United Nations
Environment Programme

WASTE TO ENERGY

CONSIDERATIONS FOR INFORMED DECISION-MAKING

Summary for policymakers

What is **Waste-to-Energy?**

Thermal Waste-to-Energy (WtE), also known as incineration with energy recovery, is a major waste treatment method in some developed countries and the most widely adopted technology that dominates the global WtE market. The European Union, however, which has relied on waste incineration for the past few decades, is now moving away from thermal WtE and other forms of incineration and is focusing on more ecologically acceptable solutions such as waste prevention, reuse and recycling as it shifts towards a circular economy.

INPUTS AND OUTPUTS OF THERMAL WASTE-TO-ENERGY PLANTS

WASTE FEEDSTOCK

Municipal solid waste, sorted or unsorted, is often used as the waste feedstock for thermal WtE plant. During the incineration process, the volume of the waste feedstock can be greatly reduced by 90%.

FLUE GAS EMISSIONS

Flue gas emissions contain the greenhouse gases and pollutants from the waste, which requires further treatment before emission to the atmosphere. Emissions may include carbon dioxide, nitrous oxide, nitrogen oxides, ammonia, carbon monoxide, volatile organic compounds, persistent organic pollutants (e.g. furans and dioxins) and some heavy metals.

HEAT

Thermal energy is one of the energy products from the combustion of waste feedstock, which can be used in district heating system in vicinity.

ELECTRICITY

Electricity is one of the energy products of thermal WtE, which is then transferred to the power grid to power up households.

FLY ASH

Fly ash is the fine particulate ash from incineration, which is considered hazardous waste and must be treated accordingly.

BOTTOM ASH

Bottom ash is the residual material from incineration. It contains the non-combustible fraction of waste feedstock, including stones, glass, ceramic, and metals. The bottom ash may be used for construction purposes after metals are sorted out for recycling.

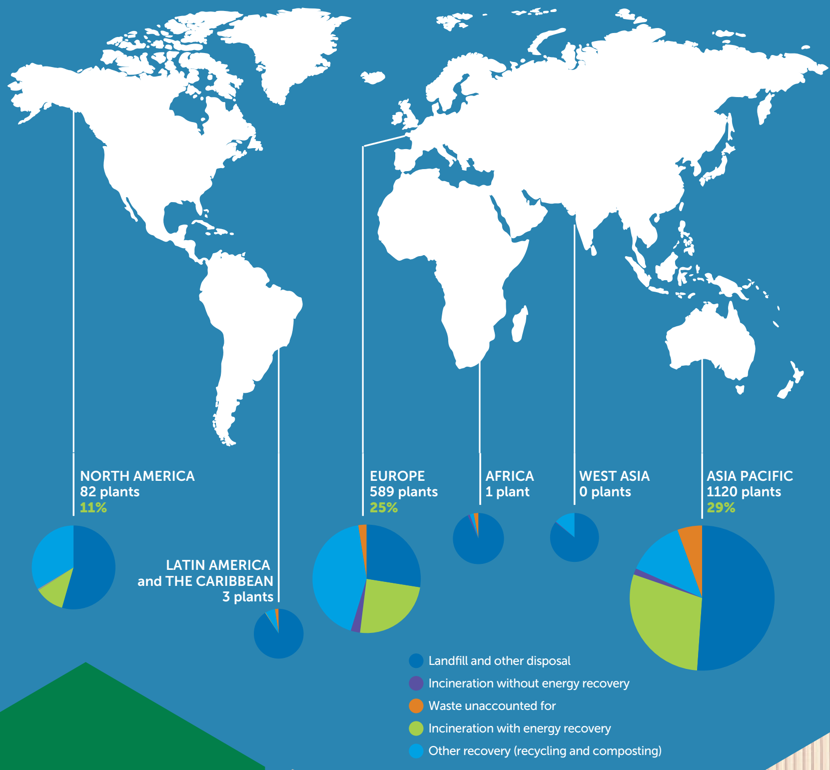
Global context **and drivers**

CURRENT STATUS

There are over 1700 thermal WtE plants worldwide. Over 80 per cent of thermal WtE plants are located in developed countries, led by Japan, France, Germany and the United States.

Globally, 216 million tonnes of collected Municipal Solid Waste (MSW) is incinerated each year, of which 15 per cent is incinerated with energy recovery. Thermal WtE accounts for 29 per cent and 25 per cent of MSW incinerated in Asia Pacific and Europe respectively.

Thermal WtE utilizes the energy value in waste to generate electricity and/or heat. The biogenic component of the waste contributes to approximately one per cent of renewable energy globally.



The size of the pie charts represents the number of WtE plants by region.

FUTURE TRENDS

Thermal WtE has received considerable attention in developing countries due to its potential benefits for energy generation and reducing waste volume. Globally, more than 200 thermal WtE plants are currently under construction and will be operational between 2020 and 2023. Thermal WtE plants are emerging in developing countries in Asia Pacific, including China, Thailand, the Philippines, Indonesia and Myanmar. The European Union, however, which has relied on waste incineration for the past few decades, is now moving away from thermal WtE and other forms of incineration as it shifts towards a circular economy.

THE MAJOR DRIVERS

CLIMATE CHANGE IMPACT

Thermal WtE plants reduce greenhouse gas emissions by diverting waste from landfills and open burning.

LAND CONSTRAINTS

WtE can reduce waste volume and mass by 75 to 90 per cent.

PUBLIC HEALTH AND ENVIRONMENTAL CONCERNS

A shift to thermal WtE could improve hygiene and environmental conditions.

ENERGY GENERATION

The energy value in waste can be utilized to generate electricity and heat during the thermal WtE process.

Challenges for developing countries

WASTE CHARACTERISTICS

Organic waste makes up 53% to 56% of MSW in low and lower-middle income countries, which yields a low calorific value.

Incineration requires a fuel with minimal average calorific value of 7 MJ/kg, and should never fall below 6 MJ/kg for combustion without auxiliary fuel.

ECONOMIC ASPECTS

Thermal WtE requires significant investment for startup, operation and maintenance.

Income from waste disposal and energy sales is usually insufficient to cover the full investment and operational cost of a thermal WtE plant.

LEGAL ASPECTS

Developing countries may lack legislation on internationally recognized emission standards, monitoring and enforcement.

ENVIRONMENTAL ASPECTS

Waste incinerators are one of the leading sources of dioxins and furans globally. Mismanaged thermal WtE plants may produce unsafe emissions.

SOCIAL IMPACT

Public opposition is often a major obstacle for building and operating thermal WtE plants.

Thermal WtE may potentially divert waste away from the 3Rs as plants require feedstock minimums, and due to this recyclable waste is often used.

The transition to WtE can impact the informal recycling sector.

KEY FINDINGS AND MESSAGES

1 The **waste management hierarchy should be used** for integrated solid waste management systems. Reduction, reuse and recycling should be prioritized and incorporated into waste management plans that include thermal WtE recovery options.

2 There have been significant improvements in emissions control for modern thermal WtE technologies compared to WtE technologies from the 1970s to the 1990s. Thermal WtE plants with advanced emission control technologies that are well-maintained have **minimum public health impacts**. Nevertheless, mismanaged thermal WtE plants have been shown to produce unsafe emissions, despite advanced emission control technologies.

3 In developing countries, the **low calorific value and high moisture content of waste** remain critical technical challenges for thermal WtE. Low calorific value of waste should average at least 7 MJ/kg, and never fall below 6 MJ/kg.

4 A large scale modern thermal WtE plant requires **at least 100,000 tonnes of MSW per year** over its lifetime. As with all large investment projects, thermal WtE can potentially **create lock-in effects** that may lead to plant overcapacity and hamper efforts to reduce, reuse and recycle.

5 Thermal **WtE requires significant investment for startup, operation and maintenance** A holistic cost benefit analysis should be carried out in the local context to assess the social, legislative and enabling conditions of the plant's life cycle. Income from waste disposal and energy sales is often insufficient to cover full investment and operational costs.

A **complete and detailed legislative framework** is a prerequisite for thermal WtE introduction in developing countries. The framework should include strategies for maintenance and plant decommission, a phase out plan, pollution monitoring, guidelines on safe disposal of toxic by-products, medical monitoring and health care for plant workers and the local community, and guidelines for accident management. 6

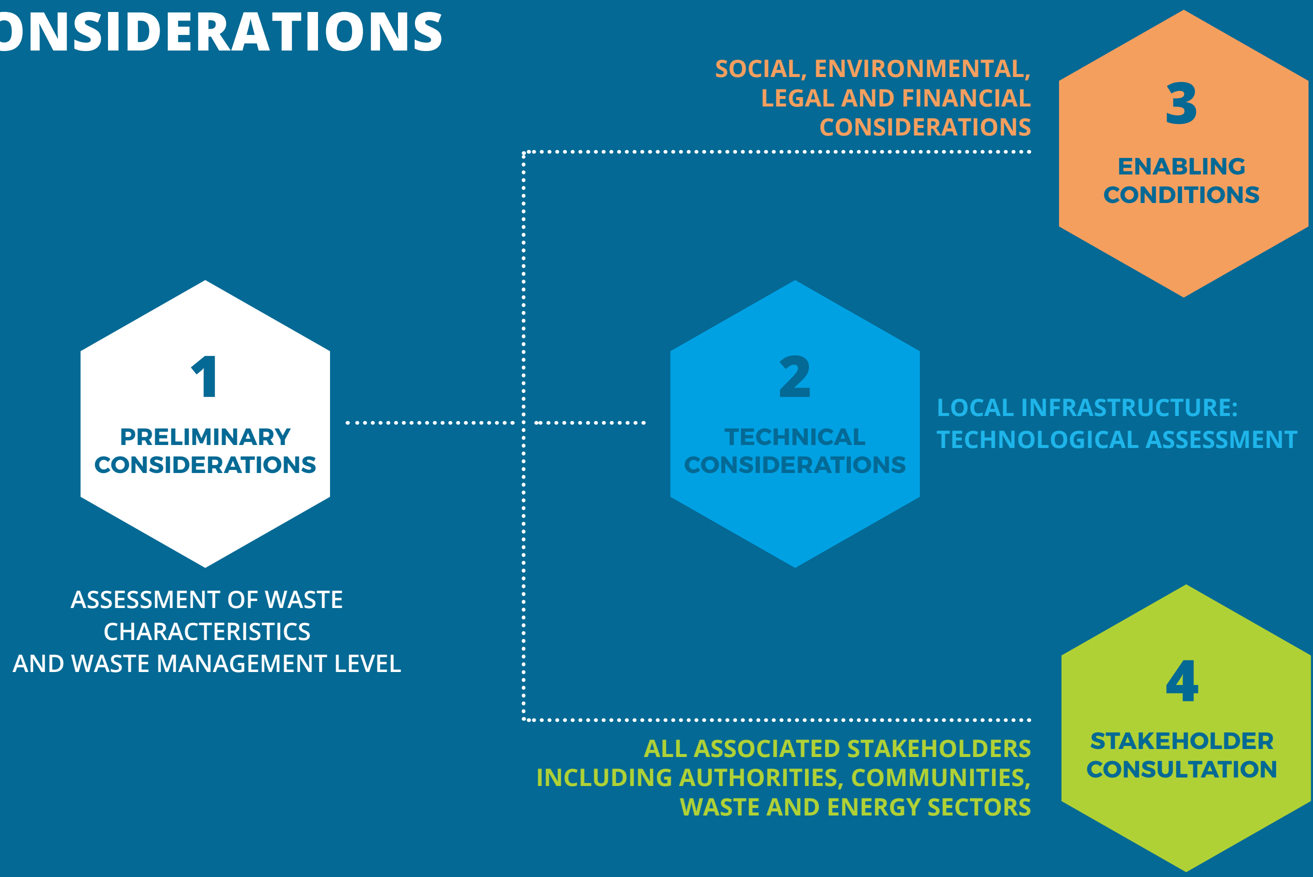
Thermal WtE **utilizes the energy value in waste to generate electricity and/or heat** The biogenic component of waste overall contributes to approximately one per cent of global renewable energy. 7

Thermal WtE can potentially reduce waste sector greenhouse gas emissions compared to open burning and landfills without methane gas capture and use, but **will not completely abate greenhouse gas emissions.** 8

Thermal WtE can **reduce the volume** of waste entering landfills by 75–90 per cent, but it **does not remove the need for landfills**. In addition, it can produce residues that are hazardous and require safe disposal. 9

Achieving Integrated Sustainable Waste Management requires integration of appropriate collection with different technologies and waste treatment methods and governance systems in the local context. 10

CONSIDERATIONS



1 PRELIMINARY CONSIDERATIONS

- Conduct a waste survey to assess waste characteristics, trends and future projections.
- Assess overall waste management performance

2 TECHNICAL CONSIDERATIONS

- Local infrastructure and city conditions must be examined.
- Use experienced consultants or private sector experts to carry out an assessment of all potential WtE technologies.

3 ENABLING CONDITIONS

- A life-cycle assessment that includes a cost benefit analysis of thermal WtE and other potential WtE technologies should be completed.
- The social, economic, and environmental impacts and co-benefits of the WtE plant throughout its life cycle should be considered.
- A comprehensive legal framework in necessary before implementing all WtE technologies.
- A financial model for the life cycle of the thermal WtE plant that includes the planning, commission, operation and decommission stages should be adopted.

4 STAKEHOLDER CONSULTATION

- Stakeholder mapping and an analysis of all of the potentially affected groups and communities must be carried out so that compensatory strategies or initiatives can be launched.
- Municipalities should present an evidence-based feasibility study on thermal WtE that includes the life-cycle assessment, cost-benefit analysis and environmental impact assessment to keep the public informed of planning progress and build support for policy decisions.

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