



# WASTE TO ENERGY

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1

# CONTENT

- Introduction to waste
- Origin of waste
- Statistics of waste generated
- Potential of waste
- Existing Disposal Methods
- Waste to Energy/Waste to Wealth
- Techniques to handle waste
- Government Initiatives
- Field visits/Case Studies

# NEED?

- Conservation of Energy?
- WASTE to ENERGY?
- Energy Crisis? Are we really facing those?
- Is it “Energy Crisis” or “Exergy Crisis”?

# WHAT IS WASTE?

- Waste are **unwanted** or **unusable** materials.
- Waste is an substance which is discarded after primary use or is **worthless**, **defective** and of **no use**.
- **A waste product may become a by-product, joint product or resource through an invention that raises a waste product's value above zero.**
- Types of waste:
  - **Municipal solid waste(MSW):** Household waste, Commercial waste, Demolition waste etc.
  - **Waste water:** Sewage waste water etc.
  - **Radioactive waste:** nuclear medicine waste, nuclear research waste etc.
  - **Hazardous waste:** biomedical waste, electronic waste, industrial waste etc.

# The origin of waste

## Mining



- waste rock
- tailings
- mine water
- chemicals
- and others

## Agriculture Forestry



- obsolete pesticides and fertilizers
- organics
- plastics and containers
- manure
- slaughter waste
- and others

## Industry



- textiles
- plastics
- chemicals
- ash
- nuclear waste
- and others

## Household, commercial and government bodies



- municipal solid waste
- electronics
- medical waste
- tyres
- and others

## Construction Demolition



- concrete
- plastic
- wood
- metal
- glass
- and others

## Wastewater treatment



- sewage sludge
- solid waste
- chemicals
- and others





# AMOUNT OF WASTE GENERATED...

- **GLOBALLY:**

- Global MSW generation levels are expected to increase to approx. **2.2 billion tonnes** per year by 2025 amounting to a significant increase in per capita waste generation rate of 1.42 kg per person per day.

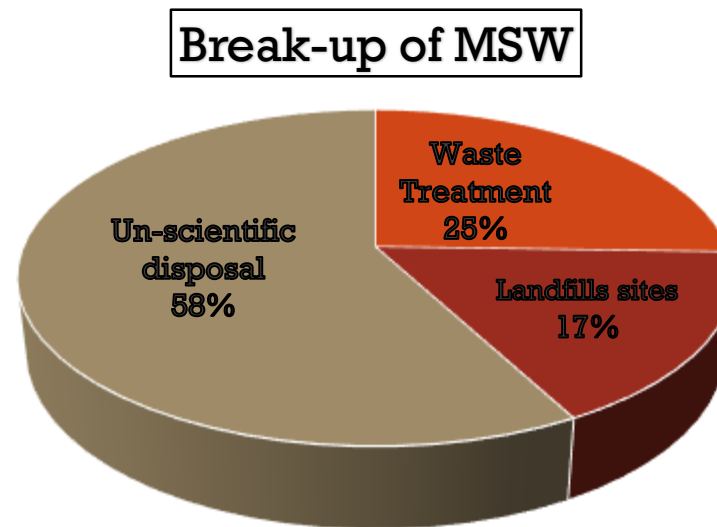
- **INDIA:**

- India generated **62 million tonnes** of waste each year. About 70% (42 million tonnes) are collected of which 12 million tons are treated and 30 million tonnes are dumped in landfill sites. It is estimated that the total urban MSW generated in India in 2041 would be 230 million tons per year.

# AMOUNT OF WASTE GENERATED...

## ■ GUJARAT:

- Approximately **10,200 MT per day** of MSW is generated in Gujarat out of which 25.5% is treated 16.7% is sent to landfills while 57.8% is disposed off in an unscientific way.
- Gujarat contributes approx. 28% of hazardous waste generation in India.
- Bharuch district of Gujarat has emerged as the highest waste generator, generating around 4.7 lakh MTA followed by Ahmedabad (3.7 lakh MTA)



■ Waste Treatment ■ Landfills sites ■ Un-scientific disposal



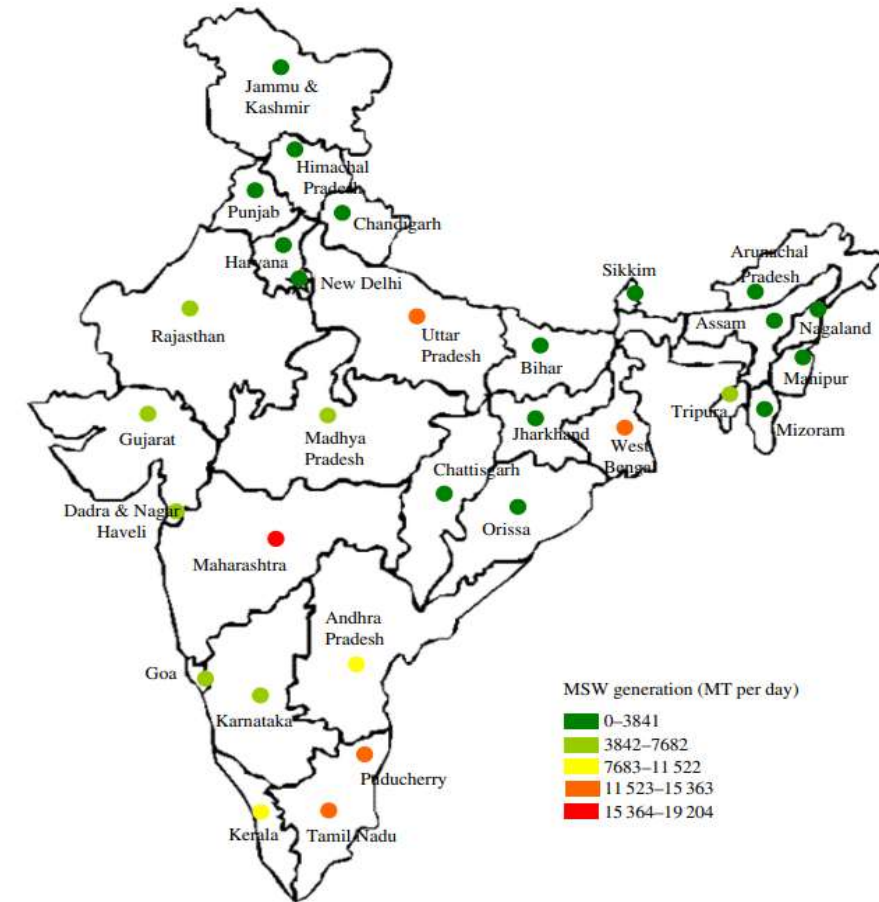
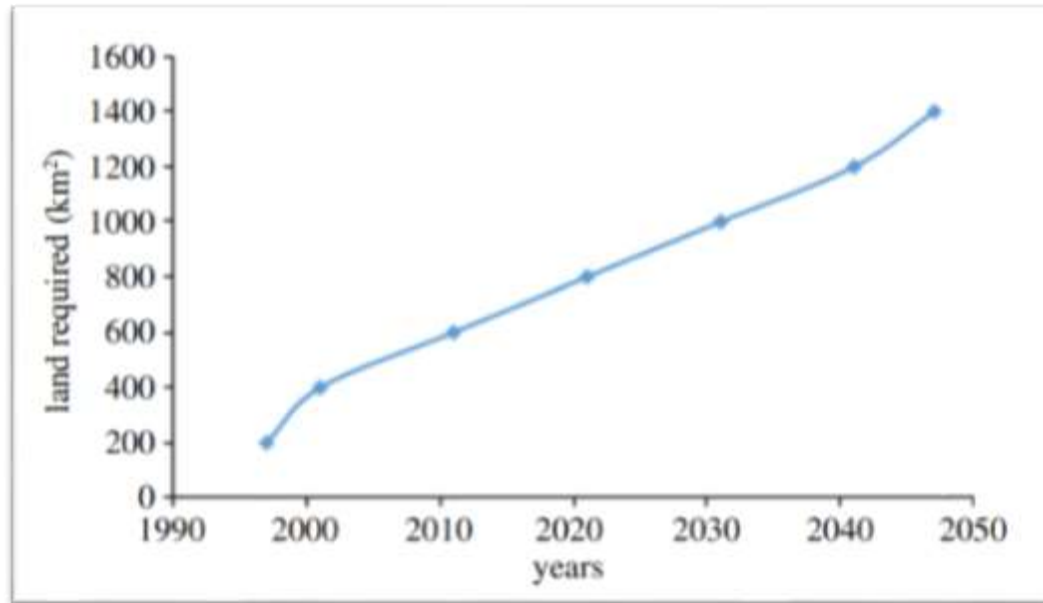
# AMOUNT OF WASTE GENERATED...

- **SURAT:**

- SMC claims that the **1,800-tonne** trash reprocesses almost 95% (1,720 tonnes) every day.
- One of the primary reasons it credits this change is its quick reprocessing of solid waste generated by the city daily.
- From prominent residential societies to vegetable markets and even at Khajod, plants were set up to process organic waste into manure.
- Today, nearly 800 tonnes of wet waste is converted to manure. Similarly, 750 to 800 tonnes of dry waste is recycled in to refuse-derived fuel (RDF).
- In case the fuel doesn't get any buyers. It is dumped at the Khajod site, which has not been barred by law.

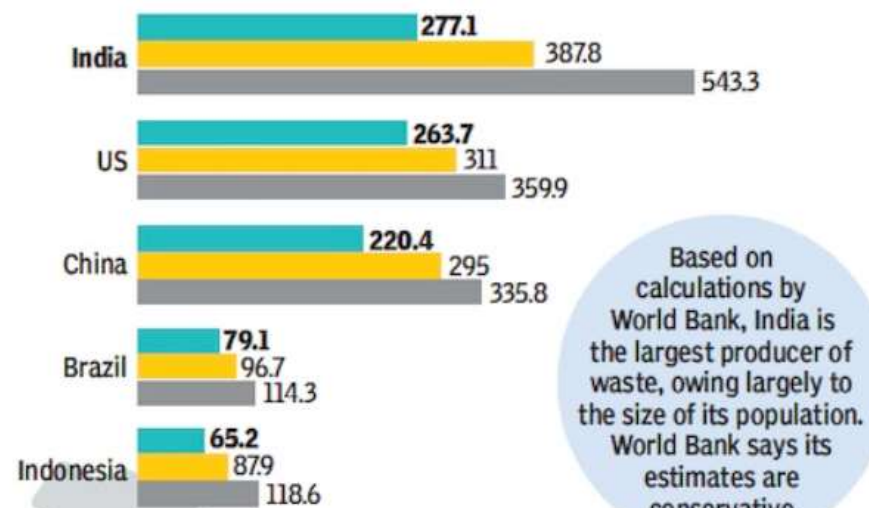
# AMOUNT OF WASTE GENERATED...

- Land Required and MSW generation in India:

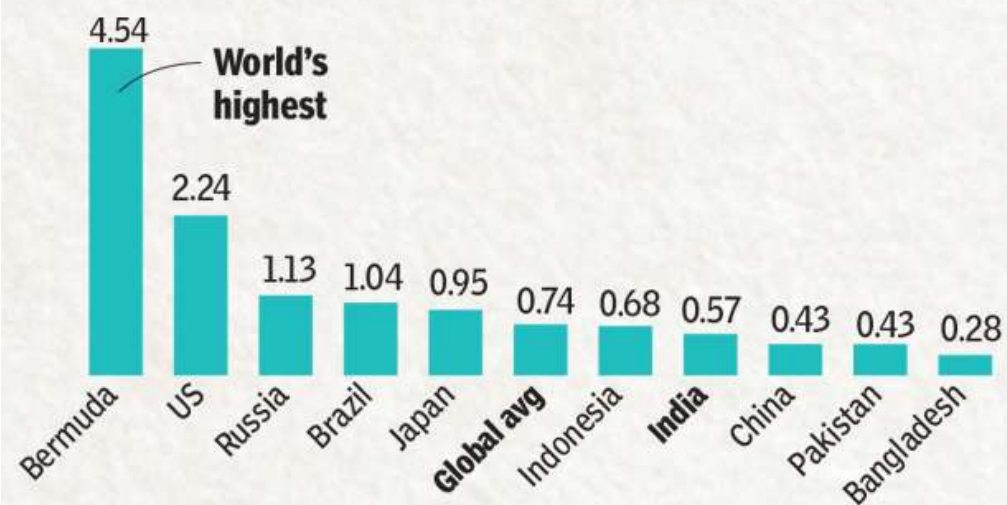


Top 5 municipal solid waste generators annually (in million tonnes)

■ 2016 estimate ■ 2030 projected ■ 2050 projected

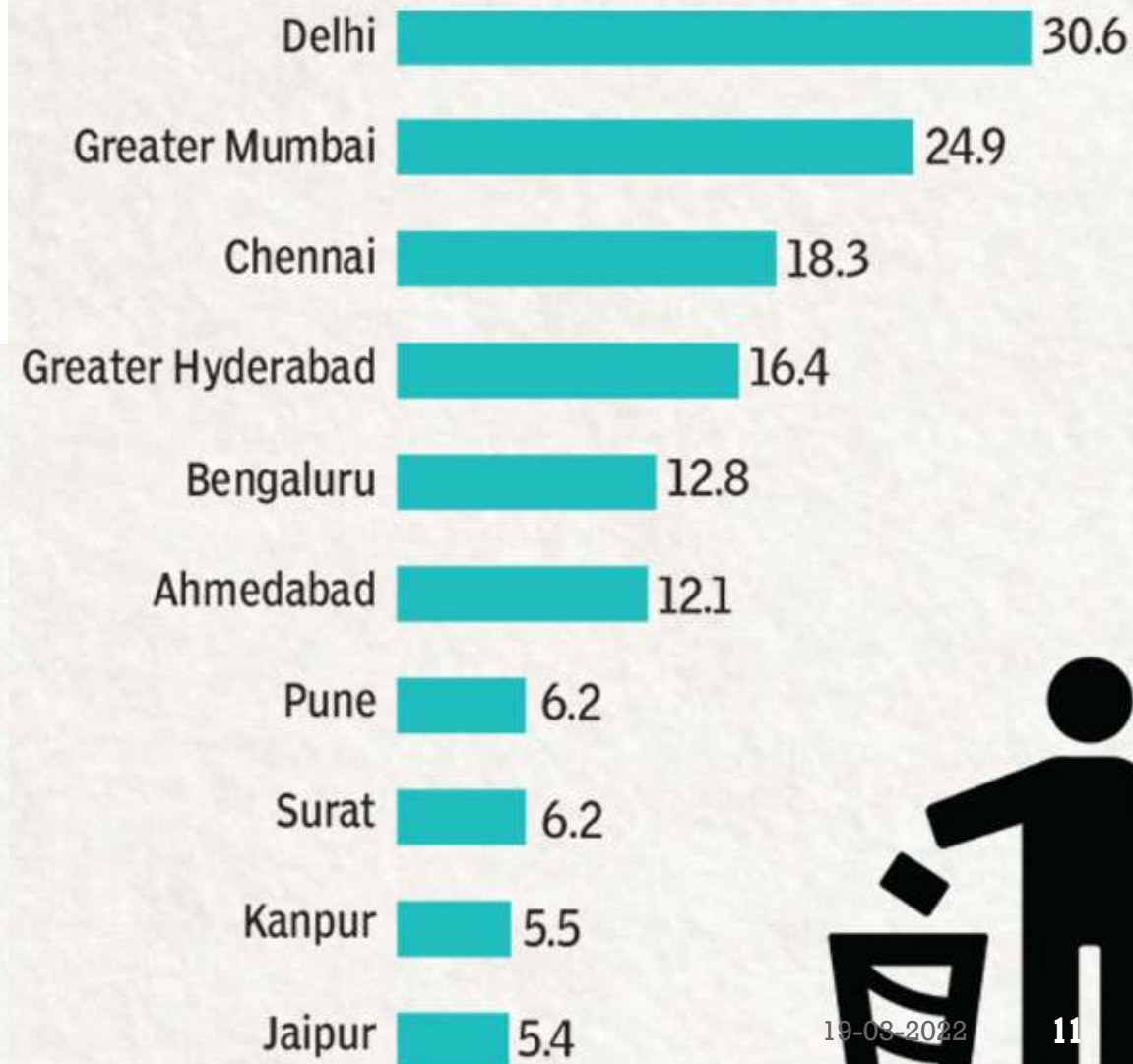


## WASTE GENERATION PER PERSON PER DAY (IN KG) IN SELECTED COUNTRIES

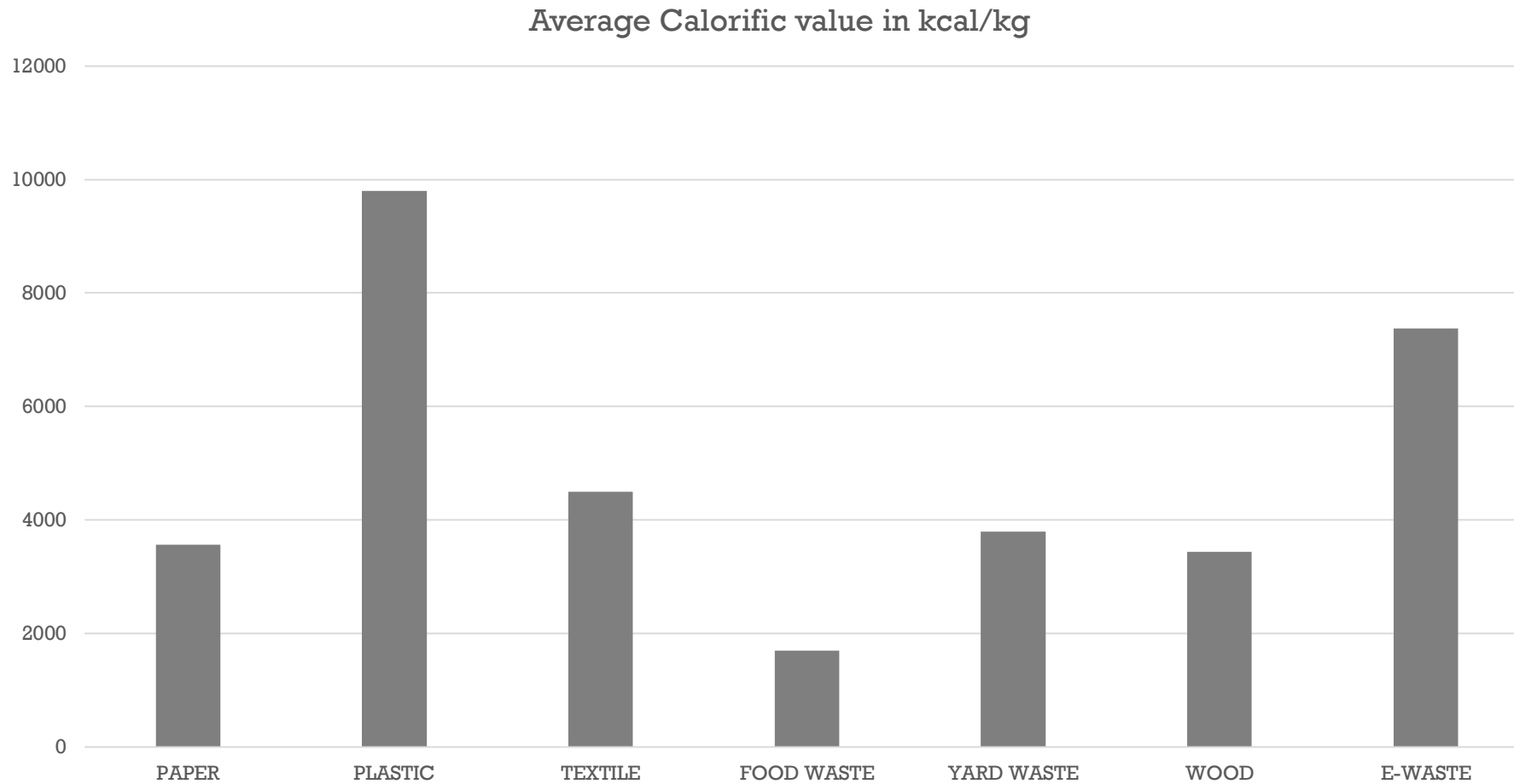


## TOP 10 INDIAN CITIES FOR WASTE GENERATION ANNUALLY

(in lakh tonnes)



# CALORIFIC VALUE OF VARIOUS WASTES...



# HOW IS WASTE DISPOSED??

- **Landfills:**
  - Throwing daily waste in the landfills is the most popularly used methods of waste disposal.
- **Recycling:**
  - Process of converting waste products into new products to prevent energy usage and consumption of fresh raw materials.
- **Composting:**
  - Natural biodegradation process that takes organic waste and decomposes it.
- **Incineration:**
  - Combustion of waste material to a very high temperature and that heat is utilized to produce steam, it is simply destruction of waste via heat.



# WHAT IS WASTE TO ENERGY?

- **Waste-to-energy (WtE) or energy-from-waste (EfW)** is the process of generating energy in the form of
  - **electricity** and/or
  - **heat** from the primary treatment of waste, or
  - **processing** of waste into a fuel source.
  - form of **energy recovery** or
  - produce a **combustible fuel** commodity, such as methane, methanol, ethanol or synthetic fuels.

# NEED FOR WASTE TO ENERGY

- The amount of solid waste generated each year has been **increasing** much faster than population growth.
- Growing **demand of energy** is also increases.
- Total estimated energy generation potential from urban and industrial organic waste on India is approx. **5690 MW**.

# ADVANTAGES OF WTE...

- Safe and economical waste disposal
- GHG reduction
- Renewable energy
- Sustainable process
- Reduce pollution
- Reduce no. of landfills required in future.

# WTE MARKET TRENDS...

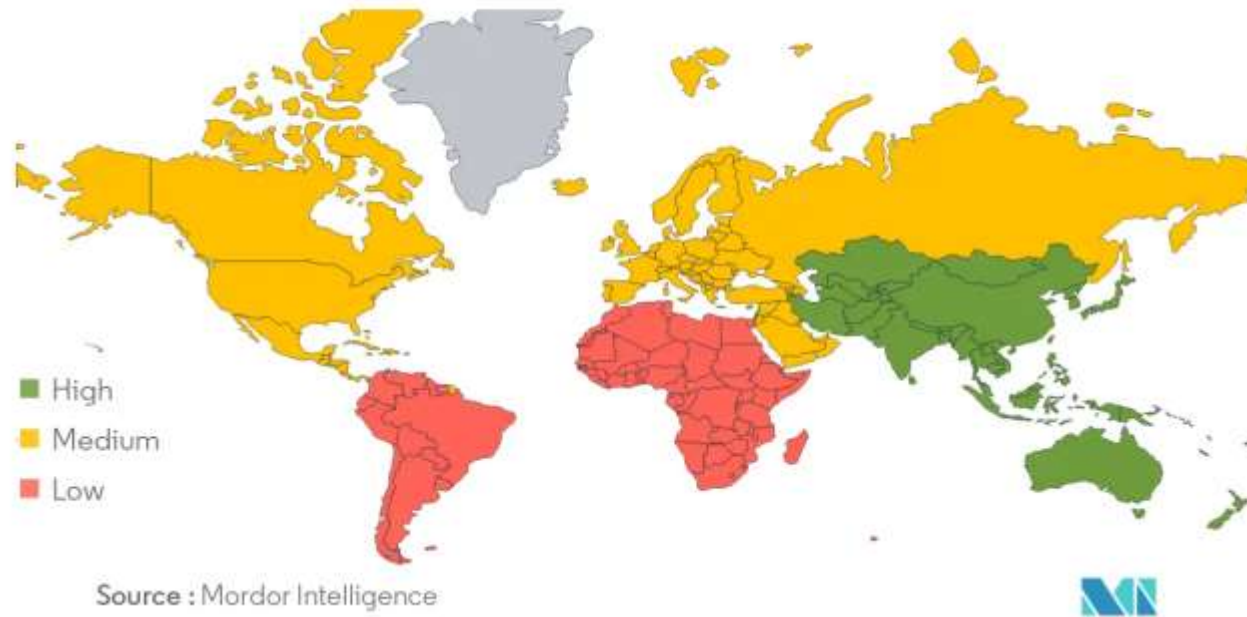
- The Global Waste-To-Energy Market size is expected to grow owing to green energy solutions.
- The waste-to-energy (WtE) market is expected to register a **CAGR of 7.35%** during the forecast period of 2022 – 2027, reaching a market size of **USD 74 billion** by 2027, up from **USD 49 billion** in 2020.
- Due to rapid depletion of conventional forms of energy sources, inclination towards techniques such as **gasification, aerobic** and **anaerobic digestion, incineration, pyrolysis** is expected to the progress market.
- Consistent waste management and **investments in public expenditure** in waste-to-energy is likely to escalate demand.
- Governments have been initiating and offering production of energy from agricultural and industrial wastes.

# WTE MARKET TRENDS...

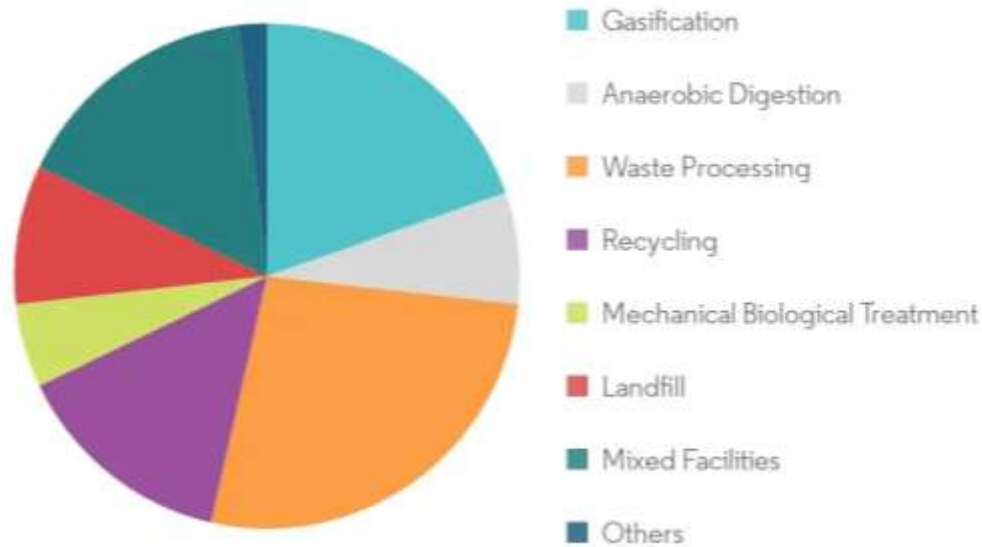
- Renewable energy requires **heavy investments** from governments, the shift of capital expenditure to the pandemic crisis also halted the Global Waste-To-Energy Market growth.
- Global Waste-To-Energy Market share is segmented on the basis of product type, application, key regions, and its countries, and key players.
- Based on **type**, the market is divided into **thermal technologies** and **biochemical technologies**.
- On the basis of **application**, the market is divided into **power plant**, **heating plant**, and others.
- Geographically; the market is spread in the Americas (U.S., Canada, Brazil, and Mexico), Asia Pacific (India, Japan, China, Korea, Australia, and Southeast Asia), Europe (U.K., Russia, Germany, Italy, and France), and Middle East & Africa (Israel, Turkey, South Africa, Egypt, and GCC Countries).



Waste to Energy Technologies Market - Growth Rate by Region, 2020-2025



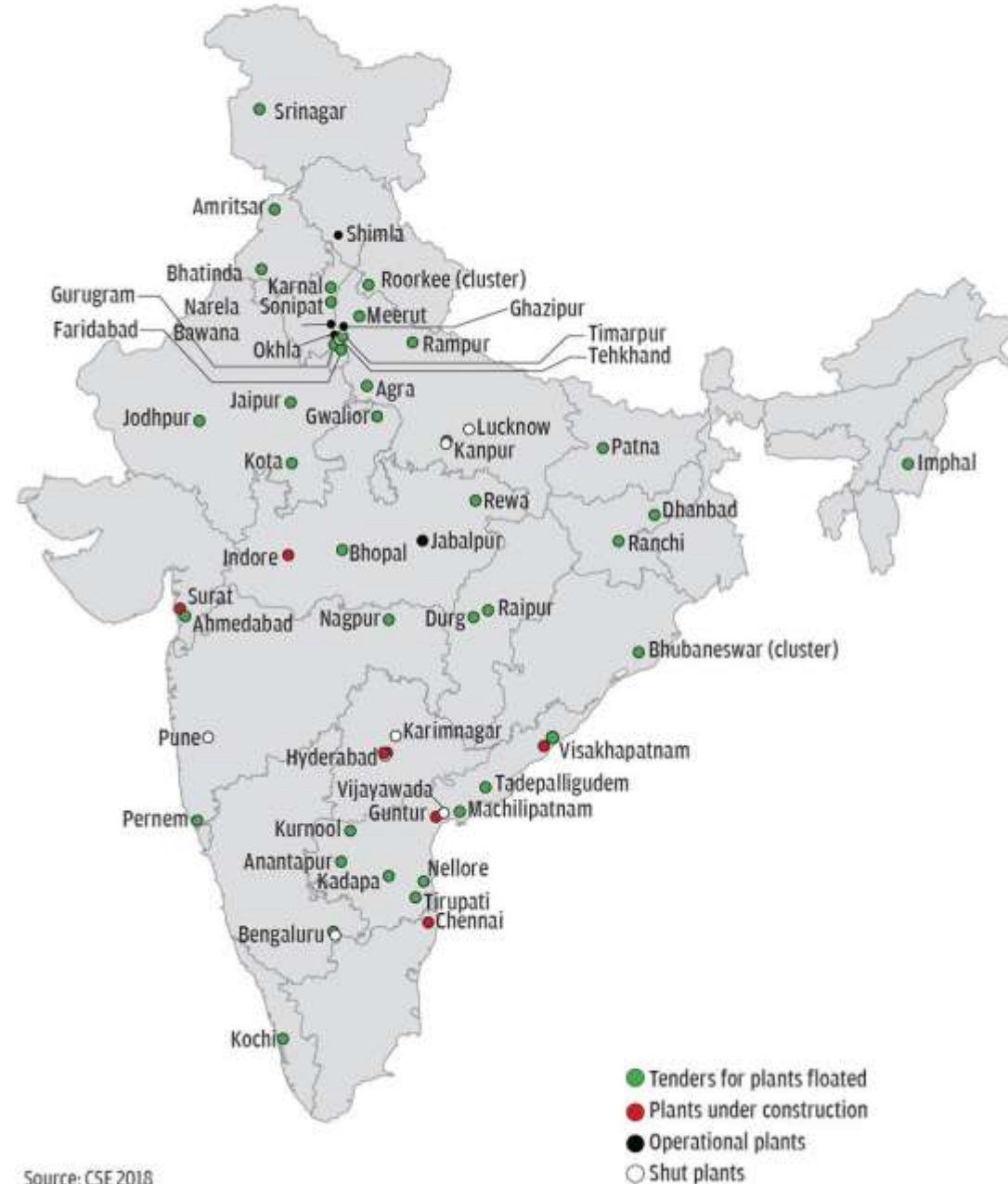
Share of Existing Utility Scale Plants (%), by Type, Global, 2018



Source : Global Waste Management Outlook

## A great gamble

Many cities with population below 2 million are constructing waste-to-energy plants



Source: CSE 2018

# PROBLEMS ASSOCIATED WITH WTE PLANTS IN INDIA...

- Around **92 plants** with aggregate capacity of 250 MW have been set up in the country for electricity generation for urban agricultural and industrial waste.
- **Effective waste management is expensive.**
- No segregation and one burn waste in its mixed form resulting in an increase in the amount of waste.
- **Low calorific value** of MSW due to high moisture content, leads to use of additional fuel which makes these plants expensive to run. This has been the main reason why WTE plants of Kanpur Bengaluru Hyderabad Lucknow Vijayawada has to be closed down.
- **Maintenance** of the plant, huge variation in type of waste.
- **Shortage of qualified engineers** and environmental professionals with the experience to deliver improved waste management systems in India.



# HEAVY MACHINERY



# Trash-fired power plants wasted in India

## PROBABLE SOLUTIONS...

Controversy mars India's ambitious target of generating 800 MW of energy by burning waste. Ironically, the country does not even generate appropriate waste to sustain these waste-to-energy plants

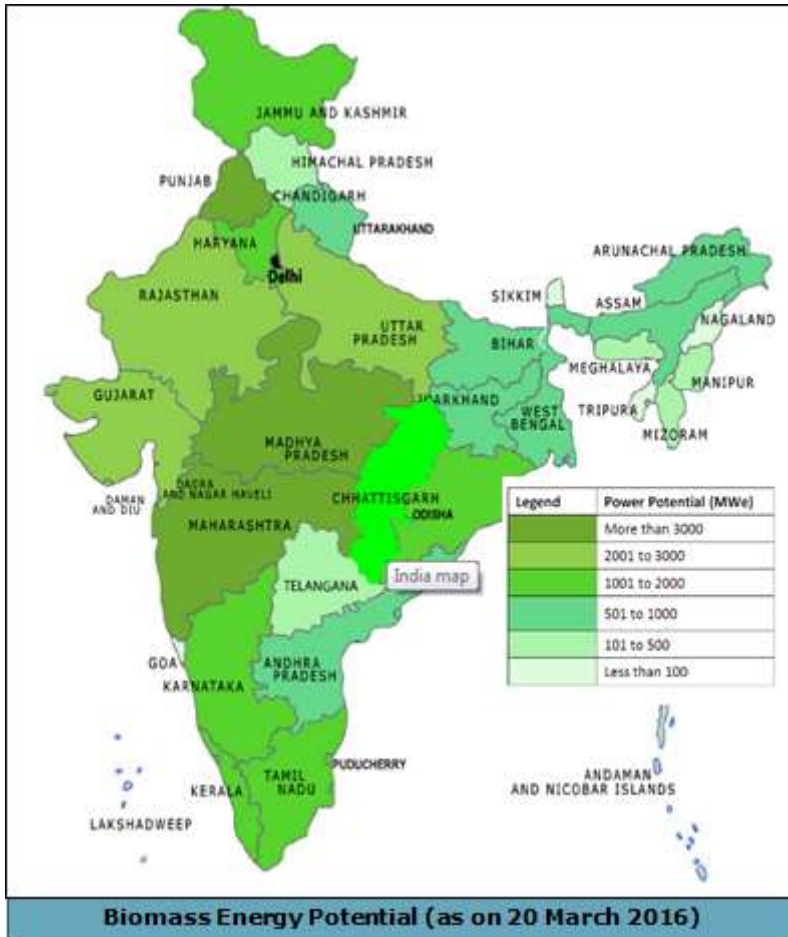
By Swati Singh Sambyal, Richa Agarwal, Rashmi Shrivastav

Published: Tuesday 23 April 2019

- MNREs financial incentives by way of interest subsidy in order to reduce the rate of interest.
- Highly segregated waste with high calorific value waste that is easy to manage.
- Installing highly sophisticated system to further segregate the waste so that consistent quality of waste is fed to plants.
- According to solid waste management rules 2016 only segregated non-cyclable high calorific value fractions like rubber tyres, multi layer plastics, discarded textile and papers are sent to WTE plants.



# INDIA'S WASTE TO ENERGY SCENARIO...



- India has a potential of about 18 GW of energy from Biomass. Currently, about 32% of total primary energy used in India is derived from Biomass.
- More than 70% of the country's population depends upon biomass for its energy needs.
- India has ~5+ GW capacity biomass powered plants: 83% are grid connected while the remaining 17% are off-grid plants
- The current availability of biomass in India is estimated at about 500 million metric tonnes per year.
- About 0.1 million tonnes of municipal solid waste is generated in India every day. That is approximately 36.5 million tonnes annually.
- Per capita waste generation in major Indian cities ranges from 0.2 Kg to 0.6 Kg.
- The difference in per capita waste generation between lower and higher-income groups range between 180 to 800 gm per day.
- The urban local bodies spend approximately Rs.500 to Rs.1500 per tonne on solid waste for collection, transportation, treatment and disposal. About 60-70% of this amount is spent on collection, 20-30% on transportation and less than 5% on final disposal.



# SCHEMES BY GOI...

- MNRE started a scheme for support and promotion of biomass based cogeneration in sugar mills and other industries in the country.
- New National Biomass and **Organic Manure Programme** NNBOMP (from 2017-2020): to provide clean cooking fuel for kitchen.
- Biogas power generation and thermal energy application programs (BPGTP): to provide decentralized energy source of power generation and to process scientifically the organic waste as feed stock.
- National Hydrogen Mission

# GOVT INITIATIVES REGARDING WASTE MANAGEMENT . . .



- **Swachh Bharat Mission:**

- Country wide campaign initiated by the Govt. of India in 2014 to eliminate open defecation and improve solid waste management.

- **Waste to wealth mission:**

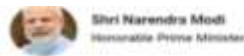
- Mission aims to identify develop and deploy technology to treat waste to energy, recycle materials and extract resource of value.

- **Gobar - dhan yojana:**

- Safely managing of cattle waste, agricultural waste and organic waste on rural areas.

- **Compost Banao- Compost Apnao campaign:**

- Aims to encourage people to convert their kitchen waste to compost which can be used as fertilizer, which can significantly reduce landfill waste.



“The motto of 3R - Reduce, Reuse and Recycle - is at the heart of any vision towards the sustainable development of mankind. All stakeholders - producers, consumers and the State alike - must adhere to this golden principle which can contribute significantly in solving the twin challenges of waste management as well as sustainable development.”

# MOTIVATIONAL STORIES:

- Ambikapur:
  - Here you can pay for meal with plastic- not cards, but real plastics- the bits and pieces that lie around your house. And you can walk on road made entirely of plastic.

**HOW AMBIKAPUR DID IT**

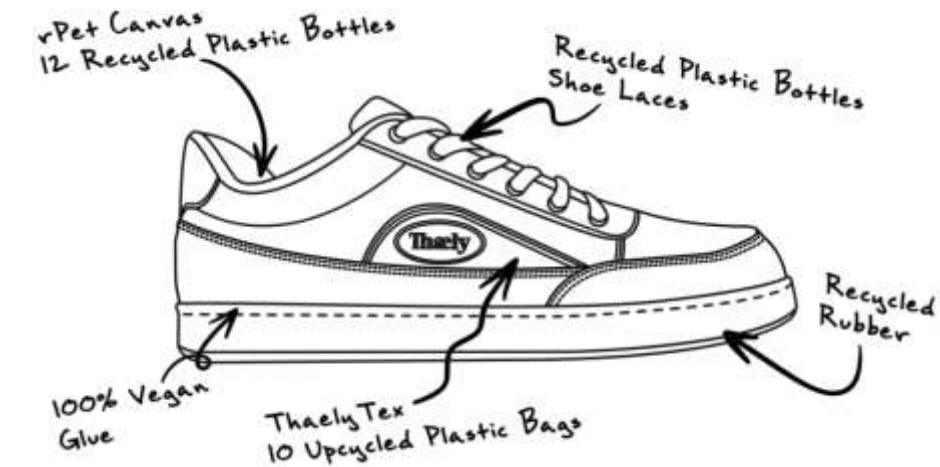
- Efficient door-to-door waste collection system
- Homes and businesses segregate waste at source

➤ Organic waste converted into compost, sold in market

➤ Plastic is separated and turned into granules, 1.5km road built

**Food-for-waste scheme**

# THAELY:

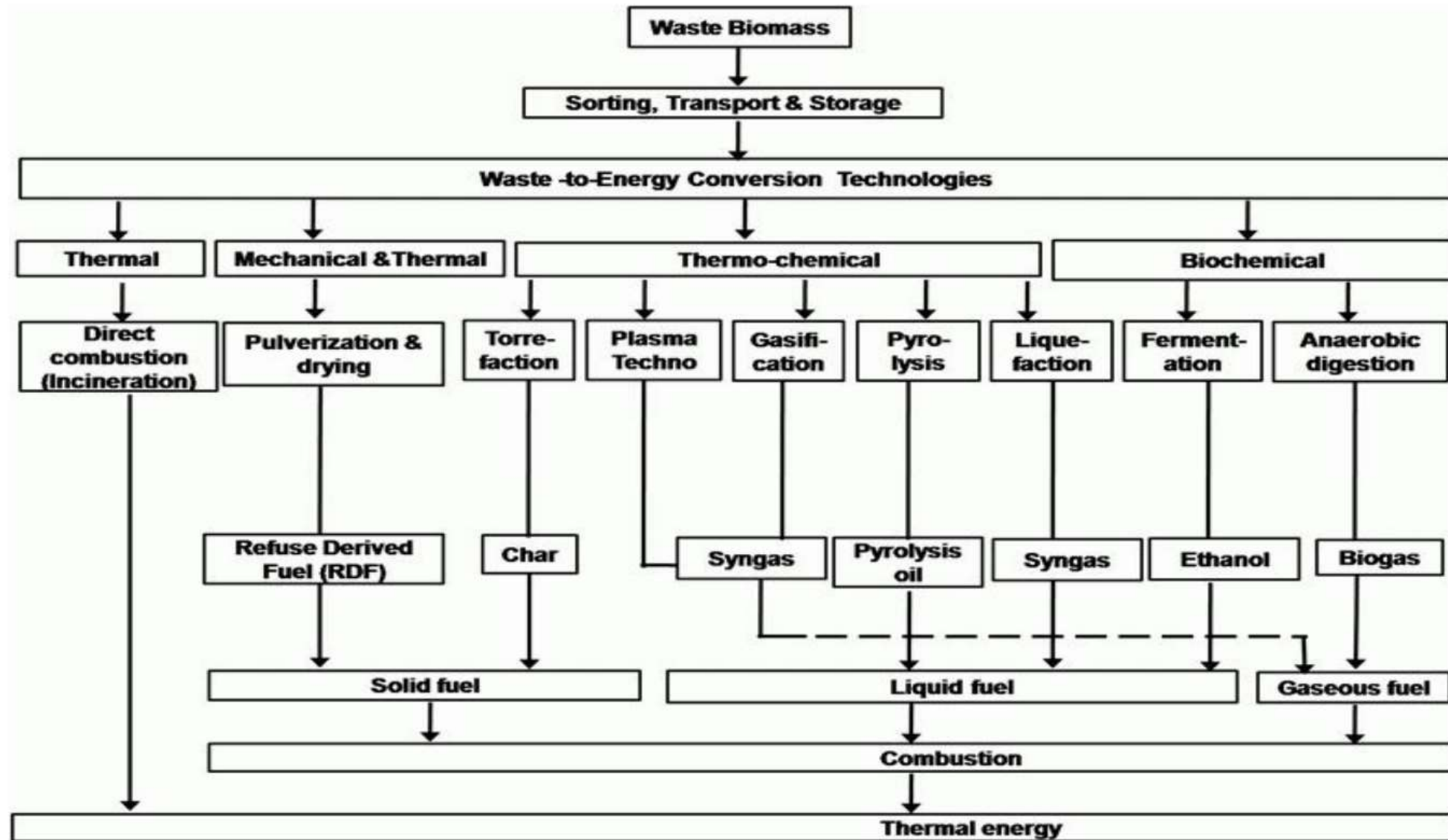


- Thaely-tex is a revolutionary new fabric that looks and feels like leather but is made entirely out of waste plastic bags, the production process doesn't need any additional chemicals nor does it releases any toxic chemicals as a by products.
- r-PET or recycled polyethene terephthalate is used for toe box lining laces and Tote. It is made of recycling waste PET plastic bottles.
- Recycled rubber is used to make sole from scrap material such as shoe soles, tires and other industrial waste.
- The Thaely box is made from recycled paper which is embedded with basil seed and dyed with waste coffee grounds. Once you get your box simply cut and plant it. You will have basil plant in 10 days.

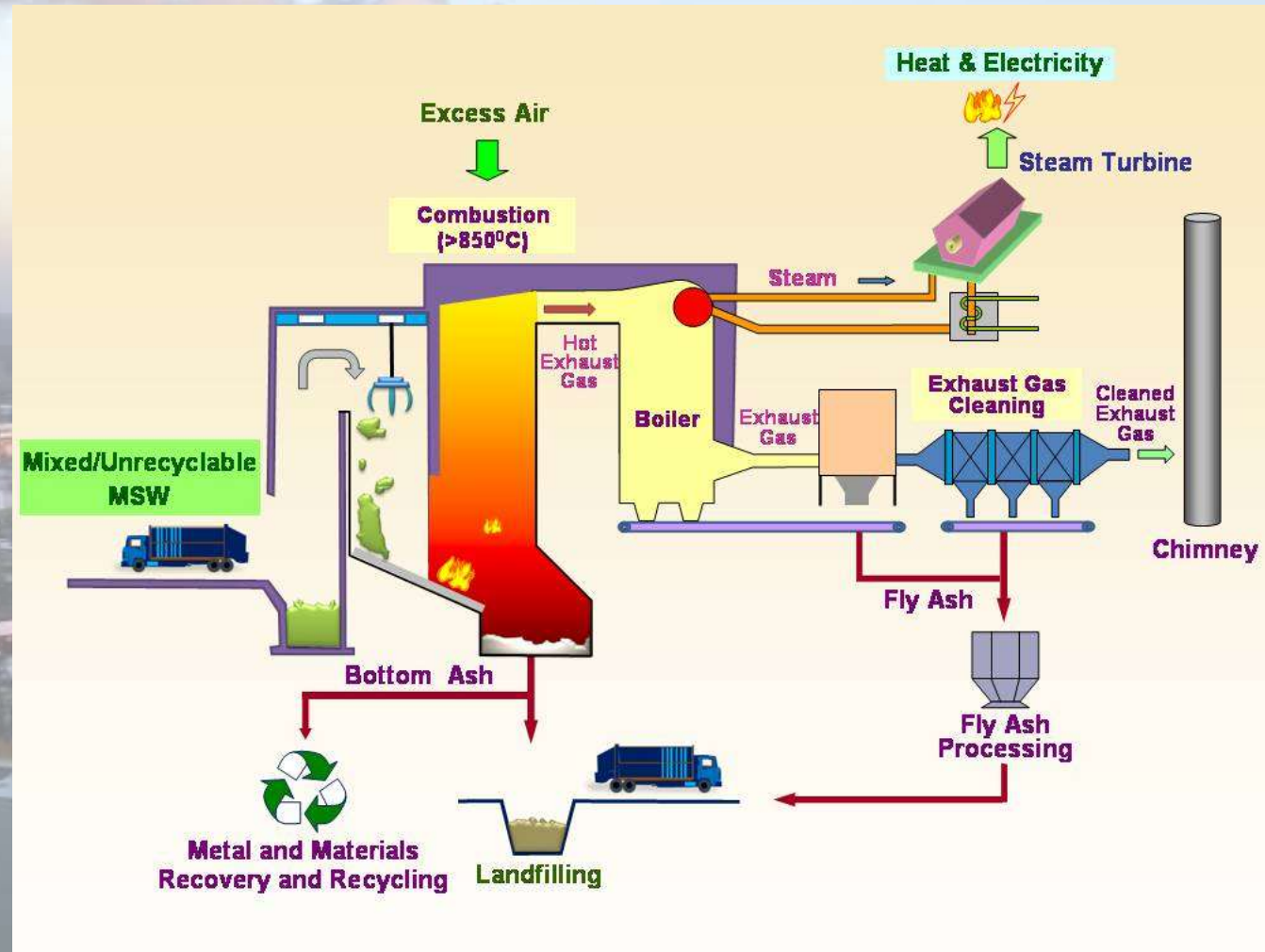
# METHODS OF WASTE TO ENERGY

- Thermal conversion
- Thermochemical conversion
- Biochemical conversion
- Physio-chemical conversion(Mechanical & Thermal)





# INCINERATION:



# THERMOCHEMICAL CONVERSION OF WASTE

- Three principal methods of thermochemical conversion of MSW are
  - combustions,
  - gasification and
  - pyrolysis

# GASIFICATION:

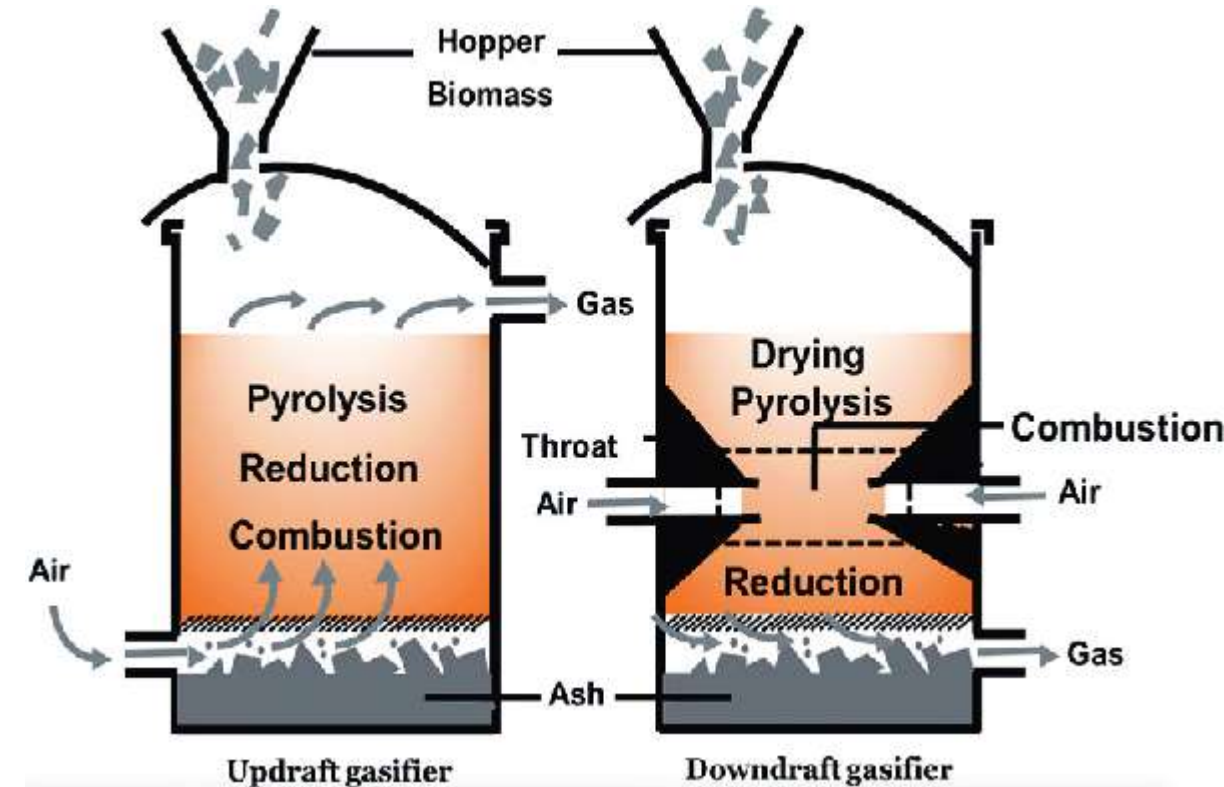
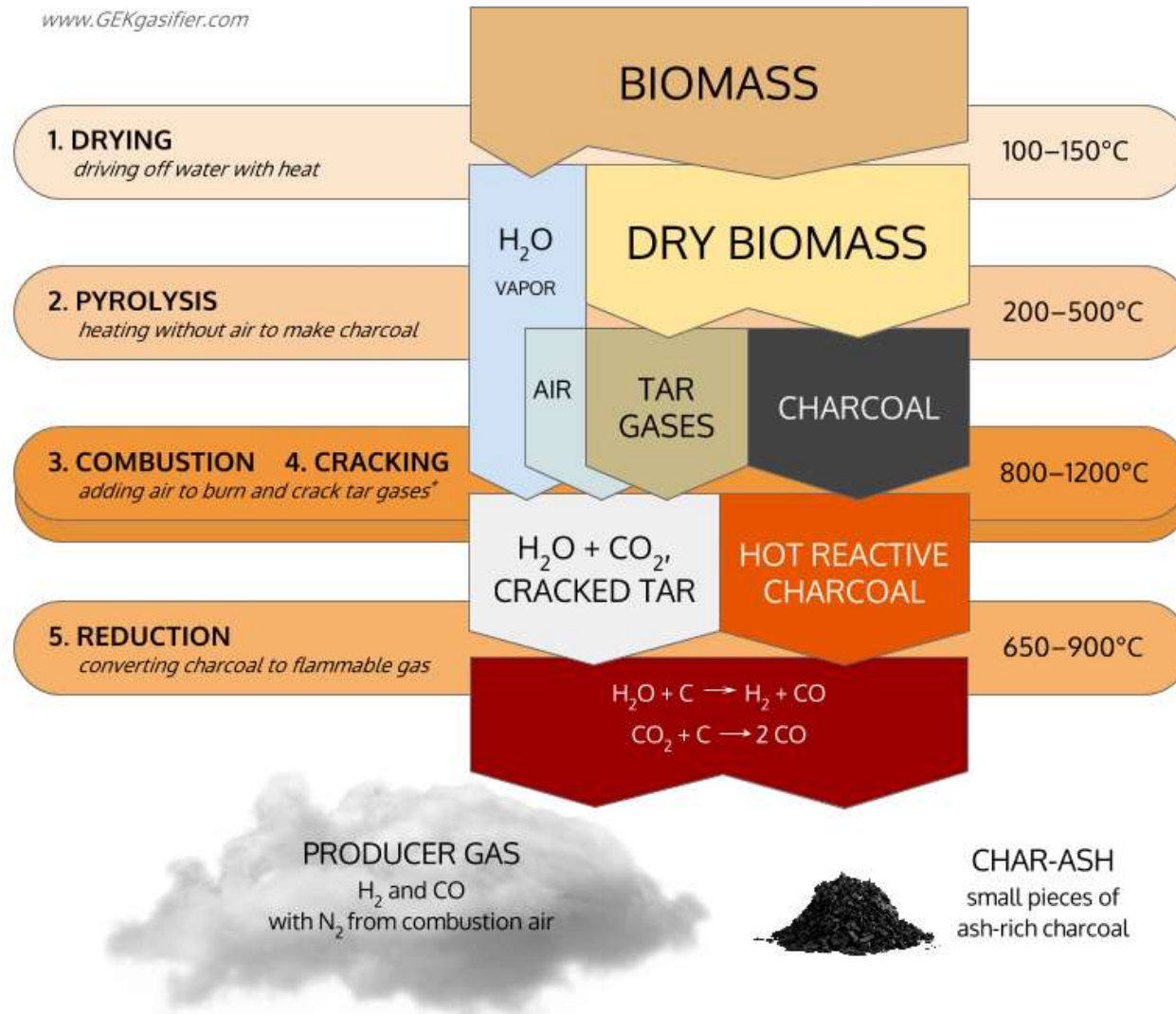
- Gasification is a process that converts biomass- or fossil fuel-based carbonaceous materials into gases, including as the largest fractions: nitrogen (N<sub>2</sub>), carbon monoxide (CO), hydrogen (H<sub>2</sub>), and carbon dioxide (CO<sub>2</sub>).
- This is achieved by reacting the feedstock material at high temperatures (typically >700 °C), without combustion, via controlling the amount of oxygen and/or steam present in the reaction.
- The resulting gas mixture is called syngas (from synthesis gas) or producer gas and is itself a fuel due to the flammability of the H<sub>2</sub> and CO of which the gas is largely composed.
- Power can be derived from the subsequent combustion of the resultant gas and is a source of renewable energy if the gasified compounds were obtained from biomass feedstock.





# The Five Processes of Gasification

ALL Power Labs  
www.GEKgasifier.com



\* tar cracking is the breakdown of tar into H<sub>2</sub>, CO, and other flammable gases by exposure to high temperatures.

# PYROLYSIS:

- **Pyrolysis** is the thermal decomposition of materials at elevated temperatures in an inert atmosphere.
- It involves a change of chemical composition.
- The word is coined from the Greek-derived elements *pyro* "fire" and *lysis* "separating".
- Pyrolysis is most commonly used in the treatment of organic materials. It is one of the processes involved in charring wood.
- In general, pyrolysis of organic substances produces volatile products and leaves a solid residue enriched in carbon, char.
- Extreme pyrolysis, which leaves mostly carbon as the residue, is called carbonization.
- Pyrolysis is considered as the first step in the processes of gasification or combustion.



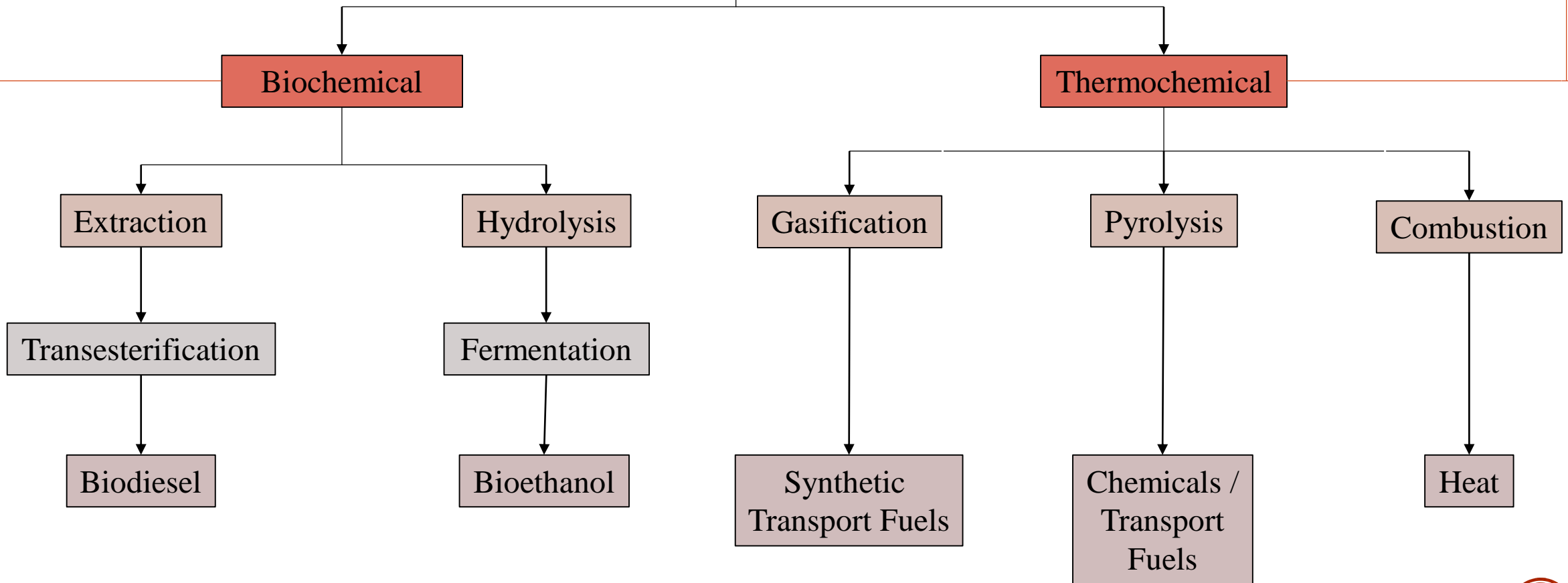
➤ Fuels produced from bio-chemical process are costly than fossil fuels

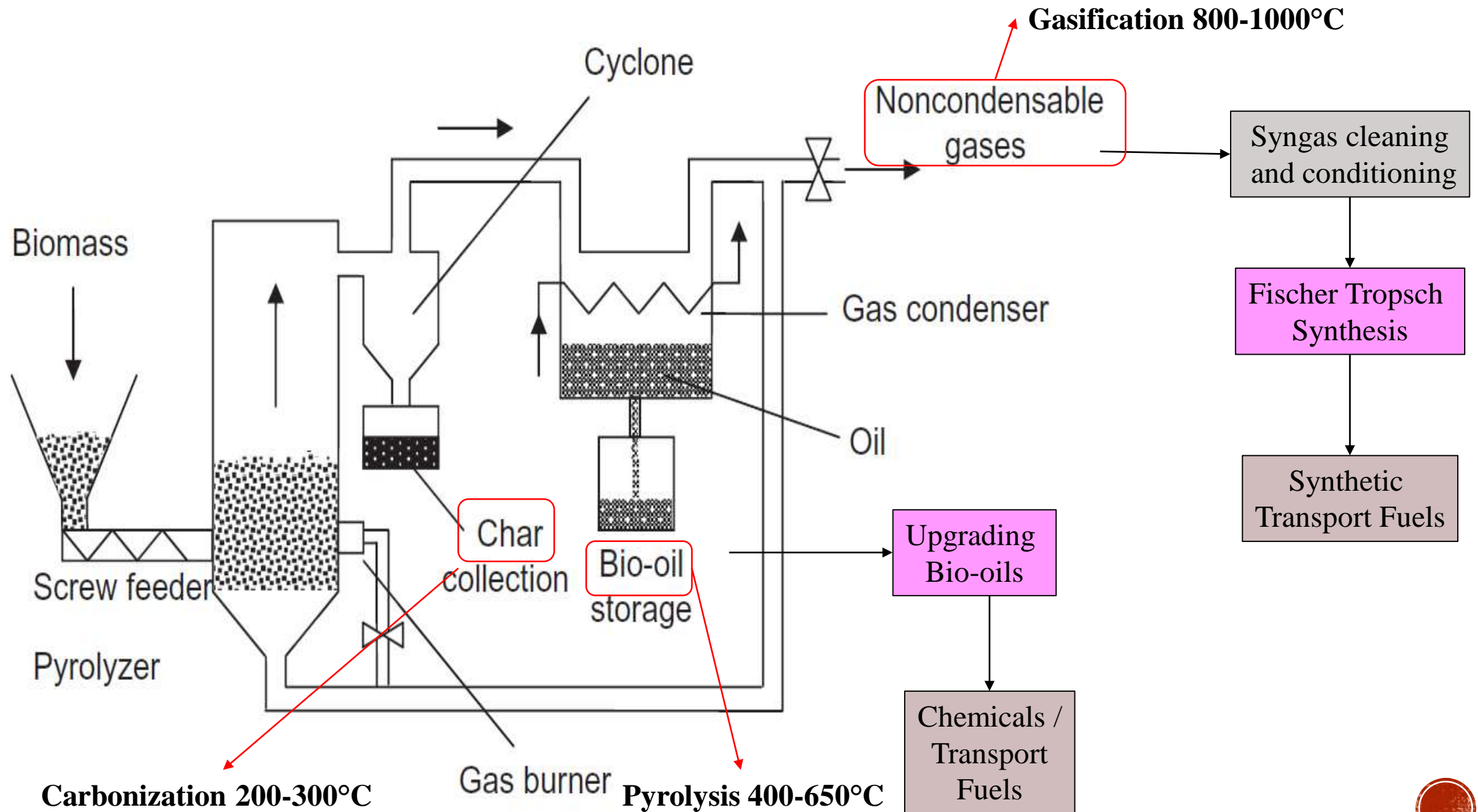
End products can be introduced in the same distribution system

- Low bulk density feedstock
- High viscosity substrate
- High enzyme costs
- Low fermentability of some substrates

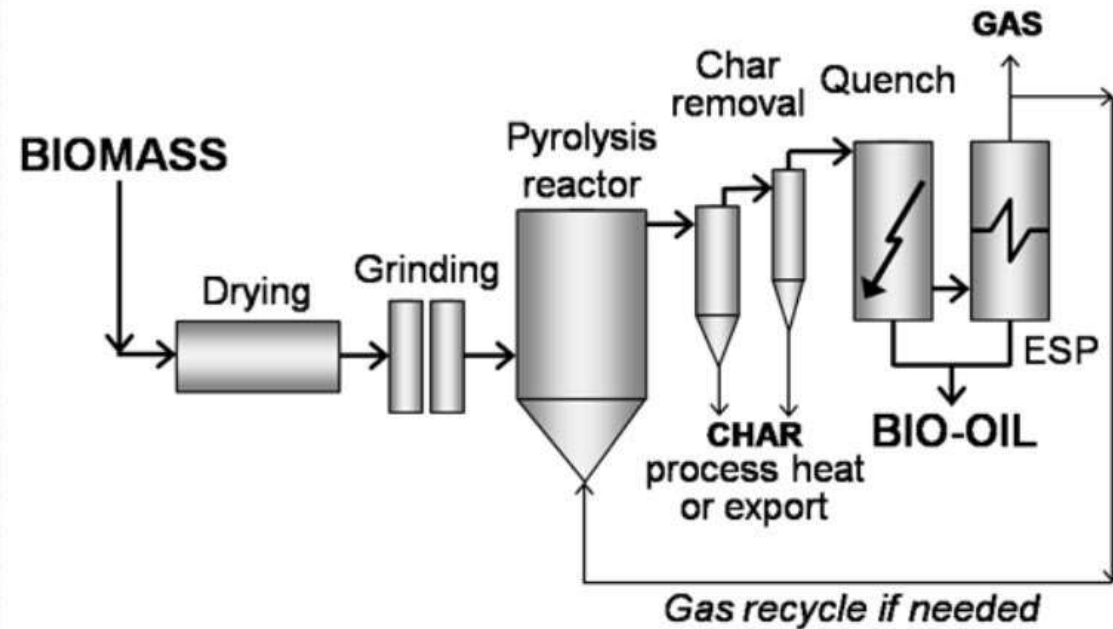
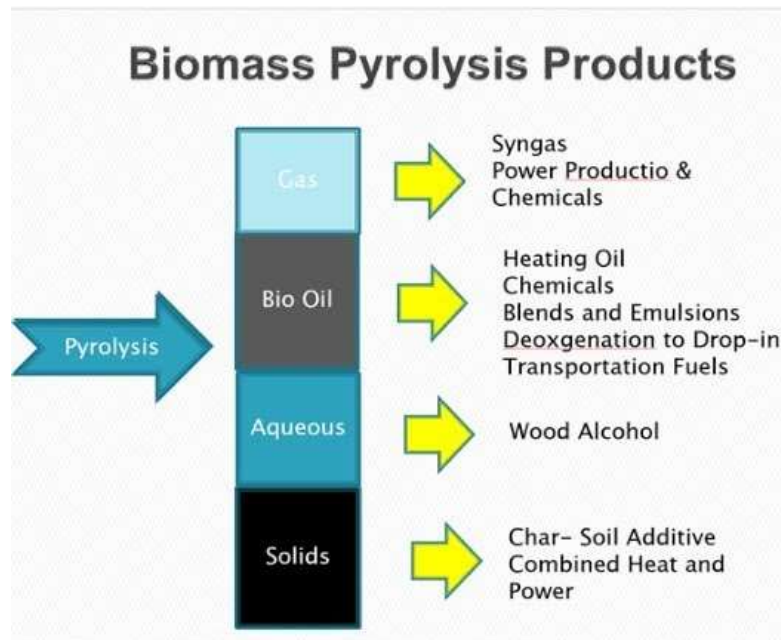
- Limited number of processing steps
- Shorter processing time

## Biomass Conversion Routes





# WHAT IS PYROLYSIS ?



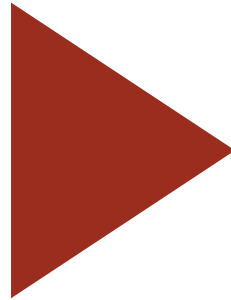
# BIOCHEMICAL CONVERSION OF WASTE

- Biochemical processes, like anaerobic digestion, can also produce clean energy in the form of biogas which can be converted to power and heat using a gas engine. Anaerobic digestion is the natural biological process which stabilizes organic waste in the absence of air and transforms it into biofertilizer and biogas.
- Anaerobic digestion is a reliable technology for the treatment of wet, organic waste.
- Variety of fuels can be produced from waste resources including liquid fuels, such as ethanol, methanol, biodiesel, Fischer-Tropsch diesel, and gaseous fuels, such as biogas and methane.



# ANAEROBIC DIGESTION:

The process by which microorganisms break down biodegradable Material in the absence of oxygen.



This process is used for Industrial or Domestic purposes to manage waste or produce fuels.

# KEY STAGES OF ANAEROBIC DIGESTION

- 1) Hydrolysis: Chemical reaction in which a molecule of water breaks one or more chemical bond.
- 2) Acidogenesis: Biological process where simple monomers are converted into volatile fatty acids.
- 3) Acetogenesis: Biological process where Volatile Fatty Acids are converted into Acetic acid, CO<sub>2</sub> and Hydrogen.
- 4) Methanogenesis: Biological reaction where Acetates are converted into Methane and Carbon Dioxide while Hydrogen is consumed.



# ANAEROBIC DIGESTION TYPES:

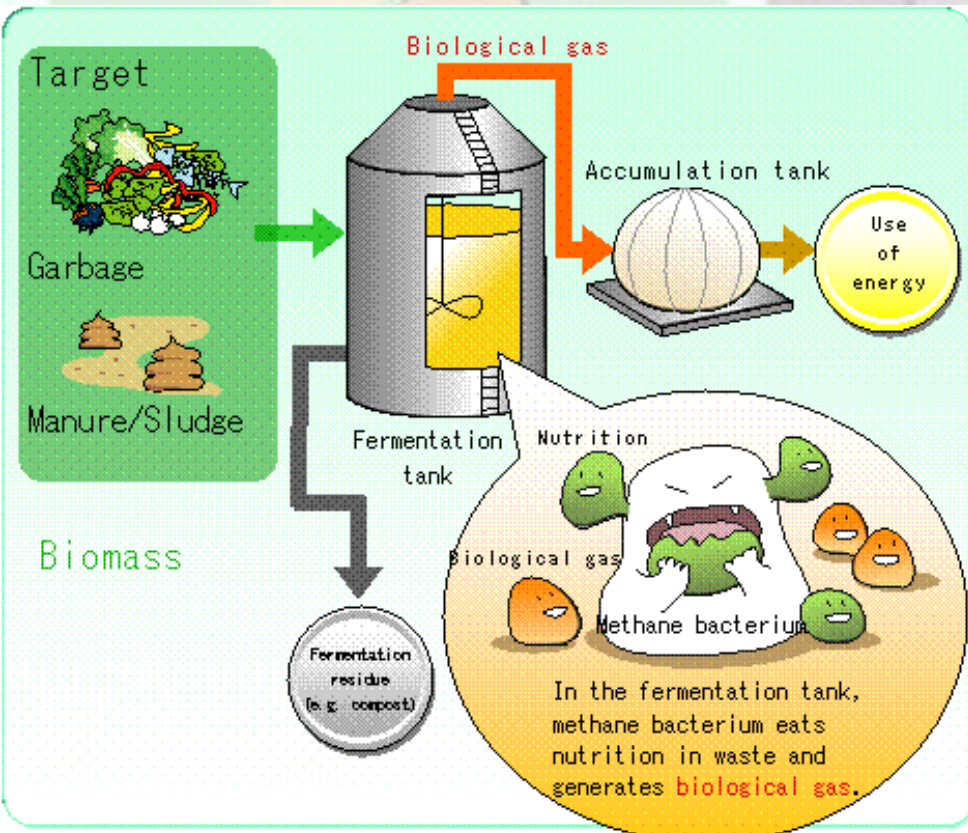
## 1. Biogas production by manure:

- The production of methane rich biogas from manure(human and animal waste) and crops take place

They utilize mixed bacterial cultures that provides optimal temperature for growth.

This mixed culture allows the digestion to operate at a wide range of temperature i.e.  $0^{\circ}\text{C}$  to  $60^{\circ}\text{C}$ .

- When functioning well, the bacteria convert 90% of the energy content into Biogas(containing about 55% of methane).
- This biogas is a readily useable source of energy for cooking and lightning.
- The sludge produced after the Anaerobic process is non-toxic and odourless.
- The sludge contains Nitrogen and other nutrients hence making a good fertiliser.



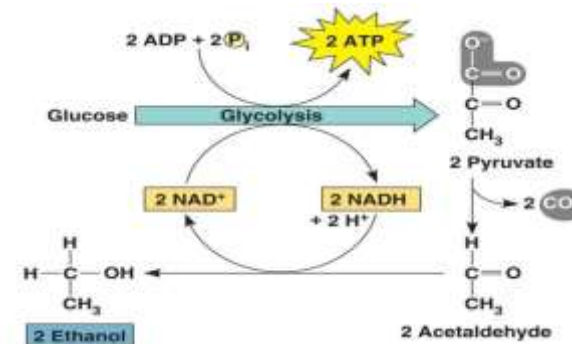
# ANAEROBIC DIGESTION TYPES:

## 2. Biogas production by Landfills:

- Anaerobic Digestion in landfills is brought about by the microbial decomposition of organic material in refuse.
- Landfill generated gas is on an average half Methane and half Carbon Dioxide with an energy content of 18 MJ/m<sup>3</sup> to 19MJ/m<sup>3</sup>
- Formation of Methane starts about Six months after the depositing the landfill.
- The landfill gas can be utilized directly on site by a boiler or any type of combustion system.
- This production does not occur under pressure.

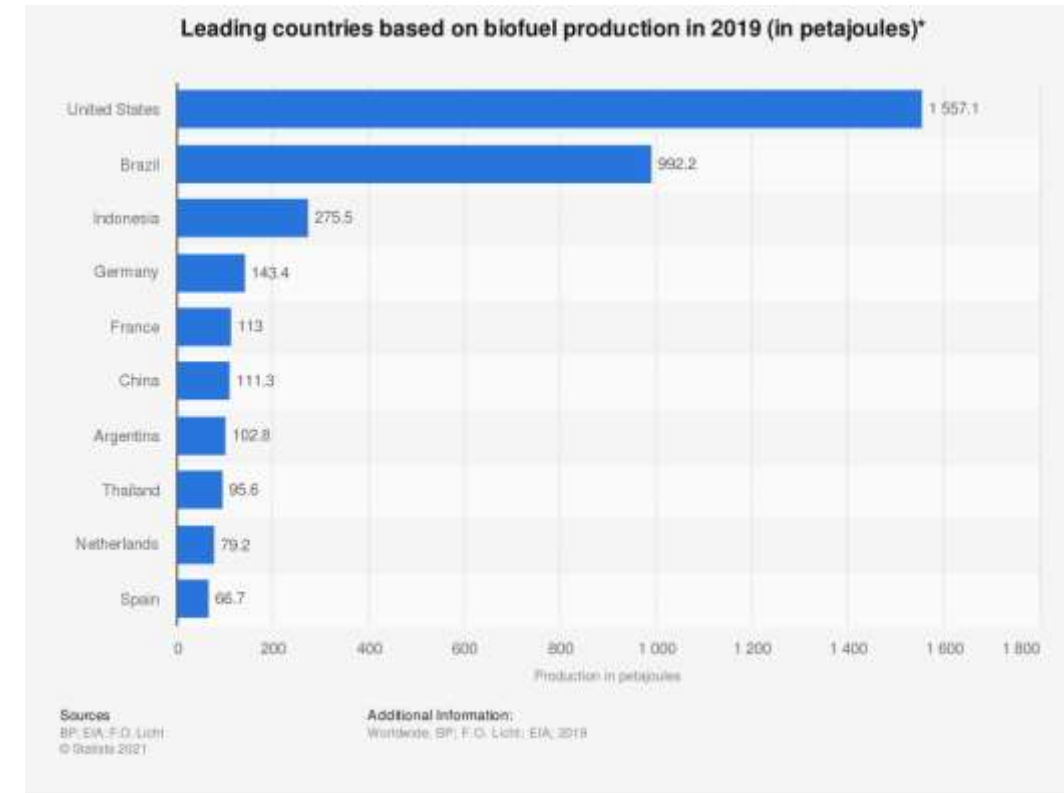
# ETHANOL FERMENTATION:

- This process converts Sugars such as glucose, sucrose and fructose into cellular energy, producing ethanol and Carbon dioxide as by-product.
- Ethanolic Fermentation is also considered as anaerobic process because yeasts perform this process in absence of Oxygen.
- Ethanol Fermentation has many uses including the production of alcoholic beverages, production of ethanol fuel and bread cooking.
- Apart from ethanol, this process produces unharvested by-products such as Heat, carbon dioxide, food for livestock, water, methanol, fertilizer etc.
- Sugarcane is the most commonly used livestock in developing countries due to its high productivity when provided with sufficient water.



# BIODIESEL/BIOFUELS':

- Biodiesel is produced through a process called *transesterification*- a process that converts fats and oils into fatty acids methyl esters(FAME).
- The raw oil can be obtained from a variety of plant species, oil palms and coconut palm.
- The oils can undergo thermal or catalytic cracking, Kolbe electrolysis in order to obtain better characteristics.
- Approximately 100 pounds of oils and fats are reacted with 10 pounds of a short-chain alcohol (usually Methanol) in the presence of a catalyst ( usually NaOH or KOH) to form 100 pounds of biodiesel and 10 pounds of glycerine ( or glycerol).





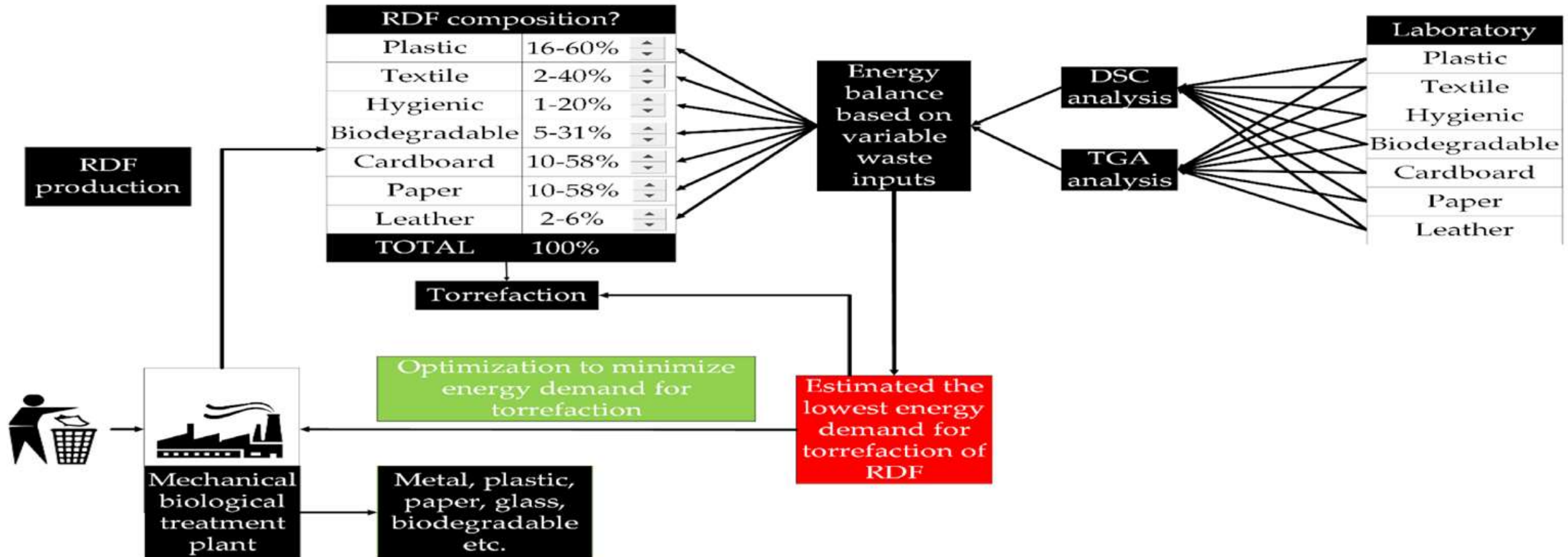
# PHYSIOCHEMICAL CONVERSION OF WASTE..

- The physio-chemical conversion of waste involves various processes to improve physical and chemical properties of solid waste. The combustible fraction of the waste is converted into high-energy fuel pellets which may be used in steam generation.
- The waste is first dried to bring down the high moisture levels. Sand, grit, and other incombustible matter are then mechanically separated before the waste is compacted and converted into fuel pellets or RDF.

# RDF:

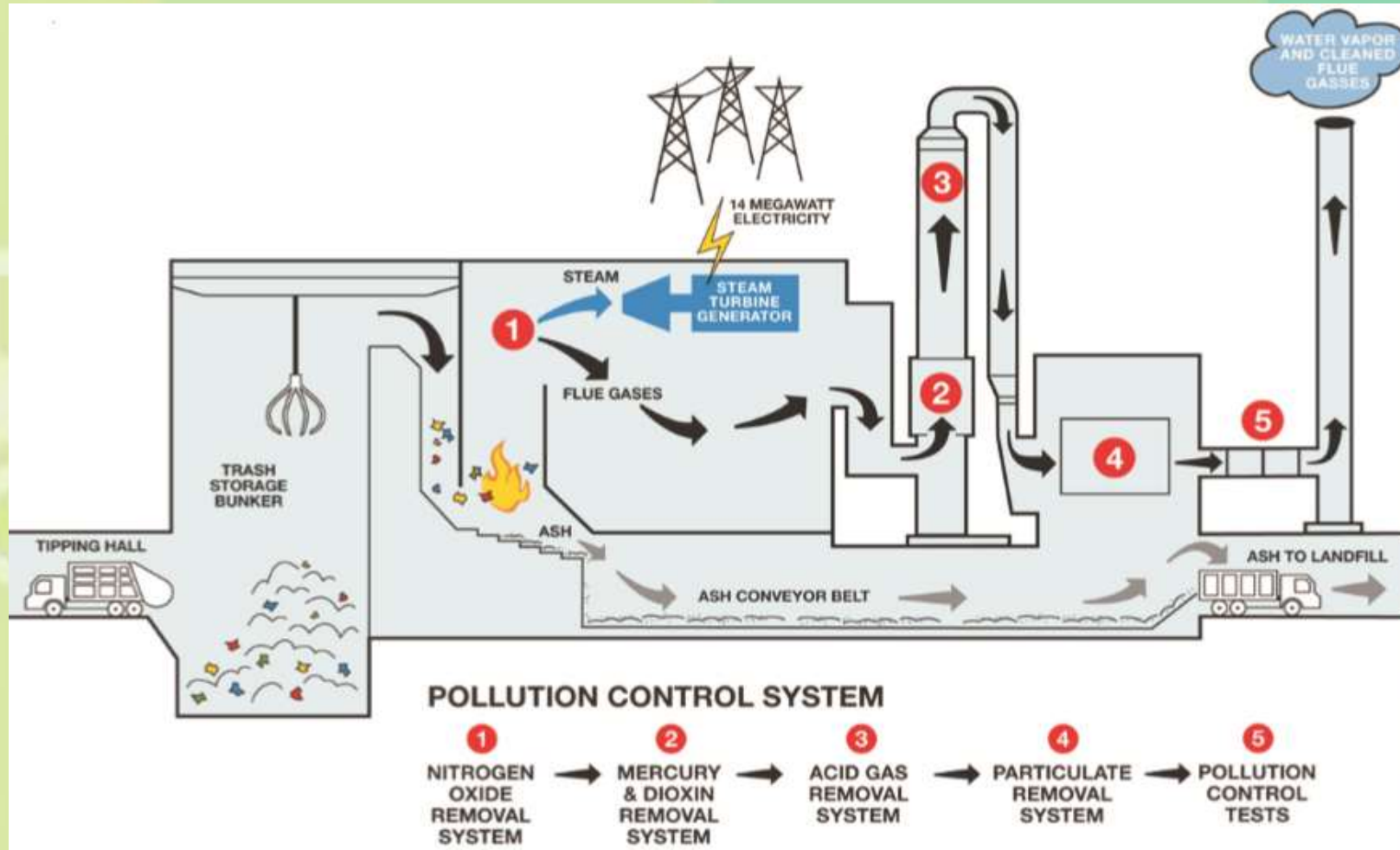
- This fuel is produced from combustible components that the industry calls Municipal Solid Waste – MSW for short
- This waste, usually taken from industrial or commercial sites, is shred, dried, baled and then finally burned to produce electricity.
- Refuse Derived Fuel is a renewable energy source that ensures waste simply isn't thrown into a landfill and instead, put to good use.
- RDF has many facets and it can be further specified into
  - TDF (Tyre Derived Fuels)
  - SRF (Solid Recovered Fuels)
  - AF (Alternative Fuels).

- **Types of materials** that can be processed as RDF are:
  - non-recyclable plastics
  - paper cardboard
  - labels
  - And many other combustible substances



COLLECTING    CONDITIONING    CONVERTING    GENERATING

# WASTE TO ENERGY PLANT LAYOUT...





# FEW NGOS IN FIELD OF WTE:

- Hand in Hand:
  - Hand in Hand India is an international NGO based in India and works in a majority of Indian states. The leading NGO works with empowering women, educating children, creating healthcare access, combating climate change and creating jobs. The NGO also nurtures social entrepreneurship in India.
  - **Aims to reduce the waste that is being used as landfills.**
  - The waste collected from the localities is processed and used to generate fuel. Bio-gas plants help generate electricity. The energy thus generated is used to power street lights or cooking. Their projects have set an example of how community participation can help our environment.

# FEW NGOS IN FIELD OF WTE:

- Saahas:
- The journey of Saahas began in 2001 with registration under the Societies Act. Wilma Rodrigues, a formal journalist, founded Saahas to promote waste management practices in alignment with the very progressive Municipal Solid Wastes (Management and Handling) Rules, 2000.
- Over the years, Saahas has been innovating, incubating and propagating waste management programs focused on two key principles of “Segregation at Source” and “Decentralized Waste Management”
- Headquartered in Bangalore, and are now operational in Gurugram, Surat, Chennai, Hubballi and Ballari.
- Saahas is a non-profit organization working in the field of waste management.
- At Saahas, it is believed that when waste is managed at source, it becomes a resource. Since 2001, they have been helping build communities across rural and urban India that manage their waste at source by reducing, reusing and recycling their waste and achieving 90% resource recovery.

# FEW NGOS IN FIELD OF WTE:

- **Chintan environmental research and action group:**
  - Chintan reduces waste and consumption, manages solid and electronic waste and advocates around materials, waste and consumption. It uses waste as a tool to fight poverty, child labour gender based violence and exclusion and climate change, while creating green livelihoods. Chintan pushes back and combats unsustainable consumption. Its work directly supports the UN's Sustainable Development Goals
- Its work includes:
  - voice for waste
  - Scavengers to managers
  - No child in trash
  - Training
  - The Safai sena secretariats

# FEW NGOS IN FIELD OF WTE:

- **Samarthanam:**

- Samarthanam is an NGO working for environment protection in India. Environmental awareness, conservation, and protecting our surroundings are an integrate part of Samarthanam's values.
- Samarthanam's two major initiatives, Parisara and WOW, are working towards promoting the 3Rs (Reduce-Reuse-Recycle), waste segregation, greener and cleaner environs, and developing sustainable waste management models.

- **Parisara:**

- Parisara was initiated in the year 2003, to provide sustainable dry waste management services to various corporates, industrial companies, institution, apartments & communities in Bangalore.
- The concept of Reduce-Reuse-Recycle is followed by Parisara who also promote the same through their awareness programmes organized across the city.
- Parisara also contributes to the disabled communities by providing livelihood opportunities to people with disabilities and the underprivileged.

# FEW NGOS IN FIELD OF WTE:

- **Nepra foundation:**

- Nepra Foundation, established in 2012, a public charitable trust, is registered under Trust Registration Act, 1950.
- Currently, it is mobilizing urban waste pickers in Ahmedabad.
- Nepra Foundation is one of the grass root voluntary organizations working for the overall socioeconomic development of rural and urban people with a special focus on Climate change.
- It owns the responsibility of community development in an obligatory manner.
- Nepra Foundation integrates with other NGOs and government schemes to diminish the widening gap between informal sector and mainstream society.



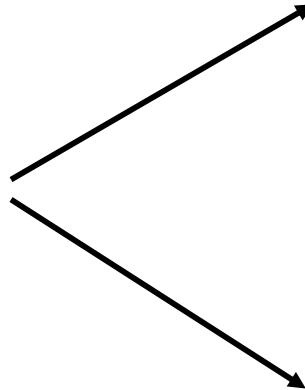
# FIELD VISITS / CASE STUDIES:

- Khajod, Surat
- Vyara, Surat
- SVNIT, Surat

# KHAJOD, SURAT-GUJARAT



# VYARA, SURAT-GUJARAT



# SVNIT, SURAT-GUJARAT



**THANK YOU**