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Research article

Evaluating Community Preferences for Waste-to-Energy Development in Jakarta: An Analysis Using the Choice Experiment Method

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Abstract: The Indonesian Presidential Regulation No. 35 of 2018 heralds a transformative agenda for producing electrical energy from biomass in an environmentally conscious manner. Jakarta emerges as a pivotal area in this transformation, with its strategic adoption of Waste to Energy (WtE) systems. In this study, we probe into the multiple layers of community preferences and the acceptance of WtE developments in Jakarta, factoring in an array of local concerns and policy-driven directives. Through a methodologically structured choice experiment, participants weighed in on various scenarios delineating shifts from the status quo to innovative WtE technological adoptions. we scrutinize a spectrum of attributes, each with defined status quo levels and proposed advancements: From enhancing awareness of landfill impacts (P1), escalating local policy commitments (K1) and integrating waste treatment facilities (F1) to diversifying waste processing outputs into liquid (PP1), solid (PP2), gas (PP3) and electricity (PP4). We also consider the transition from unmanaged landfills to controlled applications of landfill gas (PA1) and thermal treatment (PA2), as well as the initiation of emission and pollutant monitoring (M1).Our findings illuminate a significant public inclination to move beyond the current paradigms towards embracing WtE conversions, with particular willingness to support socialization of new waste processing technologies (P1), generation of energy in various forms especially liquid (PP1) and electricity (PP4) and implementation of environmental monitoring measures (M1). These attributes were marked by a notable willingness to accept (WTA) the proposed changes, signaling a readiness for policy and infrastructural advancements in waste management.

Keywords: waste to energy; public preference; willingness to accept; environmental impacts; circular economy

1. Introduction

Technology development in society can have an impact and progress as well as improvement in several life aspects such as knowledge, abilities, skills, economy, ease of carrying out activities, development of science and faster and current information [1,2]. Therefore, waste processing needs to be done as quickly and accurately as possible to reduce harmful effects [3]. This is reinforced by several policies and regulations that have been issued by the Presidential Regulation of the Republic of Indonesia, No. 35 of 2018 [4] that strengthens Electrical Energy produced from biomass with environmentally friendly technology.

Indonesia relies highly on the use of fossil energy [5,6] in which the total number of electricity customers in Indonesia has reached just over 43 GW including utilities customers from households, businesses and industry sectors [7]. With low fossil energy reserves, while energy use continues to increase, the use of new and renewable energy then becomes a significant concern for the Indonesian government [8]. Indonesia energy consumption is primarily dominated by coal at 70% of total energy consumption [9]. In fact, renewable energy sources such as hydropower, geothermal, biofuels, solar and wind power have the potential for renewable energy at 419 GW [10] but they only reached 0.89 % to be commercially developed [11].

In Indonesia, biomass is one of the renewable energy sources that can be acquired relatively easily [12,13]. In this country, also well known for its rice production, the large tracts of land are devoted to agriculture and plantations. Energy sources can be derived from various biomass raw materials [14] because these materials can be found as waste in urban areas such as Jakarta. However, the implementation is not entirely doable considering the high processing costs [15,16]. This is a manifestation of the long-term management of the energy sector by carrying out an integrated and sustainable planning related to energy resources that can ensure the long-term energy availability. In addition, this is a manifestation of efforts to carry out energy security [17,18]. Energy security efforts can be carried out by providing technical and economic-related policy measures in energy-related policies.

One of the sustainable development goals (SDGs) the United Nations (UN) has set is SDG-11, purposely to reduce any environmental impacts of cities on a per-capita basis by 2030. This goal calls explicitly for a focus on improving air quality and better managing municipal and other wastes. SDG-7 ensures that all people will have a modern, dependable, affordable and sustainable energy by 2030. Public are willing to accept the congestion charge policy as they find that income, perception of fairness, infringement on liberty, intention to reduce car usage and expectation of reducing car usage are some of the significant determinants [19]. Germany has a minimal impact on purchasing A-class energy-efficient goods; however, environmental taxes and an increase in the amount of information on energy efficiency labels has allowed for the easier promotion of energy-efficient appliances [20]. However, WtE incineration plants encounter considerable and significant opposition from the local communities in which they are placed because of the potential concerns that they pose, such as stench and dioxin emission [21–24]. In China, WtE incineration projects in many cities are failed due to persistent public opposition from the local community, which eventually presents itself as a mass occurrence [25].

Currently, Jakarta is participating in one of the experimental projects to convert waste into electricity in Indonesia [26–28]. It is a common knowledge that the management of urban trash must be sustainable - not simply from an ecological standpoint but also from an economic and social stance. To practice environmentally responsible waste management, one must adopt an all-encompassing strategy integrated into every operational activity [29]. Jakarta is the Indonesia capital with a population of over 10 million people and a GDP that accounts for approximately 17% of the country's total. As such, this city is a significant economic and political center and its energy consumption patterns can provide valuable insights of the energy challenges faced by Indonesia as a whole. Jakarta is a rapidly growing and urbanizing city with a high demand for energy to support its economic activities, transportation systems and residential needs. The city's electricity consumption has been increasing in view of population growth, rising incomes and increased urbanization. Moreover, Jakarta's electricity consumption is also affected by its status as a metropolitan city. As the center of economic and political activities, Jakarta has a higher concentration of commercial and industrial activities compared to other regions in Indonesia. These activities require more electricity to support their operations, leading to higher electricity consumption. Jakarta's urbanization also creates unique energy challenges, such as high energy consumption for transportation and air conditioning in buildings. The city's traffic congestion and air pollution have prompted some efforts to promote the use of public transportation and electric vehicles, while the high-rise buildings and tropical climate have contributed to the demand for air conditioning, which can significantly increase electricity consumption. Therefore, studying energy consumption patterns in Jakarta can provide some valuable insights related to the energy challenges faced by metropolitan cities in developing countries, particularly in terms of meeting the growing demand for energy while reducing greenhouse gas emissions and promoting sustainable development.

Furthermore, Choice Experiment have demonstrated that they are a reliable tool for forecasting behaviors and preferences across various economic sectors [30–32]. Say, environmental economics has found widespread application in analyzing the trade-offs between community experience and environment and management preferences [33,34]. choice experiment, nevertheless, have only seldom been utilized in fast changing environments in which the effects of the crisis are felt everywhere, and the need for action is pressing. When it comes to recovering energy from wasted heat, fuel and electricity, WtE is considered as a solution that is economically and environmentally effective and sustainable. In most cases, the choice of WtE technology is determined by the waste composition, the time of year and the community's socio-economic status [35–37]. WtE technologies are comparable in the amount of energy they produce, their effects on environment, economy and people's health [38]. On the other hand, renewable energy can also have some negative impacts on the environment and cause some technical and social problems. To take some appropriate precautions, and these issues must be carefully considered [39]. In addition to managing waste, the technology of WtE can play an important role in resolving and controlling energy challenges, particularly in developing countries such as Indonesia. The local community's preferences will serve as the basis for this article's presentation of the WtE development plan in Jakarta's preferences. In turn, we aim to assess the preferences of the WtE development plan in Jakarta based on local community preferences to accommodate.

The novelty of this research in the context of the circular economy lies in its deep examination of public preferences and willingness to accept WtE practices within the specific sociocultural landscape of Jakarta. While many studies have addressed the technical and environmental aspects of WtE, few have holistically gauged the public's perception, a pivotal factor for the successful integration of any sustainability initiative. By leveraging a choice experiment tailored to the unique attributes and considerations of Jakarta's residents, we unearth nuanced insights into the factors that most influence public acceptance, from knowledge dissemination to policy implications. Furthermore, the emphasis on knowledge as a determinative factor for acceptance reiterates the importance of informed communities in transitioning toward a circular economy. By showcasing how enhanced public awareness can facilitate the reintegration of waste as a valuable energy resource, this research underscores a key tenet of the circular economy: The transformative power of viewing traditionally discarded materials as valuable assets in a closed-loop system. Additionally, the specific focus on Jakarta, a rapidly urbanizing metropolis with its distinct challenges and opportunities, provides a fresh perspective on WtE's role in advancing the circular economy in developing urban contexts. This localized approach, combined with the broader implications of the study, adds a valuable dimension to the global discourse on sustainable waste management and the circular economy.

2. Materials and methods

2.1. Attribute dan level

To explore the community acceptance of Waste-to-Energy (WtE) initiatives in Jakarta, a choice experiment was incorporated into our survey design. In a choice experiment, respondents are presented with a set of hypothetical scenarios and are asked to select their preferred option as if these scenarios were real-life choices. Each choice set presented three alternatives: two represented varying potential configurations of WtE communities, while the third reflected the community's status quo. For clarity, in each energy community scenario (alternatives 1 and 2), we included different combinations of additional energy production facilities, as well as infrastructure for storage and transport, in contrast to the status quo (alternative 3), which did not necessitate the installation of additional equipment.

An extensive review of the literature on WtE community preferences and expert consultations helped us identify six critical attributes: Knowledge dissemination, policy frameworks, waste processing facilities, outputs of waste processing, end-stage waste processing techniques and environmental impact monitoring. The acceptance of Waste-to-Energy (WtE) initiatives is fundamentally influenced by an interconnected framework of attributes that inform public perception and endorsement. Knowledge serves as the foundation of this framework, empowering citizens with the information necessary to shape their attitudes towards environmental stewardship and innovative waste management solutions [40,41]. The strategic policies highlight the adverse environmental impacts of traditional landfill methods and serve to steer public support towards WtE technologies [42–44]. Integrated treatment facilities [27,44] are tangible embodiments of the technology's potential, enhancing the public's perception of WtE's efficacy and aligning with broader waste management objectives. The visible products of WtE processes provide a clear demonstration of renewable energy's benefits [45], showcasing its practical applications and bolstering the public's trust in these technologies. Moreover, final treatment processes like thermal technology and landfill gas capture, grounded in established methods, reduce public apprehension by providing familiar and reliable alternatives to traditional waste management practices [43,46–48]. Lastly, the role of impact monitoring is pivotal is clear communication about the environmental and social impacts of WtE helps to construct a narrative of transparency and accountability [49,50], essential for cultivating public confidence and acceptance.

Table 1 provides a detailed description of these attributes and their associated levels. The attributes and levels were rigorously selected to reflect the key considerations and trade-offs that individuals make when evaluating WtE developments. The selection process was informed by preliminary focus group discussions and expert inputs to ensure relevance and comprehensiveness.

Table 1. Attributes and labels used in choice experiment analysis.

Attributes	Description	Level
Knowledge	Knowledge can play a role in shaping citizens' attitudes and beliefs towards waste management and environmental issues, which can affect their willingness to accept WtE.	Status Quo: Community not aware of landfill impacts Level 1: Socialization of the replacement of waste processing technology into energy (P1)
Policy	Policy can promote awareness of the negative impacts of landfilling on the environment and public health, which can motivate citizens to support alternative waste management technologies such as WtE.	Status Quo: Only presidential policy Level 1: Seriousness of local policy (K1)
Treatment Facilities	Integrated WtE facilities can improve the overall efficiency and effectiveness of waste management systems, citizens may be more likely to view WtE as a positive solution to waste management challenges.	Status Quo: Still not good Level 1: Integration of Waste Treatment Facilities (F1)
Processing products	The product of WtE technologies can improve citizen acceptance of renewable energy by demonstrating its tangible benefits, potential uses and commitment to responsible and sustainable practices	Status quo: None/less Level 1: Liquid (PP1) Level 2: Solid (PP2) Level 3: Gas (PP3) Level 4: Electricity (PP4)
Final Treatment	Thermal and landfill gas technologies are based on well-established processes and technologies, which can help to build trust and familiarity among citizens to reduce uncertainty and increase acceptance of renewable energy technologies.	Status Quo: Uncontrol landfill Level 1: Landfill gas (PA1) Level 2: Thermal (PA2)
Impact monitoring	By providing citizens with clear and accurate information about the environmental and social impacts of WtE technologies, policymakers can build trust and confidence among citizens and increase their willingness to accept these technologies.	Status Quo: No emission/pollutant monitoring from waste management Level 1: There is emission/pollutant monitoring (M1)

The choice experiment design was comprised of 12 choice cards, strategically divided into two blocks, each presenting 3 pairs of scenarios. These were meticulously designed using an orthogonal array via IBM SPSS Statistics 26.0. This design method guarantees that the scenarios presented to respondents are statistically independent and that their choices provide a robust estimate of preferences for each attribute level. An illustrative paired choice scenario, as seen in Figure 1, conveys the practical implementation of the choice experiment design. It exemplifies how respondents would be presented with contrasting scenarios involving varying levels of attributes and are then asked to state their preference. The thoroughness of our design, backed by an orthogonal array, allows us to confidently parse out the influence of each attribute on the respondents' preferences, providing us with clear insights into the drivers of community acceptance for WtE initiatives.

Attribute	Alternative 1	Alternative 2	Status Quo
Knowledge	Community not aware of landfill impacts	Socialization of waste to energy program	Community not aware of landfill impacts
Policy	Only presidential policy	The seriousness of the local policy	Only presidential policy
Treatment Facilities	Integration of Waste Treatment Facilities	Still not integrated	Still not integrated
Processing products	Electricity	Liquid	None/less
Final Treatment	Landfill gas	Uncontrol landfill	Uncontrol landfill
Impact monitoring	There is emission monitoring	No emission monitoring from waste management	No emission monitoring from waste management
Willingness to Accept	Yes	Yes	No
Pick one	▢	▢	▢

Figure 1. Example for Version of Choice Set Pair 1.

2.2. Sampling method

As shown in Figure 2, the population of this study referred to the entire population of Jakarta in 2021 with a total of 10,609,681 people [51].

The statistical framework for selecting a representative sample from this population was constructed using the Slovin formula, an equation frequently employed in research for determining sample size with a specified margin of error. By setting the confidence level at 95%, we aimed to achieve a high degree of assurance that the sample would be representative of the broader population's perspectives. To execute the Slovin formula, we considered the total population (N) as 10,609,681 and a desired margin of error (e), typically set at 4% for social science research [43,52], provided us with a calculated sample size of 625 respondents. This calculation was corroborated using statistical software to ensure precision and accuracy.

The study's geographical scope, as depicted in Figure 2, included the expansive urban environment of Jakarta, subdivided into its constituent administrative areas: West Jakarta, Central Jakarta, South Jakarta, East Jakarta and North Jakarta. Each area presents its unique demographic and socio-economic characteristics, contributing to the complexity and diversity of the metropolitan population. For the sampling procedure, we adopted a random sampling approach, universally recognized for its robustness in social research. This probabilistic technique entails that every individual within the total population has an equal opportunity to be included in the sample, thereby eliminating selection bias. The implementation of this method was meticulous: A random number generator was employed to ensure that the selection process was impartial and methodologically sound. By doing so, we could ensure that our sample was a miniature yet accurate representation of Jakarta's population.

Figure 2. Study location [53].

Our sampling method was characterized using a random sampling technique, a methodology acclaimed for its simplicity and effectiveness in research disciplines. The central tenet of random sampling is to provide each member of the population with an equal likelihood of being chosen, thus ensuring that the sample is a true reflection of the population without biases. This process eschews any form of preference or discrimination, facilitating an equitable selection process. The random sample is meticulously drawn to represent the whole population faithfully, thus reinforcing the validity and reliability of the resultant data and the conclusions drawn thereof. This method's efficacy is underpinned by its core objective: To capture a snapshot of the population that is as unbiased and representative as possible. The socio-demographic profile of our random sampling in the study reflects the intricate social fabric of Jakarta's populace as recorded in the latest data provided by the Statistical Center[51].

Demography, in its expansive scope, encapsulates a range of individual and collective traits that define human populations, including but not limited to social, educational and economic dimensions. Within these dimensions, social and demographic characteristics such as gender, age, marital status and religion form the fundamental axes along which the diversity of a community is assessed and understood. In this study, we meticulously categorized the respondents' characteristics along these axes: Gender, marital status, age, level of higher education, employment status and income bracket. These categories were chosen not only for their traditional significance in socio-demographic research but also because they play an integral role in shaping the perceptions, preferences and choices that individuals make—key elements that influence the acceptance and adoption of new technologies and initiatives.

Furthermore, the intersection of sociodemographic factors with personal interests, attitudes and needs is a fertile ground for understanding community behavior. This nexus is particularly pertinent when evaluating community responses to environmental initiatives. These insights are critical when designing choice experiment, such as those utilized in this study to gauge the community’s willingness to adopt Waste-to-Energy (WtE) technologies. To offer a more granular view of our sample's socio-demographic composition, Table 2 delineates the detailed socio-demographic data of the respondents. This presentation of data aims to provide clarity on the socio-demographic distribution within our sample, thereby allowing for a nuanced interpretation of the community's receptivity to WtE initiatives in Jakarta.

Table 2. Sosio-demographics of respondents.

Variable		Frequency	Percent	Cumulative Percent
Gender	Female	295	47.2	47.2
	Male	330	52.8	100
Marital status	Married	226	36.2	36.2
	Single	399	63.8	100
Age	20-29	319	51	51
	30-39	251	40.2	91.2
	40-49	55	8.8	100
Higher education	Bachelor, postgraduate or above	349	55.8	55.8
	Secondary school	276	44.2	100
Employment	Formal	501	80.2	80.2
	Non-Formal	124	19.8	100
Income	<IDR 5.000.000	66	10.6	10.6
	IDR 5.000.000 – IDR 10.000.001	58	9.3	19.9
	IDR 10.000.001 - IDR 15.000.000	271	43.4	63.3
	> IDR 15.000.000	230	36.7	100

2.3. Data analysis

We used a descriptive method in the form of a survey using a correlational approach. The survey method is a research method that uses a questionnaire as the main instrument for data collection. Data can be analyzed, interpreted or evaluated to become information. Moreover, the correlational approach is intended to determine whether there is a relationship between phenomena or variables. Furthermore, the analysis used a clustered conditional logit model run via the survival package in SPSS software. In conditional regression models, one of the primary assumptions is the independence of irrelevant alternatives.

Logistic models are one of the most common ways to look at data about choices [54–56]. As shown in Table 1, the random utility theory is what these models are based on attribute and level. Logit models assume that the utility of an option can be broken down into a fixed part and a random part that can be added together. Furthermore, it is assumed that the relationship between the utility and the non-random components is linear and that random components are spread out in the same way and independently to each other. The equation shows a general way to show utility (U_{ijs}) for the respondent, I based on choice set s, alternative j and respondent i. (1).

$$U_{ijs} = V_{ijs} + e_{ijs} \quad (1)$$

where $V_{ijs} = \beta' x_{ijs}$ is the deterministic component, β' is a attribute preferences. X_{ijs} refers to a vector containing observed attribute values associated to option j in choice et s. X_{ijs} is a vector containing observed attribute values connected to alternative j in choice set. e_{ijs} is the type-I extreme value distributed random component that corresponds to the expression. An option from a choice set was selected by a respondent when the utility received from selecting that option was greater than the benefit that might be acquired by selecting any of other choices.

Our second model used the multi-regression model. The concept of simple linear regression was expanded upon in multi-regression. Explaining the relationship between a dependent variable and two or more independent variables can be accomplished by using multi-regression predictive analysis [57]. When the assumptions upon which linear regression analysis is based are breached, the resulting analysis may produce some deceptive results. The assumption that the residuals follow a normal distribution is crucial to the practice of linear regression. Other assumptions are frequently mentioned in introductory texts; however, these assumptions typically focus on deviations from the norm. When determining whether something is normal, we suggested performing three visual tests. The term "linear regression" provides an impression that the connection between the predictor variables and the criterion variable ought to be linear, or at least linear-like. The most widely accepted definition of multiple regression is presented as follows:

$$y_i=\beta_0+\beta_1 x_{i1}+\beta_2 x_{i2}+\ldots+\beta_p x_{ip}+\epsilon_i \quad (2)$$

Where i represents the scores of the ith subject and p represents the total number of predictors in the study. The intercept is denoted by the symbol 0, and the regression coefficients 1 and p represent the linear effects between the criterion and predictor variables. It is assumed that the residuals, denoted by I had a normal distribution with a mean of 0 and an unknown variance of 2. In most cases, the predictors (x_1, x_2,...,x_p) ensure that inference about the intercept is not affected by the predictors included in the model. We used bold notation to refer to the collections of parameters or data points that made up vectors (y).

3. Result and discussion

3.1. Current status and socio-demography in Jakarta

WtE is a technology that converts waste into electricity, heat or other forms of energy. In Indonesia, particularly in Jakarta, it has gained attention as a potential solution to address the challenges of waste management and energy security. Jakarta produces a significant amount of municipal solid waste (MSW) every day. However, the current waste management system of the city has struggled to keep up with the growing amount of waste, causing a number of environmental problems such as pollution, health hazards and landfills reaching their capacity. To tackle these issues, the Indonesian government has been promoting the development of WtE facilities as a part of their efforts to promote sustainable waste management and renewable energy. In Jakarta, the government has planned to build several WtE facilities such as the Bantargebang WtE plant and Intermediate Treatment Facility (ITF) Sunter. The Bantargebang WtE plant uses a combination of incineration and gasification technologies to convert MSW into electricity, which is sold to the national grid. The plant has been successful in reducing the amount of waste sent to landfills, improving the city's waste management and generating renewable energy. However, the development of WtE facilities in Indonesia, including Jakarta, faces some challenges such as high capital costs, limited availability of waste feedstock and social acceptance. Furthermore, concerns have been raised over the environmental and health impacts of WtE facilities, particularly on their potential emissions of pollutants such as dioxins and furans. Overall, while WtE has a potential to contribute to sustainable waste management and renewable energy development in Indonesia, it needs to be carefully planned and managed to ensure its environmental, social and economic sustainability.

3.2. Mean data analysis

The goal of the choice experiment is to figure out which configuration of a renewable energy community has the best chance of winning over the hearts and minds of the people in the surrounding area. To begin transforming a municipality into a society that relies on renewable energy sources, there must first be a willingness to break away from the current quo. In the context of this research, option 3 stands in for the status quo; alternative 1 and alternative 2. We described our findings in terms of the shift in the probability that individuals would go with alternative 3 when the renewable energy community was organized in various ways.

Table 3. Results of Mean Data Analysis for Each Variable.

Variable	Mean	Std. Deviation
P1	-0.1666	0.98612
K1	-0.4446	0.8958
F1	-0.1108	0.99394
PP1	-0.2222	0.78597
PP2	-0.278	0.73074
PP3	-0.3058	0.70004
PP4	-0.3333	0.66699
PA1	-0.278	0.83691
PA2	-0.2775	0.8374
M1	0.3884	0.92155
WTA	0.6667	0.47145

Table 3 informs how many choices respondents had for each variable and shows that most of the choices had a negative mean value, meaning that most of the respondents' choices were in the status quo, except for M1 and WTA, where they preferred to monitor of environmental impacts and accepted WtE technology.

3.3. choice experiment result and analysis

The logistic and multilinear regression models presented in Table 4 elucidate that bolstering public knowledge through concerted socialization efforts markedly enhances the acceptance of Waste-to-Energy (WtE) initiatives. Knowledge, conceptualized as the culmination of sensory experiences, higher education and experiential learning, significantly influences individual behavior as it informs decision-making processes[58]. Knowledge stands as a pivotal predisposing factor, intricately linked to the way an individual or a community behaves towards environmental management. The underpinnings of behavior change theories suggest that informed individuals are more likely to engage in proactive behavior [59,60], such as waste segregation or support for Waste-to-Energy (WtE) initiatives. When it comes to the complex task of integrated waste management, the role of communal awareness becomes paramount. Empowering citizens with the right knowledge about the dire consequences of neglecting waste can substantially reduce the administrative and logistical burdens faced by municipal authorities[61] can make the task of city government institutions much easier. A comprehensive strategy for waste socialization, which hinges on the premise that well-informed individuals are more inclined to participate actively in environmental stewardship, is therefore essential. When people are aware of the implications of improperly managed waste, they become more receptive to the idea of converting waste into energy. This is where the role of the government and allied stakeholders becomes critical. They must take the lead in implementing robust waste management practices [62] in which, when they are in the community, they can be the pioneers for independently processing waste into energy. By fostering a culture of knowledge and awareness, they can encourage communities to become self-reliant in their waste management efforts. When individuals in the community possess the knowledge and understanding of waste's environmental impact, they are more likely to adopt and even innovate sustainable practices. They can serve as catalysts for change, inspiring others to adopt WtE processes. Such a community-driven approach not only supports the operational aspects of waste management but also builds a supportive network that can sustain and scale these initiatives. It promotes a sense of ownership and responsibility among citizens, thereby facilitating a collaborative effort in the transition towards sustainable waste management and energy production.

Indonesia has embarked on a significant phase in addressing its waste management challenges. A landmark step in this journey is the enactment of Presidential Regulation No. 18 of 2016, which aims to expedite the construction of waste-based power plants across various key regions, including the DKI Jakarta Province, Tangerang City, Bandung City, Semarang City, Surakarta City, Surabaya City and Makassar City. This regulatory action underscores the government's commitment to fostering Waste-to-Energy (WtE) technologies as a viable strategy for reducing the volume of waste. Several cities in Indonesia, such as Surabaya [63], Cilacap [64,65], Bekasi [66], Depok [67] and Bali [68–70], have implemented waste management used as fuel for electricity. However, the potential of waste as a source of electrical energy is still unknown in some regions in Indonesia [71]. Despite these advances, the full potential of waste as an energy source remains untapped in many Indonesian regions. To bridge this knowledge gap, educational outreach and counseling about the advantages and processes of WtE plants are essential to cultivate public awareness and acceptance. The transformation of waste into fuel through technological conversion processes offers a convenient, efficient and cost-effective method of energy production. This approach is further supported by Presidential Regulation No. 35 of 2018, which calls for the establishment of strategic partnerships in the realm of waste management for energy generation. Through such collaborations and public education efforts, the government aims to amplify the reach and impact of WtE facilities, ultimately steering the country towards more sustainable waste management and energy practices.

Table 4. Logistic Model and Multilinear Regression Model Result for Public Acceptance for WtE in Jakarta.

Variable	Logit Model		Linear Model	
	Coefficient	Std Errot	Coefficient	Std Errot
P1	0.086**	0.044	0.02	0.01
K1	0.045	0.042	0.011	0.009
F1	0.007	0.044	0.003	0.01
PP1	0.203***	0.073	0.049	0.016
PP2	-0.125	0.088	-0.028	0.02
PP3	-0.071	0.083	-0.018	0.019
PP4	0.25**	0.097	0.059	0.022
PA1	-0.121**	0.053	-0.029**	0.012
PA2	0.026	0.055	0.005	0.012
M1	0.159***	0.046	0.038***	0.01
WTA	0.51***	0.181	0.104*	0.04
Constant	-1.035	0.169	0.269	0.038
Percentage Correct	66.6		-	
-2 Log likelihood	7169.919		-	
Chi-square	(0.001;15.08)		-	
Hosmer and Lemeshow Test Chi-square	16.115		-	
Durbin-Watson	-		2.914	
ANOVA p-value	-		0.000	

Notes: ***,**, *: significance at 10%,5% and 1% levels, respectively.

The logistics sector relies heavily on fuel oil, particularly for road transportation, which plays a crucial role in moving high-volume freight[72,73]. With oil prices changing in hard-to-predict ways, it is deemed important to know how much fuel oil is needed based on how much traffic is on the road and goods are needed by the community. Road freight transportation, which comes from how goods are made and moved between zones in a region's internal region, is hard to limit because it directly results from the region's economic system [74]. In line with this, in terms of energy, fuel oil is needed by the people in Jakarta at most (PP1; *P*-value > 0.001). Therefore, the refinery needs to make significant changes to increase the capacity of processes that turn residues into cracked gas oil and develop more effective processes for removing sulfur from residues [75–77].

Regarding the utilization of landfill gas (LFG), community acceptance shows a notable significance, albeit inversely proportional to the non-use of LFG technology, as indicated by a negative coefficient in the model results (PA1; *P*-value > 0.05). This is indicated by the coefficient value generated from the model results showing a negative value. LFG use is the process of collecting and processing LFG, coming from the decomposition of solid waste in a landfill so that it can be used to make electricity, fuel, heat and other useful chemicals. Around the world, more technologies that use

LFG are working. However, Africa's technology for using LFG, and the rate at which this technology is improving is prolonged [78]. LFG is a complex mix of gases made when microorganisms in a landfill break down the waste [48]. The mismanagement of landfills can lead to the uncontrolled emissions of LFGs such as CH_4 and CO_2, which highly contribute to climate change, bad smells, trash and dust in the area and leachate from the landfill seeping into groundwater and surface water [79].

The adoption of landfill gas (LFG) technologies in Indonesia has not reached its potential, posing a significant barrier to maximizing gas production from existing landfill sites, such as the Supit Urang Landfill [80–83]. These technologies are critical because they can convert the decomposition of organic waste into a valuable source of energy, addressing both the environmental concerns associated with waste disposal and the energy needs of the local communities [84]. Without improvements, the country is likely missing opportunities to tap into a sustainable and locally generated energy resource.

To effectively harness LFG, one must consider the various types of bioreactor landfills, as classified by the United States Environmental Protection Agency (USEPA). These categories include aerobic, anaerobic and hybrid landfills, differentiated by the nature of biological decomposition processes that occur within them. The type selected typically depends on the composition of the waste and the specific conditions of the landfill site [85] has put bioreactor landfills into three groups: Aerobic, anaerobic and hybrid. The successful extraction of LFG hinges on the careful management of several critical environmental parameters within these landfills. Factors such as the moisture content (which affects the activity of the microbes responsible for waste decomposition), pH (which can influence the breakdown of different waste components), temperature (which impacts microbial metabolic rates), redox conditions (which determine the type of decomposition—whether aerobic or anaerobic), biochemical kinetics (rates of chemical reactions) and gas emissions (quantities and types of gases released) all play integral roles in LFG production. Careful monitoring and regulation of these conditions can help to increase the efficiency of LFG capture and use, thereby maximizing the utility of landfill sites as sources of renewable energy and reducing their environmental impact [86,87].

While governments are recognizing waste-to-energy (WtE) facilities as a potential waste management solution, there are significant considerations regarding both the financial outlay and environmental impact [88,89].

WtE processes can conflict with waste reduction goals by providing an outlet for waste that might otherwise be reduced, reused or recycled. The community's preference signals that thermal treatment technologies, while potentially beneficial, are not without their drawbacks. They should be selected and utilized with caution, accompanied by rigorous monitoring to minimize any negative consequences. Community concerns about thermal technology facilities are valid and warrant serious consideration in the site selection and planning phases of such projects. Engaging with local communities early on through transparent and open communication can help alleviate concerns and foster a more collaborative relationship between the facility operators and the residents.

The need for counseling on WtE to enhance public knowledge emphasizes the critical role of communication and outreach in advancing sustainable waste management initiatives. Given the public's apprehension towards the environmental and health ramifications of WtE plants, bolstering public comprehension and involvement is pivotal. Educating the populace about the waste-to-fuel conversion process could potentially shift public opinion towards a more favorable view of WtE technologies. Furthermore, the focus on fostering strategic partnerships for the conversion of waste to electrical energy is vital, resonating with the directives of Presidential Regulation No. 35 of 2018. This regulation promotes a synergistic approach, bringing together government bodies, the private sector and local communities. Such collaborations can enhance the efficacy of waste management strategies and hasten the move towards a more resilient, sustainable and circular economic model. Establishing these alliances also facilitates the exchange of knowledge and resources, which can drive innovation and uptake of renewable energy, ultimately supporting environmental sustainability and community welfare.

3.4. Policy Implication and Future Research

People significantly modify their acceptability rating even when they are not personally impacted, demonstrating that communication and understanding of relevant trade-offs may lead to local and general opposition to renewable energy projects [90]. These findings are critical for enhancing information supply and policy interventions. A concrete assessment of acceptance can reveal the downsides that cause the greatest drop in acceptability, highlighting the necessity for communication or mitigation actions to assure the people's approval of renewable energy initiatives. Creating a WtE involves investigating the policies already in place regarding WtE and creating a policy network for future WtE development to re-create that policy network [91]. The use of renewable energy will continue to grow, especial ly regulations in several developed countries accompanied by incentives [92–94]. Latin American countries, for example, have provided incentives for the private sector to utilize renewable energy in their production and operational processes [95].

WtE can be a substitute energy source for energy sources generally used to meet energy needs [96]. Innovation contributes to provide new and helpful knowledge for public policy. In contrast, public policy provides supplementary theories, guidelines and methodologies that can strengthen public policy innovation.

The selection and determination of the types of energy sources and technologies developed based on the potential of WtE in an area need to continue to be carried out as the basis for policy formulation. This aims to make WtE development able to give optimal benefits. There are several options for WtE policy formulation and development. The author, in this case, suggests innovation in the formulation and development of WtE policies based on initial conditions. The community preference model, in this case, can be used as the basis for an adapted policy system and follow-up/sustainability. The initial conditions for developing the potential of WtE in Jakarta include resources, politics and regulations, community culture and bureaucracy/institutional as the capital base for developing WtE policies in Jakarta (Figure 3).

The transition to a circular economy is contingent on the efficient management of resources and the minimization of waste. In this context, the findings from the current study underscore the imperative for continued research into the ramifications of WtE initiatives on both environmental and economic fronts. This research should not only assess the direct impacts of WtE plants but also explore the innovation of technologies that further reduce waste and enhance renewable energy production. A circular economy thrives on the principles of redesign, reuse, recycling and recovery of products and materials in all forms of economic activity. It aims to extend the lifecycle of resources, reduce waste to a minimum and recapture the embedded energy and materials. Integrating WtE technologies with other forms of renewable energy like solar or wind could potentially create a synergistic effect that aligns with these principles. Such integration would contribute to a more resilient and sustainable energy infrastructure, where the waste of one process becomes the input for another, thereby creating a closed-loop system that reduces the overall ecological footprint.

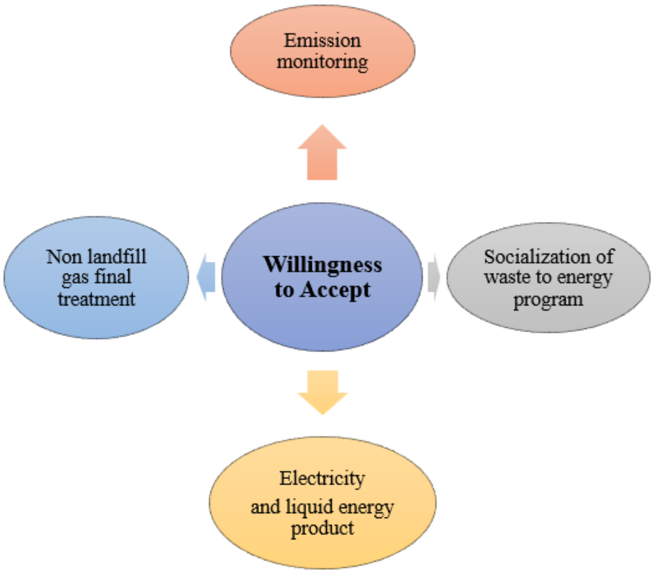

Figure 3. Public Preference on Acceptance Framework to WtE Program.

Moreover, investigating how WtE technologies can be adapted to complement the circular economy framework can offer insights into developing energy systems that are not only efficient but also environmentally benign. This might include research into the use of waste as a resource for generating energy without detracting from the recycling and reuse objectives of a circular economy. The significance of effective communication and stakeholder collaboration cannot be overstated. These factors are essential for achieving buy-in and for the successful implementation of circular economy principles. Future research must also delve into innovative ways of fostering such collaborations, ensuring that the diverse interests and expertise of all stakeholders are harmoniously integrated.

4. Conclusion

This research has provided valuable insights into the public's willingness to accept Waste-to-Energy (WtE) initiatives in Jakarta, with a particular focus on the role of public knowledge. Our empirical findings confirm that enhanced public awareness is not merely a contributing factor but a critical driver for the acceptance of WtE strategies. This extends beyond a general understanding, underpinning the necessity for targeted educational efforts to foster informed community support. Contrary to the suggestion that the significance of public knowledge may be an assumed conclusion, our study quantitatively establishes its paramount importance. The significance levels attained for attributes related to public knowledge in the willingness-to-accept (WTA) models distinctly indicate that without sufficient understanding and awareness among the populace, WtE initiatives are likely to encounter considerable resistance. While our study has been geographically confined to Jakarta, the implications of our findings are far-reaching. The necessity for policy-driven incentives and regulatory frameworks, as corroborated by our data, aligns with the successful practices in various developed nations. However, it is crucial to delineate the direct applicability of these practices to the context of Jakarta. Therefore, future research should endeavor to draw more explicit connections between the unique socio-economic and cultural dynamics of Jakarta and the broader discourse on renewable energy policies.

Moreover, the assertion that the expansion of renewable energy use requires policy and incentive support is not unfounded. The link between our data and broader policy implications is drawn from comparative analysis. The study's recommendations for policy-driven incentives are substantiated by observing similar successful frameworks in developed countries, which have shown that well-crafted policies and incentives can effectively stimulate the adoption of renewable energy technologies, including WtE. Although the study is geographically specific to Jakarta, the policy parallels drawn are based on the success stories of developed countries where similar socio-economic dynamics exist. By applying analogous policy measures adjusted for Jakarta's unique socio-economic context, it is reasonable to anticipate similar positive outcomes.

Considering the above, future research will extend these findings by examining the causal relationships between policy interventions and the growth of renewable energy adoption in Jakarta. This will involve a detailed comparative study of international case studies and an assessment of their applicability to Jakarta, thus creating a robust logical chain from the global context to the local implementation. The conclusion, therefore, stands not as a broad claim but as a targeted and evidence-backed call for action. It is one that underscores the necessity for strategic policies and educational campaigns tailored to the specific needs and characteristics of Jakarta's communities, thereby fostering an environment conducive to sustainable waste management practices.

Use of AI tools declaration

The authors declare they have not used Artificial Intelligence (AI) tools in the creation of this article.

Conflict of interest

The authors declare no conflict of interest.

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