Borneo Waste Industries Sdn. Bhd.
INTEGRATED WASTE MANAGEMENT

Information Deck

Integrated Waste Management Processing Plant

Suite 10-1, Binjai 8
Lorong Binjai 50450
Kuala Lumpur, Malaysia

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Glossary

AD	Anaerobic digestion
Bina Daya	Perunding Bina Daya Sdn. Bhd.
Base Facilities	Include MRF, anaerobic digestion plant, recovered plastics plant, bottled CNG plant, e-waste recycling centre, RDF pellet plant
bil	Billion
Bio-CNG	Bio-Compressed Natural Gas
Bottled CNG	Bottled Compressed Natural Gas
BWI	Borneo Waste Industries Sdn. Bhd.
C&D	Construction & demolition
CO_2	Carbon dioxide
DBFO	Design, build, finance and operate
DBKK	Dewan Bandaraya Kota Kinabalu
e-waste	Electronic waste
EU	European Union
FAO	Food and Agriculture Organisation
FIAM	Fertilizer Industry Association of Malaysia
GLB	Garden, livestock and beach
Glomus	Glomus Ecology Sdn. Bhd.
GDP	Gross domestic product
GNI	Gross national income
GTFS	Green technology financing scheme
H_2S	Hydrogen sulphate
HDPE	High-density polyethylene, such as paint buckets, folding tables and chairs, water / natural gas pipes
Inorganic MSW	Plastics, metals and paper
IWMPP	Integrated Waste Management Processing Plant
kg	Kilogram
kj	Kilojoule
KMSL	Kayu Madang Sanitary Landfill
LDPE	Low-density polyethylene, such as grocery bags, plastic laminate for cardboard milk and juice bottles
LSS	Large scale solar
Other Recyclables	Extracted recyclable paper and metals that are immediately sold without further processing
Other incoming waste	C&D waste and used tyres
MBT	Mechanical biological treatment
mil	Million
MoU	Memorandum of Understanding
MPOC	Malaysia Palm Oil Council
MRF	Material recovery facility
MSW	Municipal solid waste which includes domestic, commercial, industrial, organic waste and e-waste
MW	Megawatt
MWth	Megawatt thermal power
PET	Polyethylene terephthalate, such as packaging of cooking oils, mouthwash and shampoo
Phase 1	Base Facilities

Phase 2	Bottled CNG, Organic Fertiliser and Installation of Rooftop Solar Panels
POME	Palm Oil Mill Effluent
PP	Polypropylene, such as containers and carpet
ppm	Parts per million
Project	IWMPP
RDF	Refuse derived fuel
Recovered Plastics	Recovered plastic flakes and pellets
RFID	Radio-Frequency Identification
RM	Ringgit Malaysia
SCADA	Visualisation and supervisory control and data acquisition
SESB	Sabah Electricity Sdn. Bhd.
SWCorp	Solid Waste and Public Cleansing Corporation
SWM	Solid Waste Management
TPA	Tonnes per annum
TPD	Tonnes per day
TWh	Terawatt hour
USD	United States Dollar
WTE	Waste to Energy

Executive Summary

Borneo Waste Industries Sdn. Bhd. ("BWI") is a Sabah-based waste management service provider that was established in November 2012. It has offices in Kuala Lumpur and Kota Kinabalu, Malaysia. BWI was awarded a 30-year concession to develop and operate the Integrated Waste Management Processing Plant ("IWMPP") at the Kayu Madang Sanitary Landfill ("KMSL") in Telipok, Sabah from April 2018 to April 2048 by the Sabah State Cabinet through a tender process. The KMSL is the central disposal site for waste from Kota Kinabalu, Kota Belud, Penampang, Putatan and Tuaran.

With the concession agreement, BWI aims to develop the IWMPP which has the capacity to process up to 800 tonnes per day of municipal solid waste (MSW) which includes electronic-waste ("e-waste"). The IWMPP will be occupying 20 acres within the 115 acres KMSL boundary. Development of the IWMPP is divided into two phases. Phase 1 encompasses the Base Facilities which comprises the material recovery facility (MRF), recovered plastics plant, e-waste recycling centre and refuse derived fuel ("RDF") pellet plant. Phase 2 includes the anaerobic digestion (AD) plant, bottled compressed natural gas plant, organic fertiliser plant and installation of rooftop solar panels. Phase 3 includes a Waste to Energy plant (WtE).

The aspirations of the project are threefold, economic, environmental and social sustainability. BWI aims to maximise the recovery of incoming waste into the landfill, to enhance the market for intermediary materials and set a precedent for economically viable waste management projects in Sabah. Other aspirations include prolonging the lifespan of the KMSL as well as reducing negative social implications of untreated waste and implementing latest technologies in a sustainable manner.

In the future, BWI intends to expand its business model to other landfills in Sabah and Peninsular Malaysia and venture into other businesses in the same industry when the opportunity arises. Some of the potential ventures are generating and supplying electricity to Sabah from biogas or RDF pellets as feedstock, recycling used tyres and construction & demolition waste, and producing liquid fertiliser. Furthermore, BWI plans to develop a solar farm and participate in large scale solar (LSS) as well as venture into landfill mining in the future.

Total Project Cost (Phase 1, 2 & 3) is approx. RM 170M (USD 41M).

Development Plan approval for the project was obtained on 17 October 2019.

The Building plan was approved on 8 January 2021.

Environmental Impact Assessment study has been submitted to the Department of Environment and approval is expected by end-November 2021. This would be the last government approval required for the Project.

Deloitte Corporate Advisory Services Sdn. Bhd. ("Deloitte") is the Financial Advisor for the Project.

1

Overview of Borneo Waste Industries

1.1 Company Profile

Borneo Waste Industries

Established in November 2012, BWI is a waste management service provider based in Sabah. It has offices in Kuala Lumpur and Kota Kinabalu, Malaysia. BWI executed a 30-year concession to develop and operate the IWMPP at the KMSL from April 2018 to April 2048. The KMSL is the central disposal site for waste from Kota Kinabalu, Kota Belud, Penampang, Putatan and Tuaran.

With its concession agreement, BWI aims to develop an IWMPP which has a capacity to process up to 800 TPD of waste which includes e-waste.

The IWMPP will sort the waste at the KMSL and subsequently process these wastes with environmentally sustainable technologies to produce useful intermediary products for various industries. Recyclable waste that are not converted into products will be sold directly to domestic traders and wholesale customers whereas unrecycled waste will be sanitised for landfilling.

Once the Base Facilities are operational, BWI intends to install rooftop solar panels to participate in the Net Electricity Metering Program in 2023.

Company History

BWI's sustainable waste management journey started with the idea to create a proper waste management system for society. Since then, BWI has broadened this growth by undertaking a waste management project which can process up to 800 TPD of waste.

The Beginning of Borneo Waste Industries

BWI was established with the goal of developing a proper waste management system in Sabah.

The Initial Stages of the Business Venture

In 2013, BWI was invited to participate in a tender to develop an integrated waste management facility at the KMSL.

The Start of the Waste Management Project

On 16 April 2018, the City Mayor of Kota Kinabalu on behalf of Dewan Bandaraya Kota Kinabalu ("DBKK") executed the Concession Agreement for a period of 30 years.

The Development of the Waste Management Project

In October 2019, BWI obtained planning approval from DBKK to develop the 20-acre IWMPP.

1.2 BWI's Sustainability Principles

As a proponent of sustainable practices, BWI does not focus on pure monetary returns only. Instead, the company emphasises on social, environmental and economical sustainability with the Triple Bottom Line of People, Planet and Profit.

People

BWI prioritises social sustainability as elaborated below:

- Current KMSL conditions have created a negative social impact in the form of illegal scavenging activities, foul odour and rodent infestation.
- The Kota Kinabalu Industrial Park owners, local villages and The National Institute of Public Administration were not supportive of the overflow of waste in the landfill. Thus, BWI will transform the KMSL into a recycling centre, with the aim of alleviating the negative social impacts on the local communities in Sabah.
- Long-term employment opportunities to be created throughout the 30-year lifespan of the project.

Planet

BWI aims to design the IWMPP around the theme of environmental sustainability by implementing the following:

- Diversion of disposal of waste from landfill cells to preserve landfill space, through recycling and recovery activities.
- Ensure adequate treatment of organic waste, and hence avoid hygienic hazards caused by organic waste degradation.
- Reduce carbon footprint of MSW disposal by eliminating methane emission, reducing wastewater generation, and promoting use of recyclables to substitute virgin materials.
- Application of Mechanical Biological Treatment ("MBT") system as it utilises minimal energy consumption.
- Application of bio-based treatment in the MBT system to eliminate the use of chemicals and other synthetic materials.

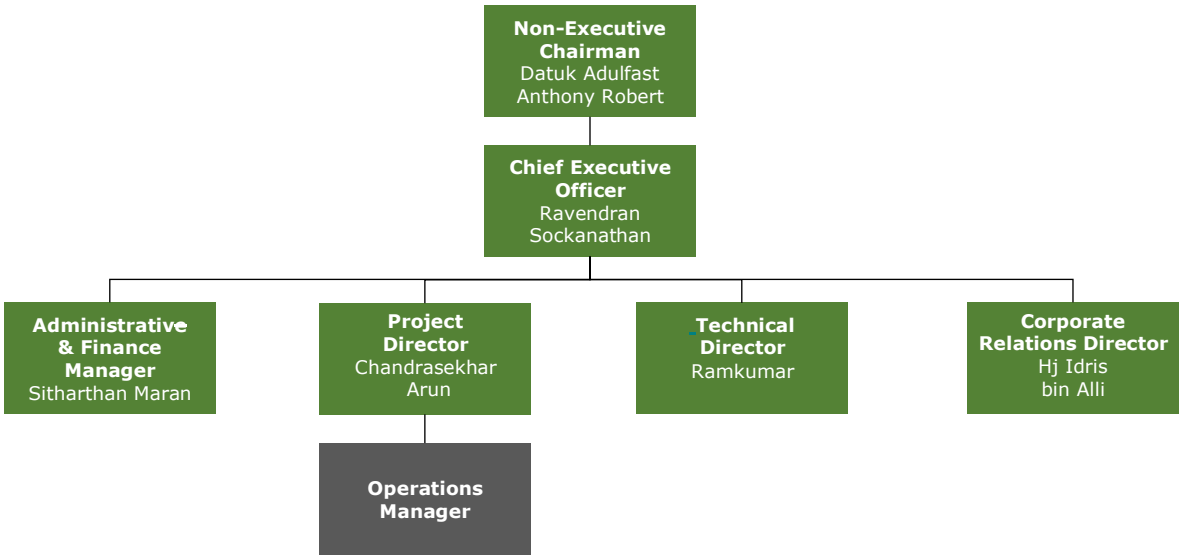
Profit

As one of the first waste management facilities in Sabah, the IWMPP aims to enhance the growth of Sabah's waste management industry, resulting in:

- The foundation for an industry that will flourish in the future due to the expected increase in waste.
- The growth of supporting industries that include security services, manufacturers, among others.

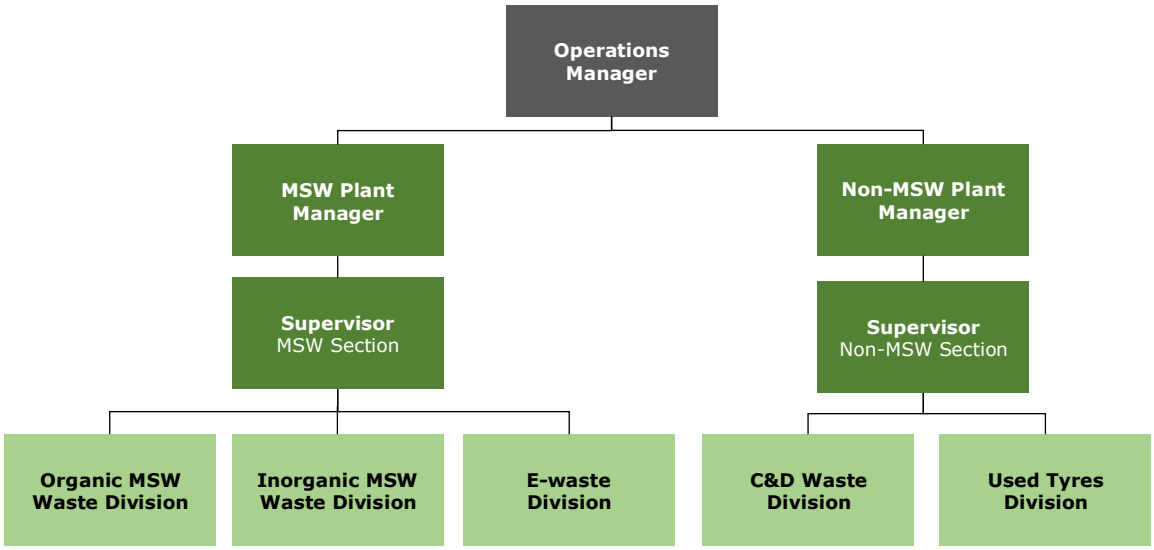
1.3 Organisation Structure of BWI

Management Team Structure



** The Operations Manager leads the operations team, illustrated in the following chart.*

Operations Team Structure



1.4 Management Profile

Ravendran Sockanathan
Chief Executive Officer

- Mr. Sockanathan holds a Bachelor of Science in Economics from the University of Michigan, Ann Arbor, USA and a Bachelor of Arts in Theology from St.Paul's Theological College Malaysia.
- He started his career in Hanifiah Raslan & Mohamad's audit department and thereafter transitioned into Corporate Finance with Bumiputera Merchant Bankers Bhd.
- He has held various executive directorships locally and internationally in areas of trade finance & counter trade, water utility privatisation, loyalty programs, healthcare, oil & gas, and renewable energy.
- He was a two term former president of the Malaysian Association of the Philippines and a committee member of the Royal Selangor Golf Club for four years.

Ramkumar
Technical Director

- Mr. Ramkumar holds a Bachelor of Engineering in Mechanical Engineering from University of Mysore, India.
- He has more than 22 years of experience in environmental engineer with specialities in Environmental Impact Assessment Studies, industrial process evaluation, process automation and controls, project management, solid waste management including incineration, air emission control and the design of air emission control systems.
- He is also the Managing Director and Principal Consultant of GSR Environmental Consultancy Sdn. Bhd. with primary responsibility in project management and engineering.
- He was part of the consortium involved in the proposed Integrated Solid Waste Management Facility in the Kingdom of Bahrain.

Chandrasekhar Arun
Project Director

- Mr. Arun was a Class 1 Marine Chief Engineer.
- His career commenced as a seagoing marine engineer with Neptune Orient Lines, Singapore and thereafter he took on a Technical Ship Management role.
- Mr. Arun has held various senior management roles in Maju Group, MBF Holdings Berhad, and Muar Ban Lee Group.
- His 28 years of project management experience spans multiple countries, multiple project types and project budgets in excess of RM200 mil.
- Mr. Arun is the owner of Trunk Busters Sdn. Bhd. which manufactures patented Pulveriser machines.

Sitharthan Maran
Administrative & Finance Manager

- Mr. Sitharthan holds a Bachelor of Science (Hons) Degree in Applied Accounting from Oxford Brookes University, United Kingdom.
- He has more than 10 years of experience in accounting, finance, taxation, secretarial and human resource management.
- Mr. Sitharthan is a member of the Malaysian Institute of Accountants and the Association of Chartered Certified Accountants, United Kingdom.

Hj Idris bin Alli
Corporate Relations Director

- En. Hj Idris holds an Executive Diploma in Engineering Business Management and a Certificate in Accounting from the London Chamber of Commerce.
- He began his career as an Accounts & Administrative Manager in Progressive Insurance Bhd, subsequently moving to Takaful Nasional Bhd where he served as the branch manager.
- He later progressed as the Assistant Vice President in Maybank Group-Etiqa Insurance Bhd, where he was responsible for the annual production budget as well as business development of various business channels.
- He is currently a member of the Australian and New Zealand Institute of Insurance and Finance.
- At present, En. Hj Idris holds directorships in several private companies.

Awasino bin Jumin
Operations Manager

- Mr. Awasino holds a Diploma in Civil Engineering from Politeknik Port Dickson.
- He started his career as a lab technician and subsequently progressing into the position of operations officer within the construction industry.
- His core experiences include material testing, operating heavy machinery and performing site inspections.

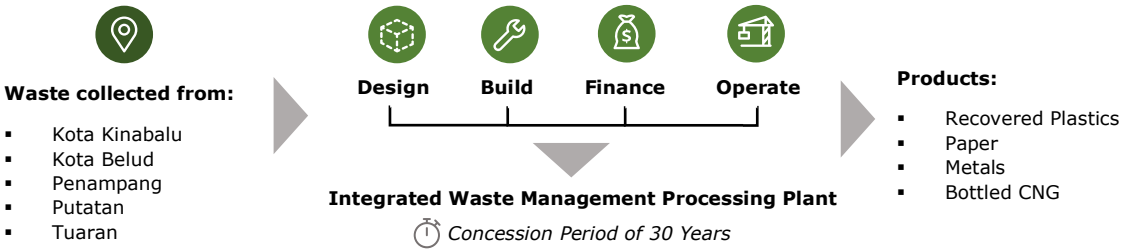
2

Overview of the Project

2.1 About the Project

The IWMPP at the KMSL will be under BWI's management, with the aim to design, build, finance and operate the Project ("The Project" also refers to the IWMPP).

Following the tender requirements and BWI's project proposal, the facilities and plants of the IWMPP will be constructed according to DBKK's requirements, as stated in the Concession Agreement.



The IWMPP has the capacity to process up to 800 TPD of waste collected from Kota Kinabalu and the four districts. The waste recovered will be processed into various intermediary products that can be used in different industries.

2.2 Project Objectives

The objectives of this project are divided into three segments, focusing on economic, environmental and social sustainability, as highlighted below:

Economic Sustainability	▪ Improvement of market for recycled intermediary materials as there is an increase in awareness within the community about using eco-friendly products. ▪ Setting a precedent for economically viable waste management projects in Sabah.
Environmental Sustainability	▪ Maximum recovery of incoming waste – to target up to 90% waste diversion from landfilling. ▪ Reduction of landfill gases to the environment. ▪ Maximise lifespan of the KMSL. ▪ Manage leachate generation in a sustainable manner.
Social Sustainability	▪ Reduce the negative social implications of untreated waste such as the landfill odour and pest infestation. ▪ Providing employment to Sabahans and local residents.

2.3 Project Highlights

30-year concession agreement

- Executed a concession agreement with DBKK process up to 800 tonnes of waste at the KMSL daily.
- Successfully executed by the Mayor of Kota Kinabalu on behalf of DBKK on 16 April 2018.

At least 5 Years income tax exemption and 2% interest rebate

- Eligible for various benefits and incentives such as the Pioneer Tax Status and Green Technology Financing Scheme ("GTFS") due to the nature of BWI's operations and the industry in which it operates in.
- A Pioneer Tax Status will provide an income tax exemption for a period of at least 70% for a minimum period of 5 years, whereas GTFS will allow BWI to enjoy a 2% interest rate rebate.
- Approached the Malaysian Investment Development Authority and the relevant authorities for the application of the incentives mentioned.
- Able to operate with lower financing costs and a lighter tax burden for at least 5 years.

Saving more than RM600,000 per annum in electricity cost

- Participate in the solar Net Energy Metering Programme upon the installation of its rooftop solar panels.
- Electricity savings from BWI's solar panels not only contribute to a greener planet, but also enhances the company's profit margins.

Recycle plastic waste equivalent to more than 800,000 plastic bottles daily

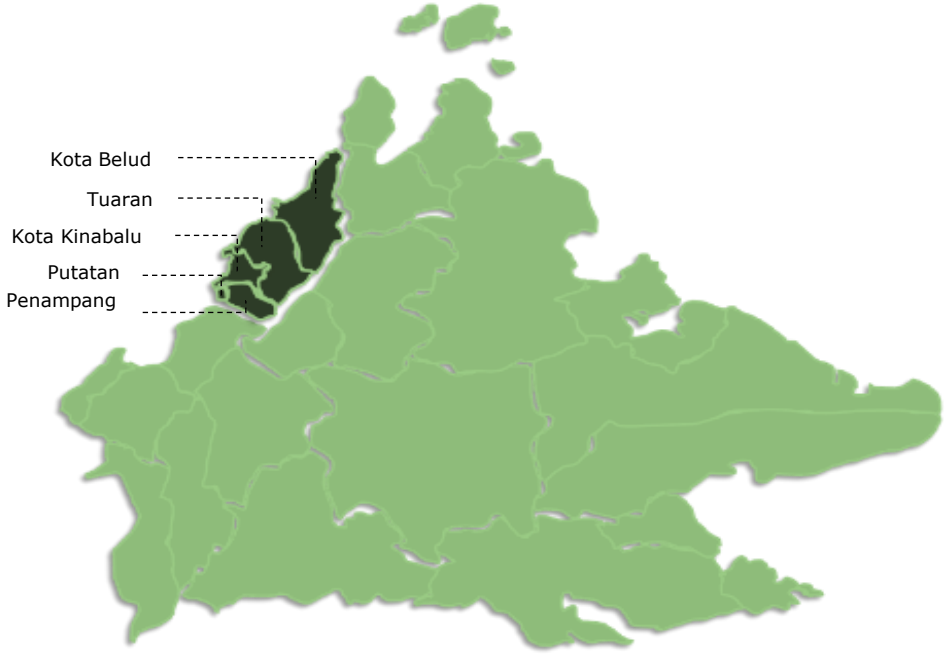
- Effectively prevent 800,000(1) plastic bottles equivalent of plastic waste from being disposed at the KMSL daily through recycling activities.
- Reduce the amount of time spent by plastics being buried in the KMSL by 500 years (degradation period of plastics) and generate a sustainable source of plastic products.

Notes: (1) 1 tonne of plastic waste = 20,000 plastic bottles
Source: "The ImpEE Project", the Cambridge – MIT Institute.

2.4 The Kayu Madang Sanitary Landfill

The Location of the IWMPP

The IWMPP's project area is 20 acres and is within the 115 acre KMSL. The KMSL is the central disposal site for waste from Kota Kinabalu, Kota Belud, Penampang, Putatan and Tuaran. It is situated adjacent to the Kota Kinabalu Industrial Park boundary and can be easily accessed by main roads.



Legends:
- Closed cell 1
- Active cell 2

Current Condition at the KMSL

At present, the KMSL demonstrates negative environmental and social conditions, specifically foul stench with large amounts of fly and rodent infestation. Thus, to improve current conditions at the KMSL, the request to tender proposal for proposed MSW reduction and treatment was made.

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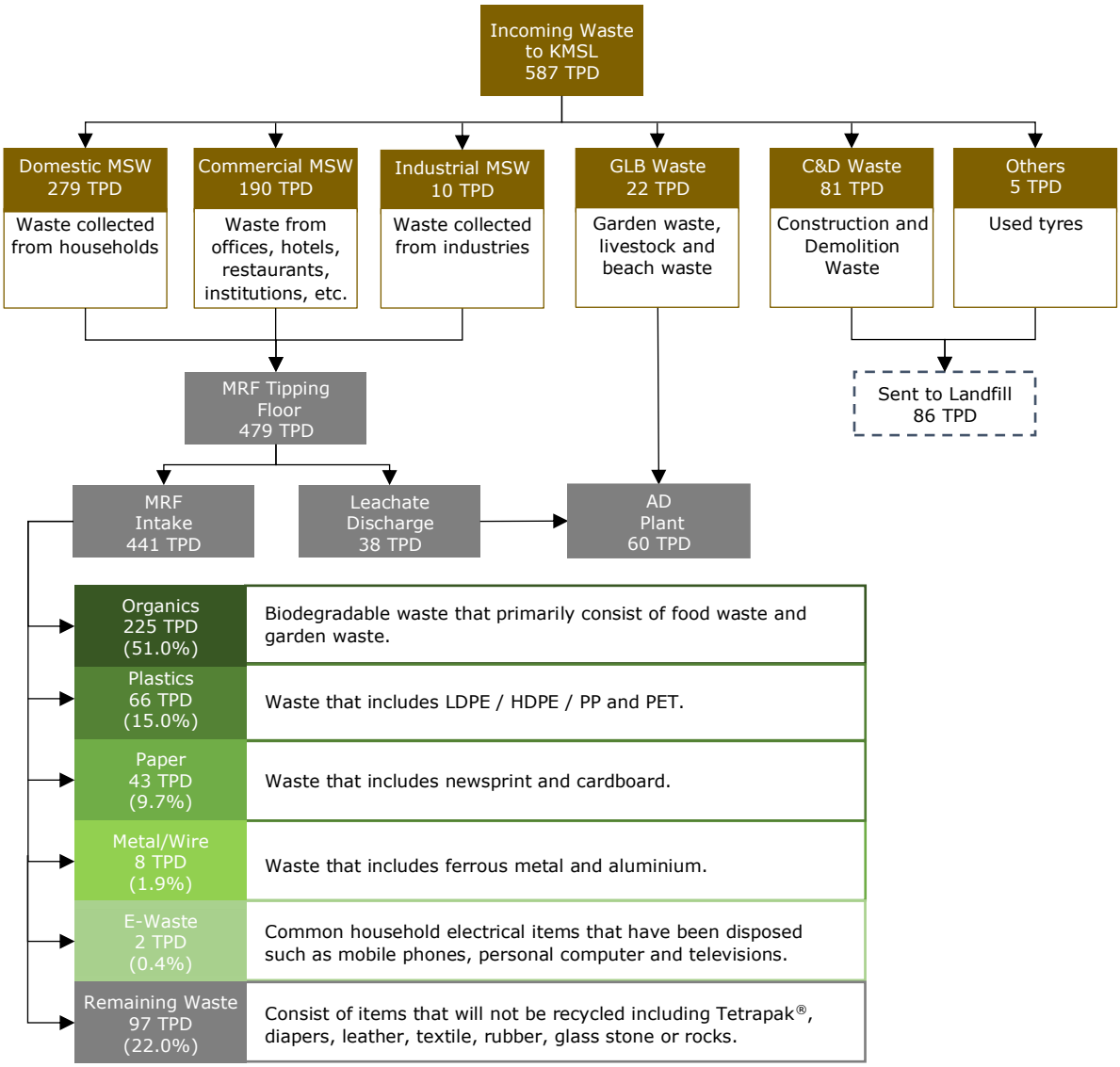
2.5 Waste Composition at Kayu Madang Sanitary Landfill

BWI conducted an extensive waste study in 2018 to determine the average amount and composition of waste that is delivered to the KMSL each day. This study serves as a reference point for the design of the IWMPP's material recovery facility and downstream production capacity. The MRF is a facility which receives, separates and sorts waste manually or through an automated system into different types of waste for recycling.

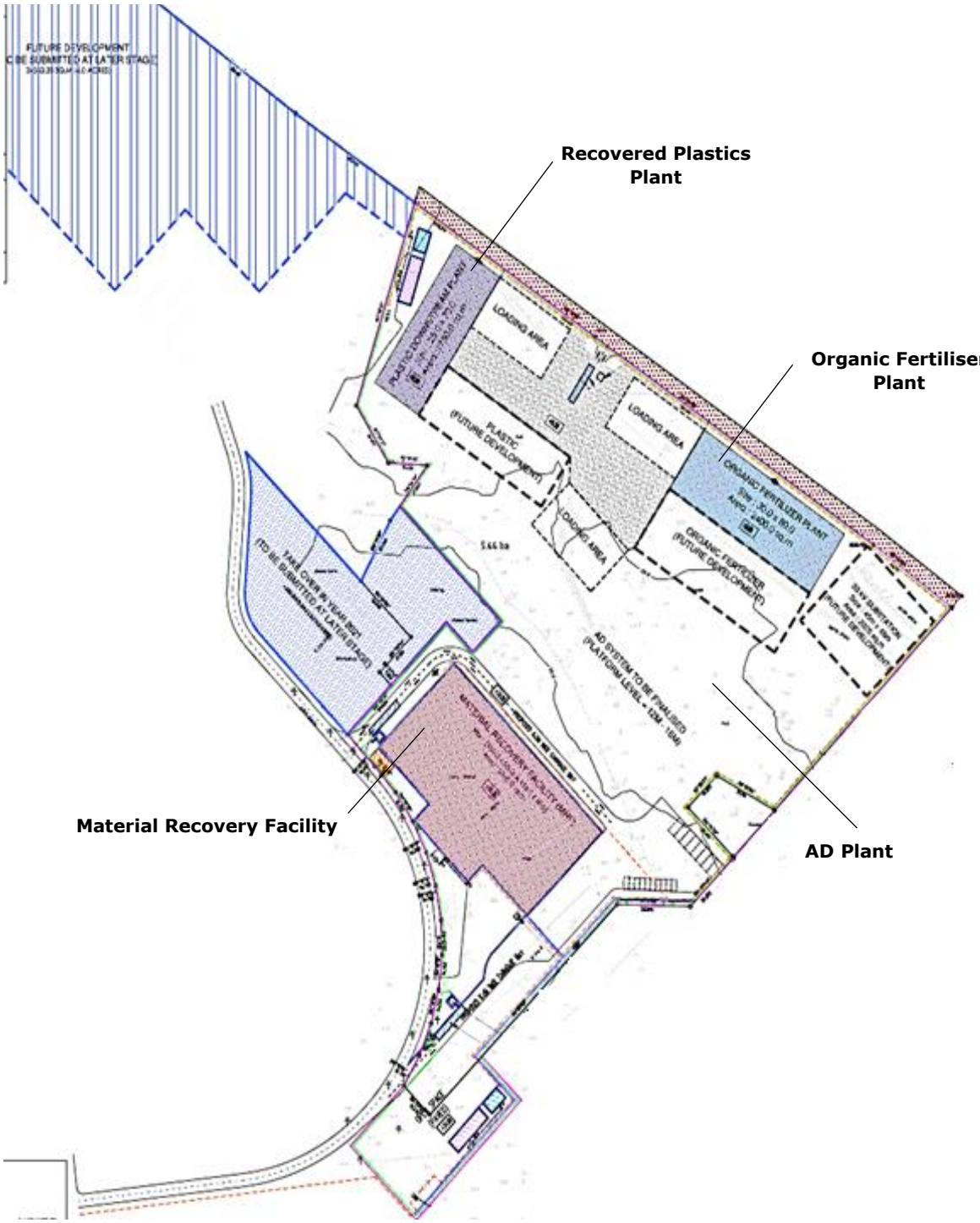
The results of the study are illustrated below:



2.6 The Integrated Waste Management Processing Plant

The Plant Boundary

The layout of the 20 acres IWMPP within the KMSL is represented by an extract of the development plan submitted to DBKK in December 2018. (Please refer to Section 5 Appendix for the A3 version of development plan.)



2.7 Current Status of the Project

Manual Sorting Operations

Since October 2018, BWI commenced manual sorting operations at the KMSL for a period of 24 months. The cash flow generated from the manual sorting operations will be rechanneled to fund the initial working capital requirements of the IWMPP.

Construction Status and Progress

The Development Plan was submitted on 8 October 2018 and was approved on 17 October 2019.

The Building Plan was submitted on 5 March 2020 and was approved on 8 January 2021.

EIA has commenced.

The overall implementation of the project is divided into two main phases as summarised below:

Construction Phase			Start Date	End Date
Phase 1	Base Facilities	MRF, recovered plastics plant, e-waste recycling centre and RDF pellet plant	01-Aug-21	31-Aug-22
Phase 2	Rooftop Solar	AD plant, Bottled CNG plant Installation of Rooftop Solar panels	01-Nov-23	30-Apr-24

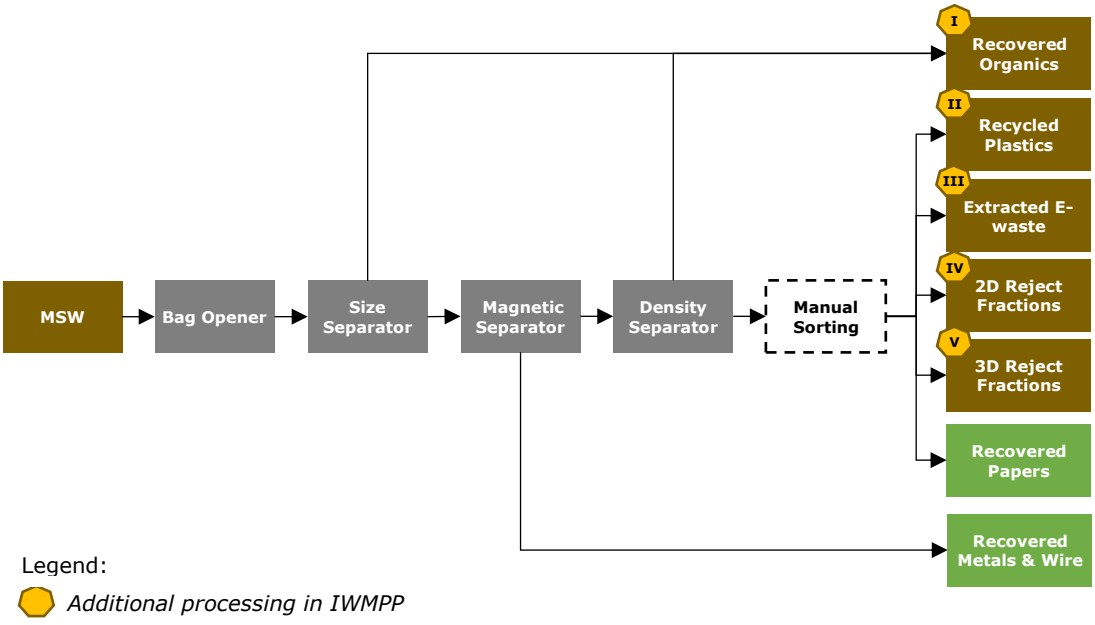
Professional Consultants

As part of the company's preparations for implementing the IWMPP project, BWI has assembled a team of experts to support BWI in several key areas of the project as elaborated below:

Expertise	Professional Consultant	Roles & Responsibilities
Civil & Structural Engineer	Perunding Bina Daya Sdn. Bhd. ("Bina Daya")	▪ Responsible for managing the structural design and construction of the IWMPP according to BWI's design criteria. ▪ Coordinates the construction of the plant with the Mechanical & Electrical consultants as well as making statutory submissions to the relevant authorities such as DBKK.
Mechanical & Electrical Engineer	PEM Consult Sdn. Bhd.	▪ Responsible for the IWMPP's electrical and mechanical system based on the structural designs provided by Bina Daya.
Quantity Surveyor	Kinabalu Setia Konsult Sdn. Bhd.	▪ Responsible for managing the tender process for vendors involved in the construction of the IWMPP.
Financial Advisor	Deloitte Corporate Advisory Services Sdn. Bhd.	▪ Responsible for evaluating BWI's financial model and assessing the feasibility of the project using the inputs and assumptions provided by BWI. ▪ Determines the funding requirements of the project based on the project rollout plans and capital expenditure.

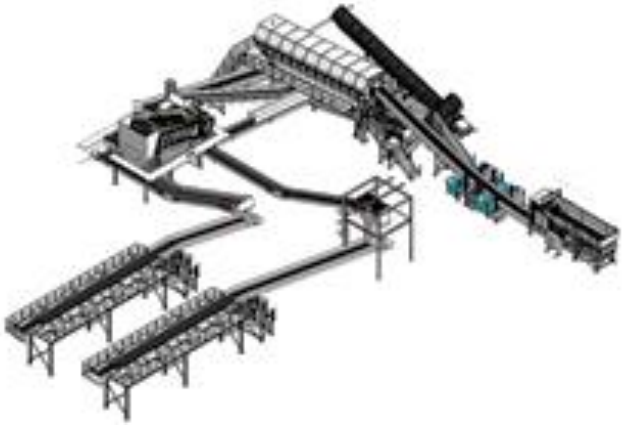
2.8 Process Flow Overview

Material Recovery Facility Process Flow



BWI's mechanised MRF can separate municipal solid waste ("MSW") into its different components efficiently and effectively to extract recyclable materials for direct sale or raw materials that can be converted into valuable downstream products.

- Bags of MSW that enter the MRF will be placed into a bag opener that automatically rips open each bag of waste.
- The contents of the bags will then flow onto a conveyor belt that moves the MSW through a sequence of mechanisms that maximises the separation and extraction of recyclable waste.
- A size separator contains multiple perforated metal screens that separates components of solid waste by size, effectively filtering out the larger components of waste such as organic waste.
- Ferrous metals and wire will be extracted with a magnetic separator.
- The remaining waste will go through the density separator which separates the waste into categories of 2D and 3D.
- Lastly, the waste will be manually sorted for plastics, e-waste, papers, metals and wire and 2D & 3D reject fractions.
- Recovered organics, recycled plastics, 2D & 3D reject fractions and extracted e-waste will be transported to other parts of IWMPP to be further processed into products.
- Recovered papers as well as metals and wire will not undergo further downstream processing, and are immediately sold to other downstream manufacturers or recyclers.



Source: Eggersmann GmbH

Technology Adoption

BWI has identified a wide range of recovery technologies to be adopted based on their efficiency and productivity.

The examples of recovery technologies to be adopted are as follows:

- Bag opener that can rip and empty multiple layers of bags without cutting or damaging the contents. It is suitable for packaging material, residual waste, household waste and wastepaper.
- Size separator or trommel screen is designed to separate MSW of various sizes.
- Sturdy and solid design of density separator or ballistic separator separates MSW into three fractions in one step with up to 90% precision. It removes fine debris and adhesions from lightweight fractions of MSW.

Potential Technology Providers

BWI has identified several companies as its potential MRF provider. BWI will conduct a rigorous assessment of each vendor's product from a financial and technical standpoint prior to selecting its ideal technology provider.

The details of the technology providers are summarised as follows.

Potential Provider	Business Description
Eggersmann GmbH	Specialises in designing and engineering equipment for recycling and waste sorting applications.
Dezhou Qunfeng Machinery Manufacturing Co Ltd.	Dedicated to manufacturing and operating environmental sanitation equipment, weighing product, waste sorting equipment and steel structures.
Beston (Henan) Machinery Co., Ltd.	Principally manufactures waste pyrolysis plants, biomass carbonization plants and waste sorting machines.

Source: Eggersmann, Peaks-Eco, Beston (Henan) Machinery Co. Ltd. company profiles

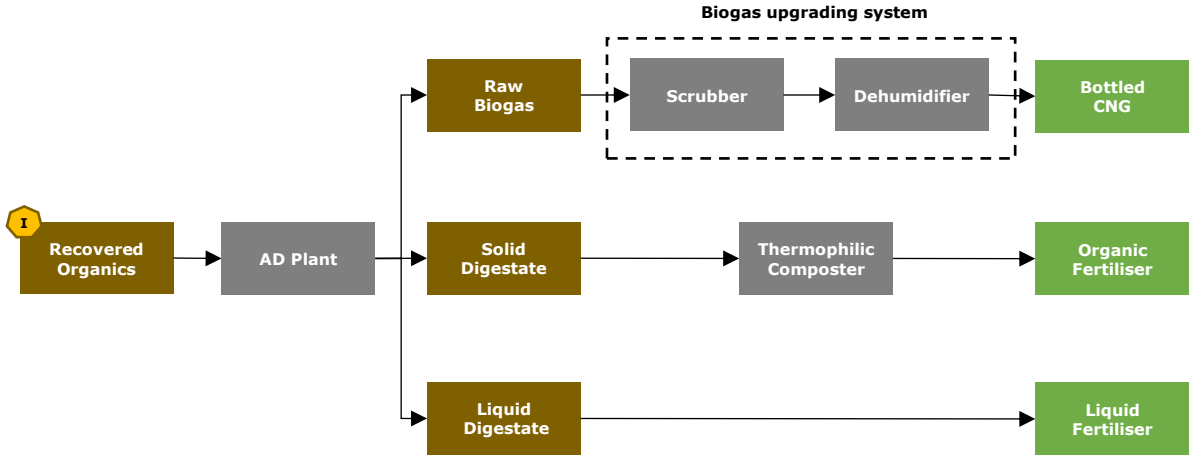
Track Records of Potential Technology Provider

BWI's potential technology providers have extensive experience in manufacturing and supplying waste management equipment. Some examples of relevant work and experiences are indicated as follows:

<u>Eggersmann GmbH</u>

- Designed, delivered, installed, commissioned a mechanical treatment and composting plant with a capacity of 40,000 tonnes per annum ("TPA") for Veolia, BMA Mainz-Essenheim, Germany for approximately RM65 mil. Supply of technologies includes composting tunnels, air and water processing technology, biofilter, automatic filling system, electrical control, visualisation and supervisory control and data acquisition ("SCADA").
- Designed, delivered, installed and commissioned a mechanical treatment plant with a capacity of 90,000 TPA for Transwaste Ltd., Melton, United Kingdom for approximately RM46 mil. Supply of technologies include conveyors, bag opener, screens, ballistic separators, magnetic / eddy current separators, air-belt separator, sorting cabins and electrical control, visualisation and SCADA.

I. Recovered Organic Waste Process Flow



The Anaerobic Digestion ("AD") Plant will consist of three distinct technologies that will be supplied by reputable companies. These technologies include the AD technology, Biogas Upgrading Technology and the Bottling Technology. Organic or biodegradable waste such as food waste is fed into AD plant in batches. Organic waste will be decomposed by bacteria in the absence of oxygen for 21 days in this plant. Throughout this period of time, the temperature in the AD plant is continuously monitored and adjusted to create an optimal environment for decomposition. As a result, the contents of the AD plant are converted into raw biogas, solid digestate and liquid digestate. The raw biogas and solid digestate shall undergo further processing to create marketable end products whereas the liquid digestate shall be commercialised when the opportunity arises.

Biogas Upgrading technology, treats the generated biogas from the AD plant which generally contain between 55 – 60% methane concentration. The main function of the Upgrading plant is to remove Hydrogen Sulphide, Moisture, Carbon Dioxide and other minor contaminants, so that the final output, of Biomethane (bioCNG, 92% methane concentration), has a much higher methane concentration. For our project we have used the existing pipeline natural gas quality as the benchmark to which we should upgrade the AD plant biogas output. Based on the Waste Composition Study, 200 metric tonnes of OFMSW daily will generate up to 16,000m^3 of bioCNG.

The Bottling Technology that will be used at our facility will be the Adsorbent Natural Gas (ANG) technology, we will be able to offer bioCNG at a lower pressure with a higher energy density.

The process for raw biogas to Bottled CNG is as follows:

- The raw biogas produced will be channeled into a scrubber that removes H_2S from the gas, in order to reduce the amount of pollutants in the biogas.
- Then, the biogas is dehumidified to eliminate any water vapour that could contaminate the gas.
- The raw biogas is sent into a purifier for methane enrichment which ultimately enhances its purity to levels similar to that of natural gas.
- Commercial user (especially F&B outlets) and certain industrial users are the target customer group and pricing structure will be designed to be lower than LPG on an equivalent energy basis.

The process for solid digestate to organic fertiliser is as follows:

- Solid digestate will be channeled into a thermophilic composter containing composting enzymes.

- The high temperature environment within the thermophilic composter would accelerate the biodegradation of solid digestate into organic compost – the base component of organic fertiliser.
- A nutrient solution that contains essential agricultural nutrients such as nitrogen, potassium and phosphorus are then mixed into the organic compost to produce solid fertiliser.

Technology Adoption

BWI has identified a wide range of organic waste processing technologies to be adopted based on their efficiency and productivity.

The examples of organic waste processing technologies to be adopted are as follows:

AD Plant

- All OFMSW from the MRF is fed into the AD plant will be completely processed with zero leakage.
- Applicable for both liquid and solid organic waste input and able to process more variations of dry organic waste as compared to conventional AD of processing lesser amount of organic waste.

Bio-Compressed Natural Gas ("Bio-CNG") Plant

- Biogas upgradation systems are proven to be more environmentally sustainable as they offer methane purity of up to 98% with methane losses of less than 1%.

Bio-CNG bottling Plant

- BWI will use patented ANG technology to store Bio-CNG into gas cylinders.
- Adsorption is a process that occurs when a gas or liquid accumulates on the surface of a solid or a liquid (adsorbent) forming a film of molecules or atoms (adsorbate)
- Adsorption enables Bio-CNG to be stored with moderate levels of temperature and pressure as compared to conventional methods such as absorption, leading to energy efficiencies.
- With ANG technology, BWI can store larger quantities of Bio-CNG in gas cylinders while maintaining a lower pressure.
- In turn, enabling BWI to market its Bio-CNG in gas cylinders of a dimension and pressure similar to Liquefied Petroleum Gas cylinders.

Organic Fertiliser Plant

- Rapid Thermophilic System converts organic waste into 100% premium grade organic fertiliser at high temperature within 24 hours.
- Such technology is known as the fastest process in organic waste treatment industry so far.

Potential Technology Providers

BWI has identified several companies as its potential provider for the AD plant and organic fertiliser plant. BWI will conduct a rigorous assessment of each vendor's product from a financial and technical standpoint prior to selecting its ideal technology provider.

The details of the AD technology providers are summarised as follows:

Potential Provider	Business Description
JOG Waste to Energy Pvt. Ltd	Specialises in renewable energy solutions primarily in the area of solar and biogas.
Shandong Mingshuo New Energy Technology Co.	Specialises in the production of desulfuriser and biogas equipment.
Shanghai Jacn Energy & Environment Co., Ltd	Specialises in AD technology R&D, project engineering and complete plant equipment supplying with the support from a University in Thailand.
Botres Global of Austria	Specialises in AD technology research and development, project engineering and complete plant equipment supply with the support from Austrian technical team.

WABIO Technologie GmbH	Focuses on the development, commercial application and distribution of its proprietary WABIO® - bio-fuel power plant concept that generates biogas from various organic substances such as food waste.

The details of the Bio-CNG technology provider is summarised as follows:

Potential Provider	Business Description
AtmosPower Pvt. Ltd.	▪ Focuses on manufacturing facilities such as Turbine By-Pass valves, crystallizers, surface condensers, evaporator, vacuum systems and gas separation systems.

The details of the organic fertiliser technology provider is summarised as follows:

Potential Provider	Business Description
Biomax Green Pte Ltd	▪ Focuses on the development of composting treatments for organic waste.

Track Records of Potential Technology Provider/Partners

BWI's potential technology providers have extensive experience in manufacturing and supplying waste management equipments. The relevant work and experiences in the recent years are indicated as follows:

Botres Global GmbH (preferred)

- Designed and constructed AD for organic fractions of municipal solid waste and food waste that is capable of processing 280,000 tonnes per annum and generating 4MW of power in Italy.
- Designed and constructed AD for OFMSW that is capable of processing 700,000 tonnes per annum and generating 2.75MW of power in Germany.
- Designed and constructed AD for organic fractions of municipal solid waste that is capable of processing 55,000 tonnes per annum and generating 2.0MW of power in France.
- Designed and constructed AD for organic fractions of municipal solid waste and food waste that is capable of processing 500,000 tonnes per annum and generating 12MW of power in Italy.
- Designed and constructed AD for OFMSW that is capable of processing 100,000 tonnes per annum and generating 3MW of power in Turkey.

WABIO Technologie GmbH

- Designed and constructed the world's first self-sufficient biogas power plant with an installed capacity of 20-Megawatt thermal power ("MWth") in Indonesia for approximately RM90 mil.
- Constructed the first combined biogas and bioethanol plant with an installed capacity of 10MWth and an annual production capacity of 8 mil litres or bioethanol in Germany for approximately RM89 mil.
- Developed the first AD plant with a thermal output of 2.1 MWth, in Neukirchen, Germany.

AtmosPower Pvt. Ltd.

- Constructed and installed a biogas purification plant in Bangolore with a capacity of 500m^3/hour
- Constructed and installed a biogas purification plant in India with a capacity of 850m^3/hour.
- Constructed and installed a biogas purification plant in India with a capacity of 350m^3/hour.

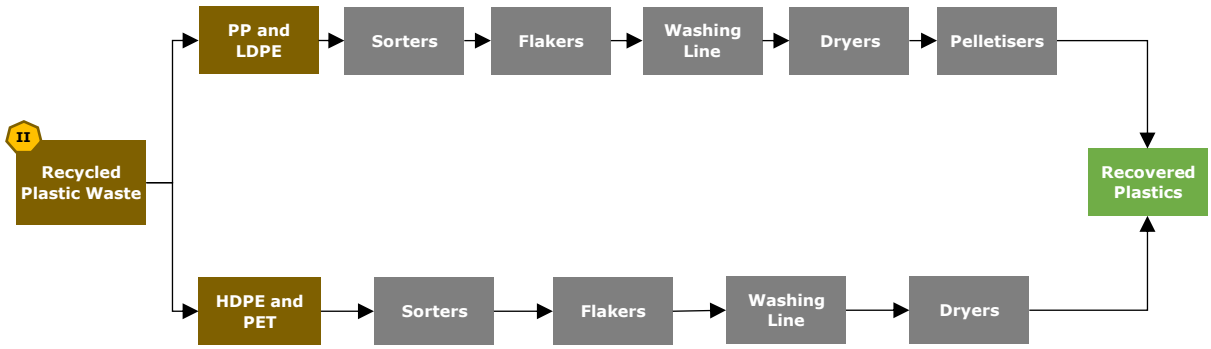
Malaysia Japan International Institute of Technology (MJIIT)

- BWI has an ongoing interaction with MJIIT to assist in the technical evaluation of potential vendors, for which a formal RFQ (Request for Quotation) exercise will be floated soon. The plant design metrics is based on a preliminary assessment carried out during this engagement and is using conservative assumption.

Source: JOG Waste to Energy Pvt Ltd, Shandong Mingshuo New Energy Technology Co. Ltd, Shanghai Jacn Energy & Environment Co., Ltd, WABIO Technologie GmbH and Biomax Green Pte Ltd company profiles

II. Recovered Plastic Waste Process Flow

- Recycled plastic waste is first separated into light plastics and heavy plastics. Examples of the light plastics include films like low-density polyethylene ("LDPE"), whereas the heavy plastics category includes plastics such as high-density polyethylene ("HDPE"), polypropylene ("PP") and polyethylene terephthalate ("PET").
- The separated plastics are fed into their respective sorter, followed by shredder or flakers.
- Shredded PP and LDPE plastics will then be transported to the washing line, dryer, and pelletisers for pelletisation and subsequently converted and sold as recovered plastic pellets.
- In contrast, the HDPE and PET flakes will be washed and dried before they are further processed and sold as recovered plastic flakes.



Technology Adoption

BWI has identified a wide range of plastic recovering technologies to be adopted based on their efficiency and productivity.

The examples of plastic recovering technologies to be adopted are as follows:

- Crusher and shredder have a combination of advanced controls, low rotor speed and smooth hydraulics create a reliable and easy to use system.
- PET flake pelletising line has good performance, high and stable output, low energy consumption, low maintenance cost.
- Dry washing line increases pellets quality and material yield. The cost of cleaning per ton of water is about 30% lower than the cost of traditional cleaning.

Potential Technology Provider

BWI has identified a few companies as its potential providers for the recovered plastic plant. BWI will conduct a rigorous assessment of each vendor's product from a financial and technical standpoint prior to selecting its ideal technology provider.

The details of the technology providers are summarised as follows:

Potential Provider	Business Description
Wanrooe Machinery Co., Ltd	Manufacturer, exporter and supplier of plastic and tyre processing machinery.
DaLongKai Technology (M) Sdn. Bhd.	Focuses on collection of recyclable materials, manufacture of diverse plastic products.
Suzhou Polyretec Machinery Co. Ltd.	Focuses on research and development and manufacturing of industrial machinery for plastic recycling.

Source: Wanrooe Machinery Co., Ltd, DaLongKai Technology (M) Sdn. Bhd., Suzhou Polyretec Machinery Co. Ltd. company profiles

Track Records of Potential Technology Provider

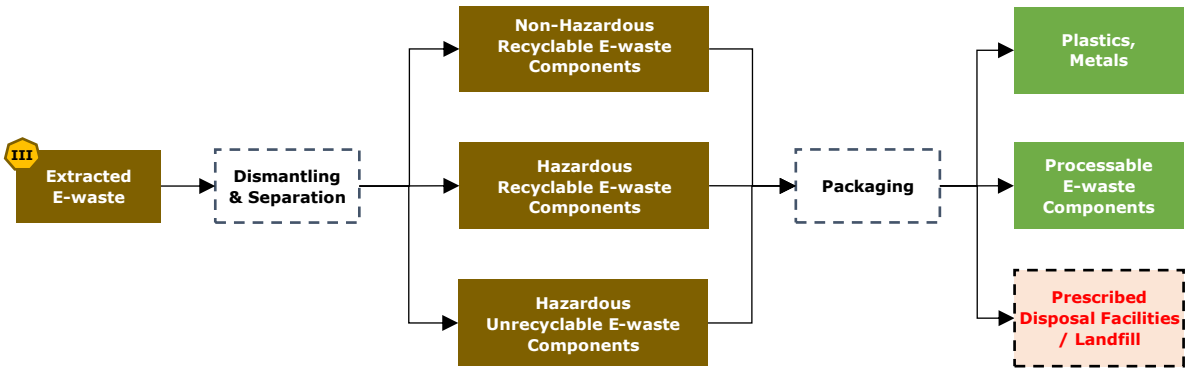
BWI's potential technology providers have extensive experience in manufacturing and supplying waste management equipments. The relevant work and experiences in the recent years are indicated as follows:

Wanrooe Machinery Co., Ltd

- Manufactured and supplied plastic separator systems to San Miguel Industrias Pet S.A, a plastic manufacturing and packaging company in Peru.
- Manufactured and supplied a list of plastic processing equipments such as plastic pelletiser, plastic screw feeder, plastic washing line, metal detector, etc. to Gailani Rodwan Plastic Factory.

III. E-waste Process Flow

- Firstly, the e-waste extracted from the MRF are inspected for quality assurance.
- Then they will be sent for dismantling and separation to segregate them into non-hazardous recyclable, hazardous recyclable and hazardous unrecyclable e-waste components.
- They will be sent for packaging before being manually separated into plastics, metals and processable e-waste components, also known as extracted e-waste components.
- The separated plastics and metals are stored and sent for recovery onsite or to offsite recyclers.
- The processable e-waste components will be shipped to licensed offsite e-waste recycling whereas the rest will be transported to the prescribed disposal facilities or landfill.



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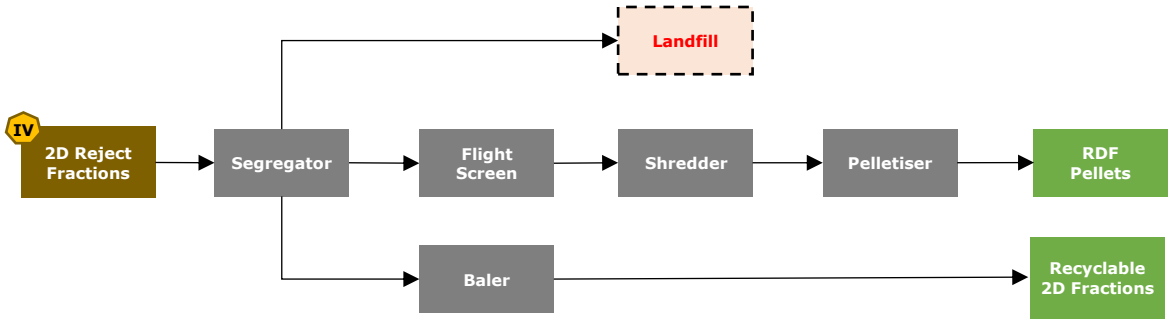
IV. Refuse Derived Fuel Waste Pelletisation Process Flow

- The 2D reject fractions such as LDPE dirty plastics and dirty dry paper collected from the MRF will be further segregated at the segregator.
- The waste components which are not suitable for pelletisation will be extracted and disposed at the landfill.
- However, any recyclable 2D waste extracted from the segregator will be sent to the baler to be compressed and processed into recyclable 2D fractions.
- The remaining waste components which are suitable for pelletisation will be sent to the flight screen, shredder, followed by pelletiser to be processed into RDF Pellets.



Technology Adoption

BWI has identified a wide range of RDF pelletisation technologies to be adopted based on their efficiency and productivity.

The examples of RDF pelletisation technologies to be adopted are as follows:

- Shredder has a unique cutter shape which allows it to shred objects into small and uniform particles. The shredder is able to shred 2D reject fractions that are smaller than 300mm.
- The modularity of the RDF pelletiser enables damaged parts to be replaced easily, hence minimising maintenance cost.
- The RDF pelletiser consumes lower amount of electricity as no additional drying facility is required, in turn, reducing its operating cost.

Potential Technology Provider

BWI has identified a few companies as its potential providers for the RDF pellet plant. BWI will conduct a rigorous assessment of each vendor's product from a financial and technical standpoint prior to selecting its ideal technology provider.

The details of the technology providers are summarised as follows:

Potential Provider	Business Description
Geor-Ding Machinery Co., Ltd	Specialises in crushing, washing and drying line, turnkey plant for recycling plastic, rubber and plastic pelletising, special composite materials, color master-batch, etc.
JST Co., Ltd	Provides WTE solutions for solid combustible waste and the production of alternative fuel such as RDF.

Source: Geor-Ding Machinery Co. Ltd, JST Co. Ltd company profiles

Track Records of Potential Technology Provider

BWI's potential technology providers have extensive experience in manufacturing and supplying waste management equipments. The relevant work and experiences in the recent years are indicated as follows:

Geor-Ding Machinery Co., Ltd

- Installed RDF plant equipment and wood shredding equipment in Japan in 2017 for the customer to cooperate with the government to set up a model factory towards sustainable regeneration.
- Supplied and installed 6 lines of Geor-Ding RDF whole plant equipment to the largest industrial paper and paper container company in Taiwan. Geor-Ding planned the fully automatic equipment and the process towards high efficiency, the end product of RDP line enhances the performance of energy production for customers.

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2.9 Key Products

With its own manufacturing facilities and established business partnerships, BWI will be producing the following products.

01 ***Recovered Plastics***

- Products that fall under this category typically include HDPE/PP, LDPE, and PET plastics, where PP and LDPE are sold in pellet form whereas HDPE and PET plastics are sold as flakes.
- Both uncoloured and coloured variants of the product are available for sale.

02 ***Other Recyclables***

- Other Recyclables comprise of recyclable papers and metals that do not undergo further downstream processing at the IWMPP and are immediately sold to other downstream manufacturers.
- Products in this category include newspapers, cardboards, ferrous metals and aluminium.

03 ***Bottled CNG***

- Biogas generated from organic fractions of MSW is compressed and bottled as CNG that can be sold for commercial and industrial use.

04 ***Others***

RDF Pellets

- RDF is a renewable and cheaper substitute for coal that is commonly used as fuel in energy intensive processes such as brick or cement manufacturing.

Extracted e-waste components

- Extracted e-waste components include items such as circuit boards and chips.
- These recyclable items in e-waste will be sold to other downstream players for further recycling.

2.10 Commitments of Commercial Partners

To ensure the continued financial success of the IWMPP, BWI has negotiated commercial commitments for their respective products with the following parties.

Product	Commercial Partners	Business Collaboration with BWI
Recovered Plastics & Metals	Goline Global Sdn. Bhd. ("Goline")	▪ Goline is in the business of handling waste material and recycling plastics in Malaysia. ▪ It specialises in processing all kind of recyclable plastics into high quality raw material such as PET, PP, etc. as well as metals. ▪ Goline will be purchasing recovered plastics and metals according to the offtake agreement, once the operation of plastics pelletisation & metals separation starts.
RDF pellets	Cement Clinker Plant	▪ BWI is currently in negotiations with the owners of a cement clinker plant in Sabah for the offtake of its entire production of RDF pellets as a fuel source.
Bio CNG	Samaja Baru and Borneo Gaz	▪ BWI has signed offtake agreements with Samaja Baru and Borneo Gaz for the offtake of approximately 55% of the Phase 1 production of Bio CNG.
Organic Fertiliser	Glomus Ecology Sdn. Bhd. ("Glomus")	▪ Glomus was set up primarily to venture into the production and sale of natural fertiliser. ▪ It recycles, packs and distributes 100% premium grade natural organic fertiliser which is suitable for all plantation, landscaping, home garden and vegetable farm. ▪ Glomus has signed a MoU with BWI on 17 Jan 2019 to provide the equipment and technology for decomposing organic waste and manufacturing organic fertiliser. ▪ Glomus will be operating, marketing and selling the organic fertiliser in Malaysia.

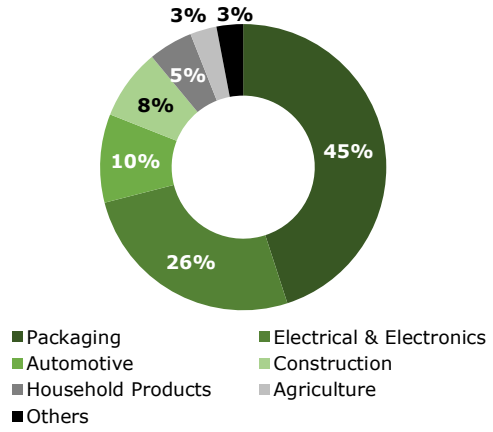
2.11 Product Outlook

2.11.1 Plastic Pellets

Plastics are applied in most products in the world from food containers to components in aircrafts, it is one of the most ubiquitous man-made material available. Its numerous properties that are not limited to thermal and chemical-resistance, high durability and low cost, gives plastics a versatility that is uncommon in most materials.

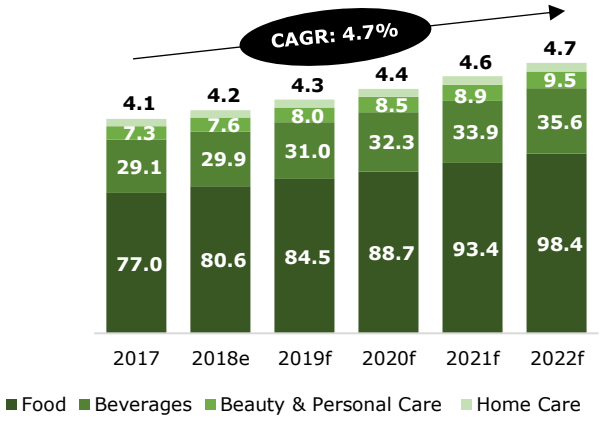
According to PlasticsEurope, an association of European plastic manufacturers, the major end users of plastic products are from various industries including, packaging, electric & electronics, automotive, construction and household products(1).

Malaysia Plastics Market Segmentation



Source: Malaysian Plastics Manufacturers Association

Plastic Packaging Retail Sales Volume (hundred mil)



Source: Euromonitor

The Malaysian Plastics Manufacturers Association estimated that the largest segment in Malaysia's plastics market is packaging which makes up nearly half of the sector's total revenue in 2016, followed by electrical & electronics which contributes 26% of revenues(2).

These group of manufacturers represent a potential customer base for BWI as plastic packaging is widely used in most of the consumer products in Malaysia, therefore making it a stable source of demand for plastic pellets. Furthermore, manufacturing activity for plastic packaging is expected to experience significant tailwinds from strengthening sales of consumer products in the near future.

Key Trends in the Plastics Market

Aside from the growth of the domestic market, other major trends that would positively impact the growth of BWI's plastic pellets are as follows:

- One trend underlying Malaysia's growing plastic packaging usage is the widening adoption of e-commerce in the country. In 2017, Digital News Asia and Xinhuanet described that Malaysia's transformation into a regional e-commerce hub for prominent companies such as Alibaba and Zalora will lead to a surge in plastic packaging as more deliveries are made to Malaysian consumers.
- China's National Sword program which banned the import of scrap plastics to stem the inflow of contaminated plastics into the country resulted in the closure of many domestic plastic recyclers(3). Consequently, this led to the creation of plastics shortfall which could be fulfilled with the importation of recycled plastic pellets.

Sources: (1) "Plastics – the Facts 2017", PlasticsEurope, 2017;
(2) "Mega Science 3.0 - Plastics and Composites Sector", Academy of Sciences Malaysia, 2016; and
(3) "National Sword may create new trade route for plastics beyond China", Expo-ChinaReplas 2018

2.11.2 Biogas

Biogas is a form of biofuel that is harnessed from anaerobic digesters when organic waste undergoes fermentation. It has various household and industrial applications such as being used as cooking fuel or feedstock to generate electricity and heat – a common practice in Europe and nascent one in Malaysia.

Biogas can be further compressed into Bio-Compressed Natural Gas ("Bio-CNG") where it is similar to Natural Gas in composition and properties. This not only enables it to be distributed in natural gas pipelines but the usage of Biogas is further expanded. A primary example is its use as a renewable vehicular fuel source.

Parameters	Biogas	Bio-CNG	Natural Gas
Methane	55-65%	>94%	>92%
CO_2	35-45%	<4%	<2%
H_2S	2,500-4,000 ppm	<10 ppm	<3 ppm
Other Impurities	Present	Not Present	Not Present
Calorific Value	~19,500 kilojoules ("kj")/kg	35,950 kj/kg	36,600 kj/kg

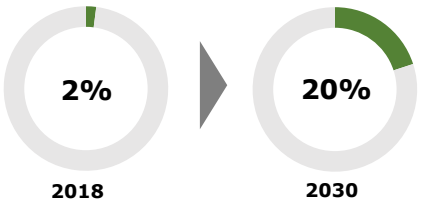
Source: Malaysian Palm Oil Board, 2017

The Malaysian Palm Oil Board noted that most biogas digesters are located at palm oil mills as, POME, a liquid by-product generated from palm oil processing mills is a principal feedstock. However, another source of biogas feedstock that is abundant but underutilised in Malaysia is MSW, specifically the organic component which forms a major fraction. Currently, there is no reported biogas facility that utilises MSW as the main feedstock in Sabah or Malaysia, leaving a major opportunity for BWI to fill in this gap.

Malaysia's Biogas Outlook

The national demand for biogas as an alternative energy source arises from the exhaustion of national fossil fuel reserves and the push for environmental sustainability. The Ministry of Energy, Science, Technology, Environment and Climate Change has also promoted the shift towards renewable energy sources by setting targets relating to energy generation. For instance, a target to generate 20% Malaysia's electricity from renewable sources by 2030(1).

Electricity Generation Sources



Source: The Edge Markets

Potential Compressed Biogas Markets

Major East Coast Towns

- Sandakan
- Lahad Datu
- Semporna
- Tawau

Major towns such as Sandakan and Tawau are not connected to the main natural gas pipeline, i.e. the Sabah – Sarawak Gas Pipeline, hence, they rely on compressed natural gas from Sabah Energy Corporation's virtual gas pipeline for their daily activities. This pipeline is a modular system that comprise of gas tankers, compression and decompression stations that can deliver natural gas to rural areas or places that are out of reach from the underground natural gas pipelines(2). Moreover, the cancellation of the Trans Sabah Gas Pipeline project announced in the 2019 Malaysian budget further enhances BWI's opportunity to serve the eastern towns of Sabah(3).

Sources: (1) "Malaysia sets new goal of 20% clean energy generation by 2030", the Edge Markets, 2018;
(2) "Compressed Natural Gas (CNG) Via Virtual Pipeline System (VPS)", Sabah Energy Corporation Sdn. Bhd., 2018 and;
(3) "Cancelled or postponed infrastructure projects due to budget constraints", EdgeProp, 2018

2.11.3 Organic Fertiliser

Organic fertiliser is a form of nutrient that mainly comes from renewable carbonaceous materials from plant or animal origin. It is processed from digestate - a fully fermented nutrient-rich material -produced by AD.

A research finding by the European Biogas Association in 2015 shows that organic fertiliser adds nutrients through the natural processes of nitrogen fixation, solubilising phosphorus and stimulating plant growth through the synthesis of growth substances(1). With the emerging trend of environmentally sustainable agriculture, organic fertiliser can be expected to displace the use of chemical fertiliser and pesticides.

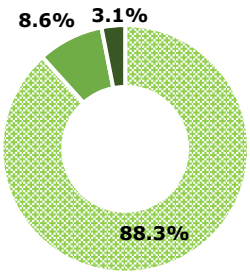
Over the years, the Malaysian Government has rolled out initiatives and subsidies to promote the use of organic fertiliser, due to two main reasons:

- Organic agriculture is seen as important for the sustainable use and management of natural resources.
- Food and Agriculture Organisation has identified organic fertiliser as a niche market for fruits and vegetables in the Third National Agricultural Policy.

Examples of initiatives and subsidies include additional one-off assistance in infrastructural development to organic farmers, eligibility for existing credit schemes and special loans.

Key Trends in the Organic Fertiliser Market

Fertiliser Consumption by Major Crops (%)



Source: Fertilizer Industry Association of Malaysia ("FIAM")

According to Malaysian Palm Oil Council ("MPOC"), Malaysia is known as one of the biggest producers and exporters for palm oil. Malaysia currently accounts for 39% of world palm oil production and 44% of world exports. Large tracts of land are cultivated with perennial tree crops such as palm oil where the large quantities of fertiliser are required annually to sustain high crop yields and ultimately profitability. Other than the palm oil industry, the key consumers of fertiliser are paddy and rubber plantations.

The Roundtable on Sustainable Palm Oil has indicated that the recent developments in the oil palm industry such as a reduction of oil palm import taxes in India and the push for sustainable oil palm plantations. Hence, they promise a sustainable market for BWI's organic fertiliser.

The growth of the organic agriculture industry is another boon to the consumption of organic fertiliser. Consumer interest in organic products has grown rapidly as a result of increasing awareness toward nutrition, quality and food safety. The Food and Fertiliser Technology Center for the Asian and Pacific Region found that the trend in consumer demand has encouraged Malaysian farmers to increase the share of organic crop, as evident in the rise in myOrganic accredited farms from 3 in 2003 to 151 in 2015. This not only implies a shift in consumer preferences, it also highlights the opportunities available for BWI to market its organic fertiliser within Malaysia.

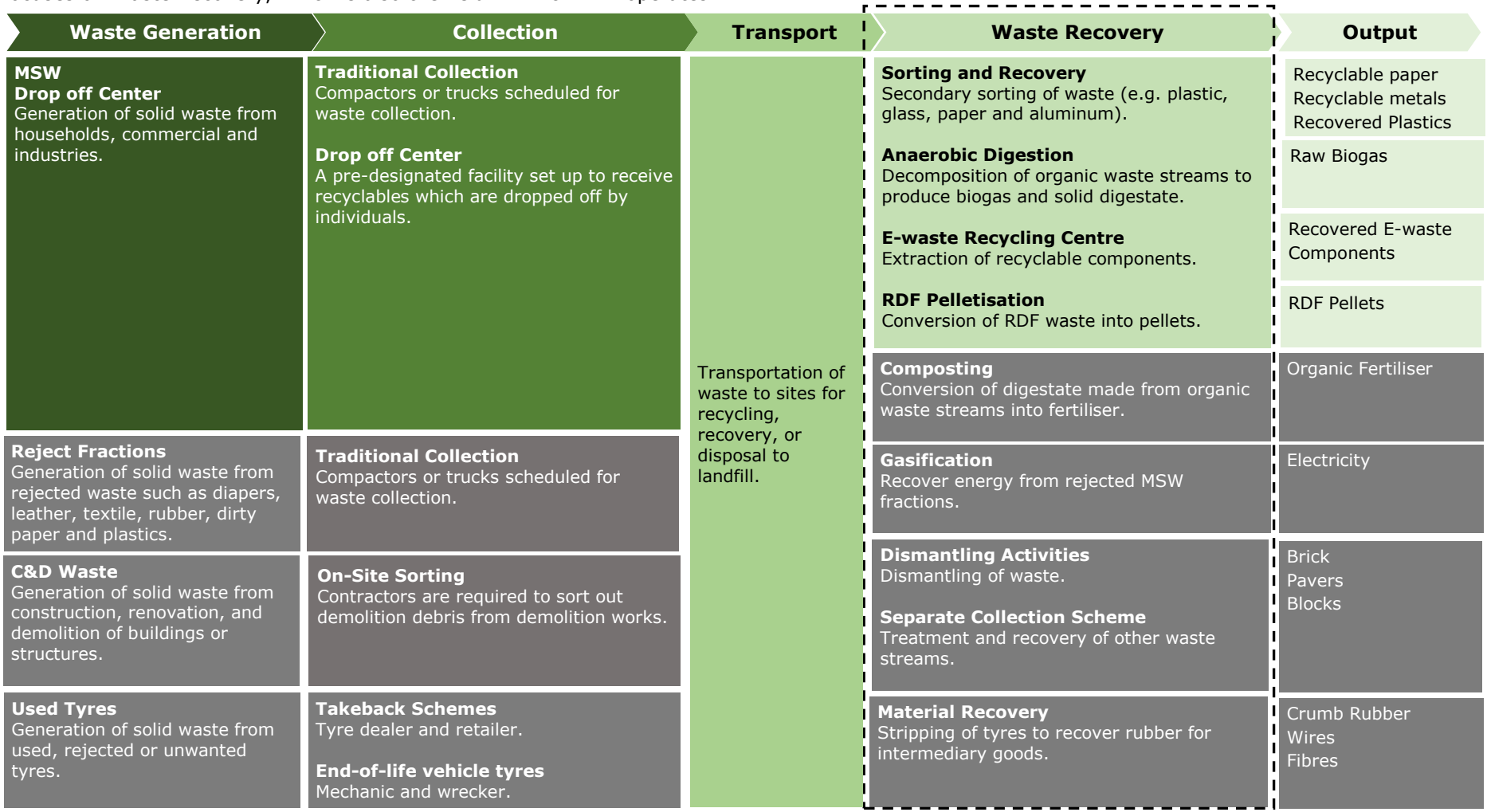
Source: (1) Digestate Factsheet, European Biogas Association, 2015

3

Overview of Waste Management Market

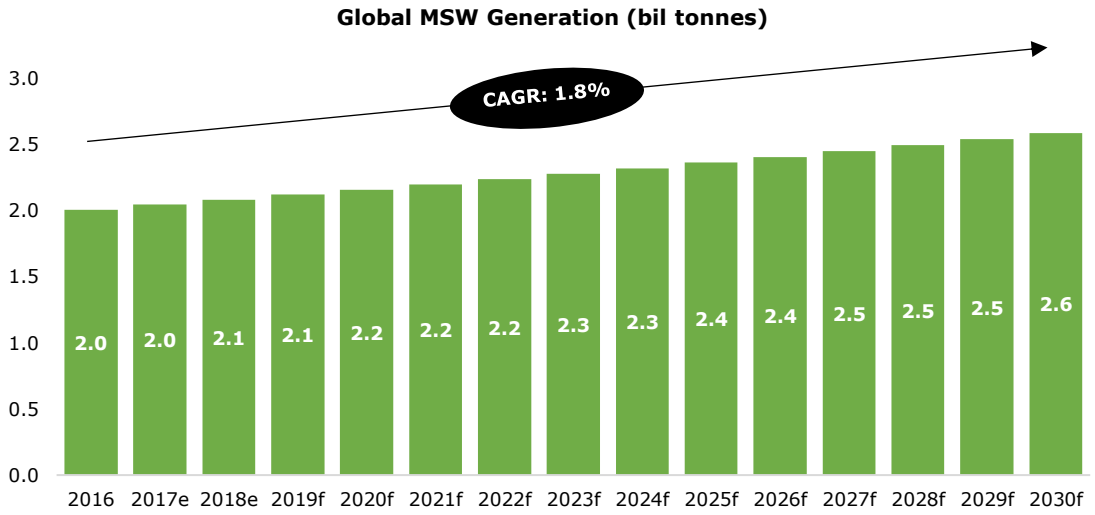
3.1 The Waste Value Chain

The waste value chain is introduced to provide a better understanding of the waste management market in the following sections. This value chain is divided into five stages, starting from waste generation to its output. The following sections under Section 3: Overview of the Waste Management Market focuses on Waste Recovery, which is also the field in which BWI operates in.



3.2 Global Waste Management Market Overview

Global MSW Landscape



Source: World Bank, 2017

Economic prosperity and rising populations have resulted in a surge of consumerism across the globe. Although, the virtuous cycle of consumption driven economic growth is a sign of a healthy global economy, a symptom of this cycle emerges – increasing waste generation. As highlighted in the figure above, global MSW generation levels are projected to increase from approximately 2.0 bil tonnes in 2016 to 2.6 bil tonnes in 2030(1). This phenomenon presents several issues, most prominently, negative environmental consequences and the wastage of valuable materials. As a result, many countries are prioritising waste management to mitigate the ramifications of escalating waste generation.

Driving Forces of MSW management activities

- **Escalating MSW Generation**

  Waste management is universally considered as a necessary public utility. Without sufficient waste treatment or disposal, increasing MSW generation will inevitably lead to poorer living conditions. Key factors that influence the generation of MSW are population growth, urbanisation and economic growth(2).

  Population Growth

  - It significantly influences MSW levels, as the size of a population increases, more waste is generated due to higher levels of overall consumption.
  - Moreover, it further amplifies the amount of waste generated when coupled with increased waste generation rates per capita.

  Urbanisation

  - World Bank has highlighted that countries with larger urban populations generate more waste than countries that are less urbanised(3).
  - Typically, urban residents are more inclined to consume goods and services due to their access to higher disposable incomes.
  - Population growth is also more concentrated in the urban regions due to rural to urban migration, given the ample job opportunities available in cities relative to the rural areas.

Sources: (1) "What a Waste 2.0: A Global Snapshot of Solid Waste Management to 2050", the World Bank, 2018;
(2) "Asia Waste Management Outlook", International Solid Waste Association, 2017; and
(3) "What a Waste: A Global Review of Solid Waste Management", the World Bank, 2012

Economic Growth

- It is inextricably linked to greater waste generation as economic growth directly influences income levels.
- An uplift in the economy will eventually boost household disposable income levels, thereby, increasing the propensity for consumption.
- A more consumption heavy lifestyle results in higher MSW generation, further magnifying the need for more extensive waste management facilities.
- In their seminal waste study, "What a Waste", the World Bank has found that on average high income countries produces more MSW per capita relative to their lower income counterparts as illustrated in the following table:

Income Level	GNI/Capita(1) (USD)	Example Countries	Waste Generated/Capita (kg/day)		
			Lower Bound	Upper Bound	Average
High	>12,476	Germany, Singapore	0.70	14.00	2.10
Upper Middle	4,036 – 12,475	Malaysia, Indonesia	0.11	5.50	1.20
Lower Middle	1,026 – 4,035	Cambodia, Mongolia	0.16	5.30	0.79
Lower	<1,026	Senegal, Nepal	0.09	4.30	0.60

Source: World Bank, 2012
Note: (1) GNI/Capita has been adjusted to World Bank's latest figures.

- **Environmental Awareness**

  Untreated MSW can negatively impact the environment in the form of global warming and water contamination. For instance, landfills are a major producer of greenhouse gases, in particular, methane which is 28 times more harmful to the environment than carbon dioxide(1). One estimate by the Environmental Protection Agency suggest methane generated at landfills represent 16% of the total global methane emission(2). Groundwater and surface water can be contaminated by the leachate generated at landfills. Leachate often contains fecal matter and heavy minerals such as lead and mercury that are hazardous to the human body. Improper waste management adversely impacts the environment and should create an impetus for the public, authorities as well as private companies to actively minimise this impact.

- **Shift from Waste Disposal to Waste Diversion**

  Currently, the most widely used method for managing MSW is the conventional "throw & forget" of disposing MSW at designated landfills. However, alternative methods of waste management have emerged to divert waste away from the landfill and capitalise on the abundant amount of resources available in MSW via resource recovery. Unlike conventional waste disposal, waste diversion plays a pivotal role in the creation of a circular economy in which resources are recycled and recovered instead of being wasted away, resulting in a zero waste environment. Creative solutions that include MBT, WTE, among others, enable the recovery of various resources from waste such as compost, electricity or metals.

3.3 Regional Waste Management Market Overview

Regional MSW Trends

According to Worldometers, Asia, with a total population of 4.5 bil people in 2018, is the largest waste-producing continent on earth. Urban waste streams such as e-waste, C&D waste, food waste, healthcare waste and microplastic are the key concerns. With the exception of Japan and South Korea, all countries in Asia have experienced an increase in average waste generation per capita over the past 20 years[3].

The World Bank[4] estimated waste generation from urban cities in Asia ranges from 450,000 to 760,000 tonnes per day. The waste generation by the urban cities in Asia alone is projected to be 1.8 mil tonnes by 2025. This is due to Asia having the largest population in the world which is equivalent to approximately 60% of the world population.

The escalation of MSW generation and greater environmental awareness have escalated amount of MSW treated in the recent years. The table below indicates the amount of MSW generated in different regions of Asia in 2016 and the proportion that is disposed at landfills, incinerated and composted.

MSW Generation, Waste Management Treatment and Disposal Practices in Asia in 2016

Region	MSW Generation Rate (tonnes/cap /year)	Percentage of MSW			Percentage of other MSW management, unspecified
		Disposed at disposal sites (% of MSW)	Incinerated (% of MSW)	Composted (% of MSW)	
Eastern Asia	0.37	55%	26%	1%	18%
South-Central Asia	0.21	74%	-	5%	21%
South-East Asia	0.27	59%	9%	5%	27%

In recent years, the World Bank[2] has committed infrastructure financing and technical assistance to support numerous initiatives.

- In Indonesia, a USD100 mil loan is supporting a USD1 bil national program to reform waste management practices for around 70 participating cities, impacting around 50 mil people. The loan supports the strengthening of local policies and institutions, closure and rehabilitation of old and informal dumpsites and installation of sustainable disposal sites including modern sanitary landfills with landfill gas collection mechanisms.
- In China, a USD80 mil loan has been provided to support the construction of a modern AD plant to ferment and recover energy from organic waste, which will benefit 3 mil people.
- In Vietnam, investments in solid waste management are helping the city of Can Tho prevent the clogging of drains, resulting in the reduction of flood risk.
- In Philippines, investments reduce flood risk by minimising solid waste ending up in waterways. In addition, investments in improved collection systems, particularly in Manila Bay, contributed to the reduction of marine litter.

Asia holds the potential to be the largest market for secondary materials, especially in more populated countries such as China and India where the secondary materials industry is growing rapidly(1). The growth of this industry is important because it acts as an alternative to the use of virgin materials as materials would be used again after recycling or recovery. High volume of MSW such as C&D waste, plastic and paper offer high potential for material recovery. In view of rising consumption and the state of poor waste management infrastructure, an improvement is required to building a circular economy framework.

Sources: (1) "Greenhouse Gas Emissions", United States Environmental Protection Agency;
(2) "Global Greenhouse Gas Emissions Data", United States Environmental Protection Agency;
(3) Asian Waste Management Outlook, 2018; and
(4) World Bank "Solid Waste Management", 2018

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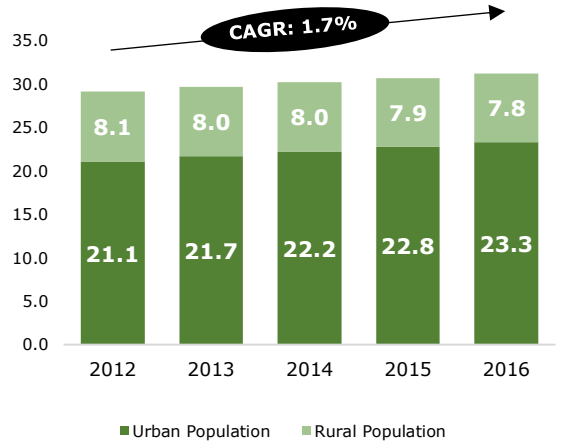
3.4 Malaysia Waste Management Market

Malaysia's MSW Landscape

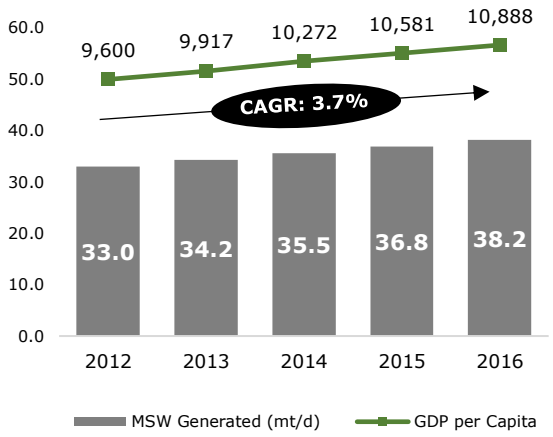
Malaysia is an upper middle-income nation with a population that has grown at ~1.7% per year to 31.2 mil, with urbanisation being a key trend over the years. Between 2012 and 2016, average income levels have risen rapidly as reflected in its growth rate of ~3.2% per year, correspondingly, waste generation in Malaysia has shown an upward trend due to better living standards and increased levels of consumerism.

Population in Malaysia (mil)



Source: World Bank

Daily Solid Waste Generation ('000 TPD) and GDP per capita (USD '000)



Source: SWCorp; World Bank

As Malaysia aims to transform into a developed economy by 2024, the nation's economic engine is expected to fuel greater waste generation, further reinforcing the importance of creating an effective waste management system(1). As a response to this trend, the Malaysian Government has reaffirmed its commitment to manage the volume of waste by establishing several key targets, namely, 40% waste diversion from landfills and a 22% recycling rate by 2020(2).

The state of Malaysia's waste management

Presently, Malaysia heavily relies on landfills as its primary method of disposing waste. Estimates in 2014 have shown that approximately 80-90% of Malaysia's MSW is dumped at 165 disposal sites where only eight of them are sanitary landfills(3). This means Malaysia's current waste management system is not only highly detrimental to the environment due to uncontrolled leachate and greenhouse gas emissions, but it is also resource intensive as more land is needed to accommodate Malaysia's growing waste output. Apart from landfilling, the only other waste treatment facilities are small capacity incinerators located in Langkawi, Tioman, Pangkor and Cameron Highlands(4).

To mitigate these issues, the Ministry of Housing and Local Government intends to phase out landfills to focus on more environmentally friendly solutions that include WTE, biodigesters, biomass and incineration(4). Additionally, Malaysia has made headways into improving the nationwide recycling rate by implementing a separation at source scheme in several states whereby households separate their waste into different categories prior to collection since 2016(5). In turn, this enhances the quality of recycled goods by reducing contamination of recyclable waste.

Sources: (1) "Malaysia may only become high-income nation by 2024", the Edge Markets, 2018;
(2) "Solid Waste Management Lab 2015". Pemandu, 2015;
(3) "Green Technology Foresight 2030: Waste", MiGHT, 2014;
(4) "Government to phase out landfills and adopt more eco-friendly waste disposal systems", The Star, 2018; and
(5) "Waste segregation enforcement starts today", Malaymail, 2016

Apart from governmental initiatives, there is a wave of private sector led investment, most notably in assets that focus on the recovery of resources and energy from waste. Several examples of private investment in Malaysia's waste management space are outlined in the following table.

Location	Operator of Plant	Description	Status
Port Dickson, Negeri Sembilan[(1)]	Kualiti Alam	▪ Malaysia's scheduled waste to energy facility that has a treatment capacity of 100 tonnes of waste per day and a generation capacity of 3.4MW[(1)].	▪ Currently in testing and commissioning phase ▪ Expected date of commission: End of 2018
Ladang Tanah Merah, Negeri Sembilan[(2)]	Cypark Resources Berhad	▪ Integrated waste management facility that will be able to produce 25MW of power from handling solid waste disposal and has the ability to increase in the future[(2)]. ▪ Apart from WTE facilities, other assets within the facility encompasses the following: • Waste Receiving Facility • Waste Segregation Facility with material recovery / recycling facility • Fully Anaerobic Bioreactor System Plant • Sanitary Landfill for commingled, inert solid waste and processed waste residuals • Environmental Treatment Systems including leachate treatment facility	▪ Currently in construction ▪ Expected date of commission: End of 2019
Jeram sanitary landfill, Kuala Selangor[(3)]	Worldwide Landfills	▪ The facility includes a WTE plant, a recycling plant, AD plant, composting plant, construction waste recycling site and a research and development centre. ▪ The plant is designed to process 1,500 tonnes of MSW per day and will have a generation capacity of 25MW[(3)].	▪ Currently in planning stage ▪ Expected date of commission: 2023

Sources: (1) Cenviro Corporate Website;
(2) Cypark Corporate Website "SMART WTE Plant"; and
(3) Solid plant to manage waste, The Star, 2017

Under the Solid Waste and Public Cleansing Management Act 2007, the Department of National Waste Management will work hand in hand with the Solid Waste and Public Cleansing Corporation ("SWCorp"). The Department of National Waste Management is responsible for the proposition of policy, plans and strategies. Meanwhile, the SWCorp is responsible for the implementation of the policy and plans set by the department. Since 1 June 2016, a '2+1 collection system' been implemented in certain states and Federal Territories in Malaysia, include Kuala Lumpur, Pahang, Johor, Melaka, Negeri Sembilan, Perlis, Kedah and Putrajaya. Solid Waste Management Environment stated that the collection for residual waste will be done twice a week while the collection for recyclable waste and bulky waste will be done once a week upon implementation.

Key Initiatives on Waste Management

According to Malaysia's Housing and Local Government Minister, Zuraida Kamaruddin, with a population of over 32 mil, Malaysia generates about 38,000 tonnes of waste on a daily basis. Out of the huge amount, the majority of the waste 76% goes to the landfill[(1)]. As landfills are not sustainable in the long run, frameworks for reduction of waste, recovery and treatment facilities have been established. The table below summarises the key initiatives established in the top 3 most populous states in Malaysia which are Selangor, Johor and Sabah.

Location	Key Initiatives	
	Focus	**Targets**
Selangor	Waste Treatment and Disposal	▪ More MRFs to be established in an attempt to reduce waste production. ▪ 80% of the total waste can be recycled, reused and resold before sending the remaining waste to the landfill sites[(2)]. ▪ Plans to invest about RM1.5 bil over the next several year to manage its solid waste in a systematic and sustainable way by undertaking the development of the country's biggest WTE project at the Jeram sanitary landfill[(3)].
Iskandar Malaysia, Johor (Main southern development corridor in Johor)	Waste Generation and Collection	▪ 100% environmentally sound waste collection extended to all areas including village, rural and squatter areas. ▪ Zero illegal dumping through licensing, strict enforcement and penalties. ▪ Provision of drop-off points for household hazardous waste and treatment of all household hazardous waste.
	Reduction of solid waste through 3Rs (reduce, reuse and recycle)	▪ Implementation of source separation scheme: household recyclables, commercial / industrial organics and landfill bans of recyclables and certain organics. ▪ Provision of approximately 300 drop-off points. ▪ Introduction of recycling incentive scheme. ▪ Achieving household recycling rate of 30% from source separation scheme.
	Waste Treatment and Disposal	▪ Treatment of all waste that can be treated by 2025, focusing on long term pollution prevention, with recovery of by-products and energy. ▪ All non-hazardous by products from waste treatment to be utilised and recycled. ▪ Commercial / Industrial organic waste collection and treatment in place by 2020. ▪ Not more than 10% of original waste (residues and inerts) to be landfilled by 2025. ▪ Eliminate pollution from landfills: Existing landfills upgraded and closed; new landfills to be for residual waste and inerts only.
	Strategic facility planning and facility cost recovery	▪ Implementation of site and technology specific considerations for all future waste facilities. ▪ Implementation of direct billing system for cost recovery for waste services and facilities.
Sabah[(4)]	Raise Awareness	▪ Promote hygiene and raise awareness on cleanliness through promotion or announcement, emphasising the concept of LiFE, conducting seminar, no plastic bag campaign, etc.
	Waste Minimisation	▪ Conducting recycling activities, food waste separation, composting as well as reducing waste generation.
	Waste Management Partnerships	▪ Entered into partnerships with waste management companies or programmes, e.g. Micro Enterprise, Program Kasih Sayang Pulau Gaya, Program LA 21 to tackle the waste management issues and challenges faced by Sabah.

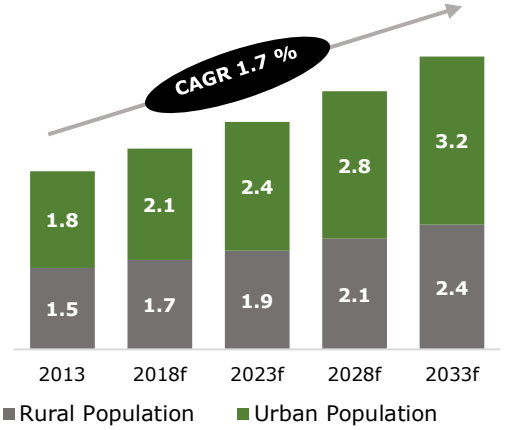
Sources: (1) "Green ways to manage waste", The Star, 2018;
(2) "Selangor Ranked 1st in Solid Waste Production", Selangor Journal, 2018;
(3) "Selangor to invest RM1.5bil in waste disposal programme (Update)", The Star, 2018; and
(4) "Managing Waste Effectively: DBKK Experience", DBKK

Sabah's MSW Landscape

Sabah with a current population of 3.8 mil is the third most populous state in Malaysia. The Ministry of Local Government and Housing of Sabah projects Sabah's population to grow at an average annual growth rate of ~1.7% to reach a population of 5.6 mil by 2033, surpassing Johor to become the second most populous state in Malaysia. Urbanisation is also a visible trend in Sabah's population, as Sabah's population gravitates to urban regions such as Kota Kinabalu and Penampang, more MSW will be diverted to landfills including the KMSL.

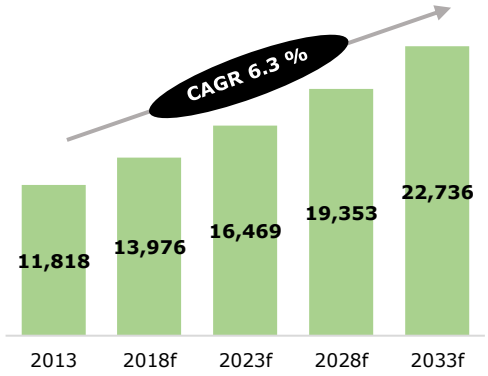
Complementing Sabah's population outlook is the strengthening income levels in the state. Sabah is expected to become a much wealthier state by 2033, as the MLGH forecasts income levels to grow at an average annual rate of ~6.3%. Higher income levels amongst the populace of Sabah would induce greater amount of consumption of goods, both of the discretionary and non-discretionary nature. Therefore, greater spending levels invariably drives waste generation across the state, most notably in urban areas around Sabah adding further pressure on existing landfills in the near future.

Population of Sabah (mil)



Source: Ministry of Local Government and Housing of Sabah, 2014

Sabah GDP per capita (RM)



Source: Ministry of Local Government and Housing of Sabah, 2014

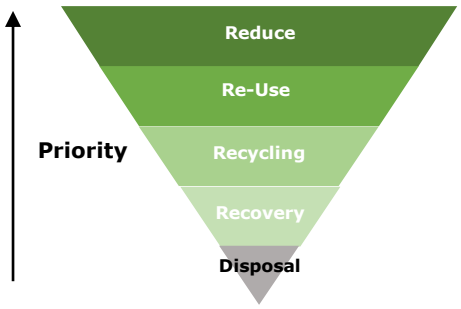
Based on publicly available data, the demand for waste management facilities will continue to grow into the future due to the combination of greater MSW generation and the lack of waste management facilities. At present, landfilling still remains the dominant method of waste disposal in Sabah as integrated waste management in the state is still in its infancy(1). Nonetheless, private players are beginning to venture into the Sabah waste management space, with one example being a WTE plant planned for construction in Semporna, a tourist town on the East Coast of Sabah(2).

Sources: (1) "800 tonnes of trash goes to landfill daily", The Borneo Post, 2017; and
(2) "Project to convert waste into energy in Semporna", The Borneo Post, 2018

3.5 International Waste Management Market

Introducing 4R

The waste management hierarchy is a practical guide for public authorities or private companies when they decide on introducing new waste management policies or activities. This hierarchy incorporates the 4R principles of waste management which are Reduce, Re-Use, Recycle and Recovery in ranking activities based on their environmental benefits. As illustrated below, activities that reduce waste generation such as bans on the usage of single-use plastics or Pay-As-You-Throw schemes should receive the greatest priority in contrast with the status quo of waste management – landfilling.



Reduce: Activities that aim to prevent the generation of waste.

Re-Use: Repeated use of products in the way it was conceived for.

Recycling: Extraction and reprocessing of resources from waste.

Recovery: Recovery of energy from waste in the form of heat or electricity.

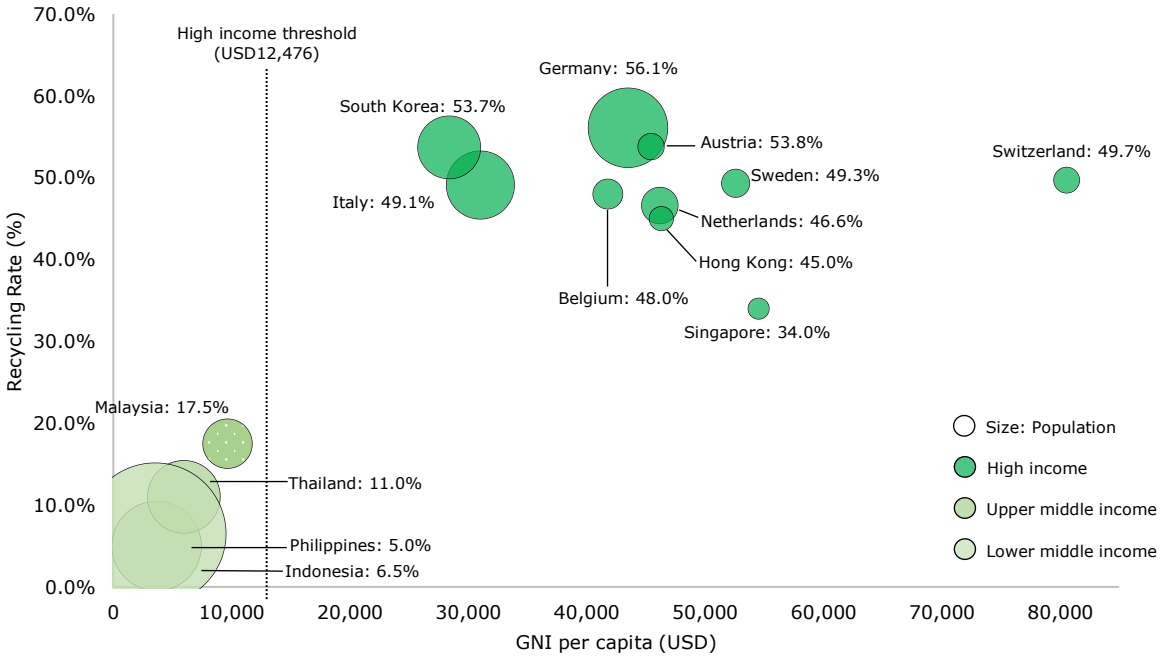
Disposal: Disposal of waste at landfills.

Source: European Commission

Most countries that have demonstrated leading waste management practices, for example, Germany, Sweden and Japan, have used the waste management hierarchy as a guide for crafting policy instruments or promoting investment in waste management facilities.

As part of BWI's goal to adopt best in class technologies in its IWMPP and introduce the technologies into the Malaysian market, it is beneficial to understand the practices and facilities that are widely adopted in countries that are at the forefront of waste management. One indicator to compare the effectiveness of a country's waste management system is its recycling rate which measures the total amount of waste recycled as a proportion of total waste generated.

Recycling Rate (%) and GNI per capita (USD)



Sources: World Bank, 2017; Eunomia, 2017; Waste Atlas; Waste management world; Avfall Sverige, 2018

A comparison between national income levels and recycling rates suggests that high income nations recycle more than their lower income counterparts. These superior recycling levels are attributable to the emphasis placed on 4R principles resulting in the cultivation of recycling among residents and the prevalence of waste management facilities to manage various waste streams, with the latter being the focus of the following sections.

This section further examines a selection of nations, in particular Sweden, Germany, South Korea, Japan and Singapore. These countries were selected for various reasons, most notably, the availability of publicly available data regarding their waste management activities, high recycling rates and reputation as role models in waste management.

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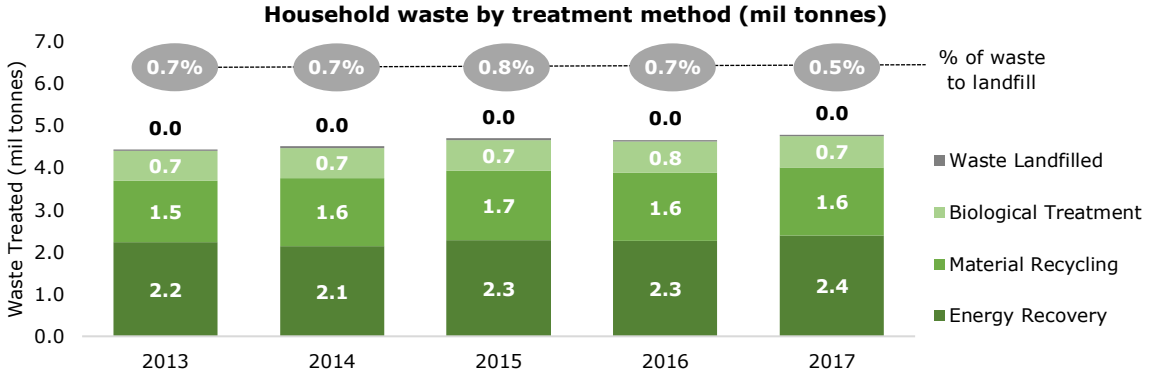
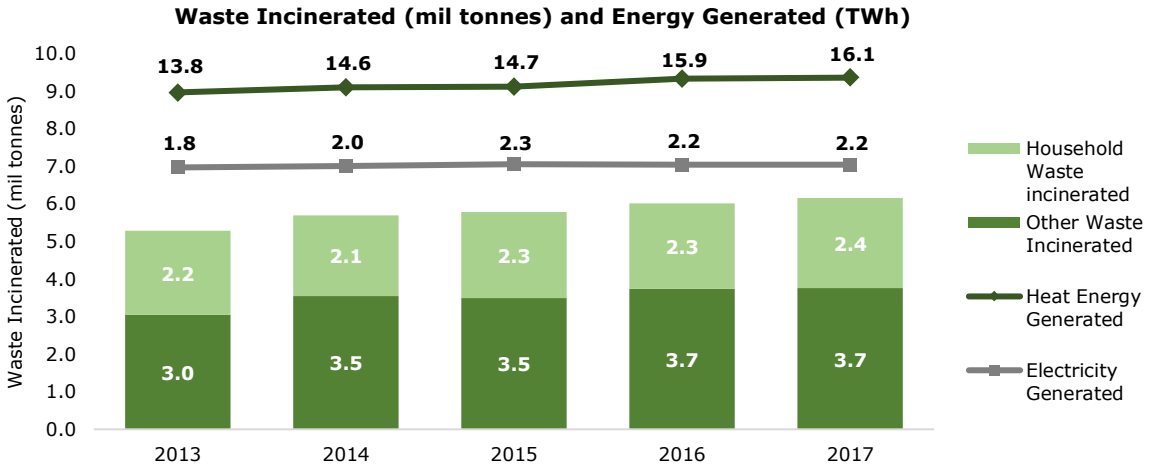
I. Sweden

Minimizing landfilling has been a top priority in Sweden's waste management agenda. From 2013 to 2017, the nation has successfully maintained landfilling at below one percent. This achievement is the result of the availability of various waste management facilities that process multiple types of waste streams into valuable resources.



Source: Avfall Sverige, 2018

In 2017, most of Sweden's household waste – 50.2%– was incinerated in the nation's 35 WTE plants to produce 18.3 Terawatt hour ("TWh") of energy, satisfying the heating needs of 1.25 mil households and electricity for another 680,000 households(1). Aside from meeting the nation's energy needs, Sweden also dedicates spare incinerator capacity to imported waste from other European countries, in turn creating a secondary market with its WTE assets and ensuring the plants are fully utilised(2).



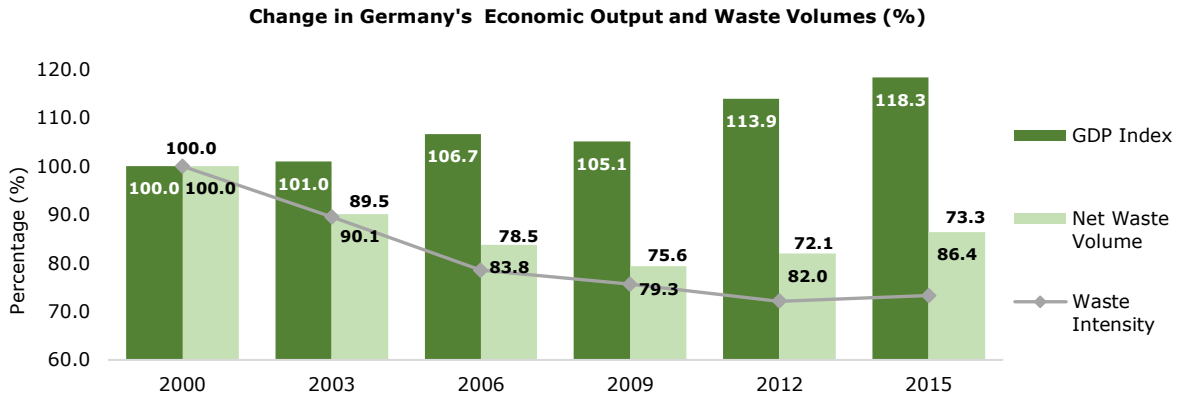
Source: Avfall Sverige, 2018

Material recycling is the second largest activity in Sweden, waste materials that are eventually recycled include packaging, recyclable paper, plastics, metal, among others. According to FTI, Sweden's national waste collection system, most recyclable waste are recycled by the producers of materials themselves under Sweden's Producer Responsibility system. As such, household waste generators are primarily responsible for separating their waste and delivering them to recycling stations located in public areas. The waste is then collected by the producers for recycling.

Lastly, Sweden treats its organic waste with two methods, composting and AD, with the latter being the more common method(1). Sweden's AD activities provide a sustainable source of plant nutrients by converting food waste into digestate that are used as fertiliser. Another product from this activity is biogas which is a renewable source of fuel for vehicles.

Sources: (1) "Swedish Waste Management 2018, Avfall Sverige, 2018
(2) "The Swedish Recycling Revolution", Sweden Sverige, 2018

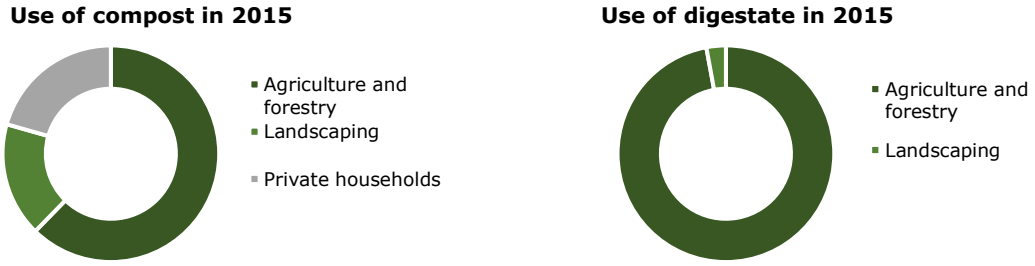
II. Germany



Source: Federal Statistical Office 2017

Over the years Germany has managed to substantially decouple MSW generation and economic growth as measured by the nation's waste intensity which decreased until 2012 and has only increased slightly in 2015. Waste intensity is calculated as the percentage of waste volume over GDP at a point in time, it tracks the extent of wasteful economic growth. Germany's progress in waste management is attributable to the availability and establishment of facilities that focus on recycling and recovery.

As of 2018, Germany has more than 15,500 waste management facilities that range from MBT plants, composting facilities, anaerobic digesters, among others(2). In 2017 alone, the nation has treated 5 mil tonnes of MSW with its 45 MBT plants, resulting in a 90 percent diversion of MSW from landfills(2). Among all the facilities, Germany has 868 composting facilities and 1,392 AD plants that processes approximately 13.9 mil tonnes of bio-degradable waste in Germany into compost, digestate and biogas that are used for various purposes(2).



Source: Federal Statistical Office 2017

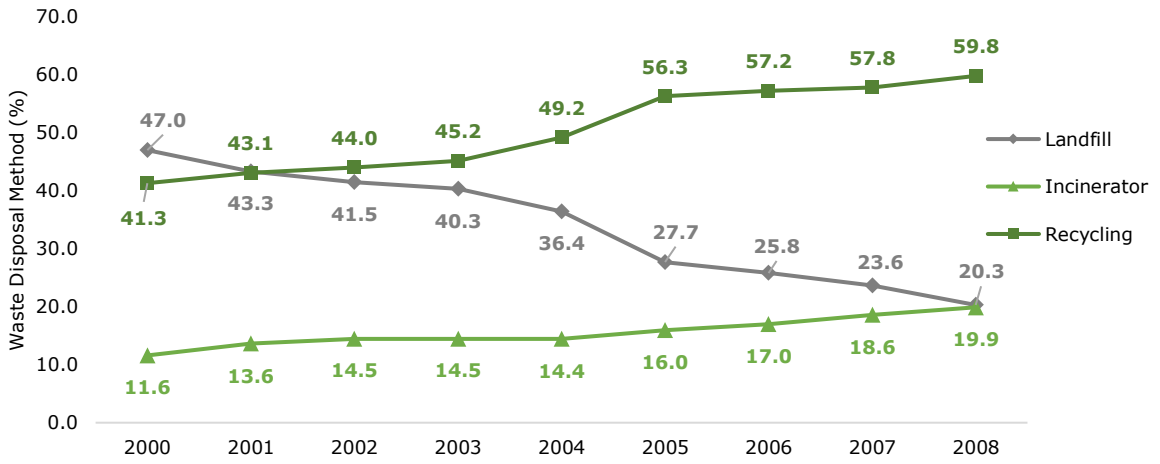
Sources: (1) "Swedish Waste Management 2018, Avfall Sverige, 2018
(2) "Waste Management in Germany 2018, Federal Ministry for the Environment, Nature Conservation

WTE is another major avenue for Germany to recover resources from its waste. A majority of WTE plants in the country incinerates waste to generate energy in the form of heat, steam or electricity. For instance a WTE plant in the district of Göppingen can generate 88,000 Megawatt hour per year, enough to meet the electricity needs of 25,000 households(1). According to the Confederation of European WTE Plants in 2016, Germany has the second most number of WTE plants in Europe behind France but treats the most waste in the region.

III. South Korea

Similar to the approach taken by Germany to combat MSW growth, Korea's strategy also focuses on increasing the establishment of assets that enable alternative waste treatment. Based on the figure below, Korea has reduced its reliance on landfilling over the years whereas recycling and recovery activities progressively become the preferred methods of managing waste.

Allocation of Waste Disposal Methods (%)



Source: "Korean household waste and recycling behavior", 2011

Volume based Waste Disposal Mechanisms

RFID Food Waste Bins

Payment Stickers

Standard Issue Bags

Source: Ministry of Environment, 2017

Technology is at the heart of Korea's waste management system. As part of its waste prevention initiative, a volume-based waste disposal system, Korean government introduced Radio-Frequency Identification ("RFID") enabled food waste bins to complement its existing suite of mechanisms(2). These bins save residents from the hassle of needing to purchase payment stickers or bags from approved vendors. First, each household is given a magnetic card that contains their information in order to activate the RFID bins. The RFID bins would read their cards and measure the amount of food waste disposed. Then, households will be charged a monthly fee based on the data collected from the RFID bins.

WTE also forms a major component in Korea's push for improved waste management and the achievement of greater environmental sustainability. For example, WTE plants are crucial infrastructure assets in the nation's Eco Energy Town projects – the South Korean Ministry of Environment's initiative to construct cities that rely on renewable energy sources. One of the pioneering Eco Energy towns, Cheong-ju, has anaerobic digesters that produce 8,300m^3 of biogas from food waste and sludge, the biogas produced would then be used to generate heat or gas for the local residents.

Sources: (1) "Taking the lead at the Goppingen site", EEW, 2018
(2) "South Korea cuts food waste with 'pay as you trash'", The Strait Times, 2016

IV. Japan

According to Ministry of the Environment Government of Japan, the size, geography and high population density of Japan lend it unfit to sustain the 43.2 mil tonnes of total waste emission each day in 2016 by its mass consumption society. In an effort to overcome this issue, the Japanese federal government has enacted laws and cooperated with local governments, private businesses and residents to promote proper waste management, the effective use of resources, as well as the steady development of a sound material-cycle society where waste prevention and recycling take precedent over landfilling.

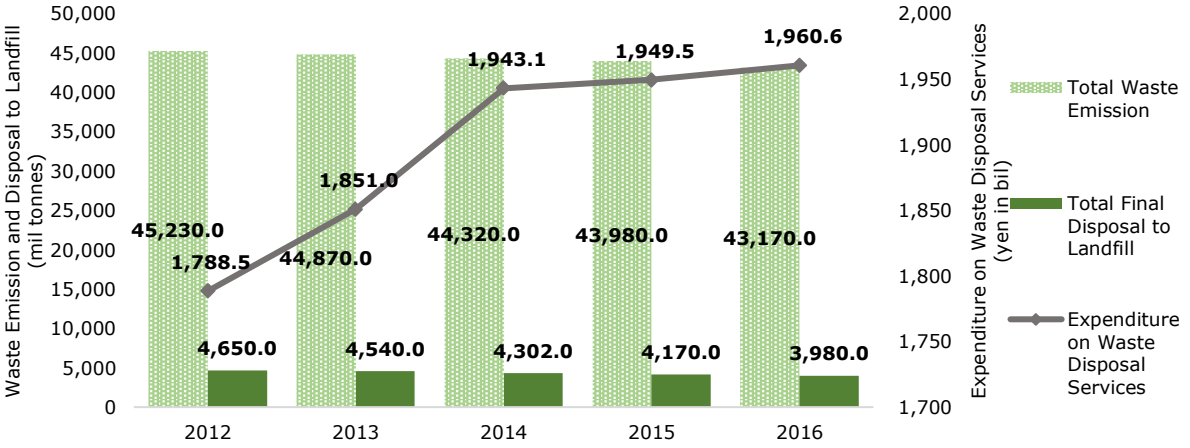
Thermal treatment is Japan's primary method of waste treatment. Japan's Ministry of Environment reported that the nation has 1,161 incineration plants across its 47 prefectures, with capacities that vary according to the population in the area of coverage. Most incineration plants in the country are self-sustaining whereby the electricity generated is used to meet the plants electricity needs; any surplus electricity generated would then be sold to the domestic electrical grid.

Nake Waste Treatment Plant

Maishima Incineration Plant

Source: Reaching Japan

Waste Disposed to Landfill against Expenditure on Waste Disposal Services



Source: Ministry of Environment

According to the Ministry of Environment, the total waste emission in Japan, which includes household waste and business-related waste, has reduced from 2012 to 2016 despite an increase in the population as a result of waste prevention activities. Overall, the percentage of waste disposed to landfill exhibits a downward trend, decreasing from 10.3% in 2012 to 9.2% in 2016 which are equivalent to 4,650 mil tonnes of waste and 3,980 mil tonnes of waste, respectively. This can be explained by the increase in spending on waste disposal services, which includes the cost of construction and improvement services on waste treatment facilities, disposal and operating expenditure.

Other than direct incineration, the second largest waste management treatment in Japan is recycling. Under the 3R policy, Japan has been collecting PET bottles, food trays and cans separately for reuse resources in the manufacturing of new products. The collected bottles are cleaned, compressed and delivered to reproduction contractors. Moreover, the nation has deployed various techniques to manage organic waste. They include composting, methane fermentation, refuse derived fuel as well as the use of semi-aerobic landfill technology to enable early use of land after the completion of its role as landfill.

Source: (1) "Solid Waste Management and Recycling Technology of Japan – Towards a Sustainable Society", Ministry of the Environment, 2012

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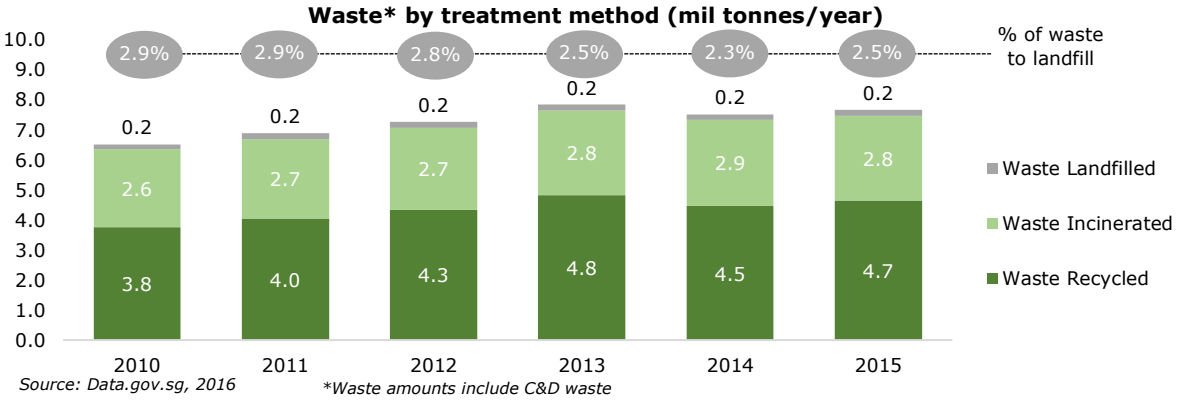
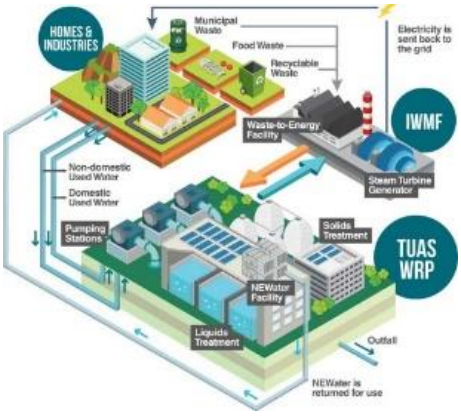
V. Singapore

Unlike its neighbor Malaysia, landfilling is not the nation's primary method of disposal due to the minimal land space available. Instead, most waste are treated with incinerators to minimise the need for landfilling as well as generate electricity. Four incinerators are currently operating around the country with a total capacity to treat 7,900 TPD and also satisfy approximately 2% of Singapore electricity needs. The combination of the nation's recycling efforts and incineration activities enable Singapore to dispose below 3% of the country's waste into landfills.



Source: Data.gov.sg, 2016

**Waste amounts include C&D waste*



Source: National Environmental 2018

Integrated Waste Management Facility at Tuas View Basin Site

In its efforts to expand the nation's waste management capabilities, the National Environmental Agency is developing an Integrated Waste Management Facility beside the Tuas Water Reclamation Plant. The IWMF's location allows it to reap the synergies between water and waste treatment. For instance, the IWMF will have digesters that would produce biogas from the food waste it receives from waste collectors and sludge from Tuas Water Reclamation Plant. In turn, the biogas produced would be used to improve the IWMF's thermal efficiency and power production. Moreover, the facility is designed to be multi-functional as it contains a MRF, food waste treatment facility, dry sludge incinerator, WTE facility, solids and liquids facility. Thus, enabling multiple types of waste to be processed at a single location and economies of scale.

3.6 Common Waste Management Technologies

An effective waste management system should consist of technologies that treat and process waste in an environmentally friendly and resourceful manner. Whether it is recovering materials or reducing greenhouse gas emissions, these technologies are crucial in ensuring that countries can experience continued economic growth with minimal implications to the environment.

These common technologies as summarised in the following tables, vary in functionality, position in the waste management hierarchy and adoption.

Recycling Activities

Recycling activities will be adopted by BWI Countries that have adopted the technologies

Technology	Description	Adopters
MRF 	▪ Facilities that separate and sort waste manually or through an automated system into different types of waste for recycling. ▪ These facilities are further categorised into "clean" or "dirty" MRFs, clean MRFs sort dry waste that has been separated at source whereas the dirty counterparts accept and sort mixed waste – a mixture of dry and organic waste. ▪ The recyclables extracted in the process include plastics, paper, metals, cardboard, etc.	
MBT 	▪ MBT facilities are integrated systems that typically combine MRFs and biological processes such as composting or AD to separate waste into its organic and inorganic components and treat them accordingly. ▪ The biological process can minimise the organic waste's methane generation capacity by reducing its biodegradability (aerobic) or convert it into biogas (anaerobic). ▪ Outputs from MBTs vary according to the processes adopted, but common ones include recyclables, compost and biogas.	
Composting 	▪ Composting is a widely adopted aerobic process that naturally breaks down biodegradable organic waste into a base material that is commonly used in organic fertiliser. ▪ This process is applicable to most types of organic waste. ▪ Compost is principally used to enhance the quality of soil due to its erosion resistance and water retention properties. It is also used as feedstock for bio-fertilisers.	
AD 	▪ In the AD process, microorganisms break down organic substances in the absence of oxygen to produce methane gas and digestate. ▪ AD is often used to treat wet organic waste such as sewage sludge or food waste. ▪ Methane gas also known as biogas can be used as vehicle fuel or to generate electricity in WTE plants, whereas digestate is common base components of plant fertiliser.	

Source: International Solid Waste Association

Recovery Activities

Technology	Description	Adopters
Incineration 	▪ Waste will undergo controlled burning to be reduced to a fraction of its weight and volume, minimising the space it occupies in landfills. ▪ Incinerators recover electricity from waste by using the steam produced to drive power generating turbines; heat energy is recovered via the production of hot water.	
Gasification 	▪ Gasification is a process that thermally converts waste into syngas, a gas used to synthesise other chemicals, in a low oxygen environment. This form of incomplete combustion reduces the production of major pollutants such as dioxins. ▪ Syngas is a feedstock for various products and activities, for example, synthetic petroleum or as a fuel to generate electricity and heat.	
Pyrolysis 	▪ Pyrolysis involves the thermal degradation of waste in the absence of oxygen, enabling waste to be broken down without combustion. ▪ This method of treatment is suitable for waste that contain high calorific values, for instance, wood and plastic waste. ▪ Byproducts from this process include bio-oils, which can act as a substitute fuel for vehicles after further upgrading, and bio-char, charred biomass that serves as an effective soil conditioner.	
Landfill Gas Utilisation 	▪ Landfill gas, methane, is often produced at closed landfills as byproduct the natural anaerobic decomposition of organic waste. ▪ The methane is then extracted, processed and treated at landfill gas treatment facilities in the vicinity of the landfill to create usable natural gas. ▪ Common usages of landfill gas include electricity generation or fueling vehicles.	

Source: International Solid Waste Association

4

Way Forward

4.1 Future Expansion

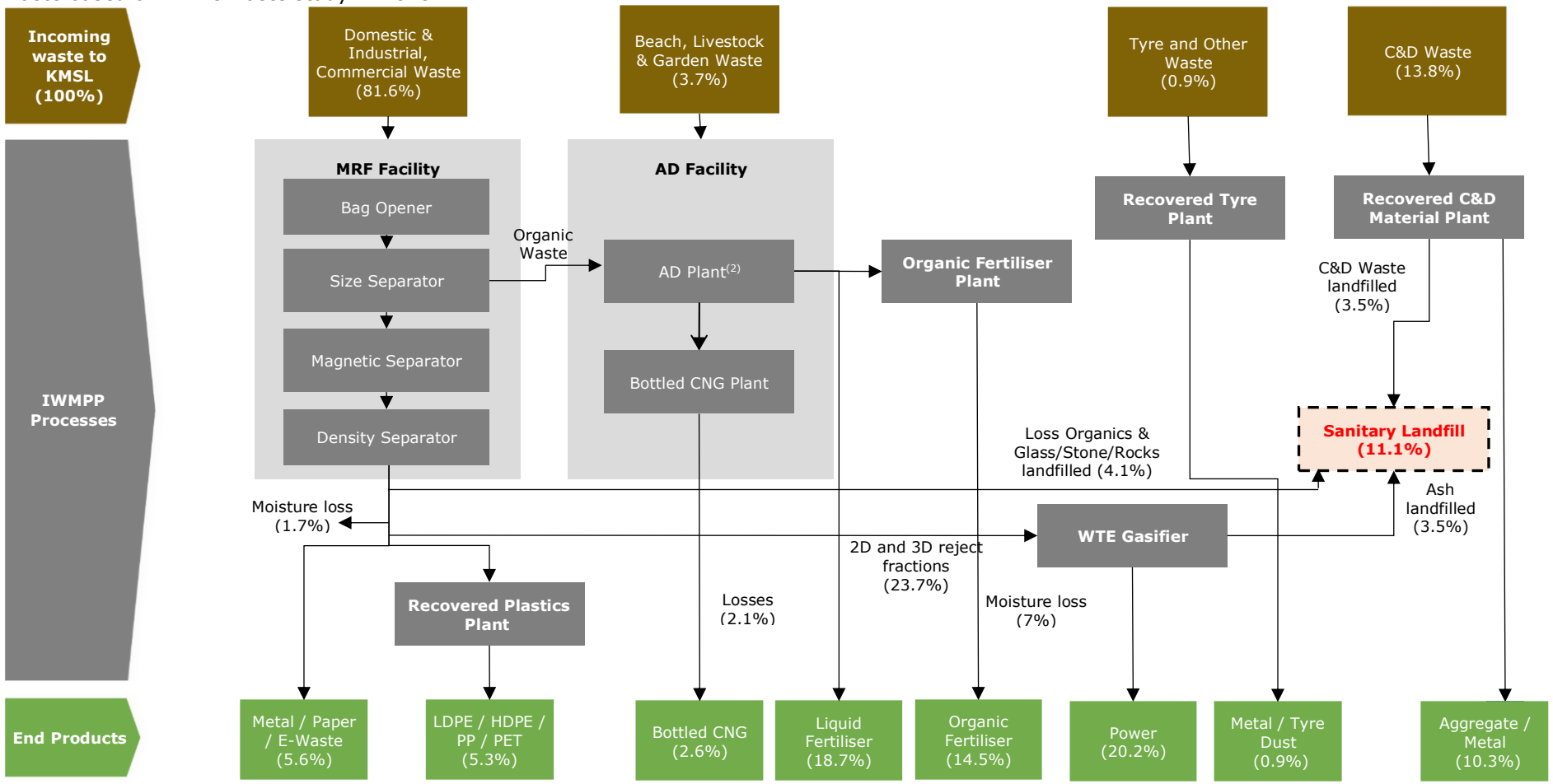
IWMPP project serve as a starting point for BWI's plans to expand their service coverage to several other districts within Sabah such as Tawau in the future. BWI also plans to apply its business model to landfills in Peninsular Malaysia and venture into other downstream activities when the opportunity arises such as WTE, producing organic fertiliser and recycling used tyres as well as C&D waste.

Several of the potential expansion plans are as follows:

The WTE Business	▪ The increasing generation of domestic and industrial waste has urged government bodies to encourage the recovery of energy from waste by offering Feed in Tariffs. ▪ Therefore, BWI plans to take advantage of the renewable energy Feed in Tariffs by exporting electricity via a gasification plant.
Power Generation from Biogas	▪ BWI intends to undertake alternative avenues to monetize biogas, an example would be electricity generation. ▪ The biogas generated at the AD plant shall be diverted into a biogas power plant to produce and export electricity.
Used Tyres Recycling	▪ Incoming and existing used tyres at the KMSL shall be recycled for their recyclable components. ▪ Any recyclable components within the tyres, such as steel wires or rubber crumbs, will be sold to recyclers or reprocessed into other intermediary products that include asphalt.
Organic Fertiliser Production	▪ BWI intends to process solid digestate into organic fertiliser that is rich in essential plant nutrients, , with a nitrogen, phosphorus and potassium concentration that is greater than 9%.
Liquid Fertiliser Production	▪ Liquid digestate - a byproduct of anaerobic digestion – can be processed and converted into liquid fertiliser, a product that can be marketed to customers in the agricultural sector.
C&D Waste Recycling	▪ To further reduce the usage of space at the landfill, C&D waste will be crushed and any recyclable materials inside C&D waste extracted for sale or further processing before the waste is landfilled. ▪ In addition, C&D waste shall be further processed into construction materials such as road pavers and bricks.
Solar Farm Development and Participating in LSS	▪ BWI intends to develop a solar farm at the KMSL to gain a foothold in commercial solar energy generation. ▪ Moreover, BWI plans to participate in future LSS programmes when the opportunity arises.
Landfill Mining	▪ BWI plans to extract MSW rejects from existing closed landfill cells at the KMSL to be recycled as feedstock for the gasification plant or to manufacture RDF pellets.

4.2 Waste Flow Overview

The diagram below illustrates the end to end process of the IWMPP and includes future expansion plans comprising WTE gasification, liquid fertiliser production, used tyres and C&D waste recycling as well as power generation. The 587 TPD of waste sent to the KMSL represents the average volume of waste based on BWI's waste study in 2018.



Notes: (1) All % is a relative to Waste sent to KMSL; (2) Facilities can be expanded to accommodate the growth in available waste.

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Borneo Waste Industries Sdn. Bhd.
INTEGRATED WASTE MANAGEMENT

BWI refers to Borneo Waste Industries Sdn. Bhd., a Sabah-based waste management service provider. BWI aims to divert up to 90% of waste from disposal at the Kayu Madang Sanitary Landfill by recycling the waste and subsequently processing these waste into useful intermediary products that can be used in various industries. These wastes are then sorted and processed into intermediary materials using environmental-friendly biological methods.

About the Project
BWI can process up to 800 tonnes of waste per day from Kota Kinabalu, Kota Belud, Penampang, Putatan and Tuaran. Different types of waste are processed into different intermediary materials. By using environmentally sustainable processes, municipal solid waste which is the main type of waste BWI receives, is recycled and further processed into plastics pellets and any 2D or 3D reject fractions of municipal solid waste will be converted into refuse derived fuel pellets. Recyclable waste that do not require further processing are sold to other downstream recyclers or manufacturers. Bottled compressed natural gas and organic fertilizer are other downstream products.