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BALANCING ACTS: UNVEILING SOCIO-ECONOMIC AND ENVIRONMENTAL DIMENSIONS OF WASTE-TO-ENERGY POLICIES IN INDONESIA

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ABSTRACT

Indonesia has turned to Waste-to-Energy (WtE) initiatives, recognizing their potential to mitigate waste accumulation while contributing to renewable energy objectives. This article delves into the multifaceted landscape of Indonesia's Waste-to-Energy policies, analysing their effectiveness and implications across various dimensions. Through a Policy Effectiveness Assessment framework grounded in Policy Implementation Theory, the study evaluates key metrics such as energy mix targets, WtE plant performance, waste management progress, socio-economic dynamics, technology adoption, and community engagement. Despite ambitious energy targets, Indonesia faces challenges in diversifying its energy mix, with coal remaining predominant. Incremental progress in waste management is noted, but socio-economic disparities and environmental justice concerns persist. Moreover, varying community perspectives on WtE projects underscore the importance of inclusive engagement strategies, such as public hearings and workshops.

INTRODUCTION

Indonesia is at the forefront of waste management, dealing with the complex challenges of being one of the largest waste producers in Southeast Asia. According to the 2022 report by the Environment and Forestry Ministry, Indonesia generates a staggering 18.99 million tonnes of waste annually. The urgency of Indonesia's waste problem is emphasised by the fact that only 60% of the 142 million urban residents have access to waste collection services, and a mere 55% of urban solid waste is managed at transfer stations or processing facilities (Wang & Karasik, 2022). The substantial volume of untreated urban solid waste raises serious concerns about public health, sanitation, and the emission of hazardous methane gas within communities. This situation has reached a critical point, requiring the implementation of efficient waste management solutions.

Indonesia's pursuit of efficient waste management and environmental sustainability relies on the Waste-to-Energy (WtE) legislation enactment. Waste-to-energy (WtE) constitutes a vital component of the country's renewable energy and sustainable development objectives, with the potential to address the burgeoning waste crisis and fulfil the nation's energy demands. Indonesia's commitment to raise the proportion of renewable energy in its energy mix to 23% by 2025, compared to the present 13%,

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highlights the significant role assigned to Waste-to-Energy (WtE) in achieving this complex objective (Darmawan & Nathania, 2022).

The Indonesian government's management of the waste-to-energy initiative includes not only acknowledging WtE as a National Strategic Programme but also vigorously promoting incineration throughout the archipelago. In 2017, President Joko Widodo's directive significantly expedited the implementation of Waste-to-Energy (WtE) facilities in prominent urban areas such as Jakarta, Surabaya, and Bandung. Indonesia's decision to permit foreign investment in power generation projects, particularly in waste management, demonstrates its dedication to attracting international partners directly without relying on local intermediaries.

Financial incentives are essential components in this complex movement, serving as motivating factors for developers of Waste-to-Energy (WtE) plants. The "tipping fees" implementation for waste disposal, determined by weight and limited to a maximum of IDR500,000 per tonne, aligns with supportive trends from the national government towards local authorities(Green Investment Group, 2020). Additionally, developers are attracted by the fixed feed-in tariffs offered for grid-supplied energy, exceeding the rates typically available to other renewable projects, as a deliberate tactic to promote the expansion of waste-to-energy (WtE) in Indonesia.

One compelling example of Waste-to-energy (WtE) technology that attracted interest in Indonesia as a potential solution to waste management and energy security issues is the case of Jakarta. Jakarta, renowned for its significant daily generation of municipal solid waste (MSW), has encountered environmental issues such as pollution, health risks, and landfills nearing maximum capacity due to its inadequate waste management system. To address these problems, the Indonesian government has actively encouraged the establishment of Waste-to-Energy (WtE) facilities, including the Bantargebang WtE plant and the Intermediate Treatment Facility (ITF) Sunter. These facilities have effectively reduced the amount of waste disposed of in landfills, enhanced waste management, and generated renewable energy.

While the waste incineration process offers a means to manage waste and produce electricity, it also poses significant social and environmental hazards. Incineration facilities frequently encounter resistance from neighbouring populations primarily due to concerns regarding air pollution and potential health risks. Incinerators release emissions containing hazardous substances such as dioxins, heavy metals, and particulate matter, which are associated with respiratory disorders, cancer, and other health issues in nearby residents. Furthermore, the placement of incinerators often has a greater negative effect on marginalised groups, intensifying concerns about environmental justice and deepening socio-economic inequalities. From an environmental perspective, incineration constitutes a notable source of greenhouse gas emissions, contradicting initiatives to reduce carbon footprints. Moreover, the ash residue generated during combustion may contain hazardous substances requiring careful disposal, posing potential risks to soil and water quality if not managed appropriately. While incineration offers waste management solutions, its adverse social and environmental impacts require extensive mitigation measures and alternative approaches to ensure sustainable transitions to waste-to-energy systems.

As Indonesia strives to balance waste management, renewable energy development, and environmental sustainability, the socio-economic and environmental dimensions of its Waste-to-Energy policies assume paramount importance. This article aims to explore the intricacies, challenges, and potential benefits of the complicated process of developing and

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implementing Indonesia's Waste-to-Energy policies. It intends to provide a clear understanding of the subtle strategies involved in shaping and implementing Indonesia's Waste-to-Energy policies.

METHODS

The research methodology employed in this study centres around Policy Effectiveness Assessment, utilizing assessment metrics derived from the literature review. The theoretical framework guiding this assessment is the Policy Implementation Theory, which posits that the effectiveness of policies can be evaluated based on their ability to achieve intended outcomes and address underlying issues within the policy domain (Sabatier & Mazmanian, 1980).

Each assessment metric corresponds to specific dimensions of policy effectiveness and is informed by relevant theoretical perspectives and empirical evidence from the literature.

Socio-economic Dynamics of Waste-to-Energy: Potential Disparities and Environmental Justice Concerns: Drawing on environmental justice theory (Walker & Bullard, 1992), this metric evaluates the distributional impacts of WtE policies on local communities, particularly in terms of socio-economic disparities and environmental justice concerns. It examines issues such as job creation, economic benefits, and community engagement to assess the equitable distribution of WtE benefits and burdens.

Energy Mix Targets: This metric assesses the extent to which WtE policies contribute to achieving renewable energy targets set by the government. Drawing on theories of energy policy and transition management(Geels, 2002), this metric examines the alignment between policy objectives and actual outcomes in terms of renewable energy integration into the national energy mix.

Waste-to-Energy Plant Performance: Utilizing theories of infrastructure development and performance management (Flyvbjerg & Rothengatter, 2004), this metric evaluates the operational efficiency, reliability, and environmental performance of WtE plants in Indonesia. It considers factors such as energy output, emission levels, and waste diversion rates to gauge the overall effectiveness of WtE infrastructure.

Waste Management Progress: Informed by theories of environmental governance and policy implementation (Jordan et al., 2005), this metric assesses the progress made in waste management practices, including waste reduction, recycling, and landfill diversion. It examines the degree to which WtE policies complement broader waste management strategies and contribute to sustainable waste practices.

Technology Adoption and Innovation: Informed by theories of technological innovation and diffusion(Rogers, 2017), this metric evaluates the adoption and innovation of WtE technologies in Indonesia. It considers factors such as technological readiness, research and development efforts, and the diffusion of innovative WtE solutions across different regions.

Community Perspectives and Engagement: Drawing on theories of participatory governance and deliberative democracy(Dryzek, 2002), this metric assesses the extent of community engagement and participation in WtE decision-making processes. It examines community perceptions, concerns, and involvement in policy development and implementation to gauge the legitimacy and social acceptance of WtE projects.

Each assessment metric is operationalized using relevant indicators and data sources obtained through the literature review. By applying this multidimensional framework, the study aims to provide a comprehensive analysis of policy effectiveness in promoting sustainable WtE transitions in Indonesia.

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RESULTS AND DISCUSSION

Policy Effectiveness Assessment

(1) Socio-economic Dynamics of Waste-to-Energy

The socio-economic dynamics of Waste-to-Energy (WtE) initiatives in Indonesia represent a pivotal aspect in assessing their efficacy and broader implications. This section delves into the intricate interplay between economic, social, and environmental factors inherent in WtE programs, aiming to unravel their multifaceted impacts. Central to this exploration is the concept of socio-economic dynamics (Giampietro & Mayumi, 1997), which encompasses the complex interactions between waste management, energy production, and socio-economic factors. Understanding these dynamics is essential for evaluating the holistic implications of WtE policies. By examining the economic ramifications, job creation potential, and disparities associated with WtE projects, this discussion endeavours to provide a nuanced understanding of their socio-economic dimensions. Furthermore, the concept of environmental justice within the context of WtE initiatives is expounded upon, underscoring the imperative of equitable distribution of benefits and burdens. Through this comprehensive analysis, we aim to shed light on the socio-economic complexities of WtE policies and their broader implications for sustainable development and social equity in Indonesia.

Job creation: Waste-to-energy initiatives in Indonesia hold significant potential for addressing waste management issues, fostering economic development, and generating employment opportunities. A notable example is the waste-to-energy facility operated by PT Jabar Bersih Semesta in Bandung, West Java. This facility efficiently manages municipal solid waste and has created over 100 employment opportunities in waste collection, sorting, and plant operation. This has resulted in a positive economic impact on the local community (Jabar Bersih Lestari, 2023). Additionally, the collaboration between the Tangerang Regency Government and private investors led to the establishment of a waste-to-energy facility. This facility effectively addressed waste management concerns while also generating a consistent and sustainable source of income for local development initiatives.

Economic Benefits: Waste-to-energy efforts hold significant potential promote economic expansion by diversifying the energy portfolio, reducing reliance on fossil fuels, and generating income through the sale of electricity. In addition to the immediate economic advantages derived from energy production, waste-to-energy initiatives can also lead to cost savings in waste management by diverting waste from landfills and reducing disposal expenditures. Furthermore, the revenue derived from the sale of power can be allocated towards improving local infrastructure, enhancing public services, and supporting community development initiatives, thereby making a greater contribution to economic progress. As an illustration, the Tangerang Regency Government collaborated with private investors to establish a waste-to-energy facility in the area. The project effectively addressed waste management issues and generated a sustainable income stream for the local government, thereby supporting public services and infrastructure development in the region.

Potential Disparities: Waste-to-energy efforts potentially exacerbate socio-economic inequality in local communities, notwithstanding their potential benefits. For instance, underprivileged groups, such as informal waste collectors or low-income households, may encounter obstacles when seeking employment opportunities in the waste management and energy sectors. Additionally, there may be disparities in the distribution of economic benefits when gains primarily accrue to private corporations or investors instead of directly benefiting local populations. The construction of a waste-to-energy project in Surabaya has raised

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concerns among informal waste collectors who rely on waste picking as their source of income (Windi et al., 2021). In the absence of sufficient assistance and integration into the official waste management system, these individuals experienced economic instability and displacement, emphasizing the necessity of comprehensive policies for social and economic inclusion in conjunction with waste-to-energy programs.

Environmental Justice Concerns: Waste-to-energy initiatives can give rise to concerns related to environmental justice, namely addressing the selection of locations for facilities and the potential health effects on neighbouring communities. Waste-to-energy plants in Indonesia are frequently situated in heavily populated regions, which raises concerns about air pollution, water contamination, and health hazards for residents, particularly those living near the facilities. In the absence of adequate environmental regulation and community involvement, waste-to-energy projects have the potential to place a disproportionate cost on vulnerable groups, hence worsening socio-economic disparities. Residents of Bekasi demonstrated their opposition to the establishment of a waste-to-energy facility in their vicinity due to apprehensions regarding air pollution and potential health risks (The Jakarta Post, 2019). The project was suspended, emphasizing the significance of community involvement and the inclusion of environmental justice factors in waste-to-energy planning and decision-making procedures.

(2) Energy Mix Targets

The National Energy Policy (KEN) 2014 aims to achieve a primary energy composition of 23% from new and renewable sources, 22% from gas, 55% from coal, and 0.4% from oil by the year 2025. The objective of the National Electricity Plan (RUKN) is to achieve a 28% share of new and renewable energy, a 25% share of gas, a 47% share of coal, and a 0.1% share of oil in the overall electricity consumption in the long run. Additionally, energy efficiency programs aim to decrease energy use by 1% annually (Asian Development Bank, 2020).

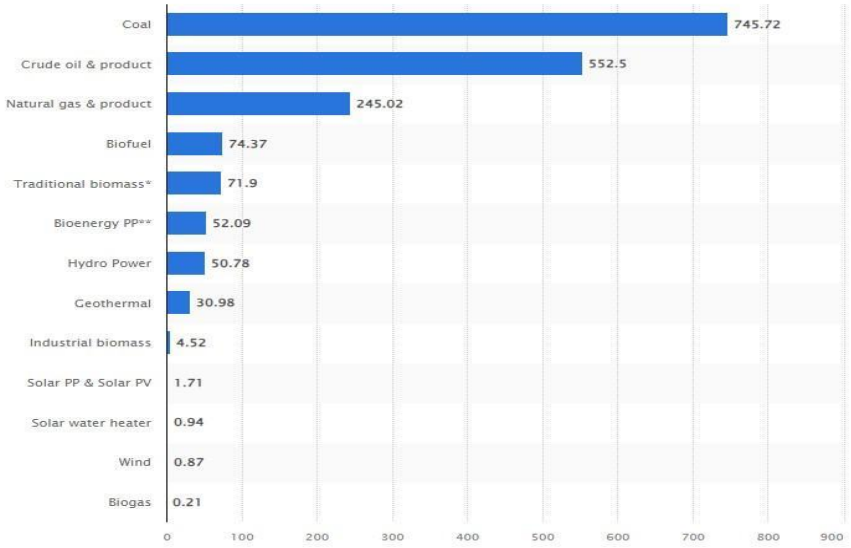

Figure 1. Primary energy supply in Indonesia
Source: BPS Statistics Indonesia, 2023

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Nevertheless, the post-COVID-19 economic rebound has led to the mobilization and relocation of resources. Consequently, there has been a rise in all facets of energy generation. In 2022, there was a 7.7% increase in domestic primary energy production compared to 2021. Coal has the highest production of primary energy, amounting to 17,267,940 terajoules. Natural gas follows with a production of 2,388,615 terajoules, followed by crude oil and condensate with a production of 1,364,177 terajoules. In 2022, the total electricity production amounted to 310,660 GWh. Out of this, 206,204 GWh (66.4%) was generated by steam power plants, 38,475 GWh (12.4%) was generated by steam gas power plants, 22,355 GWh (7.2%) was generated by hydropower plants, and 6,080 GWh (2.0%) was generated by diesel power plants. The remaining 37,638 GWh (12.1%) was generated by a combination of gas turbines, geothermal, gas machines, solar, and other types of power plants. (BPS Statistics Indonesia, 2023).

The increase in primary energy output, primarily from coal, casts doubt on Indonesia's ability to achieve the desired energy mix, notwithstanding the country's commitment to moving towards a more sustainable energy mix. The primary source of energy consumption in Indonesia is coal, accounting for 70% of the total energy consumed. Renewable energy sources, including hydropower, geothermal, biofuels, solar, and wind power, have a total potential of 419 GW for generating renewable energy. However, their current commercial development only amounts to 0.89% of this capacity. Policymakers should reconsider regulations to strengthen the advancement of renewable energy sources, focusing specifically on expanding waste-to-energy (WtE) programs to make a significant contribution to the entire energy mix.

(3) Waste-to-Energy Plant Performance

Operational Plants

The city of Bekasi in Jakarta is home to one of Indonesia's authorized Waste-to-Energy (WtE) plants, representing a major advancement in waste management and energy production. Another functioning facility is located in Surabaya, playing a significant role in the nation's dedication to Waste-to-Energy (WtE) programs. PLTSa Merah Putih, a pilot plant for waste-to-energy incineration, was constructed as an alternative measure to mitigate waste. The study conducted by Kristyawan et al., (2021) assessed the efficacy of PLTSa Merah Putih Bantargebang in mitigating waste volume. Throughout the initial half of 2021, the pilot plant operated for 174 days, incinerating a total of 5647. Approximately one metric ton of waste was incinerated, resulting in the production of approximately 1000 metric tons of ash. The pilot plant is capable of demonstrating a waste reduction of more than 79%, even when dealing with waste containing high moisture content.

This reduction is based on the feedstock waste and the resulting ash. To minimize the production of hazardous gasses, maintain the furnace temperature at 800°C and the grate temperature at 1000°C. The study demonstrated that the PLTSa Merah Putih Bantargebang achieved an average waste reduction of 79%. This figure is within the performance range of WTE incineration, which is between 70% and 90%. Last year, the waste-burning power plant operated for a total of 221 days. It successfully processed a total of 9,879 tons of waste, according to Syaripudin, the Acting Head of Jakarta Environment Agency. The production of Fly Ash and Bottom Ash (FABA) amounted to 1,918 tons. According to Muthiariny (2021), for every ton of waste burned, 110.59 kilowatts per hour of energy were created from a total energy of 783.63 MWh. While the current waste reduction is considered adequate, there is certainly room for improvement. This enhancement can be achieved by collaboration with all parties involved, particularly in standardizing waste properties at the source. Additionally, enhancements in the pre-treatment procedure are necessary since the bottom ash retains various uncombusted

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substances such as metal, glass, and construction materials.

The current waste-to-energy (WtE) process involves utilizing campaign materials from the previous Indonesia election in the WtE plant. The surplus campaign materials are sent to the waste filter plant located in the TB Simatupang neighbourhood of South Jakarta. At this facility, the local government oversees the Refuse Derived Fuel (RDF) process, which involves drying and reducing the water content of pre-shredded waste. The shredded waste is additionally utilized for the production of electricity (Afifa, 2024).

Ongoing and Planned Projects

As of June 2023, the development of the Intermediate Treatment Facility (ITF) in Sunter, Jakarta, was delayed because PT Jakarta Propertindo (Jakpro), the city-owned developer, needed to evaluate partners and investors. The delay, caused by administrative and financial obstacles, is expected to result in construction starting in 2023, with a total investment of IDR 5.2 trillion. Once finished, the Sunter facility is expected to handle 720 tonnes of waste per year, producing 35 MW of power daily.

In June 2023, the Jakarta Provincial Government and state-owned power business PT Perusahaan Listrik Negara (PLN) initiated an eco-friendly electricity generation program together. The WtE project, which focuses on integrated waste disposal facilities in Bantar Gebang, aims to utilize around 3,000 tonnes of waste per day as fuel for power plants. This project not only facilitates electricity generation but also alleviates the burden on landfills, specifically targeting Jakarta's substantial waste output of more than 7,500 tonnes per day (Chakraborty, 2023).

In Tangerang, a city located in Banten province, ongoing efforts are underway to construct a Waste-to-Energy (WtE) facility with the capacity to convert 2,000 tonnes of waste into usable energy daily. The project is expected to commence construction in 2023, with an investment of IDR 2.58 trillion. The Oligo Infrastructure Group will oversee it for 25 years before transferring it to the Tangerang local administration (Mariska, 2022).

The Makassar WtE plant, planned as a 20 MW bio-power facility in South Sulawesi, is still undergoing the regulatory process as of April 2023. Construction is scheduled to commence in 2024, with the plant projected to start commercial operations in 2025, according to Data Insights in 2024.

Waste-to-Energy (WtE) plants in Indonesia have made notable advancements and continue to expand as part of the country's commitment to sustainable waste management and renewable energy production. The operational plants located in the Jakarta suburbs of Bekasi and Surabaya serve as prime examples of effective advancements in waste management and energy production. Moreover, the continuous and scheduled initiatives highlight Indonesia's dedication to utilizing the capabilities of Waste-to-Energy (WtE) technology. The Intermediate Treatment Facility (ITF) in Sunter, Jakarta, was expected to begin construction in 2023. The project experienced delays due to paperwork and funding issues. Once completed, the facility aims to process 720 tonnes of waste per year and generate 35 MW of electricity daily. This information was reported by The Jakarta Post in 2022. The Jakarta Provincial Government and state-owned power group PT Perusahaan Listrik Negara (PLN) have collaborated to launch environment-friendly power generation programs at integrated waste disposal sites in Bantar Gebang. The programs aim to utilize almost 3,000 tonnes of waste daily for power plants (Southeast Asia Infrastructure, 2023).

Furthermore, the proposals for Waste-to-Energy (WtE) facilities in Tangerang and Makassar demonstrate Indonesia's dedication to sustainable waste management and the advancement of renewable energy. The PLTSa

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Merah Putih WtE plant in Bantargebang is a notable example of how waste incineration technologies may effectively reduce waste volume and generate power. Research assessing the efficiency of these plants shows notable decreases in waste, in line with global requirements for waste-to-energy incineration performance. The operating success of the Merah Putih WtE plant, along with advancements in waste management across the country, highlights Indonesia's progress in attaining global sustainability objectives.

concerted efforts to improve waste reduction, reuse, and recycling initiatives.

(4) Waste Management Progress

In 2019, Indonesia achieved a waste reduction, reuse, and recycling rate of just 14.58%, while 34.60% of waste was managed through methods such as landfilling or incineration. This brings the overall national waste management rate to 49.18%, according to data from the Ministry of Environment and Forestry (KLHK). As of 2020, there has been a 16.23% improvement in waste reduction and a 34.60% improvement in waste management, resulting in a total of 54.15%. (AHK Indonesien, 2021).

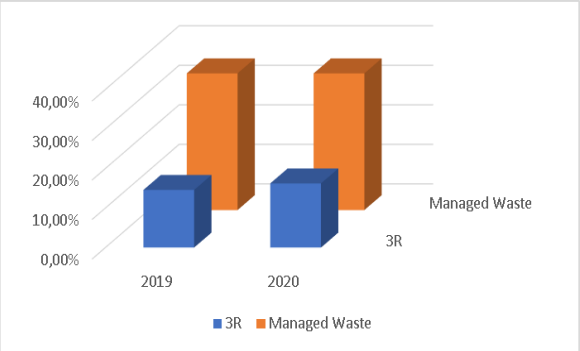

Figure 2. Progression in waste reduction, recycling, and overall waste management from 2019 to 2020.

Data from the Ministry of Environment and Forestry (KLHK) sheds light on Indonesia's evolving waste management landscape, showcasing both progress and persisting challenges. The figures reveal a marginal increase in waste reduction and management from 2019 to 2020, with the nation achieving a total waste management rate of 54.15%. While this uptick demonstrates some headway in addressing the country's waste management concerns, it also underscores the pressing need for more

As indicated in the chart below, the modest increase in waste reduction from 14.58% in 2019 to 16.23% in 2020 indicates incremental advancements in waste minimization strategies (AHK Indonesien, 2021). However, these figures fall short of optimal targets, highlighting the ongoing struggle to curb the generation of waste at its source. Achieving higher rates of waste reduction requires comprehensive approaches encompassing public awareness campaigns, policy interventions, and incentives to promote sustainable consumption and production practices. Additionally, enhancing infrastructure for waste segregation and recycling facilities is imperative to facilitate greater participation in recycling efforts among communities.

Figure 3. Comparison of Waste Reduction Rate in Indonesia, 2019 and 2020.

As indicated in the chart above, the modest increase in waste reduction from 14.58% in 2019 to 16.23% in 2020 indicates incremental advancements in waste minimization strategies (AHK Indonesien, 2021). However, these figures fall short of optimal targets, highlighting the ongoing struggle to curb the generation of waste at its source. Achieving higher rates of waste reduction requires comprehensive approaches encompassing public awareness campaigns,

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policy interventions, and incentives to promote sustainable consumption and production practices. Additionally, enhancing infrastructure for waste segregation and recycling facilities is imperative to facilitate greater participation in recycling efforts among communities.

Similarly, the proportion of waste managed through landfilling or incineration remains substantial at 34.60% (AHK Indonesien, 2021), reflecting the persistent reliance on conventional waste disposal methods. While incineration technologies can offer a means to manage waste and generate energy, their environmental and social impacts necessitate careful consideration. Encouragingly, the increase in waste management rates signals a growing recognition of the importance of proper waste disposal practices. However, efforts to mitigate the environmental footprint of waste management activities, particularly incineration, should be prioritized to minimize air and water pollution, protect public health, and ensure environmental sustainability.

(5) Technology Adoption and Innovation

Businesses often need help with the substantial financial expenses that come with setting up Waste-to-Energy (WtE) facilities. Although the government offers incentives and financial assistance, numerous enterprises need help to obtain the money required for infrastructure expansion and technology purchases. Moreover, the scarcity of waste feedstock presents a substantial impediment, especially in rural regions with inadequate waste-collecting facilities.

In response to these difficulties and to encourage the adoption of WtE technology, novel solutions have arisen, thereby contributing to the concepts of a circular economy. For example, several businesses have implemented sophisticated sorting and pre-processing technology to improve the quality and quantity of waste materials used as feedstock for waste-to-energy processes. PT Jabar Bersih Semesta, a waste management firm located in Bandung, West Java, has successfully integrated cutting-edge sorting and pre-processing technology to improve the quality of waste materials used in its waste-to-energy (WtE) plant. PT Jabar Bersih Semesta efficiently segregates and prepares waste for energy recovery processes by using advanced sorting equipment and methods (Jabar Bersih Lestari, 2023).

PT Bumi Mas Era Muda, a Surabaya-based company in East Java, has made investments in advanced sorting and pre-processing technology to enhance the quality and quantity of waste feedstock for its Waste-to-Energy (WtE) operations. The company's sophisticated sorting facilities provide the segregation of recyclable materials, organic waste, and non-recyclable wastes, consequently optimizing energy retrieval and reducing environmental consequences (Bumimas Group, 2020). PT Tirta Wahana Bali International, a prominent waste management company in Bali, has adopted advanced sorting and pre-processing technology to enhance the efficiency and efficacy of its waste-to-energy (WtE) operations. The company utilizes automated sorting systems and advanced pre-processing procedures to guarantee that the waste treated at its facilities is of superior quality. This results in improved energy recovery rates and a decrease in environmental contamination.

These examples demonstrate how Indonesian enterprises are utilizing advanced sorting and pre-processing technology to enhance the efficiency of waste feedstock for waste-to-energy (WtE) processes. This, in turn, helps to promote more sustainable waste management practices and the production of renewable energy. By allocating resources towards the implementation of effective waste collection and segregation systems, these enterprises may guarantee a steady stream of raw materials while simultaneously reducing expenses and enhancing energy production. Moreover, advancements in technology within Waste-to-Energy (WtE) operations have played a

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crucial role in enhancing efficiency and environmental sustainability. For instance, by combining gasification and pyrolysis technologies with traditional incineration methods, waste-to-energy (WtE) plants can now achieve greater energy recovery rates and simultaneously decrease the release of harmful pollutants like dioxins and furans. In addition, improvements in gas cleaning and treatment systems have aided in reducing environmental effects, hence enhancing the sustainability and social acceptance of Waste-to-Energy (WtE) as a waste management solution.

It can be seen that, while challenges persist, the adoption of WtE technologies in Indonesia is steadily progressing, driven by both government initiatives and private sector innovations. By overcoming barriers to technology adoption and embracing innovative solutions, businesses can contribute to the country's transition towards a more sustainable and circular economy while addressing pressing environmental and energy security concerns.

(6) Community Perspectives and Engagement

Indonesian local communities have different viewpoints on waste-to-energy (WtE) projects, influenced by factors such as socio-economic position, cultural beliefs, and environmental considerations. While certain individuals perceive Waste-to-Energy (WtE) efforts as viable resolutions for waste management issues and as a means to produce renewable energy, others hold doubts and concerns regarding potential health and environmental consequences. Communities living near planned Waste-to-Energy (WtE) plants frequently express worries regarding the contamination of air and water, as well as the possible health risks linked to the incineration procedures. Concerns have arisen regarding the potential rise in emissions of contaminants, including dioxins and furans, which potentially endanger human health and exacerbate pre-existing environmental problems. In addition, communities express concerns regarding the visual and aesthetic effects of Waste-to-Energy (WtE) infrastructure on their surroundings, as well as the possibility of property values decreasing.

Furthermore, socioeconomic factors play a significant role in shaping community attitudes toward Waste-to-Energy (WtE) initiatives. Certain local inhabitants perceive these projects as prospects for employment generation and economic advancement, especially in regions with elevated unemployment rates or restricted economic prospects. However, some individuals may raise concerns regarding the equitable allocation of advantages and the possibility of inequalities in terms of access to jobs and economic prospects. Various community involvement tactics have been utilized to promote discussion and consultation on Waste-to-Energy (WtE) projects. These encompass public hearings, community forums, stakeholder workshops, and information campaigns designed to educate local inhabitants on the advantages and drawbacks linked to WtE technologies. Additionally, participatory methods such as community advisory panels or liaison committees have been employed to ensure that community perspectives are acknowledged and incorporated into project design and execution.

Efficient community involvement is paramount for the success and acceptance of Waste-to-Energy (WtE) initiatives in Indonesia. Engaging local communities in meaningful discussions and decision-making processes can effectively address challenges, instil confidence, and foster cooperation among project developers, government agencies, and community stakeholders. Research by the Asian Development Bank (2021) underscores the significance of community participation in waste management projects, highlighting its role in enhancing project viability and social acceptance.

The effectiveness of community engagement strategies hinges on various factors,

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including the level of transparency, inclusiveness, and responsiveness demonstrated by project developers and government authorities. Studies by Kamil & Agustin (2019) emphasize the importance of transparent communication and active involvement of stakeholders in decision-making processes to mitigate conflicts and build trust in Indonesia. Conversely, superficial or tokenistic engagement approaches may breed scepticism, opposition, and ultimately, project delays or cancellations. Thus, prioritizing authentic and ongoing dialogue with local communities, attentively considering their input, and integrating their perspectives into project planning and implementation is imperative. Project developers can nurture trust, address concerns, and promote societal acceptance by adopting transparent, inclusive, and participatory community engagement methods. For instance, holding regular community meetings, establishing feedback mechanisms, and providing accessible information channels can empower local residents and facilitate meaningful participation in project deliberations. Moreover, incorporating traditional knowledge and cultural values into project design and implementation processes can enhance community ownership and promote sustainable outcomes (Ali & Tawakkal, 2024).

By embracing collaborative decision-making processes and actively involving communities in WtE initiatives, project proponents can cultivate a sense of ownership, build social capital, and engender support for sustainable waste management practices (Reid et al., 2019). This collaborative approach not only enhances project legitimacy and effectiveness but also fosters resilient and inclusive communities capable of addressing complex environmental challenges.

CONCLUCION

The policy effectiveness assessment of Waste-to-Energy (WtE) initiatives in Indonesia reveals a multifaceted landscape characterized by progress, challenges, and opportunities. Indonesia's dedication to shifting towards a more sustainable energy combination is evident. However, the significant increase in coal-based primary energy output raises concerns about achieving renewable energy goals. Furthermore, while operational waste-to-energy (WtE) plants exhibit noteworthy advancements in waste management and the production of renewable energy, they continue to face obstacles such as development delays and limitations in financing. Additionally, the limited progress in waste management methods suggests that additional investments in infrastructure and regulatory interventions are necessary. Furthermore, the socio-economic factors related to WtE projects highlight the potential for job growth and economic progress but also underscore the importance of fair project planning and community involvement. Technological advancements in waste sorting and pre-processing have the potential to optimize waste-to-energy (WtE) processes and contribute to a more sustainable waste management system. Ultimately, despite the existence of obstacles, Indonesia's advancements in Waste-to-Energy (WtE) projects demonstrate its commitment to addressing waste management issues and fostering ecological sustainability. The implications underscore the need for improved legislative measures, investments in infrastructure, and strategies for engaging the community to further advance the Waste-to-Energy (WtE) agenda in Indonesia.

Actionable Policy Recommendations for Enhancing the Sustainability of Waste-to-Energy Transition in Indonesia

To enhance the sustainability of the waste-to-energy transition in Indonesia, particularly addressing the socio-environmental effects of the incineration process, the following actionable policy recommendations are proposed Comprehensive Environmental Assessments (EIAs), Promotion of Cleaner Incineration

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Technologies, Community Engagement and Participation, Investment in Waste Reduction and Recycling, Capacity Building and Training, Monitoring, Enforcement, and Compliance.

For the future research, we suggest considering aspects of socio-economic and environmental dimensions of waste-to-energy in the formulation of policy and assist government authority in identifying sustainable waste management and renewable energy.

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