the general public is critical, as it supports the public's understanding of how to ensure the technology's long-term reliability [21]. This exposition closely aligns with the context of the induction stove program, as this technology is entirely new to most Indonesian households [14], thus forming the basis for the following hypothesis:

H8: The technical competence of the project team positively influences technical sustainability.

Technical sustainability also includes repair ability and future availability of spare parts [71]. This is closely related to the readiness of actions accompanying the implementation and post-installation of new technology [21].

Aspects of continuous technology installation support can be reflected in the support of service facilities and daily operational standards [21], supporting software [72], and the involvement of user communities who already have technical understanding [69, 70]. This description is consistent with Indonesia's implementation of the induction stove program and can serve as the foundation for the following hypothesis:

H9: Post-installation technology support positively influences technical sustainability.

3.5 Institutional Sustainability

Institutional sustainability is related to an institution or organization's ability to consistently fulfill the mission of implementing technology programs that are its long-term objectives amidst changing environmental conditions and market demands [73]. It involves managing resources wisely, building trust and good relationships with stakeholders, and maintaining the organization's integrity and credibility [21]. Stable and consistent institutions for program and technology implementation support long-term sustainability success [74].

Team performance within organizations with a strong commitment to program implementation success through planning and execution also supports institutional sustainability [21]. Other researchers also argued that programs funded by mature organizational management tend to have good institutional sustainability [49, 74]. The performance of the management team in supporting this conversion program has the potential to influence institutional sustainability; thus, the following hypothesis is as follows:

H10: Organizational management team performance positively influences institutional sustainability.

Another important aspect of institutional sustainability is financial management, including transparency, regular financial audit resolution, and planning for spare parts inventory funding and system maintenance [21, 75]. Financial management is an essential part of this aspect [73, 76].

In the context of induction stove conversion in Indonesia, the financial aspect of institutions provides the basic framework for program sustainability [35, 36], making it crucial for the institutional sustainability of the program organizer organization. This exposition establishes the following hypothesis:

H11: The financial management of the program organization positively influences institutional sustainability.

2.6 Sustainability Linkage

Most researchers argue that aspects of sustainability have the potential to be interrelated [19, 77]. Social sustainability is related to economic sustainability [21, 45], because communities with good social living standards and education are more likely to leverage opportunities to increase income from program and technology implementation [21]. These opportunities can encourage communities to migrate to new technologies, which, from the business perspective of electricity providers and the government in Indonesia, are also more efficient and economical than importing LPG [35, 36]. This exposition forms the basis for the following hypothesis:

H12: Social sustainability has a positive influence on economic sustainability.

Economic sustainability is also related to technical sustainability [21, 45]. A program implementing new technology supported by facilities and infrastructure that is ready for the long term supports the business of that technology [45].

In terms of technology and economics sustainability, a proven modern and efficient technology, supports the economic aspect of an organization or industry [78, 79]. This research description is relevant to the induction stove conversion program. Thus, the formulated hypothesis is as follows:

H13: Technical sustainability has a positive influence on economic sustainability.

Technical sustainability must be integrated with the readiness of the implementing institution. Poudel et al. [21] presented their study in the field of mini-grid technology implementation, finding that technical sustainability correlates positively with institutional sustainability.

Likewise, with several other field studies [80, 81]. This exposition forms the basis for the following hypothesis:

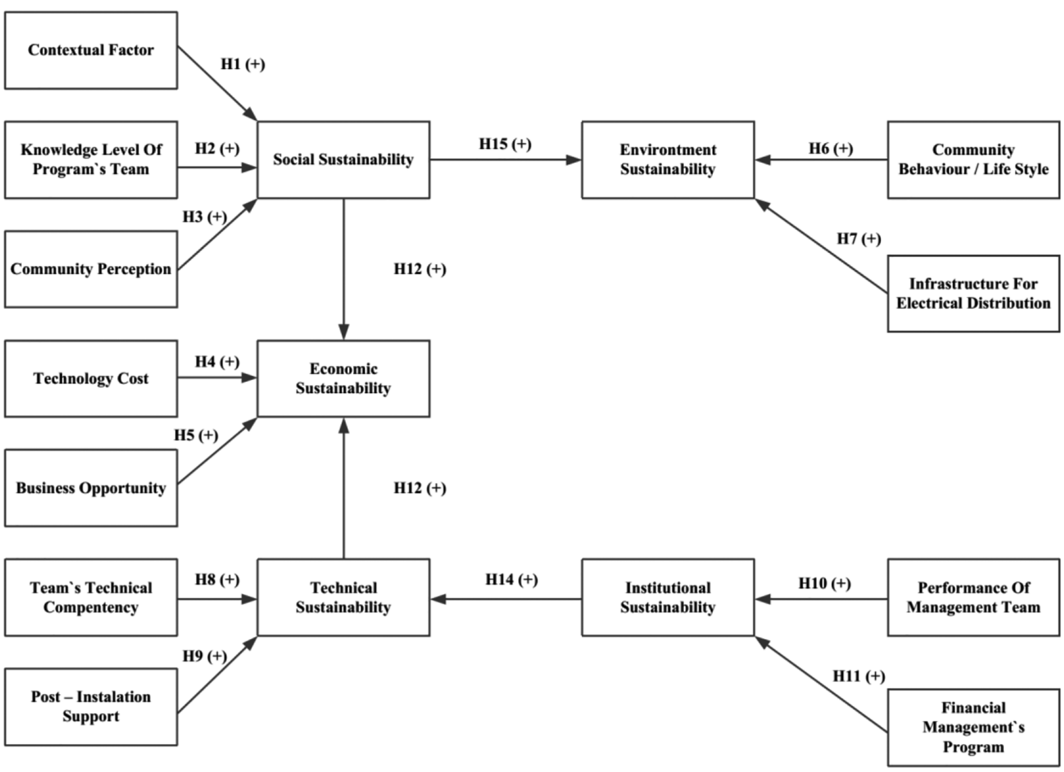
H14: Technical sustainability has a positive influence on institutional sustainability.

In the context of the induction stove conversion program, improvements in social sustainability can reduce LPG consumption because electricity on induction stoves is targeted to minimize carbon emissions into the environment from cooking activities [63]. Thus, social sustainability is also related to environmental sustainability [21, 45].

Communities with good livelihoods and incomes are likely to shift from their conventional energy consumption patterns (such as firewood and kerosene) and begin using electrical appliances (such as rice cookers, blenders, and electric stove) [2, 43]. Therefore, the hypothesis formulated from this exposition is as follows:

H15: Social sustainability has a positive influence on environmental sustainability.

As shown in Figure 1, the formulation of these hypotheses serves as the basis for building this research's conceptual model.



Hn : nth hypothesis; (+) : positive correlation.

Figure 1: The conceptual model.

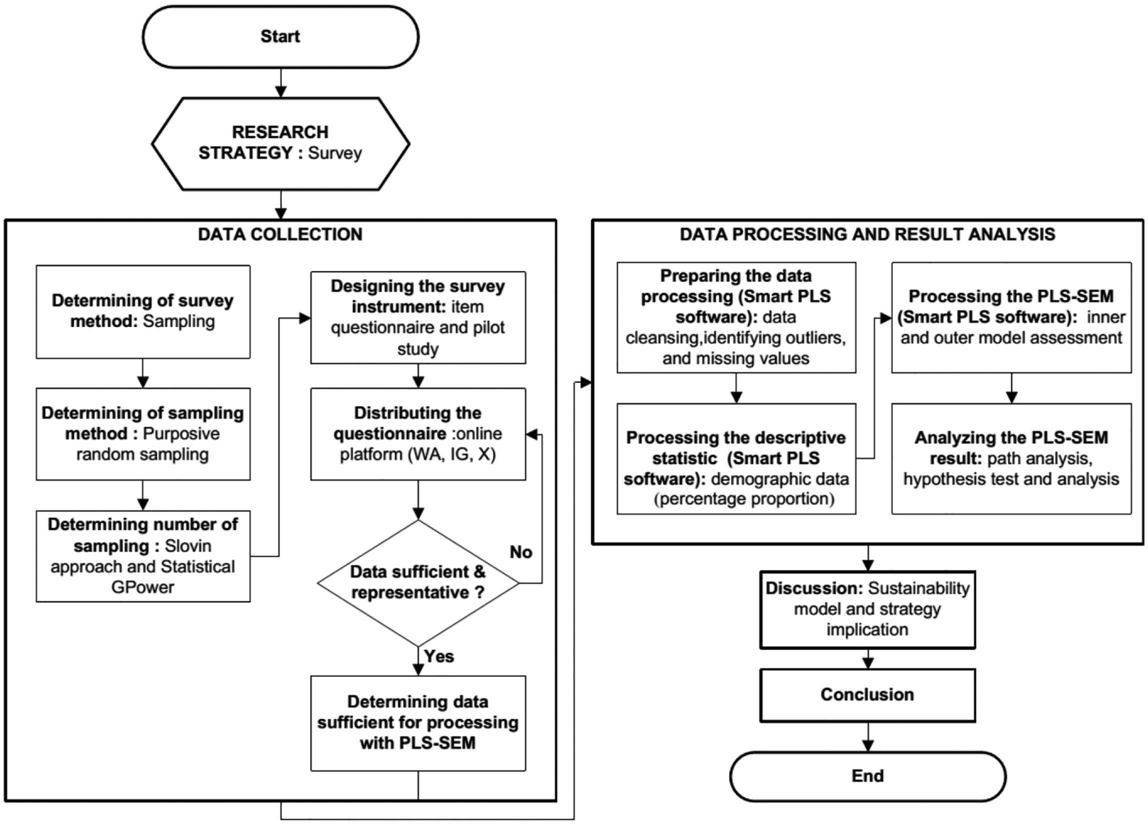


Figure 2: The research methodology.

4. Methods and Data

This section outlines the research strategy and data collection, followed by an explanation of the data processing and analysis used in this research. The research methodology flowchart is presented in Figure 2.

4.1 Research Strategy and Data Collection

This section explains the data collection strategy, which includes an explanation of the survey mechanism, the amount and mechanism of data collection, and how to develop and distribute research instruments.

4.1.1 Determining the data collection

Surveys were employed as the strategy for data collection. This study involved respondents from the Indonesian community who were 21 years of age and over, which is considered the age of adulthood where one can respond to surveys wisely [82] and as they are presumed to have an understanding of policies related to adopting new technologies [83]. According to data from the Central Statistics Agency of Indonesia, in 2023, there were 200 million adults spread across 33 provinces [84].

4.1.2 Determining the sampling method

In relation to project reporting, data collection was allocated for two months. In this context, a sampling strategy was used to capture respondents' perceptions in this induction stove sustainability analysis. The purposive random sampling approach with Slovin's formulation (Equation 1) was used to calculate the minimum sample size to ensure population representation.

$$n = \frac{N}{\left(1 + N\left(e^2\right)\right)} \tag{1}$$

Where 'n' represents the minimum sample size required for the study, 'N' was the total population size from which the sample is drawn, and 'e' denotes the desired level of precision, also known as the margin of error. In this study, it used a population size (N) of 200 million, representing the adult population of Indonesia. The margin of error (e) set in this research was at 10%, which corresponds to a 90% confidence level.

With a population target of 200 million respondents, the sample minimum required was 100. However, to strengthen the population representation, sample calculations with Gpower with the StatPower software application were carried out [85] (for 10% error rate specification; Power (1-β err prob): 0.90; Effect size f^2: 0.05), and a minimum sample of 293 was required. By applying these methods for sampling calculation, the required sample size for the survey was 100 – 293 respondents.

4.1.3 Designing the survey instrument

An efficient survey strategy to reach a large population with a spread demographic area is a questionnaire [58]. Indeed, questionnaire is beneficial to be able to reach respondents widely, but it has several weaknesses, among others the potential for limited depth in responses and misinterpretation of questions by respondents. Therefore, in future research, it will need to complement data collection with other approaches, such as interviews, to enhance data quality.

The instrument was a constructively designed questionnaire that initially consisted of 70 questions. The question items for this instrument were developed by elaborating previous questionnaire literature that was in line with it, including those related to the adoption of new electricity-based technology, especially in the household context.

A pilot study was done to ascertain the questionnaire's validity and reliability prior to its administration to actual respondents. Thirty pilot respondents participated in evaluating the initial version of the questionnaire, and its items were assessed using Cronbach's alpha. Items with a Cronbach's alpha of at least 0.7 were deemed acceptable as measurement indicators. After conducting a pilot study, 50-item questionnaires were obtained, which were declared valid and reliable for data collection.

The questionnaire was originally conducted in Indonesian (https://bit.ly/3TPupTO), with an English translation available for reference (https://bit.ly/3yqA4Yz). This research questionnaire used a five-point Likert scale, with a scale of 1 indicating strongly disagreeing and a scale of 5 indicating strongly agreeing. This scale was filled in by respondents based on their choices and opinions. To maintain the ethical aspects of the research, in the introduction of the questionnaire it was clearly stated that the researcher maintains confidentiality by anonymizing all data collected.

4.1.4 Distributing the questionnaire

In order to reach a sample of respondents spread across Indonesia, the questionnaire was distributed online through WhatsApp (WA) groups, Instagram (IG), and Twitter (X) platforms. After two months of distribution, the questionnaire has successfully reached 315 respondents. After data cleansing, 300 valid respondent data points were obtained, and this amount met the minimum sample requirement and was therefore ready for further analysis. Although the data is sufficient, it would be better if the longer period of online questionnaire distribution increase the number of respondents, which is expected to further increase the adequacy of the data.

4.1.5 Determining sufficiency data for PLS-SEM

In this study, PLS-SEM was used for statistical correlation analysis. According to the 10-time rule standard for PLS-SEM, the sample size must be at least 10 times the largest number of indicators used to measure a construct [86]. With 300 respondent data, it is feasible to further process it in the PLS-SEM correlation statistical mechanism.

4.2 Data Processing

Data analysis commenced with cleansing and identifying outliers and missing values. Descriptive statistics probed respondent demographics. The types of descriptive statistics used in this research, namely proportion (percentage) of the respondent gender and age. Furthermore, the PLS-SEM examined variable influences and relationships affecting the induction stove program's sustainability.

The SmartPLS 4.0 software is applied to support data processing, which is commonly used for correlation-based statistical exploratory studies [87]. The model analysis was conducted by measuring the outer model, including its validity and reliability, and the structural model (inner model).

5. Result and Model Measurement

This section covers respondents' demographics, outer model assessment for validity and reliability, and inner model assessment for correlation factors.

5.1 Respondent's demographics

Of the 300 respondents' data, 69% were women, with ages ranging from 25–35 years (74%), followed by the age group of 36–46 years (14%), and others. The predominance of female respondents (69%) in this sample reflects traditional Indonesian household dynamics where women typically handle cooking responsibilities [88,89] with the age of married women ranging from 20 to 50 years [90]. While this may accurately represent the primary users of cooking technology in Indonesia, it potentially underrepresents male perspectives on the induction stove program. Future research should actively seek more balanced gender participation to capture diverse household viewpoints on cooking technology adoption.

This research online survey methodology resulted in a sample predominantly comprising respondents aged 25-35 years (74%). This age skew presents limitations, namely it was underrepresentation of older generations who may have different cooking habits and technology adoption patterns, and it was limited insight into the perspectives of more experienced household decision-makers. For future study, it is recommended to apply stratified sampling to ensure better representation across age groups. Furthermore, the use of online platforms for survey distribution in this research indeed has the potential to introduce several biases, among others limited participation from rural populations with less reliable internet access; exclusion of individuals less comfortable with digital technologies and underrepresentation of elderly populations who may be less active on social media. This sampling method may have inadvertently favored urban respondents with better digital connectivity, potentially missing crucial insights from rural communities who might face different challenges in adopting induction stoves, such as less reliable electrical infrastructure, different cooking habits and needs, varying levels of technical support availability.

Future research should employ a mixed-method strategy that combines both online and offline surveys to reach a broader demographic spectrum. The offline surveys would be particularly valuable for engaging elderly participants and those less comfortable with digital technology, who were underrepresented in this current study. Additionally, conducting in-depth interviews with these underrepresented groups would provide richer, more nuanced insights into their perspectives, concerns, and needs regarding the induction stove program. This approach would help capture valuable feedback from segments of the population that may face unique challenges in adopting new cooking technologies but whose voices are crucial for developing an inclusive and effective implementation strategy.

5.2 Outer Model Assessment

The developed model uses the PLS-SEM method, which is reflective. The calculations were performed for internal consistency reliability (composite reliability [CR]), convergent validity (factor loading and average variance extracted [AVE]), discriminant validity (heterotrait-monotrait [HTMT]), and variance inflation factor (VIF) to analyze multicollinearity [86]. To support these calculations, SmartPLS 4.0 was employed (the result resumed in Table 1).

Table 1: Outer model assessment.

Construct	Item	Factor loadings	CR	AVE	VIF
Social sustainability (SCS)	SCS–1	0.778	0.864	0.679	2.221
	SCS–2	0.689			2.135
	SCS–3	0.812			1.222
Economic sustainability (ECS)	ECS–1	0.818	0.936	0.879	1.534
	ECS–2	0.801			1.244
	ECS–3	0.705			1.571
Environment sustainability (EVS)	EVS–1	0.753	0.860	0.680	2.111
	EVS–2	0.861			1.725
	EVS–3	0.822			1.315
Technical sustainability (TCS)	TCS–1	0.741	0.888	0.726	1.596
	TCS–2	0.847			1.423
	TCS–3	0.856			1.758
	TCS–4	0.881			1.441

(Table 1 continued)

(Table 1 continued)

Institutional Sustainability (ISS)	ISS–1	0.664	0.832	0.713	1.112
	ISS–2	0.732			1.231
	ISS–3	0.655			1.411
Contextual factor (CNF)	CNF–1	0.615	0.815	0.687	2.264
	CNF–2	0.667			2.160
	CNF–3	0.752			2.373
Knowledge level of the program team (KLT)	KLT–1	0.880	0.912	0.839	2.355
	KLT–2	0.844			2.446
	KLT–3	0.797			2.560
Community perception (CMP)	CMP–1	0.868	0.821	0.708	1.445
	CMP–2	0.713			1.352
	CMP–3	0.743			1.634
Technology cost (TCC)	TCC–1	0.799	0.902	0.821	1.692
	TCC–2	0.823			1.542
	TCC–3	0.838			1.483
Business opportunity (BOP)	BOP–1	0.812	0.844	0.715	1.555
	BOP–2	0.799			2.783
	BOP–3	0.805			2.888
Community behavior (CMB)	CMB–1	0.765	0.822	0.816	1.748
	CMB–2	0.772			1.893
	CMB–3	0.809			1.826
Infrastructure for electrical distribution (IED)	IED–1	0.810	0.857	0.722	1.590
	IED–2	0.794			1.677
	IED–3	0.746			1.458
Team's technical competency (TTC)	TTC–1	0.822			1.613
	TTC–2	0.798			1.728
	TTC–3	0.721	0.871	0.699	1.447
Post-–installation Support (PIS)	PIS–1	0.833	0.842	0.642	1.448
	PIS–2	0.759			1.397
	PIS–3	0.751			1.551
Performance of Management Team (PMT)	PMT–1	0.763	0.827	0.708	1.306
	PMT–2	0.819			1.887
	PMT–3	0.840			1.596
Financial Management's Program (FMP)					
	FMP–1	0.812	0.890	0.730	1.460
	FMP–2	0.838			1.620
	FMP–3	0.827			1.961

This model is adequate for analyzing the correlated factors that influence the induction stove conversion program's sustainability. As assessed by CR, all model variables are within the range of 0.60–0.95, which indicates that the indicator items within each variable are consistent enough to reflect their constructs [91].

Indicator items are also valid, as indicated by factor loading values all above 0.6 and AVE values above 0.50, meaning the indicator items can explain more than half of their respective model variable constructs [29]. To ensure that indicator items do not measure variables outside of their constructs, discriminant validity based on HTMT was also conducted, showing the model is sufficiently valid, with indicator items within the same construct being high (>0.80) and no inter-construct variables exceeding 0.85 [91].

5.2 Structural (inner) Model Assessment

The measurement of the structural (inner) model PLS-SEM is also supported by SmartPLS 4.0 software. This measurement comprises collinearity; significance and model applicability; coefficient determination (R^2); effect size (f^2); model prediction (Q^2); and the exogenous construct's contribution (q^2) [29,91]. The collinearity of the structural model was analyzed from the VIF values, and all model variable VIF values were less than 5, indicating no inter-correlation among variables [29].

Model significance was examined by bootstrapping with the default software SMARTPLS 4.0 replication, 5,000 sampling. Significance was assessed from the calculation of P and t statistics with a 10% error, according to the characteristics of exploratory models [87]. Based on a 10% error rate (or 90% confidence level), the hypothesis cannot be rejected if the P-value is less than 0.1 (10%) and the t value is above 1.65. The P and t values in Table 2 display the significance of path analysis between variables implicated in the model hypothesis.

The model assessment (Table 2) reveals that 13 tested hypotheses demonstrate significance and support the hypotheses, whereas two paths do not. Two factors that are not correlated with each other (P > 0.05) are knowledge level team (KLT) and social sustainability (SCS) (H2; P = 0.294), community behavior (CMB), and environment sustainability (EVS) (H6; P = 0.201).

Details of the hypothesis test results and analysis are presented as follows:

a. Contextual factors positively influence social sustainability.

The acceptance of this hypothesis highlights the importance of electricity policies, subsidies, and access in supporting the induction stove program's social sustainability in Indonesia. This aligns with previous research projections and emphasizes how these factors can create job

Table 2: Path analysis for hypothesis test.

Hyp	Path	Path coefficients	*t* statistics	*P*-values	Hypothesis result
H1	CNF → SCS	0.803	5.099	0.000	Supported*
H2	KLT → SCS	0.048	1.618	0.294	Not supported
H3	CMP → SCS	0.773	6.150	0.000	Supported*
H4	TCC → ECS	0.859	2.901	0.008	Supported*
H5	BOP → ECS	0.643	3.250	0.000	Supported*
H6	CMB → EVS	0.223	0.768	0.201	Not supported
H7	IED → EVS	0.792	6.101	0.000	Supported*
H8	TTC →TCS	0.081	4.051	0.000	Supported*
H9	PIS → TCS	0.307	2.485	0.003	Supported*
H10	PMT → ISS	0.132	3.771	0.002	Supported*
H11	FMP → ISS	0.391	3.441	0.001	Supported*
H12	SCS → ECS	0.240	6.043	0.000	Supported*
H13	TCS → ECS	0.146	5.325	0.000	Supported*
H14	ISS → TCS	0.132	2.211	0.009	Supported *
H15	SCS → EVS	0.122	4.003	0.000	Supported*

Note: * indicated significant support the hypothesis: if *t* value >1.645; *P*-value <0.10.

opportunities, promote equity through accessibility, and enhance overall societal well-being [21, 35]. These findings underscore the need for policymakers to carefully consider these contextual elements when implementing energy transition programs, as they play a crucial role in ensuring widespread benefits and long-term social sustainability.

b. The team's knowledge does not have a positive impact on social sustainability.

The rejection of this hypothesis is an unexpected finding that contradicts some previous studies (a.i., Poudel et al.[21]). This finding suggests that while technical knowledge is crucial for program implementation, it alone may not directly impact into social sustainability outcomes. This aligns with recent research indicating that social sustainability requires a more holistic approach beyond technical competency [92, 93].

Several factors might explain this unexpected result. First, there may be a gap between technical knowledge and its practical application in community settings. Second, cultural and social barriers could impede effective knowledge transfer. Third, other factors, such as community engagement strategies or local cultural dynamics, might have a stronger direct impact on social sustainability. Fourth, the complex nature of Indonesian society, where diverse cultural and social norms influence technology adoption patterns, may affect how technical knowledge translates into social outcomes.

This finding has important implications for future program implementation. Programs should consider adopting a more integrated approach that combines technical knowledge with social and cultural competencies. There is also a need to develop better mechanisms for translating team knowledge into community-level impacts. Additionally, how to measure and evaluate team knowledge in the context of social sustainability may need to be redefined.

Moving forward, program implementations should focus on three key areas. First, team training should expand beyond technical aspects to include community engagement skills. Second, new metrics should be developed to better capture the relationship between team knowledge and social outcomes. Third, more effective mechanisms for knowledge transfer between program teams and communities need to be established.

c. User perceptions of technology positively influence social sustainability.

This hypothesis is accepted and underscores the crucial role of public opinion in the success of the induction stove program in Indonesia. This finding aligns with previous research on the importance of community perceptions in supporting the social sustainability of new technology implementations [93, 94]. It suggests that positive views about induction stoves—potentially regarding their efficiency, safety, health benefits, or modernity—contribute to broader social acceptance and sustainable adoption.

This result strengthens the importance of public education, effective communication strategies, and addressing concerns to shape favorable perceptions [21, 95]. It implies that efforts to improve user perceptions could significantly enhance the social sustainability of the induction stove program, potentially leading to better community acceptance, more widespread adoption, and longer-term social benefits.

d. The cost of community technology usage has a positive impact on economic sustainability.

The acceptance of this hypothesis aligns with previous research, such as studies in Ecuador [26, 47], Ghana [38], and India [37], which emphasize the importance of cost considerations in energy transition programs. The positive influence suggests that when the costs associated with induction stoves—including purchase, installation, maintenance, and electricity usage—are perceived as reasonable by users, it contributes to the program's economic sustainability. This likely stems from increased adoption rates, reduced financial burden on households, and potential long-term savings compared to LPG use [36]. For policymakers and program implementers, this underscores the need to focus on cost-effective solutions, possibly through subsidies or innovative financing mechanisms, to ensure widespread adoption and the program's economic viability [35, 96].

e. Business opportunities for technology implementation in the community have a positive impact on economic sustainability.

This hypothesis is accepted, meaning that it underscores the economic potential of the induction stove program beyond just energy transition. This result aligns with previous research on the economic impacts of new technology adoption [97, 98].

The positive influence suggests that the induction stove program is creating new business opportunities in various sectors, such as electronics equipment, induction cooker tools for households and restaurants, and related industries like distribution and electronic components. These opportunities contribute to economic growth, job creation, and diversification of the local economy, all of which support the program's economic sustainability.

For policymakers, this result highlights the importance of fostering an environment that supports entrepreneurship and business development around induction stove technology, potentially through targeted incentives or support programs for small and medium enterprises in this sector.

f. The lifestyle of technology usage in cooking does not positively influence environmental sustainability.

This is an unexpected finding that contradicts some initial expectations (a.i., Paudel et al. [21]; Fiza et al. [99]; Hrvoje et al. [100]). This result suggests that, in Indonesia's induction stove program, the adoption of induction cooking technology alone may not directly translate into improved environmental sustainability as anticipated.

While induction stoves are generally more energy-efficient and produce fewer emissions than traditional cooking methods, this finding indicates that other factors may be more influential in determining environmental outcomes. It's possible that lifestyle factors, such as cooking habits or overall energy consumption patterns, are not changing significantly enough with the adoption of induction stoves to notably impact environmental sustainability.

This result is in line with previous research findings, which highlight the complexity of behavior change and suggest that community lifestyle alone may not be sufficient to drive environmental benefits [101]. It implies that additional measures, such as targeted education on energy-efficient cooking practices or broader environmental awareness campaigns, might be necessary to realize the full environmental potential of the induction stove program.

g. Infrastructure for community electricity distribution has a positive impact on environmental sustainability.

Acceptance of this hypothesis highlights the critical role of reliable energy infrastructure in achieving environmental goals through the induction stove program. This finding aligns with research on the importance of a stable electricity supply in supporting clean energy transitions [35, 102]. The positive influence suggests that a robust and widespread electrical distribution system encourages consistent use of induction stoves, potentially reducing reliance on less environmentally friendly cooking fuels. It implies that as electricity infrastructure improves, it becomes more feasible for households to sustainably adopt and use induction stoves, leading to reduced emissions and energy efficiency gains.

For policymakers, this underscores the importance of investing in and improving electrical infrastructure as a key component of the program's environmental sustainability strategy [103]. It also suggests that the environmental benefits of induction stoves are closely tied to the broader context of a country's energy system and its transition to cleaner electricity sources [21].

h. The project team's technical expertise has a positive impact on technical sustainability.

This acceptance hypothesis aligns with previous research on the implementation of new technologies [104, 105], particularly in energy transition projects [21]. The positive influence implies that a technically competent team is better equipped to address challenges ranging from electrical infrastructure issues to operational constraints. This competence likely translates into more effective installation, maintenance, and troubleshooting of induction stoves, ensuring their reliable operation over time.

For program implementers, this result highlights the need to invest in the training and development of technical staff, as well as the importance of recruiting individuals with relevant expertise. It implies that building and maintaining a skilled technical team is crucial for overcoming technical hurdles and sustaining the program's effectiveness in the long run [106].

i. Post-installation technology has a positive impact on technical sustainability.

This hypothesis result aligns with the research on the importance of after-sales service in technology adoption [21]. The positive influence suggests that elements such as call centers, service centers, and the availability of spare parts contribute significantly to the technical sustainability of induction stoves. This support likely helps users overcome operational challenges, ensure prompt repairs, and maintain the functionality of the stoves over time.

For program implementers, this result emphasizes the need to establish robust support systems beyond the initial installation phase. It implies that investing in accessible and efficient post-installation support can enhance user satisfaction, prolong the lifespan of the technology, and ultimately contribute to the program's technical sustainability [21, 107].

j. Organizational management team performance positively influences institutional sustainability.

Acceptance of this hypothesis underscores the critical role of effective leadership and management in ensuring the long-term viability of the induction stove program in Indonesia. This finding aligns with research on the importance of robust institutional frameworks in sustaining energy transition initiatives [108, 109]. The positive influence suggests that a well-performing management team contributes to the program's ability to adapt, evolve, and maintain its relevance over time. This likely involves effective decision-making, strategic planning, and efficient resource allocation.

For stakeholders, this result emphasizes the need to invest in developing strong management capabilities within the implementing institutions. It implies that focusing on enhancing team performance through training, clear organizational structures, and performance metrics can significantly contribute to the program's institutional sustainability [92, 93]. This finding highlights that the success of the induction stove program depends not just on technical aspects, but also on the quality of its organizational management.

k. The program organization's financial management has a positive influence on institutional sustainability.

In this study, this hypothesis is accepted and highlights the critical role of sound financial practices in ensuring the long-term viability of the induction stove program in Indonesia. This finding aligns with research on the importance of financial stability in sustaining large-scale energy transition initiatives [110]. The positive influence suggests that effective financial management, including aspects such as transparent budgeting, regular financial audits, and strategic financial planning, contributes significantly to the program's ability to operate consistently and adapt over time [21, 24].

For program implementers and policymakers, this result strengthens the need to prioritize robust financial systems and practices within the implementing organizations [35]. It implies that investing in financial expertise, implementing strong financial controls, and ensuring transparency in financial operations can enhance the induction stove program's credibility, efficiency, and long-term sustainability.

l. Social sustainability has a positive influence on economic sustainability.

This hypothesis is accepted and underscores the interconnected nature of social and economic factors in the induction stove program in Indonesia. This finding aligns with research on the synergies between social and economic aspects of sustainable development [21, 45]. The positive influence suggests that improvements in social conditions, such as better living standards and education, can lead to enhanced economic outcomes. In the context of the induction stove program, this could mean that as communities become more socially stable and educated about the benefits of induction cooking, they are more likely to adopt and efficiently use the technology, leading to economic benefits.

For policymakers, this result highlights the importance of considering social factors when designing economic strategies for the program. It implies that investments in social aspects, such as community education and engagement, can yield economic dividends, potentially through increased adoption rates, more efficient use of resources, and the creation of new economic opportunities related to the induction stove technology.

m. Technical sustainability has a positive influence on economic sustainability.

This acceptance hypothesis aligns with research on the economic benefits of technically robust energy solutions [78,79]. The positive influence suggests that a well-maintained, reliable, and efficient induction stove system contributes to economic sustainability by potentially reducing long-term costs, minimizing disruptions, and enhancing user satisfaction.

For program implementers and policymakers, this result underscores the importance of investing in quality technology, regular maintenance, and technical support systems. It implies that ensuring the technical sustainability of induction stoves through proper design, installation, and ongoing support can lead to economic benefits such as reduced operational costs, increased adoption rates, and potentially new business opportunities in related services.

n. Technical sustainability has a positive influence on institutional sustainability.

Technical sustainability has a positive influence on institutional sustainability, highlighting the important link between technical reliability and organizational longevity in the Indonesian induction stove program. This finding aligns with research on the interdependence of technical and institutional aspects in technology adoption programs [80, 81].

The positive influence suggests that a technically sustainable system, characterized by reliable performance and efficient maintenance, contributes to the stability and credibility of the implementing institutions. For program managers and policymakers, this result highlights the importance of maintaining high technical standards as a means of strengthening the institutional framework.

It implies that investing in robust technical systems, ongoing technical training, and continuous improvement processes can enhance the implementing organization's ability to adapt, evolve, and maintain its relevance over time. This finding emphasizes that technical excellence is not just about the technology itself, but also plays a crucial role in building and maintaining strong, enduring institutions capable of supporting the long-term success of the induction stove program.

o. Social sustainability has a positive influence on environmental sustainability.

The positive influence suggests that improvements in social conditions, such as better education, awareness, and community engagement, can lead to enhanced environmental outcomes. This result aligns with previous research on the synergies between social well-being and environmental conservation in sustainable development initiatives [21, 45].

In the context of the induction stove program, this could mean that as communities become more socially stable and informed about the benefits of clean cooking, they are more likely to adopt and consistently use induction stoves, leading to reduced emissions and energy efficiency gains. For policymakers and program implementers, this result underscores the importance of social factors in achieving environmental goals. It implies that investments in social aspects, such as community education and awareness programs about clean energy and environmental conservation, can yield significant environmental benefits. This finding emphasizes that addressing social sustainability is not just beneficial for communities, but also plays a crucial role in realizing the environmental objectives of the induction stove program.

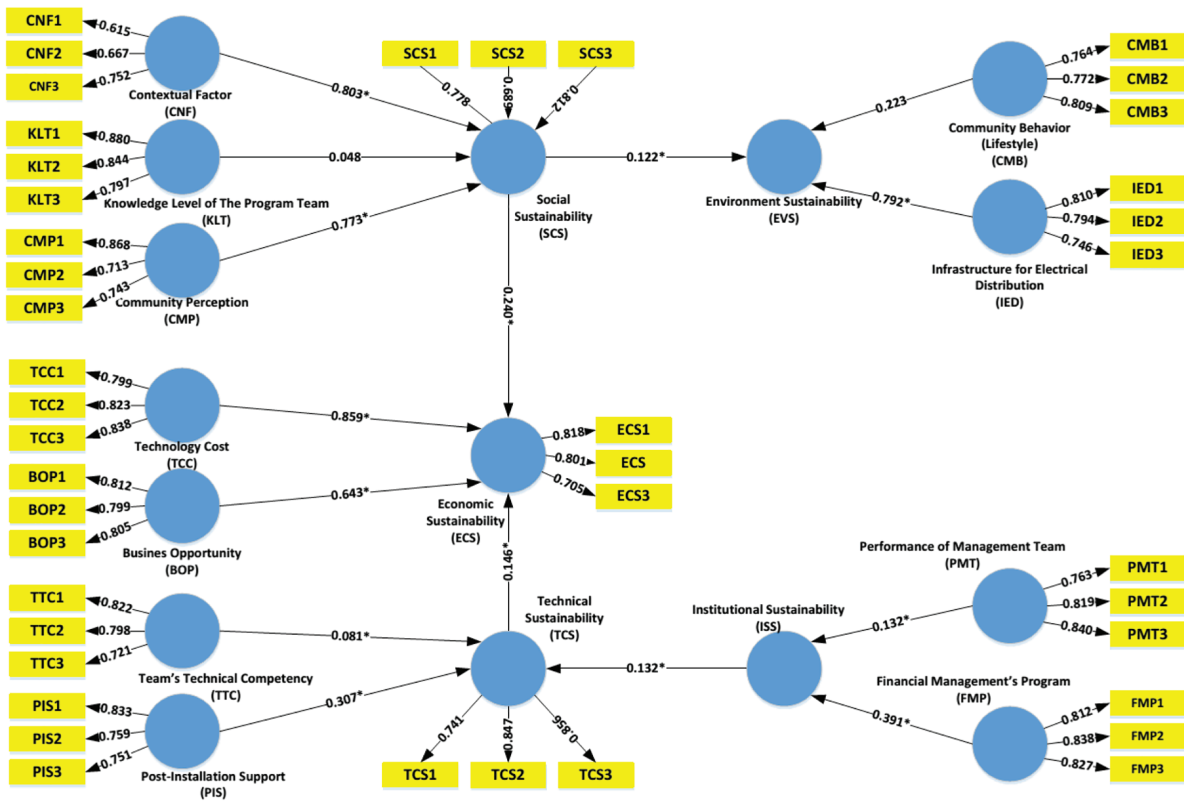
Based on the hypothesis test results, the path model sustainability for the Indonesian induction stove program is presented in Figure 3.

6. Analysis and Discussion

This passage explains the factors that influence the performance of the induction stove conversion program across social, economic, environmental, technical, and institutional sustainability.

6.1 Social sustainability achievement

The induction stove conversion program's social sustainability in Indonesia is influenced by two significant variables: contextual factors and positive community



Note: * significant positive correlation.

Figure 3: Final model for path coefficients and correlations.

perception. Contextual factors relate to electricity tariff policies and regulations, subsidy programs for induction cooking appliances, and the availability and flexibility of electricity access in the community. This reinforces Hakam et al.'s study [35], which conceptually projected that these factors support the implementation of induction stove programs in Indonesia.

Policies, regulations, electricity programs, and their promotions are critical factors for electricity-based technology implementations' success [111, 112], as empirically evidenced in this study. These factors support the induction stove program's social sustainability in Indonesia, promoting the opening of new job opportunities for the community and ensuring society's health, safety, security, and comfort.

Community perception also contributes to social sustainability. These findings strengthen the study on community perception and support the social sustainability of implementing new technology [113]. Positive community perceptions must be established and conditioned from the program's inception for long-term implementation success [114].

6.2 Economic sustainability achievement

Supporting economic sustainability in Indonesia's induction stove conversion program entails both technology costs and business opportunities. Affordable technology costs impact economic sustainability, covering stove prices, utensils, installation, maintenance, and damage, including electrical installation. Economic sustainability ties to household and governmental financial benefits, including savings from not purchasing LPG cylinders periodically. The government's logical technology costs are critical for the community to switch to induction stoves [23], which aligns with the findings of this study.

With appropriate technology costs for implementing the induction stove conversion program, the government can reduce the budget for importing LPG materials, saving state expenditures. This finding is in line with the implementation of induction stoves in Ecuador [47], Ghana [38], and India [115].

This study also confirms that improving performance in technical aspects or technical sustainability supports economic sustainability. Technical sustainability support facilitates the financial benefits of energy conversion projects for both the community and the country [116].

6.3 Environment sustainability achievement

Environmental sustainability is influenced by electrical infrastructure and social sustainability. The assurance of stable electricity distribution to induction stove users and the sustainable social welfare of the community motivate people to use induction stoves for cooking, which is projected to strongly contribute to reducing carbon emissions and maintaining environmental sustainability [117].

Although there is a positive correlation, Indonesian society's lifestyle has yet to significantly influence environmental sustainability in this program. Comfort factors affect people's intention to utilize induction stoves based on environmental awareness. Nevertheless, the introduction of environmentally friendly electrical appliances to society in Indonesia remains to be improved, and strong encouragement from the Indonesian government is necessary [44].

6.4 Technical sustainability achievement

The first significant aspect influencing the technical sustainability of this conversion program in Indonesia is the competence of the technical team involved in the program. The technical team must have knowledge and competence to address various challenges, which range from electrical infrastructure to operational constraints [72].

The second aspect is post-installation support. To support the long-term reliability and durability of the technical products, call centers, service centers, and the availability of spare parts for induction stoves are required. Another aspect is technical support for post-installation electrical facilities, which must be supported by electricity providers. In the implementation of new technologies, after the initiation or introduction phase, an ecosystem that supports the program [118] must be provided, including technical facilities [21].

Furthermore, institutional sustainability significantly correlates with technical sustainability. This means that the presence of institutions with excellent organizational and financial team management supports the technical sustainability aspect of this program. This finding aligns with studies on the sustainability of implementing new technologies in various fields [21].

6.5 Institutional sustainability achievement

Institutional sustainability is affected by the performance of management teams and the financial management of programs. This underscores the need for institutions, both governmental and non-governmental, to commit to professional performance aligned with the conversion program team.

Such institutions require long-term institutional financial management and system support. This has been proven in various implementations of new technologies and programs in the energy field [119, 120].

7. Managerial Implication

The nine factors supporting program sustainability (economic, social, environment, technical, and institutional) consist of contextual factors, community perception, technology cost, business opportunity, infrastructure for electrical distribution, the team's technical competency, post-installation support, the performance of the management team, and financial management's program. Those factors imply strategies requiring development and reinforcement by various stakeholders (Table 3).

Table 3: Strategy for supporting induction stove conversion program sustainability.

Factors	Strategy	References	Stakeholders	Policy Recommendation
Contextual Factors	Policies and regulations (e.g., electrical tariff, subsidy, and others) aligned across the central and regional levels	[34, 35, 44, 121, 122] [5, 34, 123]	Ministry of Energy and Mineral Resources, Ministry of Finance, Ministry of Trade and Industry, National State Electricity Company, National Standardization Agency.	Targeted Subsidies: Subsidy system for induction stoves based on household income levels. Incentives for early adopters to accelerate the transition.
Community perception	Social media influencer strategy, training cooking,		Ministry of information and communication, Ministry of Women's Empowerment and	Educational Campaign: Develop comprehensive awareness programs highlighting the benefits of induction cooking. Conduct community-based

(Table 3 continued)

(Table 3 continued)

			Child Protection, Press and media	demonstrations and workshops to familiarize potential users with the technology. Create targeted messaging for different demographic groups, addressing their specific concerns and needs.
Technology Cost	women's community with induction stoves Standardized, affordable parts and maintainable induction stove designs.	[25, 34, 124]	Ministry of Industry, Induction stove manufacturers, National standardization agency	Research and Development Funding: Funding for research into more efficient and cost-effective induction cooking technologies. National Standardization Agency establishing quality standards that balance affordability with performance and safety.
Business Opportunity	Create a business climate (e.g., banking loans, training) for induction stove businesses.	[35, 121]	Ministry of Small and Medium Enterprises, Ministry of State-Owned Enterprises, Ministry of Tourism and Creative Economy.	Financial Incentives for society: Favorable banking loans for small and medium enterprises in the induction stove supply chain Training programs for entrepreneurs interested in induction stove businesses. Incentives for existing businesses to transition to induction stove-compatible products and services. Provide tax incentives for businesses investing in induction cooking technology
Infrastructure for Electrical Distribution	Strengthening national electricity infrastructure and a new renewable energy power plant (gradually).	[125 - 128]	Ministry of Energy and Mineral Resources, Ministry of State-Owned Enterprises National State Electricity Company and its subsidiaries.	Infrastructure Investments: Prioritize upgrading electrical infrastructure in areas targeted for induction stove adoption. Invest in smart grid technologies (other renewable energy power) to improve power distribution efficiency
Team's Technical Competency	Team training in technical and soft skills.	[41, 129]	Ministry of Manpower, Professional Competency Institutions	Capacity Building: Invest in training programs for local technicians to build capacity for installation and maintenance of induction stoves. Develop partnerships with educational institutions to incorporate induction cooking technology into relevant vocational programs. Create a certification program for induction stove installers and technicians
Post Installation Support	Special call center, technology failure guarantees, training, and community assistance	[41, 129]	Ministry of Manpower, Professional Competency Institutions, Higher education institutions.	Dedicated support system: Call center for induction stove users. A network of certified technicians. Community assistance programs.
Performance of Management Team	Reward system	[75, 130]	Ministry of State-Owned Enterprises National State Electricity Company, Professional Competency Institutions	Financial Program Reward system for management teams overseeing the induction stove program. Develop key performance indicators (KPIs) specifically tailored to measure the effectiveness of management in implementing and sustaining the program.
Financial Management's Program	Structured and transparent funding, special finance team	[21, 35]	Ministry of Finance, state financial institutions	A specialized finance team for the program.

8. Conclusion

This research examines factors aiding sustainability in Indonesia's induction stove conversion program across social, economic, environmental, technical, and institutional dimensions. Key factors supporting social sustainability include contextual policies, regulations, and electricity access (path coefficient = 0.803), as well as community perception (path coefficient = 0.773). Economic sustainability is primarily driven by technology costs (path coefficient = 0.859) and business opportunities (path coefficient = 0.643). Electrical infrastructure, which ensures stable and widespread electricity supply, strongly supports environmental sustainability (path coefficient = 0.792).

Post-installation support had the strongest positive influence on technical sustainability (path coefficient = 0.307), followed by team technical competency (path coefficient = 0.081). Institutional sustainability is significantly impacted by program financial management (path coefficient = 0.391) and the performance of the management team (path coefficient = 0.132).

This research also confirms prior findings on sustainability aspects. Social sustainability bolsters economic (path coefficient = 0.240) and environmental aspects (path coefficient = 0.122), aligning with research on the synergies between social and economic factors in sustainable development [21,45,19]. Technical sustainability impacts economic sustainability (path coefficient = 0.146), supporting studies on the economic benefits of technically robust energy solutions [78,79]. Institutional sustainability influences technical sustainability (path coefficient = 0.132), consistent with research on the interdependence of technical and institutional aspects in technology adoption programs [80,81].

The findings of this research have significant implications for the design and implementation of future clean cooking and energy transition programs, both in Indonesia and potentially in other developing countries, as follows:

- Policy Development: Understanding the strong influence of contextual factors (path coefficient = 0.803) on social sustainability can guide policymakers in crafting more effective regulations and incentives. Future programs could prioritize creating supportive policy environments that address electricity access, tariffs, and subsidies to enhance program acceptance and sustainability.
- Community Engagement: The importance of community perception (path coefficient = 0.773) in social sustainability underscores the need for robust community engagement and education strategies in future programs. This could involve developing targeted communication campaigns and participatory planning processes to build public support and understanding.
- Economic Viability: The significant impact of technology costs (path coefficient = 0.859) on economic sustainability suggests that future programs should focus on strategies to reduce costs and enhance affordability. This might include exploring bulk procurement, local manufacturing, or innovative financing mechanisms to make clean cooking technologies more accessible.
- Infrastructure Development: The strong link between electrical infrastructure and environmental sustainability (path coefficient = 0.792) highlights the need for integrated planning of energy transition programs. Future initiatives should consider coordinating cooking technology transitions with broader electrification efforts to maximize environmental benefits.
- Technical Support Systems: The importance of post-installation support (path coefficient = 0.307) for technical sustainability emphasizes the need for comprehensive after-sales service in future programs. This could involve developing local technical capacity, establishing service centers, and creating user support networks.
- Institutional Capacity Building: The influence of financial management (path coefficient = 0.391) on institutional sustainability suggests that future programs should invest in building robust financial systems and management capacity within implementing organizations.

Furthermore, the interconnections between different sustainability aspects (economic, social, environmental, technical, and institutional) underscore the need for holistic, integrated approaches to program design. Future initiatives should consider these complex relationships to create more comprehensive and effective strategies.

By applying these insights, future clean cooking and energy transition programs can be designed with a more nuanced understanding of the factors that contribute to long-term sustainability. This could lead to more effective implementation, improved adoption rates, and ultimately greater success in achieving clean energy goals and improving quality of life in developing countries.

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References

[1] UNESCAP. Energy Transition Pathways for the 2030 Agenda - SDG 7 Roadmap for Indonesia. New York: United Nation; 2020. https://www.unescap.org/resources/energy-transition-pathways-2030-agenda-sdg7-roadmap-indonesia (accessed April 3, 2024).

[2] Babayomi OO, Dahoro DA, Zhang Z. Affordable clean energy transition in developing countries: Pathways and technologies, iScience (2022) p 104-178. https://doi.org/10.1016/j.isci.2022.104178.

[3] International Energy Agency (IEA). An Energy Sector Roadmap to Net Zero Emissions in Indonesia. Indonesia: IEA Publicatons; 2022. https://www.iea.org/reports/an-energy-sector-roadmap-to-net-zero-emissions-in-indonesia (accessed March 15, 2024).

[4] WHO Team. Indoor Air Quality Guidelines: Household Fuel Combustion. Geneva: World Health Organization;2014. https://www.who.int/publications/i/item/9789241548885 (accessed August 10, 2024).

[5] Thoday K, Benjamin P, Gan M, Puzzolo E. The Mega Conversion Program from kerosene to LPG in Indonesia: Lessons learned and recommendations for future clean cooking energy expansion, Energy Sustain Dev (2018) p 71-81, https://doi.org/10.1016/j.esd.2018.05.011.

[6] IESR. Indonesia Energy Transition Outlook 2023: Tracking Progress of Energy Transition in Indonesia: Pursuing Energy Security in the Time of Transition. Jakarta: Institute for Essential Services Reform (IESR); 2022. https://iesr.or.id/wp-content/uploads/2024/03/Indonesia-Energy-Transition-Outlook-2023.pdf (accessed April 9, 2024).

[7] Zhou Y, Huang X, Peng S, L. Li. Comparative study on the combustion characteristics of an atmospheric induction stove in the plateau and plain regions of China. Appl. Therm. Eng. 111 (2017) p 301–307. https://doi.org/10.1016/j.applthermaleng.2016.09.095.

[8] Rizky DL, Damayanti RW, Laksono P W. Induction Stove Implementation for Sustainable Clean Energy Consumption: A Literature Study, Renewable Energy Systems and Sources. ICRCE 2023. Kolhe ML. Ed. Singapore: Springer (2023) p 93–103. https://doi.org/10.1007/978-981-99-6290-7_8.

[9] Pie OC. The Gas vs Induction stove debate. Japan: Japan Simple Life; 2023. https://japansimplelife.com/viewtopic.php?t=831 (accessed August 9, 2024).

[10] Kim HJ, Lim SY, Yoo SH. Are Korean households willing to pay a premium for induction cooktops over gas stoves?. Sustain. 9 (2017) p 1-10. https://doi.org/10.3390/su9091546.

[11] Daouda M, Carforo A, Miller H, Ventrella J, Tan YA, Feliciano M, Tryner J, Hallward-Driemeier A, Chillrud S, Commane R, Hernández D, Johnson M, Jack D. Out of Gas, In with Justice: Findings from a gas-to-induction pilot in low-income housing in NYC, Energy Res. Soc. Sci. 116 (2024) p 1–10. https://doi.org/10.1016/j.erss.2024.103662.

[12] EnergyAustralia. Is an induction cooktop right for you?. Australia; 2020. https://www.energyaustralia.com.au/blog/better-energy/induction-cooktop-right-you (accessed August 9, 2024).

[13] Energy Sector Management Assistance Program (ESMAP). The State of Access to Modern Energy Cooking Services. Washington, DC: World Bank; 2020.

[14] Damayanti RW, Setiadi H, Laksono PW, Rizky DL, Entifar NAE. Factors Affecting Technological Readiness and Acceptance of Induction Stoves : A Pilot Project. Emerg. Sci. J. 7 (2024) p 1892–1923. https://doi.org/10.28991/ESJ-2023-07-06-04.

[15] Banerjee M, Prasad R, Rehman IH, Gill B. Induction stoves as an option for clean cooking in rural India. Energy Policy 88 (2016) p 159–167. https://doi.org/10.1016/j.enpol.2015.10.021.

[16] Pratiwi CD, R. Damayanti RW, Laksono PW. Public Sentiment Analysis to Support Indonesian Government Induction Stove Program. E3S Web Conf. 465 (2023) p. 02006. https://doi.org/10.1051/e3sconf/202346502006.

[17] Purwanti A. The Long Road to Converting LPG to Induction Stove. Jakarta: Kompas; 2022 p 17. https://www.kompas.id/baca/riset/2022/09/20/jalan-panjang-konversi-lpg-ke-kompor-induksi (accessed December 2, 2024).

[18] Kshirsagar VS, Pawar PM, Mehetre ST, Holistic approach for biogas technology implementation to improve sustainability. Curr. Sci. 116 (2019) p 249–255. https://doi.org/10.18520/cs/v116/i2/249-255.

[19] Ben-Eli MU. Sustainability: definition and five core principles, a systems perspective. Sustain. Sci. 13 (2018) p 1337–1343. https://doi.org/10.1007/s11625-018-0564-3.

[20] Ruggerio CA. Sustainability and sustainable development: A review of principles and definitions. Sci. Total Environ. 786 (2021) p 147481. https://doi.org/10.1016/j.scitotenv.2021.147481.

[21] Poudel B, Parton K, Morrison M. The drivers of the sustainable performance of renewable energy-based mini-grids. Renew. Energy 189 (2022) p 1206–1217. https://doi.org/10.1016/j.renene.2022.03.006.

[22] Glavič P. Updated Principles of Sustainable Engineering. Processes. 10 (2022). https://doi.org/10.3390/pr10050870.

[23] Paudel J, Sharifi A, Khan GD. What are the drivers of sustainable energy transition? Insights from an empirical analysis of household preferences for electric induction cooking in Nepal. J. Clean. Prod. 417 (2023) p 138021. https://doi.org/10.1016/j.jclepro.2023.138021.

[24] Yudiartono Y, Windarta J, Adiarso A. Sustainable Long-Term Energy Supply and Demand: The Gradual Transition to a New and Renewable Energy System in Indonesia by 2050. Int. J. Renew. Energy Dev. 12 (2023) p 419–429. https://doi.org/10.14710/ijred.2023.50361.

[25] Moraskar A, Daigavane PM. Analysis &Design of Technical Feasibility of Electric Cooking for Scalable India, *in 10th International Conference on Emerging Trends in Engineering and Technology - Signal and Information Processing* (ICETET-SIP-22) (2022) p 1–6. https://doi.org/10.1109/ICETET-SIP-2254415.2022.9791496.

[26] Martínez-Gómez J, Ibarra D, Villacis S, Cuji P, Cruz PR. Analysis of LPG, electric and induction cookers during cooking typical Ecuadorian dishes into the national efficient cooking program, Food Policy 59 (2016) p 88–102. https://doi.org/10.1016/j.foodpol.2015.12.010.

[27] Ochoa Avilés JP, E Silva VVR, Tofoli FL. Household induction cooking system based on a grid-connected photovoltaic system. IET Circuits. Devices Syst. 14 (2020) p 1117–1128. https://doi.org/10.1049/iet-cds.2019.0305.

[28] Ahmad W, Hassan M, Masud SFB, Amjad MS, Samara F, Zeshan, Anwar M, Rafique MZ, Nawaz T. Socio-economic benefits and policy implications of generating sustainable energy from municipal solid waste in Pakistan. Energy Clim. Chang. 5 (2024) p. 100124. https://doi.org/10.1016/j.egycc.2023.100124.

[29] Hair JF, Sarstedt M, Hopkins L, Kuppelwieser VG. Partial least squares structural equation modeling (PLS-SEM): An emerging tool in business research. Europe Business Review 2014;26:106–121. https://doi.org/10.1108/EBR-10-2013-0128.

[30] Abudayyeh D, Almomani M, Almomani O, Jaber D, Alhelo E. Examining the Determinants of Electric Vehicle Acceptance in Jordan: A PLS-SEM Approach. World Electr. Veh. J. 14 (2023) p 1–24. https://doi.org/10.3390/wevj14110304.

[31] Sundarakani B, Rajamani HS, Madmoune A. Sustainability study of electric vehicles performance in the UAE: moderated by blockchain. Benchmarking 31 (2024) p 199–219. https://doi.org/10.1108/BIJ-10-2021-0624.

[32] Duc ML, Viet QNK. Analysis Affect Factors of Smart Meter A PLS-SEM Neural Network. Int. Res. J. Adv. 4 (2022) p 288–301. https://doi.org/10.47392/irjash.2022.071.

[33] ISO/TR 19867-3:2018(E). Clean cookstoves and clean cooking solutions — Harmonized laboratory test protocols — Part 3: Voluntary performance targets for cookstoves based on laboratory testing vol. 2018. Geneva: ISO; 2018.

[34] Astuti SP, Day R, Emery SB, A successful fuel transition? Regulatory instruments, markets, and social acceptance in the adoption of modern LPG cooking devices in Indonesia. Energy Res. Soc. Sci. 58 (2019) p 101248. https://doi.org/10.1016/j.erss.2019.101248.

[35] Hakam DF, Nugraha H, Wicaksono A, Rahadi RA, Kanugrahan SP. Mega conversion from LPG to induction stove to achieve Indonesia's clean energy transition. Energy Strateg. Rev. 41 (2022) p 100856. https://doi.org/10.1016/j.esr.2022.100856.

[36] Al Irsyad MI, Anggono T, Anditya C, Ruslan I, Cendrawati DG, Nepal R. Assessing the feasibility of a migration policy from LPG cookers to induction cookers to reduce LPG subsidies. Energy for Sustainable Development 70 (2022) p 239–246. https://doi.org/10.1016/j.esd.2022.08.003.

[37] Menghwani V, Zerriffi H, Dwivedi P, Marshall JD, Grieshop A, Bailis R. Determinants of Cookstoves and Fuel Choice Among Rural Households in India 16 (2019) p 21–60. https://doi.org/10.1007/s10393-018-1389-3.

[38] T Tawiah T, Iddrisu S, Gyaase S, Twumasi M, Asante KP, Jack D. The feasibility and acceptability of clean fuel use among rural households. A pilot study in Central Ghana. J. Public Health Africa 13 (2022) p 1–11. https://doi.org/10.4081/jphia.2022.2205.

[39] Osiolo HH. Cook stove technology adoption: Evidence from Kenya. Energy Sustain. Dev. 63 (2021) p 133–144. https://doi.org/10.1016/j.esd.2021.06.004.

[40] Ganewo Z, Kare S, Mulugeta M, Alemu A, Mathewos M. Determinants of improved cookstove adoption and its benefits Ethiopia. World J. Innov. Res. 3 (2023) p 2454–8236. https://doi.org/10.21203/rs.3.rs-3526232/v1.

[41] Damayanti RW, Setiadi H, Kurnianto DK, Entifar NAE. Configuration Analysis of Technology Readiness, Technology Acceptance, and Public Satisfaction Regarding Continued Induction Stove Use in Indonesia. Int. J. Adv. Sci. Eng. Inf. Technol. 14 (2) p 428–438. https://doi.org/10.18517/ijaseit.14.2.19010.

[42] Tama A. Deployment of Electric Induction Technologies into Cooktops Plates as a Part of Energy Sustainability. Smart Grid Renew. Energy 13 (2022) p 55–74. https://doi.org/10.4236/sgre.2022.133004.

[43] Gould CF, Schlesinger SB, Molina E, Bejarano ML, Valarezo A, Jack DW. Household fuel mixes in peri-urban and rural Ecuador: Explaining the context of LPG, patterns of continued firewood use, and the challenges of induction cooking. Energy Policy 136 (2020) p 111053. https://doi.org/10.1016/j.enpol.2019.111053.

[44] Hilmiyati-Mas'adah H, Sudiro A, Rohman F, Yuniarinto A, Hakam DF, Nugraha H. Assessing the Impact of Urban

Lifestyle and Consumption Values on Conversion Intention: A Study towards Energy Sustainability. *Sustain.* 15 (2023) p 1–18. https://doi.org/10.3390/su15086549.

[45] Wanamaker C. The Environmental, Economic, and Social Components of Sustainability. Soapboxie; 2022. https://soapboxie.com/social-issues/The-Environmental-Economic-and-Social-Components-of-Sustainability (accessed July 9, 2024).

[46] Broska LH. It's all about community: On the interplay of social capital, social needs, and environmental concern in sustainable community action. Energy Res. Soc. Sci. 79 (2021) p 102165. https://doi.org/10.1016/j.erss.2021.102165.

[47] Goldemberg J, Martinez-Gomez J, Sagar A, Smith KR. Household air pollution, health, and climate change: Cleaning the air. Environ. Res. Lett. 13 (2018). https://doi.org/10.1088/1748-9326/aaa49d.

[48] Vidhi R, Shrivastava P, Parikh A. Social and Technological Impact of Businesses Surrounding Electric Vehicles. Clean Technol. 3 (2021) p 81–97. https://doi.org/10.3390/cleantechnol3010006.

[49] Apenko SN, Fomina IA. Analysis of the maturity of sustainable project management in Russian enterprises in the transition to the digital economy. J. Sib. Fed. Univ. - Humanit. Soc. Sci. 12 (2019) p 530–544. https://doi.org/10.17516/1997-1370-0407.

[50] Digalwar AK, Thomas RG, Rastogi A. Evaluation of Factors for Sustainable Manufacturing of Electric Vehicles in India. Procedia CIRP 8 (2021) p 505–510. https://doi.org/10.1016/j.procir.2021.01.142.

[51] Z Tarigan ZJH. The influence of social media marketing on customer loyalty through perceived usefulness of streaming technology, perceived enjoyment, and brand loyalty. Int. J. Data Netw. Sci. 8 (2024) p 1001–1016. https://doi.org/10.5267/j.ijdns.2023.12.007.

[52] Spampatti T, Hahnel UJJ, Trutnevyte E, Brosch T. Short and long-term dominance of negative information in shaping public energy perceptions: The case of shallow geothermal systems. Energy Policy 167 (2022) p 113070. https://doi.org/10.1016/j.enpol.2022.113070.

[53] Xiao J, Goulias KG. Perceived usefulness and intentions to adopt autonomous vehicles. Transportation Research Part A: Policy Practice. Transp. Res. Part A Policy Pract. 161 (2022) p 170–185. https://doi.org/10.1016/j.tra.2022.05.007.

[54] Irwin NB. Sunny days: Spatial spillovers in photovoltaic system adoptions. Energy Policy 151 (2021) p 112192. https://doi.org/10.1016/j.enpol.2021.112192.

[55] Sanguino R, Barroso A, Fernández-Rodríguez S, Sánchez-Hernández MI. Current trends in economy, sustainable development, and energy: a circular economy view. Environ. Sci. Pollut. Res. 27 (2020) p 1–7. https://doi.org/10.1007/s11356-019-07074-x.

[56] Arianpoo N, Islam ME, Wright AS, Niet T. Electrification policy impacts on land system in British Columbia, Canada. Renew. Sustain. Energy Transit. 5 (2024) p 100080. https://doi.org/10.1016/j.rset.2024.100080.

[57] Abdallah SM, Bressers H, Clancy JS. Energy reforms in the developing world: Sustainable development compromised?. Int. J. Sustain. Energy Plan. Manag. 5 (2015) p 41–56. https://doi.org/10.5278/ijsepm.2015.5.5.

[58] Market Research Report 2019-2022. Induction Stove Market Size, Share & Industry Analysis. Fortune Business Insight; 2023. https://www.fortunebusinessinsights.com/induction-stove-market-104494 (accessed December 20, 2023).

[59] Verghese S. Induction Cookstop Market. Future Market Insight; 2023. https://www.futuremarketinsights.com/reports/induction-cooktops-market (accessed December 20, 2023).

[60] Foulds C, Khalid R, Jensen EA, Sule O, Lorenz L. Social responsibility in research and innovation practice and policy across global regions, institutional types, and fields: Interview data and qualitative content analysis outputs revealing the perspectives and experiences of professionals. Open Res. Eur. 3 (2023). https://doi.org/10.12688/openreseurope.15688.1.

[61] Ali K, Kausar N, Amir M. Impact of pollution prevention strategies on environment sustainability: role of environmental management accounting and environmental proactivity. Environ. Sci. Pollut. Res. 30 (2023) p 88891–88904. https://doi.org/10.1007/s11356-023-28724-1.

[62] Din AU, Ming J, Rahman IU, Han H, Yoo S, Alhrahsheh RR. Green road transportation management and environmental sustainability: The impact of population density. Heliyon 9 (2023) p 19771. https://doi.org/10.1016/j.heliyon.2023.e19771.

[63] J Martínez J, Martí-Herrero J, Villacís S, Riofrio AJ, VacaD. Analysis of energy, CO2 emissions and economy of the technological migration for clean cooking in Ecuador. Energy Policy 107 (2017) p 182–187. https://doi.org/10.1016/j.enpol.2017.04.033.

[64] Zhao F, Bai F, Liu X, Liu Z. A Review on Renewable Energy Transition under China's Carbon Neutrality Target. Sustain. 14 (2022). https://doi.org/10.3390/su142215006.

[65] Popkova EG, Sergi BS. Energy infrastructure: Investment, sustainability and AI. *R*esour. Policy 91 (2024) p 104807. https://doi.org/10.1016/j.resourpol.2024.104807.

[66] T Kativhu T, Mazvimavi D, Tevera D, Nhapi I. Implementation of Community Based Management (CBM) in Zimbabwe: The dichotomy of theory and practice and its influence on sustainability of rural water supply systems. Phys. Chem. Earth 106 (2018) p 73–82. https://doi.org/10.1016/j.pce.2018.05.003.

[67] Dauenhauer PM, Frame D, Eales A, Strachan S, Galloway S, Buckland H. Sustainability evaluation of community-based, solar photovoltaic projects in Malawi. Energy. Sustain. Soc. 10 (2020). https://doi.org/10.1186/s13705-020-0241-0.

[68] Ferdoush MR, Al Aziz R, Karmaker CL, Debnath B, Limon MH, Bari ABMM. Unraveling the challenges of waste-to-energy transition in emerging economies: Implications for sustainability. Innov. Green Dev. 3 (2024) p 100121. https://doi.org/10.1016/j.igd.2023.100121.

[69] Mukhtar N. Conceptual Model of Technical Sustainability for Integration into Electrical/Electronic Engineering Programmes in Nigerian Polytechnics. IEEE Access. 8 (2020) p 128519–128535. https://doi.org/10.1109/ACCESS.2020.3002579.

[70] Mukhtar N, Bin Kamin Y, Saud MSB. Quantitative validation of a proposed technical sustainability competency model: A PLS-SEM approach. Front. Sustain. 3 (2022). https://doi.org/10.3389/frsus.2022.841643.

[71] Moreira-Santos D, Au-Yong-Oliveira M, Palma-Moreira A. Fintech Services and the Drivers of Their Implementation in Small and Medium Enterprises. Inf. 13 (2022). https://doi.org/10.3390/info13090409.

[72] Wong S, Yeung JKW, Yip Lau Y, So J. Technical sustainability of cloud-based blockchain integrated with machine learning for supply chain management. Sustain. 13 (2021) p 1–20. https://doi.org/10.3390/su13158270.

[73] Morse S, McNamara N. This Is Where We Have Scored': Exploring the Interface between Project and Institutional Sustainability Facilitated by a Faith-Based Development Organisation in Sierra Leone. Sustain. 15 (2023). https://doi.org/10.3390/su15097292.

[74] Hondroyiannis G, Sardianou E, Nikou V, Evangelinos K, Nikolaou I. Energy market dynamics and institutional sustainability: How affect the Europe's circular economy. Circular Economy. Circ. Econ. 2 (2023) p 100048. https://doi.org/10.1016/j.cec.2023.100048.

[75] Kayaga S, Mugabi J, Kingdom W. Evaluating the institutional sustainability of an urban water utility: A conceptual framework and research directions. Util. Policy 27 (2013) p 15–27. https://doi.org/10.1016/j.jup.2013.08.001.

[76] Nicli S. Socio-economic, political, and institutional sustainability of agroforestry in alta verapaz, guatemala. J. Agric. Rural Dev. Trop. Subtrop. 120 (2019) p 105–117. https://doi.org/10.17170/kobra-20190613561.

[77] Purvis B, Mao Y, Robinson D. Three pillars of sustainability: in search of conceptual origins. Sustain. Sci. 14 (2019) p 681–695. https://doi.org/10.1007/s11625-018-0627-5.

[78] Schöggl JP, Rusch M, Stumpf L, Baumgartner RJ. Implementation of digital technologies for a circular economy and sustainability management in the manufacturing sector. Sustain. Prod. Consum. 35 (2023) p 401–420. https://doi.org/10.1016/j.spc.2022.11.012.

[79] Chen X, Kurdve M, Johansson B, Despeisse M. Enabling the twin transitions: Digital technologies support environmental sustainability through lean principles. Sustain. Prod. Consum. 38 (2023) p 13–27. https://doi.org/10.1016/j.spc.2023.03.020.

[80] Nagariya R, Kumar D, Kumar I. Sustainable service supply chain management: from a systematic literature review to a conceptual framework for performance evaluation of service only supply chain. Benchmarking 29 (2022) p 1332–1361. https://doi.org/10.1108/BIJ-01-2021-0040.

[81] Katre A, Tozzi A. Assessing the sustainability of decentralized renewable energy systems: A comprehensive framework with analytical methods. Sustain. 10 (2018). https://doi.org/10.3390/su10041058.

[82] Andrade C. The Limitations of Online Surveys. Indian J. Psychol. Med. 42 (2020) p 575–576. https://doi.org/10.1177/0253717620957496.

[83] Jain P, Rekha. Impact of Demographic Factors : Technology Adoption in Agriculture. In SCMS Journal of Indian Management. September (2017) pp. 93–102. https://www.scms.edu.in/uploads/journal/July-September%202017.pdf (accessed January 10, 2024).

[84] Central Statistics Agency of Indonesia. Indonesian Population Data; 2023. https://www.bps.go.id/en. (accessed August 10, 2024).

[85] Faul F, Erdfelder E, Lang AG, Buchner A. G*Power 3: A flexible statistical power analysis program for the social, behavioral, and biomedical sciences. Behav. Res. Methods 39 (2007) p 175–191. https://doi.org/10.3758/BF03193146.

[86] Hair JF, Hult GT, Ringle C, Sarstedt M. A Primer on Partial Least Squares Structural Equation Modeling (PLS-SEM). Los Angeles: SAGE Publications, Inc; 2017. http://lccn.loc.gov/2016005380.

[87] Hair JF, Risher JJ, Sarstedt M, Ringle CM. When to use and how to report the results of PLS-SEM. Eur. Bus. Rev. 31 (2019) p 2–24. https://doi.org/10.1108/EBR-11-2018-0203.

[88] Puji LGK, Adianto J, Gabe RT. Gender Performance in the Kitchen of Indonesian Middle-Class. Int. J. Built Environ. Sci. Res. 7 (2023) p 61. https://doi.org/10.24853/ijbesr.7.1.61-74.

[89] Djono, Sukmawati F, Salimi M. Indonesian Culinary History and Values: Exploration Study in Solo City, Indonesia. *I*nt. J. Sustain. Dev. Plan. 18 (2023) p 961–969. http://dx.doi.org/10.18280/ijsdp.180332.

[90] David W, Widianingsih NN, Ardiansyah.Cooking behaviour of different ethnic groups residing in and around lowland rainforests of Sumatra, Indonesia. Int. J. Agric. Resour. Gov. Ecol. 13 (2017) p 162–174. http://dx.doi.org/10.1504/IJARGE.2017.086444.

[91] Hair J, Hollingsworth CL, Randolph AB, Chong AYL. An updated and expanded assessment of PLS-SEM in information systems research. Ind. Manag. Data Syst. 117 (2017) p 442–458. http://dx.doi.org/10.1108/IMDS-04-2016-0130.

[92] Demir A, Ergün E. Justice Fosters the Effect of Team-Building Interventions on Viability and Performance. Sustain. 15 (2023) p 1–18. http://dx.doi.org/10.3390/su151512023.

[93] Balassa BE, Nagy NG, Gyurián N. Perception and social acceptance of 5G technology for sustainability development. J. Clean. Prod. 467 (2024). http://dx.doi.org/10.1016/j.jclepro.2024.142964.

[94] Wang K, Ke Y. Social sustainability of communities: A systematic literature review. Sustain. Prod. Consum. 47 (2024) pp. 585–597. http://dx.doi.org/10.1016/j.spc.2024.04.031.

[95] Zhao X, Toronjo H, Shaw CC, Murphy A, Taxman FS. Perceived communication effectiveness in implementation strategies: a measurement scale. Implement. Sci. Commun. 3 (2022) p 1–13. http://dx.doi.org/10.1186/s43058-022-00284-4.

[96] Bajracharya Y, Adhikari P, Sharma BP. Factors Determining the Adoption of Induction Stove for Household Cooking in Bhaktapur. J. Sci. Eng. 10 (2023) p 31–37. http://dx.doi.org/10.3126/jsce.v10i1.61015.

[97] Mendoza JMF, Gallego-Schmid A, Velenturf APM, Jensen PD, Ibarra D. Circular economy business models and technology management strategies in the wind industry: Sustainability potential, industrial challenges and opportunities. Renew. Sustain. Energy Rev. 163 (2022) p. 112523. http://dx.doi.org/10.1016/j.rser.2022.112523.

[98] Rydehell H, Löfsten H, Isaksson A. Novelty-oriented value propositions for new technology-based firms: Impact of business networks and growth orientation. J. High Technol. Manag. Res. 29 (2018) p 161–171. http://dx.doi.org/10.1016/j.hitech.2018.09.001.

[99] Shaheen F, Lodhi MS, Rosak-Szyrocka J, Zaman K, Awan U, Asif M, Ahmed W, Siddique M. Cleaner Technology and Natural Resource Management: An Environmental Sustainability Perspective from China. Clean Technol. 4 (2022) p 584–606. http://dx.doi.org/10.3390/cleantechnol4030036.

[100] Mikulčić H, Baleta J, Klemeš JJ. Cleaner technologies for sustainable development. Clean. Eng. Technol. 7 (2022). http://dx.doi.org/10.1016/j.clet.2022.100445.

[101] Gaglioppa B, Tabone F. Human behaviours: New paradigms of energy efficiency. Communication tools to deliver a technical message to non-experts. E3S Web Conf. 343 (2022). http://dx.doi.org/10.1051/e3sconf/202234305001.

[102] Akter S, Mary N, Edward M. The impact of an improvement in the quality and reliability of rural residential electricity supply on clean cooking fuel adoption : Evidence from six energy poor Indian states. World Dev. 172 (2023) p 106366. http://dx.doi.org/10.1016/j.worlddev.2023.106366.

[103] Selçuklu SB, Rodgers MD, Movlyanov A. Economically and environmentally sustainable long-term power system expansion. Comput. Ind. Eng. 164 (2022). http://dx.doi.org/10.1016/j.cie.2021.107892.

[104] Černák I, Rojček M, Jenčo M. Analysis of Sustainability of IT Team Development in an Organization. TEM J. 12 (2023) p 43–51. http://dx.doi.org/10.18421/TEM121-06.

[105] Pearce JM. Ensuring technical competency for management of research-focused organizations. J. High Technol. Manag. Res. 29 (2018) p 172–180. http://dx.doi.org/10.1016/j.hitech.2018.09.002.

[106] Olawumi T O, Chan DWM. Key drivers for smart and sustainable practices in the built environment. *Eng. Constr. Archit. Manag*. 27 (2020) p 1257–1281. http://dx.doi.org/10.1108/ECAM-06-2019-0305.

[107] Gill N, Osman P, Head L, Voyer M, Harada T, Waitt G, Gibson C. Looking beyond installation: Why households struggle to make the most of solar hot water systems. Energy Policy 87 (2015) p 83–94. http://dx.doi.org/10.1016/j.enpol.2015.08.038.

[108] Pavanelli JMM, Sang EV, Oliveira CE, Campos FE, Lazaro LLB, Edomah, N, Igari, AT. An institutional framework for energy transitions: Lessons from the Nigerian electricity industry history. Energy Res. Soc. Sci. 97 (2023). http://dx.doi.org/10.1016/j.erss.2023.102994.

[109] Blohm M. An enabling framework to support the sustainable energy transition at the national level. Sustain. 13 (2021). https://doi.org/10.3390/su13073834.

[110] Hossain MR, Rao A, Sharma GD, Dev D, Kharbanda A. Empowering energy transition: Green innovation, digital finance, and the path to sustainable prosperity through green finance initiatives. Energy Econ. 136 (2024) p 107736. https://doi.org/10.1016/j.eneco.2024.107736.

[111] Shah RV. Financial incentives for promotion of electric vehicles in India - An analysis using the environmental policy framework. Nat Environ Pollut Technol 21 (2022) p 1227-1234. https://doi.org/10.46488/NEPT.2022.v21i03.028.

[112] Xu T, Liu D, Mo L. Policy design of government subsidy for end-of-life solar panel recycling. Appl Math Model 129 (2024) p 390-407. https://doi.org/10.1016/j.apm.2024.01.047.

[113] Colmenares-Quintero RF, Benavides-Castillo JM, Rojas N, Stansfield KE. Community perceptions, beliefs and acceptability of renewable energies projects: A systematic mapping study. Cogent Psychol 7 (2020). https://doi.org/10.1080/23311908.2020.1715534.

[114] Tribbe J, Zuin V, Delaire C, Khush R, Peletz R. How do rural communities sustain sanitation gains? Qualitative comparative

analyses of community-led approaches in Cambodia and Ghana. Sustain. 13 (2021). https://doi.org/10.3390/su13105440.
[115] Arora, P, Rehman, IH, Suresh R, Sharma A, Sharma, D, & Sharma An. Assessing the role of advanced cooking technologies to mitigate household air pollution in rural areas of Solan, Himachal Pradesh, India. Environmental Technology and Innovation 20 (2020) p 101084. https://doi.org/10.1016/j.eti.2020.101084.
[116] Manesh MHK, Onishi VC. Energy, exergy, and thermo-economic analysis of renewable energy-driven polygeneration systems for sustainable desalination. Processes 9 (2021) p 1-29. https://doi.org/10.3390/pr9020210.
[117] Jayashree S, Reza MNH, Malarvizhi CAN, Mohiuddin M. Industry 4.0 implementation and Triple Bottom Line sustainability: An empirical study on small and medium manufacturing firms. Heliyon 7 (2021) p e07753. https://doi.org/10.1016/j.heliyon.2021.e07753.
[118] Damayanti RW, Hartono B, Wijaya AR. Project Managers' Perspectives on the Complexity of Construction Megaproject in Indonesia: A Multicase Study. IEEE Eng. Manag. Rev. 49 (2021) p 153–171. https://doi.org/10.1109/EMR.2021.3063812.
[119] Boadu S, Otoo E. A comprehensive review on wind energy in Africa: Challenges, benefits and recommendations. Renew. Sustain. Energy Rev. 191 (2024) p 114035. https://doi.org/10.1016/j.rser.2023.114035.
[120] Khosravani F , Abbasi E, Choobchian S, Ghazizade MJ. A comprehensive study on criteria of sustainable urban waste management system: using content analysis. Sci. Rep. 13 (2023) p 1–15. https://doi.org/10.1038/s41598-023-49187-x.
[121] Noverita R, Mussry DJS. Proposed PT PLN (Persero) marketing capability to realize induction stove as a preferable option for LPG substitution and electrifying lifestyle growth. In: Proceedings of the 2020 4th International Conference on Business Management and Research (ICBMR). 160 (2020) p 36–44. https://doi.org/10.2991/aebmr.k.201222.006.
[122] Razmjoo AA, Sumper A.Investigating energy sustainability indicators for developing countries. Int. J. Sustain. Energy Plan. Manag. 21 (2019) p 59–76. https://doi.org/10.5278/ijsepm.2019.21.5.
[123] Damayanti RW, Setiadi H, Lakson PW, Rizky DL. Indonesia Induction Stoves Conversion Program: Technology Adoption and Behavior. In: Kurniawan, D., Nor, F.M. (eds) Advances in Manufacturing Processes and Smart Manufacturing Systems. GCMM 2023. Lecture Notes in Networks and Systems, 1214. Springer, Cham (2024). https://doi.org/10.1007/978-3-031-80341-3_1
[124] Huang MS, Liao CC, Li ZF, Shih ZR, Hsueh HW. Quantitative Design and Implementation of an Induction Cooker for a Copper Pan. IEEE Access 9 (2021) p 5105–5118. http://dx.doi.org/10.1109/ACCESS.2020.3046713.
[125] Al Hasibi RA. Multi-objective Analysis of Sustainable Generation Expansion Planning based on Renewable Energy Potential: A case study of Bali Province of Indonesia. Int J of Sust Energy Plan and Mgt 31 (2021) p 189–210. https://doi.org/10.5278/ijsepm.6474.
[126] Østergaard PA. Editorial - International Journal of Sustainable Energy Planning and Management Vol 28. Int J of Sust Energy Plan and Mgt 28 (2020) p 1–2. https://doi.org/10.5278/ijsepm.5737.
[127] Østergaard PA, Johannsen M. Energy Transition in the Global South – Editorial for the International Journal of Sustainable Energy Planning and Management Vol 35. Int J of Sust Energy Plan and Mgt 35 (2022) p 1–4. https://doi.org/10.54337/ijsepm.7393.
[128] Tumiran S, Putranto LM, Priyanto A, Savitri I. Generation expansion planning for high-potential hydropower resources: The case of the Sulawesi electricity system. Int J of Sust Energy Plan and Mgt 28 (2020) p 37–52. https://doi.org/10.5278/ijsepm.3247.
[129] Damayanti R. W., E. Pujiyanto, Z. H. Rahman, D. L. Rizky, and N. A. E. Entifar, Utilising Failure Mode And Effect Analysis and The Kano Model for Induction Stove Performance Improvement During Indonesia's Energy Conversion Program. J Eng Manag Inf Technol 2 (3) (2024) p 119–128. https://doi.org/10.61552/jemit.2024.03.003.
[130] Nguyen M, Malik A, Sharma P, Kingshott R, Gugnani R. High involvement work system and organizational and employee resilience: Impact of digitalisation in crisis situations. Technol Forecast Soc Change 205 (2024) p 123510. https://doi.org/10.1016/j.techfore.2024.123510.