Waste-to-Energy Plants [UPSC Notes]

Waste-to-energy conversion and plants to implement this are in the news very often. This is an important topic for the IAS exam environment and ecology segment. Under this topic, you need to understand what the process of waste-to-energy is all about, the advantages it offers and also the challenges associated with it. This is part of the GS Paper III of the UPSC syllabus.

What is waste-to-energy conversion?

Waste-to-Energy is an advanced way of waste disposal using modern technologies.

- It is widely recognized for reducing greenhouse gasses such as methane from landfills which is a greenhouse gas that is 84 times more potent climate-warming gas than CO_2.

How do waste-to-energy plants work?

- A typical waste-to-energy plant burns municipal solid waste (MSW) to produce steam in a boiler, and the steam is used to power an electric generator turbine.
- MSW is a mixture of energy-rich materials such as paper, plastics, yard waste, and products made from wood.

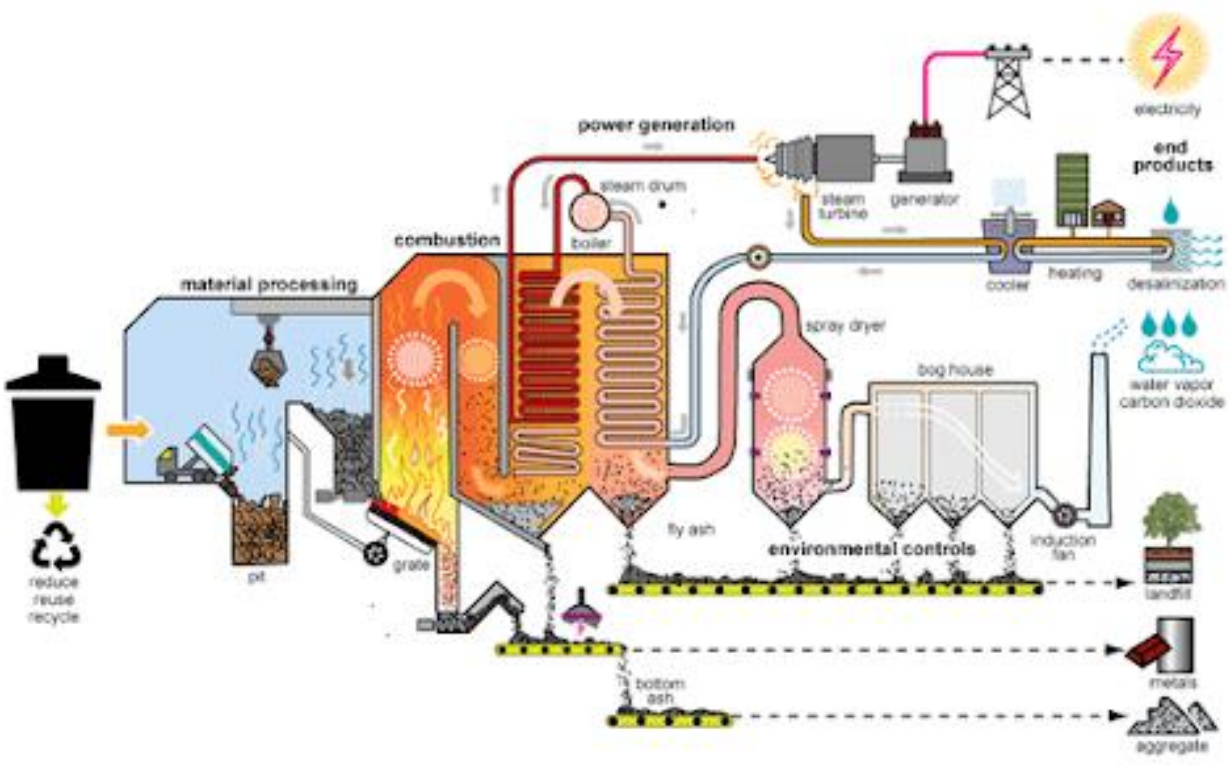

Image: A mass-burn waste-to-energy plant

The energy generation in a mass-burn waste-to-energy plant has the following stages:

1. Waste is collected and dumped into a large pit.
2. The dumped wastes are transferred to a combustion chamber.
3. The waste (fuel) is burned, releasing heat.
4. The heat turns water into steam in a boiler.
5. The high-pressure steam moves the blades of a turbine generator to produce electricity.
6. An air pollution control system eliminates pollutants from the combustion gas before they get released through a smoke stack.
7. Ash is collected from the boiler and the air pollution control system.

Waste-to-Energy (WTE) Technologies

- **BIOMETHANATION:** It is an anaerobic digestion of organic materials which converts them into biogas. Anaerobic digestion is a bacterial fermentation process that operates without free oxygen and results in biogas containing mostly methane (~60%), carbon dioxide (~40%) and other gasses. Biomethanation has dual benefits. It gives biogas as well as manure as the end product.
- **INCINERATION:** It is the complete combustion of waste (MSW or refuse-derived fuel) with the recovery of heat to produce steam which in turn produces power through steam turbines.
- **GASIFICATION:** It is a process which uses high temperatures (500-1800 degrees C) in the presence of limited amounts of oxygen to decompose materials to produce synthetic gas (a mixture of carbon monoxide (CO) and hydrogen (H2)). Biomass, agro-residues, segregated MSW and RDF pellets are used in the gasifier to produce Syngas. This gas further can be used for thermal or power generation purposes.
- **PYROLYSIS:** Pyrolysis uses heat energy to break down combustible materials in the absence of oxygen. It produces a mixture of combustible gasses (e.g. methane, complex hydrocarbons, hydrogen, and carbon monoxide), liquids and solid residues.

Key challenges faced by waste-to-energy projects

- **Low calorific value:** Solid wastes in India have low calorific value mainly due to improper segregation.
    - Calorific value refers to the amount of heat energy released during the complete combustion of a unit mass of fuel.
    - The calorific value of coal is around 8,000 kcal/kg.

  - However, the calorific value of mixed waste in India is around 1,500 kcal/kg and is not feasible for power generation.
  - Mixed wastes consist of biodegradable waste that has high moisture content and hence cannot be used for power generation.
- **High costs of energy production:** The cost of producing power from waste is about ₹7-8/unit, whereas the cost at which the electricity boards of the States buy power from coal, hydroelectric, and solar power plants is around ₹3-4/unit.
- **Other issues:** Other key challenges faced by waste-to-energy plants in India include high expectations, improper assessment and characterisation studies, and neglect of on-ground realities while establishing such plants.

Way forward:

In India, the total estimated energy generation potential from urban and industrial organic waste is approximately 5690 MW and it could boost our energy security endeavours. Moreover, the WTE plants can be a game changer in terms of fighting global warming and climate change. It can also alleviate the menace of many types of pollutants thus saving the environment.