NON THERMAL WASTE TO ENERGY OPPORTUNITY - INDONESIA

Anaerobic Digester (AD) Technology

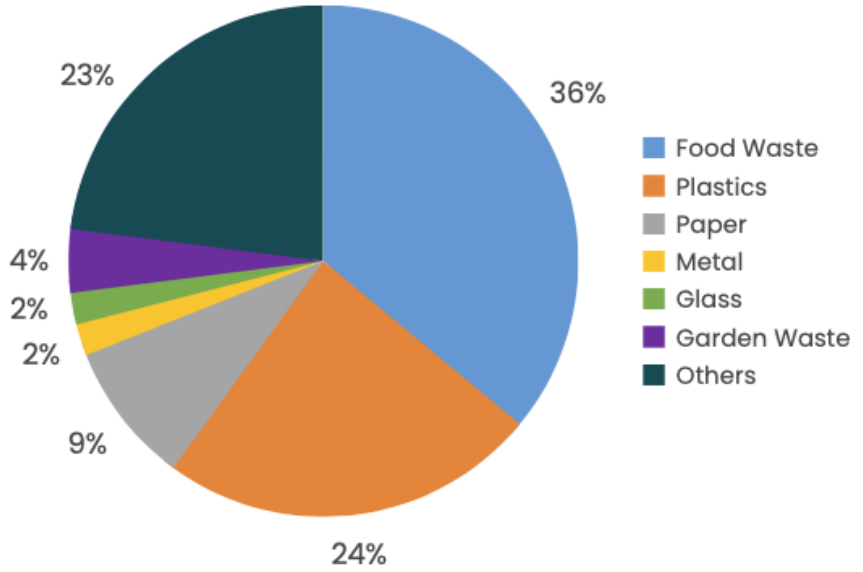
Municipal Solid Waste
To
Commercial Natural Gas

Anaerobic Digester Facility

SOLUTION

Municipal Solid Waste (MSW)

A Typical Solid Waste Composition, Good Amount Of Percentage For AD Feedstock



1. High MSW Generation
2. Low Recycling Rate
3. Reliance on Landfill
4. High Fraction of Organics Waste

Methane Capturing Technology Applied To Landfill

Stages of waste management from open non sanitary landfill , methane gas extraction and our solution a full fledge non thermal waste to energy solution

Gas to Electricity

Methane gas

Atmosphere

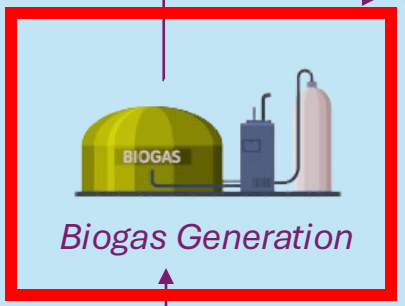
Methane Gas

Open dumping

Landfill gas collection

MSW Separator

Organic Waste



Biogas Generation

Downstream Processes

- Renewable Natural Gas (RNG)
- Green Methanol
- Green Ammonia
- Green Hydrogen
- Green Formaldehydes
- Others green chemicals

- Plastics & others recoverable items
- <20% → Landfill

Present → **Future**

Anaerobic Digester – Methane Upgrading

Proposed Gas Production Via Methane Capture As A Solution

MSW

Plastics *Metals* *Others Recyclable materials*

Organic Waste

Biogas

Renewable Natural Gas (RNG)

Objectives

- *To offer better solutions, which are capable of :*
  - *Increase recycling rate (up to 80%)*
  - *Become a cleaner option (no methane and particulate matter emissions)*
  - *Provide intermediate product (RNG), for a greener downstream applications.*
- *Maintaining similar to minimal extra fee than existing fee structure;*
- *Minimizing MSW volume to be landfilled. Hence to prolong landfill lifetime.*
- *Contributing to a technological advancement for downstream products, thus enhancing waste lifecycle.*

Potential Off-takers

PERTAMINA GAS NEGARA

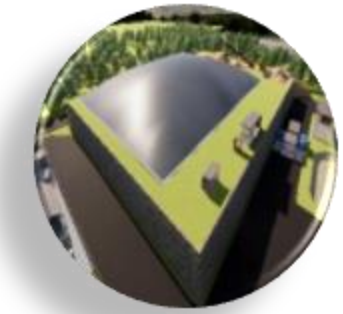
PERTAMINA PERTAGAS NIAGA

Integrated Solid Waste Management Center (ISWMC) Facility

A Complete Bolt On ISWMC Model To Existing Landfill Or Act As A Transfer Station

Depot

Material Recovery Facility



Anaerobic Digester

Gas Upgrading Facility

Weighbridge

Gas Entry Station

Buy Back Centre

Sludge Dewatering Plant

Leachate Treatment Plant

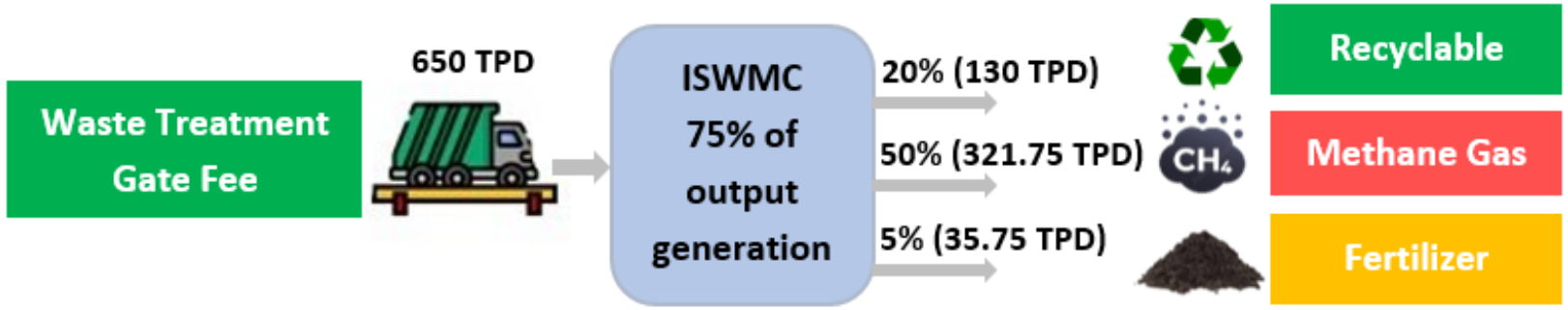
Surau

Operation Office

Guardhouse

Integrated Solid Waste Management

Case of having a sorting facility and AD thus having the ability to reduce waste by 75%



PRODUCT	QUANTITY	DESCRIPTION
Biomethane	200,000 MMBtu/year	Biomethane generated yearly after purification process from the raw biogas. After purification, the gas upgrading facility will increase the pressure to a certain level which suitable for gas pipe injection.
Recyclables	130 tpd *	Estimated 20% of recyclables will be recovered at the MRF
Sludge	35.75 tpd *	Estimated 5% of bio sludge will be produce by the anaerobic digester

***Amount is based on 650 tpd input**

Anaerobic Digester – Has High Tolerance To Co-Mingle Feed Stocks

Robustness of Anaerobic Digester and Output Efficiency Comparison

Category	Description
1. Garden Waste	Grass clippings, leaves, twigs, branches, pruning waste from parks or homes
2. Agricultural Residue	Rice husks, corn stalks, coconut husks, palm fronds (especially in rural/urban fringe)
3. Fruit & Vegetable Scraps	Peels, cores, spoiled produce (from wet markets and distribution centers)
4. Animal Manure	Cow, goat, chicken waste from domestic or small farms
5. Paper & Cardboard (Soiled)	Napkins, paper towels, food-contaminated cardboard (not recyclable)
6. Seafood & Fish Waste	Scales, heads, shells from markets and fish processing
7. Meat & Bone Waste	Leftover or spoiled meat, bones, fat trimmings
8. Coffee Grounds & Tea Leaves	Common from cafes, households, and hotels
9. Oil & Fat Residue	Cooking oil sludge, grease (in small quantities)
10. Wood Dust & Sawdust	Biodegradable if untreated (from carpentry shops, especially in Java)
11. Coconut Shell & Husk	Very common in Indonesia, can be used in biomass or compost
12. Food Waste	Left over and stale foods

Anaerobic Digester – Energy Output Comparison

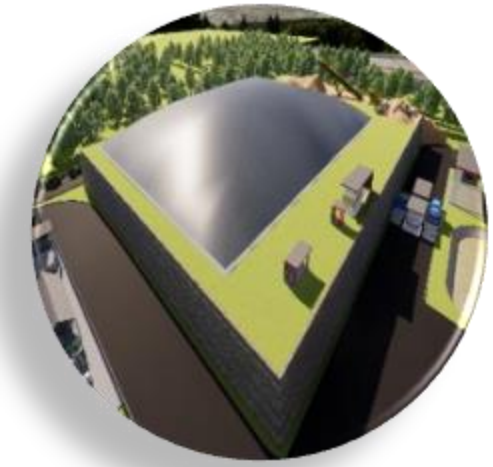
Gas Production Through Anaerobic Digester With Different Feedstock Options

Item / Metric	Unit	Typical Value (2024 Estimate)
Diesel Fuel Price (Industrial Use)	USD/litre	1.00
Diesel Energy Content	MMBTU/litre	0.135
Diesel USD/MMBTU Cost	USD/ MMBTU	7.037
Methane Gas (Green Biogas) Selling Price (depending One Buyer or Seller side vs local and international market)	USD/MMBTU	4-11
Carbon Credit Value from Methane Capture	USD/ton CO_2e avoided	20
Methane Energy Content Per Ton	MMBTU / Ton	50
Carbon Credit Price Per MMBTU (lowest)	USD / MMBTU	USD 0.40
Methane Yield from Cow Manure	Nm^3 CH_4/ton	20–30
Methane Yield from Palm Oil Mill Effluent (POME)	Nm^3 CH_4/ton	20–50
Methane Yield from Organic Municipal Waste	Nm^3 CH_4/ton	50–100
Methane Yield from Food Waste	Nm^3 CH_4/ton	100–150

1 MMBTU avoid 0.9 tons C02 Emission

Anaerobic Digester - Components

Anaerobic Digester Specific Process

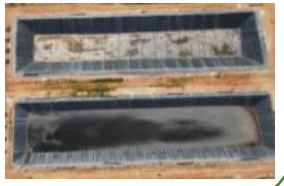


OTHER ORGANIC WASTE FROM INDUSTRIES

MRF STATION

ORGANIC WASTE → GRINDER/ MACERATOR

EQUALIZATION POND



ANAEROBIC DIGESTER

Methane: 52%-55%
CO2: 42%-45%

BIO-SCRUBBER

METHANE UPGRADING

Methane: 93%-95%
CO2: max 4%

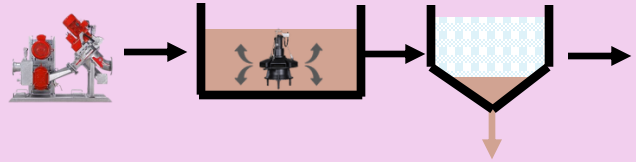
GAS PIPELINE

SLUDGE DEWATERING

DIGESTATE

Anaerobic Digester – Lagoon vs Tank Option

Lagoon Option Is Preferred Due To Longevity and Durability



Material Preparation Unit

(MPU)

Organic Fraction	400mt/d	800mt/d	1000mt/d
Est. Biogas Generation	*2,500m3/hr*	*3,333m3/hr*	*4,166m3/hr*
Gross Heating Value	*41MMBtu/hr*	*55MMBtu/hr*	*70MMBtu/hr*
Diesel Equivalent	*1,230 liter/hr*	*1,650 liter/hr*	*2,100 liter/hr*

Continuous Stirred Tank Reactor (CSTR)

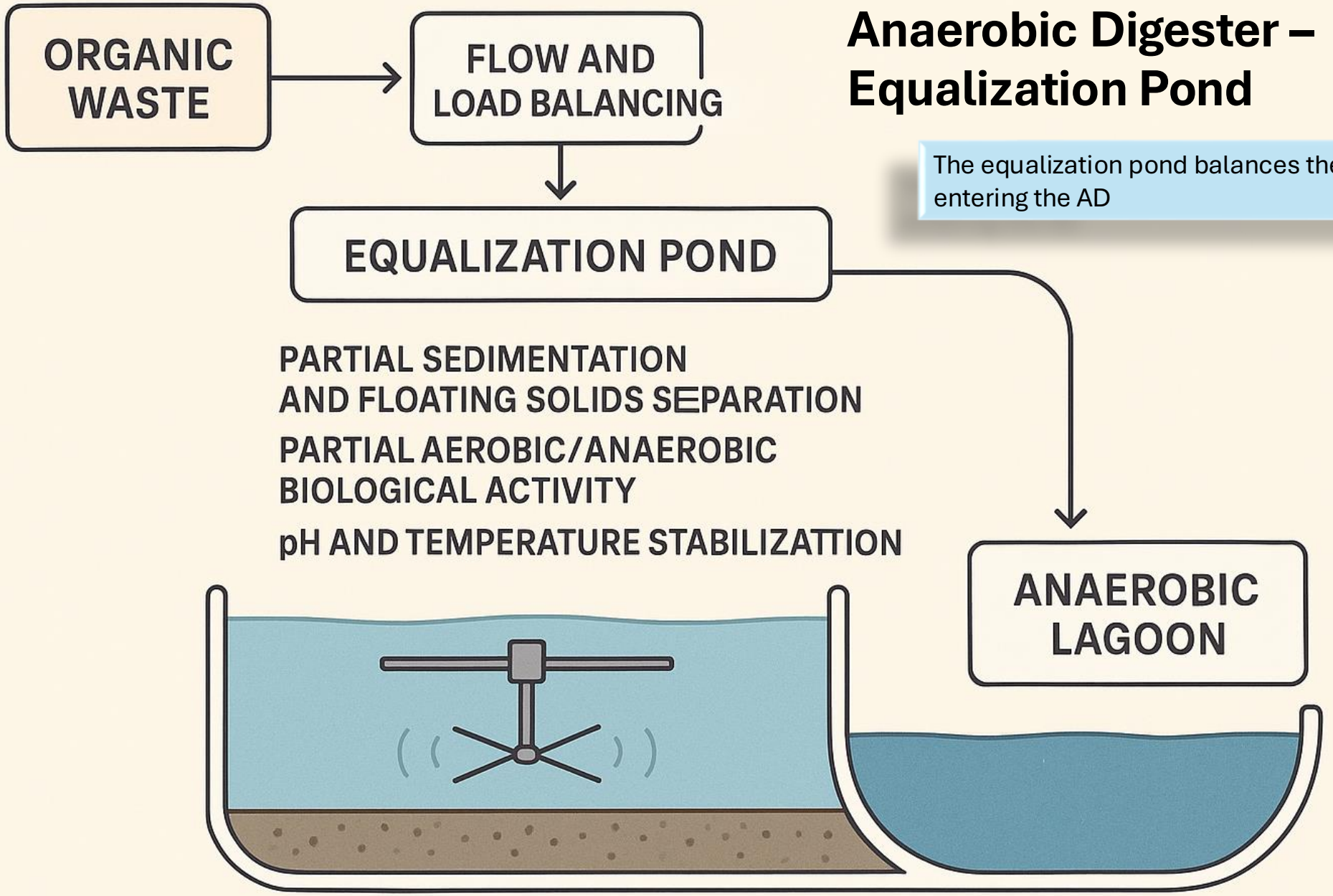
- *For space constraint area*
- *Soil not suitable for lagoon type*
- *High density population area*
- *Limited water access*

Covered Lagoon Anaerobic Digester (CLAD)

- *Mineral soil or sturdy area*
- *Ample area footprint (150m X 50m)*
- *Cheaper option*

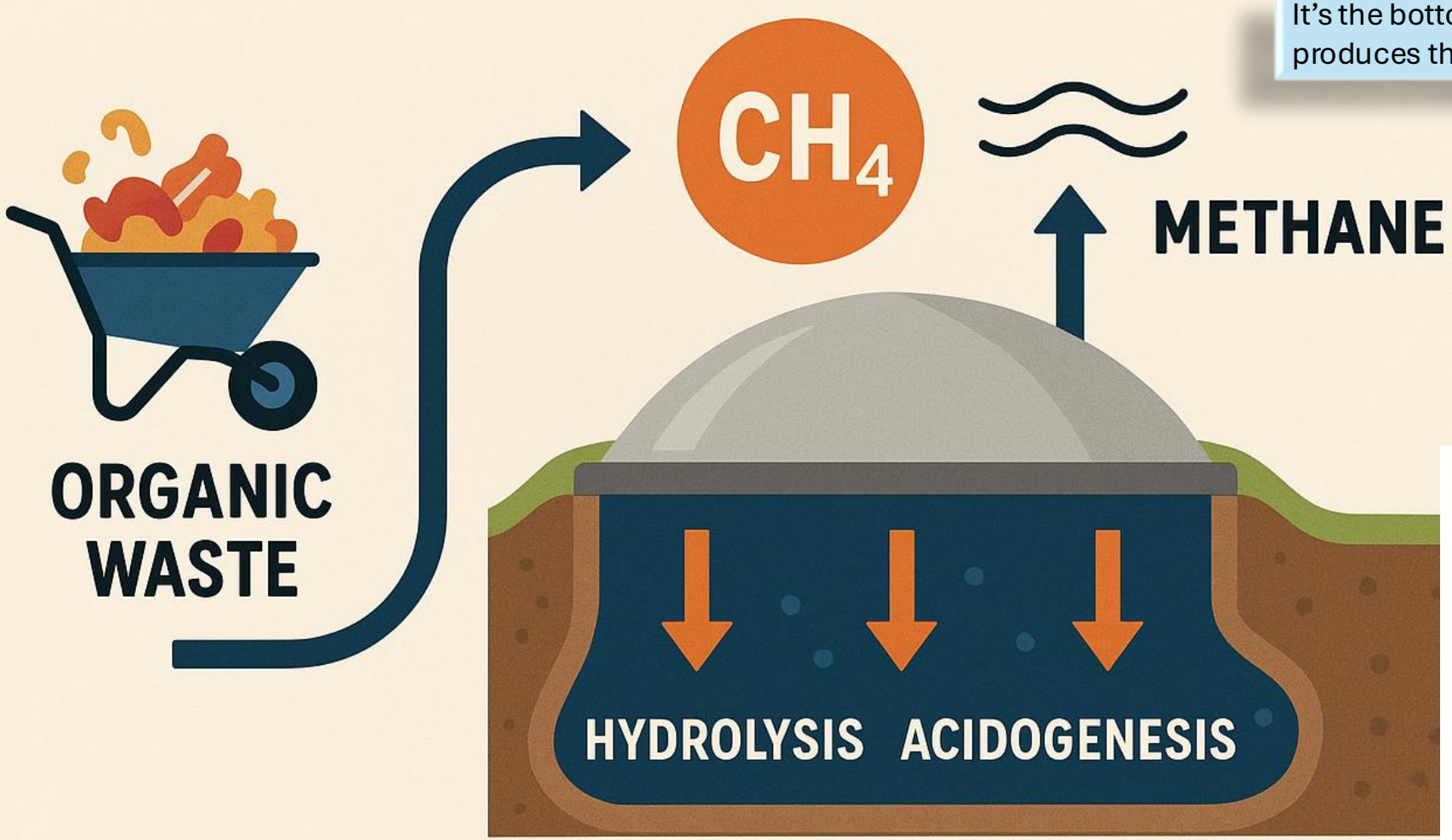
Anaerobic Digester – Equalization Pond

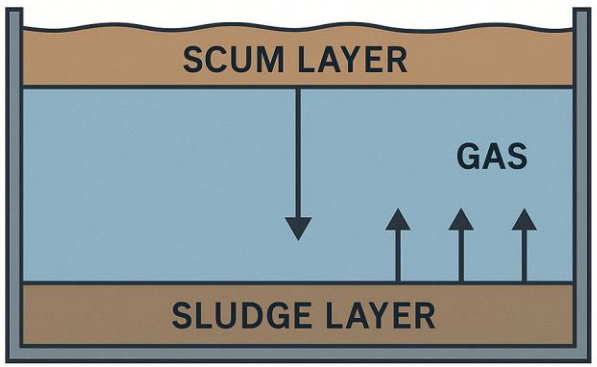
The equalization pond balances the organic waste before entering the AD



ANAEROBIC DIGESTER LAGOON

It’s the bottom part of the waste in the AD that produces the gas





ANAEROBIC DIGESTER LAGOON

Anaerobic Digester – Major Equipment & Process

No.	Main Components	Process Units
4.	Moving Bed Biological Reactor (MBBR)	a) MBBR media
		b) Nutrient dosing system
		c) Air blower and diffuser
		d) DO meter
5.	Secondary Dissolved air floatation (DAF-2)	a) Floatation tank
		b) Air saturation vessel
		c) Sludge/scum scraper
		d) Compressed air
		e) Sludge pump
		f) Recycling pump
6.	Retention tank	a) Filter feed pump
		b) Level sensor
7.	Sand filter	a) Pressure sensor
		b) Backwash pump
8.	Carbon filter	a) Pressure sensor
		b) Backwash pump
		c) Flow meter
9.	Sludge day tank	a) Level sensor
		b) Mixer
10.	Filter press	a) Filter press feed pump
		b) Polymer dosing system

Major equipment List Snapshot

Common Questions

Typically asked questions relating to the biogas production

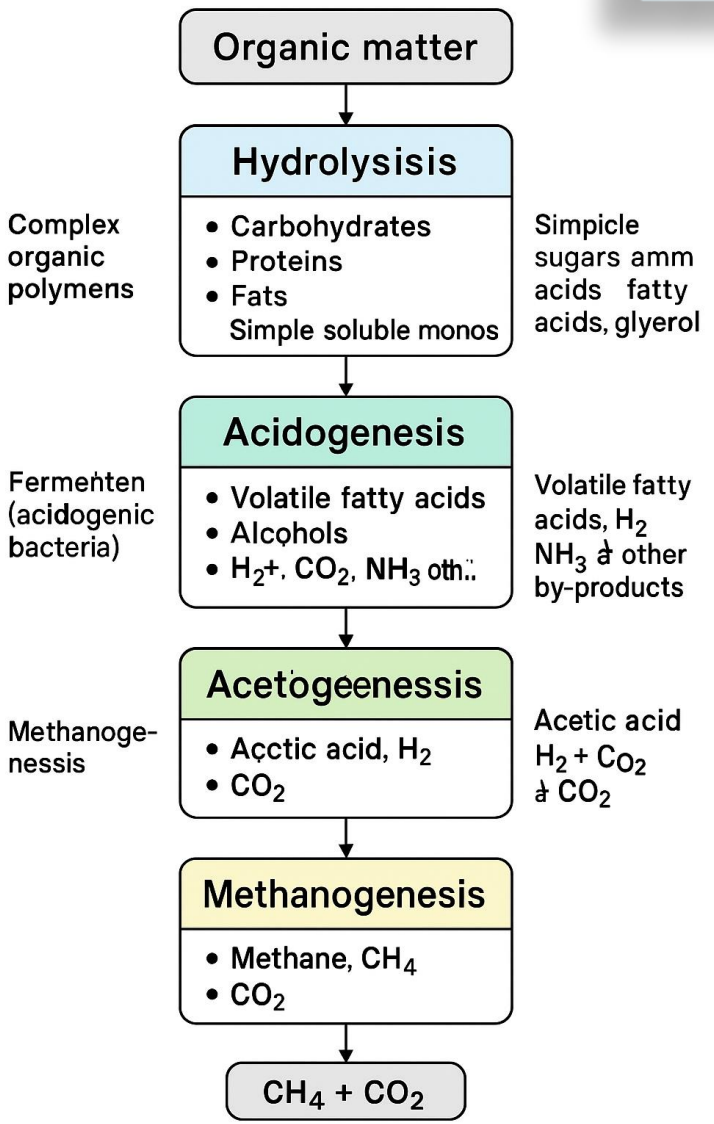
- One (1) Ton of Co Mingled Solid Waste may produce 1 MMBTU of Methane
- One (1) Ton of 90% Organic Waste may produce Two (2) MMBTU of Methane
- One (1) MMBTU avoids 0.9 tons of CO2
- 2.0 Hectares of land for 400 Co Mingle Waste
  0.5 Hectares per additional 100 tpd co-mingle waste
- Petronas Gas pipeline pressure 20 barg and our operating for direct injection method is 22barg
- One (1) MMBTU equivalent to 28.3278 m3 but for biogas we take higher as it has lower calorific value. 30m3 is most common.
- 250,000 MMBTU = 7.5 mil m3 per year
- 680 MMBTU or 20,000 m3 per day
- For above compressor size is 128 m3/hr @ 20 barg
- Bare CAPEX USD 10.0 mil per 200 tons of organic waste

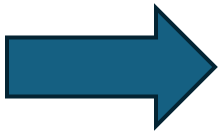
COMPRESS

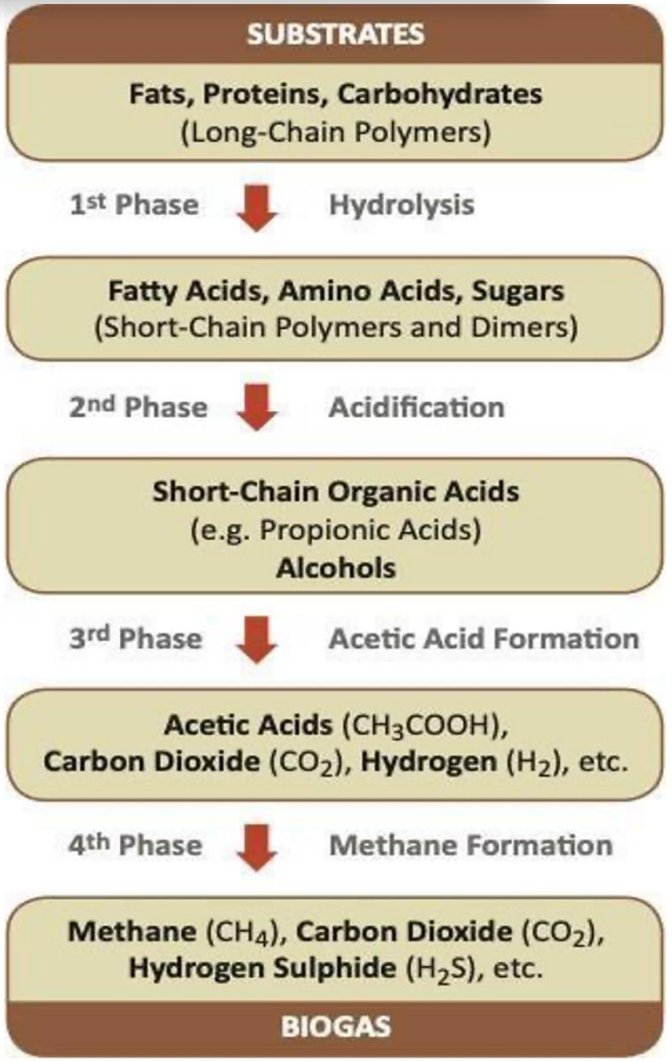
- Compress with 250bar > for 1 MMBTU it is 110 liters in volume
- 200 Tons of Comingle Waste Compressed To 22,000 liters compressed
- 200 Ton of Comingle Waste is equal to 1,400 > 3Kg Green Gas Tank
- 50 kg compressed gas tank has 100 liters of gas

Anaerobic Digester – Microbiology Process

Simple high level description of the AD biochemical process

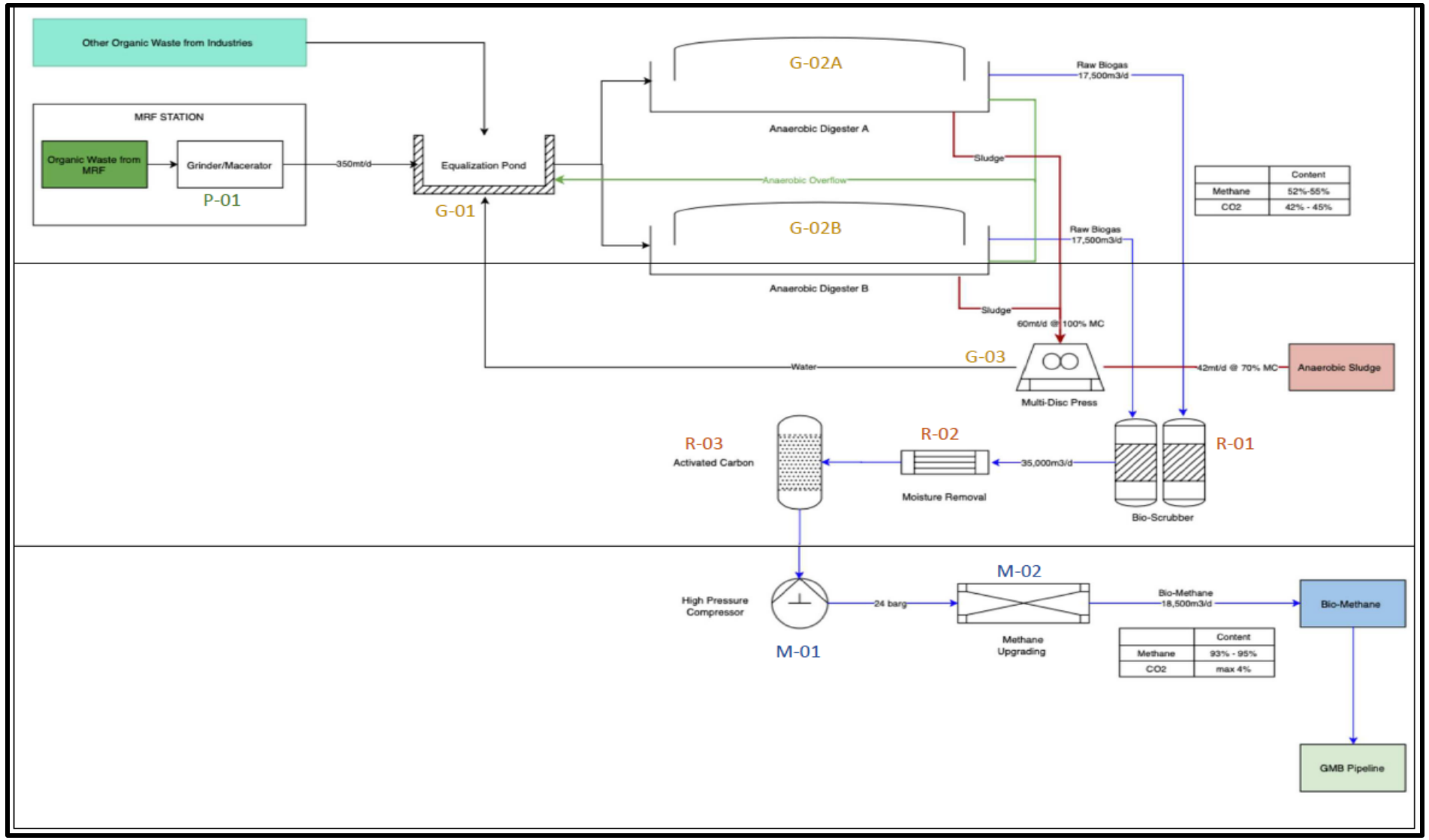






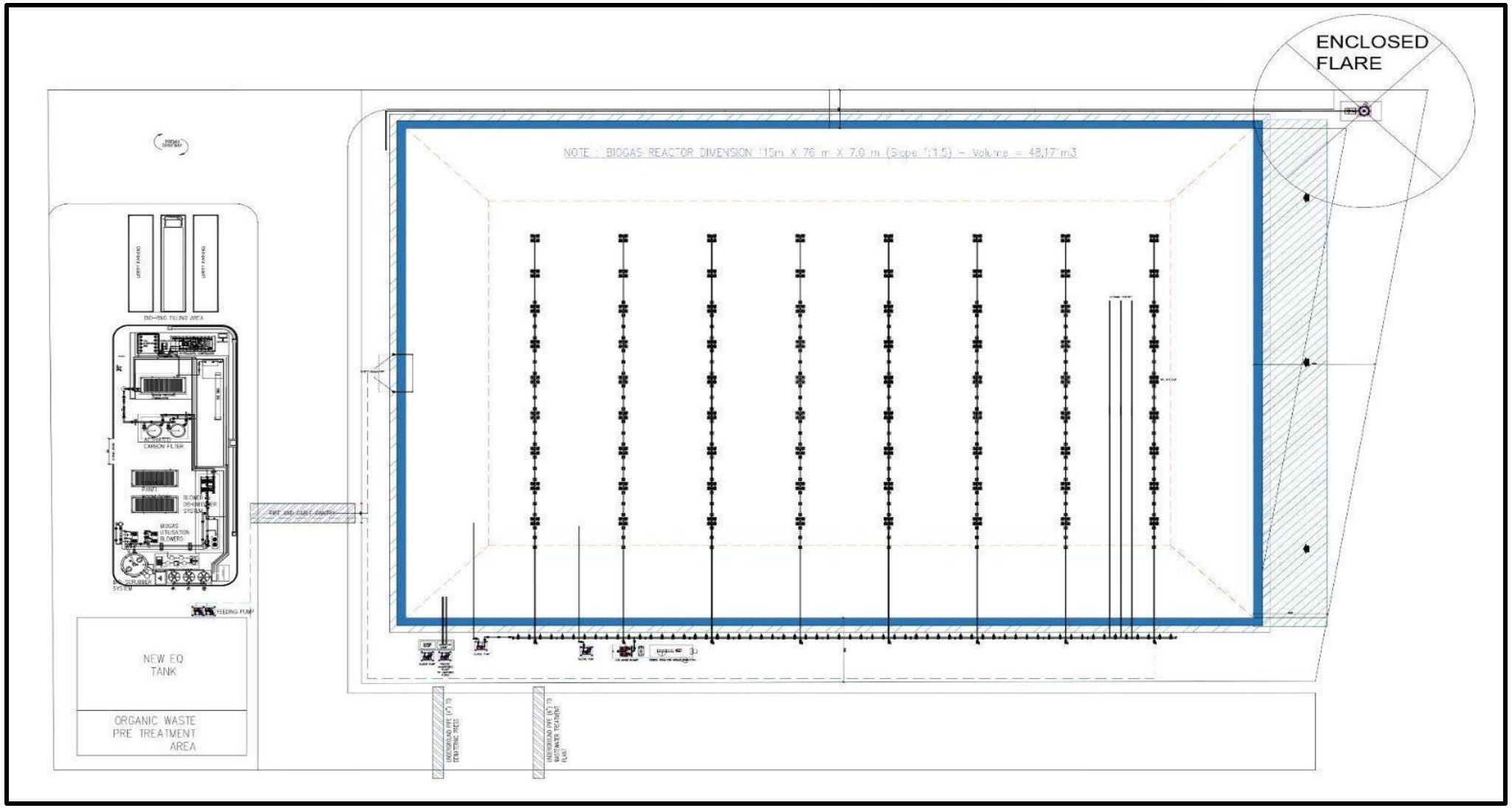
Anaerobic Digester – System Overview

The AD equipment and process



Anaerobic Digester – Site Layout

The lagoon and its supporting equipment layout



AD Methane Gas Output Specification

Biomethane gas production output meeting Petronas and Shell specification

PARAMETER	SPECIFICATION RANGE	DESCRIPTION
Methane Content (CH_4)	≥ 85% (typically ~90%)	High calorific methane-based gas
Wobbe Index	47.2 – 52.5 MJ/m^3	Interchangeability in end-use appliances
Gross Calorific Value	35 – 45 MJ/m^3	Energy content suitable for pipeline transport
Relative Density	0.55 – 0.70 (air = 1)	Operational Balancing
Hydrogen Sulphide (H_2S)	≤ 5.7 mg/m^3	Pipeline corrosion protection
Total Sulphur	≤ 30 mg/m^3	Prevents SOx emissions
Carbon Dioxide (CO_2)	≤ 2 mol%	CO_2 content
Oxygen (O_2)	≤ 0.2 mol%	Pipeline corrosion protection
Water Dew Point	≤ -10°C at max operating pressure	Prevents condensation and hydrate formation
Hydrocarbon Dew Point	≤ -2°C at max operating pressure	Avoid liquid dropout in pipelines
Particulate Matter	Negligible (per ISO 8573-1 Class 1)	Ensures no solids for meter protection

COMMERCIAL

A Nationwide Application

A suitable solution in many cities, not only major cities

Current Pursuit: Bandung, Jakarta, Lampung/Sumatra
Next: Medan, Padang, Surakata, Bali, Makassar

Waste and Feedstock

Theres urgent need for organic waste management solution that the AD scale can provide

City / Region	Area (km^2)	Population (≈ mid-2023 or latest)	Waste tpd	TPA / TPS notes	Status
Medan (city)	281.99	~2,474,166 (2023 est.)	~2,000 t/day	TPA Terjun (Medan Marelan District)	Manageable
Padang (city)	~695	~909,000 (2020–23 estimate)	~660 t/day	TPA Aie Dingin (Balai Gadang, Koto Tangah District)	Manageable
Bandar Lampung (city)	183.77	~1,100,109 (mid-2023)	~600 t/day	TPA Natar, TPA Kalianda	Manageable
Lampung (province)	33,575.40	~9,313,990 (mid-2023)	~4,000 t/day	TPA Bakung (~14 ha)	Overcapacity
Jakarta (city)	~662 (DKI Jakarta)	~8.54 million (city proper)	~7,000 t/day	TPA Bantar Gebang:	Overcapacity
Bandung (city)	~167	~2,444,160 (2024 est.)	~1,800 t/day	TPA Sarimukti, TPS Gede Bege	Overcapacity
Surakarta (Solo)	~46–50	~1.5 million metro	~1,300 t/day	TPA Putri Cempo (Mojosongo/Jebres area)	Overcapacity
Denpasar (Bali)	125.98	~1.5 million Bali + 2.5 mil foreigners	~1,000 t/day	TPA Suwung (~16 ha)	Manageable
Makassar (city)	175.77	~1,474,393 (mid-2023)	~1,100 t/day	Tamangapa / Antang	Overcapacity

16,000 tons of waste per day

The business case for Non Thermal Waste To Energy solution

Context and Challenges

- Globally and particularly in urban regions, population growth has led to an exponential rise in waste generation.
- Limited and costly land availability for new landfills.
- Escalating logistics costs to transport waste to central, large-scale facilities.
- Existing Thermal Waste-to-Energy (WTE) incinerators are capital intensive and require high throughput volumes (1200 tons/day) to remain economically viable. (refer next page)
- RDF (Refuse-Derived Fuel) incineration relies heavily on high calorific value (CV) feedstocks, such as plastics, and tends to reject organic wet waste.
- There is now an urgent need for an alternative technology that can process smaller volumes, handle organic-rich fractions, and align with sustainability goals.

The NTWTE Model: Core Features

- Our Non-Thermal Waste-to-Energy model is built on Anaerobic Digester technology supported by MRBs.
- Designed for distributed deployment, closer to waste generation points, reducing logistics costs.
- Targets organic-rich fractions from municipal, commercial, and industrial waste streams.
- Waste collection from multiple sources: municipalities, landfills, RDF and incineration plants, private collectors, wet markets, hotels, malls, hospitals, and industrial facilities.
- Pre-treatment with macerators/mixers and equalization ponds
- Anaerobic digestion to produce biogas.
- Upgrading biogas through bio-scrubbers and methane enrichment systems.
- Requires only 1/3 of the CAPEX and 1/2 of the OPEX compared to incinerators.
- Processes mixed MSW of 400–800 tons/day, or sorted organic waste of 200–500 tons/day
- Compressed Natural Gas (CNG): delivered via pipelines or trucks (200 tons waste → 200 MMBTU → 2 trucks).

Commercial Viability and Revenue Model

- Land requirement: 2 acres per 200 tons of daily waste throughput.
- The NTWTE model is designed for long-term sustainability requiring 25-years concession.
- Significanty reduce waste transportation and handling costs.
- Diverts 80% of waste from landfills, extending landfill life by 300%.
- Each 1 MMBTU of gas generated offsets 0.9 tons of CO_2 emissions.
- **Approximate USD 5.0 million per 200 tons of waste capacity for investment for 20 year concession**
- **Sale of natural gas at USD 9.50/MMBTU plus a 10% premium from carbon credits, resulting in USD 1,900/day for every 200 tons of waste processed.**

Strategic Advantages

- Scalability: Modular design allows deployment in multiple regions or smaller communities.
- Flexibility: Works with both unsorted and sorted waste streams.
- Alignment with National Goals: Supports initiatives for renewable energy, greenhouse gas (GHG) reduction, and circular economy principles.

Government Decree On Incinerator WTE Paving Way For Anaerobic Digester

Non Thermal Anerobic Digester is a complementary solution

MENTERI LINGKUNGAN HIDUP /
KEPALA BADAN PENGENDALIAN LINGKUNGAN HIDUP
REPUBLIK INDONESIA

Jakarta, 18 Maret 2025

Nomor : S.233/A/S/PLB.0.1/8/03/2025
Sifat : Biasa
Perihal : Arahan Mengenai Pengolahan Sampah Secara Termal

Kepada Yth.
Para Bupati / Wali Kota se-Indonesia
di
Tempat

Sehubungan dengan pengolahan sampah secara termal, bersama ini kami sampaikan hal sebagai berikut:

1. Pengolahan sampah secara termal adalah proses pengolahan sampah yang melibatkan pembakaran bahan yang dapat terbakar yang terkandung dalam sampah dan/atau menghasilkan energi, meliputi penggunaan teknologi insinerator, gasifikasi, dan pirolisis.
2. Dalam pelaksanaan pengolahan sampah secara termal harus memenuhi ketentuan pada Peraturan Menteri Lingkungan Hidup dan Kehutanan Nomor P.70/MENLHK/SETJEN/KUM.1/8/2016 tentang Baku Mutu Emisi Usaha dan/atau Kegiatan Pengolahan Sampah Secara Termal dengan rincian sebagai berikut:
   a. Pengolahan sampah secara termal hanya dapat dilakukan terhadap sampah rumah tangga dan sampah sejenis rumah tangga yang tidak mengandung B3, limbah B3, kaca, Poli Vinyl Clorida (PVC), dan aluminium foil.
   b. Penanggung jawab usaha dan/atau kegiatan pengolahan sampah secara termal wajib memenuhi baku mutu emisi yang tercantum dalam Lampiran I Peraturan Menteri Lingkungan Hidup dan Kehutanan Nomor P.70/MENLHK/SETJEN/KUM.1/8/2016.
   c. Terhadap pengolahan sampah secara termal, penanggung jawab usaha dan/atau kegiatan wajib melakukan pemantauan emisi untuk mengetahui pemenuhan ketentuan baku mutu emisi dan pemantauan emisi dilakukan pada seluruh sumber emisi usaha dan/atau kegiatan pengolahan sampah secara termal.
   d. Pemantauan Emisi dilakukan dengan cara:
      - Terus Menerus
        Pemantauan Emisi dengan cara terus menerus dilakukan terhadap proses pengolahan sampah dengan kapasitas lebih besar dari 1000 (seribu) ton per hari dengan menggunakan *Continuous Emission Monitoring Systems* (CEMS) yang memiliki spesifikasi memantau dan mengukur parameter Partikulat, Sulfur Dioksida (SO_2), Nitrogen Oksida (NOx), Hidrogen Fluorida (HF) dan Laju Alir.
      - Manual
        Dilakukan paling sedikit 1 (satu) kali dalam 6 (enam) bulan yang wajib dilakukan oleh laboratorium terakreditasi dan teregistrasi di Kementerian Lingkungan Hidup/Badan Pengendalian Lingkungan Hidup (khusus untuk pengukuran dioksin dan furan dilakukan setiap 5 (lima) tahun sekali).
   e. Penanggung jawab usaha dan/atau kegiatan pengolahan sampah secara termal wajib menyampaikan laporan kepada pejabat pemberi izin lingkungan dan dalam hal izin lingkungan diterbitkan oleh gubernur atau bupati/walikota, laporan disampaikan dengan tembusan kepada Menteri Lingkungan Hidup/Kepala Badan Pengendalian Lingkungan Hidup.
3. Penanggung jawab kegiatan/usaha wajib mengurus persetujuan lingkungan sebagaimana ketentuan pada Peraturan Menteri Lingkungan Hidup dan Kehutanan Nomor 4 Tahun 2021 tentang Daftar Usaha dan/atau Kegiatan yang Wajib Memiliki Analisis Mengenai Dampak Lingkungan Hidup, Upaya Pengelolaan Lingkungan Hidup dan Upaya Pemantauan Lingkungan Hidup Atau Surat Pernyataan Kesanggupan Pengelolaan dan Pemantauan Lingkungan Hidup dengan ketentuan sebagai berikut:
   a. Jika kapasitasnya ≥ 50 ton/hari, maka skala/besarannya adalah AMDAL;
   b. Jika kapasitasnya < 50 ton/hari, maka skala/besarannya adalah UKL/UPL.
4. Badan usaha yang akan melakukan pengolahan sampah secara termal wajib memiliki perizinan berusaha sebagaimana ketentuan untuk Klasifikasi Baku Lapangan Usaha Indonesia (KBLI) 38211 Treatment dan Pembuangan Limbah dan Sampah Tidak Berbahaya.

Demikian disampaikan, atas perhatian dan kerja sama Saudara kami ucapkan terima kasih.

Menteri Lingkungan Hidup /
Kepala Badan Pengendalian Lingkungan Hidup

Hanif Faisol Nurofiq

Tembusan Yth.:
1. Bapak Presiden Republik Indonesia;
2. Bapak Wakil Presiden Republik Indonesia;
3. Menteri Sekretariat Negara.

Installation Coverage

The AD component with an option of a sorting facility

MSW delivery to site

Material Recovery Facility(MRF)

Requires 2.5 ha of land area .
CAPEX Investment MRF: USD 5 mil

Plastics & other recyclables

Organic Fraction + Leachate

Industrial Organic Waste

Pre-Treatment

500 tons of Waste, Requires 2.5 ha of land area .
0.5 Ha per additional 100 tpd
CAPEX Investment AD: USD 10 mil

Anaerobic Digester (AD)

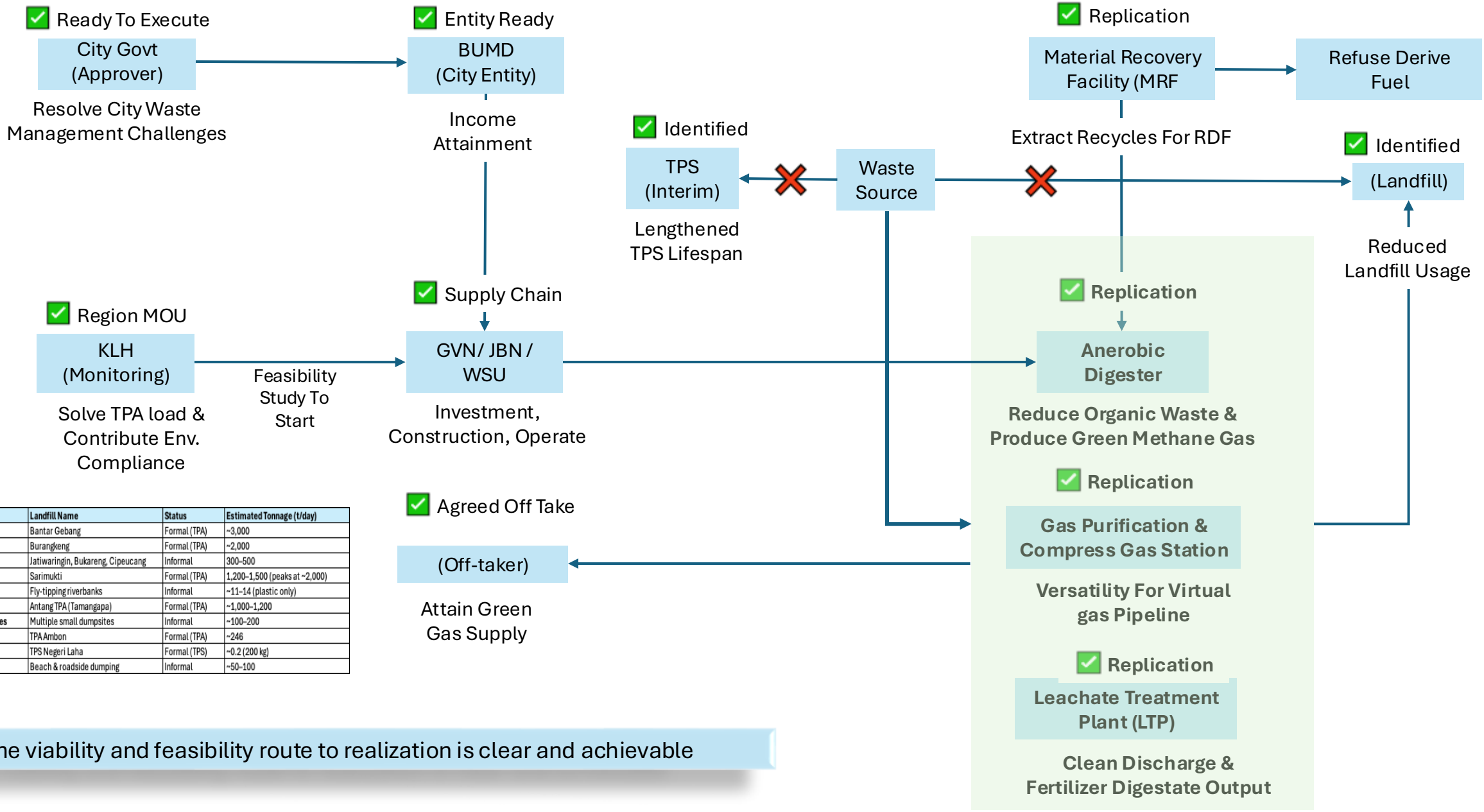
Methane Upgrading

Leachate Treatment Plant (LTP)

Bio-Methane

Liquid Discharge

Indonesia NTWTE Business Model Flow



Location	Landfill Name	Status	Estimated Tonnage (t/day)
Bekasi, Jakarta	Bantar Gebang	Formal (TPA)	~3,000
Bekasi, Jakarta	Burangkeng	Formal (TPA)	~2,000
Jakarta & Bekasi	Jatiwaringin, Bukareng, Cipeucang	Informal	300–500
Greater Bandung	Sarimukti	Formal (TPA)	1,200–1,500 (peaks at ~2,000)
Greater Bandung	Fly-tipping riverbanks	Informal	~11–14 (plastic only)
Makassar (Antang)	Antang TPA (Tamangapa)	Formal (TPA)	~1,000–1,200
Makassar Coastal Zones	Multiple small dumpsites	Informal	~100–200
Ambon, Maluku	TPA Ambon	Formal (TPA)	~246
Laha, Ambon, Maluku	TPS Negeri Laha	Formal (TPS)	~0.2 (200 kg)
Ambon Coastal Areas	Beach & roadside dumping	Informal	~50–100

The viability and feasibility route to realization is clear and achievable

Partnership Model

Project delivery eco system with more than 50% of local component