Municipal Solid Waste in Indonesia: Challenges, Opportunities, and the Role of Waste-to-Energy Power Plants

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OVERVIEW

Municipal solid waste (MSW) has emerged as a critical component in enhancing climate resilience in Indonesia. The data published by Indonesia's National Waste Management Information System (SIPSN) shows that between 2019 and 2023, Indonesia's total MSW generation has been on a steady rise. In 2023, Indonesia produced 43 million tons of MSW, a 56% increase from the amount in 2019 (SIPSN - Sistem Informasi Pengelolaan Sampah Nasional, 2025). What comes from the increase in waste generation is that Indonesia's methane emissions from this sector grew by 70% over the period from 2000 to 2022 (Republic of Indonesia, 2024). In 2022, Indonesia accounted for an estimated 26 Mt CO_2 eq/year of methane emissions from the MSW sector, of which 83% was from unmanaged MSW disposal sites while the rest was from open burning of MSW, this calculation is based on Indonesia's National Inventory Document, where the emission from the waste sector utilized the 2006 IPCC methodology, combined with waste activity data sourced from the Indonesia's Ministry of Forestry and the Ministry of Public Works. As of 2024, landfill remains the predominant method of waste disposal in Indonesia. According to the data from SIPSN, approximately 40% of the total generated waste was not subjected to any form of treatment. Organic waste dominates Indonesia's waste generation. In 2023, food waste accounted for the largest portion of Indonesia's waste, with more than 48%, followed by plastic with 22% (SIPSN, 2025). Addressing MSW challenges in Indonesia has not only environmental but also significant economic implications. Aye and Widjaya (2006) estimated that the annual operating cost of a typical open dumping site in Indonesia is about USD 231,882. In contrast, Waste to Energy (WtE) technologies such as biogas or landfill gas utilization incur operating costs ranging from USD 171,000 to USD 2.19 million per year, but offer the potential to generate revenue between USD 492,000 and USD 4.76 million annually (Aye & Widjaya, 2006).

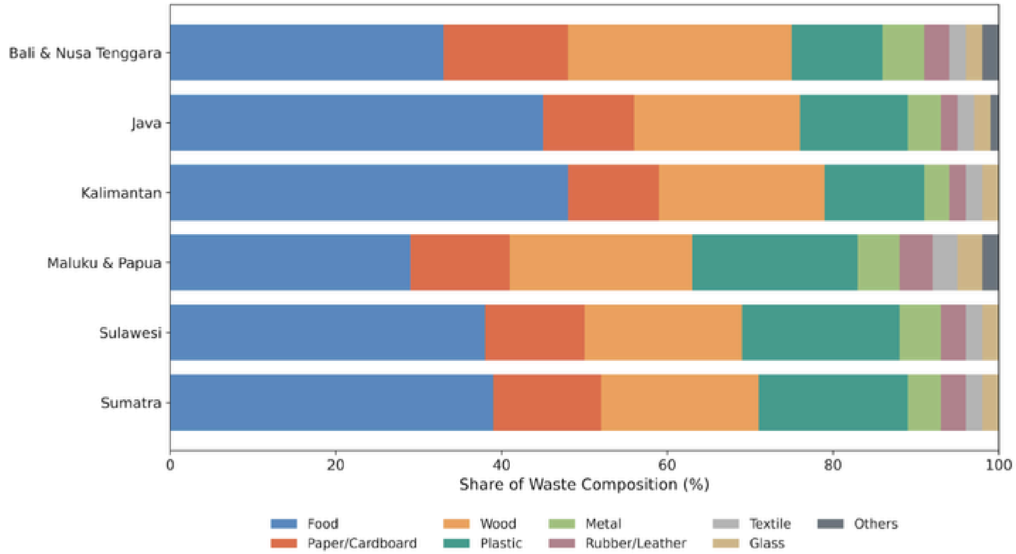

Figure 1. MSW composition in Indonesia by island in 2023 (CGS compiled data)

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WASTE-TO-ENERGY POLICY CONTEXT

The government of Indonesia has recognized the importance of addressing MSW in achieving its climate goals. As reflected in the country's enhanced Nationally Determined Contributions (NDCs) submitted in 2022, the government sets a goal of unconditionally reducing 40 million tons of CO_2-eq emissions by 2030 from the waste sector (Government of Indonesia, 2022a). This target is more ambitious than the goal of 11 million tons of CO_2-eq reduction established in its first NDC (Government of Indonesia, 2022b). Indonesia further advances its climate ambition in the draft 2024 NDC, which includes a long term objective of achieving "Zero Waste" by 2040 and near-zero waste related emissions by 2050 (Salsabila & Wong, 2024).

Subsequently, building on Indonesia's MSW management goal, the WtE industry in Indonesia was introduced through Law No.18/2008 on waste management, which mandated the national and provincial governments to recognize waste as a resource, with an emphasis on composting, recycling, and energy recovery. Eight years later, WtE was formally adopted as a national strategy under the Presidential Regulation No.3/2016. This was followed by Presidential Regulation No.35/2018 that selected 12 cities to implement WtE projects (PLTSa), targeting the management of 16,000 tonnes of MSW per day. No.35/2018 also provides groundwork for tipping fees in the WtE industry. This regulation mandates a tipping fee from the province/regency government that is as high as USD 35 for each ton of waste being processed by the WtE plant. The No.35/2018 also mandated the State Electricity Company (PLN) to establish a purchase tariff for electricity generated by WtE plants, setting the rate at USD 13.35 cents/kWh for plants with capacity of less than 20 MW and USD 14.54 cents/kWh for those with a capacity exceeding 20 MW.

The Ministry of Energy and Mineral Resources (ESDM) is currently drafting a new Presidential Regulation aimed at streamlining the permitting process and reducing the electricity production cost. Under the new regulation, only a single permit will be required to process waste into electricity, needing approval solely from ESDM before being forwarded directly to the state-owned utility, PT PLN. The new regulation will reduce regulatory barriers and aim to expand the No.35/2018's 12 WtE projects into 30 projects, which will have a combined total capacity of 1 GW. In some regions, initiatives are underway towards eliminating the tipping fee and implementing direct subsidies that would not only simplify contracts between local governments and private investors but also reduce financial burdens on local governments (Soehandoko & Maskur, 2025).

In addition to these, to address the issue of unsorted MSW, Indonesia has implemented a sorting initiative through the establishment of waste banks. Waste banks are a community-based waste management system supported by government funding. In this system, residents would sort their household solid waste and receive payment based on the type and weight of the waste material, typically ranging between 300-500 IDR (USD 0.019-0.031). The waste bank would then sell the sorted waste to recycling factories and other agencies (Alam et al., 2020).

WASTE-TO-ENERGY TECHNOLOGIES

WtE technologies can be categorized as thermal and non-thermal technologies. Thermal technologies are the most widely deployed WtE technologies in the global market, with more than 1,000 plants operating worldwide and 125 years of usage history (Ministry of Energy and Mineral Resources, 2015). Key thermal methods include Incineration, Gasification, Pyrolysis, and Landfill Gas Recovery. Thermal WtE technology can achieve an 80-90% reduction in waste volume, with the exception of Landfill Gas Recovery, which provides little to no waste volume reduction (Ministry of Energy and Mineral Resources, 2015). Among non-thermal WtE technologies, Anaerobic Digestion is the most common method. It utilizes microorganisms to break down the methane gas coming from organic waste, then converts the methane into electrical energy. However, Anaerobic Digestion has a lower reduction potential compared to thermal WtE technology, about 45–50% (Alao et al., 2022). Most of the WtE technologies do require pre-treatment of the MSW, except Incineration and Landfill Gas Recovery.

In addition to direct generation of electricity from MSW, Refuse-derived fuel (RDF) represents a WtE technology that converts waste into high-calorific fuel products. The process involves separation of plastics and biodegradable materials from the waste feedstock, followed by drying and shredding to enhance the calorific value per unit mass of waste (Ministry of Energy and Mineral Resources, 2015).

WASTE-TO-ENERGY POWER PLANTS IN INDONESIA

The government of Indonesia and local governments have taken some measures to implement WtE power plants. Based on Presidential Regulation No.35/2018, twelve cities had planned or entered into an agreement to develop WtE power plant facilities (Mudofir et al., 2025). However, as of 2024, only two of these facilities (PLTSa Benowo in Surabaya and PLTSa Putri Cempo in Surakarta) had become operational, indicating a significant gap between planning and implementation. The delays in the technology deployment have resulted from multiple reasons, including regulatory, budget, and operational challenges. PLTSa Benowo processes approximately 1500 tons of municipal solid waste per day and generates around 11 MW of electricity through a combination of landfill gas recovery and gasification technologies (Mudofir et al., 2025). Benowo plant implements a high rate of source-level waste separation, which improves feedstock quality and enhances overall process efficiency. Furthermore, there is continued support from both the city government and local authorities that played a critical role in the plant's operation viability (Affandi et al., 2024).

A notable example of an operationally constrained WtE project is the PLTSa project in Semarang City PLTSa. The project had successfully passed the initial feasibility study and secured a power purchase agreement with State Electricity Company (PLN). The facility was planned for construction at Jatibarang landfill, the city's primary waste disposal site and which accommodates approximately 80% of Semarang's solid waste. The data from SIPSN shows that Semarang's waste composition remained relatively stable from 2019 to 2024, with food waste (primarily organic matter) constituted more than 60% of the total waste stream. A gasification WtE technology was constructed and began commercial operation in April 2020 with a capacity of 200 kW. However, declining performance reduced the plant's output to 40 kW by 2022, leading the operator to shut down the plant in 2023 due to revenue losses (Sudrajat et al., 2023).

The failure of Semarang PLTSa can be attributed to several factors. First, performance issues arose because gas canals were repeatedly damaged by local scavengers and cattle. In addition, logistical problems disrupted the timely delivery of sorted organic waste to the landfill, resulting in an inconsistent feedstock supply to the gasifier (Sudrajat et al., 2023). Lastly, the budget burden on the plant operator was a significant factor in the case of Semarang PLTSa. The Presidential Regulation No.35/2018 required the provincial government to pay a tipping fee of max USD 35 per ton of waste processed in PLTSa; however, the provincial government in Semarang only had the budget to pay USD 19 per ton of waste, since per No.35/2018, the highest level of tipping fee is not guaranteed (Sudrajat et al., 2023).

Table 1: Operational WtE plants in Indonesia.

Plant	Location	Year Commissioned	Waste Processing Capacity (tons/day)	Technology	Plant Operator	GHG Reduction (tons/day)	Emission Control Technology	Capital Cost (Million USD)	O&M Cost (Million USD)	Feed-in Tariff (US cents/kWh)
PLTSA Putri Cempo	Surakarta	2023[1]	545[1]	Plasma Gasification[1]	PT Solo Citra Metro Plasma Power[1]	8.29[2]	Gas Cleaning System[2]	20.6[2]	6.59[3]	13.35[4]
PLTSa Benowo	Surabaya	2021[1]	1500[1]	Gasification and Landfill Gas Recovery[1]	PT Sumber Organik[1]	821.92[5]	Deacidification Tower, Dust Collector and Chimney[6]	50[7]	12.1[3]	13.5[8]

Sources: 1. (Mudofir et al., 2025) 2. (Daerobi, 2019) 3. (Azis et al., 2021a) 4. (Murdifi, 2022) 5. (Nurdiansah et al., 2020) 6. (Affandi et al., 2024) 7. (Umah, 2021) 8. (Primayanti, 2025)

SOCIAL IMPACT

Waste management in Indonesia has raised several socio-environmental concerns. In the Bantar Gebang landfill, public acceptance of the plant has been limited due to environmental disturbances such as river pollution, noise pollution, and combustion odors from the facility (Aliansi Zero Waste Indonesia, 2024). The environmental burden disproportionately falls on the low-income scavenger community. Around 3,000 scavenger families reside and work near the landfill's WtE plant, often under hazardous conditions despite their critical role in sorting and recycling waste. These informal workers are routinely exposed to contaminated soil, polluted air, and toxic effluents, conditions that pose severe long-term health risks (Hicks, 2023). Many community members in these areas are often migrants from rural areas with limited access to formal education seeking better livelihoods (Hodal, 2011). Children are often involved in scavenging and living in unsanitary housing conditions. This case illustrates the broader pattern of environmental injustice, where the population least responsible for waste generation experience severe environmental and health impacts.

A similar pattern of externalities is also observed in Benowo PLTSa. Faldi et al., 2023 quantified the environmental and health-related external costs borne by surrounding communities. Their analysis estimated significant annual per capita costs associated with environmental degradation and healthcare related costs amounting to a combined economic burden of about USD 35,000 per year (Faldi et al., 2023). However, the broader assessment of Benowo PLTSa reveals tangible benefits. The facility processes approximately 1,500 tons of waste per day, contributing to significant reductions in waste accumulation. It also mitigates GHG emissions by an estimated 821 tons per day and creates employment opportunities for 250 individuals (Yunnan Health & Cultural Tourism Holding, 2024). Additionally, the plant engages in public outreach through educational study tours aimed at raising awareness about sustainable waste management practices (Hakim, 2022). These findings highlight the complex trade-offs between the socio-environmental costs and the operational benefits of WtE infrastructure. There is the urgent need for targeted policies and mitigation strategies to address socio-environmental injustices in local communities. At the national and provincial levels, WtE plants contribute to broader climate mitigation goals by reducing waste volumes and lowering GHG emissions.

KEY TAKEAWAYS

Indonesia faces a critical challenge in managing its rapidly growing MSW stream. It is difficult to approach the choice of WtE technology in Indonesia through a one-size-fits-all model. The country exhibits unique features in terms of geographic fragmentation across several islands, population density, urbanization patterns, and MSW composition. Major urban cities that have high waste generation rates and relative access to infrastructure could support large scale centralized incineration or gasification plants. Conversely, rural and remote areas with MSW that are heavily organic-rich waste. A closer look at MSW data across Indonesia's six major island groups reveals a high proportion of organic content dominated by food waste, wood, and other biodegradable materials indicating a significant opportunity for deploying anaerobic digestion and other biological WtE solutions. To achieve higher calorific conversion efficiencies, lower emissions, and ability to recover syngas, advanced thermal treatments such as gasification and pyrolysis could be considered as alternative approaches for MSW management.

To unlock the potential of these advanced WtE pathways, several policy interventions could be considered. Investing in new and improving existing local preprocessing infrastructure is required to segregate waste at source and supply tailored feedstocks suitable for specific WtE technologies. Although Presidential Regulation No.35/2018 assigns this responsibility to local governments, cities such as the Semarang have shown lack of fiscal capacity to fund these fees once the plants are operational.

Regulatory barriers also significantly delay project implementation. PLTSa projects often require multiple stakeholders. For example Bekasi (Bantargebang) PLTSa was canceled due to regulatory conflicts after the project was announced (Pemkot Bekasi, 2024). Additionally, the state owned electricity utility, PLN faces significant financial pressure due to the requirement to purchase electricity generated by PLTSa facilities at tariffs that exceed the national average of USD 9.76 cents/kWh (Azis et al., 2021). The Presidential Regulation No.35/2018 mandates a feed-in tariff ranging from USD 13.35-14.54 cents/kWh; however, the levelized cost of electricity production from incineration can reach as high as USD 21.03 cents/kWh (Sisungkunon et al., 2023). Municipalities must often commit to long-term contracts with WtE operators to supply a minimum waste volume, but uncertainties in future waste generation, collection plans, and reliance on subcontracted collectors can hinder agreement (Rawlins et al., 2014).

In addition to economic challenges, the successful deployment of WtE technologies is hindered by low levels of public awareness regarding MSW handling. Data from Indonesia’s Central Bureau of Statistics indicate that in 2021, 58% of total households did not practice waste sorting, thereby complicating the MSW pretreatment processes necessary for PLTSa operations (Statistics Indonesia, 2022). Increased public education and community engagement in proper waste sorting and disposal practices is critical to ensure the long-term sustainability and efficiency of advanced WtE systems in Indonesia.

For future research, the next step should be to develop and evaluate scenario-based models of Indonesia’s MSW management policy options. This analysis would include quantifying the potential of emission reduction, investment requirement, and assessing possible revenue streams within the waste sector. By comparing alternative pathways, such research would support policymakers to prioritize strategies that maximize environmental benefits, optimize financial returns, and ensure the long-term sustainability of the country’s waste management system and infrastructure.erm sustainability of the country’s waste management system and infrastructure.

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