KPMG

Southeast Asia Waste-to Energy

Infrastructure Advisory

KPMG in Malaysia

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Introduction

The world is building up more waste than ever, with waste generation increasing by a rate of 6.6% annually (2010–2019) as cities continue to urbanize. In Southeast Asia ("SEA"), 6 key countries namely Malaysia, Indonesia, Philippines, Singapore, Thailand and Vietnam, have a combined population of more than 570 million people. Over the next 10 years the waste generation is expected to grow annually by 2.7% (2019 –2030).

Recognizing this, more countries are stepping up efforts to reduce waste volume and better manage waste. While most SEA countries have policies and regulations in place to improve waste management and sustainability practice, the efforts and enforcement of waste management in all countries except Singapore are fragmented and poorly coordinated among institutions and stakeholders.

There is a significant potential to improve the waste management process in SEA through waste-to-energy ("WtE"). WtE plants generate electricity out of waste as a fuel source, minimizing waste going directly into the landfills. By using waste as a fuel source, WtE plants offer another solution to help governments in their green energy agenda. In the SEA region, the solid waste management market is projected to grow at a moderate rate of 1.9% annually (2019 - 2030) and the WtE market on the other hand is expected to grow at a faster pace of 29.4% annually (2019 - 2022).

Countries like Malaysia and Indonesia are already having tenders for WtE concessions, whereas Thailand and Vietnam are contemplating policy framework. Globally experienced companies that are ready to get onboard of the sustainable waste management opportunities will thrive in this new landscape of renewable energy production and environmental sustainability trends.

This report provides insights to the waste management landscape in SEA, key challenges in the waste management industry and key considerations for WtE project investment, as well as the best practices of the waste management industry.

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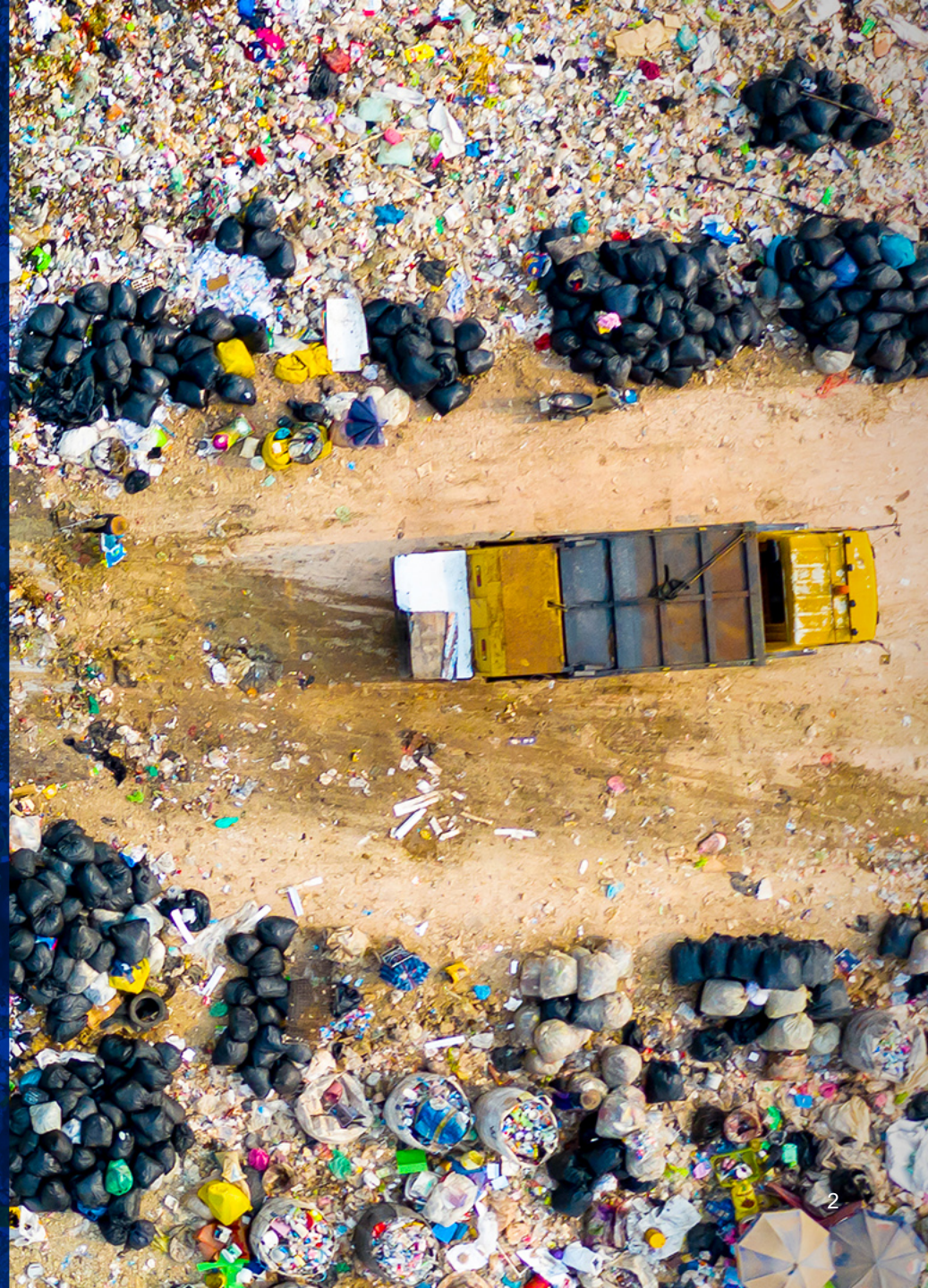


WtE benefits multiple stakeholders

If done right, a waste-to-energy (WtE) project can positively impact the society, environment and the economy of a country.

Key consideration for investors

In 2019, global investment in waste-to-energy has grown annually by 9% which indicates good future prospects within the sector. However, investors should take note of some key factors before venturing into a waste-to-energy project.

Key Factors To Be Considered

High Capital Investment

WtE facilities help in reducing waste going into landfill and converting non-reusable and non-recyclable waste into electricity and heat. The configuration of a WtE plant is complex due to the waste composition and moisture content. This complexity adds to the investment in pre-treatment & sorting of waste in addition to the appropriate conversion technologies such as thermal, biological or landfill gas recovery. Investors should consider the sources of revenue (including ancillary revenue) and the financing structure when venturing into a WtE plant to recover all the costs involved.

Geography

The location of the WtE plant is an important consideration as it affects transportation cost, accessibility to the plant and also any potential regulatory and environmental issue in respect to the use of land. Ideally, the WtE plant should be nearby a suitable electricity gird, distribution network. However, its also important to consider the community nearby and their potential reaction to the plant being built, especially if it's near residential estates.

Waste Supply & Composition

As WtE facilities are long term investments, investors need to identify the optimal level of waste to be processed and the long-term prospects of obtaining such quantity of waste material and a back up plans should the volume of local waste were to decline.

Investor should also consider the waste composition as it determines the technology required for the WtE plants. Generally, high income nations would produce higher waste per capita with a higher proportion of plastics and paper waste that is favorable for energy conversion. Contrastingly, low income countries would have higher organic waste proportion which is not ideal for energy conversion and majority of these countries neither practice sorting at source. Hence, lower efficiency and higher cost for WtE consideration.

Regulation And Policies

The country's waste management regulations and policies together with their energy policies can determine the success of WtE. However, given that many countries are still in their infancy stage, the regulations and policy might be subjected to change which might be detrimental to the sector or investors.

Revenue Stream

There are 2 main revenue sources of a WtE project which are the waste gate fees and revenue generated from the sale of power (energy fee). Waste gate fees are usually received for the disposal of waste the WtE facilities received and are significantly influenced by the respective countries' government. For the energy fee, the structure of revenue depends on the type of energy produce. The revenue can either be fully exposed to the merchant energy prices which is subjected to daily volatility of the energy market or it can be a pre-contracted take or pay basis at a pre-agreed price, thus limiting risk of revenue volatility.

Sources: UNEP - Global Trends in Renewable Energy Investment 2020

Recent M&A in the waste-to-energy in Asia

There have been acquisitions as market entry into Asia's waste industry. The table below summaries some of the recent M&A transactions within the industry.

Country	Financial Close Year	Deal Value	Description
Thailand	Expected by 1Q 2021	USD 67m	Sale of a 8MW waste-to-energy project in Nakhon Ratchasima province in Thailand. The plant is designed to have a waste processing capacity of 500 tonnes per day and a contracted capacity of 8MW.
Malaysia	Sept 2020	USD 11.1m	BiON's acquisition of Nasarudin and Seberang Perak biogas plants, the Malaysia-based biogas plants with an installed capacity of 3 MW, from Megagreeen Energy Sdn Bhd (MGE), for a consideration of MYR45.99m (USD 11.17m).
Japan	Aug 2020	Undisclosed	Japan-based developer of smart energy solutions, NTT Anode Energy Corporation has acquired an undisclosed stake in Forest Energy Inc., a developer and operator of biomass energy projects, for an undisclosed sum.
South Korea	Aug 2020	USD 886m	Affirma Capital divested 100% stake in EMC Holdings Co., Ltd. ("EMC Holdings") to SK Engineering & Construction Co., Ltd. ("SK E&C") for an enterprise value in excess of KRW1 trillion. EMC Holdings provides fully integrated environmental services platform that operates over 970 sewage and wastewater treatment facilities, 4 waste incineration facilities, 1 waste landfill site and 1 waste oil refining business.
India	Mar 2020	USD 35m	Sale of 30% stakes of IDFC Infrastructure Finance Limited, formerly IDFC Infra Debt Fund Limited by IDFC Financial Holding company Limited, a subsidiary of IDFC Limited, to Aseem Infrastructure Finance Limited ('AIFL'), a subsidiary of National Investment and Infrastructure Fund II ("NIIF Fund II").
Indonesia	June 2018	USD 120m	Divestment of a 95% stake in PT Indo Green Power to China Jinjiang Environment Holding Company Limited subsidiary PT Jinjiang Environment Indonesia. Pt Indo Green Power has the concession to construct, own and operate the Palembang waste-to-energy facility in Palembang, Sumatra, which has a total installed waste treatment capacity of 1000 tonnes daily.

Sources: News articles & company's website

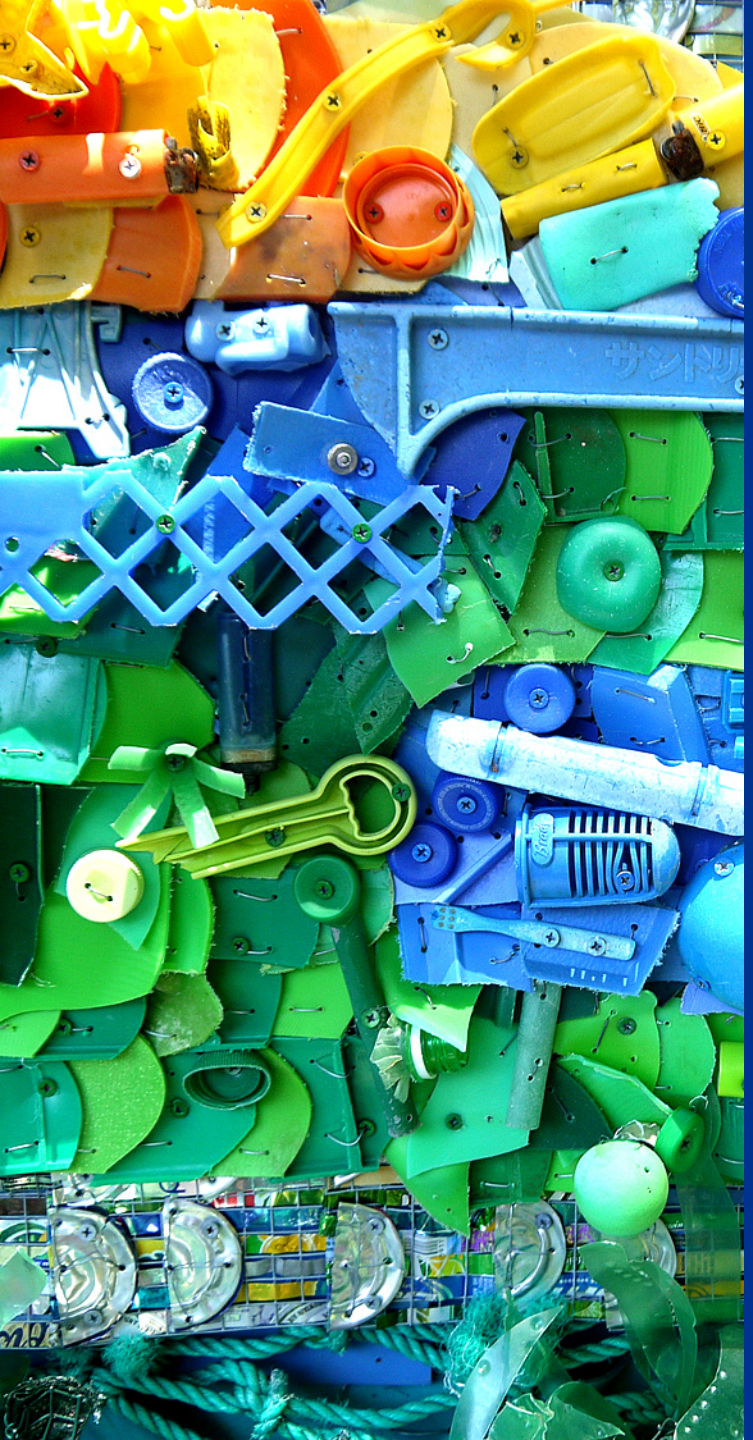


Table of Contents

Southeast Asia Overview

Regional WtE landscape

High percentage of waste disposal to landfill is a common practice in most developing ASEAN countries except for Thailand. Waste-to-energy (WtE) capacity per million population is far behind in all developing ASEAN countries compared to Singapore.

Market	MSW Generated (tpd)	% of landfill disposal	WtE capacity (tpd per mn pop.)
 Vietnam	64,658	71%	8.2
 Thailand	76,616	29%	28.6
 Malaysia	29,260	85%	5.4
 Singapore	8,559	3%	1,333
 Philippines	40,164	85%	0
 Indonesia	175,342	69%	4.4

Sources: Vietnam: National Environmental Status Report, Asia Waste Management Outlook, Malaysia :Characterisation of Municipal Solid Waste in Malaysia, Indonesia and Philippine: Asia waste management outlook 2017, Thailand: Thailand State of Pollution 2018, Singapore: NEA website, UNCRD-State of the 3Rs in Asia and the Pacific

Why bother for WtE?

With the exception of Singapore, the development of WtE capacity in ASEAN is still in its infancy stage due to its limitation in terms of expertise, finance and experience.

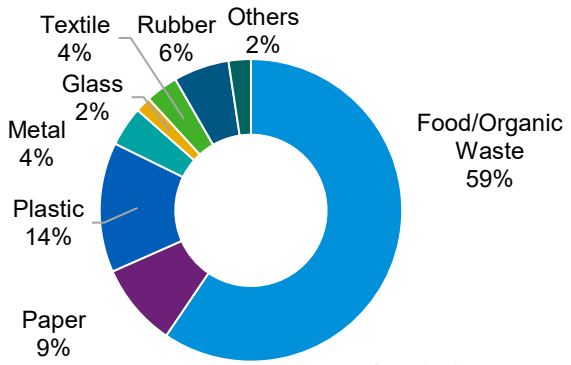
Technology	WtE / waste treatment	Solar	Onshore Wind	Offshore wind	Biomass
Development complexity / time	High and time consuming	Simple and very quick	Medium	Medium – high	Medium
Competition	• Limited established Asian developers. • Require deep experience and track record to provide lenders comfort	Extremely competitive with minimal entry barrier – no track record required	Local companies have started building up track-record with the help of East Asia's players	• Large untapped potential in Vietnam for foreign developers • Presence of large equipment manufacturer	Emergence of strong local players within each country
Levered returns/ economics	• Development: 14-25% • Late stage / RTB: 10-15% • LCOE range from USD 0.03 – 0.14/kWh depending on technology	• Development: 10-15% • Late stage / RTB: 7-9% • LCOE around USD 0.06 – 0.08/kWh	Considerably high LCOE USD 0.12/kWh, doubled of North America	LCOE ~20% higher than onshore wind	LCOE around USD 0.05-0.08/kWh
Scale of opportunity (ASEAN)	Significant in developing countries with high % landfill to waste ratio	Country dependent	Good in Vietnam, Philippines and Thailand	Vietnam has good potential due to proximity to load center	Significant for all countries with agriculture activity
Requirement for strong grid / storage	Not applicable	Yes	Yes	Yes	Not applicable
Stakeholders	• Gov't concession • Electricity offtake • Waste supply • Landfill right (for residual) • Local communities	• Land / building owner • Electricity offtake	• Land / building owner • Electricity offtake	• Land / building owner • Electricity offtake	• Electricity offtake • Agriculture residues supply

Sources: WtE: Asian Development Bank-Waste to energy circular economy handbook,Solar:AFRY- Renewable energy in Southeast Asia, Wind: Insurer Consulting Group Asia-Asia Offshore Wind Insurance Opportunities, Biomass: IRENA- Bioenergy for Power

Municipal Solid Waste (MSW) Composition by Country

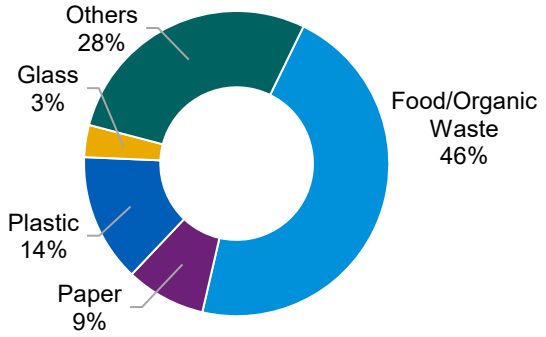
Other than Singapore, most waste in ASEAN countries mainly consist of organic/food waste.

Indonesia MSW composition (%)



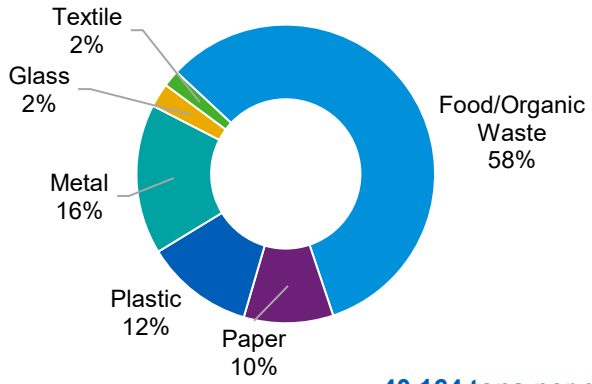
175,342 tons per day

Malaysia MSW composition (%)



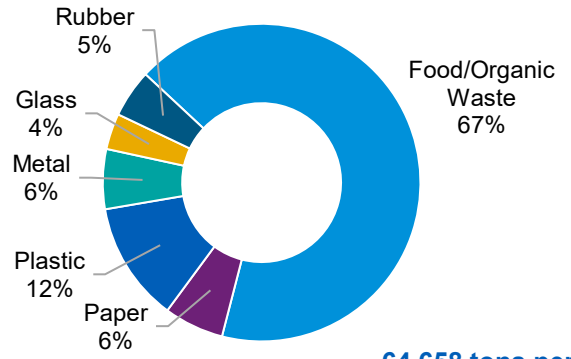
29,260 tons per day

Philippines MSW composition (%)



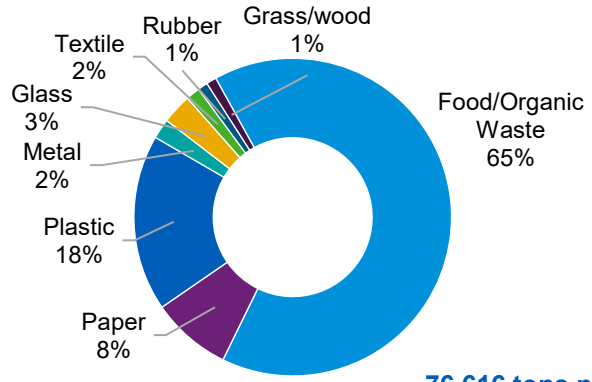
40,164 tons per day

Vietnam MSW composition (%)



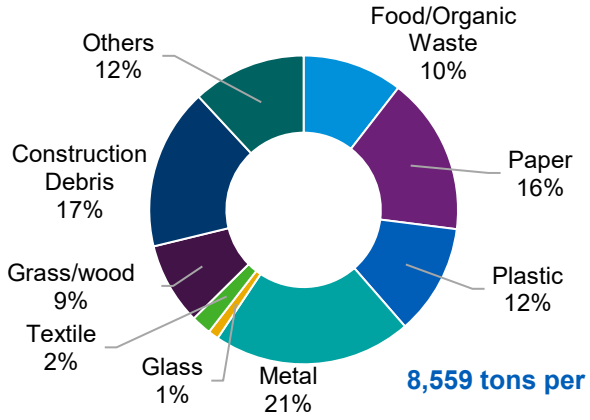
64,658 tons per day

Thailand MSW composition (%)



76,616 tons per day

Singapore MSW composition (%)



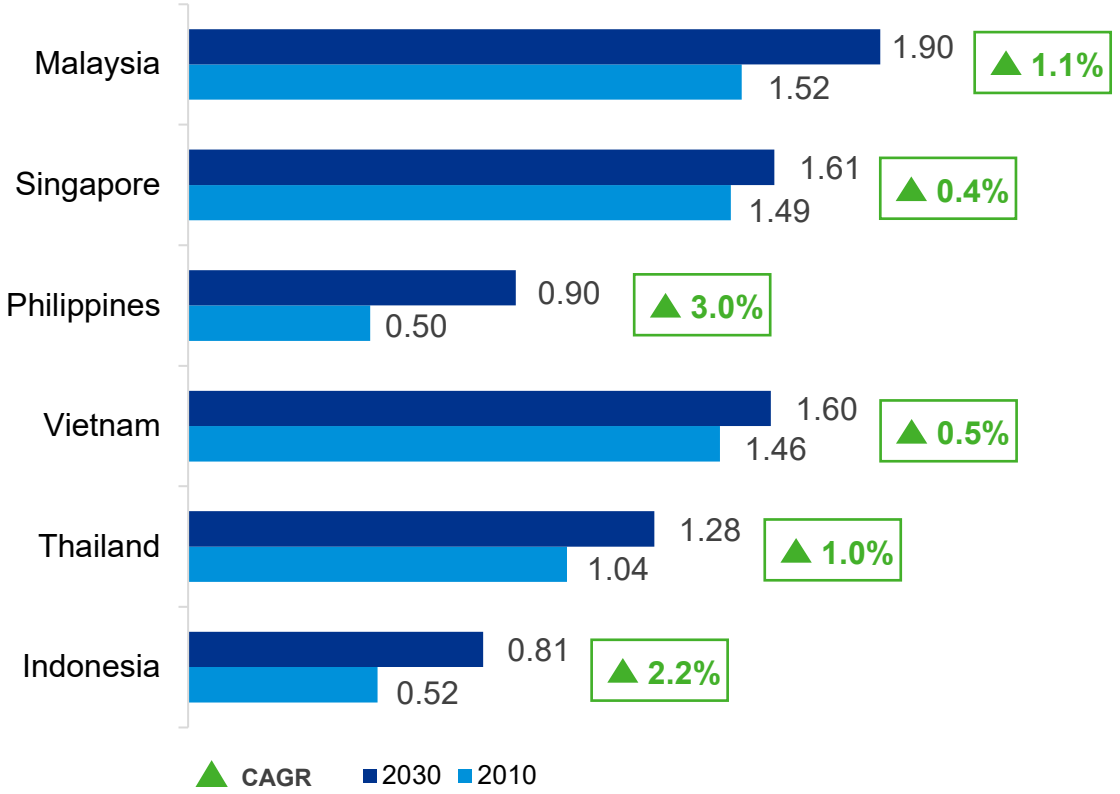
8,559 tons per day

Source: Waste Management in ASEAN countries UNEP and UNCRD-State of the 3Rs in Asia and the Pacific

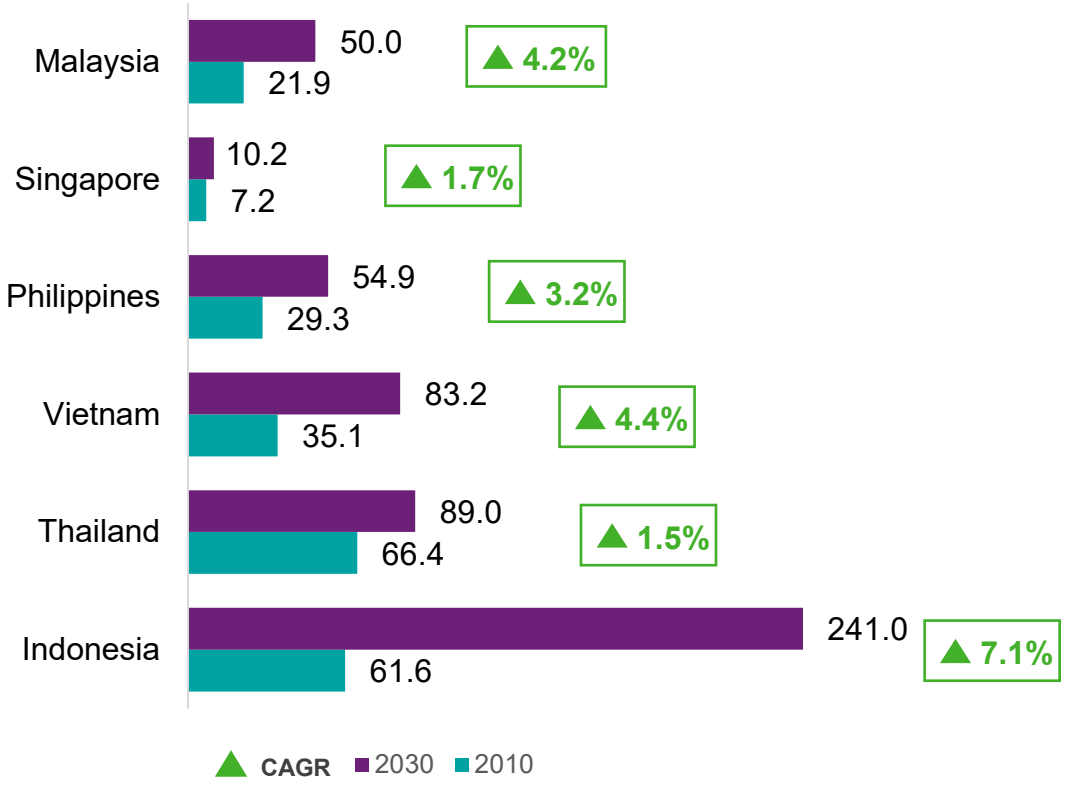
Municipal Solid Waste (MSW) Generation Projection

Rapid urban population growth in Southeast Asia is expected to drive the waste generation.

MSW Generation Per Capita (kg/capita/day)



MSW Generation (thousand tons/day)



Sources: Worldbank - What a Waste 2.0: A Global Review of Solid Waste Management, UNCRD-State of the 3Rs in Asia and the Pacific

WtE Challenges & Risks

Key Challenges for WtE

Listed are some key challenges and also potential mitigation measures in respect of waste-to-energy project.

Challenges for WtE	Description	Potential Mitigation
Poor waste composition and management	• Most of Southeast Asia's municipal waste are made up of organic waste. • Organic waste has high water content and low calorific value lead to poor efficiency of energy conversion.	• Waste sorting enables separation of organic waste vs non-organic waste. • Separation of organic waste out from the feedstock can improve the calorific value.

Commercial feasibility of WtE plant	• WtE projects rely on two main revenue sources:
	  • Sales of electricity
	  • Tipping fees
	• Both the revenue sources are generally not sufficient for commercially feasible operation of a WtE plant.
		• Government support on:
		  • Feed-in-tariff for WtE generation
		  • Tipping fees support
		  • Guarantee
		  • Grant/ loan for construction
		  • Partial investment on WtE plant
		  • Carbon credit

Behavioral challenge	• Waste separation at source is a huge behavioral challenge in Southeast Asian cities.	• Require serious social engineering and strong regulation implementation.
Public perception	• The public typically have strong opposition if a WtE were to be constructed around inhabitant areas. • Odor pollutants and health impacts are two of the most concerning issues.	• Technical knowledge, environmental standards, and regulatory policies should be popularized to the residents.

Sources: Worldbank - A Global Review of Solid Waste Management, UNEP - Waste Management in ASEAN countries.

Potential risk and mitigation

Like every investment, WtE projects are also subjected to multiple risks. The following are some risks that should be considered when determining the feasibility of a WtE project.

Risk	Mitigation
Market risk Exposure to competitive or unfavorable regulations would make it hard to secure long-term contracts for the supply of high calorific waste or industrial waste or contracts for the distribution of energy. This is a key market risk as it ultimately drives investors to abandon the project due to the fluctuation in revenue.	• WtE facilities should be constructed nearby waste producers or on waste producers' sites to provide a guaranteed waste for energy production and to prevent underutilization of infrastructure. • Enter into a "take or pay" agreement with public agencies whereby the public agency agrees to guarantee a monthly payment on a specific quantity of electricity regardless whether the electricity is accepted on the electric grid or not.
Financial risk Given that a WtE project is susceptible to risks such as technical risk and market risk which can quickly erode profit, the implementation of the project itself requires large initial investment due to the specific expertise required in the design, construction, and operation of these facilities which could further expose investors to financial risk.	• Enter a joint venture with a credible and experienced partner (or partners) whereby all project stakeholders who invest capital into the project are then mandated to design, build, own and operate the project. • Engage a competent and specialized independent financial consultant to conduct detailed and comprehensive financial feasibility study. Robust sensitivity analysis should be performed with respect to changes in interest rate, equity percentage, project economic and operation parameters.

Sources: Journal article - Risk identification for PPP waste-to-energy incineration projects in China, Capital Cost Comparison of Waste-to-Energy (WtE), Facilities in China and the U.S.

Potential risk and mitigation (continued)

Risk	Mitigation
Public Opposition risk Failure in protecting the public interest during the project development phase or operation phase would lead to public opposition which in turn can result in delays in development or even suspension or termination of the WtE. Emerging public opposition due to “not in my back yard” syndrome might led to mass disturbance or protest.	• Disseminate the operational information to local residents • Improve the transparency and publicity of the project during operation • Investigate and evaluate potential problems that might cause the public opposition. Put in place a contingency plan to handle such situation.
Environmental risk There are various kinds of contaminating materials are produced during conversion, Most of which are extremely poisonous and require stringent attention and careful treatment as excessive discharge of contaminating materials without treatment can led to serious long-term health issue and also pollute the surrounding environment.	• Control the emissions according to the legislation. • Report on the contaminations discharged by means of producing a social and environmental audit report to promote transparency.
Technical risk Inappropriate design or equipment for a WtE project can cause serious operational problems; a mismatch of incinerating technology and the local MSW composition (moisture level) would result in sub-optimal production or energy.	• Undertake detailed analysis of the characteristic of the targeted local MSW. • Promote research on WtE technology prior to purchasing and enhance personnel technical training to ensure efficient handling of it.

Sources: Journal article-Risk identification for PPP waste-to-energy incineration projects in China, Global infrastructure hub - Waste to Energy report

Foreign Investment Restriction

As different countries have different foreign investment regulations, listed below are the relevant foreign investment polices that should be considered when searching for a suitable location to establish a WtE project.

Country	Foreign Ownership Restriction	Description
Indonesia	49 – 95% depending on capacity	• Power generation projects in Indonesia generally fall under the line of business of KBLI No. 35101 (power generation). This line of business is open for foreign investment with certain restrictions. • Projects having a capacity of 1 - 10 MW are open for a maximum 49% foreign ownership, while projects with a capacity higher than 10 MW are open for a maximum 95% foreign ownership (or 100% if it is a PPP project).
Thailand	No restriction other than land ownership	• Generally, there is no restriction on the number of shares or percentage of shares held by a foreign entity, as the power generation business is not a restricted business activity under the Foreign Business Act B.E. 2542 (1999) (FBA). • However, under the Land Code of Thailand (“Land Code”), a company in which more than 49% of the total shares are held by foreigners or where foreign shareholders make up more than half of the total number of shareholders, shall be considered a foreigner and shall not be permitted to own land.
Vietnam	No restriction	• Currently, there is no restriction concerning the foreign ownership of a WtE plant but the transmission and distribution of electricity is not open to foreign investors as EVN and its subsidiaries has a monopolistic role in this area. • At the moment, most foreign investment occurs by means of BOT (Build Own Transfer). • Some of the key factors that challenge foreign investors are the lack of government guarantees for debt finance, EVN’s low purchase price of electricity from waste-to-energy projects and the lack of government guarantee for EVN’s payment obligation

Sources: Indonesia: Global business guide - Expanded Coverage of Indonesia WtE project, Thailand: BOI - A guide to the board of investment 2020, Vietnam

Foreign Investment Restriction (continued)

Country	Foreign Ownership Restriction	Description
Singapore	No restriction but requires license from EMA	• Generally, there is no restrictions on foreign ownership of electricity companies or assets. However, a license from the Energy Market Authority (EMA) is required for companies who are involved in the generation, retail and transmission of electricity. • Under 30B of the Electricity act, requires an acquiring party to obtain the EMA approval when holding and controlling 12% or more or 30% or more of the voting power or equity interest in the designated licensee, entity or business trust or inform the EMA if they holding 5% or more but less than 12% of the total equity interest in the licensee, the entity or the business trust
Malaysia	At least 51% of the WtE project is owned by local Malaysian company	• The concessionaire company of a WtE project will require at least 51% of Malaysian ownership. • Under the Electricity Supply Act 1990, a license is required to supply electricity to consumer by electricity utilities. Whereby installation capacity of 30MW and above, requires an approval from the Minister before being process by the Department of Industry Development and Electricity Market Regulation, but the Minister approval is not required for installation capacity below 30MW.
Philippines	No restriction on foreign ownership	• The Philippines government imposed a 60:40 equity arrangement on renewable energy project where Filipinos must own a 60% stake in the RE project and only 40% is granted to foreign investor-partners. However, The Department of Energy (DOE) has recently undertaken a policy revision which allows 100% foreign ownership for waste-to-energy technology, thus, foreign firm do not need a Filipino partner to undertake a WtE project.

Sources: Singapore: Thomas Reuters: Overview of Electricity regulation in Singapore, Malaysia: Energy Commissioner - Guidelines on Licensing under Section 9 of the Electricity Supply Act 1990 , Philippines: Manila times: Biomass Now open to 100 foreign stake

Country Overview - Malaysia

Country Summary - Malaysia

The Housing and Local Government Ministry (KPKT) plans to set up six waste-to-energy (WtE) plants towards 2025 with various technologies to be evaluated. The National Recycling Rate in June 2020 is 30.67%, which is a 2.61% increase from 2019. By 2025, KPKT is targeting to achieve 40% National Recycling Rate.

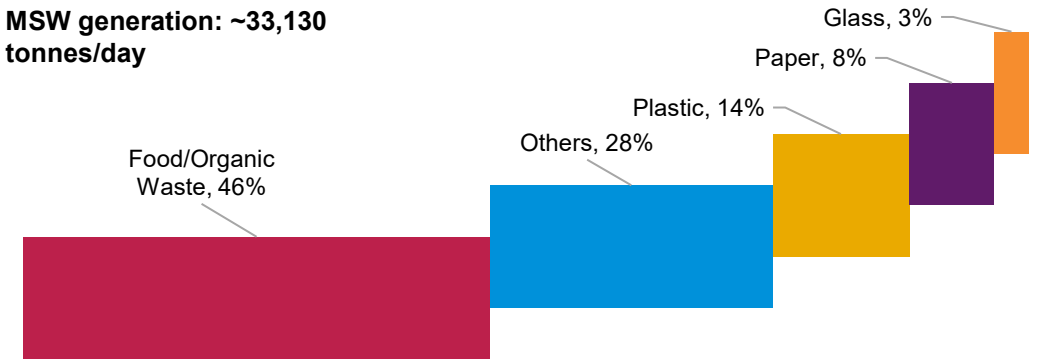
Key challenges

1. **Low budgetary allocation restrict innovations for sustainable waste management:** The expense of Municipal Waste Management administration per premise is around RM15 while the CAPEX for new landfill is more than RM30 million and OPEX is around RM30–40 per ton
2. **Lack of awareness of waste sorting and recycling:** Malaysia has attempted to enforce waste separation from 2015 to 2017, however, the waste separation has not materialized due to a lack of awareness and enforcement.
3. **Inadequate waste facilities:** Only a fraction of the waste facilities planned were approved due to constraint in funds and also due to limited manpower.
4. **Gaps in policies, guidelines and standards:** The gaps in policies and standards together with lack of coordination among all stakeholders hinders actual implementation.

Foreign investment restriction in WtE plant: The concessionaire company of the WtE project will require at least 51% of Malaysian ownership. Additionally, under the Electricity Supply Act 1990, a license is required to supply electricity to consumers via electrical utilities. Whereby an installation capacity of 30MW and above requires an approval from the Minister of Energy and Natural Resources before being processed by the Department of Industry Development and Electricity Market Regulation, the Minister's approval is not required for an installation capacity below 30MW.

Malaysia's MSW composition (%)

MSW generation: ~33,130 tonnes/day

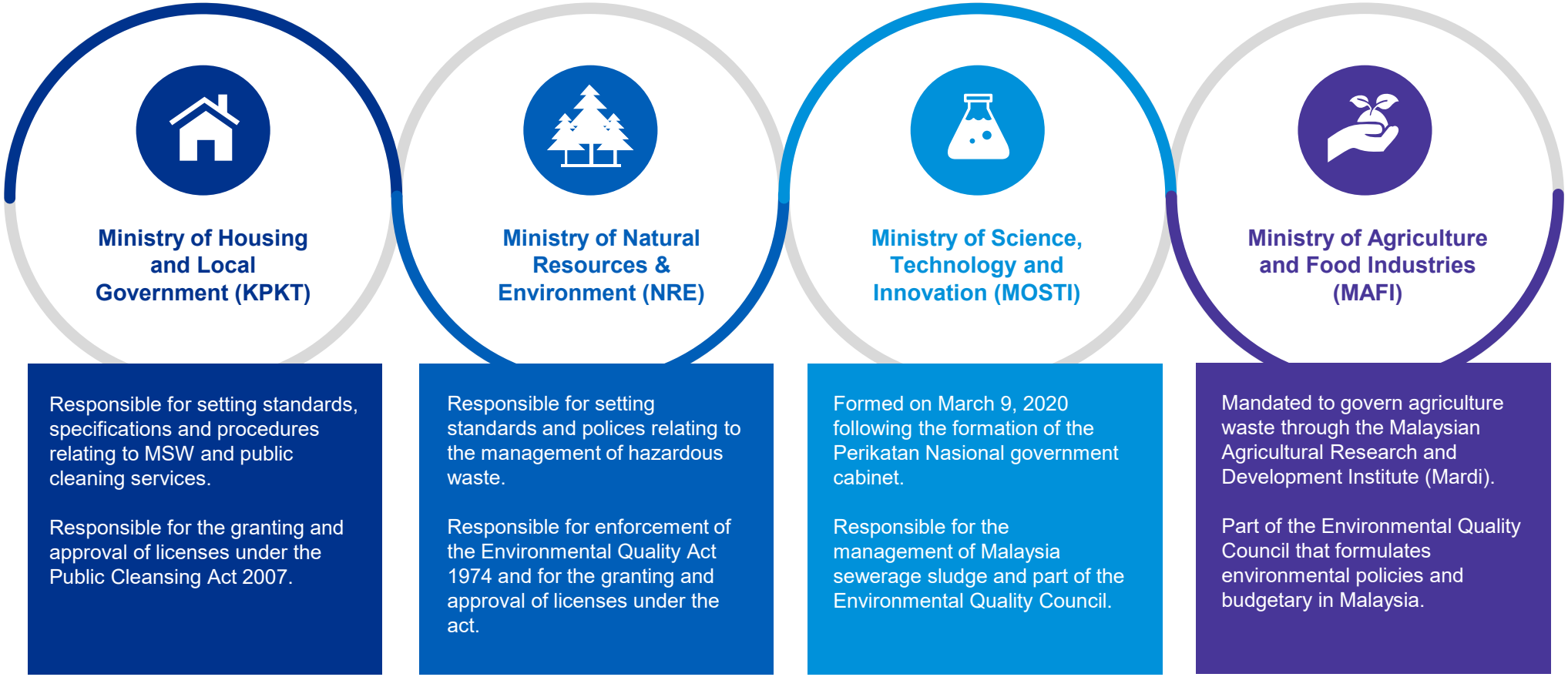


Key Market Participants	Description
Alam Flora	MSW collection for Kuala Lumpur, Putrajaya and Pahang
SWM Environment	MSW collection for Johor, Melaka and Negeri Sembilan
KDEB Waste Management	MSW collection for Selangor
E-Idaman	MSW collection for Perlis and Kedah
Cypark Resources	Constructing a 25MW RM300 million WtE plant in Ladang Tanah Merah Negeri Sembilan
Worldwide Holding Group	Constructing a 25MW WtE plant in Jeram, Kuala Selangor is expected to be commissioned by 2022

Sources: Worldbank - UNEP :Waste Management in ASEAN countries, Energy Commissioner: Guidelines on Licensing under Section 9 of the Electricity Supply Act 1990

Malaysia's Government Body

There are multiple stakeholders involved in different phases of the municipal solid waste management system. Set out below are the relevant government departments and the respective responsibilities.

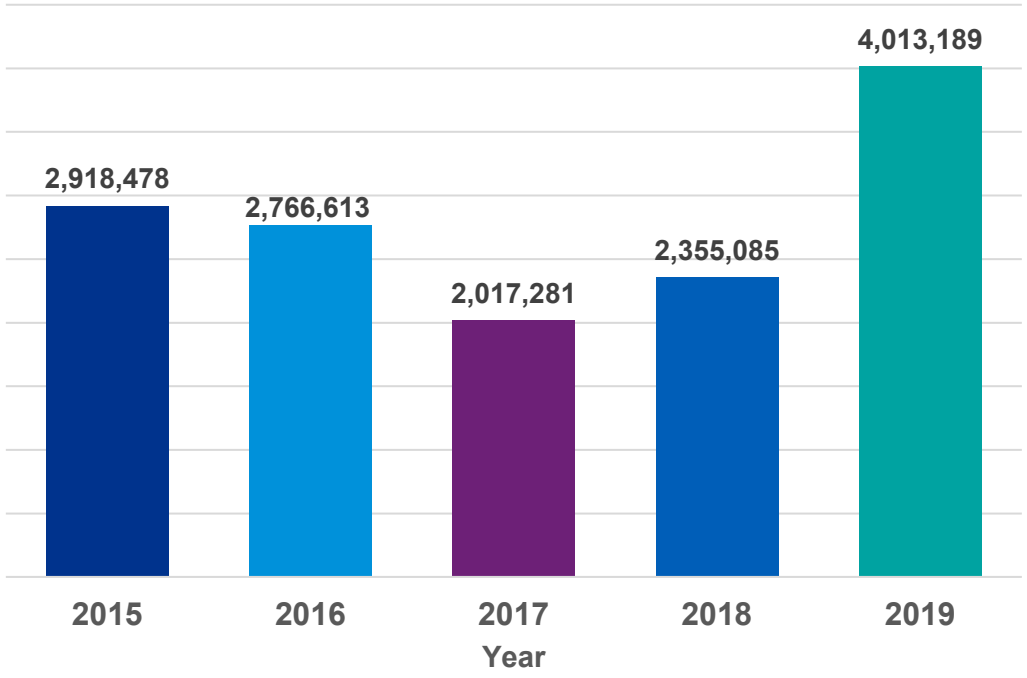


Sources: Government Ministry's Website

Hazardous Waste

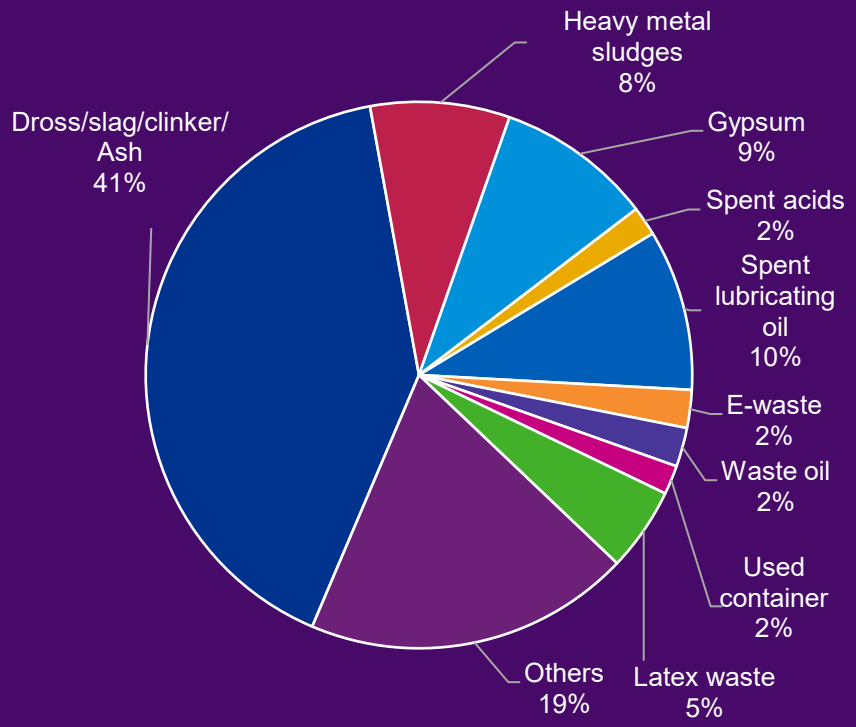
Hazardous waste management is governed under the revised Environmental Quality (Scheduled Wastes) Regulations 2005, which prescribed 77 categories of Hazardous Waste. The Act is enforced by the Ministry of Natural Resources & Environment (NRE) through the Department of National Solid waste Management and Solid Waste and Public Cleansing Management Corporation (SWCorp).

Malaysia's Hazardous waste in tonnes (2015-2019)



Sources: Worldbank - UNEP :Waste Management in ASEAN countries, UTM: Development of Policy and Regulations for Hazardous Waste Management in Malaysia

Malaysia's Hazardous waste composition (%)

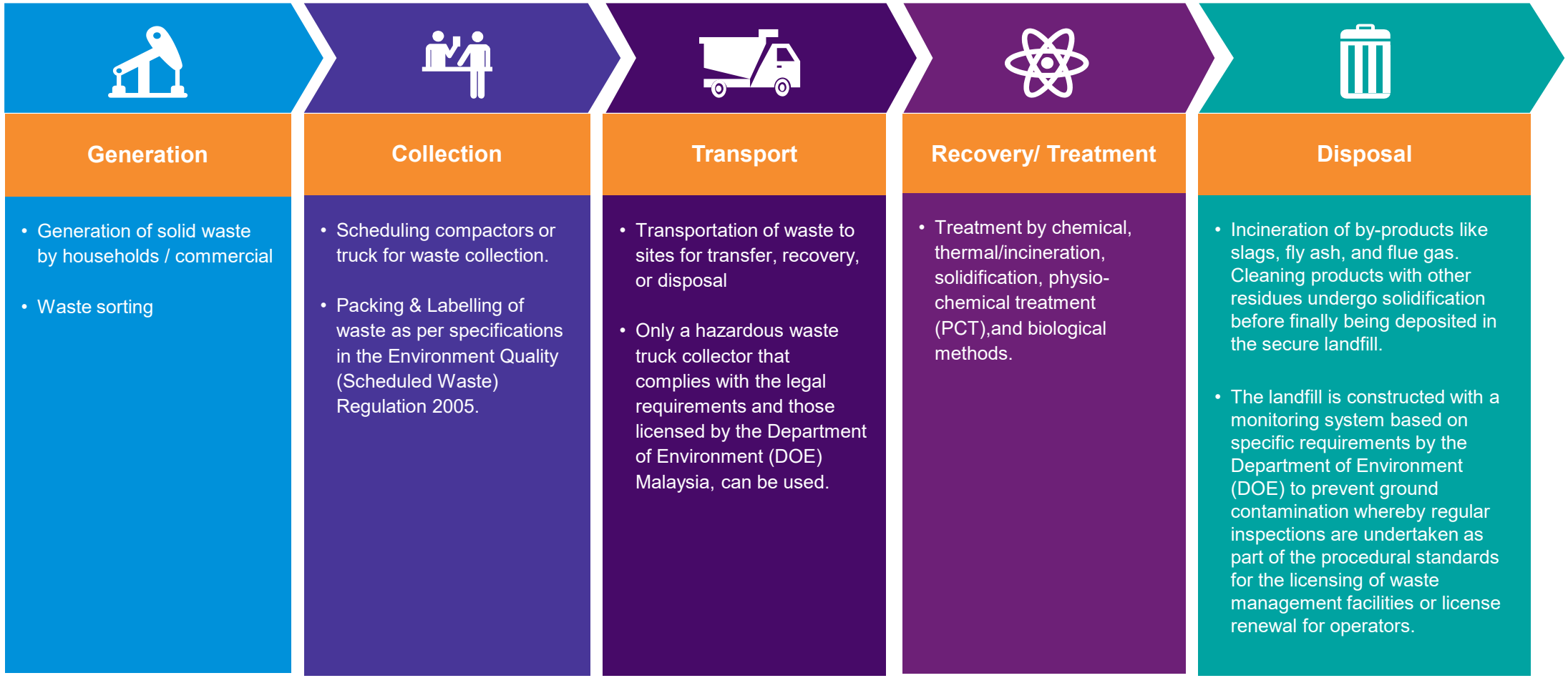


Hazardous waste generation: ~4,013,189 tonnes per year

As of 2019, the state that contributed the largest volume of hazardous waste is Selangor with a total of 1,019,932 tonnes, follow by Johor with 917,343 tonnes and Negeri Sembilan with 434,975 tonnes.

Waste Management Process – Hazardous waste

Generally, there are 5 stages of the hazardous waste management process that involves multiple stakeholders at different stages.



Sources: Intechopen: Overview of Hazardous Waste Management Status in Malaysia

Key Market Participants- Hazardous waste

Most key market participants within Malaysia's hazardous waste sector are involved in all level of the hazardous waste management value chain.

Cenviro Sdn Bhd	5E Resources Sdn Bhd	Amita Berjaya Sdn Bhd	Tex cycle Technology (M) Berhad	Victory Recovery Resources Sdn Bhd
▪ Cenviro provides integrated hazardous waste management service through its subsidiary company, Kualiti Alam Sdn Bhd, with their waste management center in Negeri Sembilan. ▪ Cenviro has the license to handle 76 categories of 77 scheduled wastes and to also provide logistics and packaging service for hazardous waste.	▪ A company that is licensed by the DOE to provide integrated waste management for 27 categories of 77 scheduled waste. ▪ The company is also licensed to provide packaging and waste transportation from waste generators to their waste recycling plant using their DOE approved vehicles and drivers.	▪ A subsidiary under Berjaya group, ABSB is a licensed company that can manage 15 codes of scheduled wastes. ▪ ASBS is also licensed to provide transportation services to collect and transport of scheduled waste from waste generators to their waste recycling plant.	▪ An investment holding company listed on the ACE Market with a main business of collecting hazardous waste directly from electronic, oil & gas, engineering and other industries to be treated for reuse or removal of contaminants from soiled materials prior to disposal.	▪ A company who holds the license for the treatment of 17 approved codes of scheduled waste. ▪ The company is also licensed to provide off-site recycling and transportation of hazardous waste.

Sources: Department of Environment website and the companies' website

Waste Recovery/Treatment Plant

Only companies that are licensed by Malaysia's Department of Environment are allowed to handle the transportation, treatment and recovery or hazardous waste. The following is a list of companies who are licensed to provide such services:

No	Company	Category	Location	COD	Type of Waste
1	Kualiti Alam Sdn Bhd	Incinerator Facilities	Negeri Sembilan	1995	**76 waste groups** (Acidic substance and alkalis, heavy metals, Inorganic sludge and organic solvents and organic oil containment, resins and paints)
2	KA Petra Sdn Bhd	Off-Site Storage	Labuan	2008	**77 waste groups** (Dust, slag, ash, waste containing mercury, e-waste, waste oil, uncured resin waste, acidic substance and alkalis, heavy metals, Inorganic sludge and organic solvents)
3	Tex cycle Technology (M) Berhad	Off-site recovery	Selangor	2007	**33 waste groups** (Waste containing mercury, Oil sludges, alkalis, mineral sludges)
4	Victory Recovery Resources Sdn Bhd	Off-site recovery	Melaka	2011	**18 waste groups** (Dust, slag, ash, waste containing mercury, e-waste, waste oil, uncured resin waste)
5	5E Resources Sdn Bhd	Off-site recovery	Johor	2012	**27 waste groups** (Waste inks, papers, Disposed containers, Contaminated soils, organic alkali, waste oil, spent lubricating oil and hydraulic oil)
6	E-concern (M) Sdn Bhd	Off-Site Storage	Sarawak	2016	**76 waste groups** (Acidic substance and alkalis, heavy metals, Inorganic sludge and organic solvents and organic oil containment, resins and paints)

Sources: Companies' website and Malaysia's Department of Environment Portal.

Merger and Acquisition within Malaysia's waste management sector

The following is a list of merger and acquisition transactions that had occurred within Malaysia's waste management sector in recent years.

Acquiring Entity	Target company	Year	Details
Berjaya Group Bhd	KUB-Berjaya Enviro Sdn Bhd (KUBE)	2020	KUB Malaysia Bhd disposed of its 40 per cent equity interest in KUB-Berjaya Enviro Sdn Bhd (KUBE) comprising nine million shares (share sale) to Berjaya Group Bhd (BGB) for RM80 million. The deal gives BCorp full ownership of the solid waste disposal facility in Bukit Tagar, Selangor that is operating under a 30-year concession granted by the Government of Malaysia expiring on Jan 19, 2044.
Cypark Resources Bhd	BAC Biogas (Kg Gajah) Sdn Bhd	2020	Cypark Resources Bhd subsidiary, Reviva Sdn Bhd entered into an agreement to acquire 51% equity stake (1.53 million ordinary share) in biogas plant operator BAC Biogas (Kg Gajah) Sdn Bhd for a total consideration of RM6 million
Malakoff Corp Bhd	Alam Flora Sdn Bhd	2019	Malakoff Corp Bhd completed the acquisition of a 97.37% stake in Alam Flora Sdn Bhd from DRB-Hicom with a price tag of RM869 million. Alam Flora Sdn Bhd holds a 22-year concession for solid waste collection and public cleansing management awarded by the Malaysian government, which runs through Sept 1, 2011 until Sept 1, 2033

Sources: News articles & company's website

Merger and Acquisition within Malaysia's waste management sector (continued)

Acquiring Entity/ Entities	Target company	Year	Details
Blue Planet Environment Solutions Pte. Ltd.	Globecycle Holding Sdn. Bhd.	2019	Blue Planet, a Singapore firm, took over Globecycle Holdings Sdn. Bhd. for an undisclosed price. Globecycle is a waste management company based in Penang which collects, segregates and recycles general and scheduled waste such as plastic scrap, e-waste, ferrous and non-ferrous metals and other waste streams. Its is also the second company in the country to obtain an integrated secure landfill permit.
Employees Provident Fund (EPF) and Taliworks Corp Bhd	SWM Environment Holdings Sdn. Bhd.	2016	Employees Provident Fund (EPF) and Taliworks Corp Bhd have invested a combined RM490 million to buy a 35 per cent stake each in solid waste management firm SWM Holdings Sdn Bhd. The remaining 30% of SWM is held by Kembangan Restu Sdn Bhd.
Khazanah Nasional Bhd	Cenviro Group	2014	Khazanah Nasional Bhd acquired 100% of UEM Environment Sdn Bhd, the environmental holding company from the UEM Group Bhd. The holding company has since been re-branded as Cenviro Group.

Sources: News articles & company's website

Country Overview - Indonesia

Country Summary - Indonesia

Recent regulatory changes in Indonesia promotes WtE. The government plans for a major WtE plant in Indonesia with aims to deliver a combined capacity of 234 MW of power generation by 2022. However, this timeline could be impacted due to Covid-19. It is also worth noting that in Indonesia, the municipal solid waste management is typically done by the Cleaning Department of each district.

Key challenges

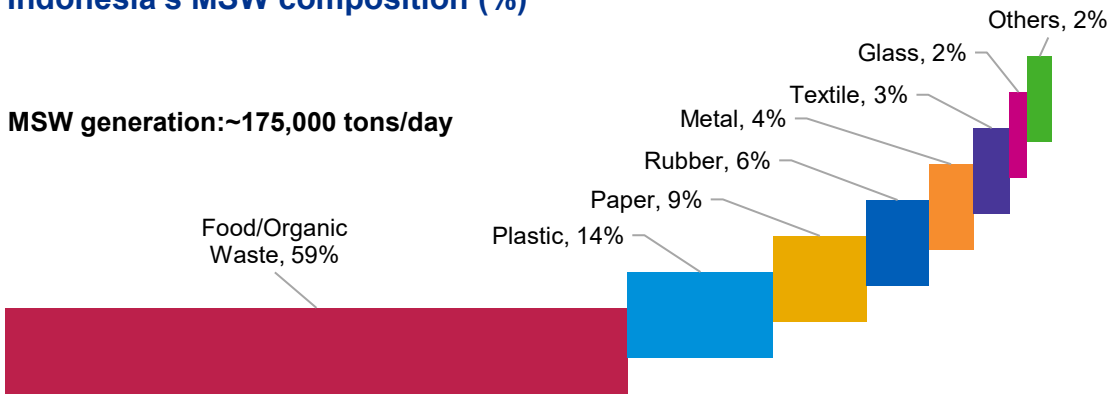
1. **Waste Gap:** Only 69% of total MSW generated is dumped to landfill while the rest is handled privately, burned or dumped into the river.
2. **3R facilities for MSW are not operated properly, waste is not separated at source:** This is due to the lack of know-how on the application of 3R throughout the country and barriers to 3R facilities for Industrial Solid Waste due to the lack of technical implementation and financial support.
3. **Dominated by open dump landfill:** Lack of sanitary landfill types in Indonesia and low implementation of waste management and WtE projects in the country.
4. **Hazardous waste:** Improper treatment and disposal of hazardous waste such as medical waste.
5. **Difference in tipping fee:** Different WtE projects have different tipping fees. In some regions, the tipping fee changes annually based on the budget set forward by the local government.

Foreign investment restriction in WtE plant:
Power generation projects in Indonesia generally fall under the line of business of KBLI No. 35101 (power generation). This line of business is open for foreign investment with certain restrictions.

a. 1 - 10 MW are open for a maximum 49% foreign ownership,
b. Projects with a capacity higher than 10 MW are open for a maximum 95% foreign ownership (or 100% if it is a PPP project).

Indonesia's MSW composition (%)

MSW generation:~175,000 tons/day

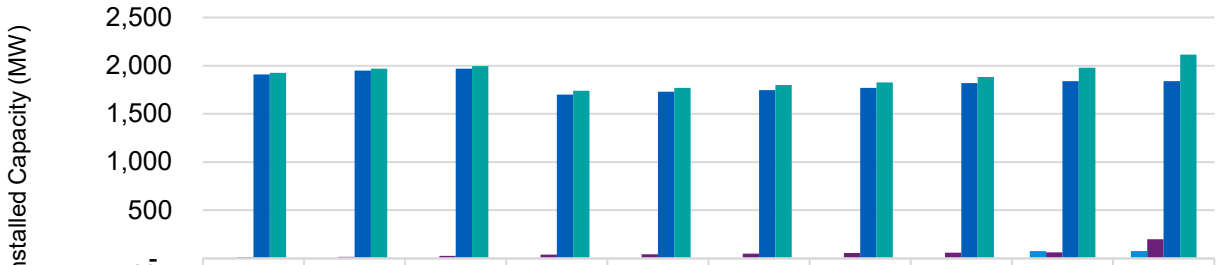


Key Market Participants	Description
Oligo Infrastructure Group	In charge of establishing waste management in Tangerang with waste volume of 2,034 tonnes per day (tpd).
Fortum (Finland)	Fortum forms JV with Jakarta Propertindo to develop 2,200 tpd Sunter ITF Project, currently still in development phase.
Wijaya Karya and Indoplas Karya Energi (strategic alliance with SBW Energy Group – Germany as financier and technology provider)	Consortium between PT Wijaya Karya Tbk & PT Indoplas Karya Energi, currently awarded as the winner of West Jakarta ITF project by Jakpro.
PT Indo Green Power (affiliate of Hangzhou Jinjiang Group)	Develop Palembang City WtE project with total capacity of 20 MW to process 1,000 tpd of waste.
PT Zhongde Waste Technology Indonesia (China)	Develop Manado City WtE project with total capacity of 10 MW to process 1,000 tpd of waste.

Sources: Worldbank - What a Waste : A Global Review of Solid Waste Management, UNEP- Waste Management in ASEAN countries report, GBG-Expanded Coverage of Indonesia WtE project

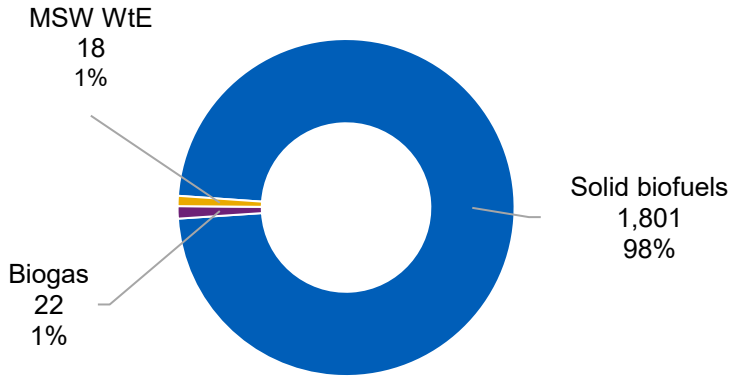
Indonesia's Renewable Energy and WtE

Indonesia's Installed capacity of RE (excl. hydro) (2010-2019)



Year	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Wind	0	1	1	1	1	1	1	1	76	76
Solar	15	17	26	38	42	51	58	60	62	198
Bioenergy	1,911	1,950	1,970	1,701	1,729	1,748	1,769	1,821	1,840	1,841
Total	1,926	1,968	1,997	1,740	1,771	1,799	1,827	1,882	1,978	2,114

Indonesia's bioenergy installed capacity (MW) composition (%) 2019



Relevant Waste Management Policy	Description
Presidential Regulation No. 35 of 2018 ("Regulation 35")	• Regulation 35 rectifies this contradiction, and provides a more comprehensive legal framework for the development of waste-to-energy projects in some major cities in Indonesia. It also provides a wider city coverage than Regulation 18, covering twelve major cities in Java, Bali, Sumatra and Sulawesi, including DKI Jakarta. • Other key features of Regulation 35 are the introduction of a new single feed-in tariff and a specific subsidy from the state budget (APBN) for the payment of the waste management fee (commonly referred to as the "tipping fee").
Regulation No. 4 of 2020 under Ministry of Energy and Mineral Resources	• Under the revision of Reg.4/2020, for WtE projects, PLN (Utilities in Indonesia) will not need to carry out a separate IPP appointment and, instead, will purchase the electricity directly from the awardee of the WtE project procured by the applicable regional government.

Sources: IRENA- Renewable Energy Statistics 2020, Cekindo-Overview of Waste Management Sector in Indonesia, Ashurst -MEMR Regulation 4/2020: Changes to the tendering regime for Indonesian Renewables IPPs

WtE projects - Indonesia

In 2019, Indonesia's Ministry of Energy and Mineral Resources reported 4 operating WtE plants, and 12 plants under construction and due to operate by 2022. However, some projects have since been postponed or cancelled due to Covid-19.

Potential WtE plants in Indonesia

Name	Company	Location	COD/Trial Year	Capacity	Type of Conversion
Rawa Kucing WtE	PT Oligo Infrastruktur Indonesia	Tangerang, Banten	2023/2024	12-20 MW	Biogas and RDF
West Jakarta ITF	Wika-Indoplas Consortium	West Jakarta	2022	35-40 MW	Moving Grate Incineration
Sunter ITF	Jakpro – Fortum Joint Venture	Sunter, Jakarta	2022	35-40 MW	Plasma, Gasification
Palembang WtE	PT Indo Green Power	Palembang, South Sumatra	2022	20 MW	Gasification
Manado WtE	PT Zhongde Waste Technology Indonesia	Manado, North Sulawesi	N/A	10 MW	Under study

Sources: News articles

Bankability of WtE projects in Indonesia

There are two forms of private participation for Indonesia's WtE project: Public Private Partnership (PPP) and Business to Business (B2B). Most WtE projects are under the PPP scheme whereby the local government is the owner of the project and a private entity builds and operates the plant for a concessionary period.

General details of PPP Project in Indonesia

- It is each regional government's responsibility to provide a budget for the management of waste, including the tipping fee.
- Currently, Indonesia's tipping fee is capped at a maximum of IDR 500,000 per tonne of waste.
- PT Perusahaan Listrik Negara (PLN) Indonesia's electric distribution monopoly, is required to procure a 'build, own and operate' renewable energy project from a private developer after the term of the power purchase agreement has elapsed.
- PLN is obliged to accept all the power generated at the WtE plants onto the electricity grid at a feed in tariff of 100% ~ 85% of the local production cost, or at a rate that is determined based on mutual agreement between PLN and the project developer.
- Parties in a WtE project share the responsibility for force majeure events, but the responsibility for unforeseen ground conditions and majority operating risks and financing still falls on the private entity.

Government Support

- WtE projects are categorised as infrastructures in the public interest. PR 38/2015 requires the Government Contracting Agency (GCA) to pay the cost of land acquisition in advance to those who would then be reimbursed by the project developer.
- A government guarantee (GG) which is backed up by the Minister of Finance (MoF) through the Indonesia Infrastructure Guarantee Fund (IIGF) is provided to ensure that the GCA is able to meet its financial obligations towards the contracting private entity.
- Feasibility Support for Part of Construction Cost is available to improve the financial feasibility and bankability of PPP projects with intention of covering construction costs such as equipment costs, installation costs, interest cost during the construction period.
- Viability gap funding (VGF) is also provided by the MoF in the form of tax incentives or fiscal contributions to mitigate revenue risk.

Sources: Ministry Of Energy and Mineral Resource- Waste to Energy Guidebook, Pinsent Mason- Waste to energy Indonesia opportunities and challenges

Process flow of PPP model for WtE in Indonesia

The initiation of a WtE project under the PPP Scheme involves various agreements between the project developer and various other stakeholder groups, all of whom play significant roles in influencing the project's progress.

- The winning bidder must establish an SPC within 6 months after being identified by the Government Contracting Agency (GCA).
- Note that PPP regulations prohibit shareholders from transferring their shares to other parties before the WtE is ready for commercial operation, and that shareholder agreements should comply with Indonesia Company law with parties subscribing to a percentage of equity in line with the debt to equity ratio that is stipulated in the request for proposal document.

- The GCA enters into a PPP agreement with the SPC, setting out the rights and obligations of the parties during the concession period.
- Some of the rights and obligations are: i) the SPC must obtain financing for the project no later than 12 months after the PPP agreement is signed. ii) the quantities of electricity to be delivered to PLN and the FIT rate. iii) the quality and quantities of waste supply and tipping fee and payment mechanism.

- The guarantee agreement is signed between the Indonesia Infrastructure Guarantee Fund (IIGF) and SOC which provide government guarantee for loan agreement and financial compensation.
- The recourse agreement is made between the GCA and the IIGF whereby the main provision is the payment mechanism covering the obligation between the GCA and IIGF.

- The SPC need to seek funds from a financial institution to operate the plant. Operation and establishment activities can be undertaken by the SPC or they are authorized to sub-contract the work to a third party.
- All sub-contracted work must have specific agreements to ensure that the work done is in line with the standards and provisions laid out in the PPP agreement.
- Additionally, the SPC may also appoint an insurance company to establish an insurance policy for the project.

- In the operational phase, the regional government, through the Sanitation Authority or any regionally-owned sanitation enterprise, supplies the waste the facility needs to operate. The WtE plants would produce the electricity to be delivered to PLN in accordance to the quality and quantities within the PPP agreement.

Sources: Ministry Of Energy and Mineral Resource – Waste to Energy Guidebook

Country Overview - Thailand

Country Summary - Thailand

Under the revised 2018 national power development plan, the Thai government set a target to produce an additional 400MW under WtE for sale to the state grid. WtE power plants currently operate in 41 areas, with combined capacity of 347.5 MW as of 2020. There is a total capacity of 121.6MW under construction.

Key challenges

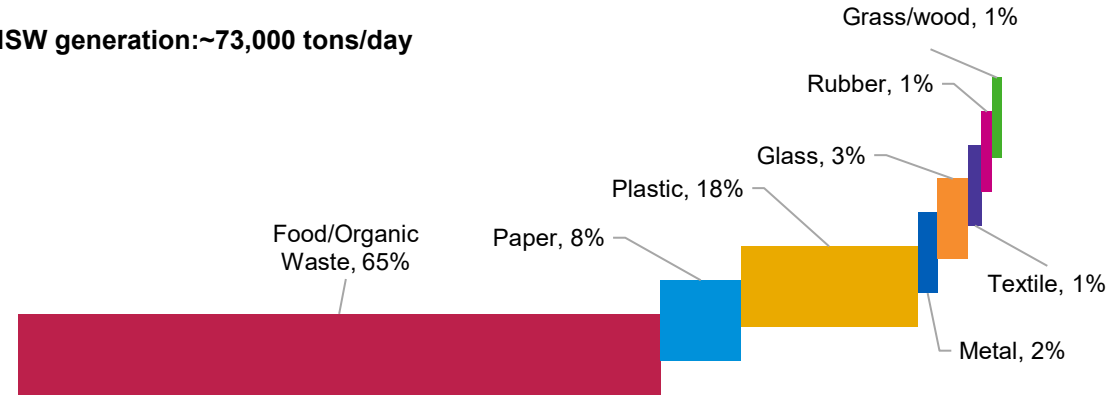
1. **Insufficient waste collection points:** Inadequate waste collection points or street litter bins for locals which leads to random disposal of waste.
2. **Poor public awareness of waste sorting and recycling:** Lack of public awareness of recycling etiquette and public opposition against waste disposal facilities. Poor participation of household source segregation of waste.
3. **Waste gap:** In 2016, only 36% of the total generated waste is disposed through acceptable processes such as incineration, composting and landfilling.
4. **Low participation of private investor due to lack of financial support and bureaucratic barrier:** PPP projects exceeding 5,000 million THB must comply with the Public Private Partnership Act, which has many procedural steps and requires time for approval.
5. **Local citizens dissatisfaction with the WtE plant:** Local citizens are opposed to WtE plant due to concerns over negative health impacts from wastewater and air pollution

Foreign investment restriction on WtE plants: As the power generation business is not a restricted business activity under the Foreign Business Act B.E. 2542 (1999) ,there is no restriction on foreign ownership.

However, under the Land Code of Thailand ("Land Code"), a company is considered to be a foreign company when 49% the total shares are held by foreigners or when foreign shareholders make up more than half of the total number of shareholders. Thus, the company is not permitted to own land. However, a foreign company under Thailand Board of Investment (BOI) promotion will be permitted to own land and enjoy tax benefits.

Thailand's MSW composition (%)

MSW generation:~73,000 tons/day

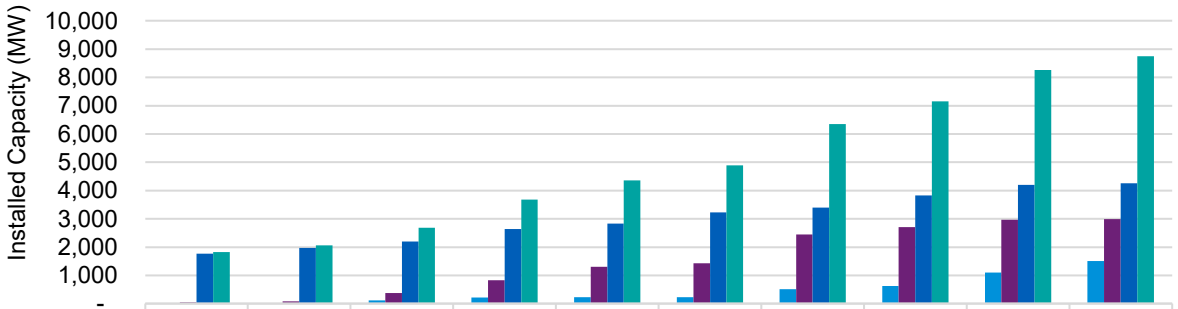


Key Market Participants	Description
TPI Polene Power (TPIPP)	Largest WtE operator in Thailand, runs a large-scale refuse-derived fuel processing facility for three WtE power plants
PJT Technology Co., Ltd.	A subsidiary of Yunnan Water, a Chinese company, operates the three incineration (MSW) power plants; two Phuket Incinerator Power Plants, each with an installed capacity of 7 MW and Amata Incinerator Plant in Chonburi with a capacity of 1.5 MW
Green Power Energy Co., Ltd	A subsidiary of Super Energy Corp Public, a leading RE power plant business, located in Sra Kaew, COD in 2018 with total installed capacity of 9.9 MW
Ratchaburi-EEP Renewable Energy Co., Ltd	A member of EEP Group which is a MSW management company, RDF-driven power plant, COD in 2017, located in Samut Prakan with installed capacity of 9.9 MW
C&G Environmental Protection (Thailand) Co., Ltd.	A subsidiary of SDIC Power, a Chinese state owned company, that operates incineration (MSW) power plant with a capacity of 9.8 MW at Nong Kheam, Bangkok

Sources: Worldbank - A Global Review of Solid Waste Management, UNEP- Waste Management in ASEAN countries, BOI- A guide to the board of investment 2020

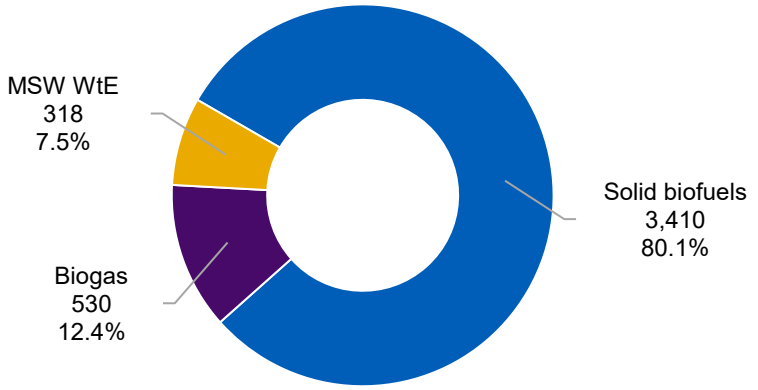
Thailand's Renewable Energy and WtE

Thailand's Installed capacity of RE (excl. hydro) (2010-2019)



Year	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Wind	6	7	112	223	225	234	507	628	1,103	1,507
Solar	49	79	382	829	1,304	1,425	2,451	2,702	2,967	2,987
Bioenergy	1,767	1,975	2,196	2,634	2,829	3,231	3,395	3,824	4,196	4,258
Total RE	1,821	2,061	2,690	3,685	4,357	4,889	6,353	7,154	8,266	8,752

Thailand's bioenergy installed capacity (MW) composition (%) 2019



Relevant Waste Management Policy	Description
Cleanliness and Orderliness of the Country Act in 2017	• Outlined the authority of Thai Local Administration Organizations (instead of districts) in the field of waste collection and management under supervision of the provinces and the Ministry of Interior (MOI).
Alternative Energy Development Plan (AEDP) (2015-2036)	• AEDP2015 sets out guidelines to archive a target of 30% renewable energy consumption by 2036 through the increase in the sources of renewable energy; Electricity (15%-20%),Heat (30%-35%), Bio-Fuels (20%-25%)
AEDP (2018-2037)	• AEDP2018 aims to increase additional capacity of WtE by 400 MW
Energy Regulatory Commission Notification 3/2021	• After 2017, FiT will continue to increase in accordance with core inflation, FiT (2021) for waste (Integrated Solid Waste Disposal) installed capacity ≤ 1 MV: 3.2773 THB/unit, > 1-3 MW: 3.2773 THB/unit, >3 MW: 2.7464 THB/unit

Sources: IRENA – Renewable Energy Statistics 2020, ERIA - "Toward Regional Cooperation of Local Governments in ASEAN" Report

WtE projects - Thailand

As of November 2019, Thailand's Alternative Energy Development and Efficiency Department's database listed 33 operational waste-to energy plants in Thailand amounting to total installed capacity of 283MW from waste-to energy as of the end of 2018

Top 5 plants contributor of WtE in Thailand

Name	Company	Location	COD Year	Capacity	Type of Conversion
Saraburi Plant	TPI Polene Public Company Limited	Saraburi Province	2018	80 MW	Incineration (Coal and RDF-fired)
PJT Plant	PJT Technology Co. Ltd.	Muang, Phuket	2012	12 MW	Incineration (MSW)
EEP RDF-drive power plant	Eastern Energy Plus Co (EEP)	Samut Prakan	2017	9.9 MW	Incineration (RDF)
Bangkok WtE Project	C&G Environmental Protection (Thailand) Co., Ltd	Nongkham, Bangkok	2015	9.8 MW	Incineration (MSW)
ETC power plant	Earth Tech Environment Plc (ETC)	Saraburi Province	2017	9.4 MW	Incineration (MSW and Industrial waste as fuel)

Sources: News articles

Country Overview - Vietnam

Country Summary - Vietnam

The government plans to prioritize domestically developed technologies, including waste-to-energy ("WtE") among others. However, currently WtE plants account for an insignificant percentage in total installed capacity (nearly 1%). In the forthcoming power development plan, the total installed capacity of WtE plants is expected to increase to over 2,000MW, albeit its proportion remains minimal (around 2% of total capacity).

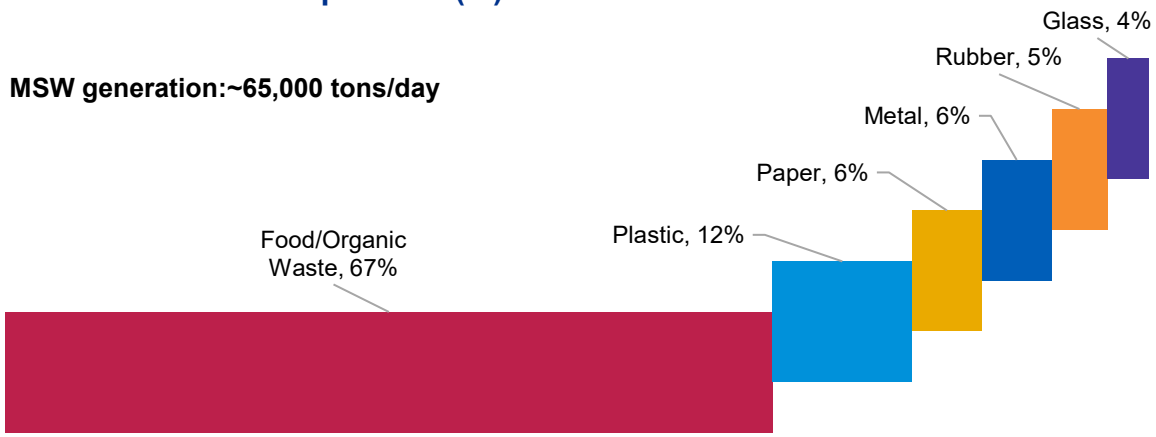
Key challenges

1. **Lack of incentives for waste classification at source:** Mechanisms and policies to promote activities of classifying domestic solid waste at source remain limited, leading to difficulty in deploying WtE projects.
2. **Lack of incentives for high-technology solid waste treatment:** In Vietnam, direct landfilling are preferred due to its economical nature. However, it has resulted in many complex environmental and social problems.
3. **Time-consuming legal process:** Business registration, work permit, environmental permit and so forth are complex, unnecessarily expanding the project length. For WtE licensing, the project needs to be added to the Power Development Plan, which can take a great amount of time.
4. **High initial investment:**Investment rates for WtE projects are in the range of USD3.5 to 4 million/ 1MW of electricity, which is 4 times higher than solar projects.

Foreign investment restriction in WtE plant Currently, there is no restriction concerning the foreign ownership of a WtE plant. However, transmission and distribution of electricity is not open to foreign investors as EVN and its subsidiaries has a monopolistic role in this area. At the moment, most foreign investment occurs by means of BOT (Build Own Transfer). Some of the key challenges for foreign investors are the lack of government guarantees for debt finance, EVN's low purchase price of electricity from waste-to-energy projects and the lack of government guarantee for EVN's payment obligation.

Vietnam's MSW composition (%)

MSW generation:~65,000 tons/day

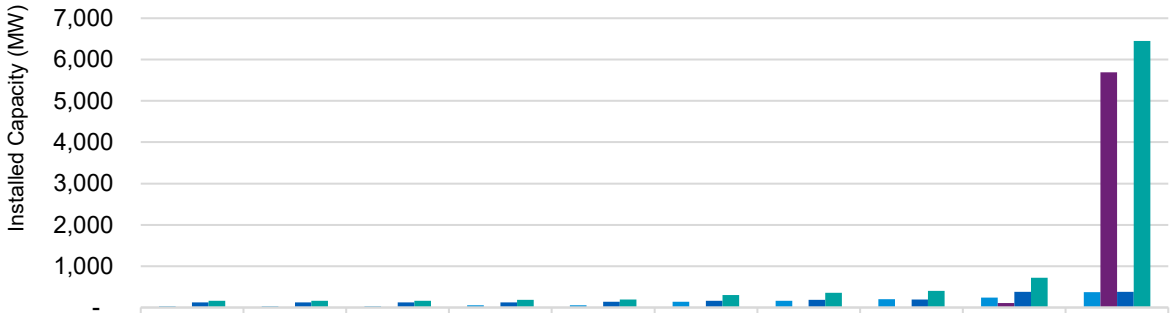


Key Market Participants	Description
Vietnam Waste Solutions	The largest solid waste treatment company in Ho Chi Minh City, with one operational landfill of 10 thousand tons per day (overloaded and polluting) and one under construction treatment plan of 21.4 thousand tons per day
Thien Y Hanoi Energy and Environment JSC	Developer of a WtE project that has a total investment of USD300 million at Hanoi, with a capacity of 4,000 tons of waste per day
Vietstar JSC	Developer of a WtE project that has a capacity of 2,000 tons of waste per day
Tam Sinh Nghia Environment JSC	Developer of a WtE project that has a capacity of 2,000 tons of waste per day

Sources: UNEP: Waste Management in ASEAN countries, Thomas Reuters: The External Effects of the Energy Union Strategy on Trade and Investment in Vietnam

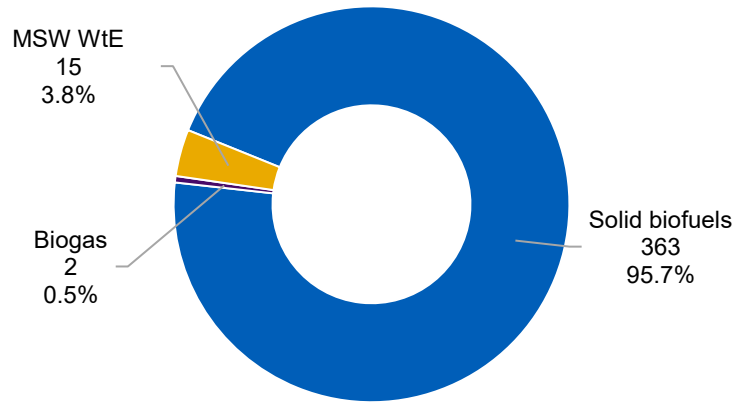
Vietnam's Renewable Energy and WtE

Vietnam's Installed capacity of RE (excl. hydro) (2010-2019)



Year	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Wind	31	31	31	53	53	136	160	205	237	375
Solar	5	5	5	5	6	6	6	9	106	5,695
Bioenergy	125	125	125	125	136	161	188	192	380	380
Total RE	161	161	161	183	195	303	354	405	722	6,449

Vietnam's bioenergy installed capacity (MW) composition (%) 2019



Relevant Waste Management Policy	Description
Decision 491/QD-TTg dated 07 May 2018	For Waste Management, by 2025, the government aims to achieve three major objectives: • Waste collection: increase up to 100% collected, depending on different classification of waste • Waste recycle: up to 100% recycled, especially for electronic equipment producers • Waste treatment: gradually transferring to more technologically advanced treatment processes
Decision No. 31/2014/QD-Ttg dated 5/5/2014	WtE projects will enjoy Value Added Tax credit, Corporate Income Tax incentives, import tax exemption and reduction for raw materials, machinery and land rental. In addition to investment incentives, taxes and land rent, all electricity produced by the waste power plant will be purchased by EVN within 20 years at the price of 10.05 US cents / kWh

Sources: IRENA – Renewable Energy Statistics 2020, ERIA - "Toward Regional Cooperation of Local Governments in ASEAN" Report, Solid Waste Management in Vietnam: State and Institutional Framework and Challenge

WtE projects - Vietnam

In 2018, there were only 35 waste treatment facilities with a total capacity of 6,500 tons/day; 5 facilities are incinerators, 12 for composting and 18 facilities undertake both incineration and composting. It was not until 2017 that Vietnam had its first operating waste-to-energy plant in Hanoi.

Top 5 plant contributor of WtE in Vietnam

Name	Company	Location	Planned COD	Capacity	Status	Type of Conversion
Soc Son WtE Plant	Thien Y Hanoi Energy and Environment JSC	Hanoi	2020*	75 MW	Under construction (Since 2017)	Incineration (mechanical furnace)
Vietstar WtE Plant	Vietstar JSC	HCMC	2020 – 2021	40 MW (2 phases in total)	Under construction (Since August 2019)	Incineration
Tam Sinh Nghia WtE Plant	Tam Sinh Nghia Environment JSC	HCMC	2022	40 MW	Under construction (Since October 2019)	Incineration
Can Tho WtE Plant	China Everbright International	Can Tho	2018	~7 MW	In operation	Incineration
Hau Giang WtE Plant	Greenity Hau Giang Company Limited	Hau Giang	2022	12 MW (phase 2)	Under construction (Since October 2020)	Incineration

Note: (*) Delayed due to Covid-19

Sources: News articles

Country Overview - Singapore

Country Summary - Singapore

Due to land scarcity, Singapore has adopted waste incineration as their waste treatment method whereby incineration technology is used to reduce waste volume up to 90%. As of 2019, Singapore has 4 WtE plants that generate 3% of Singapore's total electricity demands.

Key challenges

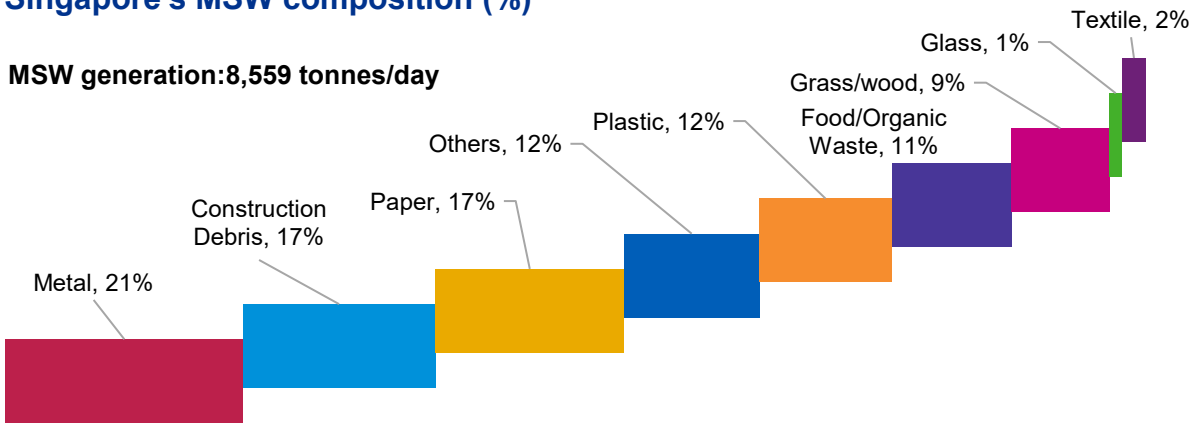
1. **Land scarcity:** There is land constraint for waste management activities including building of WtE plants and landfills.
2. **Labour issues:** Difficulties in hiring and retaining manpower. 14% less waste collection workers are deployed daily compared to pre-Covid-19 due to the lockdown measures imposed which affected Malaysian workers.
3. **Increasing growth of E-waste:** Singapore produces on average 60,000 tonnes of e-waste every year with less than 6% of it being recycled.
4. **Low recycling rate:** Despite awareness raising campaigns, a 2018 study by the Singapore Environment Council found that 70% of respondents did not fully know what items are considered recyclable. Singapore's domestic recycling rate also dropped from 22% in 2018 to 17% in 2019.

Foreign investment restriction in WtE plant: There is generally no restrictions on foreign ownership of electricity companies or assets. However, a license from the Energy Market Authority (EMA) is required for companies who are involved in the generation, retail and transmission of electricity.

Under 30B of the Electricity act, an acquiring party is required to obtain the EMA approval when holding and controlling 12% or more or 30% or more of the voting power or equity interest in the designated licensee, entity or business trust, or to inform the EMA if they hold 5% or more but less than 12% of the total equity interest in the licensee, the entity or the business trust

Singapore's MSW composition (%)

MSW generation:8,559 tonnes/day

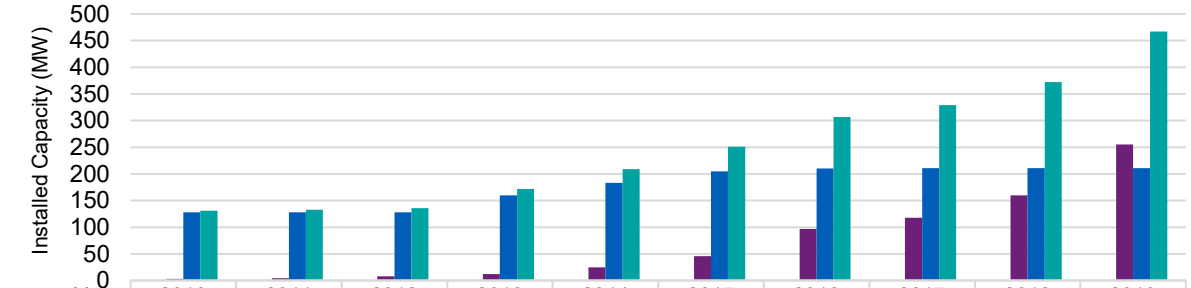


Key Market Participants	Description
Keppel Seghers	Operate Keppel Seghers Tuas WtE Plant and Senoko WtE plant and is currently in a JV (Keppel Seghers-China Harbour-ST Engineering Marine Joint Venture) to build Singapore first integrated waste management facility ,Tuas IWMF.
Hyflux Ltd	TuasOne WtE project majority shareholder with a 75% stake whereas JV partner Mitsubishi Heavy Industries owns the remaining 25%.The plant is expected to operate in 2021 with a capacity of 120 MW
Sembcorp Industries	The first government-contracted public waste collector company who provide MSW collection and recycling services for 5 geographical sector in Singapore.
Colex Holdings Limited	A waste management and recycling services provider who is provides MSW collection service for Jurong sector

Sources: UNEP - Waste Management in ASEAN countries, Thomas Reuters, Practical Law: Electricity regulation in Singapore

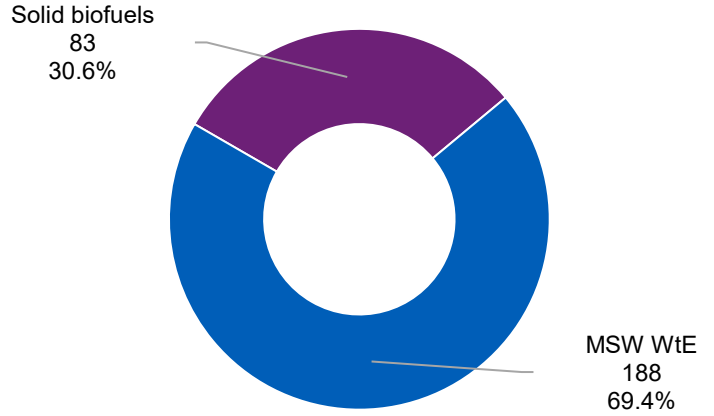
Singapore's Renewable Energy and WtE

Singapore's Installed capacity of RE (excl. hydro) (2010-2019)



Year	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Wind	0	0	0	0	0	0	0	0	0	0
Solar	2.9	4.6	8	12	25	46	96.6	117.9	160	255
Bioenergy	128	128	128	160	183	205	210	211	211	211
Total RE	131	133	136	172	209	251	307	329	372	467

Singapore's bioenergy installed capacity (MW) composition (%) 2019



Relevant Waste Management Policy	Description
Resource Sustainability Bill	The bill will be enacted as the Resource Sustainability Act and implemented incrementally from 2020 to 2025 with key features such as: • Setting out a framework for mandatory segregation of food waste for prescribed buildings. • Introduction of Producer Responsibility Scheme which requires larger producers of regulated consumer producers to be responsible for collecting and recycling e-waste. • Layout a mandatory packaging framework whereby producers of packaging and packaged products is required to report on the amount and type of packaging and their plans to reduce and recycle them.
Zero waste Masterplan	To extend Semakau Landfill's lifespan beyond 2035 and to achieve reduce the amount of waste (per capita) sent to landfill by 30% with an overall 70% overall recycling rate by 2030
Sustainable Singapore Blueprint 2015	To increase domestic recycling rate to 30% and non-domestic recycling rate to 81% by 2030

Sources: IRENA - Renewable Energy Statistics 2020, NCCS-Sustainable Blueprint 2015, Pinsentmason-Sustainability act Singapore road to zero-waste

WtE projects - Singapore

As of 2019, Singapore's National Environment Agency listed 4 operational waste-to energy plants in Singapore with 2 more WtE plants currently being built.

Top plant contributor of WtE in Singapore

Name	Company/Department	Location	COD/Trial year	Capacity	Type of Conversion
Tuas South Incineration Plant	National Environment Agency	Tuas South Avenue 3	2000	80 MW	Incineration
Senoko Waste-to-Energy Plan	Keppel Infrastructure	Attap Valley	1992	56 MW	Incineration
Keppel Seghers Tuas Waste to-Energy Plant	Keppel Infrastructure	Tuas South Avenue 3	2009	22~20 MW	Incineration
Tuas Incineration Plant	National Environment Agency	Tuas Avenue 20	1986	30 MW	Incineration
TuasOne waste-to-energy plant	Hyflux Ltd & Mitsubishi Heavy Industries Asia Pacific JV	Tuas South Avenue 3	Target:2021	120 MW	Incineration
Tuas IWMF	Keppel Seghers-China Harbour-ST Engineering Marine Joint Venture	Tuas Nexus Drive	Target:2027	230 MW	Incineration

Sources: News articles & National Environment Agency website

Case study – Keppel Seghers Tuas project

The Keppel Seghers Tuas project is the first and longest tenor waste-to-energy project tendered out under the Singapore Government's PPP initiative.

Project Features

- Keppel Seghers Tuas project bid was won by Keppel Seghers SPV (owned by Keppel Infrastructure group) on 8 September 2005 after beating 5 other international and local bidders.
- The plant was developed under a Design, Build, Own and Operate (DBOO) model and commenced in 2009 to replace Singapore's first WtE plant at Ulu Pandan.
- The construction of the plant took 4 years (November 2005 till May 2009) and is located on 1.6 hectares of land.
- The plant has a 25 years incineration service agreement that expires in 2038 and is able to treat 800 tonnes/day of solid waste and has the power capacity of 22MW.

Financing Information

- Source of funding: equity & 23 years term loan worth SGD105 million. (A tripartite agreement was signed by NEA, Keppel and the lending banks to protect the interests of the lenders).
- Debt to equity ratio : 65:35

Revenue Stream

Availability payment from NEA on a monthly basis which consist of combustion capacity payment, electricity generation payment, service payment (also known as refuse disposal fees) at SGD77/ tonne.

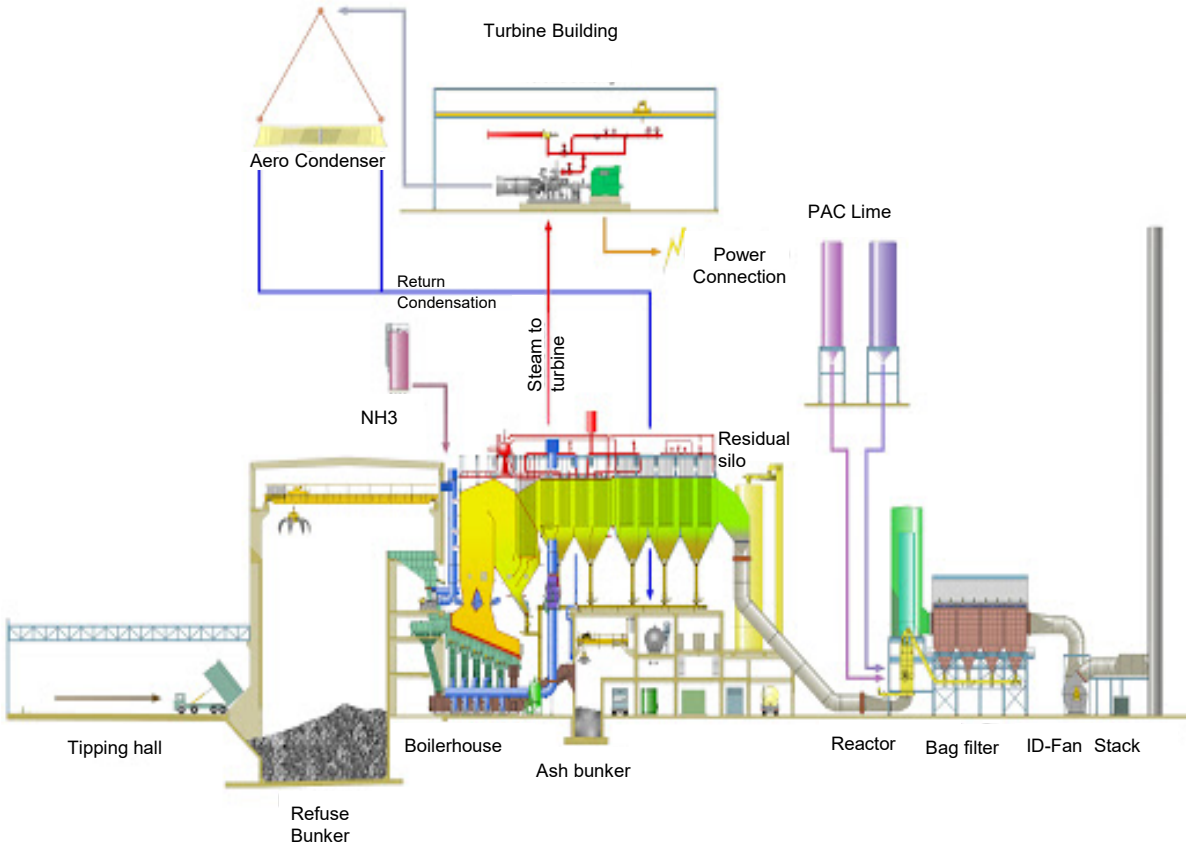
Parties Involved				
National Environment Agency	Dz Bank AG	ING Bank NV	Keppel Infrastructure group	Mizuho Corporation Bank Ltd

Sources: News articles & National Environment Agency website

Case study- Keppel Seghers Tuas project

The Keppel Seghers Tuas plant uses a moving grate incinerator technology and has a capacity of treating 800 tonnes/day of solid waste and a power capacity of 20MW ~ 22MW

Keppel Seghers Tuas Project Layout



Sources: Keppel Seghers Website

Step 1

Waste Acceptance

Residual waste is tipped into a bunker upon arrival. A crane places it into a feed hopper which then drops it into a feed chute and onto the grate.

Step 2

Incineration

The moving grate would fully burn the waste, producing burnt out ashes which passes through an ash discharger and onto an ash handling system whereby extraction of metal is undertaken for the purpose of recycling. The remaining ashes are recovered and used within the construction industry.

Step 3

Steam Production

Hot gases produced during the combustion process is funneled through the boiler to produce steam. The gases produced by the boiler would undergo an extensive flue gas cleaning process using scrubber and a bag filter to filter out particulates before it is released into the atmosphere.

Step 4

Electricity Production

The steam produced by the boiler is funnel to the turbo generator whereby it is used to produce electricity which is then exported to local power provider.

Country Overview - Philippines

Country Summary – Philippines

Philippines main MSW disposal method is by solid waste disposal (85%) and composting (10%). However, recent proposal of the waste-to-energy bill promotes the development of WtE facilities in tackling Philippines' waste issues while also assisting with the development of the country's renewable energy sector to achieve the country's envisioned target of 34,000 MW renewable energy by 2040 as stated in the National Renewable Energy Program 2020-2040.

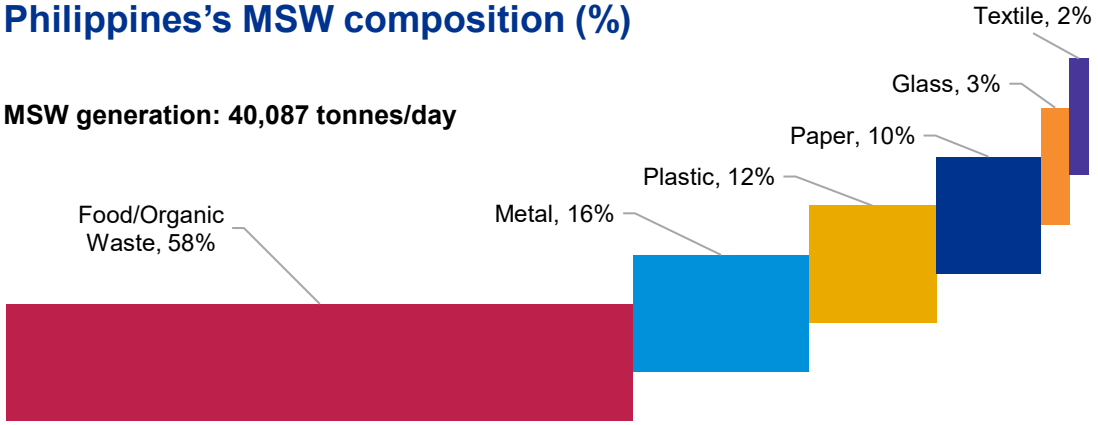
Key challenges

1. **Lack of awareness of waste sorting and recycling:** Lack of citizen's participation in waste segregation at the source for proper recycling/treatment/ disposal of waste.
2. **Gaps in effective enforcement of regulations:** No comprehensive monitoring and evaluation system for waste management at all levels; MSW collection efficiency range is below 50%.
3. **Limited external funding and technical support assistance:** Limited funding and technical support assistance for municipalities waste separations, recycling and composting technologies.
4. **Lack of accessibility to sanitary landfills:** Over 70% of the population do not have access to disposal facilities and sanitary landfills, causing waste to leak into the ocean; 74% of plastics ends up in the ocean.

Foreign investment restriction in WtE plant: The Philippines government imposed a 60:40 equity arrangement on renewable energy projects where Filipinos must own a 60% stake in the RE project and only 40% is granted to foreign investor-partners. However, The Department of Energy (DOE) has recently undertaken a policy revision which allows 100% foreign ownership for waste-to-energy technology, thus, foreign firms do not need a Filipino partner to undertake a WtE project.

Philippines's MSW composition (%)

MSW generation: 40,087 tonnes/day

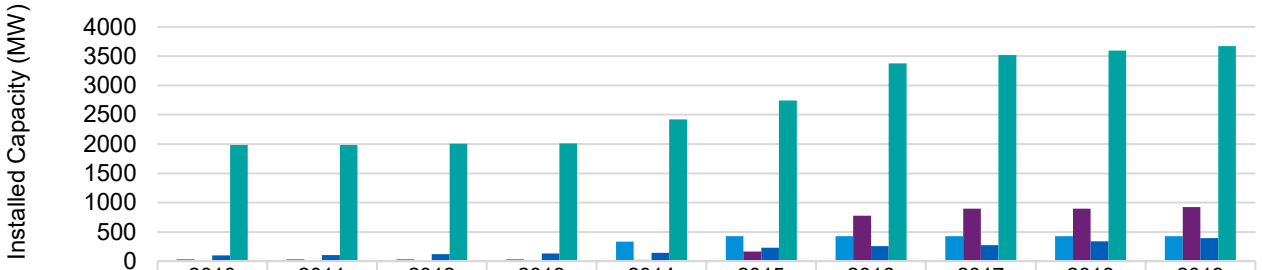


Key Market Participants	Description
Leonel Waste Management Corporation	An integrated waste solutions company which provides garbage collection services, solid waste segregation, waste transportation and disposal to sanitary landfills to several cities in Metro Manila
IPM Holdings, Inc.	Through its subsidiary IPM-Construction and Development, IPM provides environmental and sanitary services or operation for the city of Bacolod and management of landfill in Barangay Felisa
Green Atom Renewable Energy Corporation	A renewable energy corporation which was established in February 2015 who was awarded three waste-to-energy plant project to be established in Mabalacat, Laoac and San Jose City
CJ Global Green Energy Philippines Corp.	A renewable energy corporation who is awarded to the 20 MW waste-to-energy project in Luzon which uses thermal gasifier conversion

Sources: UNEP: Waste Management in ASEAN countries, Manila times: Biomass Now open to 100 foreign stake, Department of Environment website.

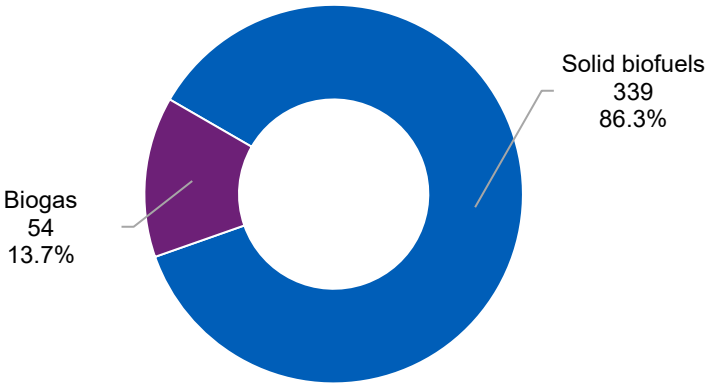
Philippines's Renewable Energy and WtE

Philippines's Installed capacity of RE (excl. hydro) (2010-2019)



Year	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Wind	33	33	33	33	337	427	427	427	427	427
Solar	1	1	1	1	23	166	775	897	897	922
Bioenergy	102	104	124	131	143	233	259	276	341	393
Total RE	1983	1985	2005	2012	2419	2741	3377	3516	3594	3671

Philippines's bioenergy installed capacity (MW) composition (%) 2019



Relevant Waste Management Policy	Description
Ecological Solid Waste Management, Act 2000	• The acts defines solid waste, municipal waste, hazardous waste, agriculture waste, bulky wastes, special wastes and yard waste. • The act provides for a systematic, comprehensive and ecological waste management program and outlines institutional arrangements, roles and responsibilities, incentives, unlawful activities, reduction targets, collection mandates and sanctions of SWM. • The act is the first initiative taken in introducing reuse, recycling and resource recovery of wastes at the barangay level.
The Philippine Environnemental Code (PD 1152)	• The code requires cities and municipalities to enforce sanitation requirements with clear guidance to provide efficient collection, transportation and disposal of waste.
DENR Administrative order No.2019-21	• The Administrative order provides a guidelines on the requirement, establishment and operation of WtE facilities for municipal solid waste.

Sources: IRENA - Renewable Energy Statistics 2020, UNEP: Waste Management in ASEAN countries, Department of Environment and Natural Resources website

WtE projects- Philippines

As of 2020, Philippines does not have any operational municipal solid waste-to-energy plants. However, the Department of Energy has awarded 6 waste-to energy plant projects which are currently in the development phase.

Potential WtE plants in Philippines

No	Company/ Organisation	Location	COD/Trial Year	Potential Capacity	Type of Conversion
1	CJ Global Green Energy & Hitachi Zosen	Naga City , Camarines Sur	Supposedly by 2015, but still in development	20 MW	Incineration
2	Green Atom Renewable Energy Corporation	San Jose, Batangas	2022-2023	6 MW	Incineration
3	Green Atom Renewable Energy Corporation	Mabalacat, Pampanga	2022	6 MW	Incineration
4	Green Atom Renewable Energy Corporation	Laoac, Pangasinan	2023	6 MW	Incineration
5	AustWorks Corporation	Puerto Princesa, Palawan	Supposedly by 2020 but still in development	5.22 MW	Incineration
6	Sure Global W2W Pte Ltd	Angeles City, Pampanga	Supposedly by 2019 but still in development	11.1 MW	Incineration

Sources: News articles & Philippines Department of Environment website

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WtE and other RE

Appendix

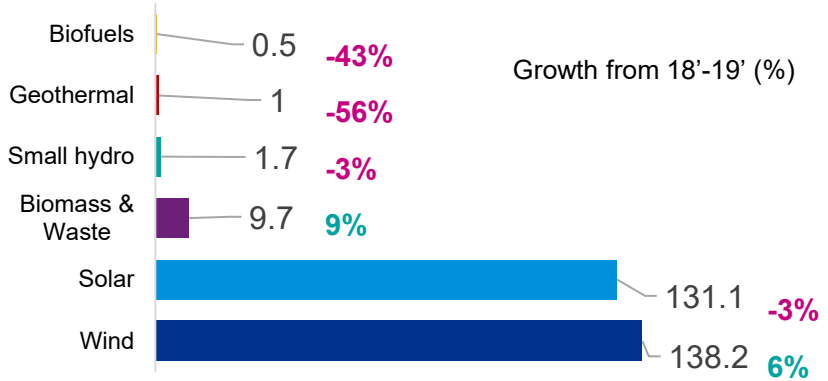
Comparison of WtE and other renewable energy

In 2019, global renewable energy investment was $282.2 billion, a 1% growth increase from the previous year's investment of $280.2 billion. This investment growth is mainly attributed to the wind, biomass and waste sectors.

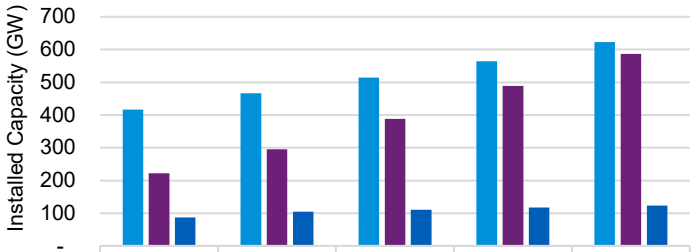
	WtE	Solar	Wind
Global investment as of 2019	$9.7 billion	$131.1 billion	$138.2 billion
Global Installed Capacity	14.5 GW	585 GW	623 GW
Levelized cost of energy (cost per MWh)	$38.75 (Incineration) $118.83 (Landfill gas)	$51	$47 (Onshore) $78 (Offshore)
IRR	8% to 14%	< 7%	4.5% to 10%

The IRR for each renewable energy plant project varies as it is dependent on variables such as the type and rate of the feed in tariff, the capacity of each renewable energy plant and the cost of operation, source of financing the project, government subsidies, policies (license and permit),tax rates, the availability of other revenue stream and the plants operational lifetime

Global investment in renewable energy in 2019, $ bn



Global installed capacity of Solar, Wind and WtE (2015-2019)



Year	2015	2016	2017	2018	2019
Wind	416	467	514	564	623
Solar	222	296	389	489	586
WtE - Bioenergy	87	105	111	118	124

Sources: IRENA - Renewable Energy Statistic 2020, UNEP - Global trends in renewable energy investment 2020

Comparison of WtE and other renewable energy

When investing in a renewable energy project, it is important to take note of the environmental impact which might occur during the production of the renewable energy to ensure that actions are taken to minimize those impacts.

Type of Renewable Energy	Typical Capacity Range	Green Consideration
Waste-to-Energy	1MW--40 MW depending on the type of waste facilities technology utilized	• Waste incineration produces gas with high content of toxic compounds such as nitrous oxide, hydrochloric acid, and heavy metals. However, studies show that the amount of toxic content produced has reduced with the help of technological advancement. • WtE plants produce ash that needs to be disposed safely in landfills that are lined with barriers to prevent ground water contamination.
Solar	Typically <10 MW. However due to its modularity, it can be up to 1,000 MW	• Solar panels production emits greenhouse gases and uses toxic materials such as lead, gallium, arsenide and cadmium which led to increase in mining activity. • Solar panels contribute to e-waste with IRENA reporting a total of 78 million metric tons of solar panels will have reached the end of their life by 2050 and a 6 million metric tons of new global solar e-waste annually.
Wind	2 MW onshore 3–5 MW offshore	• Wind farms can significantly impact the landscape as farms typically need to be spread over more compared to other power stations and is built in wild and rural areas which can lead to habitat loss and deforestation. • Landfill issue; wind turbine blades are disposed at landfills as it cannot be easily recycled or repurposed.
Small Hydro	500 kW to 10 MW	• Release global warming emission; small hydro power plants emit between 0.01 and 0.03 pounds of CO2 equivalent per kWh • Hydropower generators changes water chemistry, the river flow and also obstruct fish migrations, and led to killing or injuries of fishes; 5%- 10% of fishes are killed when passing through the turbine

Sources: IRENA - Renewable 2020 Report, KPKT - Solid Waste Management Lab 2015, Wired.com - Solar panel are starting to die, UCUSA - Environmental impact of wind power, EIA-Hydropower and the environment

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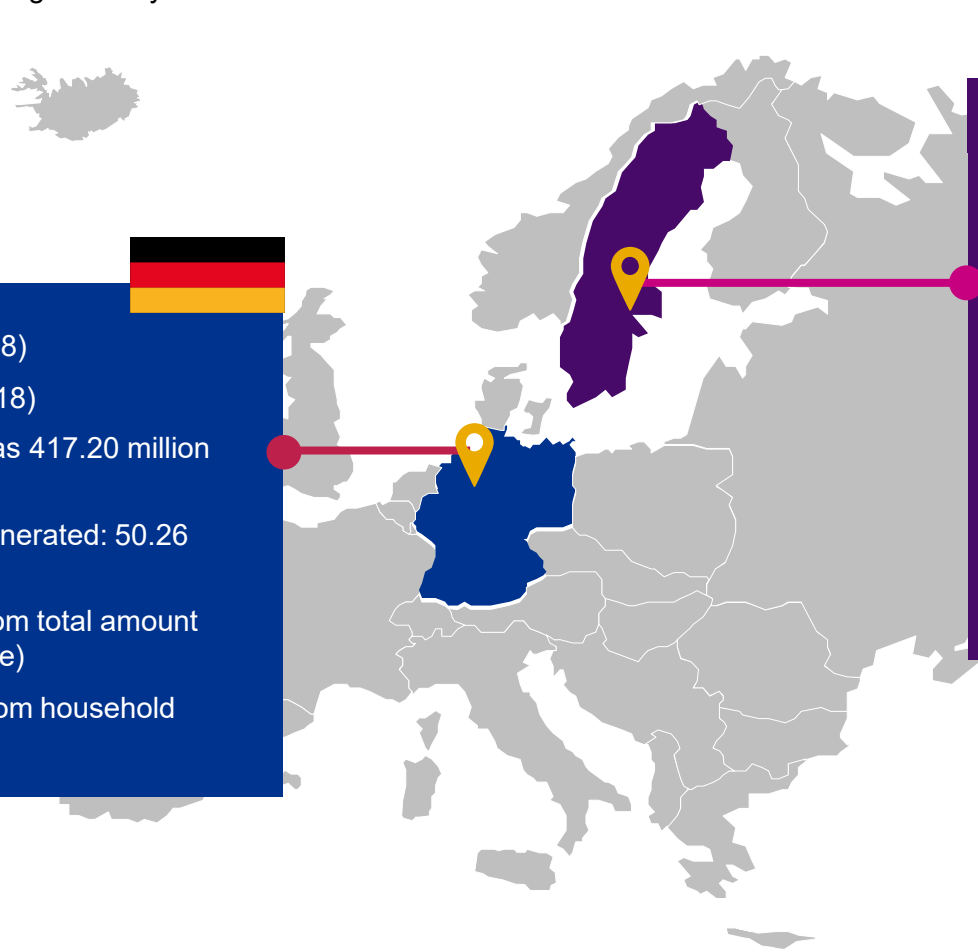
International Case Studies

Appendix: An Analysis Of Germany and Sweden Waste-to-Energy and Waste Management System

Waste management system comparison

Germany and Sweden have continuously been the forefront countries when it comes to waste management. This warranted an analysis of the success factors behind the their effective waste management system.



Germany

- Population of 82,905,782 (2018)
- GNI per capita of $57,810 (2018)
- 2018 total waste generated was 417.20 million tonnes
- Total municipal solid waste generated: 50.26 million tonnes (2018)
- 87% of waste recovery rate from total amount of waste (exclude mining waste)
- 67% of waste recycling rate from household waste

Sweden

- Population of 10,120,242 (2018)
- GNI per capita of $57,220 (2018)
- 2018 total waste generated was 138.67 million tonnes
- 2018 total municipal solid waste generated was 4.771 million tonnes
- 78% of waste recovery rate from total amount of waste (exclude mining waste)
- 34% of waste recycling rate from household waste

Sources: Eurostate website, Worldbank website, Avfall Svergie - Swedish Waste Management 2018, BMU - Waste Management in Germany 2018

Waste Management in Germany

Germany is a state member of the European Union (EU) and is widely influenced by EU laws and policies. Therefore, EU legislation plays an essential role in forming the context of the German legal framework.

Waste Management Policy/ Legislation	Description
EU Waste Framework Directive (EU WFD) 2008	• The directive establish a waste hierarchy; prevention, re-use, recycling, recovery for energy generation and lastly disposal. • It layout the 'polluter-pays principle' whereby waste generators must pay the corresponding cost of waste management and introduces the concept of 'extended producer responsibility' which details the obligation of manufacturers/distributors/ importers to accept and dispose products returned after use.
Circular Economy Act (KrWG 2012)	• The act serve as the main federal law regulating waste management in Germany and introduce the five-level waste hierarchy as per the requirement of EU WFD. • The act requires manufacturer to design and produce their products in a way to avoid waste and ensure smooth recycling. • The act obliges all municipalities and business in Germany to separate their waste at source into 7 waste categories (paper ,glass ,plastics ,metals ,biowaste ,wood ,textiles) to reduce the incineration of commercial waste and to promote recycling.
BioWaste Ordinance (DE BioAbfV 2013)	• The ordinance regulates recycling, reuse and treatment of organic waste, treated and untreated biowaste that is used on land for landscaping, agricultural, silvicultural and horticultural purposes. Besides that, the ordinance sets out targets for all parties involved in biowaste production, collection, transport, treatment and use
Packaging act 2019 (replacing the Packaging Ordinance	• The act sets a recycling target of plastic packaging of 63% by 2022 and a 90% recycling target for metal, glass, paper and cardboard. • The act requires every manufacturer to register with LUCID Packaging Register and to obtain a Packaging License from a German recycling scheme. Failure to do so might result in 200,000 EUR fine as all manufacturers are responsible to collect, recycle or reuse their packaging after it has been disposed of by consumers.

Sources: Germany's waste management policy development: A focus on Municipal Solid Waste

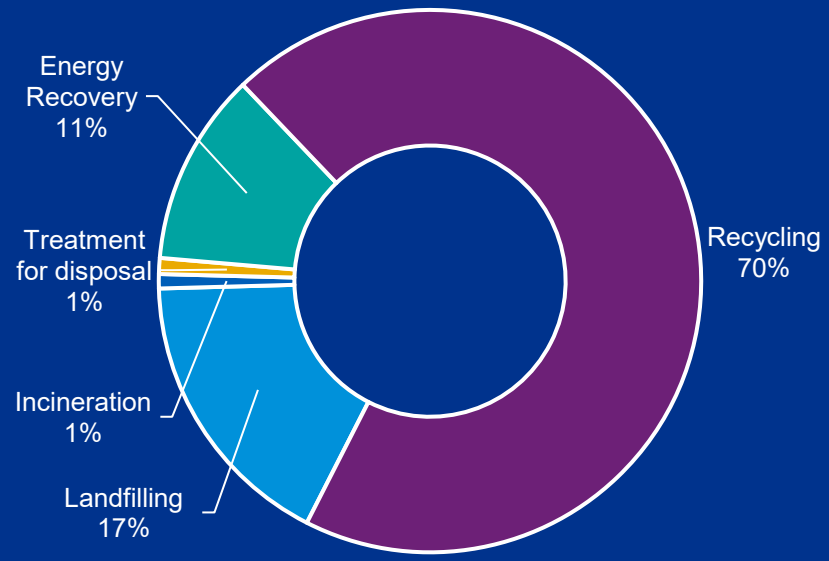
Waste Management in Germany

Germany is highly advanced when it comes to waste management. Germany's waste management sectors have an annual turnover of 70 billion euro and employs more than 270,000 employees with a total of 15,500 waste management facilities. The country practices the waste hierarchy as imposed by the EU and has a high recycling rate, reporting recycling rates of 67% for household waste, around 70% for production and commercial waste, and almost 90% for construction waste in 2018.

Critical success factor	Description
Polluter-Pays- Principle & Green Dot system	Corporations in Germany are responsible for the elimination of their waste products and many do so by paying green dot license fee to DSD (Dual System Germany). This encourages corporations to package goods with fewer material as the more the packaging the higher the fee charged by DSD to treat the waste.
Investment in waste management facilities	In 2017,Germany had a total of 68 waste incineration plants,32 refuse derived fuel (RDF) power plants and 45 MBT plants which in total has a capacity of 30 million tonnes.
Germany's recycling culture	Germans practise waste segregation at the source and adopt recycling as a way of life. There is also easy accessibility to recycle bins and also incentives; Germans pay a 'deposit' on bottles which can be reimburse when returning it to a bottle disposal unit.
Emphasis of renewable energy growth	Germany commitment to reduce reliance on nuclear and fossil fuels for energy has propel the growth of the renewable energy sector which includes WtE plants.

Sources: White Paper: Waste no more, DW – Plastic waste and the recycling myth, Germany's Department Of Statistic portal, DW - Germany's "Energiewende"

Germany's municipal solid waste treatment composition (%) 2018



In 2018, Germany has generated 417.18 million tonnes of waste with 338.48 million tonnes of waste recovered; energy recovery,48.02 million tonnes, and recycling 290.46 million tonnes.

Waste Management in Sweden

Like Germany, Sweden is also a member of the EU and is heavily influenced by their laws and policies. Historically, Sweden is also one of the earliest country to show strong commitment to waste management initiative with the introduction of their first Environment Protection Act in 1969.

Waste Management Policy/ Legislation	Description
The Environmental Code,1999	• The code is currently Sweden's main environmental legislation that defines and categorised each type of waste and also lay out rules relating to the management of land and water, nature conservation, the protection of plant and animal species, environmentally hazardous activities and health protection, water operations, genetic engineering, chemical products and waste management. • The act also place the municipality responsible of having their own plan in dealing with all types of waste found within their jurisdiction and to report on actions undertaken for the management of those waste. • Introduce the ecology principle which aims to minimize the use of resources by means of reusing, recycling and disposing all materials extracted from the natural environment in a sustainable manner without damaging the environment.
The Waste Ordinance	• The ordinance layouts specific provisions governing waste sorting, collection and disposal, resource management, permitting system, supervising authority and penalties for breaching relevant rules.
National waste plan and waste prevention programme 2018-2023	• The programme details ways to reduce the amount of waste generated, harmful substance produced and promotes the application of the waste hierarchy and waste resources. However, there is no quantitative target set in except for a target of not exceeding 40 plastic bags per person annual by 2025.
The Law on Waste Tax,1999	• The act introduced the landfill tax scheduled to take effect by 1 January 2000 at a rate of 250 SEK/ tonne of waste which was then increased in 2002,2003 and 2006 to further reduce waste disposal at landfill. The landfill tax as of 2020 currently stands at 520 SEK/tonne.
Extended Producer responsibility ordinance (EPR)	• Place the responsibility on producers to cover collection and recycling of EPR products once they reach their end-of-life stage and also the financing of the scheme. Some EPR products are packaging, batteries, vehicles, tyres and pharmaceuticals.

Sources: MOE - The Swedish Environmental Objectives-Interim Target and Actions Strategies, MOE - The Swedish Environmental Code RECO Baltic 21 Tech Project - National Waste Management Review, Sweden.

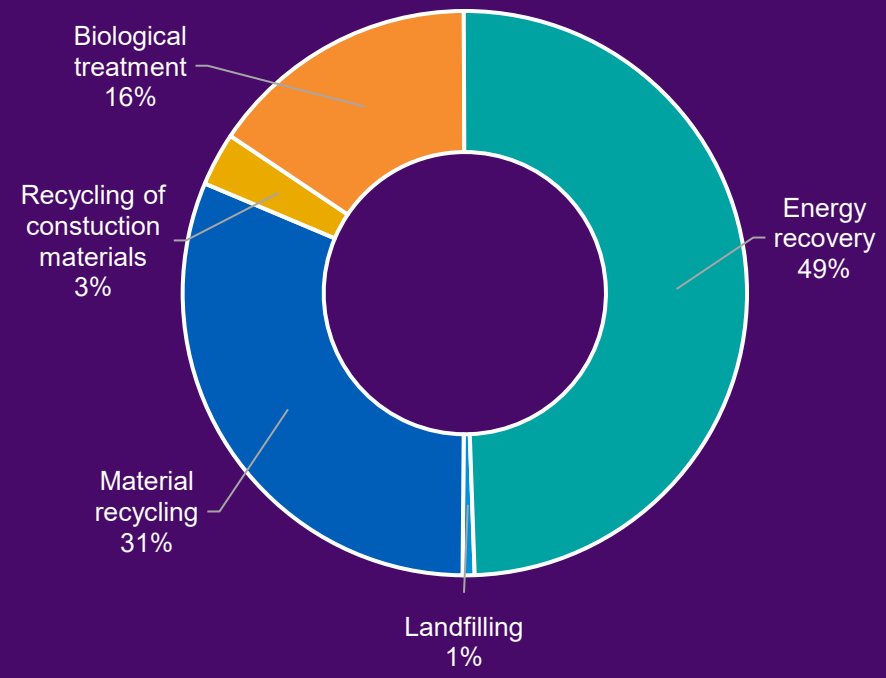
Waste Management in Sweden

Sweden's environmental goods and services sector is reported to contribute an annual SEK 81 billion to the nation's economy and employs more than 270,000 employees. Currently, Sweden has a track record of recycling and recovering about 99% of their waste and only sending less than 1% of their waste to their landfill for the past 5 year.

Critical success factor	Description
Implementation of taxes	Landfill tax was introduced to discourage the disposal of waste at landfill and to encourage recycling was proven effective with an annual fall of 1 million tonnes of household waste landfilled from 1994 to 2004. The landfill tax also led to the landfill ban on combustible waste (2002) and organic waste (2005).
Clear defined legalization for EPR	Sweden EPR legislation which clearly defines roles and responsibility and close collaboration between stakeholders are the driving factors of Swedish successful recycling system resulting in Sweden having one of the world highest e-waste collection rate at a 70% (2019)
Citizen engagement and availability of recycling drop off	Extensive recycling campaigns has cultivated Sweden's recycling culture which is further encourage by easy accessibility to drop-off station; ERP producers provide 6000 drop-off stations nearby household.
Developed waste treatment facilities	Sweden has 32 WtE plants which not only provides treatment to the country's waste but also to imports waste from UK, Italy, Norway and Ireland in order to generate electricity and heating for Sweden's households.

Sources: Huffingtonpost-99% of Sweden's garbage is now recycled, Avfall Svergie-Swedish Waste Management 2018, Naturvardsverket - A strategy for sustainable waste management.

Sweden's municipal solid waste treatment composition (%) 2018



In 2018, Sweden has produced 466 kg of household waste per capita which led to a total of 4.771 million tonnes of municipal solid waste. Of which 32,710 tonnes of waste being was landfilled and a total of 4.74 million tonnes of waste was recycled and recovered.

Case study- Sweden's Waste Management System

Sweden's MSW management applies the waste hierarchy obtained within the Waste Framework Directive (2008/98/EC) which was set forward by the European Parliament in June 2008

Most favored method

Least favored method

Waste hierarchy	
Reduce	Minimize the amount of waste produced during design and manufacturing stage and reduce consumptions of nonessential products.
Reuse	Reusing waste in its current form by checking, cleaning, repairing or refurbishing.
Recycle	Processing waste to be recovered and transformed into new products or substances.
Energy Recovery	Recovering energy by means of incineration, anaerobic digestion, gasification, pyrolysis.
Disposal	Waste are landfilled or incinerated without energy recovery.

Key stakeholders

Municipalities

- Each municipality is responsible for the transportation, recycling and disposal of the municipal waste.
- 64% of Sweden's municipalities hire private contractors to undertake the collection of food and residual waste. Where as 33% of municipalities handle the waste management themselves and the other 4% uses a combination of private contractors and in-house collection services.

Producers/ Corporations

Each producers have the responsibility of collecting and disposing their products when it approach its end life. This responsibility is usually carried out by outsourcing to material companies. Some of the material under the producer responsibility policy are paper, packaging, tyres, electronics and batteries.

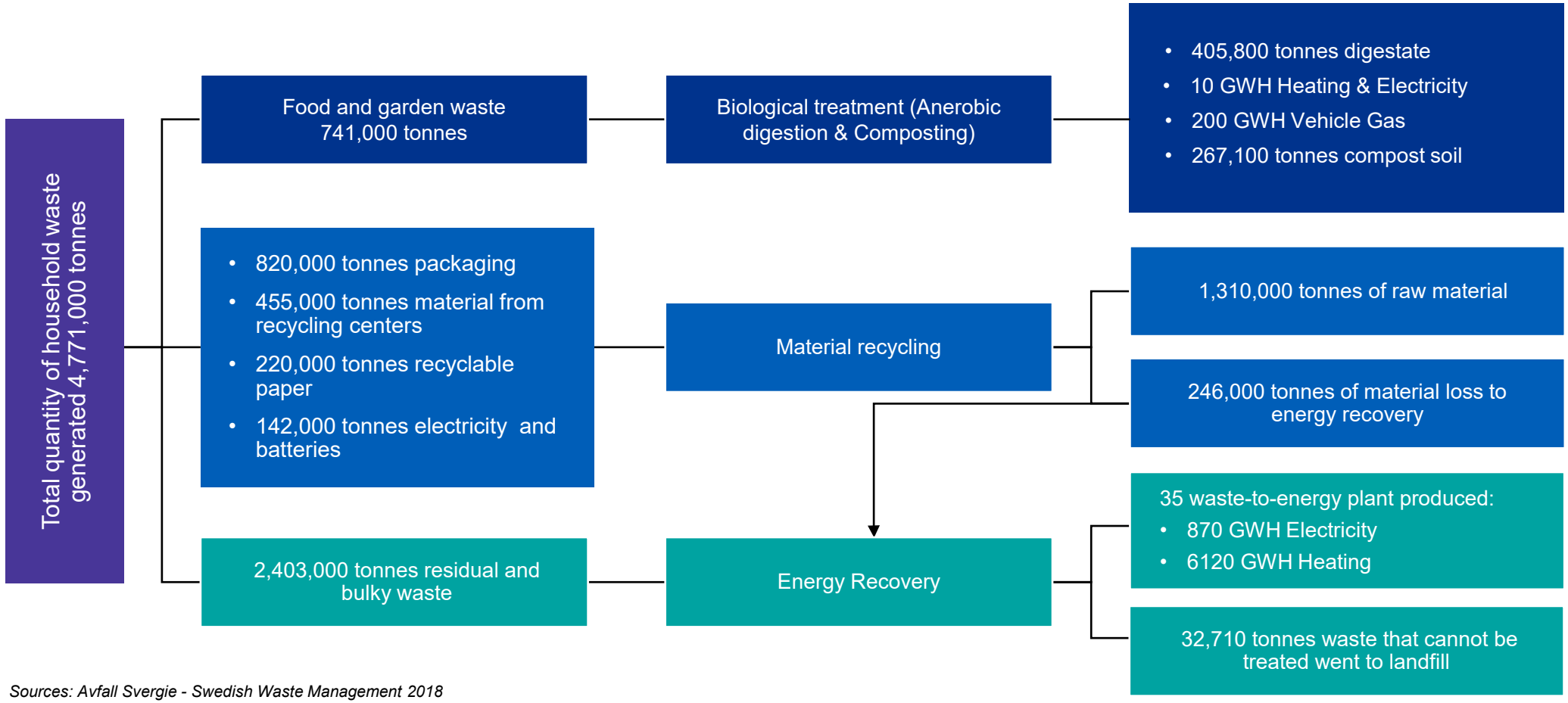
Households

Each households are responsible for separating and depositing waste at available collection points.

Sources: Avfall Svergie - Swedish Waste Management 2018, Naturvardsverket – A strategy for sustainable waste management.

Case Study -Sweden Waste Management System

Overview of Sweden's Municipal Waste System as of 2018



Sources: Avfall Svergie - Swedish Waste Management 2018

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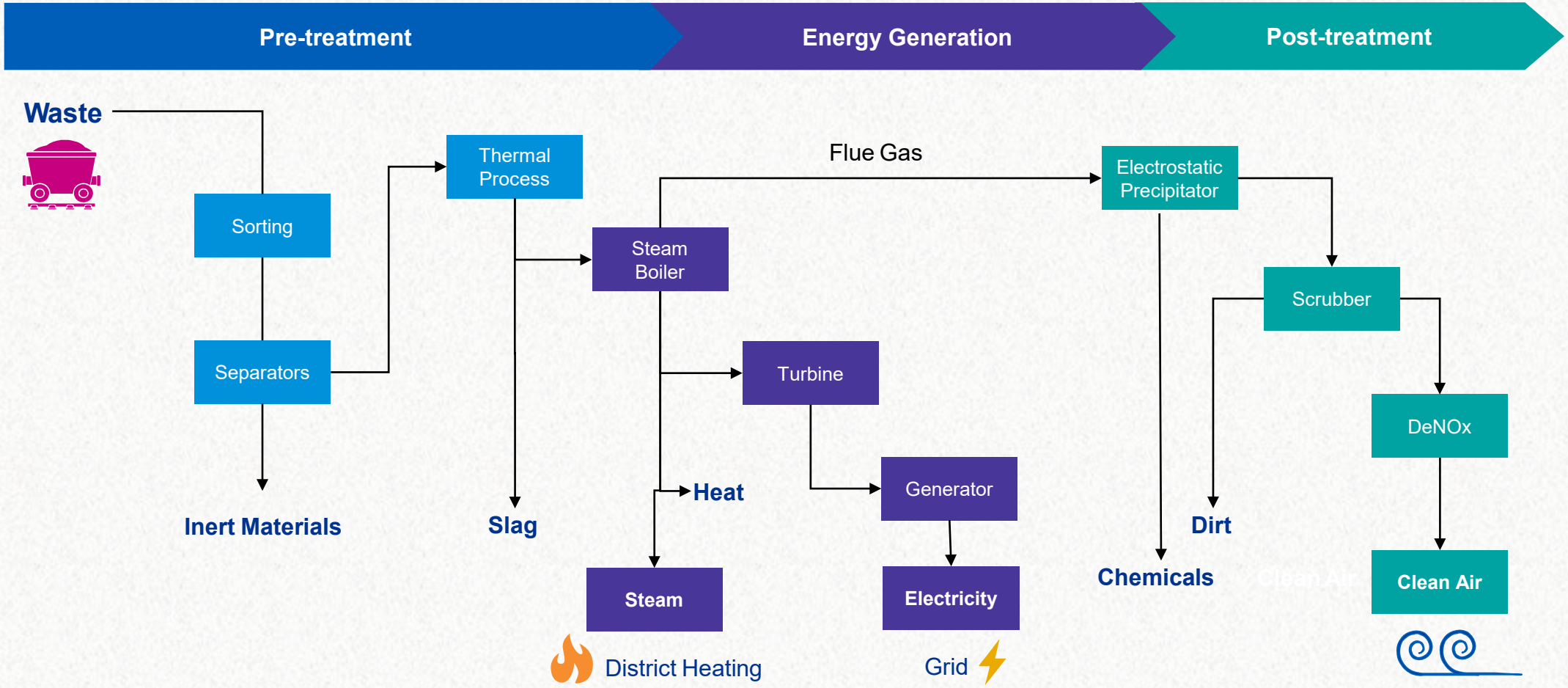
WtE terminologies

Appendix

Waste-to-Energy Process

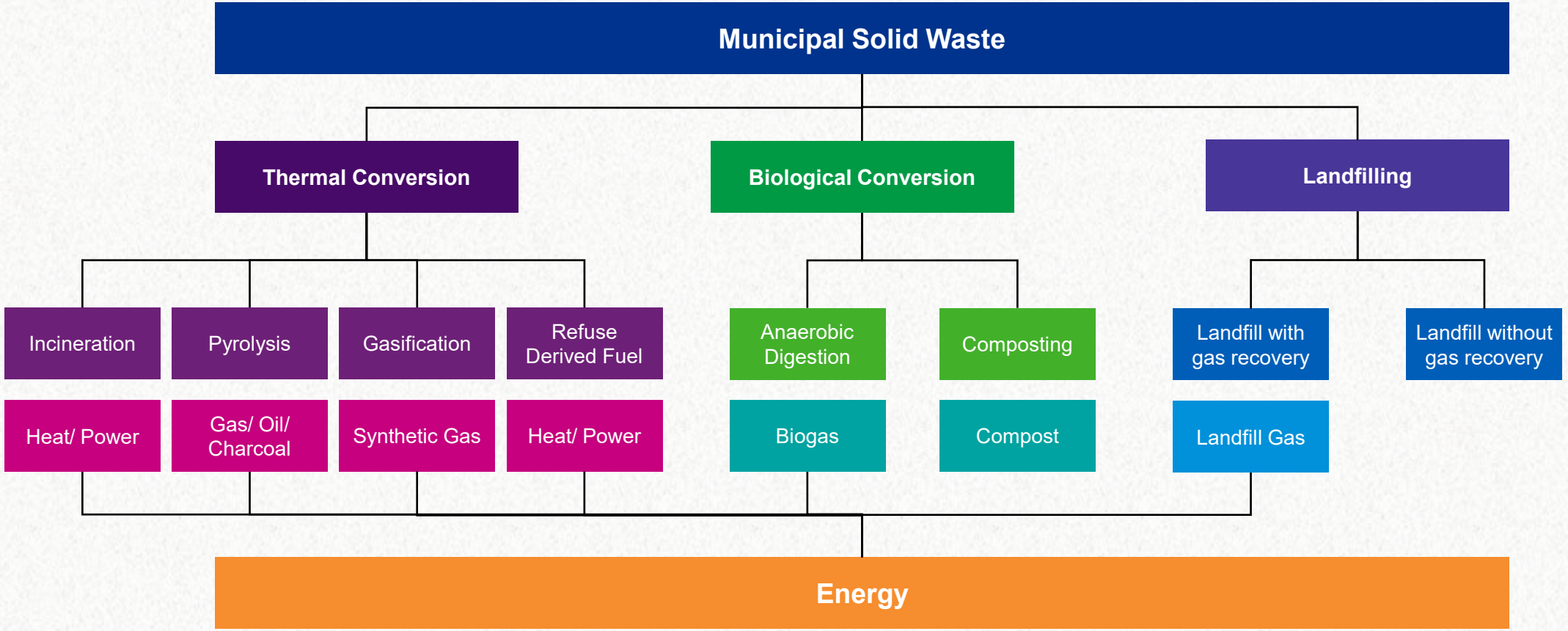
The waste-to-energy process can be broken down into 3 stages: the pre-treatment stage, energy generation stage and post-treatment stage.



Sources: Journal Article - A review on technological options of waste to energy for effective management of municipal solid waste

WtE Options

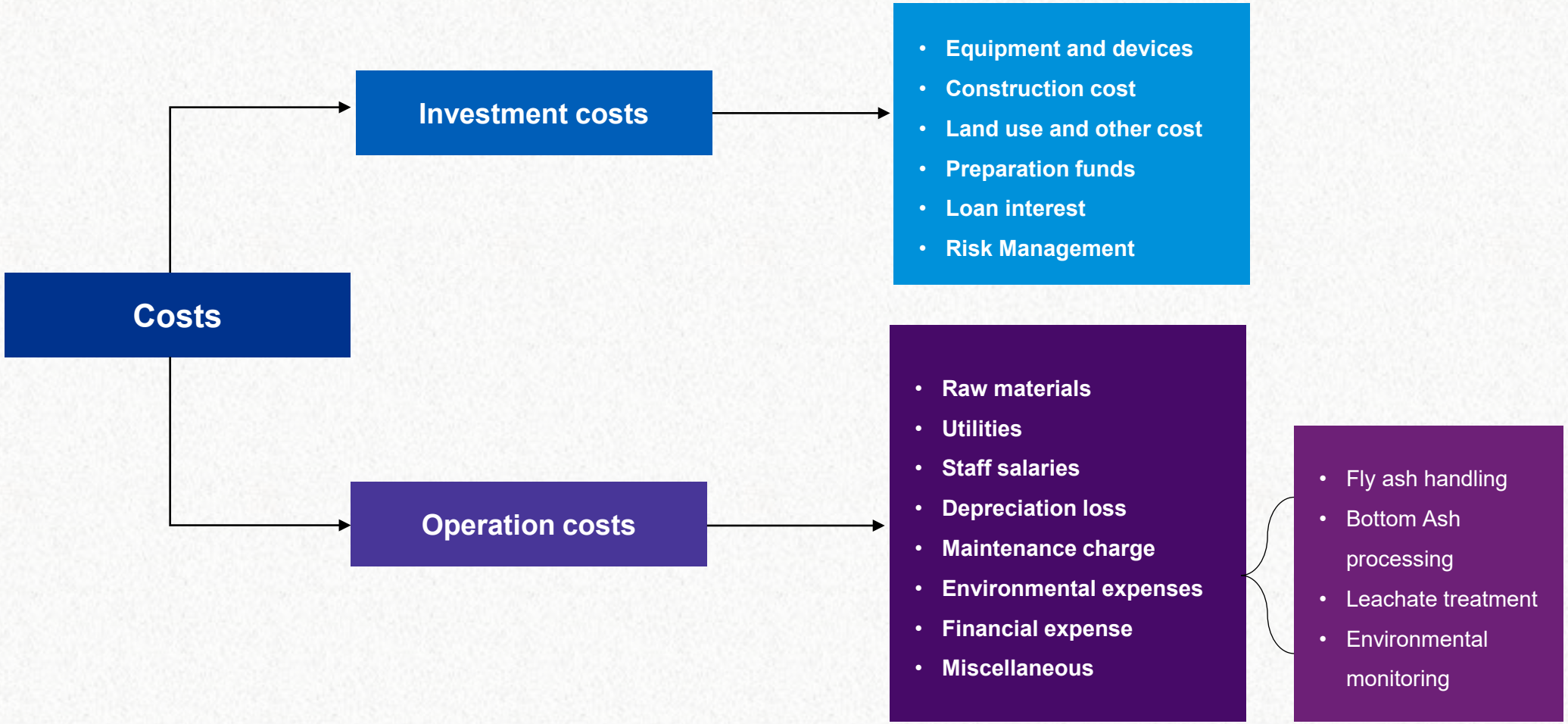
Generally, the municipal sold waste undergoes 3 types of conversion to produce energy: Thermal conversion, Biological conversion and Landfilling.



Sources: Journal Article - A review on technological options of waste to energy for effective management of municipal solid waste

Cost structure of a WtE Plant

The diagram below shows a typical cost structure of a WtE project.



Sources: Journal Article -Technology, cost, a performance of waste to energy incineration industry in China

Cost breakdown of a WtE Plant – Case Study

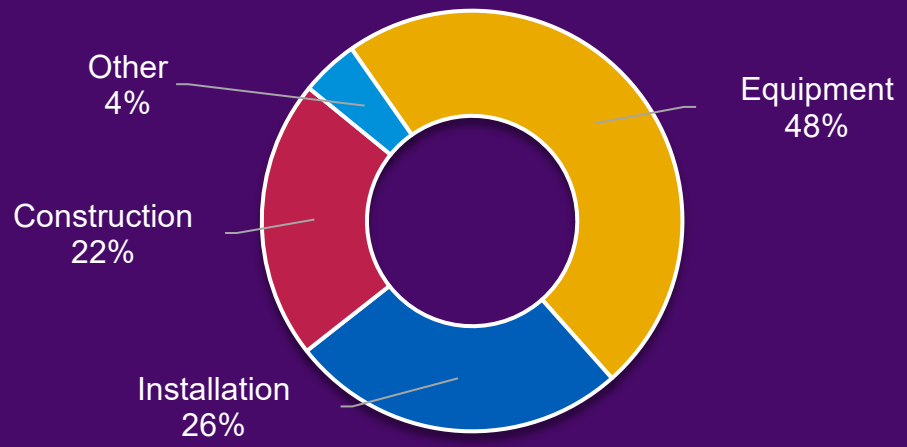
Generally, the average cost to build a WtE facility in China or by a Chinese company is cheaper than other countries. Chinese WtE projects have a range of USD 143-USD 320 per annual ton capacity compared to US WtE facilities average initial capital cost of USD 386 to USD 1,811 per annual ton capacity.

The differences are mainly attributable to favorable regulatory conditions, China's mass manufacturing ability and their relatively cheaper WtE equipment.

Equipment	Average Investment (USD per ton)	Operating Cost Range (USD per ton)
Imported Mechanical-grate	73,350–81,500	16.3 – 32.6
China-made Mechanical-grate	48,900–57,050	
Imported circulating fluidized bed combustion	65,200–73,350	9.8 – 19.6
China-made circulating fluidized bed combustion	40,750–48,900	

Sources: Journal Article- Capital Cost Comparison of WtE facilities in China and the US, Technology, cost, a performance of waste to energy incineration industry in China

Composition of investment cost of China 1000 tons /day WtE Plant (%)



The operating cost for a WtE plant differs based on the waste incineration technology used.

The operating cost of mechanical-grate incineration technology has a range of USD16.3 per ton to USD32.6 per ton which is more expensive compared to the circulating fluidized bed combustion incineration technology which has a range of expenses from USD9.78 per ton to USD19.56 per ton.

It is to be noted that the major expense is depreciation and maintenance cost which amounts to 36% of total operating costs, follow by auxiliary fuel, 31% and labor cost of 14%

How KPMG can help

KPMG's Infrastructure Advisory team in Malaysia draws on extensive experience to assist clients with defining their infrastructure project strategy. Building from knowledge across a full range of sectors and KPMG's Global Infrastructure network, the team can move quickly to deliver practical, implementable and outcome-oriented strategies.

KPMG has been working closely with the regulators, waste management players, WtE project developers and utilities companies in the SEA region. Our team includes experts who have accumulated extensive experience in the energy and sustainability industry. We are ready to create strategic values for our clients through regulatory, financial, technical and risk management support.

Our team of professionals help businesses in the waste management and waste-to-energy ("WtE") sector with the following:

- **Market research and trend analysis**
  - Analyze the waste management business market conditions and conduct benchmarking
  - Understand regulatory trend and sustainability policy
  - Identify and assess waste management market/ WtE project risks and opportunities
- **Develop market entry / go-to-market strategies for waste management segments (i.e. recycle, hazardous waste, schedule waste, used oil recycling, transfer and processing etc.)**
  - Market segment prioritization
  - Design the entry/ go-to-market strategy
  - Collaboration with external partners
  - Mergers and acquisitions support
- **WtE project feasibility studies**
  - Assess financial and commercial viability of WtE project
  - Structure project delivery models
  - Financial modelling and project bankability support
- **Strategy / project implementation**
  - Execute new strategy / project
  - Monitor, track and report on the strategy / project implementation progress
  - Asset management and portfolio improvement

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