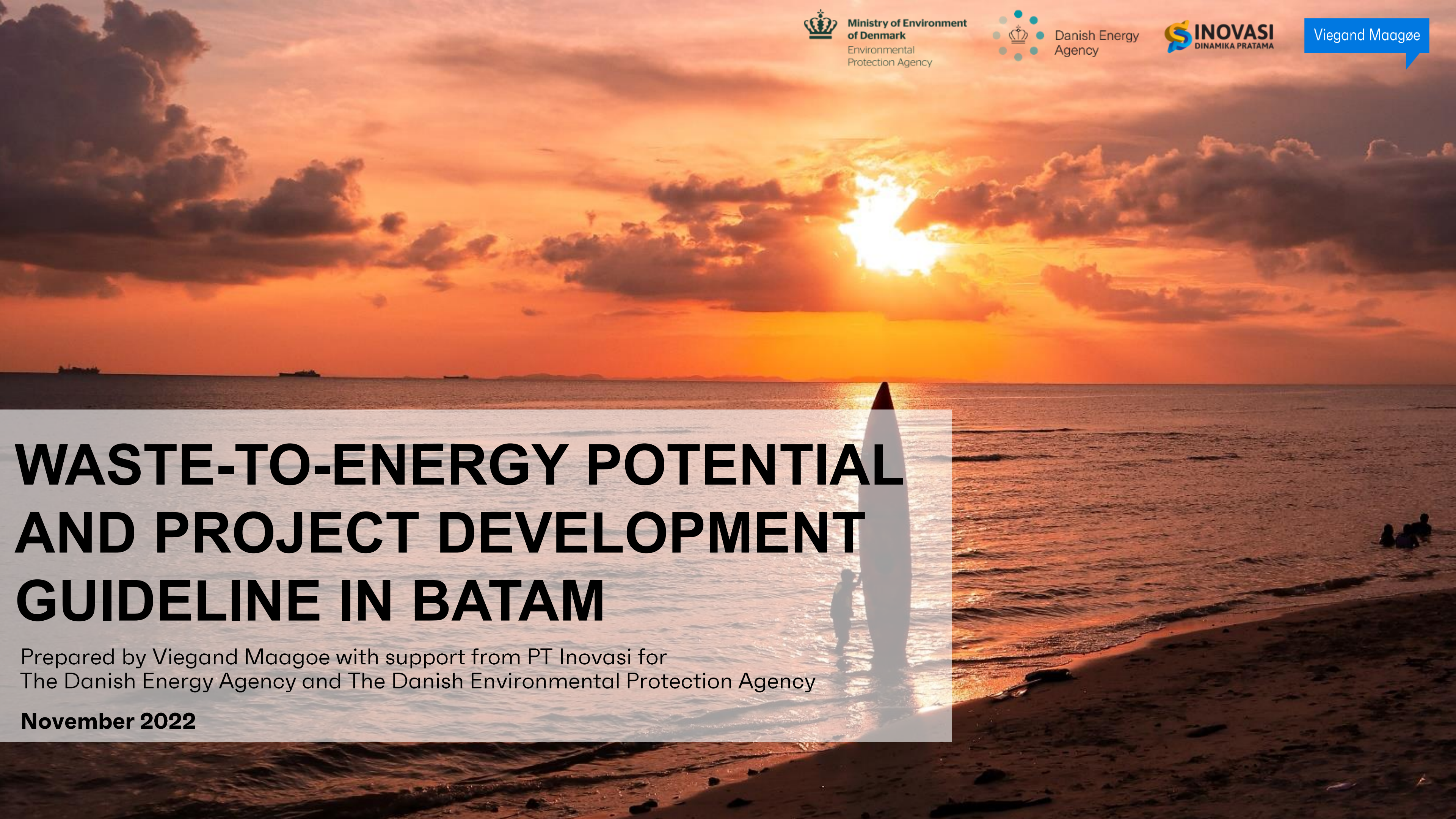

WASTE-TO-ENERGY POTENTIAL AND PROJECT DEVELOPMENT GUIDELINE IN BATAM

Prepared by Viegand Maagoe with support from PT Inovasi for
The Danish Energy Agency and The Danish Environmental Protection Agency

November 2022

SCOPE OF REPORT

Indonesia's National Waste Policy sets increasingly high standards with regards to the handling of solid waste streams to reduce the environmental and climate impacts of waste. On top of that, the government of Indonesia has an ambition to integrate higher shares of renewables while preserving the supply of power in a time where demand for power is increasing due to high economic growth.

Waste-to-energy has the potential to address both issues: generation of renewable energy and waste management. However, the deployment of waste-to-energy technologies in Batam remains low.

The purpose of this report is to enhance local knowledge in Batam - concerning the island's waste-to-energy potential, the benefits and challenges of different waste-to-energy solutions and the critical steps when developing a waste-to-energy project.

This report is part of the Sustainable Island Initiative (SII), an add-on initiative to the energy partnership program between Indonesia and Denmark. SSI concerns sustainable waste management and waste-to-energy on two islands: Lombok and Batam.

This report, which focuses on Batam, is divided into three chapters:

1) Screening of the waste-to-energy potential in Batam
2) Assessment of four waste-to-energy technologies
3) Project development guideline for waste-to-energy development

The ambition with this report is to synthetize existing knowledge concerning waste-to-energy when it comes to different WtE solutions and aspects that are critical to a WtE project development process.

Four WtE solutions are assessed: Waste Incineration, Anaerobic Digestion (AD), Landfill gas power generation and Mechanical Biological Treatment (MBT). Each technology is evaluated according to environmental impact and overall feasibility.

In order to facilitate and enable investments into the waste-to-energy sector, the report also provides a "10-step project development guideline" for waste-to-energy technologies.

Data

The assignment is a combination of desk top research and primary data collection. The report partly builds upon the "Cross-sectoral Technology Catalogue for Solid waste management and Waste to Energy - Lombok and Batam/Kepri" conducted by COWI.

Additional interviews and site visits have been completed with a range of local stakeholders in Batam (See Appendix 1).

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1. SCREENING OF WASTE-TO-ENERGY POTENTIAL IN BATAM

BATAM HAS POPULATION OF 1.2 MILLION AND IS LOCATED 20 KM SOUTH OF SINGAPORE

Batam City

Batam is the largest city in Riau Islands. With only 20 km to Singapore, Batam is strategically located to international shipping routes.

Batam administers 12 subdistricts, including three main islands (Batam, Rempang and Balang). Of the 12 sub districts, Batam Kota has the highest population density (4,243/sq.km). Batam City has a total land area of 415 sq.km and a population of around 1,196,000, expected by BPS Batam to increase to 1,282,000 in 2037 (7 % increase).

Batam has had the status of a special trade zone since 2016 with the purpose of accelerating economic development through tax holidays and other benefits.

In light of the ambition of the province with regards to the trade and investment and the anticipated population growth, Batam's waste problems are expected to increase and therefore should be addressed.

Google Earth

THE TOTAL WASTE GENERATION OF BATAM WAS ~560,000 TONS OF IN 2018 EXPECTED TO INCREASE TO ~730,000 TONS IN 2025

Waste generation and handling in Batam City

The management of municipal solid waste is the responsibility of the Office of Environment of Batam. According to the Office of Environment, total waste generation in Batam was 1,546 tons/day in 2018, which sums up to 560,000 tons for the full year. Of that, 67% was handled by the system, corresponding to 375,200 tons. Only ~6% of the total waste generation in Batam was reused, reduced, or recycled (so-called "3R process") in 2020. 7% of waste is not managed according to regulatory requirements, which means it is either burned or dumped. It has not been possible to obtain information on what happens with the residual waste.

With a daily volume of 850-1100 tons of waste, Telega Punggur landfill is responsible for the majority of Batam's waste handling. The split between domestic and non-domestic waste is 850/300 tons/day.

Population increase is expected to lead to an increase in the amount of waste generated from 1,500 tons/day in 2018 to 2,000 tons/day by 2025.

% of waste handling in Batam City (2017-2019)

Waste generation tons/day

	2014	2015	2016	2017	2018	2025
Domestic	731	768	806	844	881	1,145
Non-Domestic	551	580	608	636	665	863
Total	1,282	1,348	1,414	1,480	1,546	2,008

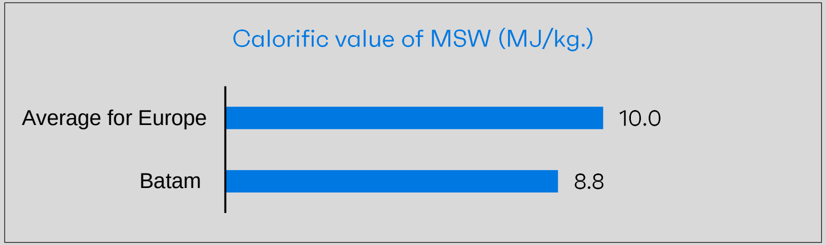
Dinas Lingkungan Hidup (2021); Viegand Maagoe Analysis (2022)

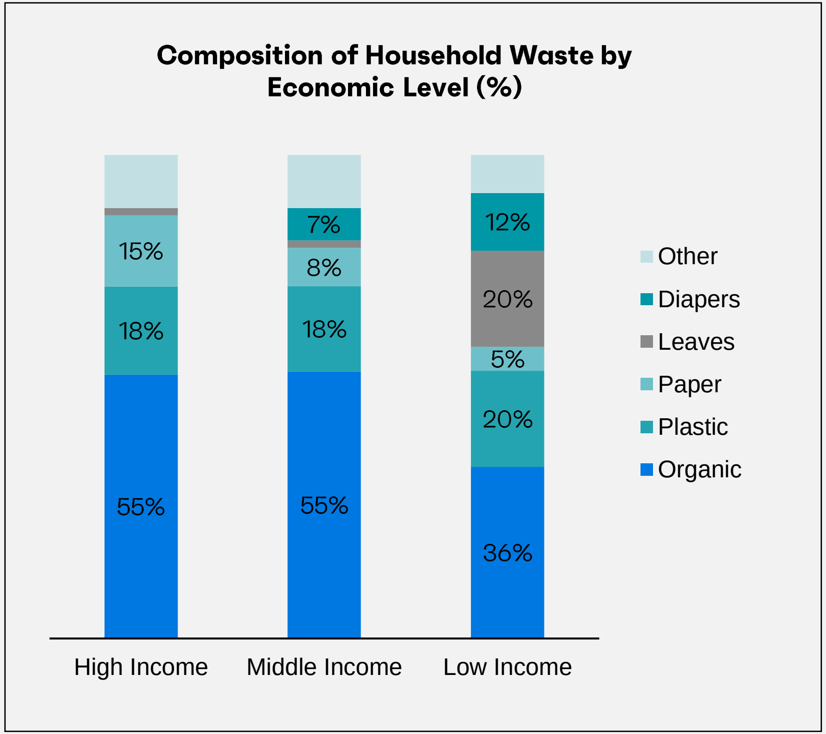
MAINLY ORGANICS WITH HIGH MOISTURE LEVELS

Waste composition in Batam

The waste composition in Batam varies depending on the economic level of the consumer – high incomes has highest share of organic waste and paper waste. Low income has the highest share of diapers (due to the relative share) and particularly leaves (has to do with the fact the low income typically live in more rural areas). For all income groups, organic waste constitutes the largest share of household waste.

The very high level of organic waste yields a high moisture level of the waste. This results in a relatively low heating value of around 8-9 MJ/kg. The optimal heating value of waste for incineration is around 10 MJ/kg.





Dinas Lingkungan Hidup (2021); Bapelitbangda (2021); Viegand Maagoe Analysis (2022)

BATAM HAS 1 LANDFILL, 1 COMPOSTING FACILITY, 197 WASTE BANKS and 800 SCAVENGERS

Waste handling system in Batam

Batam has 1 active landfill (TPA Telega Punggur), 197 TPS facilities (bins or permanent) and 1 TPS 3R facility.

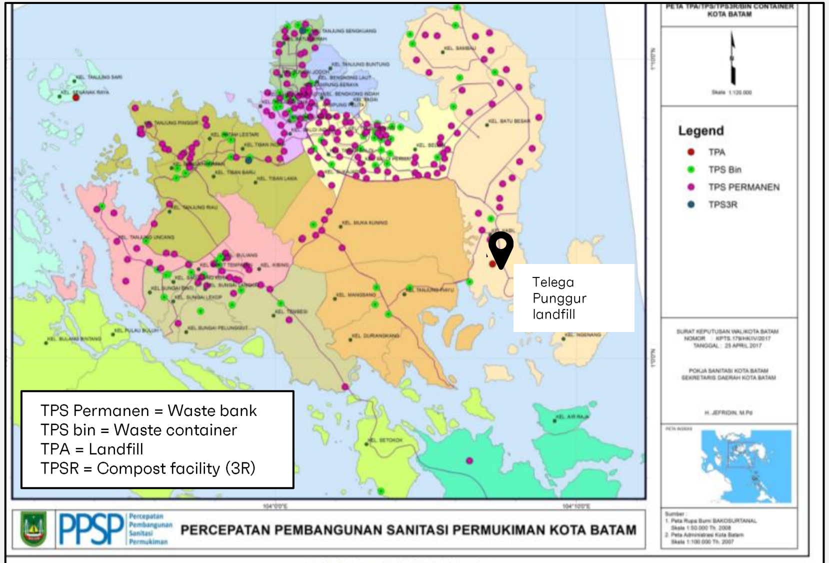
TPA Telega Punggur is Batam's only landfill, which has been in operation since 1997. The landfill has reached capacity, why measures to extend the landfill and divert waste from the landfill is necessary

TPS bins are waste containers, which function as temporary landfills where waste from villages is dumped until it is picked up and sent to Telega landfill for final disposal. **TPS Permanen** are waste banks where waste is sorted into cardboard and plastic from large waste aggregators, including community groups, schools, institutions and the university of Batam.

Batam's only **TPS 3R facility** is a composting facility where organic waste is transformed into fertilizer.

With a total of 800 "scavengers" (waste collectors), Batam has a large informal sector. Telega Punggur currently has 400 active scavengers, who make a living of collecting the valuable waste streams (e.g. cardboard and plastic that ends up at the landfill).

Solid waste management facilities in Batam



Gambar 2. 8 Peta TPA/TPS/TPS3R/Bin Container
Sumber : Pokja Sanitasi Kota Batam Tahun 2017, diolah

Source: Strategi Sanitasi Kabupaten/Kota, PPSP: Link

Source: Batam Office of Environment (Dinas Lingkungan Hidup), 2021; SIPSN;

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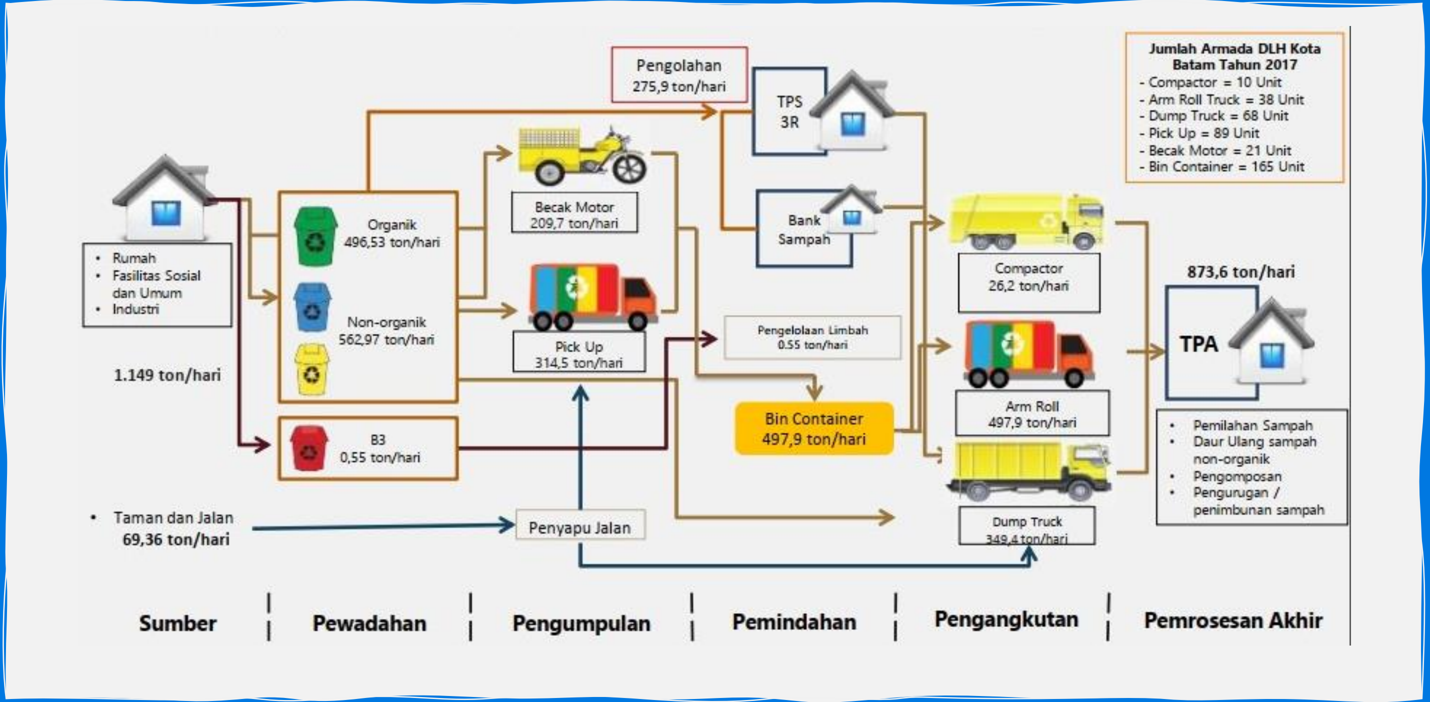
MUNICIPAL SOLID WASTE MANAGEMENT IN BATAM 2019-2024



Figur taken from Batam municipality masterplan of waste management system, 2016. NB: Missing mass balance of waste flow. Figures are indicative.

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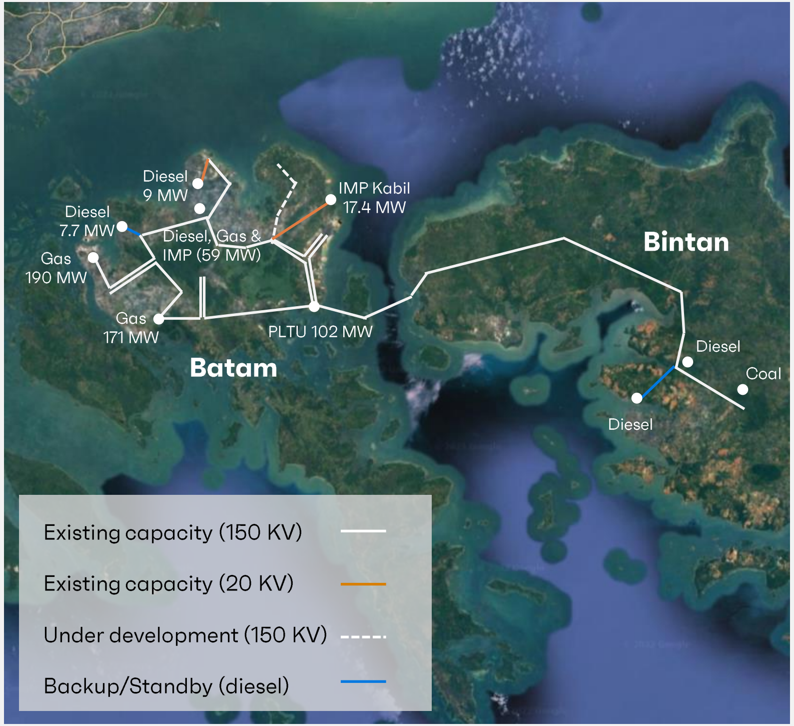
THE POWER SYSTEM OF BATAM IS DISTRIBUTED ACROSS THE ISLAND WITH INTERCONNECTION TO BINTAN – VERY LOW RESERVE MARGIN

Batam's power system

The electricity management in Batam is carried out by PT PLN Batam, with status as a subsidiary of PT PLN (Persero), as an independent unit that manages electricity from upstream to downstream. The majority shares of PLN Batam are owned by PT PLN Persero, while YPK PLN has a small portion.

The electricity system of Batam has a large coverage with power plants distributed evenly according to load centers. Batam has been connected to the neighboring region Bintan since 2019, which adds additional flexibility to the system. The average export capacity from Batam to Bintan is 70-80 MW.

The peak load demand in the system is around 520 MW, covered by a total power capacity installed of around 560 MW – leaving a very low reserve margin of around 6%. A challenge that will rapidly increase due to commissioning of data centers on the island, which is expected to increase the peak load to around 580 MW.



Google Earth

PLN Batam (2022); Viegand Maagoe Analysis (2022)

THE PRIMARY ELECTRICITY CUSTOMERS IN BATAM ARE HOUSEHOLDS, BUSINESS AND INDUSTRY

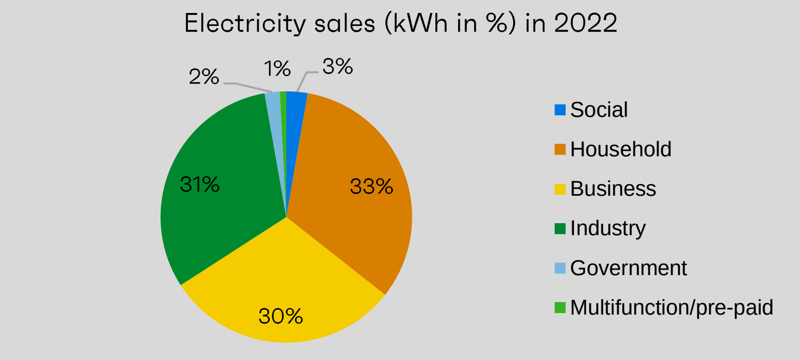
Electricity customers in Batam

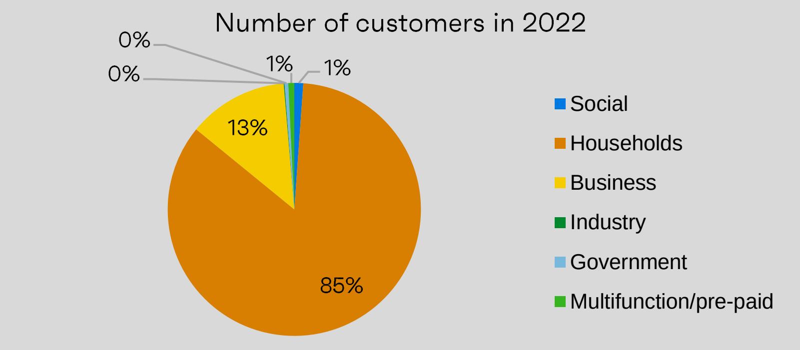
In 2022, PLN Batam served 350,277 customers with the largest number of customers coming from households. In terms of electricity sales, households, businesses and industry customers each represents about a third of the total electricity demand in Batam.

The costs of electricity for customers in Batam is about 10 cUSD/kWh. Based on discussions with PLN Batam, PLN is open to Waste-to-energy and other renewables if the independent power producers are willing to accept a maximum PPA price, which corresponds to or is lower than the current cost of generation (BPP). In 2022, the BPP price was 1150 IDR/kWh corresponding to 7.7 cUSD/KWh.

PLN Batam cannot accept a higher purchase price for renewables because PLN Batam, being an independent subsidiary of PT PLN, is not entitled to government subsidies for renewable energy.

The share of renewables in PLN Batam's power system is less than 1%.





 PLN Batam (2022); Viegand Maagoe Analysis (2022)

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2. ASSESSMENT OF WASTE-TO-ENERGY TECHNOLOGIES

SCREENING OF WASTE-TO-ENERGY OPTIONS IN BATAM

Technologies producing energy from MSW

In the previous pages, an assessment of Batam's waste management situation with respect to volume, location and waste characteristics, is provided. It is concluded that Batam has a range of possibilities for waste-to-energy.

COWI for the DEA published in 2021 a Technology Catalogue for Solid Waste Management and Waste to Energy, which covers all possible technologies including but not limited to landfill gas extraction, gasification, pyrolysis, retrofit of coalfired blocks, anaerobic digestion and incineration. In 2022, Ramboll published for the DEPA and the DEA a prefeasibility study on waste for another island (Lombok) where they recommend mechanical biological treatment (MBT) in combination with anaerobic digestion (AD) and composting for treatment of the organic fraction of the waste, bio-drying of RDF for energy production in a co-firing process (power plants or cement kilns) and material recycling to separate plastic, metal, glass, paper and cardboard.

On the following pages, a range of waste-to-energy options is assessed with respect to the environmental impact, costs, requirement for source separation and maturity of technology. The technologies chosen are 1) Incineration, 2) Landfill gas power generation, 3) Anaerobic Digestion (AD) and 4) Mechanical Biological Treatment (MBT).

High-level assessment of WtE technologies

The City of Batam has set a number of criteria for waste-to-energy technologies, including:

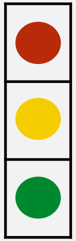
1. Able to reduce min. 1,050 tons of waste per day
2. Environmentally friendly
3. Does not require large land area
4. Extends the life of the existing landfill
5. Proven technology

In 2018, the Office of Environment pointed at three technologies, which are considered to be the most promising. Those include sanitary landfill, incineration and gasification.

High-level assessment of WtE technologies

- The four selected WtE technologies are assessed according to their environmental impact and overall attractiveness with respect to a number of parameters such as costs, residues and complexity of technology.

- A traffic light system is used to illustrate how one technology performs on different parameters relative to the other technologies. Red indicates a low score and green indicates a high score.



DEPA, DEA & Ramboll (2022); DEA, DEPA & COWI (2021); Viegand Maagoe Analysis (2022)

INCINERATION IS AN EFFECTIVE WASTE MANAGEMENT TECHNOLOGY PRODUCING BASELOAD "RENEWABLE ENERGY"

Overall sustainability assessment of incineration

Incineration is part of the modern waste management system and a very effective technology for handling of waste streams that are difficult or too costly to recycle. This includes:

1. Non-recyclables fractions of waste from material recovery facilities;
2. Contaminated and greasy household waste;
3. Some fibers lose their ability to be recycled if recycled too many times (e.g., paper fibers);
4. Different materials (e.g., plastics from paper or foil from plastic) are sometimes impossible or too costly to recycle.

CO_2 is emitted from the combustion process, however up to 50% is biogenic CO_2, which can be reused for other purposes, such as carbonized beverages or synthetic fuels if captured. It can also be stored permanently in geological structures. Some of these technologies are however in the emerging stage and thus not fully commercial.

Incineration contributes to reduction of green house gases if it replaces fossil-based energy sources.

Energy generation	• Incineration is a base-load power capacity that produces all year around.	
Climate emission reductions	• Production of power from incineration emits CO_2, however compared to coal power plants, it has a lower carbon footprint, since approximately 50% derives from the biogenic part of the waste. • Modern incineration is equipped with advanced flue gas cleaning capable of complying with the most stringent air emission requirements, e.g. the EU Industrial Emission Directive.	
Reduction and handling of waste	• Very suitable for large scale waste management as incineration can handle MSW (general/residual waste)/C&I waste.	

DEPA, DEA & Ramboll (2022); DEA, DEPA & COWI (2021); Viegand Maagoe Analysis (2022)

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INCINERATION IS COSTLY – BUT CAN HANDLE LARGE WASTE AMOUNTS AND DOESN'T REQUIRE PRE-TREATMENT

Overall assessment of incineration

Incineration based on grate fired combustion technology is a well-proven technology, which has been developed and refined over decades, and more than 2000 plants exist worldwide. Still, many countries, including Indonesia, have very little experience with incineration. The lack of experience and high complexity of the technology makes it costly to build and operate. Due to limited incineration experience, finding the required staff may prove difficult. Besides, environmental planning is often a challenge and takes time (5-6 years from planning to operation).

Electrical efficiency depends on steam data but is typically 25-30%. The financial feasibility of incineration can be improved by utilizing surplus energy as process steam for industrial applications.

Modern incineration has advanced flue gas cleaning technology and does not constitute a problem to the environment or human health. Bottom ash and flue gas cleaning residues need to be handled. Bottom ash can be used for road construction purposes while flue gas cleaning residues must be treated as hazardous waste although options also exist to use it as aggregate for special brick production or extract valuable metals.

Incineration can handle large volumes of waste and doesn't require separation nor pre-treatment of the incoming waste. This is an advantage in places like Indonesia where source separation is still in early stages. It is however important that the calorific value of the waste is reasonable high (at least > 6 MJ/kg).

Environmental impact	High energy generation potential. Could potentially treat all MSW/C&I waste and solve some of the waste problem.	Green
CAPEX/OPEX	High investments dependent on quality level. Large and highly trained/ experienced staff and high maintenance	Red
Land requirement	3-5 hectares or even more dependent on plant size or storage needs	Red
Complexity of technology	Complex technology that requires high skilled labour	Red
Maturity of technology in Indonesia	Well-proven technology in developed countries, but so far little experience with incineration in countries like Indonesia. However, the first incineration plants in Indonesia are in the planning phase.	Yellow
Require pre-treatment	Incineration does not require pre-treatment of waste. However, the heating value might be too low, or need to be dried.	Yellow
Residue Management	High amount of bottom ash (150-200 kg/tons of waste) that could potential be used for construction purposes and a smaller amount of flue gas cleaning residue (30-50 kg/tons of waste) that needs to be landfilled/stored (treated a hazardous waste	Red

DEPA, DEA & Ramboll (2022); DEA, DEPA & COWI (2021); Viegand Maagoe Analysis (2022)

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METHANE CAPTURE FROM LANDFILL GAS CAN PRODUCE ENERGY, BUT IT DOESN'T HELP BATAM'S WASTE SITUATION

Overall sustainability assessment of landfill gas

In the waste management hierarchy, landfills should be used only as a last resort. However, in many countries, including Indonesia, landfills are the dominant waste handling system. Where landfills are in place, methane can be collected, vented, flared or utilized for production of power, heat or renewable natural gas, either partly or fully. The latter requires removal of CO_2.

Landfills generate effluents from rainfalls and decomposition of organic waste. The effluents should be collected and treated in a leakage pool to avoid leakage of wastewater into ground water. In the absence of proper wastewater treatment, there is a risk of pollution of the water environment, which affect the quality of drinking water, particularly for villages located in areas adjacent to the landfill.

However, the open leachate pools emit release GHG gases in the form of methane.

Photo: Leachate pool at Telega Punggur landfill in Batam

Energy generation	• Methane from landfill gas is a source of renewable energy. • Power generated from landfill gas is a cleaner source of energy than e.g., coal and oil and could thereby support the green transition of Batam energy supply, however the power generation potential is low compared to other WtE technologies.	Green
Climate and enviromental impact	• Energy production from landfill gas reduce Batam's green house gas emissions through reduction of methane from uncontrolled decomposition of organic materials and the replacement of fossil-based energy sources. • Exhaust local emissions (PM, SOx and NOx) • To reduce the environmental impact of landfills both in terms of emissions and contamination of the water environment, it is advisable to install leachate and gas collection systems and surface sealing systems.	Yellow
Reduction and handling of waste	• Utilizing methane for power generation from existing landfills, does not address Indonesia's waste reduction and waste handling goals.	Red

DEPA, DEA & Ramboll (2022); DEA, DEPA & COWI (2021); Viegand Maagoe Analysis (2022)

LANDFILL GAS POWER GENERATION IS A SIMPLE AND COST-EFFECTIVE TECHNOLOGY WITH SOME ENVIRONMENTAL BENEFITS

Overall assessment of landfill gas

Harvesting and utilization of landfill gas (methane) for power generation is a well-proven technology and exists at many landfills worldwide. Batam has 1 operating landfill (TPA Telega Punggur), which is currently not utilizing methane for power generation. To produce power from landfills, you need a methane capture system and a gas engine. You also need an emergency flare in case of e.g., maintenance of the gas engine.

Electrical efficiency is lower compared to incineration (high efficiency on gas engine but efficiency per ton waste treated is lower due to the harvesting yield). The power production potential of landfills is proportionate to landfill's age and the share of organics disposed on landfills. The older the landfill the more organic waste has already been decomposed resulting in lower methane potential.

For the same reasons, the landfill gas power potential is higher in countries like Indonesia where source separation is at an early stage, since it means the share of organics on landfills is higher.

Landfill gas power generation is a relatively simple technology, and O&M costs are therefore low compared to other WtE technologies.

Methane gas is 27-30 times more potent than CO_2. Landfill gas therefore has significant green house gas (GHG) emissions effects.

Environmental impact	Reduces uncontrolled methane emissions from landfills. While some landfill already have methane collection systems, most of the gas is flared and not utilized. Power generated from landfill gas could replace other (fossil) sources of power. However, landfill gas alone does not contribute to reduction of waste or improved waste handling in Indonesia.	
CAPEX/OPEX	Relatively low investment and low maintenance. Does not require high-skilled labor.	
Land requirement	The area needed for land fill gas is less than 1 hectare, corresponding to the land required for the gas engine.	
Complexity of technology	Relatively simple technology, which consists of a methane collection system, emergency flare and gas engine.	
Maturity of technology in Indonesia	Mature technology, which is already used in Indonesia. Batam could tap into experiences with land fills gas power production from other provinces in Indonesia.	
Requires pre-treatment	Not required.	
Residue Management	Landfills generates effluents or wastewater from rainfall and aerobic and anerobic digestion of waste. This should be treated in wastewater treatment plants before final disposal. This is a case with or without the methane collection system.	

DEPA, DEA & Ramboll (2022); DEA, DEPA & COWI (2021); Viegand Maagoe Analysis (2022)

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AD IS A RENEWABLE ENERGY SOURCE THAT REDUCES METHANE EMISSIONS FROM ORGANIC WASTE STREAMS

Overall sustainability assessment of anaerobic digestion

Anaerobic digestion (AD) is considered CO_2 neutral, since it reduces methane emissions from organic waste and converts it to renewable energy. In the case of Batam, where only a small fraction of organic waste from households and industries is recycled, AD could reduce the amount of organic waste that is disposed of on landfills.

The climate impact of AD however depends on how the AD system is operated, how digestate is stored, and what type of fuel is used for process energy and transport of feedstock.

AD system may have some leakage of methane from the gas pipes, gas storage or the reactor itself. This can however be mitigated in the design process.

Modern AD plants have flue gas cleaning systems for removal of emissions of acid gases, NOx etc. will be higher.

Energy generation	• AD is renewable gas (biogas). When processed in a gas engine, it generates renewable power.
Climate and enviromental impact	• AD reduces the amount of organic waste that ends on landfills, leading to methane emissions reduction from the decomposition of organic materials from e.g. household waste. • Some methane leakages from AD technology should be expected. The more advanced the AD technology is, the lower is methane leakage. • In case digestate is stored in an open pit before it is sent for disposal, there will be emissions of methane
Reduction and handling of waste	• AD is a solution for organic waste streams, which is currently not handled or disposed of in landfills.

IEA (2017); DEPA, DEA & Ramboll (2022); DEA, DEPA & COWI (2021); Viegand Maagoe Analysis (2022)

SIMPLE AD TECHNOLOGIES CAN HANDLE ORGANIC WASTE STREAMS AT RELATIVELY LOW COSTS

Overall assessment of anaerobic digestion

Anaerobic Digestion (AD) is a well-proven technology and exists all over the world in various sizes from farm scale to industrial facilities. AD can in principle treat all types of organic waste, however depending on the complexity of the waste stream, pre-treatment, pasteurization and more advanced stirring and mixing systems may be required.

More advanced technologies, like continuous stirred tank reactors (CSTR) has the potential to generate higher yield. Box-based systems are suitable for waste with a high dry matter content. In some cases, a simple lagoon digester system may be suitable. A lagoon digester is most suited for feedstock with high moisture levels.

Aside from methane gas, AD produces degassed biomass also known as digestate. Digestate can be separated into a solid fraction and liquid fraction, and it can be used as agricultural fertilizer or bedding. When sourcing feedstock for AD, it is therefore important to measure phosphor and nitrogen values, as too high contents of P and N in the digestate can lead to nutrient run-offs and groundwater contamination.

In cases where organic waste is derived from MSW, there is a higher risk of plastic, metals and other contaminants in the digestate. It is therefore advisable to only use source separated waste for AD.

Environmental impact	With AD, Batam could reduce the amount of organics that end up at landfills. This leads to reduction of methane emissions and production of a baseload renewable energy, which can substitute fossil-based energy generation.	
CAPEX/OPEX	Relatively low investments depending on technology. Limited but trained/experienced staff. Sorting, transport and logistics require large staff	
Land requirement	AD takes up ~1-2 hectares. This includes trucks access, biomass storage and the AD plant itself incl. gas engine.	
Complexity of technology	Both advanced and less advanced technologies for AD exist, however it would be possible to start with a relatively simple technology such as a covered lagoon and later upgrade the system by adding mixers and more advanced pumping equipment.	
Maturity of technology in Indonesia	Already used in Indonesia but mainly on agricultural waste. The type of technology most commonly used in Indonesia, is covered lagoon systems.	
Require source seperation	If digestate is distributed on farmland, source separation of organic waste used for AD is required.	
Residue Management	Residues from an AD plant comprises digestate, which can be a source of revenue for the plant owner, however depending on the level of source separation it could be contaminated.	

DEPA, DEA & Ramboll (2022); DEA, DEPA & COWI (2021); Viegand Maagoe Analysis (2022)

MBT IS SUITABLE FOR HANDLING OF MSW AND CAN BE AN INTERMEDIATE STEP IN THE PRODUCTION OF "RENEWABLE ENERGY"

Overall sustainability assessment of MBT

An MBT (Mechanical and Biological Treatment) plant typically consists of a mechanical part and a biological part. The mechanical part could be in the form of a Material Recovery Facility (MRF) for sorting of the incoming waste into various fractions such as an organic fraction and other waste fractions such as plastic, metals, glass, paper, cardboard and residues.

The organic fraction can go for further treatment in the biological part such as an AD and/or Composting facility. Bio-drying is a process that can be used for both the residue fraction (RDF) from the mechanical part and for digestate and/or compost. RDF can be utilized in a co-firing process at either power or cement plants.

MBT is useful in resource recovery, designed to optimize the use of resources remaining in residual waste and could be used in an integrated waste management program.

Energy generation	• If AD on the organic fraction is included, it is renewable gas (biogas). When processed in a gas engine, it generates renewable power. • RDF can be used for co-incineration in cement plants or power plants. • Does not add to Indonesia's renewable energy target alone	
Climate and enviromental impact	• The organic part can be used to produce biogas and is thus considered green biogas. RDF produced is normally sold to offtakes in the cement or power industry.	
Reduction and handling of waste	• Suitable for large scale waste management as MBT can handle MSW (general/residual waste)/C&I waste	

DEPA, DEA & Ramboll (2022); DEA, DEPA & COWI (2021); Viegand Maagoe Analysis (2022)

WELL PROVEN AND FLEXIBLE TECHNOLOGY FOR HANDLING OF MIXED WASTE BUT REQUIRES SKILLED LABOR

Overall assessment of mechanical biological treatment

Mechanical Biological Treatment (MBT) technology consists of a Material Recovery Facility (MRF) that could be either “clean” or “dirty”. A dirty MRF is a waste processing facility, accepting deliveries from a mixed solid waste streams (otherwise known as residual waste or general waste). A clean MRF accepts only source separated materials.

MBT can be done more or less advanced dependent on different factors like costs, product quality and the need for separation.

The easy digestible organic fraction from food waste and residues can be handled in an AD facility and converted to biogas (energy) and fertilizer (nutrients). The digested fraction from the AD facility can be mixed with garden and green waste in a composting facility.

Materials like plastic, metal, glass, paper and cardboard can be sorted out and recycled. Non-recyclable residues can be used as RDF for cofiring in power plants, cement industry or stored for export.

A small portion of the MSW cannot be utilized in any of the above solutions. This fraction has to be disposed at existing landfill or sent for incineration if available.

Environmental impact	MBT can treat and separate almost all waste types, including plastic, metals and organics. A higher availability of MBT systems could help Indonesia fulfil its waste handling and reduction goals. In cases where the organics part is used for energy production, MBT indirectly increased Indonesia’s renewable energy generation potential.	
CAPEX/OPEX	Medium to high investments dependent on sorting options and quality level. Relatively high skilled labour and maintenance costs should be expected.	
Land requirement	~2-3 hectares however very dependent on size, sorting options, etc.	
Complexity of technology	Could be complicated depending on the steps/options in terms of sorting and energy production.	
Maturity of technology in Indonesia	Well proven technology, however very little experience with commercial scale MBT in Indonesia	
Require source seperation	It depends on whether it is a clean or dirty MBT. A clean MBT requires source separation of waste.	
Residue Management	A residue from MBT facilities is a fraction that can neither be recycled, used for RDF or used in the AD plant. This fraction needs to be either disposed at a landfill or incinerated if an incineration plant is available	

DEPA, DEA & Ramboll (2022); DEA, DEPA & COWI (2021); Viegand Maagoe Analysis (2022)

THE FOUR TECHNOLOGIES SOLVE DIFFERENT PROBLEMS – A COMBINATION IS THE MOST LIKELY SCENARIO

Conclusion: none of the 4 technologies should be ruled out

On the previous pages, we presented a methodology for assessing waste-to-energy technologies. Public decision makers may draw inspiration from this methodology when formulating selection criteria for public tenders.

It has not been possible to conclude, which technologies are more feasible, because in the end, it depends on the weight assigned to each assessment criteria. In addition, the technologies solve different problems. While incineration is an efficient technology for removing a large mixed waste stream while producing electricity, anaerobic digestion (AD) technology is suitable for handling bio-waste. AD also produces power, but the generation potential is lower compared to incineration. Opposed to incineration, AD and landfill power, mechanical biological treatment (MBT) does not generate power, but MBT could act as an enabler of other technologies while improving waste sorting and handling. Lastly, landfill gas power is simply utilizing the methane, which is generated from the decomposition of waste in landfills. In other words, landfill power does NOT contribute to waste reduction, which is one of Batam's priorities when it comes to waste management.

In conclusion, Batam will most likely need a combination of all four technologies in order to meet government goals. In any case, it is necessary with more detailed information on the potential of the four technologies. To that end, we recommend following four typical steps related to project maturation.

The project maturation for a WtE project can be broken down into four phases as illustrated below.

1 Identication	• Screening of project and technology ideas.
2 Concept Development	• Pre-feasibility and feasibility studies.
3 Business Development	• Waste supply, permits, off-take contracts and sites, etc.
4 Project Execution	• Civil works, construction and commissioning

Having completed the identification phase, the next step is a pre-feasibility study comparing and pricing realistic options in a local context. A pre-feasibility study can be used to rule out unattractive investments.

WtE project development is complex, and it is therefore recommended to follow a **Project Development Guideline** as the one outlined in Chapter 3.

Ministry of Environment of Denmark
Environmental Protection Agency
Danish Energy Agency
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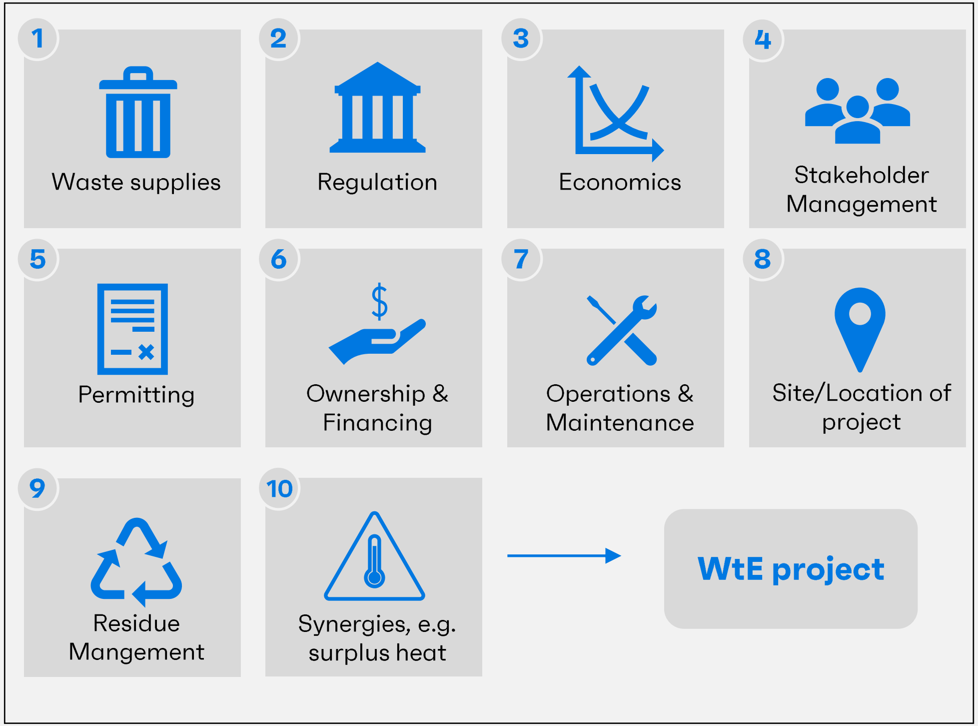
Viegand Maagøe

3. PROJECT DEVELOPMENT GUIDELINE

DEVELOPMENT OF A WASTE-TO-ENERGY PROJECT SHOULD INCLUDE ASSESSMENT OF 10 IMPORTANT STEPS

Project Development Guideline

- This brief project development guideline provides an overview of the steps a developer needs to consider when developing a Waste-to-Energy (WtE) project in Indonesia.
- The guideline is in principle generic but does include country as well as technology specific considerations for Indonesia. Some local context information is provided for Batam.
- The following pages unfold the 10 topics that as a minimum should be covered when embarking on project development for Waste-to-Energy projects.



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TECHNOLOGY CHOICE DEPENDS ON WASTE VOLUME, SHARE OF ORGANICS AND CALORIFIC VALUE OF WASTE

Waste characteristics and technological fit

The calorific value of waste is important when assessing whether a given feedstock is suitable for incineration, and approx. 5.5-6 MJ/kg is considered a minimum to keep the combustion process going without using any auxiliary firing (e.g., natural gas, LPG or oil).

The average calorific value of MSW in a European country is around 9-11 MJ/kg depending on the share of organics. For Batam the heating value is in the lower end at 8-9 MJ/kg. Source separation, upfront separation or additional C&I waste to boost the caloric value could potentially be an answer to this challenge.

Anaerobic digestion (AD) can be based on source separated organics from MSW but could be supplemented by other organic fractions from the industry or the agriculture (waste streams from dairies, breweries, chicken farms, food markets, etc.). Since organic waste constitutes a large portion of the total waste composition in Batam, the potential for power generation from AD is high.

Due to the high share of organics in Batam, resulting in low calorific values, non-source-separated waste is most suited for wet AD technology.

Lastly, when designing plants and on-site storage capacity, it is important to keep in mind the availability of waste.

Calorific value of MSW (MJ/kg.)

Difference between wet and dry AD technology

- Wet anaerobic digestion systems are designed to process biodegradable feedstock into a digestate slurry with typically less than 15% total solids. Consequently, wet systems is based on tank systems using mixers/agitators.
- Using dry anaerobic digestion, the feedstock can be stacked (over 15% solids), with leachate sprayed over the top of it which percolates through the material, breaking it down over a longer retention time.
- The main advantage of wet AD and the continuous process is that it produces higher biogas production over a shorter time period.

Dinas Lingkungan Hidup (2021); Viegand Maagoe Analysis (2022)

REGULATION SUPPORTING WASTE-TO-ENERGY PROJECT DEVELOPMENT

National Waste Policy

Presidential Regulation No.97/2017 is the regulatory framework behind Indonesia's national waste policy and strategy. The regulation sets a 70% waste handling target and a 30% target on waste reduction, reuse or recycle (3R principle) by 2025 compared to the base year in 2017. It is obligatory for local, regional and provincial governments to implement strategies, which are adapted to the local context. It is required to form a strategy, monitor, evaluate and report on progress to the national government.

With a handling rate of 67% in 2020, Batam is well on track to reach one of the two national targets. However, the share of waste following the 3R principle (reduce, reuse, recycle) only reached ~6% in 2020.

In practice, assessing waste handling ratios proves difficult. One of the reasons being that a large portion of waste collection is handled by the informal sector like scavengers. Scavengers also often operate in more regencies, which create a risk of double counting.

As stipulated in **Presidential Regulation No 35/2018**, 12 cities in Indonesia are eligible for additional support for waste-to-energy in the form of higher feed-in-tariffs for electricity and tipping fee contributions from the national government. However, Batam is not (yet) covered by this regulation.

Waste-to-energy regulation: Perpres No. 35/2018

Perpres No. 35/2018 is a specific regulation for accelerating waste incineration implementation in Indonesia in 12 strategic cities (DKI Jakarta Province, The City of Tangerang, Bandung, Semarang, Surakarta, Surabaya, Makassar, Bekasi, Manado, Tangerang Selatan, Palembang and Dempassar).

Perpres No. 35/2018 includes a specific feed-in-tariff for power generated from waste-to-energy and a subsidy from the government to cover the costs of feedstock (so-called tipping fee). **For prioritized cities under Perpres No 35/2018, feed-in tariffs of 13.35 cUSD/kWh for power plants with a capacity of less than 20 MW.**

In addition, projects in prioritized cities may receive a contribution from the state budget to cover the tipping fee – in case the contribution from the local government is insufficient to make the business case financially viable. **The maximum tipping fee for projects located in one of the 12 cities is 500.000 IDR/ton, corresponding to 38.5 USD/ton.**

PERPRES (No. 35/2018); Dinas Lingkungan Hidup (2021); Viegand Maagoe Analysis (2022)

REGULATION SUPPORTING CLEAN/RENEWABLE ENERGY

Regulatory drivers for renewable energy

The national government of Indonesia has set a goal of reaching 23% renewable energy supply in the power sector in 2025 and 31% in 2050. Still, less than 1% of Batam's power supply come from renewables.

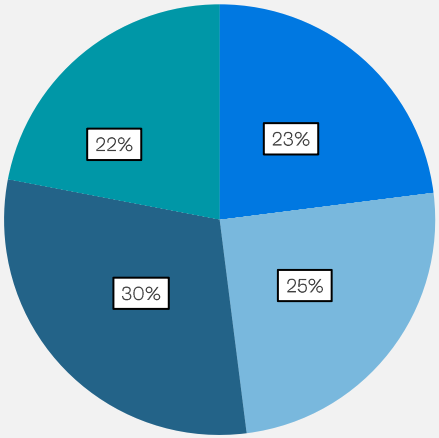
Presidential Regulation No. 50/2019 under the Ministry of Energy and Mineral Resources (MEMR) regulates the price setting of PPA contracts for independent power producers who sell power to PLN.

However, Batam is a special case, because the power system of Batam is owned and operated by PLN Batam – an independent subsidiary of PLN. Since PLN Batam is an unregulated company, PLN Batam does not have to follow the national regulation concerning price-setting for renewable energy. That also means that PLN Batam is not entitled to government subsidies for renewable energies.

The PPA price offered to any power plants including WtE is therefore not likely to be higher than the regional generation costs also referred to as BPP (Biaya Pokok Pembangkitan). In 2022, the BPP in Batam was 1,150 IDR/rupiah corresponding to 7.7 cUSD/KWh.

In the absence of government subsidies for power produced from WtE, the business case relies heavily on the tipping fee. (see page 29)

National Energy Mix in 2025 according to Government Regulation 79/2014



DEA & EA (2021); PLN Batam (2022); Viegand Maagoe Analysis

ECONOMICS – ASSESSING CAPEX/OPEX ELEMENTS

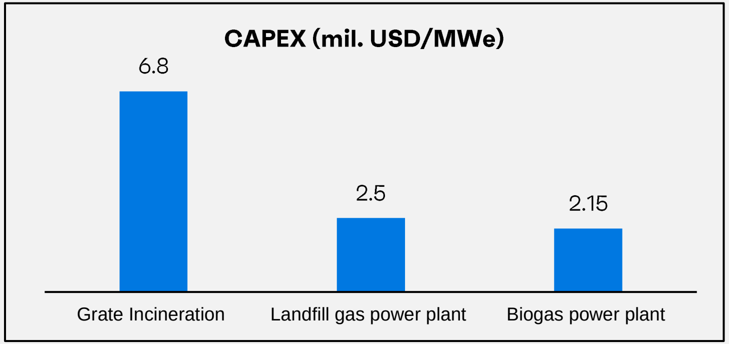
Plant quality must be determined

CAPEX varies across technologies with incineration being the most expensive at around 7 mil. USD/MWe. AD technologies can be acquired for 2-2.5 mUSD/MWe also dependent on complexity. Due to high investment costs for incineration, access to feedstock and tipping fees are determining for the economic feasibility of a project.

For incineration there is economies of scale, and the minimum size is around 10 tonnes per hour. The price/ton treated will decrease up to a unit size of 35-40 tonnes per hour which is the largest unit size available. This economy of scale also applies for other technologies.

Both high quality/high-cost suppliers and low-cost suppliers are available at the world market and thus the quality level of the equipment could vary substantially . For an incineration plant cost for the electromechanical part may vary several hundred percent between cheapest and most expensive, however also with a difference in quality and execution. For the procurement it is important to decide the quality level while drafting technical tender specifications.

OPEX includes elements like manning, administration, insurance, maintenance, consumables and handling of residues. All this could also be included in a long-term O&M contract with a contractor.



	Incineration power plant	**Landfill gas power plant**	**Biogas power plant**
CAPEX	6.8 Mil. USD/MWe	2.5 mil. USD/MWe	2.15 mil. USD/MWe
Fixed O&M	243.700 USD/MWe/year	125.000 USD/MWe/year	97.000 USD/MWe/year
Variable O&M	24.1 USD/MWh	13.5 USD/MWh	0.11 USD/MWh

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DEA, DEPA & COWI (2021); DEA & EA (2021); Viegand Maagoe Analysis (2022)

ECONOMICS – TIPPING FEES AND RESIDUES ARE SOURCES OF REVENUE FOR THE WTE PLANT OWNER

Tipping fees are difficult to negotiate due to budget constraints

Tipping fees, which are also called gate fees, typically constitute a critical source of revenue in a waste-to-energy project. This is particularly true for WtE projects in Batam due to the absence of government subsidies for power produced from renewable energy (see page 27).

Pre-feasibility studies for WtE conducted in Batam conclude that tipping fees ranging between 350,000-500,000 IDR/ton are needed to obtain a financially viable business case. However, due to budget constraints, the municipal government of Batam has indicated that they are not willing to provide a tipping fee for WtE technologies.

Although Indonesia has regulation (Perpres 35/2018, see page 26) that makes it possible to apply for national government subsidies to cover tipping fees that cannot be financed by the municipal budget, Batam is not one of the 12 cities covered by the regulation. Tipping fees are less sensitive to the bankability of landfill gas projects and biogas projects since these technologies are less capital intensive.

Residues in the form of digestate from AD or RDF are another potential source of revenue from waste-to-energy plants. It should be noted that residues from incineration may imply cost as especially flue gas cleaning residues need to be treated as hazardous waste (treatment cost in Europe are typically 150 USD/ton).

What is a tipping fee?

A tipping fee is a charge for waste disposed of at a landfill or other waste handling facility. The tipping fee is based on the weight of the waste that is disposed of. The tipping fee helps to cover the operational costs of a waste handling facility. The tipping fee is paid by anyone who disposes waste at a landfill or WtE facility.

Sales of by-products

Waste-to-energy plants generate a number of by-products or residues, which depending on regulation, level of post-treatment and demand, can be monetized and sold in various markets. Digestate, which is a by-product from AD, can for instance be used as crop fertilizers or animal bedding. The market demand for digestate for use as biological fertilizers often depends on the availability and costs of synthetic fertilizers. Depending on the composition of feedstock in AD, digestate may also have higher nutritious value for farmers.

Dinas Lingkungan Hidup (2021); Viegand Maagoe Analysis (2022)

MAP STAKEHOLDERS AND IDENTIFY NECESSARY PERMITS

Stakeholders and agreements in a WtE project

To complete a WtE project, several agreements, permits and contracts should be in place. This could include a loan agreement with financiers, grid interconnection agreement, waste supplies contracts and sales contract. Depending on the ownership model, the sales contract would typically be a PPA Agreement with PLN. Others include contracts with consultants, construction companies etc.

All aspects are vital for a financially sustainable project. If these agreements are missing, the project developer faces large risks. While some processes run in parallel, others are overlapping and interdependent. For example: most financial institutions want to see waste supply agreements and off-take agreements before they want to commit to a loan. Similarly, a developer should expect to front load costs related to permitting before a financial investment has been made, simply because environmental permits tends to be a lengthy process.

Negotiating terms of contracts and obtaining permits require a significant degree of stakeholder management to ensure that attractive pricing is achieved, and significant project risks are observed early in the process so these can be mitigated. The more complex the WtE project is, the more stakeholder engagement and management is needed.

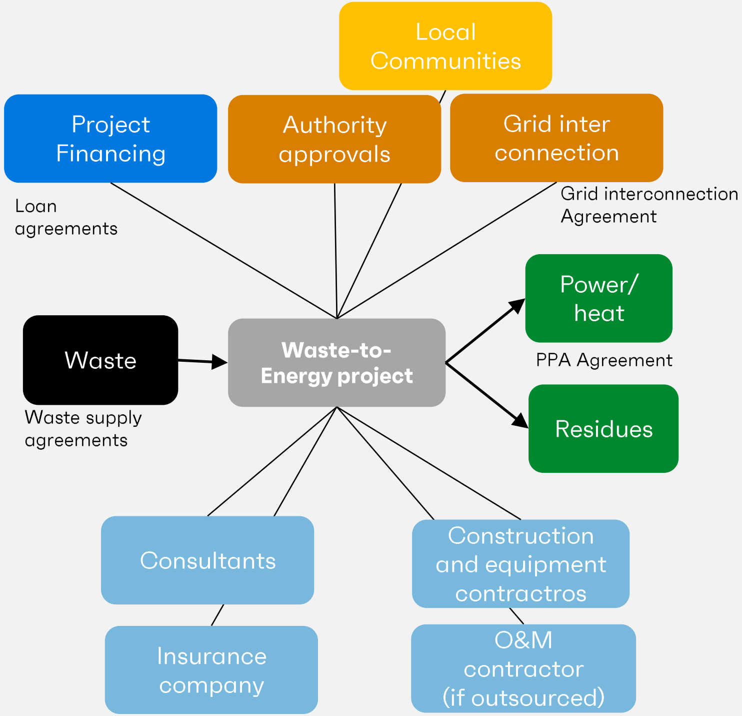
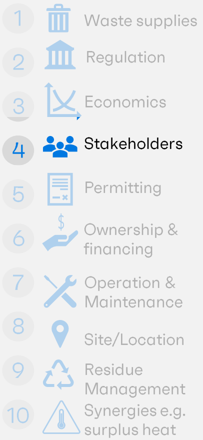


Figure: Converting Waste to Energy, Viegand Maagoe



IFC (2017); Viegand Maagoe Analysis (2022)

STAKEHOLDER ENGAGEMENT AT THE PROVINCIAL AND LOCAL LEVEL IS NECESSARY

Selected key stakeholders in Batam

Waste-to-energy generation in Indonesia involves a large group of stakeholders and public agencies. A natural starting point is to liaise with **Batam DLH** and **Bappelitbangda** as those organizations are responsible for the planning and managing of solid waste in Batam. They could connect developers with large waste generators or community organizations in charge of the local waste management around the island. **The public works and spatial agency (DPU)**, is authorized to undertake infrastructure planning and may facilitate funding for CAPEX expenditures. Besides, DPU is responsible for approval of sites for WtE.

It is also advisable to visit **Telega Punggur landfill** (managed and operated by DLH) to obtain a hands-on experience of the waste composition and waste system of Batam. Besides, the landfill in Telega Punggur is already investigating different WtE options, which will be useful to learn about for potential developers/investors.

It is recommended to understand the provincial priorities and potential support for renewable energy by talking to **Dinas ESDM for Kepri Islands.** Furthermore, any investor interested in Batam should connect with **BP Batam** to learn about financial and tax benefits regarding setting up a business in Batam. Lastly, **PLN Batam** is important for negotiating the PPA agreement and connection to the grid.

Stakeholder	Role in the waste-to-energy project development
Batam City Environment Office (Dinas Lingkungan Hidu, DLH)	Managing the implementation and operational activities of solid waste in Batam. Dinas LHK owns Batam's only landfill located in Telaga Punggur.
Dinas ESDM Riau Province	Regulator of energy planning and integration of renewables for Riau Islands. Responsible for implementation of national renewable energy targets on Riau Islands.
Dinas Pekerjaan Umum (DPU)	Dinas PU is the Public and Spatial Planning Agency of Batam. DPU is responsible for large-scale infrastructure provisions and approval of funding for capital expenditures related to WtE.
Bappelitbangda of Batam City	Responsible for the long-term development plan of Batam, including planning of government budget and development activities related to waste management.
BP Batam	Since 2007, an authority designed by the Central Government to manage the Free Trade Zone and Free Port of Batam. In relation to WtE, BP Batam's role is to support investments (incl. attracting financing) and regulation.
PLN Batam	Vertically integrated power company in Batam. PLN Batam is a subsidiary of PLN Holding. PLN Batam is responsible for grid connection and the PPA contract.

PERMITTING REQUIREMENTS SHOULD BE IDENTIFIED AT AN EARLY STAGE

Permits for a waste-to-energy project

Waste and energy projects typically require several approvals, some of them with a long lead time and thus the application process must be planned well in advance before they are needed. The permitting process typically gives the critical path in a project up to financial close.

Three types of permits are common in a waste to energy project 1) Environmental Impact Statement and Environmental Approval (EIS/EIA), 2) Building Permit and the 3) Operational permit.

Local conditions may tricker other applications like connection to the grid, sewage, etc.

Especially Environmental Impact Statement (EIS) and Environmental Approval may be costly as specialized consultants are needed and the public involvement process may be challenging. Transparency with the authorities and public is normally a key to success in the permitting process.

It is recommended to get a full overview of permits needed at an early stage and to liaise closely with the authorities and the community stakeholders from the very beginning.

Environmental Approval (EIA)

An EIA permit is granted when the government have approved that the design of the facility lives up to environmental standards and regulation related to, e.g. emissions, exhausts, and groundwater protection.

Building/construction permit

The building permit is the developer's right to build in a specific location. The approval of the building permit is typically more smooth if the location of the project is an industrial zone or even better – if it has previously been used for waste management activities.

Operational permit

The operational permit is the the developer's license to operate. In the case of a waste-to-energy project, an operational permit involves the right to operate as a waste management and electricity provider.

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DECIDE ON PROJECT OWNERSHIP STRUCTURE

Typical project ownerhip structures

The ownership structure of a WtE projects can be divided into three overall categories:

1) A public project developed, owned and financed by the local council or other public entities (operation can either be with own staff or outsourced)

2) A Public-Private-Partnership (PPP) between a private investor/ contractor and the local waste authorities signing long term waste supply agreements.

3) Merchant/commercial project (also known as IPP when it comes to power production) developed, owned, financed and operated by a private entity based on long term waste supply agreements (also with private waste management companies) and Power Purchase Agreements

Since 2017, developers of renewable energy in Indonesia were required to transfer their assets to PLN upon expiry of the PPA contract. This project model, also known as "BOOT" (build-own-operate and transfer) was scrapped in 2020, since the requirement to transfer the renewable asset to the state compromised the bankability of the project. This regulatory change is expected to increase the investments into renewable energy and waste-to-energy projects in Indonesia.

Weighted Average Cost of Capital (WACC) = 12%

$$WACC = \%D \ x \ i\_D \ (1-t) + \%E \ x i\_E$$

Share of debt of total project financing (%)	%D	70%
Cost of debt (commercial loan interest rate)	i_D	13%
Tax rate	t	25%
Share of equity of total project financing (%)	%E	30%
Costs of capital using CAPM formula	i_E = rf+B(rm-rf)	17%
Risk free return	Rf	6%
The risk of conducting business expressed as Beta (B)	B	1.2
Market return	rm	15%

The ownership and financing model for a WtE project depends on the developers' access to capital, regulation and risk profile. Where project financing depends on both equity and loan, the costs of capital can be calculated by using the WACC formula. The costs of capital for renewable projects in Indonesia is assumed to be 12%.

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ADB (2020); DEA & KPMG (2019); Viegand Maagoe Analysis (2022)

DECIDE O&M STRATEGY: IN-HOUSE OR OUTSOURCING?

Who should conduct O&M?

A developer/owner of a waste-to-energy facility should decide on how to perform Operations and Maintenance (O&M). One option is outsourcing by engaging a long-term O&M contractor and another having O&M resources in-house.

There are however several options in between, for example maintenance can be fully or partly outsourced to external contractors as this mainly takes place in the few weeks of the major overhaul. We often see owners taking responsibility for the operation with their own staff including a few maintenance staff responsible for the day-to-day maintenance. Larger maintenance jobs including insulation, scaffolding, boiler and refractory repair, etc. are outsourced to local and specialist contractors.

Another way is to contract maintenance on a component/plant basis, e.g., sign a maintenance contract with the original equipment suppliers on specific components like turbine, boiler and gas engines.

Local content requirements and local competences should be considered when deciding on outsourcing or in-sourcing of O&M activities.

In-house O&M	Outsourcing O&M
• Control of Operation with own staff that improves skills and knowledge of the plant (could be utilized in other plant later) • The long-term maintenance level may be secured better than if outsourced (O&M contract is typically fixed in time) • To a large degree independence of external assistance (time and cost wise)	• The responsibility/risk of O&M is taken by a contractor that typically gives guarantees on e.g. availability and treatment capacity. Use of spare parts is normally the contractor's responsibility • More expensive as the O&M contractor requires an overhead and a risk premium. On the other hand, the experienced contractor may introduce a high operation efficiency that is otherwise difficult to achieve.

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FIND LOCATION AND CONSIDER INFRASTRUCTURE, WASTE VOLUMES AND ENVIRONMENTAL RESTRICTIONS

Important questions when it comes to location

A critical step in developing a WtE project is finding a suitable location. Location must therefore be considered at an early stage in the development process, in order to assess whether it is worthwhile to spend more resources on project development. With regards, to location, the following questions should be investigated:

1. Is the required waste resources available in reasonable distance and with the requested quality (waste supply agreements must be explored)?
2. Does the site have reasonable planning conditions, preferable a brown field site?
3. Are there any environmental limitations (e.g., nature reserve)?
4. Does the site have reasonable ground conditions (easy foundation) and hereunder no or little contamination?
5. Does the site have good access roads for waste trucks and other trucks?
6. Are there any noise sensitive neighbors nearby?
7. Is grid connection available at a close distance (should be able to absorb all exported power without upgrades)?
    - It is also important to investigate who is paying for the grid connection (PPA and grid connection agreement must be explored)
8. Are the necessary utilities available nearby (water, sewer, etc.)?

Below table shows indicative space requirements for different technologies. It should be noted that space requirements are very dependent on the need for e.g., treatment capacity and storage capacity. The values are therefore not directly comparable and should be read merely as a best guess.

Incineration power plant	**Landfill gas power plant**	**AD power plant**	**MBT plant**
3-5 hectars or more dependent on size	<1 hectar (only power plant w. gas engine)	1-2 hectars dependent on size	2-3 hectars dependent on size

Anaerobic digestion (AD) requires less land than incineration while MBT also requires substantial land especially if combined with an Anaerobic digestion plant and power production using gas engines.

Additional land may be needed for storage, preassembly, welfare facilities and carpark during construction, bottom ash storage, sorting as well as fly ash storage.

It is advised to conduct a thorough site selection investigation in the a very early stage of the development phase.

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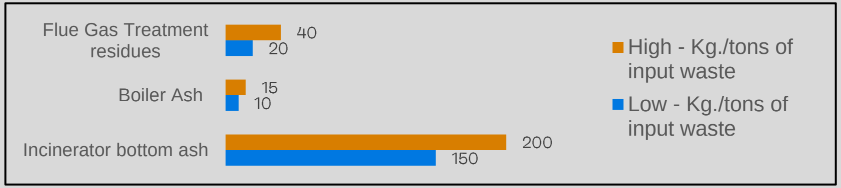
RESIDUE MANAGEMENT FOR SOME TECHNOLOGIES IS SUBJECT TO REGULATORY CONSTRAINTS AND AMENDMENTS

Residues from Waste-to-Energy plants

Waste-to-energy technologies generate residues. Residues are by-products, which may be reused or disposed of. In this respect, it is important to get familiarized with the regulation and costs associated with disposal of waste products. Some residues may have market value, in which case it becomes important to investigate potential off-takers and their willingness to pay. Incinerator bottom ash can for instance be reused for construction purposes and in some European countries it is used for road construction as a base layer substituting natural gravel. Denmark reuses approx. 99% of all bottom ash for road construction purpose. It is also possible to extract valuable metals (e.g., gold and silver) from the bottom ash using advanced sorting plants. In some cases, changes in regulation are required in order to enable the sales of residues. It is therefore advisable to investigate the rules and potentials and liaise with authorities early in the project development process.

The graph below shows indicative volumes of residues generated from incineration showing a low and a high estimate.



Typical residues from three WtE technologies

Incineration

Incineration plants generate three types of solid residues:

- Incombustible matter (ash) that remains on the grate is referred to as Incinerator Bottom Ash. I may be used for construction purposes.
- Solid residues generated from the flue gas treatment process also called Air Pollution Control (APC) residues is a mixture of activated carbon and lime and it contains hazardous substances like heavy metals and dioxin/furans.
- Boiler ash or fly ash is collected in the boiler.

Mechanical biological treatment (MBT)

A residue from MBT facilities is a fraction that can neither be recycled, used for RDF or used in the AD plant. This fraction needs to be either disposed at a landfill or incinerated if an incineration plant is available.

Anaerobic Digestion (AD)

The residues from Anaerobic Digestion is called digestate. Digestate can be separated into a solid fraction and a liquid fraction. The liquid fraction can be upgraded and used in fertilizing industry or be applied directly as fertilizer on farmland. The solid fraction can be used as soil amendment. It is important check if the quality of the digestate is sufficiently good to ensure that the use for fertilization purposes comply with relevant regulation.

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UTILIZING SURPLUS HEAT CAN BOOST THE BUSINESS CASE

How can the heat be utilized?

Incineration produce high pressure steam that can run a steam turbine/generator producing electricity that can be exported to the high voltage grid.

The surplus heat in the steam leaving the turbine backend needs to be cooled away, typically in an air-cooled condenser.

The surplus heat could potentially be used either as low-pressure steam for industrial purposes (intermedium extraction at the steam turbine) or as hot water for industrial purposes, e.g., process industry, absorption cooling, desalination, etc. In order to ensure a sound basis for the business case, it is critical that the developer can secure a stable offtake agreement of surplus heat with e.g., a desalination plant, a mall or a public building.

It is a preference however that the off taker is very stable and reliable to form basis of the business case, e.g., a desalination plant, a mall or a public building.

The electrical efficiency of incineration is 25-30% but if the surplus heat is utilized, the total efficiency of the plant could be 90% or higher.

Gas engines also offer the opportunity to produce steam/heat (exhaust gas, oil cooler, etc.) in addition to the power output.

Pros of utilizing surplus heat

- Increases the overall plant efficiency
- Increases revenue from sales of steam/hot water

Cons of utilizing surplus heat

- The electrical efficiency will decrease slightly but might be outweighed by sales of heat/steam
- Is slightly more capital intensive
- The financial viability of a business case, which includes surplus heat utilization, may not be robust enough considering the risk of off-takers go bankrupt or close.

1 Waste supplies
2 Regulation
3 Economics
4 Stakeholders
5 Permitting
6 Ownership & financing
7 Operation & Maintenance
8 Site/Location
9 Residue Management
10 Synergies e.g. surplus heat

Ministry of Environment of Denmark
Environmental Protection Agency
Danish Energy Agency
INOVASI DINAMIKA PRATAMA
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4. REFERENCES & LIST OF INTERVIEWEES

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LIST OF INTERVIEWEES

1	Office of Environment of Batam City (Dinas Lingkungan Hidu, DLH)
2	The Planning, Research and Development Agency (Badan Perencanaan Pembangunan dan Penelitian Pengembangan Daerah/BAPELITBANGDA) of Batam City
3	Technical Services Unit of DLH Batam responsible for TPA Telaga Punggur Landfill
4	PT PLN Batam
5	Office of Industry of Batam City
6	BP Batam


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