Good Practices and Technologies for

CLIMATE-FRIENDLY MUNICIPAL SOLID WASTE MANAGEMENT

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กรมควบคุมมลพิษ POLLUTION CONTROL DEPARTMENT

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Wastewater Management Authority


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DISCLAIMER

This guidebook is an output of the Integrated Waste Management for GHG reduction (TGCP-Waste) Project under Thai-German Climate Programme. The project is jointly implemented by the Pollution Control Department (PCD) of the Ministry of Natural Resources and Environment (MoNRE) and the Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH and funded by IKI of the Federal Ministry for Economic Affairs and Climate Action (BMWK). The data and information presented in this book reflect comprehensive study work on low carbon MSW and DWW management systems in Thailand and abroad conducted between April to December 2021.

Due to the limited details given in the e-book, the responsible implementing agencies, PCD and GIZ together with the Project Management Unit (PMU) strongly recommend to consult with experts in municipal solid waste and domestic wastewater management to ensure the practices demonstrated in this book are properly understood and applied in the specific context

INTRODUCTION

Thailand has ratified the Paris Agreement under the United Nations Framework Convention on Climate Change (UNFCCC) since 2016. Under the Paris Agreement, parties are required to make efforts related to climate change including reduction of greenhouse gas (GHG), climate change adaptation, building climate-resilience, and to submit plans for climate action known as nationally determined contributions (NDCs) every 5 years. From the 26th session of the Conference of the Parties (COP26) in Glasgow, the United Kingdom in 2021, Thailand has announced the target of 20-25% GHG reduction by 2030 or 40% reduction subject to provided international supports. Thailand also aims to become carbon neutrality by 2050 and to achieve Net Zero Greenhouse Gas Emission by 2065.

The Pollution Control Department (PCD) is the main agency responsible for formulation of GHG reduction measures in the waste sector, providing technical supports to other implementing agencies, and providing supports for Measurement Reporting and Verification (MRV) of municipal solid waste (MSW) management and domestic wastewater management for Thailand. PCD, in cooperation with the Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ), under the Thai-German Climate Programme - Waste Sector (TGCP-Waste), have commissioned the King Mongkut's University of Technology Thonburi (KMUTT) and Kasetsart University to study and compile good practices and best available technology on climate-friendly and low-carbon MSW and domestic wastewater management to disseminate good examples of GHG reduction in the waste sector in Thailand.

In addition to data compilation, there is an implementing mechanism based on the working group known as the Project Management Unit (PMU). PMU comprises experts representing various agencies including Office of Natural Resource and Environment Policy and Planning (ONEP), Department of Environmental Quality Promotion (DEQP), Department of Local Administration (DLA), Thailand Greenhouse Gas Management Organization (Public Organization) (TGO), Wastewater Management Authority (WMA) and Bangkok Metropolitan Administration (BMA). These experts provide technical support by giving recommendations on GHG calculation methodology, selection of reference sources and on the results of the study to improve data quality through monthly meetings.

The Pollution Control Department truly wishes that basic knowledge from this document can be utilized as a guidance for local administration organizations to study good practices and best available technology on GHG reduction from MSW and domestic wastewater management and to consider waste management options that are climate friendly and in accordance with the national GHG reduction targets.

Pollution Control Department

Ministry of Natural Resources and Environment

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ARE SOLID WASTE ACTIVITIES WHICH INCLUDE COMMUNITIES THAT DO NOT AFFECT THE CLIMATE OR DESTROY THE ENVIRONMENT BY EMISSION OF VARIUOS POLLUTANTS.

IN ADDITION, IT EMITS GHG LESS THAN THE BASELINE CASE

1

TERMS AND DEFINITIONS OF BEST PRACTICES AND TECHNOLOGIES FOR CLIMATE-FRIENDLY MUNICIPAL SOLID WASTE MANAGEMENT

1.1 TERMS AND DEFINITIONS

In this document, the terms and definitions of the good practices and technologies for climate friendly MSW management are defined as follows.

GOOD PRACTICES FOR CLIMATE-FRIENDLY MUNICIPAL SOLID WASTE MANAGEMENT

This refers to actions or activities for MSW management at the point of origin (upstream), midstream, and downstream that do not contribute to climate deterioration by emitting lower GHG or reducing GHG emissions compared with the baseline and also cause less environmental effects and health hazards from their operations. Good practices are often implemented at upstream such as waste prevention, waste reduction, waste sorting and material recovery.

TECHNOLOGIES FOR CLIMATE-FRIENDLY MUNICIPAL SOLID WASTE MANAGEMENT

This refers to technologies for MSW management implemented at upstream, midstream, and downstream that do not contribute to climate deterioration by emitting lower GHG or reducing GHG emissions compared with the baseline and also cause less environmental effects from their operations.

Most of the technologies for climate-friendly MSW management are waste treatment and disposal technologies at midstream and downstream. For example, these technologies are the organic composting, the anaerobic digestion of waste, the thermal treatment of waste and the semi-aerobic landfills.

1.2 HOW THAILAND'S GOOD PRACTICES AND TECHNOLOGIES FOR CLIMATE-FRIENDLY MUNICIPAL SOLID WASTE MANAGEMENT SHOULD RESEMBLE

To consider which good practices and technologies are climate-friendly in municipal solid waste management in Thailand, various contexts must be considered according to the following criteria.

1.2.1 COMPLIANCE WITH THE TERMS AND DEFINITIONS

Less impacts on climate deterioration

- Reduce the direct GHG emissions from the waste sector as well as other sectors by reducing methane and nitrous oxide emissions.
- Reduce and/or avoid the indirect GHG emissions from the waste sector as well as other sectors by, for example, less fossil fuels consumption in the transportation sector, energy saving from avoidance of primary materials production due to material recovery, and alternative fuels from waste that can replace fossil fuels for electricity generation in the energy sector.
- Emit low amount of greenhouse gas per amount of municipal solid waste disposed.

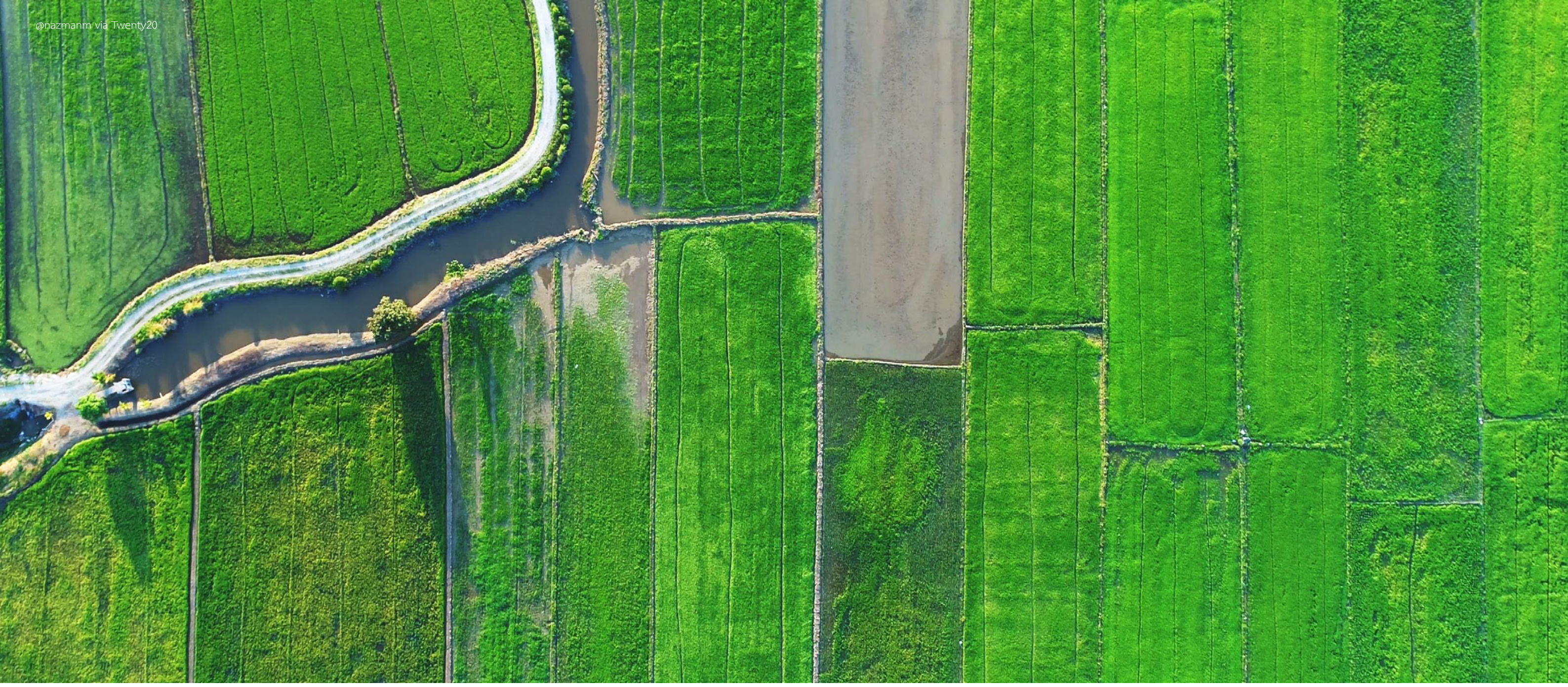
Less harmful to the environment and health

- Reduce the production of other air pollutants such as particulates and unpleasant odours.
- Reduce the production of other pollutants and possible damages that could occur in the atmosphere and surrounding ecosystems.

1.2.2 SUPPORTING THE NATIONAL GREENHOUSE GAS REDUCTION TARGETS AND MUNICIPAL SOLID WASTE MANAGEMENT POLICIES

National greenhouse gas reduction targets

Implementations of good practices and technologies for climate-friendly MSW management should support the country's GHG reduction target (Nationally Determined Contribution) for 2030, the target to achieve carbon neutrality by 2050 and the goal of achieving net-zero GHG emissions by 2065.



National policy

Implementations of good practices and technologies for climate-friendly municipal solid waste management should support the national MSW management policy and action at the upstream, midstream, and downstream management and accord with the country's waste management master plan, which is to:

- Reduce waste generation at the point of origin
- Promote waste utilisation
- Use waste disposal technologies that help reduce greenhouse gas emissions

1.2.3 APPROPRIATENESS AND TECHNICAL FEASIBILITY FOR IMPLEMENTATION IN THAILAND

The following issues should be considered:

- Efficiency in management, treatment and disposal of MSW, and in reductions of pollutant emission
- Requirement for land or area to install climate-friendly technologies to treat or dispose of MSW
- Necessity and complexity of operating and maintaining the system to run continuously; needs for sophisticated control systems and devices that require highly-skilled personnel.
- Necessity and complexity of MSW handling during the treatment and disposal process
- The operational lifespan of systems or technologies that can work continuously; the flexibility and adjustability of the system to suit the changing amounts and characteristics of MSW.

1.2.4 SUPPORTING THE SOCIAL AND ECONOMIC DEVELOPMENT TO ACHIEVE THE SUSTAINABLE DEVELOPMENT GOALS (SDGS)

The following issues should be considered:

- The perception and acceptance of people, community and society.
- The existing process for encouraging public participation in MSW management
- The suitability of the investment and its benefits to people, community and society
- The increase of locals employment, land-use change, and the utilisation of by-products obtained from local MSW treatment and disposal system.


ขยะทั่วไป
ขยะอินทรีย์
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ขยะอันตราย

2

SELECTION OF GOOD PRACTICES AND TECHNOLOGIES FOR CLIMATE-FRIENDLY MUNICIPAL SOLID WASTE MANAGEMENT

2.1 MUNICIPAL SOLID WASTE MANAGEMENT IN THAILAND

Waste management in Thailand can be divided into three levels: 1) upstream management (at source), which refers to management at the waste origin, such as in households, shops, government offices, department stores, etc. before it is transferred for further treatment; 2) midstream management, which involves the collection and transfer of municipal solid waste from the origin to the unloading station, material recovery facility and municipal solid waste sorting facility with a mechanical-biological waste treatment system; 3) downstream management, which is mostly related to final waste treatment and disposal technologies.

Figure 2.1 illustrates waste management at the upstream, midstream, and downstream levels. Practices and technologies with high potential that meet the criteria of being climate-friendly are presented in orange.

Upstream

- Waste reduction
- Waste sorting and material recovery at the source
- Home composting
- Law and regulation (ie: drop product or drop section decisions, extended producer responsibility)
- Marketing tools (ie: deposit expense, influent and motivation)

Midstream

- Environmentally friendly low-carbon waste collection
- Environmentally friendly low-carbon waste transfer
- Material recovery facility
- Mechanical-biological treatment with biodrying process and refuse-derived fuel (RDF) production.
- Refuse-Derived Fuel Production : RDF Production

Downstream

- Composting technology
- Anaerobic digestion technology
- Waste-to-energy incineration (WtEI) technology
- Semi-aerobic landfill technology
- Landfill gas-to-energy technology
- Gasification technology
- Pyrolysis technology
- Landfill gas flaring technology

Selected best practices and technologies which appeared in this e-book   Not mentioned in this e-book

Figure 2.1 Waste management at the upstream, midstream, and downstream levels.

2.2 SELECTION OF GOOD PRACTICES AND TECHNOLOGIES FOR CLIMATE-FRIENDLY MUNICIPAL SOLID WASTE MANAGEMENT

2.2.1 CALCULATION OF BASELINE AS USUAL (BAU) GREENHOUSE GAS EMISSIONS AND EMISSION REDUCTIONS FROM GOOD PRACTICES AND TECHNOLOGIES

The potential or capacity for greenhouse gas emission reduction is the crucial element in the selection of good practices and technologies for climate-friendly municipal solid waste management. The calculation of greenhouse gas emissions and reduction must be accurate and transparent. The methodologies used must refer to reliable information sources such as the Intergovernmental Panel on Climate Change (IPCC), which is globally recognised for climate change information, or the Thailand Voluntary Emission Reduction Program (T-VER), which is verified by the Thailand Greenhouse Gas Management Organization (TGO). Other accepted methodologies may also be used, e.g., the Greenhouse Gas Protocol. However, each methodology has unique objectives and different calculation assumptions. The conditions of each methodology must, therefore, be understood before implementation. In general, there are two scenarios for calculating the greenhouse gas emissions from municipal solid waste management good practices and technologies.

Calculating GHG reductions from municipal solid waste management can be classified into two terms of emission:

1) **Baseline emissions** are GHG emissions without the implementation of good practices or technologies for climate-friendly municipal

solid waste management. This refers to municipal solid waste that is disposed of using the typical technology across the country, which is the landfill disposal. Baseline emissions are calculated with municipal solid waste activity data (e.g., waste composition and volume) on landfill disposal. These activity data are used with the emission factors of landfill disposal and the recommended values from the IPCC to calculate the baseline emissions, which is mainly comprised of methane and converted into carbon dioxide equivalents for comparison with climate-friendly good practices or technologies.

2) **GHG emissions from the implementation of climate-friendly good practices or technologies** are calculated from municipal solid waste activity data generated by good practices or technologies and the emissions factor of each technology implemented, which may be a recommended value from the IPCC or a country-specific value that was obtained from actual measurements of the technology. The GHG emission, in this case, consists of methane, nitrous oxide or carbon dioxide, depending on the technology, and is converted into carbon dioxide equivalents for comparison with the baseline emissions.

THE AMOUNT OF GHG EMISSION REDUCTION EQUALS THE AMOUNT EMITTED FROM THE BASELINE EMISSION SUBTRACTED WITH ONE EMITTED FROM ACTIVITIES OF GOOD PRACTICES AND TECHNOLOGIES.

2.2.2 EMISSIONS FROM THE WASTE SECTOR, EMISSIONS FROM OTHER SECTORS AND THE AVOIDED EMISSIONS

Reducing the greenhouse gas emissions from the waste sector refers to the amount of greenhouse gas emissions **directly produced by good practices or technologies compared with baseline emission.** For example, the amount of methane reduced in municipal solid waste management by using semi-aerobic landfills compared with the amount of methane released from the baseline emission scenario of a landfill.

The **amount of GHG emissions outside the waste sector** refers to the amount of GHG emissions produced by good practices or technologies that contribute to increasing or reducing the GHG emissions in other sectors, such as the energy sector. For example, sorting and recycling plastics helps reduce carbon dioxide emissions in plastics production from the energy, industrial and other sectors. Increasing or decreasing emissions in this way is considered indirect emissions. These emissions can be calculated with the carbon cycle assessment system.

Avoided emissions refer to the amount of greenhouse gas reduced by using recovery products from good practices or technologies to offset the fossil fuels consumed in the energy sector. For example, methane gas obtained from the landfill process can be used to replace coal for electricity generation. Therefore, avoided emissions are calculated based on the amount of fossil fuel used to generate electricity in the power plant.

2.2.3 TECHNICAL AND SOCIAL SELECTION

The elements that support decision-making in selecting the appropriate good practice or technology according to each aspect were considered. The assessment was conducted with a scoring system developed by municipal solid waste management experts in which scores were ranked as low, medium or high.

2.3 SELECTED GOOD PRACTICES AND TECHNOLOGIES FOR CLIMATE-FRIENDLY MSW MANAGEMENT

2.3.1 GOOD PRACTICES FOR CLIMATE-FRIENDLY MUNICIPAL SOLID WASTE MANAGEMENT

Best practices for climate-friendly municipal solid waste management	Greenhouse reduction percentage compared with the BAU			Greenhous gas avoidance percentage	Greenhouse gas reduction percentage from project	Technical feasibility	Social and economic aspect
	Inside waste sector	Outside waste sector	Total			Level	Level
Waste sorting and material recovery at the source	19.71	38.87	58.58	0.32	58.90	High	Moderate
Composting at home (80% of public participation rate)	21.29	-	21.29	0.28	21.57	High	Moderate
Waste production resuction	5.00	-	5.00	0.07	5.07	High	Moderate
Home composting (10% of public participation rate)	2.66	-	2.66	0.04	2.70	High	Moderate

The results of the greenhouse gas emissions reduction assessment of good pracitices climate-friendly municipal solid waste management options compared with baseline emissions, including the calculated percentage of GHG reductions and ranking of high-potential good practices for reducing GHG emissions for each solid waste management practice are summarised in the table.

The assumptions used in the preliminary calculations are as follows:

- Waste reduction: the amount of municipal solid waste disposed of in landfills is reduced by 5% of the municipal solid waste generated.
- Waste separation and materials recovery: the amount of municipal solid waste disposed of in the landfill is reduced by 25% of the municipal solid waste generated.
- Home composting with 10% participation: 50% of organic waste is managed with home composting. This reduces the amount of municipal solid waste disposed of in the landfill by 3% of the amount of municipal solid waste generated.

- Home composting with 80% participation: 50% of organic waste is managed with home composting. This reduces the amount of municipal solid waste disposed of in the landfill by 22% of the amount of municipal solid waste generated.

2.3.2 TECHNOLOGIES FOR CLIMATE-FRIENDLY MUNICIPAL SOLID WASTE MANAGEMENT

The results of the GHG emissions reduction assessment technologies for climate-friendly solid waste management compared with baseline emissions, including the calculated percentage of GHG reductions and ranking of high-potential technologies for reducing GHG emissions for each solid waste management technology are summarised in the table.

Technologies for climate-friendly municipal solid waste management	Greenhouse reduction percentage compared with the BAU			Greenhous gas avoidance percentage	Greenhouse gas reduction percentage from project	Technical feasibility	Social and economic aspect
	Inside waste sector	Outside waste sector	Total			Level	Level
Mechanical-biological treatment with bio-drying process and refuse derived fuel production (include coal transport)	93.1	35.4	128.5	-	128.5	Moderate	Moderate
Mechanical-biological treatment with bio-drying process and refuse derived fuel production (exclude coal transport)	93.1	(2.0)	91.1	-	91.1	Moderate	Moderate
Waste-to-energy incineration	53.9	(2.5)	51.5	12.2	63.7	Moderate	Moderate
Landfill gas to energy	24.4	2.6	30.1	2.6	32.7	Moderate	Moderate
Semi-aerobic landfill	50.0	-	50.0	-	50.0	High	High
Composting	23.6	(3.3)	20.3	-	20.3	Moderate	Moderate

Note: The project activity operated in the technology has higher greenhouse gas emissions than BAU

MUNICIPAL SOLID WASTE

3

SELECTION OF GOOD PRACTICES AND TECHNOLOGIES FOR CLIMATE-FRIENDLY MUNICIPAL SOLID WASTE MANAGEMENT

The results of implementing good practices and technologies for climate-friendly municipal solid waste management on site are likely to be slightly different as the characteristics and situations of the implementing areas will affect the greenhouse gas emission reduction. In addition, the calculated greenhouse gas assessment may differ from the actual measurement due to the assumptions made for the calculations in cases of insufficient actual data.

The content in this chapter presents the calculation of greenhouse gas emission reduction from climate-friendly good practices and technologies implemented in Thailand and abroad by selecting good practices and technologies with high potential to reduce greenhouse gas emissions in upstream, midstream, and downstream management.

Examples of the greenhouse gas emission reduction potential for good practices and technologies for climate-friendly municipal solid waste management consist of:

UPSTREAM OPERATIONS

Waste separation and materials recovery at the source.

MIDSTREAM OPERATIONS

Mechanical-biological treatment with bio-drying process and refuse derived fuel (RDF) production.

DOWNSTREAM OPERATIONS

- Waste-to-energy incineration (WtEI) technology
- Landfill gas-to-energy technology
- Composting technology
- Semi-aerobic landfill technology

1. WASTE SEPARATION AND MATERIAL RECOVERY AT THE SOURCE

QUICK INFO

It is a good practice to manage municipal solid waste upstream. Examples include separating biodegradable organic waste for composting; sorting plastic bottles and glass bottles; the reuse, recycling and upcycling of metal cans and sorting plastic waste to be used in RDF.

GHG

Reduces the amount of municipal solid waste to be disposed of in the next step. As a result, GHG emissions are reduced during the transportation, loading and disposal of municipal solid waste. Additionally, waste sorting and material recovery also help avoid GHG emissions generated by the production of new materials.

This practice can be done easily, does not need an investment budget or expertise, good results economic to community and support a circular economy.

Examples of successful reference sites in Thailand are Umong Subdistrict, Lamphun Province and Wiang Thoeng Subdistrict, Chiang Rai Province, which were able to reduce GHG emissions by 64% and 113%, respectively, compared with the BAU.

Knowledge, understanding and social cooperation are key success factors for this good practice.

GOOD PRACTICES DETAIL

A separation process or activity categorises types of waste mostly through hand-sorting according to waste composition, such as food waste, garden waste, paper waste, used glass, scrap metal and aluminium. This separation can be done by anyone at any age, at home, at school, at community or municipal activity centres, etc. The goal is to hold back material that can be reused, recycled or upcycled, as well as being utilised in other ways, such as the production of RDF.

Waste separation and material recovery at the source brings several direct benefits to communities. For example:

1. Helps reduce the amount of municipal solid waste to facilitate further disposal.
2. Makes the process of reusing and recovering materials more effective and reduces waste contamination.
3. Facilitates further downstream technology to be more appropriate and effective in design and operation.
4. Reduces environmental pollution and greenhouse gas emissions from transportation and further disposal steps, including avoiding emissions from the production of new materials.
5. Helps conserve natural resources and protect the environment, including through sustainable energy conservation, by avoiding new materials production.
6. Generates income for households and communities (e.g., by selling recycled waste and selling processed products), creating jobs and supporting a circular economy.

Some examples of waste separation and material recovery at the source at the household and community level include separating rapidly biodegradable organic waste, such as food scraps and garden waste, to be used as animal feed, composted or to make bio-fertilizer; the production of new containers from packaging waste and the production of refuse-derived fuel from unused hard-to-recycle plastic scraps.

This practice complies with and supports the important municipal solid waste management principle of 3R. The 3R principle was first introduced in Japan in 2005 (Ministry of Environment, 2021) and consists of 1) Reduce – to use less, use sparingly, and think before use; 2) Reuse – to repeat using products and select products with long service lives; and 3) Recycle – to reprocess for reuse, such as for plastic packaging, paper, aluminium, and glass (Pollution Control Department, 2016).

Methods

Effective and maximal waste separation and material recovery at the source should consider the following:

1. The community's readiness, knowledge, understanding and cooperation, which are the core drivers of the continual implementation of this practice.
2. The market demand and utilisation characteristics of materials or products that are sorted, returned or processed. This includes the number of users or markets interested in the materials, the potential and efficiency of materials collection and transfer and market sustainability, including related value chain mechanisms.
3. The type of technology to implement after the separation process (downstream treatment).
4. Other considerations such as budget and local and national policies.

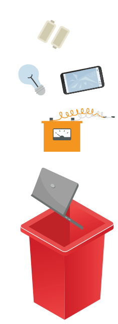
Waste separation at the source can be easily done in many ways according to site-specific needs in each area with low or no investment. However, the preparation of waste containers (e.g., bags and bins) with different colours or different coloured labels will ease the understanding of the categories and help make the municipal solid waste sorting process more convenient, faster and more efficient. Generally, municipal solid waste separation in Thailand consists of four categories and uses different coloured bins for storage:

1) GREEN BINS

for organic waste that rots and decomposes quickly, such as food waste, vegetable scraps, fruit peels, leaves, etc. However, this excludes plant residues and animal carcasses produced by laboratory experiments (Pollution Control Department, 2016)

2) YELLOW BINS

for recyclable waste such as plastics, paper, aluminium, glass, steel, beverage cans, UHT beverage boxes, etc.



3) ORANGE, RED OR GREY BINS WITH ORANGE LIDS

for hazardous waste; waste that is contaminated or contains hazardous materials that affect people, animals and the environment (Pollution Control Department, 2016)

4) BLUE BINS

for general waste or any waste not mentioned above. Most of these are contaminated waste that is difficult to classify or decompose and is not worth reusing, such as food wrapping materials.

The separation process for municipal solid waste in foreign countries is similar to that in Thailand. However, there is generally a higher level of waste separation in most developed countries compared with Thailand. For example:

- Municipal solid waste sorting in Tokyo, Japan – incinerator technology is used to manage municipal solid waste and generate electricity from the waste. Additionally, there are rules for sorting and packing municipal solid waste that vary by subdistrict and can be divided into four main categories: combustible waste, non-combustible waste, recyclable waste and bulky waste such as furniture and electronic waste (Tokyo Metropolitan Government, 2021).
- Municipal solid waste sorting in Hamburg, Germany – household municipal solid waste is separated into four categories: organic waste goes into green bins, wastepaper into blue bins, packaging or plastic waste into yellow bins and other types of waste into grey or black bins (Siechau, 2018). The bin colours and types of municipal solid waste sorted are quite similar to those in Thailand.
- Municipal solid waste sorting in Vienna, Austria – municipal solid waste from households is separated into six categories: paper and paper packaging is sorted into red bins, organic waste into brown bins, clear glass into white bins, coloured glass into green bins, UHT plastic and aluminium packaging into yellow bins and hazardous and other waste into purple bins (Stadt Wien, 2021).

GOOD PRACTICE IMPLEMENTATION IN THAILAND

The implementation of government policies such as the Department of Environmental Quality Promotion’s Zero Waste community contest project and the implementation of other policies related to alternative energy from municipal solid waste are the key driving forces that increase waste separation and materials recovery. In 2020, approximately 8.36 million tons of municipal solid waste was sorted and recycled, equal to 33% of the total municipal solid waste generated (Pollution Control Department, 2020). This value is still 7% lower than the country’s target according to the national municipal solid waste management master plan. During the coronavirus (COVID-19) pandemic, less waste was generated.

GREENHOUSE GAS REDUCTION MECHANISMS

Sorting and material recovery at the source can directly and indirectly reduce GHG emissions. Direct reductions in GHG emissions include reducing emissions from the treatment or disposal of municipal waste, such as reducing methane emissions from landfills and reducing carbon dioxide, methane and nitrous oxide emissions from incineration. In addition, the indirect reduction of GHG emissions is the reduction of emissions from the use of energy and fuel for waste collection and transportation, which also includes avoiding GHG emissions from acquiring new materials and producing new products. In addition, these guidelines’ assessment of GHG reduction potential also includes leakage emissions, which here refer to the potential GHG emissions from material exploitation; for example, the methane and nitrous oxide released into the atmosphere from composting organic waste.

EXAMPLES OF THIS PRACTICE IN THAILAND

UMONG SUBDISTRICT, MUAENG DISTRICT, LAMPHUN PROVINCE

PROJECT DETAILS

Basic information

Area: 20.09 sq. km.

Population: 12,882 people (2020)

Number of villages: 11 villages

Economic conditions: agriculture (84%), general contractor (9%), trade (2%), civil service (1%) and others (4%)

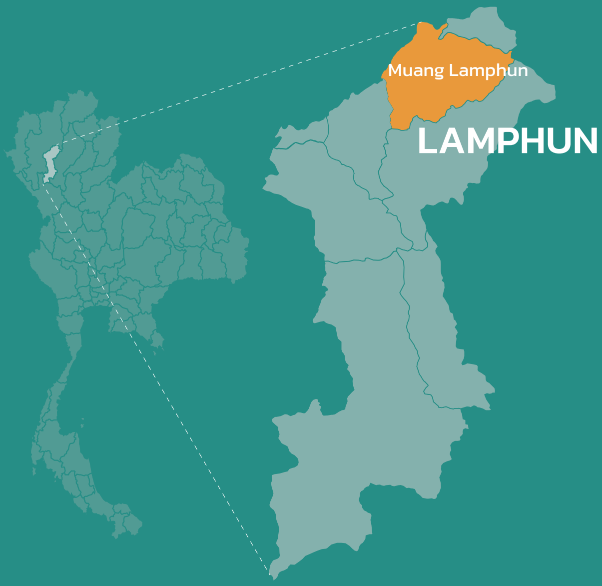


Figure 3.1 Umong subdistrict location

In the past, the Umong subdistrict had problems with incorrect municipal solid waste management, affecting the environment. In 2001, community leaders launched a campaign to separate municipal solid waste. The village health volunteers (VHV) and villagers cooperated very well and continually improved their municipal solid waste management at the source. In 2012, the large Ban Pa Sao community received the first prize from the Zero Waste Community Contest project, becoming a model community and continually expanding their practices to the surrounding communities. In 2020, the Ban Rai community in the Umong subdistrict also received the first prize from the Zero Waste project.

PROJECT BACKGROUND

1999
A crisis of overflowing wastewater and excess MSW in the city, creating a breeding ground for Aedes mosquitoes.

2001
Waste separation started with bio-composting from organic waste.

2008
Established the Community Waste Recycling Savings Bank Fund.

2012
Ban Pa Sao community became a model community that won the national Zero Waste project.

2019
Ban Rai community participated in the Zero Waste project and received the first runner-up award.

2021
The municipality made an MOU with network partners on the Lamphun Action Plan for a Clean City for Sustainability (under the municipal solid waste management strategy).

The management of municipal solid waste at the source in the Umong subdistrict focused on the management of organic waste or wet garbage at home with pot-carriers (sa-wien), organic waste bins, making fertilizers and bio-fertilizers and using the waste as animal feed. For establishments such as markets where there is a large amount of organic waste that cannot be managed locally, the municipality collects and manages the waste in Sufficiency Economy Learning Centres. The organic waste is brought to the centres to be used to feed earthworms, make compost and make bio-fertilizer. The bio-fertilizer and bio-fermented liquid produced will be used in agriculture for both the villagers' fields and the learning centres' agricultural demonstration fields. Regarding recycled waste management, every village in the Umong subdistrict has a merit fund and uses recycled waste to offer robes to Buddhist priests at monasteries. Since 2010, the value calculated is more than 5 hundred thousand baht. This fund raises charity for a member who lost his life and creates welfare support for members in the village. Recycled waste brought to the merit fund is only one part of the recycled waste; other recycled waste separated by the villagers is sold directly to recycle shops.

Figure 3.2 Using organic waste fermentation tanks or green cones at source

Figure 3.3 Villagers sell or donate recyclable waste to the Village Happiness Fund

Figure 3.4 Waste separation activity for Waste Recycling Savings Bank Fund in school

(Source: Umong Subdistrict Municipality)

For hazardous waste management, every village has a collection point for villagers to sort and dispose of the waste. At the end of the year, the municipality collects and sends this waste to private companies that handle the disposal. General household waste is sorted and placed in community black bags that are collected on certain days and times specified by the private company before proper treatment and disposal. According to the Polluter Pays Principle, the price of waste disposal depends upon the amount of waste the villagers dispose of.

Figure 3.5 Using pot-carriers (Sa-wien) to manage garden waste.

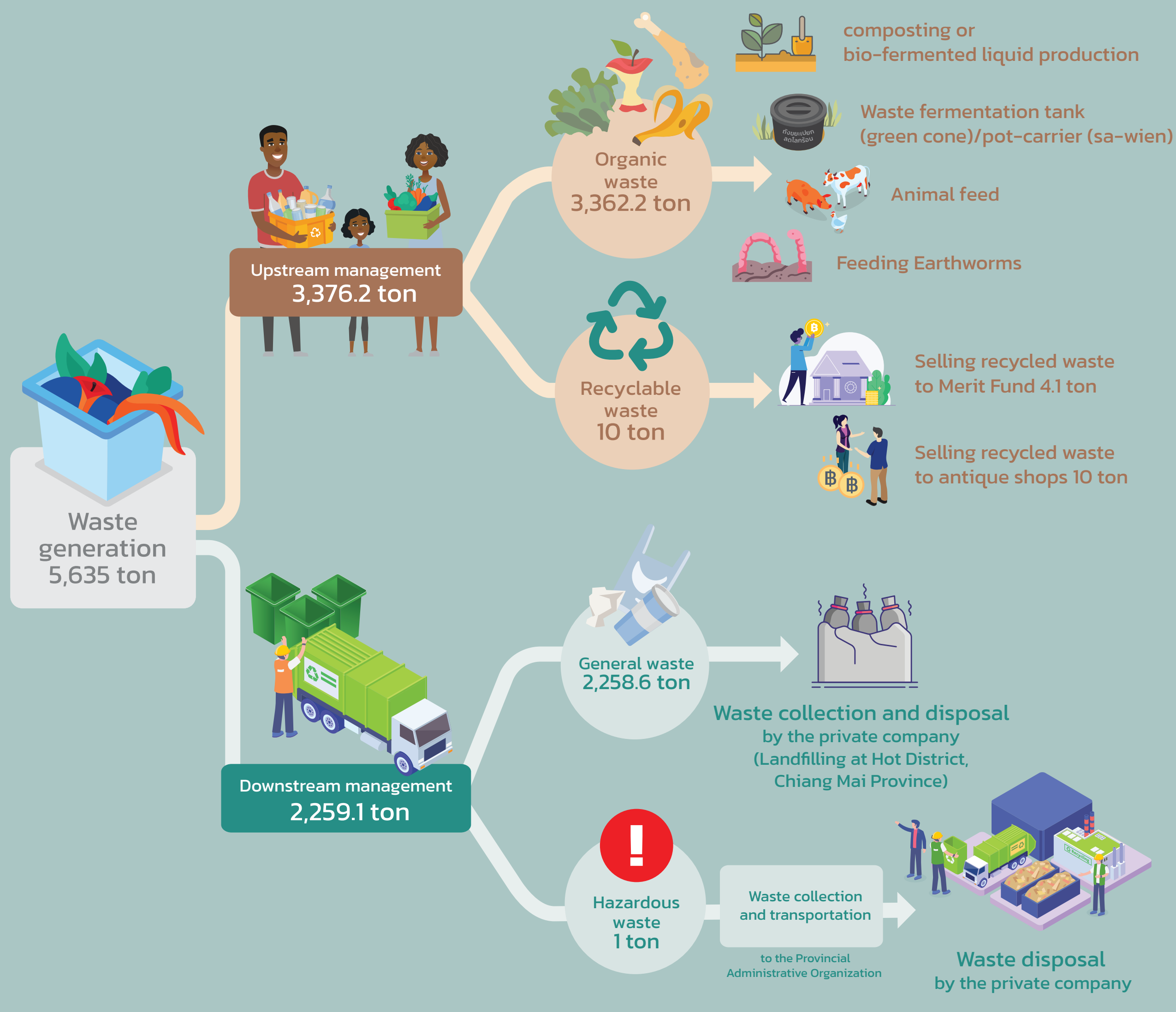
Figure 3.6 Separation of recyclable waste and general waste (community black bags) in household

Figure 3.7 Using residual wood and garden waste for making bee habitat.

Figure 3.8 Organic waste management by feeding earthworms at Sufficiency Economy Learning Centres

Figure 3.9 Waste separation activity for Waste Recycling Savings Bank Fund at Ban Pa Sao community, Umong Subdistrict Municipality

WASTE FLOW AND WASTE MANAGEMENT OF UMONG SUBDISTRICT MUNICIPALITY 2020



Figurev 3.10 Waste flow and waste management of Umong Subdistrict Municipality
(Source: Umong Subdistrict Municipality and project's calculation)

WIANG THOENG SUBDISTRICT
THOENG DISTRICT, CHIANG RAI PROVINCE

PROJECT DETAILS

Basic information

Area: 12 sq. km.

Population: 5,045 people (2020)

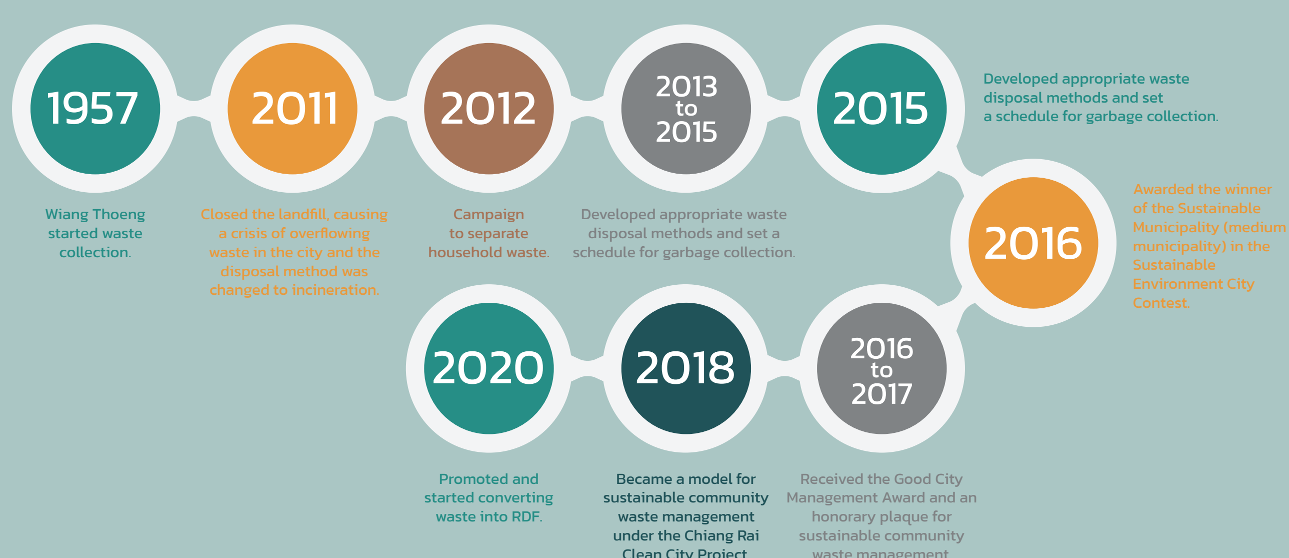
Number of villages: 5 villages

Economic conditions: trading, agriculture, government service and general contractor

Figure 3.11 Wiang Thoeng Subdistrict location

In 2011, Wiang Thoeng Subdistrict was upgraded to a municipality. The city expanded wildly while the population increased, causing a soaring amount of MSW in the city. Moreover, the city landfills were closed due to odour problems and the municipality has no land available to contain excess MSW, causing solid waste to overrun the city. The municipality, therefore, changed the disposal system to a small municipal solid waste incinerator. Nevertheless, the municipality still faced the problem of leftover waste with a high moisture content that made it difficult to burn. Therefore, a campaign for household waste separation was initiated in 2012 to reduce the amount of waste to dispose of and, thus, a sustainable waste management scheme was continuously developed. As a result, the municipality received awards for municipal solid waste and environment management and is seen as a model for other communities to this day.

PROJECT BACKGROUND



For the management of municipal solid waste at the source in the Wiang Thoeng subdistrict, the municipality has specified ordinances that the community should separate solid waste at the source. Waste is currently classified into seven categories: organic waste, general waste, recyclable waste, hazardous waste, infectious waste, broken glass or glass and wood scraps or other types of garbage. No separation of waste at the source means no waste collection and disposal services (conditions for municipal solid waste management in the ordinance follow the Maintenance of the Cleanliness and Orderliness of the Country Act, B.E. 2560). Waste separation at the source is common in Wiang Thoeng Subdistrict. In addition, a flag system is used in waste sorting and management and waste systems are divided into green, red and blue flags.

Green flag

Villagers participating in the green flag project will sort the municipal solid waste into the seven types mentioned above. Then, villagers will manage all organic waste at home with pot-carriers (sa-wien), biodegradable bins (organic waste fermentation tanks or green cones to reduce global warming) and composting, as well as other methods. Villagers will sell or donate recyclable waste to the Village Happiness Fund, and some villagers use recycled waste to create new products. Villagers will dispose of other types of community solid waste, especially general waste, according to the assigned date and time for the municipality to dispose of the waste using an incinerator.

Figure 3.12 Household participators in a municipal flag system
(Source: Pattayaporn Unroj, 2021)

Red flag

Villagers and communities participating in the red flag project will sort the municipal solid waste into the seven types described, similar to those participating in the green flag project. However, those participating in the red flag project are unable to dispose of the organic waste themselves due to the quantity of organic waste and space limitations. Most of these are shops, restaurants, schools, government agencies and private-sector businesses. The municipality, therefore, manages the organic waste by making compost.

Figure 3.13 Organic waste management in Wiang Thoeng Subdistrict Municipality (Source: Wiang Thoeng Subdistrict Municipality)

Blue flag

Villagers joining the blue flag affirm that the household or community will not produce solid waste for the municipality to dispose of, therefore having no service fee charged at all. Villagers sort and manage all of the municipal solid waste at the source. General waste such as plastic bags, old clothes, old shoes, plastic toys and milk cartons will be washed until it becomes clean waste that can be stored for long periods with no unpleasant smell. Most of the general waste components can be processed into RDF. Clean waste is collected by the municipality every Thursday to be processed into RDF and then sold to cement plants in Lampang Province.

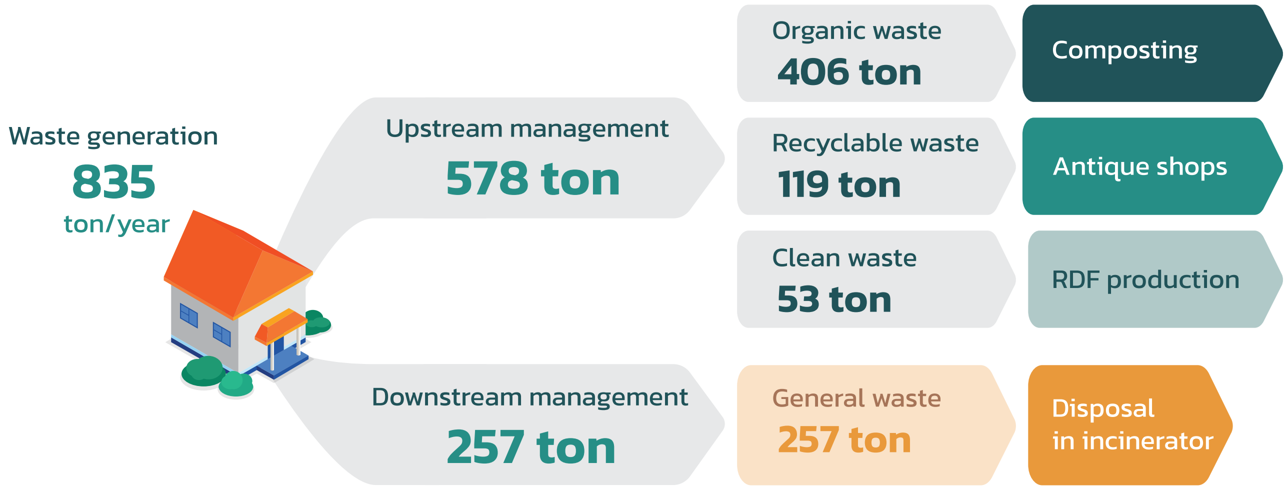


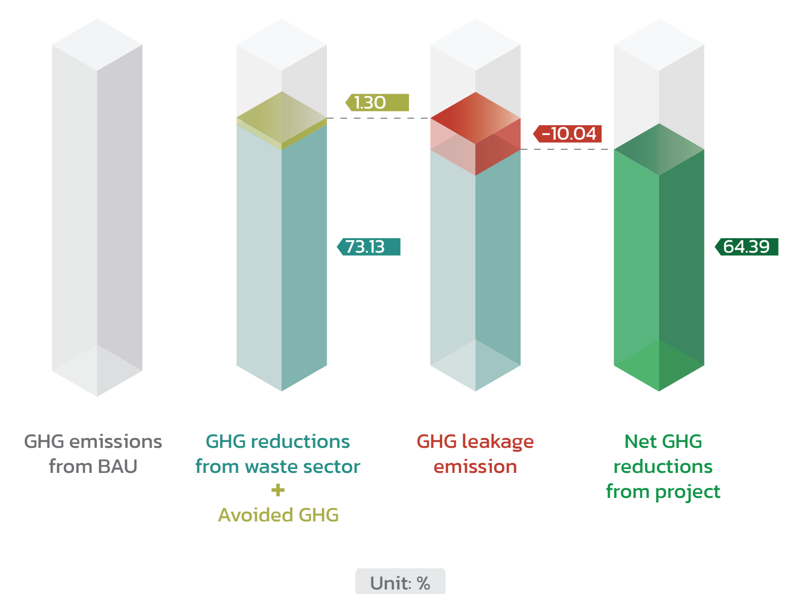
Figure 3.14 Waste flow and waste management of Wiang Thoeng Subdistrict Municipality (Source: Wiang Thoeng Subdistrict Municipality and project's calculation)

CALCULATIONS OF GREENHOUSE GAS REDUCTIONS

The greenhouse gas reduction of Umong Subdistrict was calculated by comparing the BAU case, that is, all municipal solid waste sent to landfill, with the GHG emissions from the implementation of projects with the waste flow as shown in Figure 3.10 (excluding hazardous waste). The calculation of GHG emissions reduction from the waste sector references the method from the 2006 IPCC Guidelines: Volume 5, Waste; Chapter 3, Solid waste disposal, whilst the non-waste sector does not generate GHG emissions. To calculate the avoided GHG emissions, the method from T-VER-METH-WM-09 was applied. The calculation method for GHG leakage emissions from composting references the 2006 IPCC Guidelines: Volume, 5 Waste; Chapter 4, Biological Treatment of Solid Waste, as shown in the appendix. The research project estimated the GHG emissions of the total organic waste management with compost as there is insufficient data to calculate the GHG emissions of each project. In addition, the research project uses the composition of municipal solid waste of Lamphun Municipality (Pollution Control Department, 2004) instead of the national average because the areas are close together and Lamphun is an agricultural area as well.

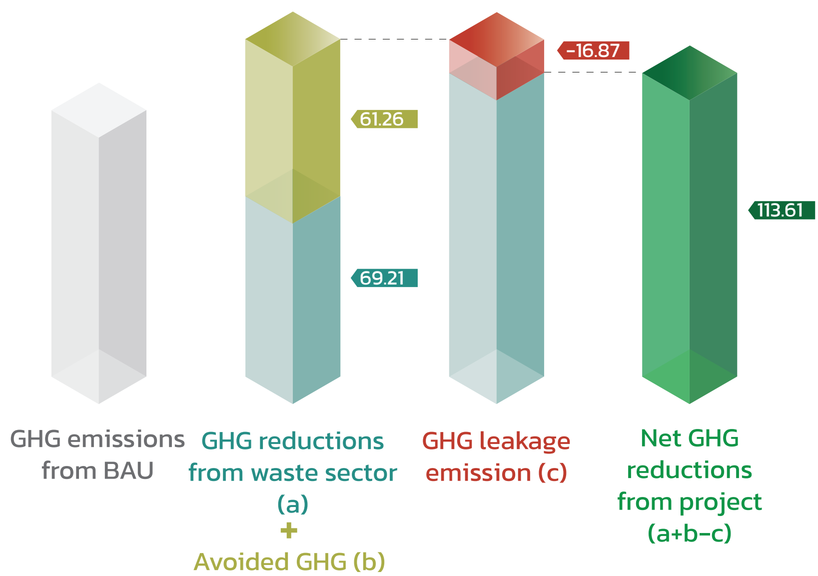
To assess the GHG reduction of Wiang Thoeng Subdistrict, project implementations that involved municipal solid waste separation and management flow were compared as shown in Figure 3.14 with BAU in two instances, which are: 1) all municipal solid waste is sent to the incinerator (BAUincin) as Wiang Thoeng Municipality disposes of municipal solid waste by using an incinerator, using calculations from

RESULTS OF GHG CALCULATION OF UMONG SUBDISTRICT MUNICIPALITY

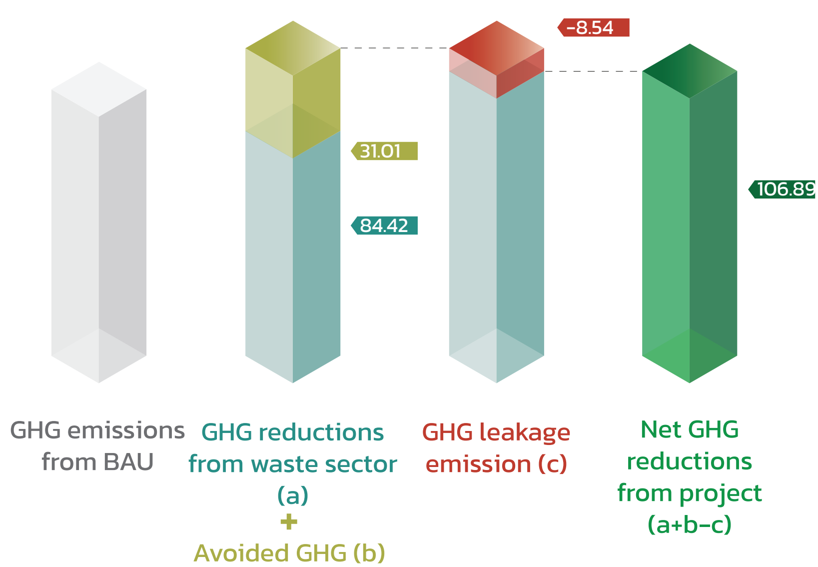


the 2006 IPCC Guidelines: Volume 5, Waste; Chapter, 5 Incineration and open burning of waste, and 2) all municipal solid waste is sent to a landfill (BAULF) to be compared with the sample site of good practices and other technologies that use the landfill as BAU. This is calculated with the same method as the Umong Municipality.

RESULTS OF GHG CALCULATION OF WIANG THOENG SUBDISTRICT MUNICIPALITY



BAU instance: Incineration (BAUincin)



BAU instance: Landfill (BAULF)

Unit: %

LESSONS LEARNED FOR THE GOOD PRACTICE DISSEMINATION

Community cooperation from stakeholders for waste sorting and separation is one of the key success factors. There is a high tendency to expand the sorting and management of municipal solid waste at the source, both within and outside the area.

Making an agreement between the municipality and the community through a citizen constitution and legal enforcement is one mechanism to maintain effective waste separation activity.

The community earns income from activities of waste separation at the source.

The database development offers opportunities for carbon credit trading.

Fertilizers and bio-fermented liquid from organic waste were put to good use.

Clean waste is used for RDF production, helping to reduce the amount of municipal solid waste that is transferred to incinerators and increase the community’s revenue.

Having clear policies and plans for municipal solid waste management in place are essential.

Good cooperation and networking among community leaders, VHVs, villagers and municipal officials are very crucial.

Budget and knowledge from external agencies, both public and private sectors, help support the implementation of activities.

A community model of low-carbon waste management should be established, where the other communities can learn and replicate from.

CONCLUSION

Waste separation and material recovery at the source is a good practice that helps manage municipal solid waste at upstream. It is easy to implement; can be done immediately in each household, school, agency and community; requires no machinery investment and immediately reduces the municipal solid waste that must be disposed of in the next step. From the GHG reduction assessment, it was found that this practice can reduce GHG emissions at the reference site by 64%–113% compared to the BAU.

In addition to reducing environmental impact problems, this practice also reduces expenses, increases income for communities and municipalities through the sales of recycled waste and waste fuel products, makes the environment in the community clean and safe, conserves resources, promotes a circular economy, and helps make the next step of the municipal solid waste management more efficient.

Nevertheless, this practice requires the people's cooperation, whereby the creation of a strong community network with clear and serious plans and policies for the operational staff, including having support from various government and private agencies, are critical factors in driving this good practice towards a successful and sustainable practice.

CONTACT INFORMATION OF THE STUDY AREA ORGANISATION

Umong Subdistrict municipality,
Muaeng District, Lamphun Province
Umong Subdistrict Office
234 Moo.5, Umong Subdistrict,
Muaeng District, Lamphun Province, 51150
Tel: 0-5398-3234
Email : Umongcity@hotmail.com
www.umongcity.go.th

Wiang Thoeng Subdistrict municipality,
Thoeng District, Chiang Rai Province
Wiang Thoeng Subdistrict Office
3 Moo.15, Pisan, Wiang Subdistrict, Thoeng District,
Chiang Rai Province, 57160
Tel: 053-795321, 053-669194
Email : Wiangthoengcr@gmail.com
www.wiangthoeng.go.th

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Good Technology

2. MECHANICAL-BIOLOGICAL TREATMENT TECHNOLOGIES USING A BIODRYING PROCESS AND REFUSE-DERIVED FUEL PRODUCTION

QUICK INFO

Mechanical-biological treatment technology managed municipal solid waste through refuse-derived fuel and soil conditioner

GHG

Reducing organic waste in landfills has reduced GHG emissions from the decomposition of organic waste. The use of soil conditioner has helped reduce GHG emissions caused by the use of chemical fertilisers and the RDF that has been used as fuel for incinerators or power plants from solid waste can reduce GHG emissions.

A good example is the municipal solid waste management project for fuel production by the Roi Et Municipality, Muaeng District, Roi Et Province. This actual implementation can reduce GHG emissions by 66.93% and 45.63% compared with BAUs inclusive and exclusive of coal transportation, respectively.

This technology is not complicated and can be applied to another areas in Thailand.

TECHNOLOGY DETAILS

Mechanical-biological treatment (MBT) can effectively stabilise community solid waste and has a production process that is divided into two stages. The first stage is mechanical pre-treatment, which prepares municipal solid waste by sorting out recycled and metal community solid waste, and then digesting the waste into smaller pieces until it is mixed together. Then, it is sent to be treated with a biological process known as biodrying that is part of the process of decomposing organic solid waste, in which the waste is poured into a pile with an aeration system in place. The air and water will react with the organic matter in the municipal solid waste and the bio-processed waste will eventually dehydrate. Afterwards, it can be used for the second stage of mechanical treatment, which is mechanical separation, in which the compost is sieved to separate large waste with high energy values for use in RDF. The RDF may be used as fuel to generate electricity and thermal energy, such as in power plants, in the cement industry, etc. Some organic solid waste decomposed through the fermentation process has been used as a solid conditioner (Suranaree University of Technology, 2016). The diagram shows the working principles of mechanical-biological municipal solid waste treatment.

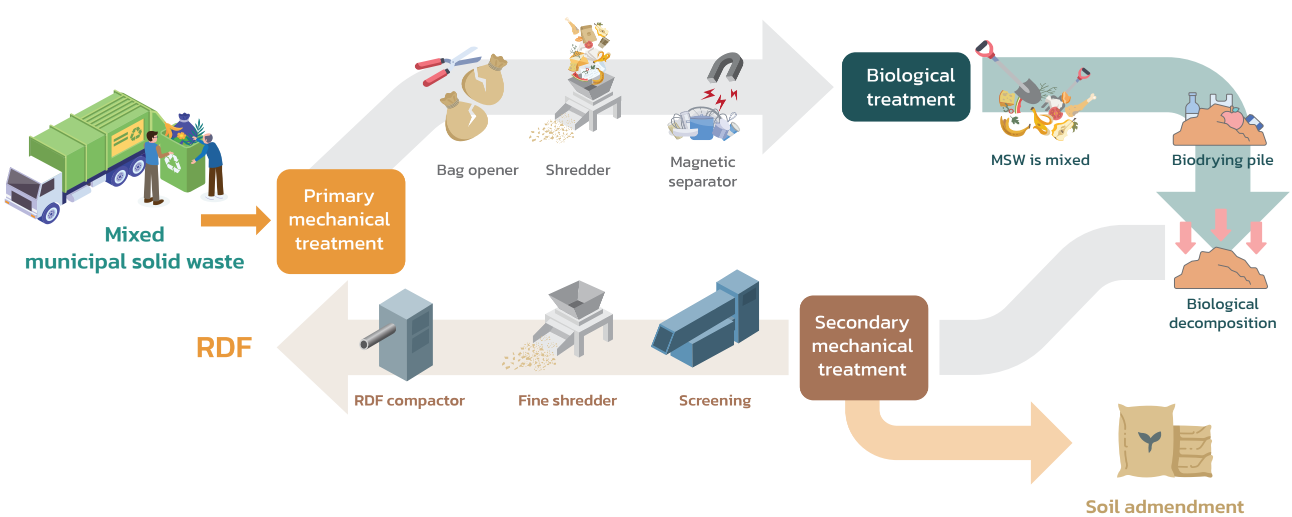
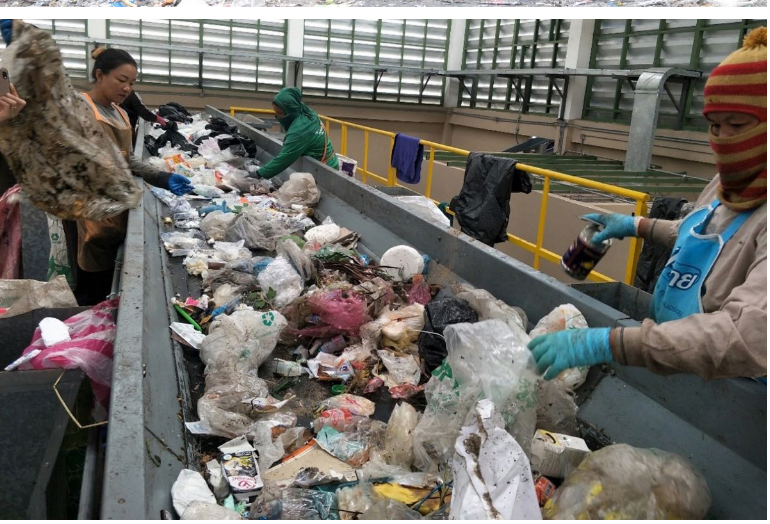


Figure 3.15 The working principles of mechanical-biological municipal solid waste treatment (MBT)
(Source: SUT, SCIeco Services Co., Ltd.)



TECHNOLOGY IMPLEMENTATION IN THAILAND

Mechanical-biological treatment technology is being applied in Thailand at a moderate level. If RDF is being sent for energy use in the cement industry or an RDF power plant, the distance from the MBT plant to the cement industry or power plant should not exceed 400 kilometres.

Currently, there are 18 MSW treatment facilities in Thailand using MBT to produce the RDF, in which 14 facilities belong to the public sector and the rest belong to the private sector. The reference site for this document, the Roi Et Municipality, Mueang District, Roi Et Province is a public sector.

GREENHOUSE GAS REDUCTION MECHANISMS

Mechanical-biological treatment using the biodrying process and RDF production can help reduce organic waste landfilling and GHG emissions from decomposing organic waste in landfills. The plastic obtained through the process becomes RDF, which can be used as fuel in the cement industry or an RDF power plant. Although this process requires energy for the production process, it can still help reduce GHG emissions.

EXAMPLES OF THIS TECHNOLOGY IN THAILAND

MUNICIPAL SOLID WASTE MANAGEMENT PROJECT FOR FUEL PRODUCTION BY ROI ET MUNICIPALITY

MUEANG DISTRICT, ROI ET PROVINCE

PROJECT DETAILS

Basic information

Area: 11.63 sq. km.

Population: 36,225 people (2019)

Number of villages: 20 villages

The Roi Et municipality received the ASEAN Environment Award for Green Area and Municipal Solid Waste Management in 2014 from the Office of Natural Resources and Environmental Policy and Planning (ONEP). In the past, the municipality's solid waste management was an open dump and there was approximately 200,000 tons of unmanaged waste due to dump space limitation causing an environmental problem. The ONEP foresaw the Roi Et municipality's potential to manage municipal solid waste within the restrictions of its area, thus, the ONEP helped drive and support the budget to create a municipal solid waste management project to produce fuel starting

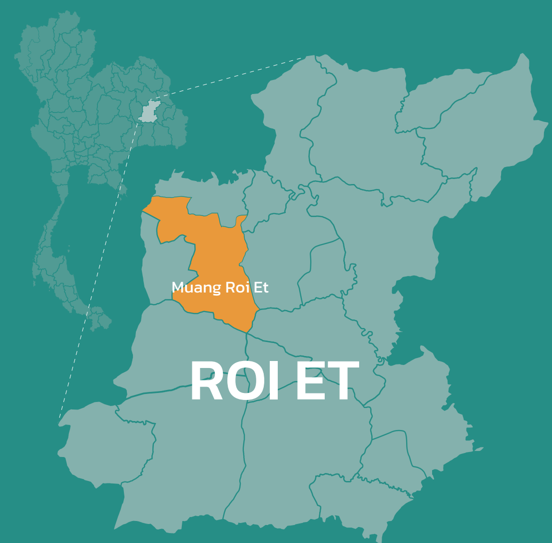
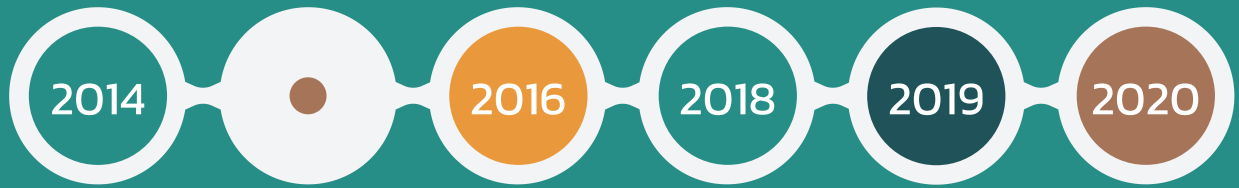


Figure 3.16 Map of the Roi Et Municipality, Roi Et Province

PROJECT BACKGROUND



2014: The municipality received the ASEAN Environment Award for green space and waste management from ONEP. At the time, the waste was managed in an open dump.

ONEP pushed forward until it was selected as one of the three RDF pilot projects in Thailand out of 22 sites. The municipality received financial support.

2016: The municipality constructed a waste management project for fuel production.

2018: The municipality joined the T-VER project and started project activities.

2019: The community started to calculate project credit.

2020: First municipality Carbon Credit sales from 01/01/2019 to 30/06/2020 (15,953 tCO_2eq)

in December 2018. The municipal solid waste involved in the project is received from within the Roi Et municipality and from local government organisations within the municipality cluster. There are a total of nine local authorities, including the Roi Et municipality, in the cluster. The system can manage 100 tons/day of municipal solid waste and operate 365 days/year. Pictures of the project location and area are shown in Figures 3.17–3.18

Figure 3.17 The location of the municipal solid waste management project for fuel production by the Roi Et Municipality (Source: the Roi Et Municipality)

Figure 3.18 The area of the municipal solid waste management project for fuel production by the Roi Et Municipality (Source: the Roi Et Municipality)

PROJECT SCOPE

The Roi Et municipality has ended the sifting system and only sells dried and chopped portions to produce products according to market demand. In 2021, an average of 93 tons of municipal solid waste entered the system per day. The scope of the project is shown in Figure 3.19.

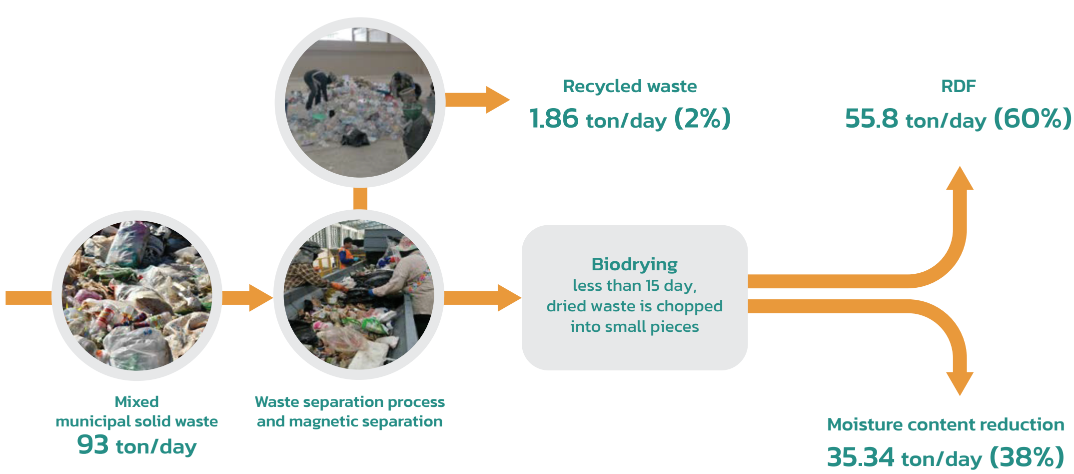
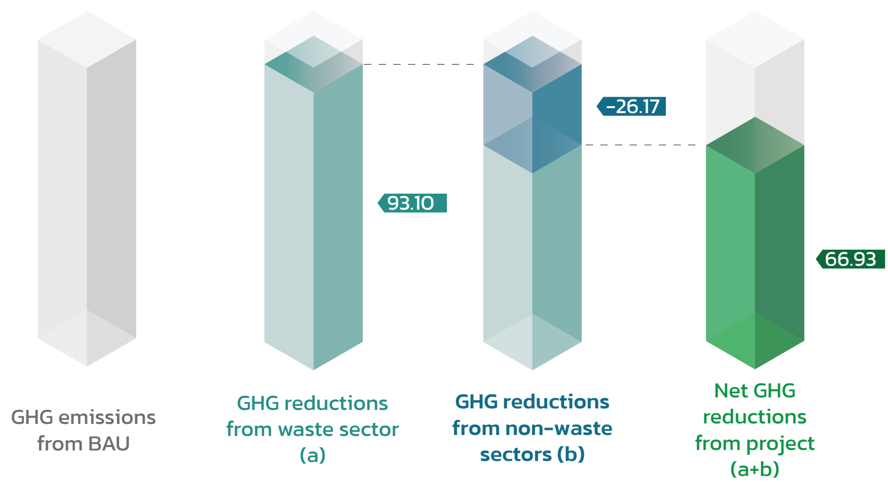


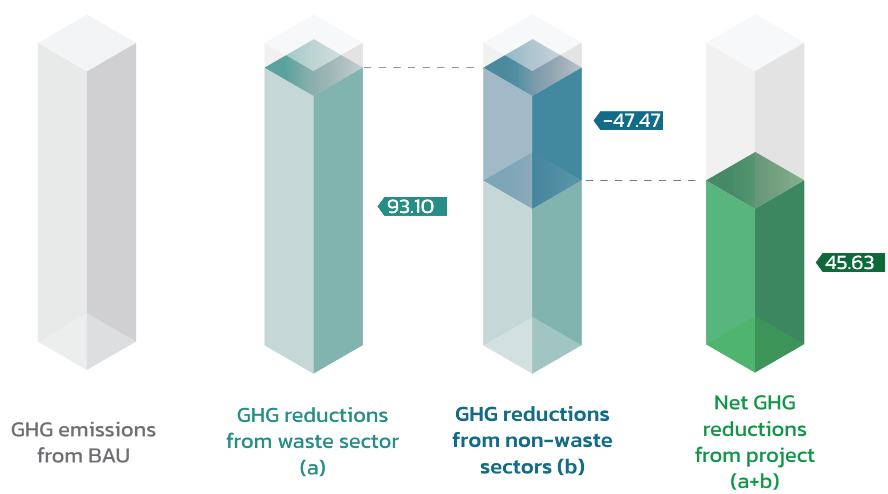
Figure 3.19 The scope of the project (Source: the Roi Et Municipality and calculations)

CALCULATIONS OF GREENHOUSE GAS REDUCTIONS

This research project assesses the GHG emission reduction from municipal solid waste management of Roi Ed's municipality using MBT compared with the BAU of sending all of the municipal solid waste to the landfill. The calculation of GHG emission reduction is divided into calculations in the waste and non-waste sectors, which were compiled for two cases: inclusive and exclusive of coal transportation. All calculation methods refer to the 2006 IPCC Guidelines: Volume 5, Waste; Chapter 3, Solid Waste Disposal, as shown in the appendix. No GHG emissions were avoided in this project. The results revealed that 66.93% of GHG emissions was reduced compared with BAU if coal transportation was included and by 45.63% compared with BAU if coal transportation was excluded, as shown in the following chart.



MSW management using MBT by the Roi Et Municipality
(transportation of coal included in calculation)



MSW management using MBT by the Roi Et Municipality
(transportation of coal excluded from calculation)

Unit: %

LESSONS LEARNED FOR THE TECHNOLOGY DISSEMINATION

This technology can be applied to other areas in Thailand and can be expanded to small- and medium-sized local administrative organisations.

There is an opportunity to further develop the technology to more effectively improve RDF quality in the short term with very simple technology.

The use of efficient machinery and equipment from experienced and reliable manufacturers should be considered. Most RDF facilities still have to use machines made in Europe with prices close to, or not much higher than, ones domestically produced..

Lessons learned and experiences from other municipalities can help mitigate risks when applying MBT system in the area.

Applying and modifying the MBT system to meet market demands contributes to the continuous and efficient operation of the system.

CONCLUSIONS

Mechanical-biological treatment technology can effectively stabilise municipal solid waste and reduce GHG emissions by 66.93% or 45.63% compared with BAU including coal transportation and excluding coal transportation, respectively.

The technology can be applied to other areas in Thailand and can be expanded to small- and medium-sized local administrative organisations. However, this technology has a relatively high cost despite its low complexity. The technology's simplicity allows further development, enabling improvements in RDF quality in the short term and ensuring that the RDF suits the demands of the purchasing market.

Nevertheless, when RDF is sent to be used in the cement industry or in a power plant, the distance from the MBT plant to the cement industry or power plant should not exceed 400 kilometres for cost-effective transportation and solve a problem of buyers' scarcity.

CONTACT INFORMATION OF THE STUDY AREA ORGANISATION

Roi Et Town Municipality,
Mueang District, Roi Et Province
258, Tewapibal Road, Nai Mueang Subdistrict,
Meuang District, Roi Et Province, 45000
Tel: 043-511222
Email : muni101@roietmunicipal.go.th
https://roietmunicipal.go.th/roiet

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3. WASTE-TO-ENERGY INCINERATION

QUICK INFO

Burning or combusting MSW in an incinerator at temperatures over 850˚C, with proper control of fuel, air, residues and emissions, can effectively reduce both mass and volume of waste by 70%–90%. The high temperatures help destroy pathogens and prevent disease transmission. The heat produced from combusting waste can be utilised to produce steam and electricity, either for immediate use or further sale.

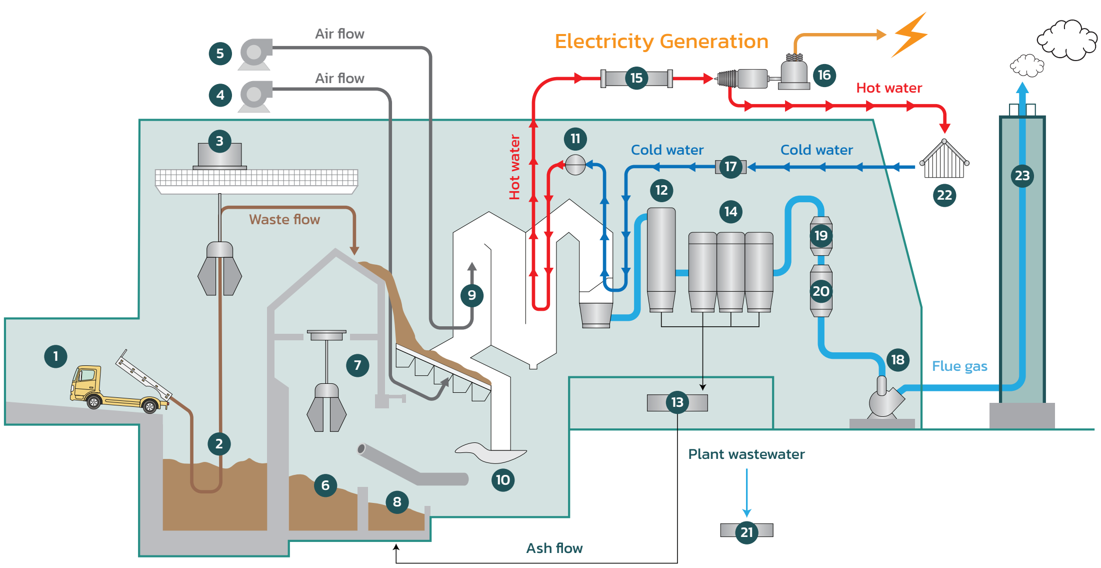
Based on three reference sites in Thailand, this technology can reduce GHG emissions by 57%–75% compared with the business-as-usual scenario of landfilling.

The technology is complicated, requiring specialists and experts to design, operate and maintain the system. It requires a large amount and continuous supply of waste to ensure that the project is technically and financially feasible. Regular monitoring and an efficient pollution control system are necessary.

Appropriate system design for the local context, efficient environmental management and pollution control, social responsibility and the promotion of cooperation amongst surrounding communities are important factors for the success of these projects.

TECHNOLOGY DETAILS

Waste-to-energy incineration (WtE incineration) is a thermal treatment technology that can convert MSW into inert materials and useful energy. It combusts waste at high temperatures with excess air (over the stoichiometric air-fuel ratio) to achieve complete combustion. It can treat heterogeneous waste with various compositions. The combustion process can reduce the mass and volume of MSW by 70%–90% and detoxify combustible carcinogens, hazardous organic compounds, pathologically contaminated materials and disease transmitters (Thares Srisatit, 2015; Niessen, 2010). The combustion reaction, bringing the furnace temperature above 850°C, produces a large amount of hot flue gas. The energy in this hot flue gas can be utilised to produce superheated steam. The steam is sent to drive a steam turbine and a generator to produce electricity either for the plant's use or for sale. The combustion of MSW generates ash; flue gases containing carbon dioxide and other pollutants such as carbon monoxide, nitrous oxide, sulphur oxide, particulates, dioxin and other incomplete combustion substances; as well as some leachate from the waste pit. Therefore, a WtE incineration plant must be equipped with proper systems for bottom ash and fly ash handling, air pollution monitoring and control and wastewater treatment. A diagram of WtE incineration plant is shown in Figure 3.20.



1 Platform
2 Waste pit
3 Waste crane
4 Primary forced draft fan
5 Secondart forced draft fan
6 Ash pit
7 Ash crane
8 Treated ash pit
9 Combustion chamber
10 Ash pusher
11 Boiler
12 Cooling tower
13 APC residue (fly ash) treatment equipment
14 Bag filter
15 Steam reservior
16 Turbine generator
17 Condensate tank
18 Induced draft fan
19 Steam-type gas re-heater
20 Catalytic reactor
21 Wastewater treatment equipment
22 ACC (Air-Cooled Condenser)
23 Stack

Figure 3.20 Process diagram of Stoker type-community solid waste incinerator (Chen et al, 2020)

WtE incineration plants can be classified by their furnace technology:

1) Stoker or grate combustion type: the most common WtE incineration style, with more than 500 installations worldwide. MSW combustion occurs on a grate system. It can accommodate pre-treated and high-moisture MSW, with a capacity ranging from 3–40 tonnes of MSW/hour. The overall efficiency for electricity production is 21%–30% (Howes and Warren, 2016).
2) Fluidised bed type: uses a bed material such as silica, sand, limestone or ceramic to transfer heat and encourage fuel-air mixing. Combustion of pre-treated waste occurs on the bed materials as they are fluidised by air injection through nozzles situated under the bed material layer. The vigorous mixing results in complete combustion. Usually, the MSW has undergone a pre-treatment process to control particle size and characteristics. The capacity is approximately 3–15 tonnes of MSW/hour. The overall efficiency for electricity production is approximately 25%. There are more than 50 fluidised-bed incineration facilities in operation globally (Howes and Warren, 2016).
3) Rotary kiln: burns waste in a cylindrical kiln that slowly rotates around a slightly-inclined horizontal axis. The rotation mixes the MSW well, leading to an increase in combustion efficiency. The capacity is smaller than the above-mentioned types, ranging from 1–75 tonnes of MSW/day (Williams, 2005). Usually, this technology is used in small-scale projects that lack a continuous supply of waste and to burn hazardous and medical waste.

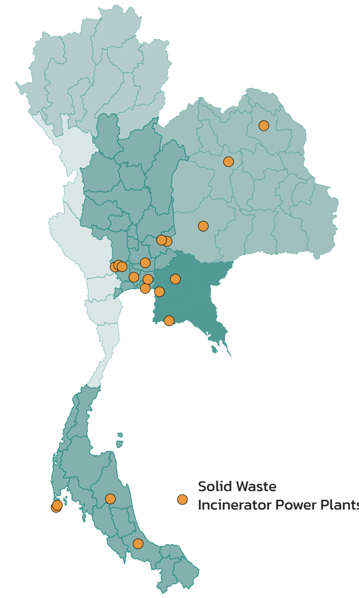


Figure 3.21. Map of the location of solid waste incinerator power plants in Thailand in the year 2020

TECHNOLOGY IMPLEMENTATION IN THAILAND

The locations of WtE incineration projects in Thailand are shown in Figure 3.21. The total installed capacity for electricity generation from these plants was 333.68 MW in 2020 (Department of Alternative Energy Development and Efficiency, 2021). This is equivalent to 37% of the 900MW electricity generation target from MSW in the national Alternative Energy Development Plan 2018–2037 (AEDP2018).

GREENHOUSE GAS REDUCTION MECHANISMS

Using WtE incineration can reduce methane emissions from landfilling organic waste, which is the key GHG source category in the waste sector. Moreover, the electricity produced by WtE incineration plants can help reduce the use of fossil fuels for electricity production, which contributes to the reduction of GHG in the energy sector.

EXAMPLES OF THIS TECHNOLOGY IN THAILAND

PHUKET CITY MUNICIPALITY AND PJT TECHNOLOGY CO., LTD.

MUEANG PHUKET DISTRICT, PHUKET PROVINCE

PROJECT DETAILS

The Phuket Waste Incinerator Plant allows the private sector to invest in state activity, resulting in cooperation between Phuket City Municipality and PJT Technology Company Limited. The project, a MSW incineration and commercial electricity generation facility, has a 15-year term and can be renewed for another 15 years.

The project uses direct combustion technology and a step-wise moving grate designed to dispose of approximately 700 tonnes/day of MSW, comprising 2 furnaces with a capacity of 350 tonnes/day each. The total installed electricity generation capacity is 12 MW. Based on 2019 data, the project receives approximately 850 tonnes of MSW/day (50% moisture content by weight). The waste is moved into the

Figure 3.22 Map showing the location of the Phuket Solid Waste Disposal Centre

PROJECT BACKGROUND

1993
Phuket Town Municipality built a sanitary landfill system following sanitation principles – 5 ponds over 120 rai.

1999
Phuket Town Municipality received a WtE incinerator with a capacity of 250 tonnes/day (2.5 MW power generation) from the Department of Public Works.

2008
Phuket City Municipality drafted a plan to replace the old incinerator with a new one, opening up opportunities for private investment.

2012
PJT Technology Co., Ltd. invested in the construction and operation of a 700 tonne/day incinerator system with a total installed capacity of 12 MW. The waste disposal service commenced in March 2012 and started sending electricity to the grid on 11 July 2012.

Figure 3.23 Phuket Solid Waste Disposal Centre: the incinerator building

Figure 3.24 Phuket Solid Waste Disposal Center: Waste Weighting Building

waste pit for 5–7 days, then sent to the combustion chamber and heated to over 950°C. The flue gas generated is used to produce steam to run steam turbines to produce energy. Approximately 15% of the electricity generated is used by the facility and the remaining 85% is sold to the Provincial Electricity Authority (PEA).

The waste and pollution caused by the project include air pollution, wastewater, fly ash and bottom ash. Semi-dry scrubber technology is used to treat the air pollution before it is sent to the bag filter system. A continuous emission monitoring system (CEMs) is used for air quality control and if the project's air pollution treatment system fails, the staff will take corrective action immediately. For wastewater treatment, the main inflow is leachate collected from the garbage dump and sent for preliminary treatment using an anaerobic baffled reactor (ABR) system that results in biogas, part of which is sent to the incinerator to heat the system wastewater that passes through the ABR system, which is then sent to the Phuket City Municipal Wastewater Treatment Plant. The fly ash is safely disposed of in a landfill while bottom ash is sorted according to the bottom ash use project. It is separated into non-combustible components such as sand, sludge, glass, iron and metals, which can be recycled and further used.

The furnace operates continuously 24 hours a day, representing 7,600–8,000 hours/year. For annual maintenance, the whole system is stopped for major maintenance every 6 months.

KHON KAEN CITY MUNICIPALITY AND ALLIANCE CLEAN POWER CO., LTD.

MUEANG KHON KAEN DISTRICT, KHON KAEN PROVINCE

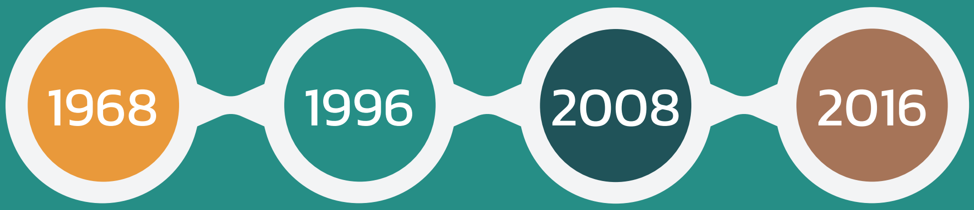
PROJECT DETAILS

Alliance Clean Power Co., Ltd. has a 20-year contract for the municipal solid waste management of Khon Kaen City Municipality. The working unit is divided into two parts: the Bureau of Health and Environment collects MSW and the Bureau of Public Works is responsible for MSW disposal. In 2019, approximately 375 tonnes of waste entered the solid waste collection system per day, for which the project uses stoker-fired direct incineration technology. A temperature control system in the combustion chamber keeps it in the range of 850–1000°C, and 5.5 MW of electricity can be generated, with 0.5 MW recycled for facility use and the remaining 5.0 MW transmitted to the grid system for sale to the Provincial Electricity Authority. Bottom ash and fly ash are disposed of outside the project.

Figure 3.25 Map showing the location of Khon Kaen City Municipality

The main wastewater generated is leachate from the waste pit, which is collected and treated with a membrane bioreactor (MBR) system. The treated water is recycled within the project.

PROJECT BACKGROUND



1968	1996	2008	2016
The landfill was started in the waste disposal site of Khon Kaen Town Municipality.	The site began to encounter overflowing garbage, affecting communities around the landfills and waste transfer station.	A plan and study for the construction of an incinerator was prepared and an announcement was made to seek a joint investor.	Alliance Clean Power Co., Ltd. started selling electricity generated by the 600 tonne/day WtE incinerator with a power generation capacity of 6 MW.

BANGKOK METROPOLITAN ADMINISTRATION AND C&G ENVIRONMENTAL PROTECTION (THAILAND) CO., LTD.

NONG KHAEM DISTRICT, BANGKOK METROPOLITAN ADMINISTRATION (BMA)

PROJECT DETAILS

The Nong Khaem Environment Power Generation Waste Disposal Project was a contract that C&G Environmental Protection (Thailand) Co., Ltd. completed under contract with BMA through the BOT system. The total investment cost for construction is approximately 960 million baht. The MSW management process starts with a truck collecting MSW from Nong Khaem District, Thawi Watthana District, Bangkok Yai District, Bang Rak District, Phasi Charoen District and Bangkok Noi District. After weighing, the MSW is deposited in the closed waste pit system. In 2019, an average of 450 tonnes of MSW entered the system per day. MSW was held in the waste collection pit for 3–5 days, during which time cranes were used to turn over the MSW pile to reduce the moisture content. The MSW accepted into the system has a moisture content of about 55%–60% and when the remaining moisture is about 30%–35%, the crane movers the garbage into the incinerator. The waste is incinerated at around 850–1,100°C, producing approximately 90% of the installed power generation capacity. Approximately 15%–20% of the electricity produced is reused by the facility while the remaining 80%–85% of electricity is transferred for sale to the Metropolitan Electricity Authority. Leachate from the waste pit is sent to the project's wastewater treatment process, which uses ultrafiltration (UF) membrane and reverse osmosis membrane (RO) systems for treatment so the treated water can be reused.

Figure 3.26 Map showing the location of the Nong Khaem Waste Disposal Power Plant for the Environment

PROJECT BACKGROUND

2010
There was a problem of insufficient waste disposal system to handle the increasing amount of waste.

2012
The BMA 20-year development plan 2013–2032 specified the use of 3,500 tonne/day incinerators.

2014
A study and plan to build an incinerator was made, with an opportunity for the private sector to invest under the Build-Operate-Transfer (BOT) system.

2016
C&G Environmental Protection (Thailand) Co., Ltd. started operation on the 500 tonne/day WtE incineration system, with 9.8 MW electricity generation capacity.

Figure 3.27 Overview of the Waste Disposal Power Plant

Figure 3.28 Incinerator Building

CALCULATIONS OF GREENHOUSE GAS REDUCTIONS

The calculation of GHG emissions of municipal solid waste disposal with incinerator technology utilises project data collected in 2019 that include the amount of waste, the composition of waste, wastewater management, electricity generation and other information from the projects. The calculations of GHG emissions for waste disposal with incinerator technology for electricity generation in the BAU case were made under the assumption that waste would be disposed of by landfilling, using the first-order decay (FOD) method based on the 2006 IPCC Guidelines: Volume 5, Chapter 3. The reduction of GHG emissions from the generation of renewable energy for distribution was calculated based on T-VER-METH-AE-01 and the reduction of GHG emissions from anaerobic wastewater treatment and storage of methane for use or incineration is calculated based on T-VER-METH-WM-01. The results of the calculation of the amount of GHG reduction from MSW disposal with incinerator technology are presented as a range of data analysed from three projects, Phuket, Khon Kaen and BMA, and summarised in the table below. By eliminating MSW with the incinerator technology, GHG emissions from landfills can be reduced from the BAU level by 45%–60%. The electricity used for the project is generated from the incineration, so there were no GHG emissions outside the waste sector. Therefore, the reduction in GHG emissions compared with the BAU ranges between 45%–60%. In addition, renewable electricity generation and methane storage for utilisation can reduce GHG emissions from fossil fuel use by 12%–15%. Overall, municipal solid waste disposal with incinerator technology and electricity generation can reduce GHG emissions by 57%–75% compared with BAU (landfill). All three projects have good technology and efficient operation. An important factor that contributed to the three projects' wide range of GHG reduction values was the difference in waste composition, especially food waste composition, where the difference was up to 15%, affecting the calculation of GHG emissions in the BAU case.

GHG reductions from BAU (%)			Avoided GHG (%)	GHG reductions from project (%)
Waste Sector	Non-waste Sector	Total		
45.35–60.48	-	45.35–60.48	12.15–15.22	57.58–75.70

The results of the calculation of the amount of GHG reduction from three projects, Phuket, Khon Kaen and Bangkok

LESSONS LEARNED FOR THE TECHNOLOGY DISSEMINATION

The technology is complicated and requires expertise in system operation and management.

MSW disposal with incinerator technology needs at least 300–700 tonnes/day of municipal solid waste to be feasible and worth the investment. In some areas, this may require several local government organisations to form a joint operation or cluster.

The project requires a very high budget for investment, operation and maintenance, no less than 400 baht/ton/year.

Environmental issues and public acceptance are key factors for the success of the project.

Waste composition, moisture content and heating value are important factors for system performance. Pollution control, better MSW management at the source and MSW treatment systems including a selection of technology that fits the context of the area are important.

Case studies found that a clear policy on MSW management and leadership vision can create cooperation to drive the project.

Building strength for the community by providing knowledge and understanding, supporting local employment and funding community development in the area surrounding the power plant can create acceptance for long-term coexistence with the community.

Private investment in government projects (public-private partnership; PPP) under BOT contracts ensures stability in project management and system operation.

CONCLUSIONS

MSW incinerator technology for power generation is outstanding in its ability to reduce the mass and volume of waste by up to 70%–90%. The high temperature of the system also helps effectively destroy pathogens and the heat energy obtained can be used to produce steam and electricity. The case study of three incinerator projects in Thailand shows that this technology can reduce GHG emissions by up to 57%–75% compared with BAU (landfill) – comprising a reduction of GHG emissions from the landfill by 45%–60% and the mitigation of GHG emissions from the production of electrical power for the grid by 12%–15%. Apart from this characteristic, if the electric power produced is sold to the grid, significant income can be generated for the project owner while helping to increase local energy security.

However, there are several limitations, such as the complicated technology; the need for experts; constant monitoring and pollution control during system operation and high investment and operating budget, as well as the need for continuous, large amounts of solid waste (at least 300 tonnes/day) to feed the incinerator and make the system cost-effective for investment. Therefore, this technology is suitable for local governments with a large amount of solid waste or when a joint effort is made to collect waste from other areas.

Factors that contribute to the success of the project and ensure sustainable coexistence with the community are appropriate system design to suit the quantity and composition of local solid waste, efficient environmental management and pollution control, the responsibility of project owners to surrounding communities, the timely resolution of problems affecting the community, the promotion of understanding and cooperation among the surrounding communities, the employment of local people and community development.

CONTACT INFORMATION OF THE STUDY AREA ORGANISATION

Phuket City Municipality and PJT Technology Co., Ltd., Mueang Phuket District, Phuket Province
Waste disposal centre, Phuket Province
Moo.1, Rattanakosin 200 years Road, Wichit Subdistrict, Mueang Phuket District, Phuket Province
Tel: 076-211570 www.phuketcity.go.th
Tel: 076-210313-4 www.pjt.co.th

Khon Kaen City Municipality and Alliance Clean Power Co., Ltd.
Absolute Clean Energy (MSW Khon Kaen Powerplant)
Khon Kaen City Municipality, Moo.7, Mittraphap Road, Non Thon Subdistrict, Mueang Khon Kaen District, Khon Kaen Province
Tel: : 043-424550 www.kkmuni.go.th
Tel: 085-4880025 www.ace-energy.co.th

Bangkok Metropolitan Administration and C&G Environmental Protection (Thailand) Co., Ltd
Environmental waste disposal power plant at Nong Khame
Nong Khame waste disposal centre, Phutthamonthon Sai 3 Road, Nong Khang Phlu Subdistrict, Nong Khaem District, Bangkok
Tel: 02-2032992 www.bangkok.go.th
Tel: 02-4087520 www.cg-ep.co.th

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4. SEMI-AEROBIC LANDFILL

QUICK INFO

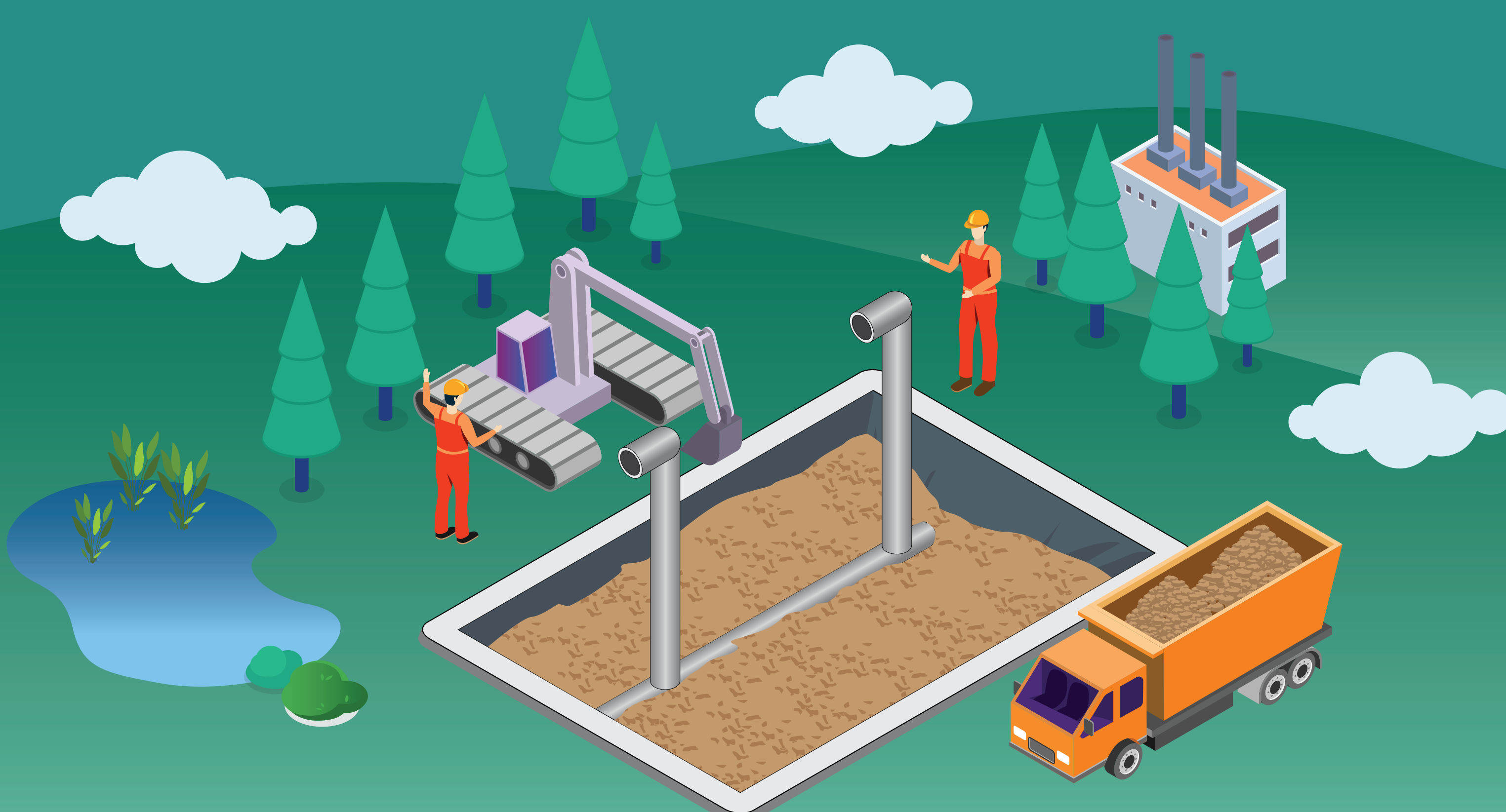
The semi-aerobic landfill method is a downstream MSW management system. It is a type of sanitary landfill that the UNFCCC has recognized as a technology that can reduce GHG emissions.

GHG

This option can reduce GHG emissions due to the circulation of oxygen within the solid waste pile, causing partially aerated decomposition of organic waste leading to a lower methane generation.

Good examples of reference sites in Thailand are (1) Mae La Subdistrict Administrative Organization/COERR Foundation (COERR), Tha Song Yang District, Tak Province, and (2) Sikhio City Municipality, Sikhio District, Nakhon Ratchasima Province. Both areas can reduce GHG emissions by 53.36% compared with BAU.

This technology can be easily performed at a minimally higher cost. However, it is best to use a design company that already has experience in design and construction.



TECHNOLOGY DETAILS

The semi-aerobic landfill method is a type of sanitary landfill that has been researched and developed for a long time by Fukuoka University and Fukuoka City and has been certified by Japan's Ministry of Health and Welfare as a national standard technology for solid waste disposal. It has also received recognition by the United Nations Framework Convention on Climate Change (UNFCCC) as a technology that can reduce GHG emissions.

This solid waste disposal scheme decomposes organic waste aerobically as the landfill is equipped with vents to allow air to infiltrate creating aerobic conditions unlike a typical sanitary landfill that produces methane, H_2S, and volatile organic compounds due to its predominately anaerobic conditions. Waste degradation in typical landfills occurs slowly, resulting in the slow settling of the landfill and affecting leachate quality. The produced leachate is more toxic than a semi-aerobic system due to the slow digestion of organic matter. This makes the system less stable.

The control of semi-aerobic degradation relies on the convection caused by the difference in temperature inside and outside the waste matrix. To achieve good convection, large leachate collection and drainage pipes are installed and connected to the gas vent pipe. This allows the air and oxygen from outside to replace the higher temperature gas inside the well that is vented to the outside. Aerobic microorganisms grow and aid in aerobic decomposition. The leachate's BOD and COD and methane, which causes global warming, are lower than in anaerobic landfills (Pollution Control Department, 2020). The semi-aerobic solid waste management model is shown in Figure 3.29. However, the limitation of this waste disposal system is that only municipal solid waste can be disposed of; hazardous and infectious waste must be separated before waste is deposited in the landfill.

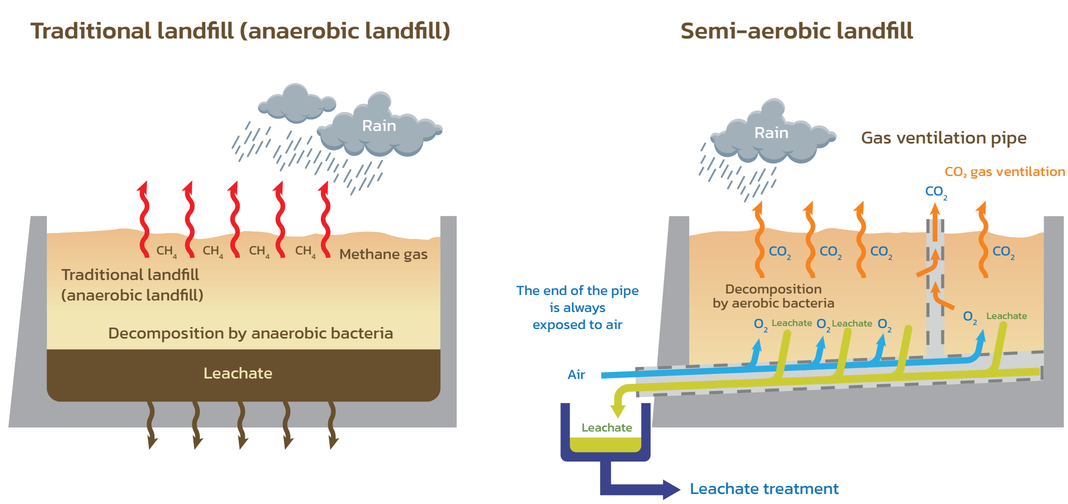


Figure 3.29 Layout of anaerobic and semi-aerobic landfills

TECHNOLOGY IMPLEMENTATION IN THAILAND

Semi-aerobic landfill technology can be disseminated to another areas in Thailand at two levels of application:

- Application with new landfills that receive waste at a rate of less than 350 tonnes/day.
- Application with old landfills that can be partially modified to operate along the principles of a semi-aerobic landfill system.

THE SEMI-AEROBIC LANDFILL SYSTEM IN THAILAND

The characteristics of solid waste in Thailand are different from solid waste in Japan, the originator of the technology. In Japan, household waste separation habits are quite strong and thus, only waste that cannot be sorted or incinerated with less organic matter is sent to a landfill. Such a system mostly buries the ash that results from the incineration of solid waste. In Thailand, the main component of solid waste is organic matter. As a result, an anaerobic digestion tends to be predominant. So, the design and operation of a semi-aerobic landfill system must account for waste composition.

Semi-aerobic landfills are still not widely used in Thailand. They have been used to manage solid waste in only two areas: (1) Mae La Subdistrict Administrative Organization/COERR Foundation (COERR), Tha Song Yang District, Tak Province and (2) Mueang Sikhio Municipality, Sikhio District, Nakhon Ratchasima Province.

GREENHOUSE GAS REDUCTION MECHANISMS

There is typically no outside airflow into the waste matrix in a landfill, resulting in anaerobic degradation inside the waste pile and methane gas production, which contributes to global warming. In semi-aerobic landfills, lower-temperature oxygen flows through pipes installed in the waste. Through the gas ventilation system installed in tandem with leachate collection, aerobic conditions occur and allow aerobic microorganisms, which produce less than half the amount of methane as the methanogens that grow in the anaerobic conditions of a typical landfill, to thrive.

EXAMPLES OF THIS TECHNOLOGY IN THAILAND

MAE LA SUBDISTRICT ADMINISTRATIVE ORGANIZATION/ COERR FOUNDATION (COERR)

THA SONG YANG DISTRICT DISTRICT, TAK PROVINCE

PROJECT DETAILS

The COERR Foundation (COERR) has an environmental stewardship policy and manages the solid waste in a temporary shelter for Burmese fugitives, Mae La, through a community-based waste management project. COERR works in conjunction with the Karen Environment Group (KEG), and COERR's primary role is to coordinate external support, raise funds, provide tools and technical advice. A Solid Waste Diversion Centre was established outside the temporary shelter area on land allocated by the Mae La Subdistrict Administrative Organization. The location and details on the use of space are shown in Figures 3.30–3.31.

Figure 3.30 Map showing the location of COERR project, Tha Song Yang Subdistrict

Figure 3.31 Details of area utilization, COERR Project, Tha Song Yang Subdistrict

PROJECT BACKGROUND

2002

A refugee centre was constructed as a temporary shelter for refugees from Myanmar.

2004

The Mae La Subdistrict/COERR Foundation (COERR) started operation through a grant from UNHCR Waste Management by engaging the community in a 3R campaign. A wastewater treatment system was started with cooperation from the Asian Institute of Technology (AIT).

2016

The original landfill filled up. The Eight-Japan Engineering Consultants Inc. (EJEC) began constructing the semi-aerobic landfill with funding provided by the Japanese government through the Japanese Embassy in Thailand under the GGP-Grant Assistance for Grassroots Human Security Projects.

2016 TO PRESENT

The system has operated since 2016. Within the Solid Waste Diversion Centre, there is a hall for sorting waste, composting machines for biodegradable waste, pollution-free incinerators, landfill pits, sewage ponds and artificial ponds to treat water contaminated by waste.

Figure 3.32 Semi-aerobic landfill system COERR, Tha Song Yang Subdistrict

Later, a semi-aerobic landfill system was initiated with assistance from the Japanese government through the Embassy of Japan in Thailand under the GGP-Grant Assistance for Grassroots Human Security Projects and Technology and technological support from Eight-Japan Engineering Consultants Inc. (EJEC) (Figure 3.31).

Currently, within the Solid Waste Diversion Centre, there is a hall for sorting waste, a composting area to manage biodegradable waste, pollution-free incinerators, a semi-aerobic landfill, sewage ponds and artificial ponds for wastewater treatment. All of the ponds are lined with plastic to prevent leakage. The water quality and smoke from the incinerators are monitored to ensure that the management system does not affect the environment and is within the criteria set by the Pollution Control Department. The refugees residing in the Ban Mae La Temporary Shelter are taught about the waste management system. It is operated by refugee volunteers and the staff of the Karen Environment Group (KEG) under technical guidance from the COERR staff.

Activities related to solid waste management start with collecting waste, loading, sorting solid waste by volunteers and separating recyclable waste for cleaning and compacting for future reuse. Then, the remaining waste from the sorting process, including some plastics, are treated in the high temperature incinerators. Finally, some of the waste, that cannot be sorted and incinerated, will be sent to the semi-aerobic landfill systemm.

SIKHIO CITY MUNICIPALITY

SIKHIO DISTRICT, NAKHON RATCHASIMA PROVINCE

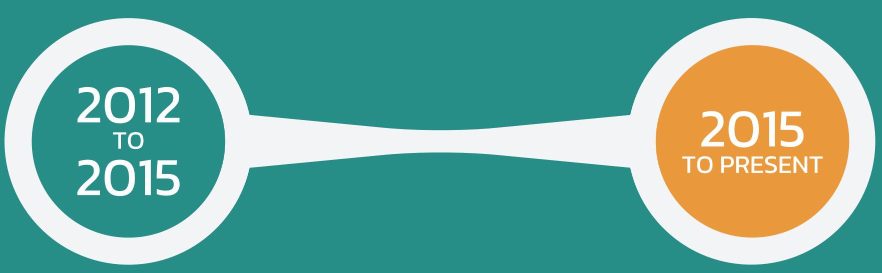
PROJECT DETAILS

Sikhio Municipality's semi-aerobic landfill is a technological cooperation between Thailand and Japan to develop a municipal solid waste landfill for small and medium-sized local administrative organisations to provide semi-aerobic landfill technology, which can change the dumpsite into a sanitary landfill in Thailand.

In the past, about 20 tonnes of waste were generated per day and disposed of by open dumping, causing wastewater and odours. To solve these problems, the municipality started to reduce the amount of dumped waste by campaigning for waste separation in all households, resulting in less waste. Later, when the Thai-Japanese cooperation was initiated, the 11th Regional Environment Office nominated Sikhio City Municipality to the Pollution Control Department and the Japan International Cooperation Agency (JICA) to construct the semi-aerobic landfill. The location of the project and solid waste management systems within the project are shown in Figure 3.33 - 3.35.

Figure 3.33 Map showing the project location, Sikhio District, Nakhon Ratchasima Province

PROJECT BACKGROUND



The Pollution Control Department (PCD) and the Fukuoka Prefecture Japan Environmental Sanitation Center (JESC), Japan International Cooperation Agency (JICA), Environment Office Region 1 (Nakhon Ratchasima) and Sikhio City Municipality jointly conduct a project to develop a municipal solid waste landfill system for medium and small-sized local administrative organisations to transfer the technology semi-aerobic landfills as alternatives to the open dumpsite of a sanitary landfill in Thailand.

The waste disposal site, with an area of approximately four rai, has operated into the present. The site can hold a total of approximately 2,700 tonnes of waste. Currently, the municipality has a project to separate plastic waste for sale. In addition, there is an MBT management plant where RDF fuel is generated and sold.

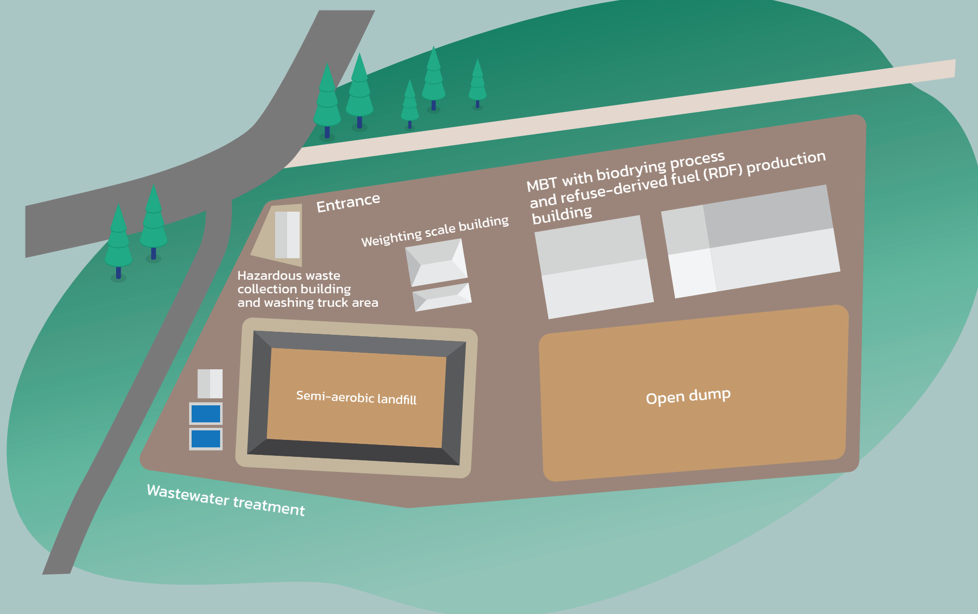
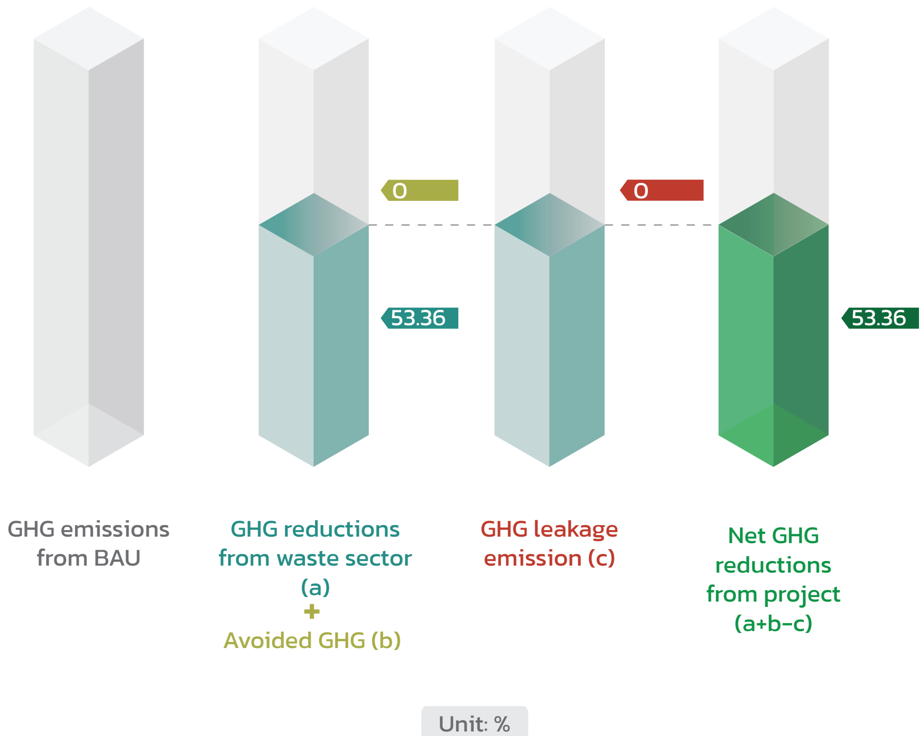


Figure 3.34 Appearance of the buildings and various solid waste management systems within the project, Sikhio District, Nakhon Ratchasima Province

Figure 3.35 Process of waste management of Sikhio Municipality, Nakhon Ratchasima Province

CALCULATIONS OF GREENHOUSE GAS REDUCTIONS

A semi-aerobic system improves solid waste disposal from the typical landfill system easily and without complications. Comparing with a waste disposal by landfilling that is widely used in Thailand, the GHG emission from semi-aerobic landfill is 53.36% lower.



Results of GHG calculation of Semi-Aerobic Landfill

LESSONS LEARNED FOR THE TECHNOLOGY DISSEMINATION

Operations should have a clear operating policy and allocate work to responsible persons. The authority should also work with the community to create acceptance in the municipality.

The quantity of MSW that enters the semi-aerobic landfill and the lifespan of the semi-aerobic landfill must be considered before landfill construction.

This technology is easy to implement and required a small amount of energy (electricity and fuels). The spare parts for equipment repair are also available in Thailand.

It is best to use a design company with experience in design and construction to transfer such knowledge to local stakeholders.

Experts should provide training to give operators the knowledge and expertise to repair and maintain the system.

CONCLUSIONS

By equipping landfills with special gas ventilation and leachate collection pipes, landfilling waste with the semi-aerobic method creates air circulation in the waste that promotes the growth of aerobic microorganisms, reducing the methane gas that causes global warming. Compared with anaerobic landfills, the GHG reduction was 53.36% in both semi-aerobic landfills.

This technology is easy to implement and required a small amount of energy (electricity and fuels). The spare parts for equipment repair are also available in Thailand. This technology costs slightly more than the anaerobic landfill system and can be applied to another areas in Thailand. Therefore, two scenarios are possible, depending on management characteristics: (1) New landfill sites that receive waste disposal at a rate of less than 350 tonnes/day, and (2) modifying and operating old landfills with the semi-aerobic principle.

Success will depend on the design, construction, and operation of the landfill. For Thailand, a design of semi-aerobic landfill should be conducted by an experienced design firm to transfer detailed design knowledge to local stakeholders. With this system, the disposed waste will decompose quickly and, after it stabilises, it can be processed to create RDF. This system also supports Thailand's circular economy and can reduce the need to acquire new landfill sites.

CONTACT INFORMATION OF THE STUDY AREA ORGANISATION

Mae La Subdistrict Administrative Organization/COERR Foundation (COERR) Tha Song Yang District, Tak Province
214 Moo.1, Mae La Subdistrict, Tha Song Yang District,
Tak Province, 63150
Tel: 055-030579
Email: saraban_tak@maehla.go.th
www.maehla.go.th

Sikhio City Municipality, Sikhio District, Nakhon Ratchasima Province
888 Moo.2, Thetsaban Road, Mittraphap Subdistrict,
Sikhio District, Nakhon Ratchasima Province, 30140
Tel: 044-986043
Email: sikhio_888@hotmail.com
www.sikhiotown.go.th

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SUMITOMO


เทศบาลเมืองสีคิ้ว

Good Technology

5. LANDFILL GAS TO ENERGY (LFGTE)

QUICK INFO

Landfill gas to energy (LFGTE) is a process of collecting and turning landfill gas into electricity for sale.

GHG

This technology can mitigate GHG emissions from the disposal site by collecting and using as an alternative fuel to generate electricity.

Successful projects in Thailand are the projects operated by Tha Chiang Thong Company Limited, Hod District, Chiang Mai Province, and the Nonthaburi Provincial Administration, Muang Nonthaburi District, Nonthaburi Province. Those projects can reduce GHG emissions by 26.28% and 22.94% compared with the BAU, respectively.

This technology has medium to high potential to be applied to another areas in Thailand, depending on the intended use of generated electricity (on-site use or grid export). However, an appropriate LFG collection system must be constructed with support from the purchasing entity regarding the price and purchase period.

TECHNOLOGY DETAILS

1. LANDFILL GAS TO ENERGY (LFGTE)

Landfill Gas to Energy (LFGTE) is the process of collecting biogas from landfills and utilising it as fuel. Therefore, LFGTE technology consists of 2 main systems: the landfill system, and gas collection and treatment systems.

Landfilling System

The landfill is the designated facility for waste disposal, designed and operated according to landfilling standards. The disposed waste must be covered by soil or high density polyethylene (HDPE) sheet to protect against animal intrusion and environmental contamination. In addition, the disposal area must be well-designed for the efficiency, safety, stability and capacity of the landfill (Tares Srisathit, 2015).

Landfill Gas Collection and Treatment Systems

The MSW disposed in landfills will be degraded in an anaerobic environment. Landfill gas (LFG) is a product of anaerobic degradation process mainly composing of methane (CH_4) and carbon dioxide (CO_2), which are greenhouse gases. The ratio between methane and carbon dioxide varies from 50:50 to 60:40, depending on the landfill operation and composition of disposed waste. The LFG can migrate to any lateral and vertical pathways, as well as mix with leachate.

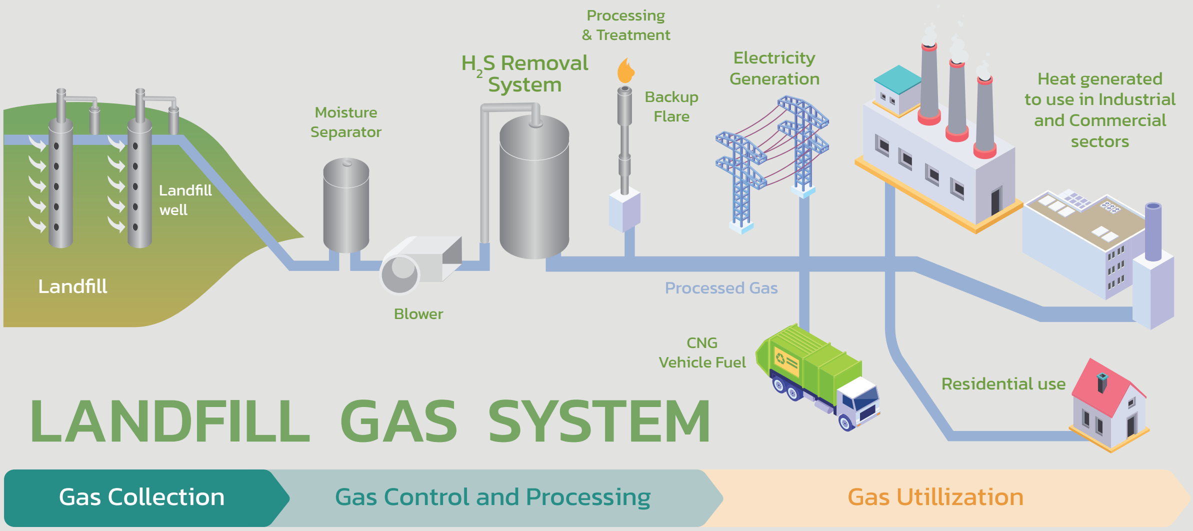


Figure 3.36 Biogas production from landfills

Landfill Gas Management

There are two treatment methods for LFG: flaring and generating electricity. LFG flaring aims to treat harmful gases and avoid environmental impact. To generate electricity, the collected LFG is burned in a combustion engine to generate electricity, with quality and quantity concerns addressed before initiating the project. A diagram of the LFG production from landfills is shown in Figure 3.36.

Technology implementation in Thailand

This technology has medium to high potential to be applied to another areas in Thailand:

- Moderate level – to generate power for commercial uses, the technology is suitable for landfills that receive more than 350 tonnes of MSW per day. Therefore, only a handful of landfills can achieve this project.
- High level – to generate energy for internal use, this can be done immediately, such as using LFG to generate energy for use in landfill activities or leachate treatment.

2. LANDFILL GAS TO ENERGY IN THAILAND

MSW management in Thailand initially consists of sanitary and non-sanitary systems (such as open dumping or unmanaged dumping, etc.). After disposal, the organic content in MSW degrades under anaerobic conditions and generates LFG, which is predominantly methane and carbon dioxide. Therefore, LFGTE investment is suitable for existing landfills by constructing an LFG collection system onsite, collecting the LFG and using it as fuel for generated electricity. However, there are two concerns for implementing LFGTE project. Firstly, the landfill should receive MSW of more than 350 tonnes/day. Secondly, the landfilling period should not exceed three years.

In Thailand, LFGTE has been used in the central and northern regions. Examples of this technology include: (1) a project operated by Tha Chiang Thong Company Limited, Hod District, Chiang Mai Province and (2) projects operated by Nonthaburi

Provincial Administration, Muang Nonthaburi District, Nonthaburi Province. Both projects have different management processes, as shown in Figure 3.37.

3. GREENHOUSE GAS REDUCTION MECHANISM

Anaerobic conditions in the landfill waste matrix cause methane production, which when emitted to the atmosphere, can cause global warming. LFGTE is a project that collects the LFG from the landfill and uses it as fuel for electricity generation. Therefore, an LFGTE project can mitigate the release of methane into the atmosphere. Moreover, the carbon dioxide emission from fossil fuel combustion for electricity generation can be avoided because the LFG is used as alternative fuel.

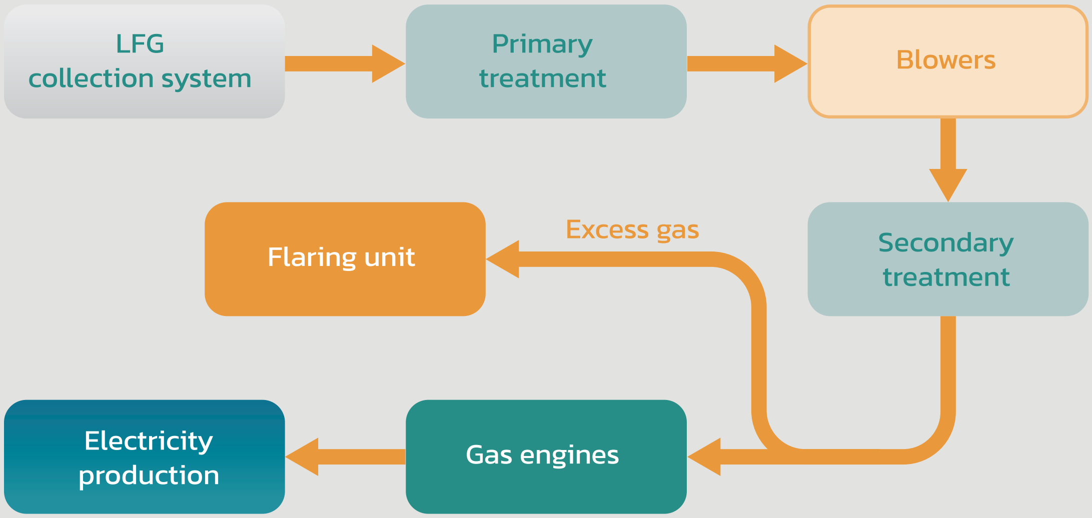


Figure 3.37 Biogas power generation process

EXAMPLES OF THIS TECHNOLOGY IN THAILAND

THA CHIANG THONG CO., LTD.

HOD DISTRICT, CHIANG MAI PROVINCE

PROJECT DETAILS

The “Collection of LFG to Generate Electricity at Tha Chiang Thong” is performed by Tha Chiang Thong Company Limited to construct and operate an LFG power plant. The project location diagram is shown in Figure 3.38. An LFG collecting system was installed in the project area (Figure 3.39). The collected LFG is used to generate electricity with a generator. LFG is collected into the balloon-type gas holder. This excess biogas is stored in the gas holder during generator maintenance or for other reasons, which is better than losing it through flaring. This process can reduce methane emissions. The collected LFG is used to generate electricity to sell to the Provincial Electricity Authority (PEA).

Figure 3.38 Map showing the project location of Tha Chiang Thong Company Limited, Chiang Mai Province

PROJECT BACKGROUND

1997 TO 1998

There was a problem of MSW overflow in Chiang Mai. The capacity of the existing disposal sites was full and the new disposal area was opposed by the neighbouring residents. To solve this problem, the company committed to controlling the environmental impact.

2007 TO 2008

The government started to buy back renewable energy from waste. Therefore, the company improved the LFG collection and utilisation systems instead of flaring. As a result, the system efficiency has continuously improved its efficiency.

01 บ่อฝังกลบขยะ
02 สถานีดูดและลด H2S โรงไฟฟ้าบ้านตาล
03 สถานีดูดและลด H2S โรงไฟฟ้าท่าเชียงทอง
04 บอลลูนเก็บก๊าซ 4 ลูก @ 2,500 ลบ.ม./ลูก
05 โรงไฟฟ้าบ้านตาล
06 โรงไฟฟ้าท่าเชียงทอง
07 อาคารสำนักงาน
08 โรงอบแห้งใช้ความร้อนทิ้งจากโรงไฟฟ้า
09 มิเตอร์ซื้อ และขายไฟฟ้า บ.โรงไฟฟ้าบ้านตาล
10 มิเตอร์ซื้อ และขายไฟฟ้า บ.ท่าเชียงทอง

Figure 3.39 Layout of buildings and various solid waste management systems within the project, Tha Chiang Thong Company Limited, Chiang Mai Province

NONTHABURI PROVINCIAL ADMINISTRATIVE ORGANIZATION (PAO)

SAI NOI DISTRICT, NONTHABURI PROVINCE

PROJECT DETAILS

The MSW is collected from the Nonthaburi province, totalling approximately 1,500 tonnes/day with a steadily increasing trend. Nonthaburi PAO has constructed a sanitary landfill since 2009 until it was occupied in 2017. The Nonthaburi PAO landfill is deep. Thus, it is suitable for developing a LFGTE project. Boon Enersys Co., Ltd. has invested in the construction and management of the LFG utilisation system from the old landfill phase of the Nonthaburi PAO. The LFG power plant is located within the waste disposal site.

Figure 3.40 Map showing the project location
Nonthaburi Provincial Administration Organization

PROJECT BACKGROUND

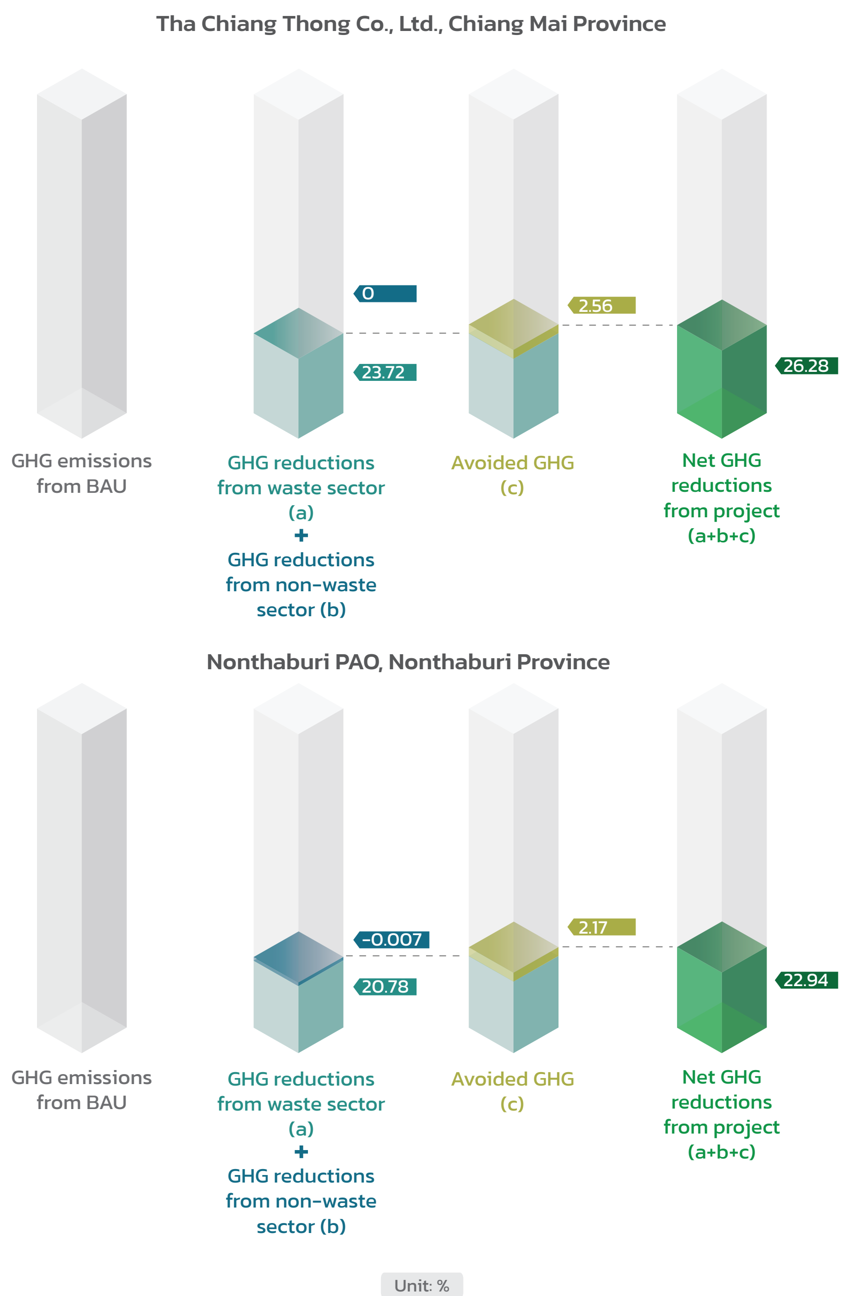
2006	Nonthaburi PAO developed a solid waste disposal system by changing the open dump into a sanitary landfill.
2008	Nonthaburi PAO constructed a landfill in the extended area totalling 120 rai.
2009 TO 2017	Nonthaburi PAO implemented Phase 1 over 50 rai until it was full.
2019	Boon Enersys Company Co., Ltd. approached Nonthaburi PAO to initiate the LFGTE project.
2019	Nonthaburi PAO registered the LFGTE project with the T-VER certification scheme with a project capacity of 6.24 MW.
2010	Boon Enersys Co., Ltd. signed a contract with the Nonthaburi PAO.

Figure 3.41 Appearance of buildings and various solid waste management systems within the project, Tha Chiang Thong Company Chiang Mai Province

The above project implementation is consistent with the government policy that encourages alternative energy form solid waste. Therefore, this project is classified as a quick win project. Quick win projects support the potential for local administrative organisations to produce electricity from waste. The LFGTE system and the production process are shown in Figures 3.40–3.41.

CALCULATIONS OF GREENHOUSE GAS REDUCTIONS

The GHG emissions after the collection of LFG for electricity generation were compared with the anaerobic landfill system that is widely used in Thailand, based on the calculation method from the 2006 IPCC Guidelines: Volume 5, Waste; Chapter 3, Solid waste disposal, applying the calculation equation from the T-VER-TOOL-WASTE-07 of TGO. The results showed that the LFGTE of Tha Chiang Thong Company Limited, Chiang Mai Province, and Nonthaburi Provincial Administrative Organization could reduce GHG emissions by 26.28% and 22.94%, respectively.



Results of GHG calculation of LandFill Gas to Energy

LESSONS LEARNED FOR TECHNOLOGY DISSEMINATION

A practitioner with a good attitude and vision to improve the system constantly will drive the project to success.

LFG collection efficiency from landfills depends on effective communication between the LFG power plant and landfill operators.

Communicating with other stakeholders is essential. A policy to subsidise the community development budget and create mutual benefits will help the community accept the LFGTE operation better.

Training staff in project implementation is important. This will allow the operator to resolve immediate problems.

Supports from government are needed for determining the price of generated electricity, and validating the project conditions for LFG power plant development.

CONCLUSIONS

The LFGTE project can collect the LFG and use it as a renewable fuel to produce electricity. This project can reduce the methane emissions that affect global warming. For example, both projects were able to reduce greenhouse gas emissions by 26.28% (Tha Chiang Thong Company Limited) and 22.94% (Nonthaburi PAO). LFGTE can be moderately applied to another areas in Thailand. For example, for commercial power generation, LFGTE will only be feasible with landfills receiving more than 350 tonnes/day of waste. Therefore, only a handful of landfills can conduct such a project. If the amount of waste fed to the system is less than 350 tonnes/day, this technology is still applicable if the generated electricity will be consumed in the facility such as for leachate collection and wastewater treatment.

However, the initial operation required a proper LFG collection system. In addition, operators should be trained to fix any problems during the operation. This technology also needs incentives from the government for power purchases both in terms of price and purchasing period.

CONTACT INFORMATION OF THE STUDY AREA ORGANISATION

Tha Chiang Thong Co., Ltd. Hod District, Chiang Mai Province
209 Moo.7, Ban Tan Subdistrict, Hod District,
Chiang Mai Province
Tel: 082-7629249, 082-7629244
Email: Lge.prayuth@gmail.com, Lge.mayuree@gmail.com

Nonthaburi Provincial Administrative Organization (PAO), Nonthaburi Province
Nonthaburi Provincial Administrative Organization Office
Mueang District, Nonthaburi Province, 11000
Tel: 025-890481-5
Email: admin@nont-pro.go.th
www.nont-pro.go.th

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ธเรศ ศรีสถิต. (2558). **วิศวกรรมการจัดการมูลฝอยชุมชน,** *วิศวกรรมสถานแห่งประเทศไทย ในพระบรมราชูปถัมภ์, กรุงเทพฯ.*

Good Technology

6. COMPOSTING

QUICK INFO

Composting is a downstream technology that allows organic waste to degrade and stabilise biologically under controlled conditions. The final product of this process is a soft, fine-grained and mineralized matter that is black to brown and relatively dry and can be used in agriculture as fertiliser or soil amendment.

Good examples of reference sites in Thailand are (1) On Nut organic compost factory, Bangkok, which can reduce GHG emissions by 11.99% and (2) the organic compost fermentation project operated by Satuk Subdistrict Municipality, Satuk District, Buriram Province, which can reduce GHG emissions by 33.09% as compared with BAU.

GHG

Composting can reduce greenhouse gas emissions because it is produced through an aerobic degradation process at high temperatures, resulting in lower greenhouse gas emissions than anaerobic landfills.

This technology can be implemented in other areas of Thailand. However, mechanical sorting technology that is appropriate and consistent with the nature of Thailand's unsorted MSW is needed and efficient and reliable machines and equipment should be selected.

Composting technology requires low investment and moderate area requirements.

TECHNOLOGY DETAILS

1. COMPOSTING

Composting is the process of decomposing biological matter in MSW to stabilise the organic matter within the waste under the controlled conditions that are most conducive to microbial activity. The final product of this process is a soft, fine-grained organic matter that is black to brown and relatively dry and can be used in agriculture as compost, fertiliser or soil amendment.

Composting technology in Thailand can be applied at different scales: (1) the production of organic compost for large-scale projects and (2) the production of organic compost at the small community level.

THE COMPOSTING PROCESS FROM MSW FOR LARGE-SCALE PROJECTS

First, the waste is manually and mechanically separated. Next, the contaminated or unwanted materials such as aluminium cans, batteries and metal waste will be removed., leaving only organic waste. Then, the separated organic waste is composted in the composting plant. After the composting process, the composted materials are sieved to separate impurities or unwanted materials from the composted materials before being packed into bags or pellets for distribution. The entire process is conducted in a closed system with continuous quality control that has no adverse effect on people or the environment.

THE COMPOSTING PROCESS FROM SOLID WASTE AT THE SMALL COMMUNITY LEVEL

The process begins with separating organic waste within the community, making it appropriate for households or small communities. Additionally, this reduces the waste that must be disposed of and eliminates the spoilage problem associated with food and vegetable scraps at the disposal site. Further, solid waste can be converted into a soil-like substance with a dark colour known as humus that can be used as a soil conditioner. Although compostable manure may contain fewer nutrients than organic manure on the market, it can help improve the soil’s porosity, necessary for plant growth.

COMPOST PRODUCTION METHOD

The organic compost production model can be divided into two types as follows:

1. WINDROW OR OPENED SYSTEM

This method dumps waste for microorganism decomposition with or without aeration. This type of composting process can be divided into two types:

a. Production of organic fertilisers in windrows with turning (turned pile). The waste materials are homogeneously mixed and stacked in a long row, turning twice a week.

b. Static piles with designated aeration; this method is suitable for relatively wet materials as it allows the material's structure to be adjusted to increase its porosity and absorb excess moisture. (Figure 3.42).

2. CLOSED SYSTEM

The waste is placed in a reaction tank and then compressed air is pushed into the tank. The closed system is divided into two types as follows:

a. Plug flow: The composted material is added to the reaction tank and agitated while air is added. Longer fermentation times result in greater amounts of waste that reach the reaction tank's end.

b. Continuous stirring (dynamic): while providing aeration, the composted material is homogeneously mixed inside the reactor, allowing for a uniform reaction throughout the system.

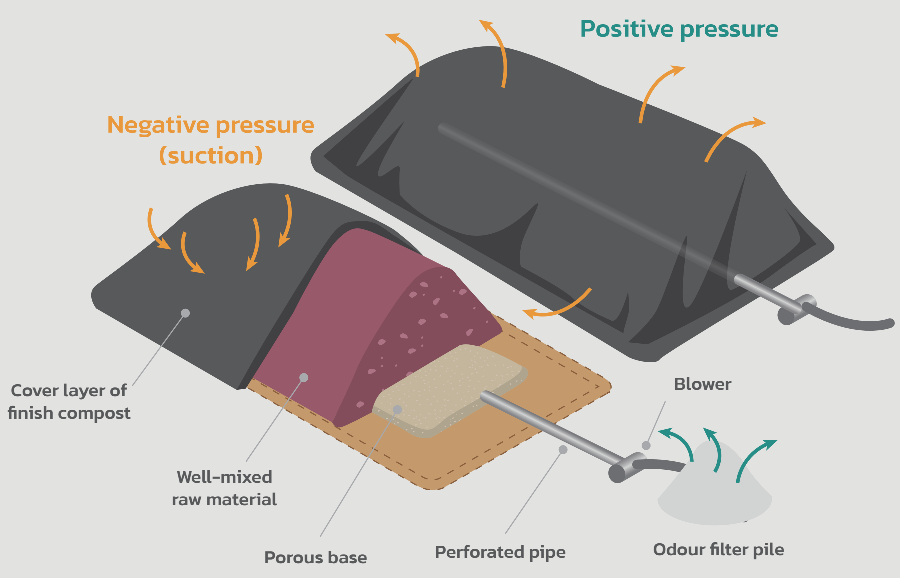


Figure 3.42 Aerated pile organic fertilizer production (R.V. Misra, R.N. Roy and H. Hiraokd, 2003)

COMPOSTING TECHNOLOGY IMPLEMENTATION IN OTHER AREAS IN THAILAND

The composing technology has high potential to be applied to another areas in Thailand, which can be divided into two cases as follows:

- When midstream waste sorting is practised, the implementation is suitable for a project with more than 50 tonnes MSW/day
- When waste sorting at the source is practised, composting can be implemented at all project levels.

2. TECHNOLOGY IMPLEMENTATION IN THAILAND

In Thailand, manufacturing fertiliser or soil conditioners often uses models from foreign composting systems. However, MSW in Thailand is different from the MSW in other countries due to its higher moisture content and wet organic waste. Additionally, different weather conditions result in variable degradation rates. Thus, when applying this technology to Thailand, the characteristics of the waste entering the system and the local climate must be considered to select the appropriate composting technology.

For Thailand, compost or soil conditioner technology has been used in many areas. Good examples of reference sites in Thailand are: (1) On Nut organic composting plant, Bangkok and (2) the composting project operated by Satuk Subdistrict Municipality, Satuk District, Buriram Province.

3. GREENHOUSE GAS REDUCTION MECHANISMS

There is no airflow from outside into the waste matrix in a typical landfill operation. This results in anaerobic degradation within the waste matrix resulting in the generation of methane, which contributes to global warming. Producing compost, organic waste is separately collected to be treated aerobically using aerobic biodegradation processes under high-temperature conditions. Thereby, no methane is being generated thus, GHG emissions are reduced compared with the typical landfill processes. In addition, the heat generated during the process kills pathogens which hygienize the material resulting in a product that can be used in agriculture as fertilizer and/or soil conditioner.

EXAMPLES OF THIS TECHNOLOGY IN THAILAND

ON NUT ORGANIC COMPOST FACTORY

ON NUT DISTRICT, BANGKOK

PROJECT DETAILS

The BMA operates a sewage treatment plant supervised by the Office of Solid Waste Management, Department of the Environment. The waste disposal process generates a significant amount of sludge. Various district offices in Bangkok are also responsible for regularly trimming and maintaining trees, whether in park areas or in the garden located in the middle of the road, which results in branches, trees and leaves that are costly for the BMA to handle. The BMA considers this method of waste management consistent with the BMA's policy of creating a greener city and actively supporting the expansion of green space.

Figure 3.43 Map showing the project location, On Nut Organic Compost Factory, Bangkok

The organic composting factory has a working capacity of 50 tonnes/day. Each phase of the organic composting factory's operation is based on mechanical principles. The work area is divided into four parts: (1) composting area, (2) composting and disinfection reception area, (3) sorting and size reduction area and (4) nutrient improvement and bagging area. The details of organic composting production are shown in Figures 3.43–3.45.

PROJECT BACKGROUND

2002
BMA began improving the compost production process by constructing a composting plant in On Nut with a capacity of at least 30 cubic metres per day.

2007
Established an organic composting facility in the vicinity of the On Nut Waste Disposal Centre.

2011
The On Nut composting plant was upgraded with new machinery.

2016
The plant was claimed for T-VER.

2017
Certified carbon credit No. 1 (1/10/2015 – 31/05/2016: 1,342 tCO_2-eq).

2019
Certified carbon credit No. 2 (1/06/2016 –31/06/2019: 1,932 tCO_2-eq).

Figure 3.44 Area use within the project for organic fertilizer production from twigs and leaves Waste by Bangkok Metropolitan Administration

Figure 3.45 Process of fertilizer production from Twig and Leaf Waste Project by Bangkok Metropolitan Administration

THE ORGANIC COMPOSTING PROJECT OPERATED BY THE SATUK SUBDISTRICT MUNICIPALITY

SATUK DISTRICT, BURIRAM PROVINCE

PROJECT DETAILS

There was inadequate landfill for waste disposal. Therefore, the municipality purchased land to be used as a landfill. Later, the Ministry of Natural Resources and Environment provided monetary support to construct an integrated solid waste management centre for Satuk Subdistrict Municipality, Satuk District, Buriram Province. The design and construction of this centre were then started. The centre started operating in 2015.

Satuk Subdistrict Municipality has a local administration organisation (LAO) that manages the central budget and establishes a comprehensive solid waste management centre.

Figure 3.46 Map showing the project location of Satuk Municipality, Buriram Province

The joint municipality in the Satuk cluster had to support a portion of the budget for constructing the integrated solid waste management centre project. Therefore, currently, there are different tipping fees charged to the joint municipality. This tipping fee is calculated based on the joint municipality's investment at the beginning of the project. Figures 3.46–4.38 show the location, management process and process of solid waste management.

PROJECT BACKGROUND

2002
Insufficient area for landfilling waste.

2003
The subdistrict purchased land, 46 rai, outside the municipality.

2005
The subdistrict purchased three additional adjacent areas as an extension of the previous area, approximately 10.5 km from Satuk Municipality.

2008 TO 2012
The subdistrict coordinated budgets supported by the Ministry of Natural Resources and Environment to create an integrated solid waste management centre for Satuk Subdistrict Municipality.

2013
Budget support was provided to conduct a feasibility study and to construct the integrated solid waste management centre.

2015
The plant started operations.

Figure 3.47 Management process within the project of Satuk Subdistrict Municipality, Buriram Province

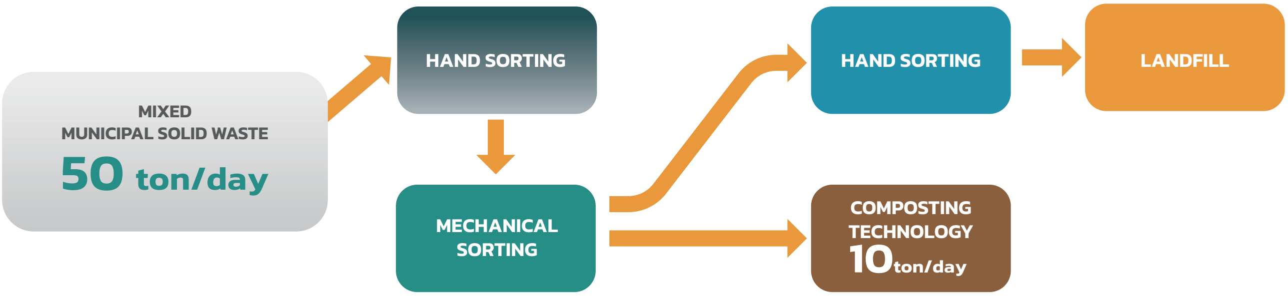
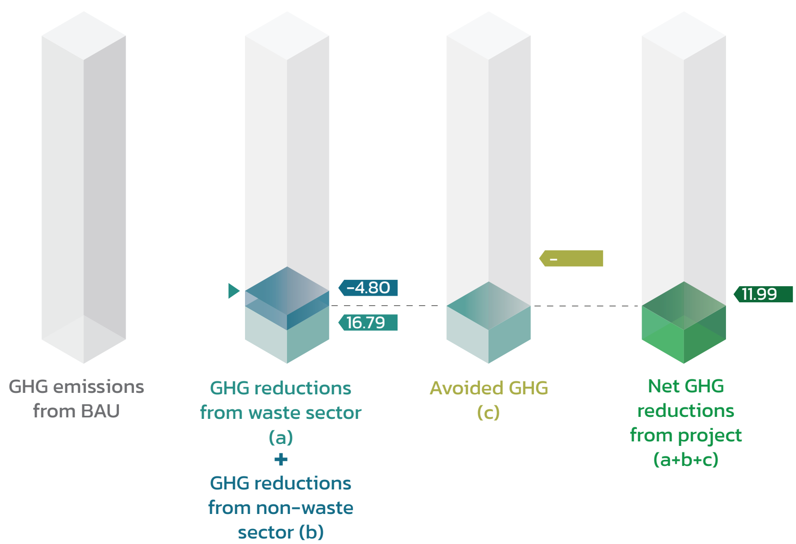


Figure 3.48 Solid waste sorting process in the Comprehensive Solid Waste Management Centre of the Satuk Subdistrict Municipality, Buriram Province

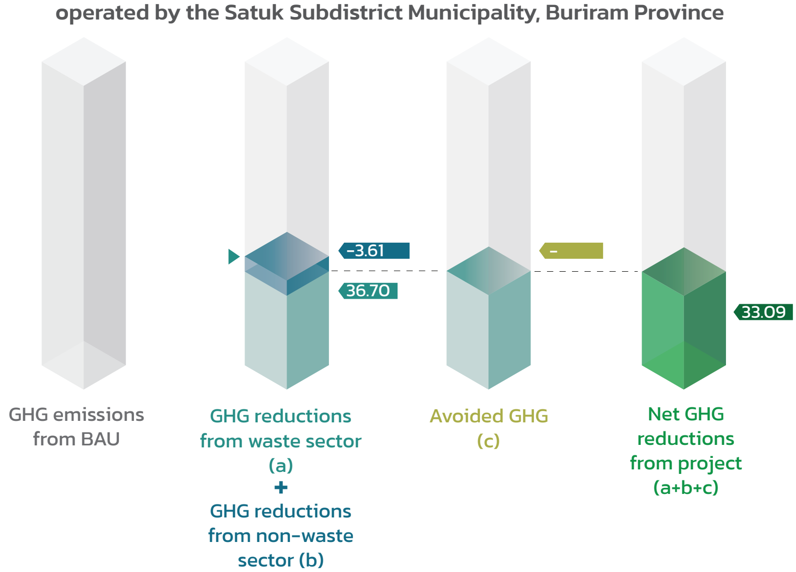
CALCULATIONS OF GREENHOUSE GAS REDUCTIONS

The GHG emissions of composting or soil conditioning technology in waste management were compared with the anaerobic landfill method that is widely used in Thailand, using national average solid waste composition data and the calculation methods from the 2006 IPCC Guidelines: Volume 5, Waste; Chapter 3, Solid waste disposal and the T-VER-TOOL-WASTE-01. The results of the GHG reduction calculated using the parameters obtained from the selected reference sites show that the BMA organic composting plant and Satuk Subdistrict Municipality, Buriram Province, were able to reduce GHG emissions by 11.99% and 33.09%, respectively as compared with BAU.

On Nut organic compost factory, Bangkok



The organic composting project operated by the Satuk Subdistrict Municipality, Buriram Province



Unit: %

Results of GHG calculation of Composting

LESSONS LEARNED FOR THE TECHNOLOGY DISSEMINATION

Visionary leaders with clear policies are essential. There must be an agreement with waste suppliers as well as local communities to obtain a good cooperation for waste sorting and share mutual benefits.

A pilot-scale experiment should be undertaken before actual operation. This will contribute to the success of the actual operation.

New employees should be trained to enhance knowledge, skills and work experience. This will allow employees to apply the problem solving skills to handle some basic problems.

If the plant is operated in an open area, it may encounter difficulties during the rainy season, rendering it incapable of operating at peak efficiency. Indoor compost storage should be considered, or an area suitable for the amount of incoming solid waste should be considered to ensure effective operations.

A facility must prepare a space for product storage.

The process is not complicated and a front-end loader can be used to flip the compost pile instead of the stirring system. The technology is simple to implement and does not require a large budget. However, the system requires a fair amount of space.

CONCLUSIONS

Composting is a technology that processes organic waste using biodegradation under aerobic, high-temperature conditions to produce compost. The product can be used in agriculture as fertilizer or soil conditioner. It can reduce the amount of methane generated when compared with anaerobic landfill practices.

The heat generated during the process can kill pathogens thus hygienizes the compost. The selected reference sites were able to reduce GHG emissions by 11.99% (On Nut composting factory, BMA) or 33.09% (composting project operated by Satuk Subdistrict Municipality, Satuk District, Buriram Province) as compared with anaerobic landfilling.

The composing technology has high potential to be applied to another areas in Thailand due to its low operating costs, which can be divided into two cases: (1) when midstream waste sorting is practised, the implementation is suitable for more than 50 t MSW/day and (2) when waste sorting at source is practised; the implementation can be carried out at all project levels .

However, there is a need for further improvement in terms of processing time, quality of products, and energy consumption. Furthermore, selecting and using appropriate mechanical waste separation technology is vital as the unsorted MSW in Thailand may lead to the feeding of inappropriate materials into the composting process. In addition, other key success factors for composting technology are the price mechanism for compost products and the development of organic waste sorting at the source.

CONTACT INFORMATION OF THE STUDY AREA ORGANISATION

On Nut organic compost factory, Bangkok
Bangkok Metropolitan Administration 2
Mitmaitri Road, Din Dang District, Bangkok, 10400
Tel: 02-2032930
Email: researchsubdivision@gmail.com
https://webportal.bangkok.go.th/environmentbma

The organic composting project operated by the Satuk Subdistrict Municipality Satuk District, Buriram Province
Satuk Subdistrict Municipality Office building
333 Moo.10, Satuk Subdistrict, Satuk District,
Burirum Province, 31150
Tel: 044-681019
Email: admin@satuk.go.th
www.satuk.go.th

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4

APPENDIX

THE EQUATIONS FOR CALCULATING GOOD PRACTICES AND TECHNOLOGIES FOR CLIMATE-FRIENDLY MSW MANAGEMENT (PTCMS)

Good practices and technologies for climate-friendly	Equations	Source of equations
Waste Separation and Material Recovery at Source	• [1]BAU Emission (BAU_y) $BAU_{LF,y} = CH_4 \text{ emissions} \times GWP_{CH4}$ $CH_4 \text{ emissions} = [\, \sum CH_4 \text{ generated}_{x,T} - R_T \,] \times (1 - OX_T)$ $BAU_{INCIN,y} = CO_2 \text{ Emissions} + CH_4 \text{ Emissions} + N_2O \text{ Emissions}$ $CO_2 \text{ Emissions} = MSW \times \sum_j (WF_j \times dm_j \times CF \times FCF_j \times OF_j) \times 44/12$ $CH_4 \text{ Emissions} = \sum_i (IW_i \times EF_i) \times 10^{-6}$ $N_2O \text{ Emissions} = \sum_i (IW_i \times EF_i) \times 10^{-6}$ • Project Emission (PE_y) $PE_{\text{อุโมงค์},y} = {}^1PE_{LF,y}$ $PE_{\text{เวียงเก็ง},y} = {}^1PE_{INCIN,y}$ • [1]Leakage Emission (LE_y) $LE_{COMP,y} = (CH_4 \text{ Emissions} \times GWP_{CH4}) + (N_2O \text{ Emissions} \times GWP_{N2O})$ $CH_4 \text{ Emissions} = \sum_i (M_i \times EF_{CH4}) \times 10^{-3} - R$ $(N_2O \text{ Emissions} = \sum_i (M_i \times EF_{N2O}) \times 10^{-3}$ • Emission avoidance (EA_y) ${}^2EA_{recycle,y} = (BE_{plastic,\,y} - PE_{plastic,\,y}) + (BE_{glass,\,y} - PE_{glass,\,y}) + (BE_{metal,\,y} - PE_{metal,\,y})$ ${}^3EA_{coal,y} = (BE_{Coal,transfer,y} + BE_{Coal,burn,y}) - (PE_{RDF-EL,y} + PE_{RDF-burn,y})$ ${}^4EA_{COL\&TRAN} = W_{REDUC} \times EF_{COL\&TRAN}$ • Emission Reduction (ER_y) $ER_{\text{อุโมงค์},y} = BAU_{LF,y} - (PE_{LF,y} + LE_{COMP,y} - EA_{recycle,y} - EA_{COL\&TRAN})$ $ER_{\text{เวียงเก็ง},y} = BAU_{INCIN,y} - (PE_{LF,y} + LE_{COMP,y} - EA_{recycle,y} - EA_{coal,y})$	[1]2006 IPCC Guidelines [2]T-VER-METH WM-09 [3]T-VER-METH WM-04 [4]Thai National LCI Database, TIIS-MTEC-NSTDA

Good practices and technologies for climate-friendly	Equations	Source of equations
MBT +Biodrying+RDF	• BAU Emission (BAU_y) $BAU_y = BAU_{LF,y}$ • Baseline Emission (BE_y) $BE_y = BAU_{LF,y} + (W_{coal-rdf} \times EF_{coal,burn,y}) + (W_{coal-rdf} \times EF_{coal,transfer,y})$ • Project Emission (PE_y) $PE_y = FC_{PJ,I,y} \times (NCV_{i,y} \times 10^{-6}) \times EF_{co2,i}) \times 10^{-3} + ((FC_{PJ,I,y} \times 10^{-3}) \times EF_{EC,y}) + (W_y \times EF_{Biodry,y})v +$ $(W_{RDF} \times EF_{RDF,y})$ • Emission Reduction (ER_y) $ER_y = BE_y - PE_y$	[1]2006 IPCC Guidelines
MSW incineration: WtE plant	• [1]Baseline Emission (BE_y) $BE_y = BAU_{LF,y}$ • [1]Project Emission (PE_y) $PE_y = CO_2 \text{ Emissions} + CH_4 \text{ Emissions} + N_2O \text{ Emissions}$ $CO_2 \text{ Emissions} = MSW \times \sum_j (WF_j \times dm_j \times CF \times FCF_j \times OF_j) \times 44/12$ $CH_4 \text{ Emissions} = \sum_i (IW_i \times EF_i) \times 10^{-6}$ $N_2O \text{ Emissions} = \sum_i (IW_i \times EF_i) \times 10^{-6}$ • [2]Emission Reduction (ER_y) $ER_y = ER_{AE} + ER_{WM}$ $ER_{AE} = BE_{AE,y} - PE_{AE,y}$ $BE_{AE,y} = (EG_{Consumer,PJ,y} \times EF_{EC,y}) + (EG_{Grid,PJ,y} \times EF_{EG,y})$ $PE_y = (EC_{PJ,y} \times EF_{EC,y}) + \sum(FC_{PJ,i,y} \times (NCV_{i,y} \times 10^{-6}) \times EF_{CO2,i}) \times 10^{-3}$ $ER_{WM} = BE_{WM,y} - PE_{WM,y}$ $BE_y = Q_{ww,PJ,y} \times (COD_{inf,PJ,y} - COD_{eff,PJ,y}) \times MCF_{BL} \times UF_{BL} \times B_o \times GWP_{CH4} \times 10^{-6}$ $PE_{WM,y} = PE_{leak,y} + PE_{flare,y} + PE_{FF,y} + PE_{EL,y}$ $PE_{leak,y} = Q_{ww,PJ,y} \times (COD_{inf,PJ,y} - COD_{eff,PJ,y}) \times MCF_{PJ} \times (1-CFE) \times UF_{PJ} \times B_o \times GWP_{CH4,y} \times 10^{-6}$ $PE_{flare,y} = V_{CH4,biogas,y} \times (1 - FE) \times GWP_{CH4}$ $PE_{FF,y} = \sum(FC_{PJ,i,y} \times (NCV_{i,y} \times 10^{-6}) \times EF_{CO2,i}) \times 10^{-3}$ $PE_{EL,y} = ECP_{J,y} \times EF_{EC,y}$	[1]2006 IPCC Guidelines [2]T-VER-METH AE-01 และ T-VER-METH WM-01
Landfill Gas to Energy	• [1]BAU Emission (BAU_y) $BAU_y = BAU_{LF,y}$ • [2]Baseline Emission (BE_y) $BE_y = BAU_{LF,y} + BE_{CH4,HG,y} + BE_{CH4,flare,y} + BE_{EG,y}$ • [2]Project Emission (PE_y) $PE_y = PE_{FF,y} + PE_{EL,y} + 0.1\,(BE_{CH4,flare,y})$ • [1]Emission Reduction (ER_y) $ER_y = BE_y - PE_y$	[1]2006 IPCC Guidelines [2]T-VER-METH WM-07

Good practices and technologies for climate-friendly	Equations	Source of equations
Composting	• [1]BAU Emission (BAU_y) $BAU_y = BE_{CH4,SWDS,y}$ • [2]Baseline Emission (BE_y) $BE_y = W_y \times (p_{\text{ไม้},y} \times 4.02 + p_{\text{กระดาษ},y} \times 3.72 + p_{\text{อาหาร},y} \times 1.00 + p_{\text{สิ่งทอ},y} \times 2.23 + p_{\text{กิ่งไม้และใบไม้},y} \times 1.68) \times CF \times 0.1$ • [2]Project Emission (PE_y) $PE_y = PE_{FF,y} + PE_{EL,y} + PE_{COMP,y}$ • [1]Emission Reduction (ER_y) $ER_y = BE_y - PE_y$	[1]2006 IPCC Guidelines [2]T-VER-METH WM-03
การจัดการมูลฝอยโดยกระบวนการผลิตก๊าซชีวภาพจากหลุมฝังกลบ (Landfill Gas to Energy)	• [1]BAU Emission (BAU_y) $BAU_y = BAU_{LF,y}$ • [2]Baseline Emission (BE_y) $BE_y = BAU_{LF,y} + BE_{CH4,HG,y} + BE_{CH4,flare,y} + BE_{EG,y}$ • [2]Project Emission (PE_y) $PE_y = PE_{FF,y} + PE_{EL,y} + 0.1\,(BE_{CH4,flare,y})$ • [1]Emission Reduction (ER_y) $ER_y = BE_y - PE_y$	2006 IPCC Guidelines

EN ไทย GLOSSARY

A

AR5 or IPCC AR5 (The Fifth Assessment Report) provides a clear and up to date view of the current state of scientific knowledge relevant to climate change. It consists of three Working Group (WG) reports and a Synthesis Report (SYR) which integrates and synthesizes material in the WG reports for policymakers. The SYR has been published in 2014 (EEA, 2022; IPCC, 2014).

B

Baseline is the emission case refer to the production of greenhouse gases that have occurred in the past and which are being produced prior to the introduction of any strategies to reduce emissions. The baseline measurement is determined over a set period, typically one year (Encyclopedia, 2019).

BAU: Business as usual is a base case for emissions projection that would result if future development trends followed those of the past and no changes in policies take place (Silva-Send, 2015).

BE: Baseline Emission is often found in equations for calculating the emission reduction that will occur in CDM projects, the equation is as follows:

Emission reduction (ER) = Baseline emission (BE) – Project emission (PE) - Leakage (L)

C

CDM: Clean Development Mechanism, defined in Article 12 of the Protocol, allows a country with an emission-reduction or emission-limitation commitment under the Kyoto Protocol (Annex B Party) to implement an emission-reduction project in developing countries. Such projects can earn saleable certified emission reduction (CER) credits, each equivalent to one ton of CO_2, which can be counted towards meeting Kyoto targets (UNCC, 2022).

Circular Economy is a model of production and consumption, which involves sharing, leasing, reusing, repairing, refurbishing, and recycling existing materials and products as long as possible. In this way, the life cycle of products is extended. A circular economy reduces material use, redesigns materials to be less resource-intensive, and recaptures “waste” as a resource to manufacture new materials and products (EPA, 2021; European Parliament, 2021).

Climate is the average weather in each area over a longer period of time. A description of a climate includes information on, e.g., the average temperature in different seasons, rainfall, and sunshine. Also, a description of the (chance of) extremes is often included. The classical period used for describing a climate is 30 years, as defined by the World Meteorological Organization (WMO) (Climateurope, 2020).

Climate change is any systematic change in the long-term statistics of climate variables such as temperature, precipitation, pressure, or wind sustained over several decades or longer. Climate change can be due to natural external forcings (changes in solar emission or changes in the earth’s orbit, natural internal processes of the climate system) or it can be human induced (Climateurope, 2020).

CO_2eq: Carbon dioxide equivalent is a metric measure used to compare the emissions from various greenhouse gases on the basis of their global-warming potential (GWP), by converting amounts of other gases to the equivalent amount of carbon dioxide with the same global warming potential, for example, Methane has a GWP 28 times that of CO_2 equivalent (Eurostat, 2017; EPA, 2021a).

D

E

Emission is something that has been emitted—released or discharged. In general, emissions consist of things like gas, liquid, heat, sound, light, and radiation. Emission can arise from different activities and natural sources such as burning fuel for energy, industrial processes, some farm activities, and deforestation (IPCC, 2019).

Emission factor is a coefficient that allows converting activity data into GHG emissions. It is the average emission rate of a given source, relative to units of activity or process/processes (EPA, 2022).

ER: Emission Reduction is often found in equations for calculating the emission reduction that will occur in projects, the equation is as follows:

Emission reduction (ER) = Baseline emission (BE) – Project emission (PE) - Leakage (L)

F

FiT: Feed-in Tariff is a policy designed to support the development of renewable energy sources by providing a guaranteed, above-market price for producers, typically based on the cost of generation of each different technology. Technologies like wind power, for instance, are awarded a lower per-kWh price, whereas technologies like solar, photovoltaic, and tidal or wave power are currently offered a higher price, reflecting their higher costs (Clark, 2018; Kenton and Estevez, 2021).

FOD: First Order Decay is the method for estimating CH4 emissions from solid waste disposal sites (SWDS). This method assumes that the degradable organic component (degradable organic carbon, DOC) in waste decays slowly throughout a few decades, during which CH_4 and CO_2 are formed (Frey et al., 2006).

G

GHGs: Greenhouse Gases is any gas that has the property of absorbing infrared radiation (net heat energy) emitted from Earth's surface and reradiating it back to Earth's surface, thus contributing to the greenhouse effect. Carbon dioxide, methane, and water vapor are the most important greenhouse gases. (To a lesser extent, surface-level ozone, nitrous oxides, and fluorinated gases also trap infrared radiation.) (Mann, 2021).

Global warming refers to the rise in global temperatures due mainly to human activities, primarily fossil fuel burning, which increases heat-trapping greenhouse gas levels in Earth's atmosphere (GISS, 2022).

Greenhouse effect is a natural process that warms the Earth's surface. When the Sun's energy reaches the Earth's atmosphere, some of it is reflected back to space and some is absorbed and re-radiated by greenhouse gases. The absorbed energy warms the atmosphere and the surface of the Earth. If the concentrations of greenhouse gases are increasing. This is increasing the greenhouse effect, which is contributing to the warming of the Earth (Australian Department of Agriculture, Water and the Environment, 2021; UCAR SciEd, 2022).

Greenhouse Gas Inventory or GHG-I is an accounting of greenhouse gases (GHGs) emitted to or removed from the atmosphere. An inventory will list, by source, the number of pollutants emitted to the atmosphere during a given period (annual emission estimates from a base year to the latest year) (EPA, 2022a).

Grid Emission factor refers to a CO_2 emission factor (tCO_2/MWh) which will be associated with each unit of electricity provided by an electricity system. It is a parameter to determine the baseline emissions for CDM projects in the renewable energy sector (hydro, wind, solar PV, geothermal power, etc.). The grid emission factor of Thailand's transmission system in 2018 was 0.5290 tCO_2/MWh for electricity producers and 0.4872 tCO_2/MWh for electricity users (Takahashi and Louhisuo, 2021).

GWP: Global Warming Potential was developed to allow comparisons of the global warming impacts of different gases. Specifically, it is a measure of how much energy the emissions of 1 ton of a gas will absorb over a given period, relative to the emissions of 1 ton of carbon dioxide (CO_2). The IPCC's The Fifth Assessment Report (AR5) defined the GWP of CO_2, CH_4, N_2O, CF_4, HFC-152a as 1, 28, 265, 6630, 138, respectively.) (EPA, 2021a).

H

I

IPCC: Intergovernmental Panel on Climate Change is the UN body for assessing the science related to climate change. It was established by the United Nations Environment Programme (UNEP) and the World Meteorological Organization (WMO) in 1988 to provide political leaders with periodic scientific assessments concerning climate change, its implications, and risks, as well as to put forward adaptation and mitigation strategies (United Nations, 2021).

J

K

L

Landfill gas is the gas that is produced under anaerobic conditions in landfills by decomposition of municipal solid waste (MSW). LFG is composed of different gases. By volume, landfill gas typically contains 45% to 60% methane and 40% to 60% carbon dioxide (Speight, 2019).

Leakage is defined as the net change of anthropogenic emissions by sources of GHG emissions which occur outside of the CDM project boundaries (in other sectors, regions, or countries), and which are measurable and attributable to the CDM project activity (Millock, 2013).

M

N

National Greenhouse Gas Inventory is part of the UNFCCC management of GHG emissions. Inventories are used to monitor progress towards reduction targets and to enable countries to access climate finance mechanisms (Wartmann, 2017).

O

P

PE: Project Emission is GHG emissions from project operations and is often found in equations for calculating the emission reduction that will occur in projects.

Project Boundary is defined as measurable and auditable characteristics for defining the framework of all emissions calculations (Livoti, 2019).

Q

R

RDF: Refuse Derived Fuel can be produced from the waste left over after sorting recoverable organic and recyclable items from municipal or general waste. This waste is shredded, dried, and baled and then finally turned into a solid fuel that is easy to transport and can be used in place of traditional solid fuels like coal. It is particularly suitable for use in cement kilns (Breeze, 2018; Broad Group, 2018).

S

T

TGO: Thailand Greenhouse Gas Management Organization (Public Organization) was established in 2007 under the Ministry of Natural Resources and Environment, as an autonomous public organization in accordance with Thai law to manage and expedite development and implementation of greenhouse gas reduction projects and support public, private and international organization partnerships to promote implementation of climate action (TGO, 2019).

U

UNFCCC: United Nations Framework Convention on Climate Change sets out the basic legal framework and principles for international climate change cooperation with the aim of stabilizing atmospheric concentrations of greenhouse gases (GHGs) to avoid "dangerous anthropogenic interference with the climate system" (ENB, 2021).

V

VERs: Voluntary Emission Reductions are reductions that are not mandated by any law or regulation but originate from an organization's desire to take active part in climate change mitigation efforts. This may enable the organization to be recognized as a proactive advocate for new technologies and approaches in this area. For Thailand, Thailand Voluntary Emission Reduction Program (T-VER) was launched in 2013 by TGO as a project-based voluntary scheme to encourage GHG reduction and promote the carbon market in Thailand (Kenichi, 2021; DNV, 2021).

VSPP: Very Small Power Plant means a generator of a private entity, state agency, state-owned enterprise or an individual with his own generating unit, whose power generating process is as described in Section B and who sells no more than 10 MW of electrical power to the Distribution Utility (FAO, 2002).

W

X

Y

Z

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INDEX

คำที่ใช้ในรายงานภาษาอังกฤษ	คำแปลภาษาไทย	คำที่ใช้ในรายงานภาษาไทย	อ้างอิง
A			
Activity data	ข้อมูลกิจกรรม	ข้อมูลกิจกรรม	ONEP
Aerated Lagoon (AL)	บ่อเติมอากาศ	บ่อเติมอากาศ	MRV
Aeration supplied	แบบเติมอากาศ	แบบเติมอากาศ (Aer-ation supplied)	
Aerobic Digestion	การย่อยแบบใช้อากาศหรือใช้ออกซิเจน	การย่อยแบบใช้อากาศหรือใช้ออกซิเจน	
Aerobic Process	สภาพใช้อากาศ	สภาพใช้อากาศ	
Anaerobic Digestion	การย่อยแบบไร้อากาศ	การย่อยแบบไร้อากาศ	MRV
Anaerobic Process	สภาพไม่ใช้อากาศ	สภาพไม่ใช้อากาศ	
Anaerobic Baffled Reac-tor (ABR)	ระบบหมักแบบถังปฏิกรณ์ไร้อากาศแบบแผ่นกั้น	ระบบหมักแบบถังปฏิกรณ์ไร้อากาศแบบแผ่นกั้น	CMU
Ammonia	ก๊าซแอมโมเนีย	ก๊าซแอมโมเนีย (NH_3)	
The Fifth Assessment Report (AR5)	รายงานฉบับที่ 5 ของคณะกรรมการระ หว่างรัฐ บาลว่าด้วย การเปลี่ยนแปลงสภาพภูมิอากาศ Intergovern-mental Panel on Climate Change (IPCC)	The Fifth Assess-ment Report (AR5)	ONEP
Avoid	การหลีกเลี่ยงการเกิดก๊าซเรือนกระจก	Avoid	
B			
Baseline Emission (BE)	การปล่อยก๊าซเรือนกระจกในกรณีฐาน	การปล่อยก๊าซเรือนกระจกในกรณีฐาน	TGO
Biodrying	กระบวนการทำแห้งชีวภาพ	กระบวนการทำแห้งชีวภาพ	
Biological Oxygen Demand (BOD)	ค่าปริมาณออกซิเจนที่ต้องการเพื่อใช้ไปในกระบวนการต่างๆของสิ่งมีชีวิตทั้งหมด	BOD	
Blower	เครื่องเป่าลม	Blower	
Boiler	หม้อไอน้ำ	หม้อไอน้ำ (Boiler)	
Build, operate, and transfer (BOT)	สัญญาแบบ Build, operate, and transfer (BOT)	สัญญาแบบ Build, operate, and transfer (BOT)	

คำที่ใช้ในรายงานภาษาอังกฤษ	คำแปลภาษาไทย	คำที่ใช้ในรายงานภาษาไทย	อ้างอิง
Bulky waste	ขยะขนาดใหญ่	ขยะขนาดใหญ่	
Business as Usual (BAU)	กรณีฐานที่ใช้ประมาณการ การปล่อยก๊าซเรือนกระจกใน	บ่อเติมอากาศ	MRV
C			
Carbonic acid	กรดคาร์บอนิก	กรดคาร์บอนิก (H_2CO_3)	
Carbon dioxide (CO_2)	ก๊าซคาร์บอนไดออกไซด์	ก๊าซคาร์บอนไดออกไซด์ (CO_2)	ONEP, TGO
Carbon credit	คาร์บอนเครดิต	คาร์บอนเครดิต	TGO
Carbon monoxide (CO)	ก๊าซคาร์บอนมอนอกไซด์	ก๊าซคาร์บอนมอนอกไซด์ (CO)	ONEP
Catholic Office for Emergency Relief and Refugees	สำนักงานคาทอลิกสงเคราะห์ผู้ประสบภัยและผู้ลี้ภัย (โคเออร์)	COERR	COERR FOUNDATION
Centimeter (cm)	เซนติเมตร	เซนติเมตร	
Chemical Oxygen Demand (COD)	ค่าที่บอกคุณภาพของน้ำ แสดงความสกปรกของน้ำเสีย	COD	
Circular economy	เศรษฐกิจหมุนเวียน	Circular economy	
Closed System	ระบบปิด	ระบบปิด	
Clustering	การแบ่งกลุ่ม	การแบ่งกลุ่ม	
Co-firing	การเผาไหม้โดยใช้เชื้อเพลิงสองชนิดขึ้นไป	Co-firing	
Combustible waste	ขยะเผาไหม้ได้	ขยะเผาไหม้ได้	
Composting	การหมักปุ๋ย	การหมักปุ๋ย	MRV
Continuous incinera-tion	การเผาแบบต่อเนื่อง	การเผาแบบต่อเนื่อง	MRV
Controlled Dump	การเทกองควบคุม	การเทกองควบคุม	
Country specific	ข้อมูลจำเพาะของประเทศ	Country specific	
D			
Degradable Organic Carbon (DOC)	สารอินทรีย์ที่ย่อยสลายได้	Degradable Organ-ic Carbon (DOC)	MRV
degree Celsius (°C)	องศาเซลเซียส	°C	
Default	ค่าแนะนำ	Default	MRV

คำที่ใช้ในรายงานภาษาอังกฤษ	คำแปลภาษาไทย	คำที่ใช้ในรายงานภาษาไทย	อ้างอิง
Dioxins	ไดออกซิน	Dioxins	PCD
Direct combustion	การเผาตรง	การเผาตรง (Direct combustion)	
Domestic Wastewater Treatment	การบำบัดน้ำเสียชุมชน	การบำบัดน้ำเสียชุมชน	MRV
Drainage layer	ชั้นรวบรวมน้ำชะขยะมูลฝอยชุมชน	ชั้นรวบรวมน้ำชะขยะมูลฝอยชุมชน (drainage layer)	
Dynamic	แบบกวนต่อเนื่อง	แบบกวนต่อเนื่อง (Dynamic)	
E			
Eight-Japan Engineer-ing Consultants Inc. (EJEC)	บริษัท Eight-Japan Engineering Consultants Inc.	EJEC	
Emission factor (EF)	ค่าการปล่อย... (...ให้ระบุว่าก๊าซอะไร เช่น ปล่อยก๊าซเรือนกระจก)	Emission factor (EF)	ONEP
Emission Reduction (ER)	การลดการปลดปล่อยก๊าซเรือนกระจกจากการดำเนิน	คาร์บอนเครดิต	TGO
Ex-ante	การคำนวณกรณีฐานที่ยังไม่มีการดำเนินโครงการ	การคำนวณกรณีฐานที่ยังไม่มีการดำเนินโครงการ (Ex-ante หรือ BAU)	
Excess air incinerator	ระบบการเผาแบบอากาศมากเกินพอ	ระบบการเผาแบบอากาศมากเกินพอ (Excess air inciner-ator)	
Ex-pose	การคำนวณกรณีฐานที่ได้ดำเนินโครงการแล้ว	การคำนวณกรณีฐานที่ได้ดำเนินโครงการแล้ว (Ex-pose หรือ BE)	
F			
Feed-in Tariff (FiT)	มาตรการส่งเสริมการรับซื้อไฟฟ้าจากพลังงานหมุนเวียนแบบ Feed-in Tariff (FiT)	Feed-in Tariff (FiT)	EPPO
First Order Decay (FOD)	การย่อยสลายอันดับหนึ่ง	First Order Decay (FOD)	MRV
Fluidized bed	เตาเผาแบบฟลูอิไดซ์เบด	เตาเผาแบบฟลูอิไดซ์เบด	MRV
Fukuoka City	เมืองฟุกุโอกะ	เมืองฟุกุโอกะ	
Fukuoka prefectural government	รัฐบาลจังหวัดฟุกุโอกะ	รัฐบาลจังหวัดฟุกุโอกะ	
Fukuoka University	มหาวิทยาลัยแห่งจังหวัดฟุกุโอกะ	มหาวิทยาลัยแห่งจังหวัดฟุกุโอกะ	

คำที่ใช้ในรายงานภาษาอังกฤษ	คำแปลภาษาไทย	คำที่ใช้ในรายงานภาษาไทย	อ้างอิง
G			
Gas Engine	เครื่องยนต์ใช้ก๊าซ	เครื่องยนต์ใช้ก๊าซ (Gas Engine)	
Gas Purification	การทำให้ก๊าซบริสุทธิ์	การทำให้ก๊าซบริสุทธิ์ (Gas Purification)	
General waste	ขยะทั่วไป	ขยะทั่วไป	PCD
Generator	เครื่องกำเนิดไฟฟ้า	เครื่องกำเนิดไฟฟ้า (Generator)	
Geomembrane	แผ่นพลาสติกความหนาแน่นสูง	Geomembrane	
Geotextile	แผ่นใยสังเคราะห์	Geotextile	
Gg CO_2 eq	กิกะกรัมคาร์บอนไดออกไซด์เทียบเท่า	GgCO_2eq	ONEP
Global Warming	ภาวะโลกร้อน	ภาวะโลกร้อน	
Global Warming Po-tential (GWP)	ค่าศักยภาพการทำให้เกิดภาวะโลกร้อน	ค่าศักยภาพการทำให้เกิดภาวะโลกร้อน	ONEP
Greenhouse Gases (GHGs)	ก๊าซเรือนกระจก	ก๊าซเรือนกระจก	TGO
H			
Hazardous waste	ขยะอันตราย	ขยะอันตราย	PCD
Hydrogen (H_2)	ก๊าซไฮโดรเจน	ก๊าซไฮโดรเจน (H_2)	
Hydrogen dioxide	ไอน้ำ	ไอน้ำ (H_2O)	
Hydrogen sulfide (H_2S)	ก๊าซไฮโดรเจนซัลไฟด์	ก๊าซไฮโดรเจนซัลไฟด์ (H_2S)	
I			
Incineration	การเผาขยะในเตาเผา	การเผาขยะในเตาเผา	MRV
Incinerator	เตาเผาขยะ	เตาเผาขยะ	
Intergovernmental Panel on Climate Change (IPCC)	คณะกรรมาธิการระหว่างรัฐบาลว่าด้วยการเปลี่ยนแปลงสภาพภูมิอากาศ	IPCC	TGO
Internal combustion engine	เครื่องยนต์สันดาปภายใน	เครื่องยนต์สันดาปภายใน (internal combustion en-gine)	

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2006 IPCC Guidelines for National Green-house Gas Inventories: 2006 IPCC Guidelines	คณะกรรมาธิการระหว่างรัฐบาลว่าด้วยการเปลี่ยนแปลงสภาพภูมิอากาศ 2549	2006 IPCC Guide-lines	MRV
Investment cost	ค่าลงทุน	Investment cost	
Iron (II) oxide	สนิมเหล็ก	สนิมเหล็ก (Fe_2O_3)	
J			
Japan Environmental Sanitation Center (LESC)	ศูนย์สุขาภิบาลสิ่งแวดล้อมของประเทศญี่ปุ่น	ศูนย์สุขาภิบาลสิ่งแวดล้อมของประเทศญี่ปุ่น (LESC)	JESC
Japan International Cooperation Agency (JICA)	องค์การความร่วมมือระหว่างประเทศของญี่ปุ่น	องค์การความร่วมมือระหว่างประเทศของญี่ปุ่น (Japan Inter-national Coopera-tion Agency ; JICA)	JICA
K			
Karen Environment Group (KEG)	กลุ่มอนุรักษ์สิ่งแวดล้อมกะเหรี่ยง	กลุ่ม KEG	
L			
Landfill gas (LFG)	ก๊าซจากหลุมฝังกลบ	ก๊าซจากหลุมฝังกลบ (Landfill gas, LFG)	TGO
Landfill gas to energy (LFGTE)	การผลิตก๊าซชีวภาพจากหลุมฝังกลบ	การผลิตก๊าซชีวภาพจากหลุมฝังกลบ (LFGTE)	
Latrine	บ่อซึม	บ่อซึม	MRV
Leachate collection pump	ชุดอุปกรณ์สูบน้ำชะขยะมูลฝอยชุมชน	ชุดอุปกรณ์สูบน้ำชะขยะมูลฝอยชุมชน(leachate collec-tion pump)	
Leachate Collection System	ระบบรวบรวมน้ำชะขยะมูลฝอยชุมชน	ระบบรวบรวมน้ำชะขยะมูลฝอยชุมชน(Leachate Collec-tion System)	
Leachate line clean-out	แนวท่อทำความสะอาด	แนวท่อทำความสะอาด (leachate line clean-out)	
Leachate sump or manhole	บ่อพักน้ำชะขยะมูลฝอยชุมชน	บ่อพักน้ำชะขยะมูลฝอยชุมชน(Leachate sump or manhole)	
Leachate trench and pipe	แนวท่อรวบรวมน้ำชะขยะมูลฝอยชุมชน	แนวท่อรวบรวมน้ำชะขยะมูลฝอยชุมชน(Leachate trench and pipe)	

คำที่ใช้ในรายงานภาษาอังกฤษ	คำแปลภาษาไทย	คำที่ใช้ในรายงานภาษาไทย	อ้างอิง
M			
Major maintenance	การซ่อมบำรุงใหญ่	การซ่อมบำรุงใหญ่ (Major mainte-nance)	
Material recovery	การคัดแยกและนำกลับคืนวัสดุ	การคัดแยกและนำกลับคืนวัสดุ	PCD
Mechanical-Biological Treatment (MBT)	การบำบัดขยะด้วยวิธีเชิงกลชีวภาพ/การบำบัดเชิงกลชีวภาพ	การบำบัดขยะด้วยวิธีเชิงกลชีวภาพ	MRV
Mechanical Pre-Treatment	การบำบัดเชิงกล	การบำบัดเชิงกลขั้นที่ 1	SUT
Mechanical Separa-tion	การแยกเชิงกล	การบำบัดเชิงกลขั้นที่ 2	
Megawatt (MW)	เมกะวัตต์	MW	
Membrane Bioreactor (MBR)	ถังปฏิกรณ์ชีวภาพแบบมีเมมเบรน	ระบบ Membrane Bioreactor (MBR)	
Meter (m)	เมตร	เมตร	
Methane (CH_4)	ก๊าซมีเทน	ก๊าซมีเทน (CH_4)	ONEP
Methane Correction Factor (MCF)	ค่าปรับแก้สัดส่วนของขยะที่ทำให้เกิดก๊าซมีเทน	Methane Correc-tion Factor (MCF)	MRV
Methane Conversion Factor (MCF)	ค่าปรับแก้สัดส่วนการปล่อยก๊าซมีเทน (ใช้กับน้ำเสีย)	Methane Conver-sion Factor (MCF)	MRV
Methane Generation Potential	ศักยภาพการผลิตก๊าซมีเทน	Methane Genera-tion Potential	MRV
Metropolitan Electric-ity Authority (MEA)	การไฟฟ้านครหลวง (กฟน.)	การไฟฟ้านครหลวง (กฟน.)	
Millimeter (mm)	มิลลิเมตร	มิลลิเมตร	
Minor maintenance	การซ่อมบำรุงย่อย	การซ่อมบำรุงย่อย (Minor mainte-nance)	
Ministry of Health and Welfare	กระทรวงสุขภาพและสวัสดิการของญี่ปุ่น	กระทรวงสุขภาพและสวัสดิการของญี่ปุ่น	
Ministry of Natural Resources and Envi-ronment (MNRE)	กระทรวงทรัพยากรธรรมชาติและสิ่งแวดล้อม	กระทรวงทรัพยากรธรรมชาติและสิ่งแวดล้อม	MNRE
Municipal Solid Waste	ขยะมูลฝอยชุมชน	ขยะมูลฝอยชุมชน	TGO

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N			
National Standard Technology for Solid Waste Disposal	เทคโนโลยีมาตรฐานระดับประเทศในด้านการกำจัดมูลฝอย	เทคโนโลยีมาตรฐานระดับประเทศในด้านการกำจัดมูลฝอย	
Nitrogen	ก๊าซไนโตรเจน	ก๊าซไนโตรเจน (N_2)	
Nitrogen Oxide (NO_x)	ก๊าซไนโตรเจนออกไซด์	ก๊าซไนโตรเจนออกไซด์ (NO_x)	ONEP
Nitrous oxide (N_2O)	ก๊าซไนตรัสออกไซด์	ก๊าซไนตรัสออกไซด์ (N_2O)	ONEP, TGO
Non-combustible waste	ขยะเผาไหม้ไม่ได้	ขยะเผาไหม้ไม่ได้	
O			
Open Burning	การเผาขยะกลางแจ้ง	การเผาขยะกลางแจ้ง	MRV
Open Dump	การเทกอง	การเทกอง	MRV
Organic waste	ขยะอินทรีย์	ขยะอินทรีย์	PCD
Oxidation Ditch (OD)	คลองวนเวียน	คลองวนเวียน	MRV
Oxidation Factor (OX)	ค่าออกซิเดชันแฟคเตอร์	Oxidation Factor (OX)	MRV
Oxygen	ก๊าซออกซิเจน	ก๊าซออกซิเจน (O2)	
P			
Percentage of Avoid reduction	ร้อยละการหลีกเลี่ยงก๊าซเรือนกระจก	% Avoid reduction	
Percentage of GHG reduction	ร้อยละการลดก๊าซเรือนกระจก	% GHG reduction	
Percentage of Leak-age	ร้อยละการลดก๊าซเรือนกระจกนอกขอบเขต	% Leakage	
Percentage of Reduc-tion with BAU	ร้อยละการลดก๊าซเรือนกระจกเมื่อเปรียบเทียบกับกรณีที่เป็นการดำเนินงานตามปกติ	% Reduction with BAU	
pilot scale	การทดลองต้นแบบ	การทดลองต้นแบบ (Pilot scale)	
Plug Flow	แบบท่อไหล	แบบท่อไหล (Plug Flow)	
Polluter Pays Principle	หลักผู้ก่อมลพิษเป็นผู้จ่าย	หลักผู้ก่อมลพิษเป็นผู้จ่าย (Polluter Pays Principle)	
Pollution Control De-partment	กรมควบคุมมลพิษ (คพ.)	กรมควบคุมมลพิษ (คพ.)	PCD

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Project Emission (PE)	การปล่อยก๊าซเรือนกระจกจากการดำเนินโครงการ	การปล่อยก๊าซเรือนกระจกจากการดำเนินโครงการ	TGO
Provincial Electricity Authority (PEA)	การไฟฟ้าส่วนภูมิภาค (กฟภ.)	การไฟฟ้าส่วนภูมิภาค (กฟภ.)	PEA
Public-Private Partner-ship (PPP)	เอกชนร่วมลงทุนในกิจการของรัฐ	เอกชนร่วมลงทุนในกิจการของรัฐ	
Q			
Quick Win Project	เป็นโครงการที่ดำเนินการได้ทันที	เป็นโครงการที่ดำเนินการได้ทันที (Quick Win Project)	
R			
Reactor	ถังปฏิกิริยา	ถังปฏิกิริยา	
Recycle	แปรรูปใช้ใหม่	แปรรูปใช้ใหม่	PCD
Recyclable waste	ขยะรีไซเคิล	ขยะรีไซเคิล	PCD
Reduce	ใช้น้อย ลดการใช้	ใช้น้อย	PCD
Refuse Derived Fuel (RDF)	เชื้อเพลิงขยะ	เชื้อเพลิงขยะ (RDF)	PCD
RDF power plant	โรงไฟฟ้าจากเชื้อเพลิงขยะ	โรงไฟฟ้าจากเชื้อเพลิงขยะ	
Reuse	ใช้ซ้ำ	ใช้ซ้ำ	PCD
Rotating Biological Contactor (RBC)	แผ่นจานหมุนชีวภาพ	แผ่นจานหมุนชีวภาพ	MRV
Rotary kiln type	เตาเผาแบบหมุน	เตาเผาแบบหมุน (Ro-tary kiln type)	
S			
Sanitary Landfill	การฝังกลบอย่างถูกหลักสุขาภิบาล	การฝังกลบอย่างถูกหลักสุขาภิบาล	MRV
Secure landfill	การฝังกลบอย่างปลอดภัย	การฝังกลบอย่างปลอดภัย	
Semi-aerobic	กึ่งใช้อากาศ	กึ่งใช้อากาศ	MRV
Semi-aerobic degra-dation	การย่อยสลายแบบกึ่งใช้อากาศ	การย่อยสลายแบบกึ่งใช้อากาศ	
Semi-aerobic landfill	การฝังกลบแบบกึ่งใช้อากาศ	การฝังกลบแบบกึ่งใช้อากาศ	
Semi Dry Scrubber	ระบบบำบัดกึ่งแห้ง	ระบบ Semi Dry Scrubber	
Sewage Sludge	กากตะกอนระบบบำบัดน้ำเสีย	กากตะกอนระบบบำบัดน้ำเสีย	MRV
Soil Conditioner	สารปรับปรุงคุณภาพดิน	สารปรับปรุงคุณภาพดิน	PCD

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Solar cell	ระบบผลิตไฟฟ้าจากเซลล์แสงอาทิตย์	ระบบผลิตไฟฟ้าจากเซลล์แสงอาทิตย์	DEDE
Solid Waste Diversion Centre	ศูนย์แปรสภาพขยะ	ศูนย์แปรสภาพขยะ	
Stabilization Pond (SP)	บ่อปรับเสถียร	บ่อปรับเสถียร	MRV
Static Pile	การผลิตปุ๋ยอินทรีย์แบบกองสถิต	การผลิตปุ๋ยอินทรีย์แบบกองสถิต (Static Pile)	
Steam turbine	กังหันไอน้ำ	กังหันไอน้ำ (Steam turbine)	
Step wise moving grate	ตะกรับเคลื่อนที่แบบขั้นบันได	ตะกรับเคลื่อนที่แบบขั้นบันได (Step wise moving grate)	
Stoker	เตาเผาแบบตะกรับ	เตาเผาแบบตะกรับ	
Sulfur dioxide (SO_2)	ก๊าซซัลเฟอร์ไดออกไซด์	ก๊าซซัลเฟอร์ไดออกไซด์ (SO_2)	ONEP
T			
THB/t CO_2 eq reduc-tion	บาทต่อตันคาร์บอนไดออกไซด์ที่ลดได้	บาท/ton CO_2 eq ที่ลดได้	
THB/t MSW	บาทต่อตันขยะมูลฝอย	THB/ton MSW	
Thailand Voluntary Emission Reduction Program (T-VER)	โครงการลดก๊าซเรือนกระจกภาคสมัครใจตามมาตรฐานของประเทศไทย	โครงการลดก๊าซเรือนกระจกภาคสมัครใจตามมาตรฐานของประเทศไทย (T-VER)	TGO
Tier	ระดับเทียร์	Tier	MRV
Tipping fee	ค่ากำจัดขยะมูลฝอย	Tipping fee	
t	ตัน	ตัน	ONEP
t/yr	ตัน/ปี	ตัน/ปี	MRV
t/d	ตัน/วัน	ตัน/วัน	MRV
t CO_2 eq	ตันคาร์บอนไดออกไซด์เทียบเท่า	ตันคาร์บอนไดออกไซด์เทียบเท่า	
t CO_2 eq /year	ตันคาร์บอนไดออกไซด์เทียบเท่าต่อปี	ตันคาร์บอนไดออกไซด์เทียบเท่าต่อปี	
t CO_2 reduction	ตันคาร์บอนไดออกไซด์ที่ลดได้	ตันคาร์บอนไดออกไซด์ที่ลดได้	
Turned Pile	กองแถวร่วมกับการพลิกกลับกอง	กองแถวร่วมกับการพลิกกลับกอง (Turned Pile)	
Turning and Agitator	แบบการหมุนและการกวน	แบบการหมุนและการกวน (Turning and Agitator)	

คำที่ใช้ในรายงานภาษาอังกฤษ	คำแปลภาษาไทย	คำที่ใช้ในรายงานภาษาไทย	อ้างอิง
U			
United Nations Framework Conven-tion on Climate Change (UNFCCC)	อนุสัญญาสหประชาชาติว่าด้วยการเปลี่ยนแปลงสภาพภูมิอากาศ	UNFCCC	MRV
United Nations Hu-man Rights Council (UNHCR)	คณะมนตรีสิทธิมนุษยชนแห่งสหประชาชาติ	UNHCR	CONSTITUTIONALCOURT
Upcycle	การแปรรูปเพิ่มมูลค่าให้กับวัสดุเหลือใช้	Upcycle	
V			
Vary Small Power Plant (VSPP)	ผู้ผลิตไฟฟ้ารายเล็กมาก	ผู้ผลิตไฟฟ้ารายเล็กมาก (VSPP)	TGO
Volatile Organic Compounds (VOCs)	สารประกอบอินทรีย์ระเหยง่าย	สารประกอบอินทรีย์ระเหยง่าย (VOCs)	EHA
W			
Waste pit	บ่อพักขยะ	บ่อพักขยะ (Waste pit)	
Waste separation	การคัดแยกขยะมูลฝอย	การคัดแยกขยะมูลฝอย	PCD
Waste Separation and Material Recovery at Source	การคัดแยกและนำกลับคืนวัสดุที่ต้นทาง	การคัดแยกและนำกลับคืนวัสดุที่ต้นทาง (Waste Separation and Material Re-covery at Source)	
Waste utilization	การใช้ประโยชน์ขยะมูลฝอย	การใช้ประโยชน์ขยะมูลฝอย	PCD
Windrow or Opened System	การผลิตปุ๋ยอินทรีย์แบบระบบเปิด	การผลิตปุ๋ยอินทรีย์แบบระบบเปิด (Windrow or Opened System)	
Z			
Zero waste		โครงการประกวดชุมชนปลอดขยะ (Ze-ro waste)	

ADVISOR AND PROJECT MANAGEMENT UNIT (PMU)

ADVISOR

Mr. Athapol	Charoenshunsa	Director General of Pollution Control Department
Ms. Preeyaporn	Suwanaged	Deputy Director General of Pollution Control Department
Mrs. Kanchalee	Navickabhum	Director of Waste and Hazardous Substance Management Bureau
Ms. Pornpimon	Chareonsong	Director of Water Quality Management Bureau
Mr. Phunsak	Theramongkol (Ph.D.)	Director of Air Quality and Noise Management Bureau

POLLUTION CONTROL DEPARTMENT (PCD)

MUNICIPAL SOLID WASTE MANAGEMENT SUB-DIVISION

Mr. Taweechai	Jiaranaikhajorn	Director
Ms. Anuda	Tawatsin	Environmentalist, Professional Level
Mr. Vicharana	Intrakamhaeng (Ph.D.)	Environmentalist, Professional Level
Mr. Suppajit	Sukkunta	Environmentalist, Professional Level
Ms. Pattaraporn	Srichumni	Environmentalist, Professional Level
Mrs. Khamkaew	Markathub	Environmentalist, Professional Level

PLANNING AND EVALUATION SUB-DIVISION

Mr. Chaiya	Boonchit	Director

DOMESTIC WASTEWATER MANAGEMENT SUB-DIVISION

Mr. Chayawee	Wangcharoenrung (Ph.D.)	Director
Mr. Yuttachai	Sarathai (Ph.D.)	Environmentalist, Senior Professional Level
Ms. Nitchaya	Trongyangkul	Environmentalist, Professional Level
Ms. Wonnisa	Wiboonchuae	Environmentalist, Professional Level

OFFICE OF NATURAL RESOURCES AND ENVIRONMENTAL POLICY AND PLANNING (ONEP)

Mr. Sivach	Kaewcharoen	Environmentalist, Senior Professional Level
Ms. Chanutsakul	Supirak	Environmentalist, Professional Level
Mr. Tachawan	Pojsompong	Environmentalist, Professional Level
Ms. Tippawan	Photiwut	Environmentalist, Practitioner Level
Ms. Pathitta	Thumcharoen	Environmentalist, Practitioner Level
Ms. Chanitsa	Warachit	Plan and Policy Analyst

DEPARTMENT OF ENVIRONMENTAL QUALITY PROMOTION (DEQP)

Mr. Sanya	Jongjit	Dissemination Technical Officer, Professional Level

THAILAND GREENHOUSE GAS MANAGEMENT ORGANIZATION (PUBLIC ORGANIZATION)

Ms. Sumon	Sumetchoengprachya (Ph.D.)	Director of Low Carbon City and Society Office
Ms. Paweena	Panichayapichet (Ph.D.)	Manager, Project Evaluation and Approval Office
Ms. Ratchaporn	Singkarotai	Technical expert, Professional Level

DEPARTMENT OF LOCAL ADMINISTRATION (DLA)

Mr. Thatathip	Yammontha	Plan and Policy Analyst, Senior Professional Level
Mr. Thanakrit	Rattanapongkawee	Plan and Policy Analyst, Professional Level
Ms. Jarida	Jitrawat	Plan and Policy Analyst, Practitioner Level

WASTEWATER MANAGEMENT AUTHORITY (WMA)

Ms. Valailak	Komolrit	Policy and Plan Analyst, Level 6
Mr. Rattapone Chor	La-eiad	Policy and Plan Analyst, Level 6

BANGKOK METROPOLITAN ADMINISTRATION (BMA)

Mrs. Suthisa	Pornpermpoon	Director of Solid Waste and Sewage Management Office Department of Environment
Mr. Aroon	Visesvongsa	Director of Sewage Management Service Section Solid Waste and Sewage Management Office Department of Environment
Mr.Trairat	Jindamoragot	Chief of Engineering Sub Division Solid Waste Disposal Division Department of Environment
Mr. Kasame	Thepnoo	Chief of Database and Tariff Collection Sub Office Water Quality Management Office Department of Drainage and Sewerage
Mrs. Wankaew	Homnan	Sanitation Technical Officer, Practitioner Level Research and Development Sub Division Solid Waste and Sewage Management Office Department of Environment

A CONSULTANT TEAM

KING MONGKUT'S UNIVERSITY OF TECHNOLOGY THONBURI (KMUTT)

Associate Professor Dr. Sirintornthep Towprayoon

Assistant Professor Dr. Komsilp Wangyao

Ms. Awassada Phongphiphat (Ph.D.)

Ms. Panida	Payomthip	Researcher
Mr. Wittawat	Wulyapash	Researcher
Ms. Thichakorn	Pudcha	Researcher
Ms. Salita	Khamsuk	Researcher

KASETSART UNIVERSITY

Associate Professor Dr. Chart Chiemchaisri

Associate Professor Dr. Wilasinee Yoochatchaval

Ms. Pattra	Chewathai	Researcher
Mr. Pongpol	Supakam	Researcher

GRAPHIC DESIGNER

Mr. Jakkaphol Phengpan

DEUTSCHE GESELLSCHAFT FÜR INTERNATIONALE ZUSAMMENARBEIT (GIZ) GMBH

Mr. Werner	Kossmann	Project Director
Mrs. Punjaporn	Weschayanwiwat (Ph.D.)	Senior Advisor
Mrs. Pimpilas	Nuntiphon Khoeiram	Project Manager
Ms. Monnapa	Poosomboonwattana	Junior Advisor
Ms. Charurin	Pholhinkong	Project Advisor





GOOD OPERATION
ESPECIALLY TO
AVOID GREENHOUSE
GAS EMISSIONS IN
THE WASTE SECTOR
HELPS INCREASE
THE COUNTRY'S MITIGATION
OF GREENHOUSE GAS.





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