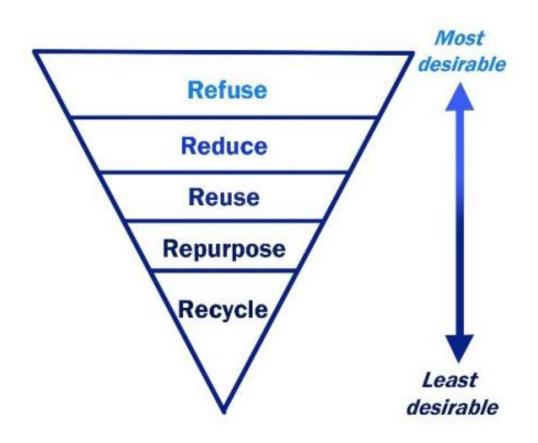
ENVIRONMENTAL ENGINEERING

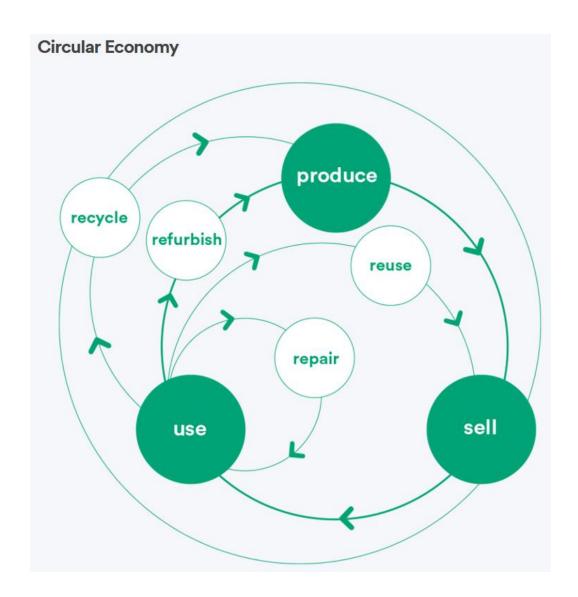
SOLID WASTE MANAGEMENT

5R PRINCIPLES

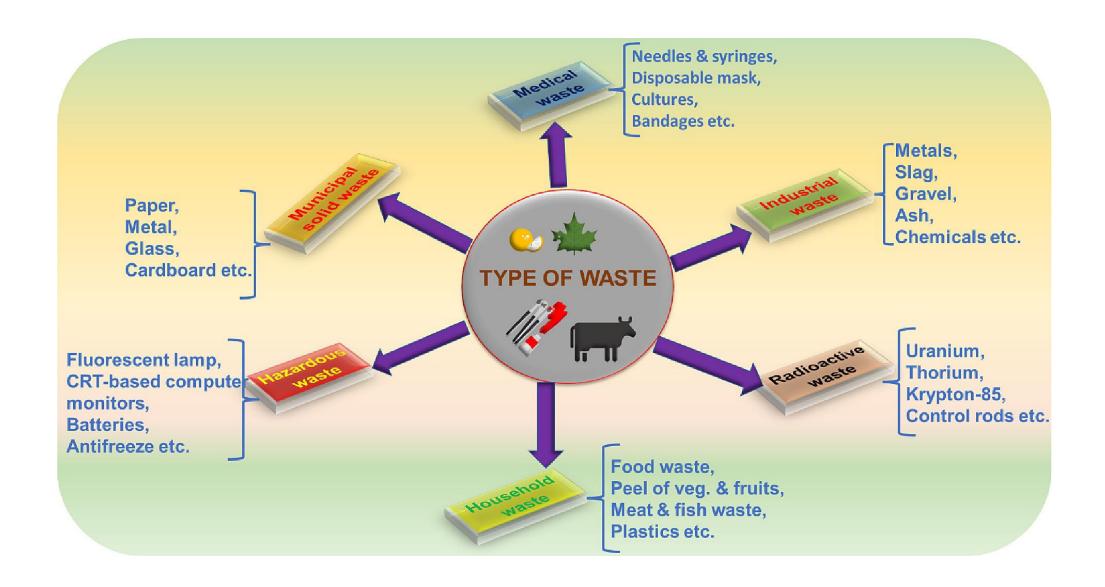


CIRCULAR ECONOMY

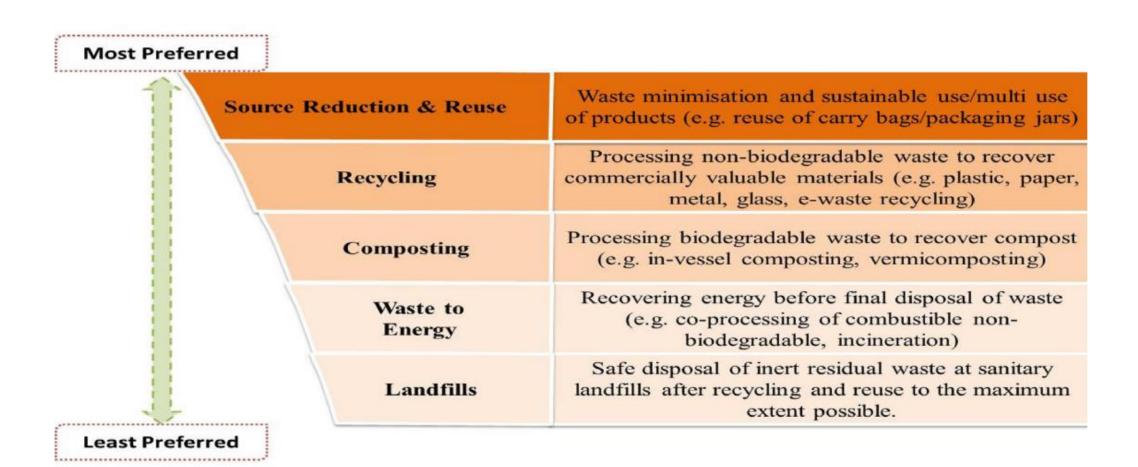




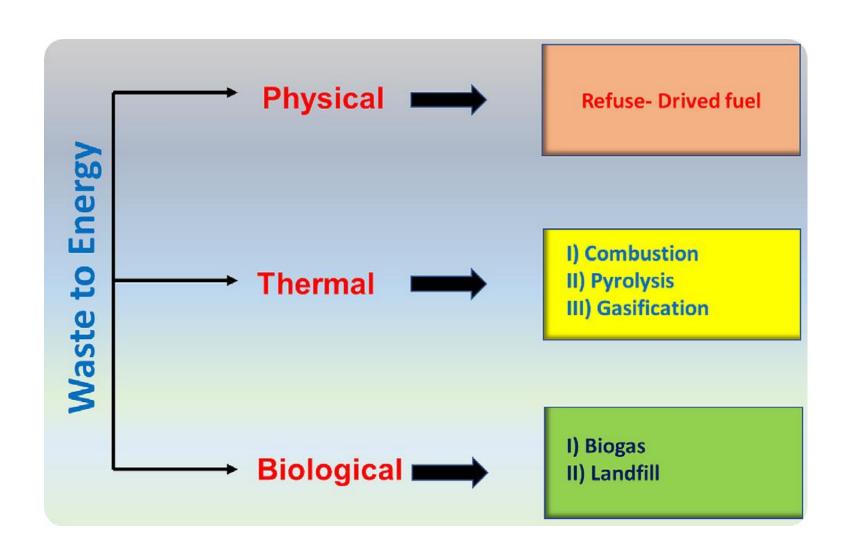
CLASSIFICATION OF WASTE



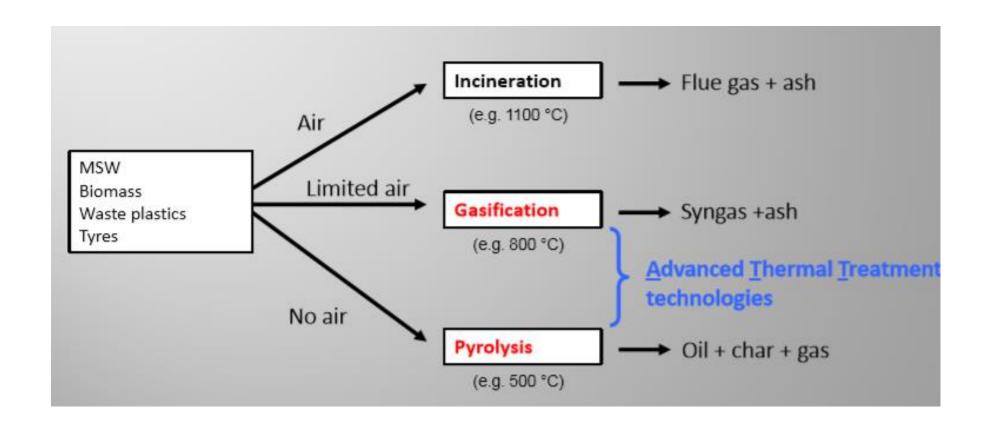
INTEGRATED SOLID WASTE MANAGEMENT HEIRARCHY



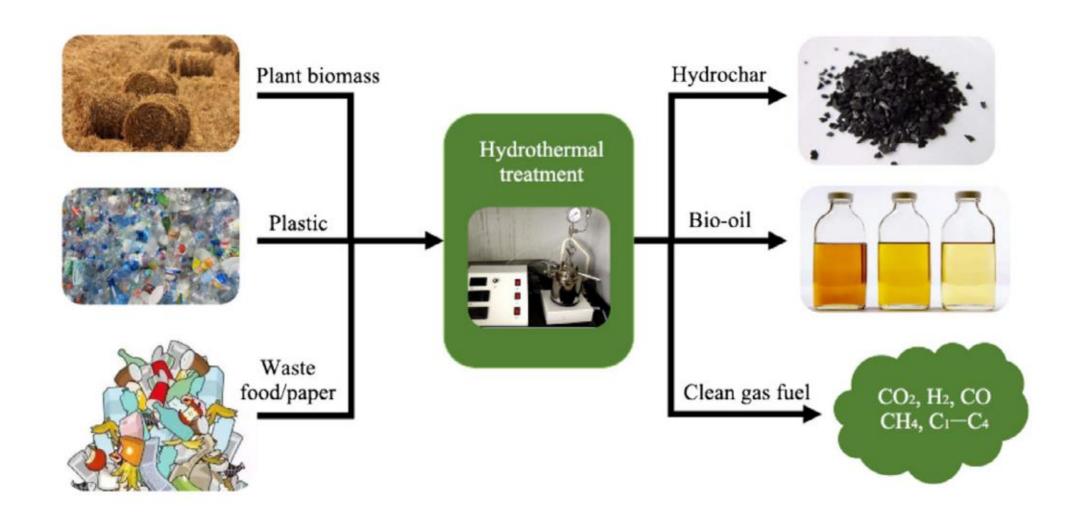
WASTE TO ENERGY



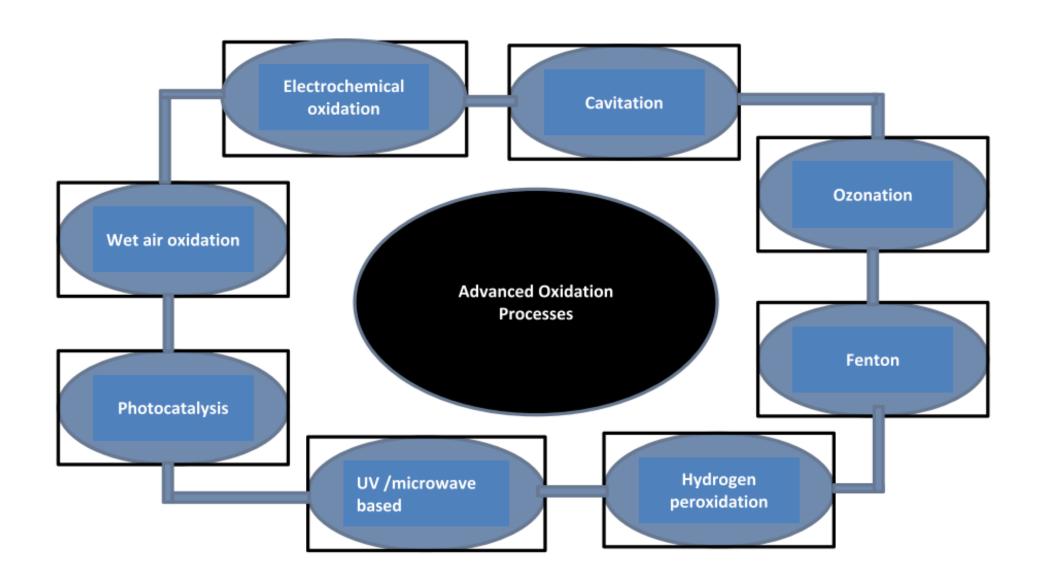
WASTE TO ENERGY – THERMAL



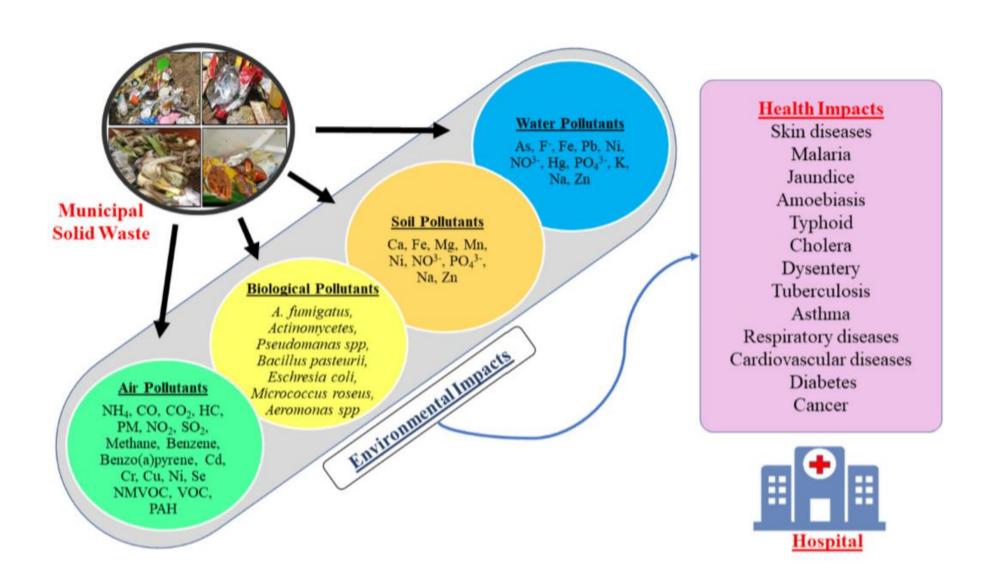
HYDROTHERMAL TREATMENT



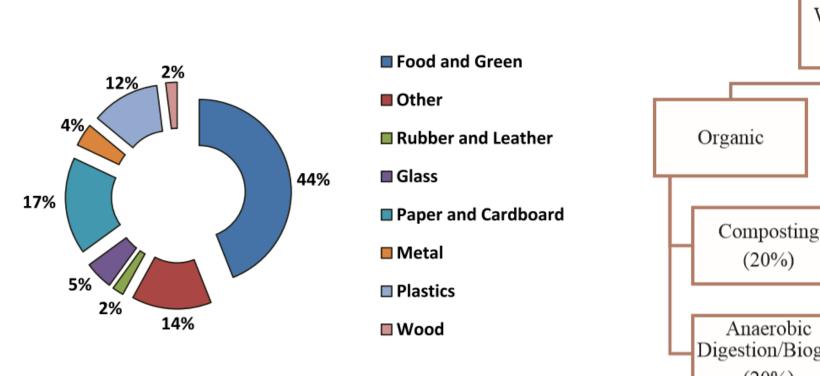
ADVANCED OXIDATION PROCESSES

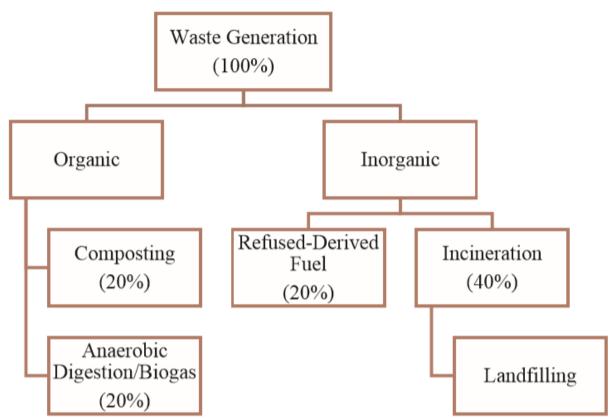


EXAMPLE – 1. MUNICIPAL SOLID WASTE



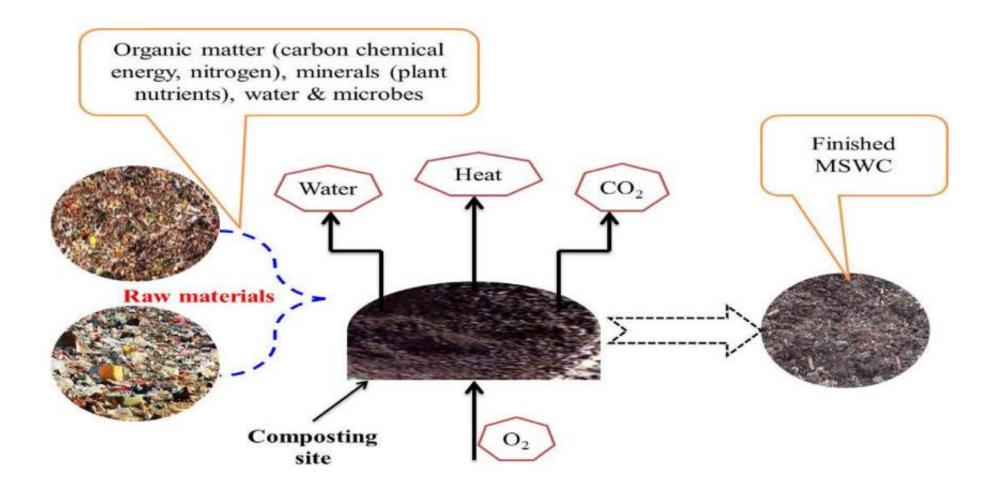
FRAMEWORK FOR INTEGRATED MSW MANAGEMENT



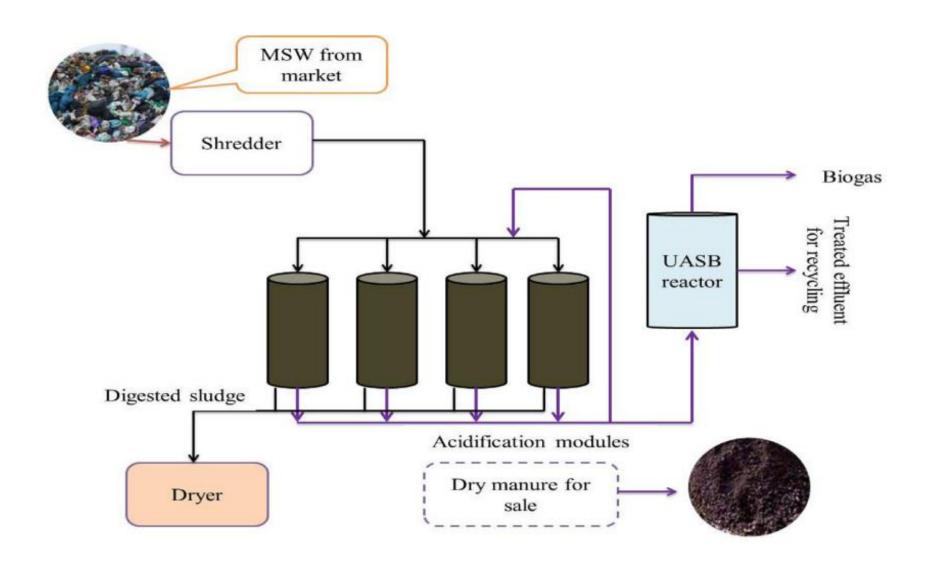


GLOBAL MSW COMPOSITION

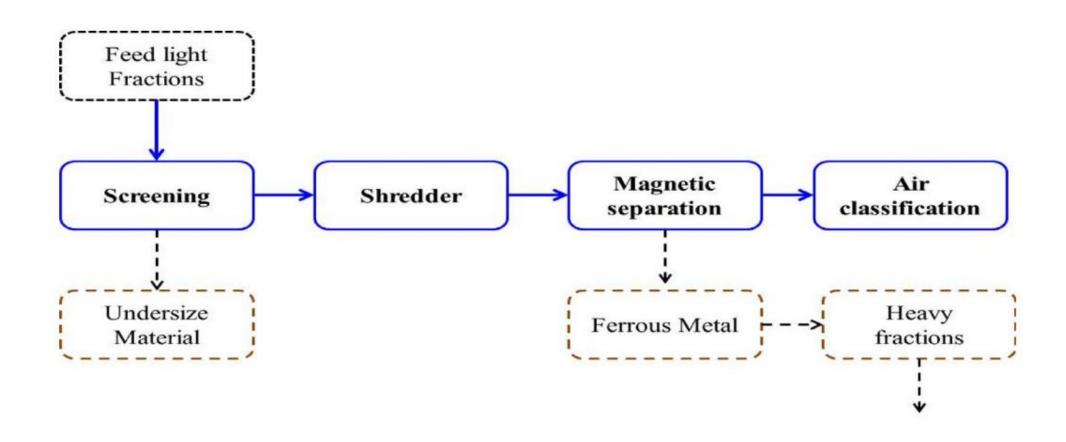
MUNICIPAL SOLID WASTE COMPOSTING

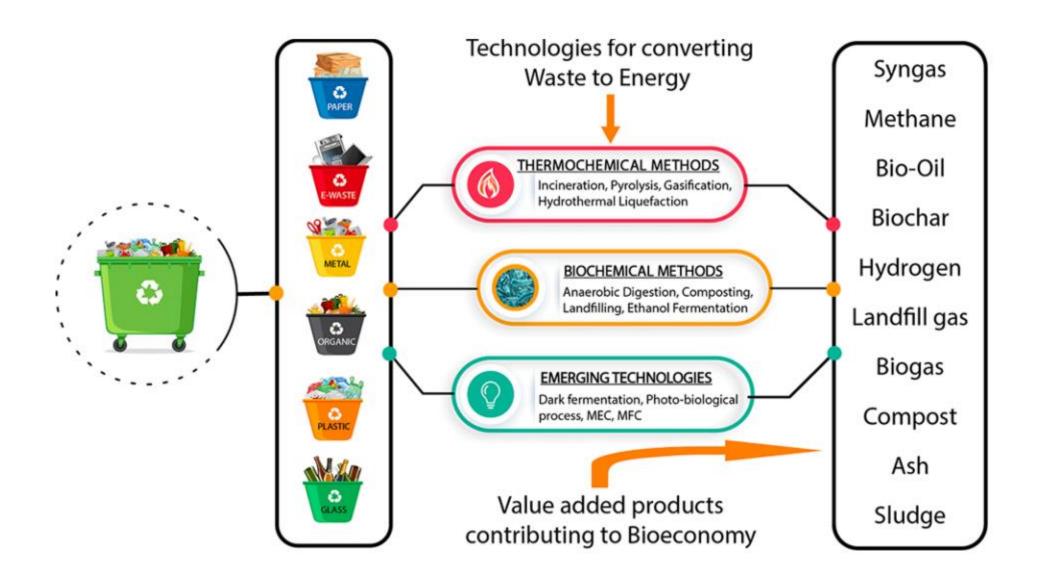


ANAEROBIC DIGESTION OF MSW

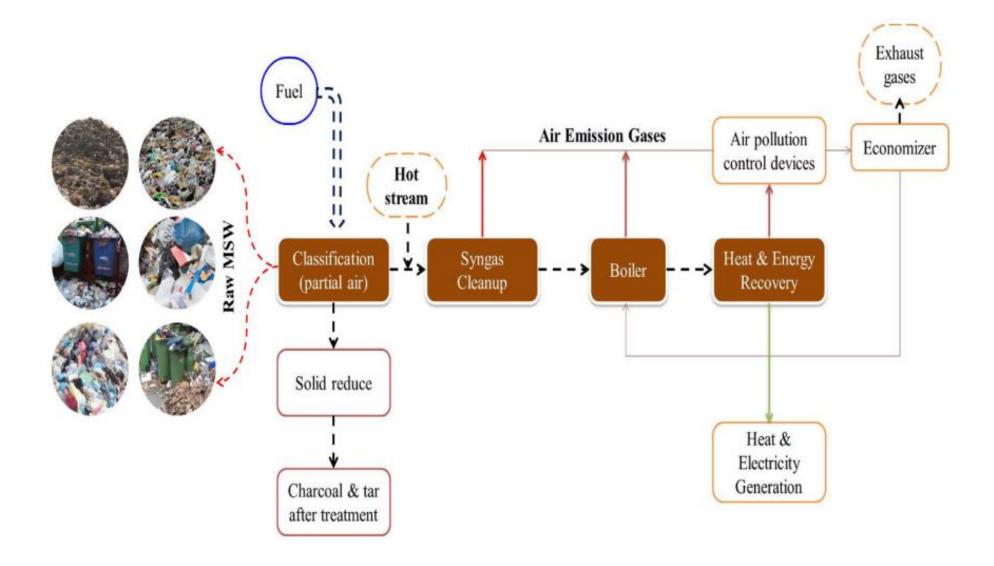


RESOURCE RECOVERY FROM MIXED SOLID WASTE

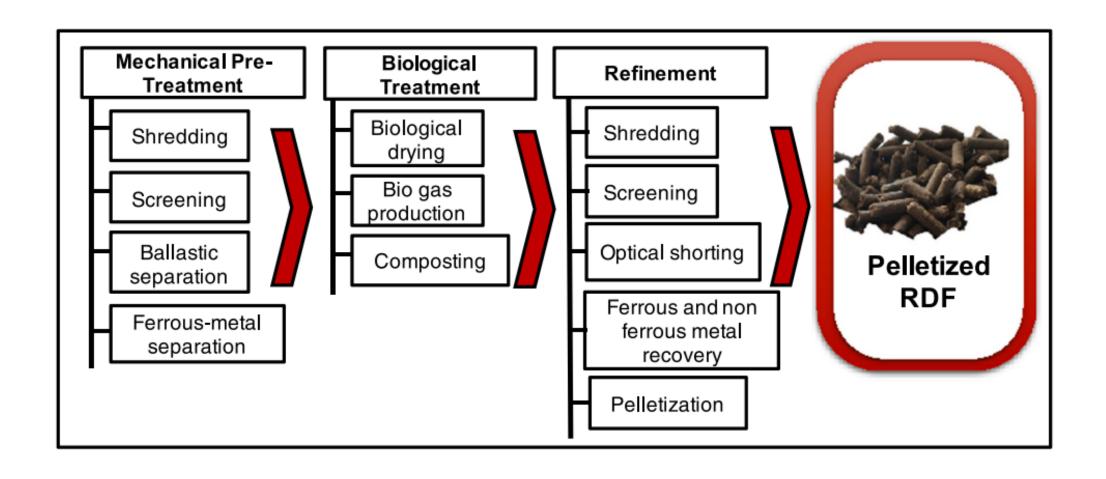




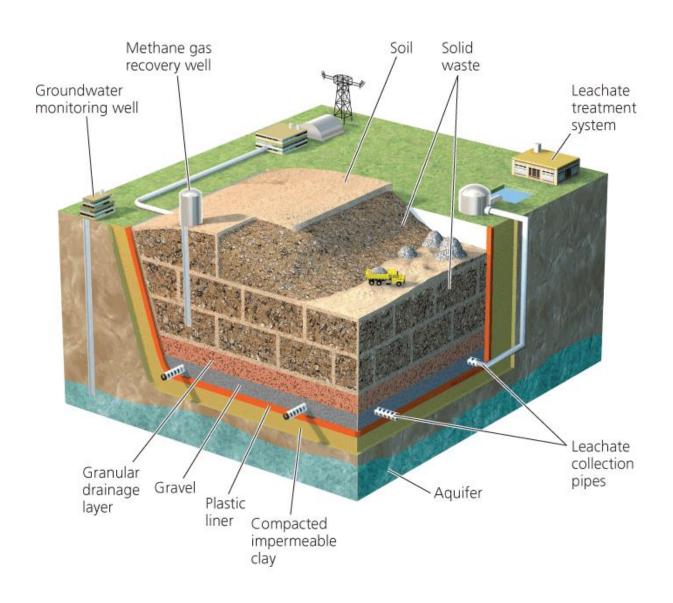
WASTE TO ENERGY FOR MSW DISPOSAL



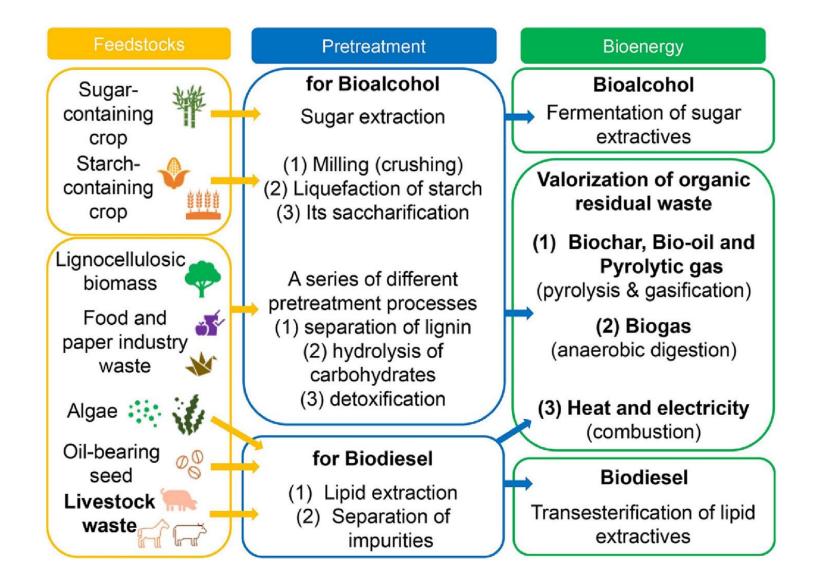
REFUSE-DERIVED FUEL OR SOLID-RECOVERED FUEL



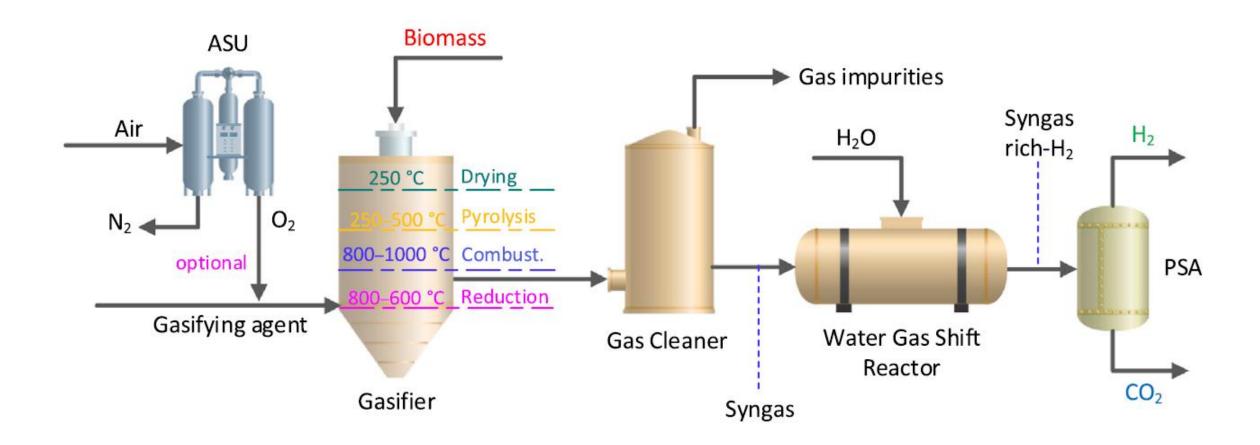
LANDFILLING



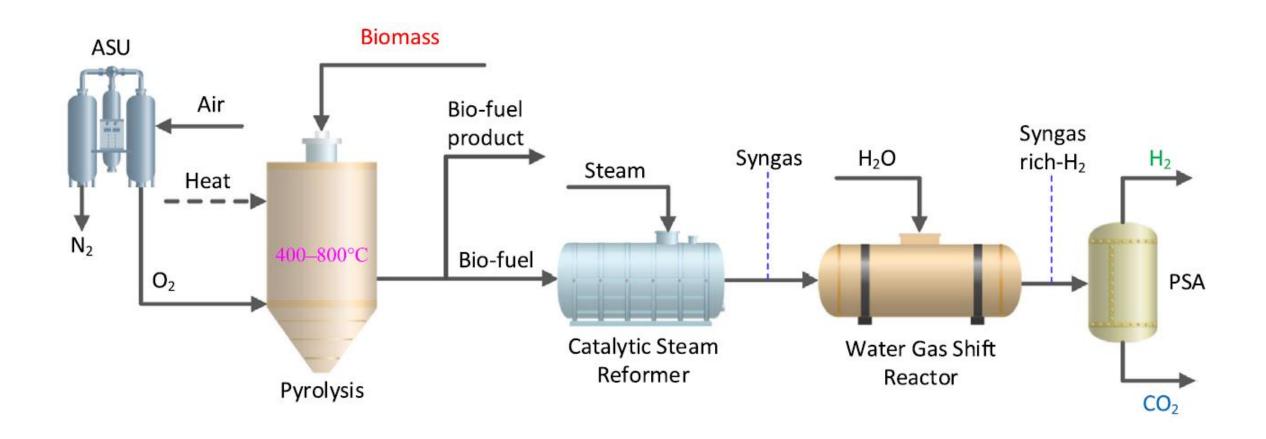
EXAMPLE – 2. BIOMASS



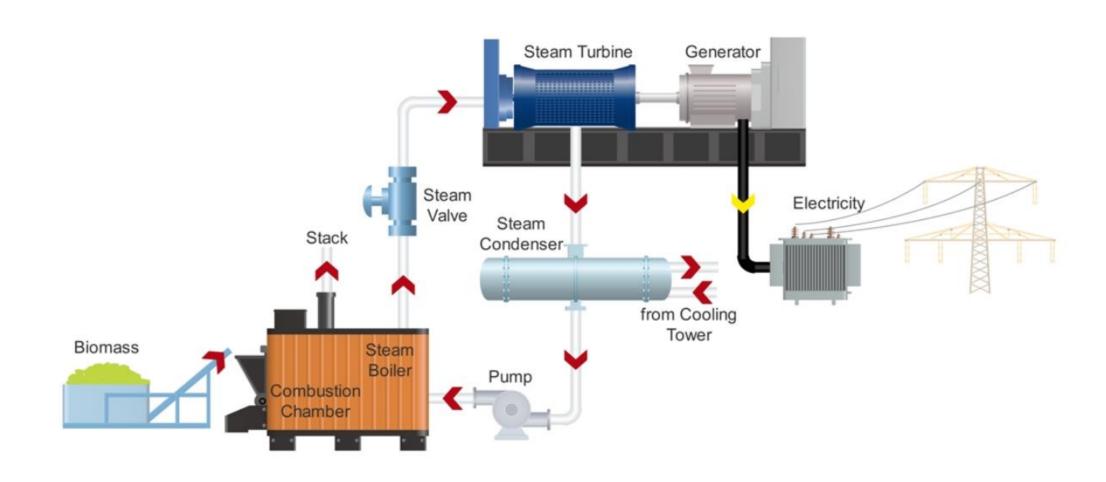
BIOMASS GASIFICATION



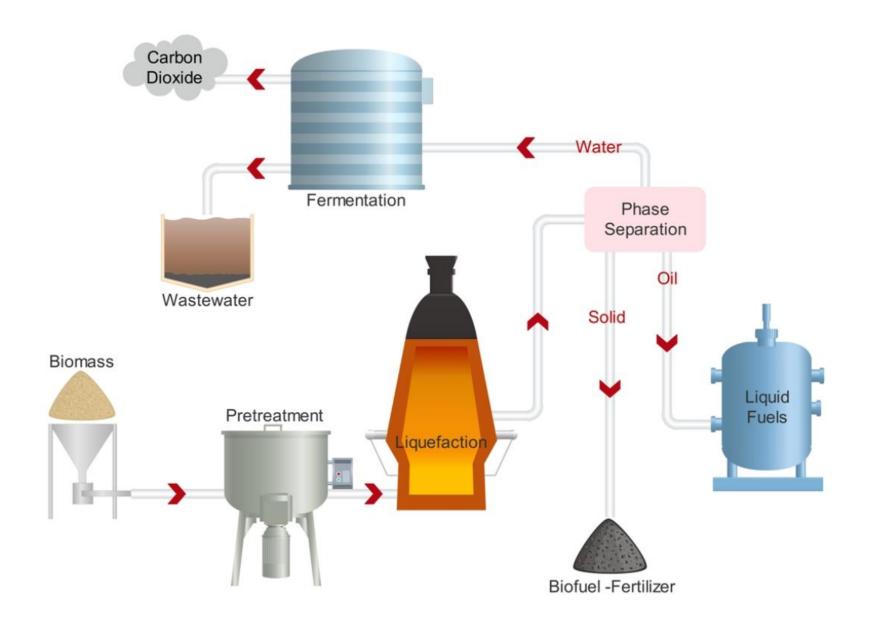
BIOMASS PYROLYSIS



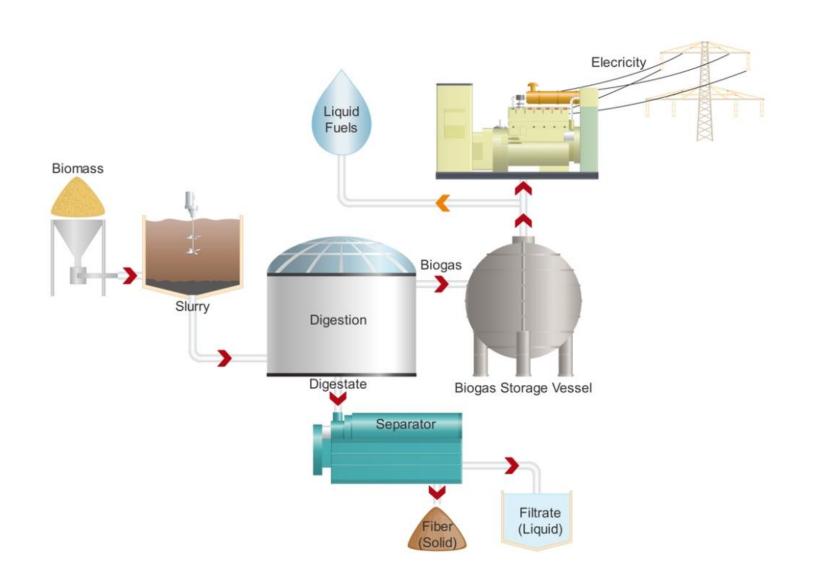
BIOMASS COMBUSTION



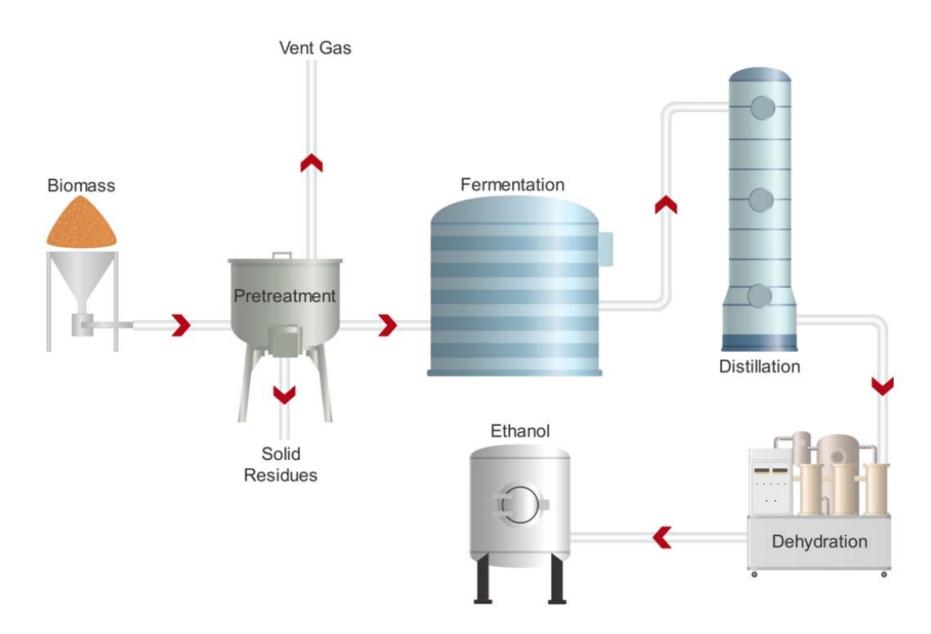
BIOMASS LIQUEFACTION



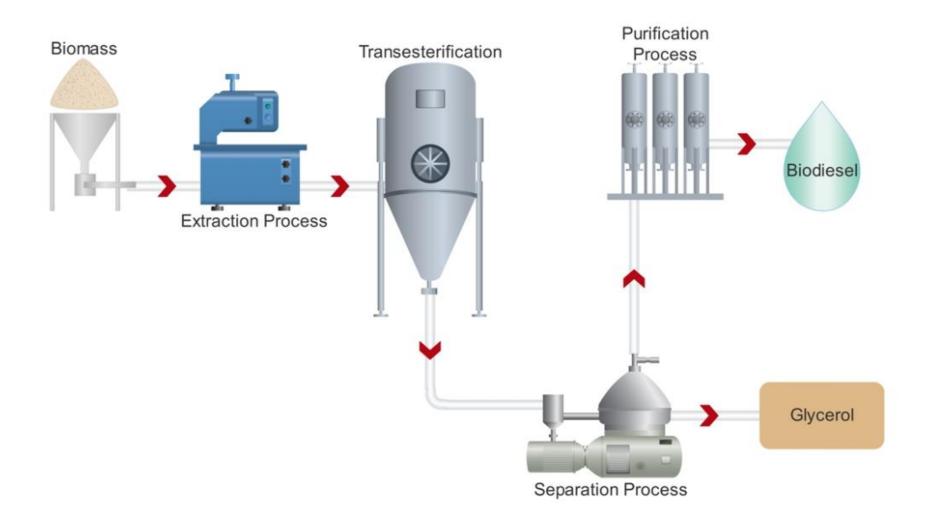
ANAEROBIC DIGESTION OF BIOMASS



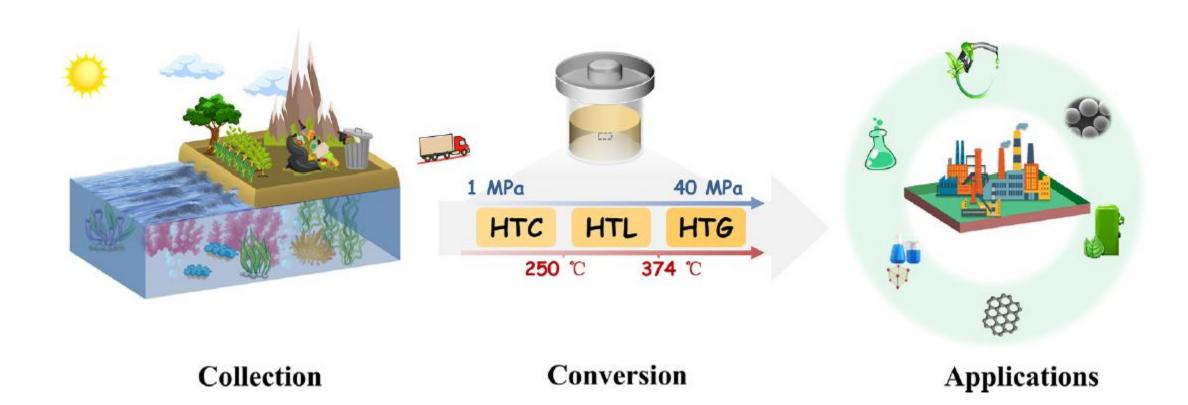
BIOMASS FERMENTATION



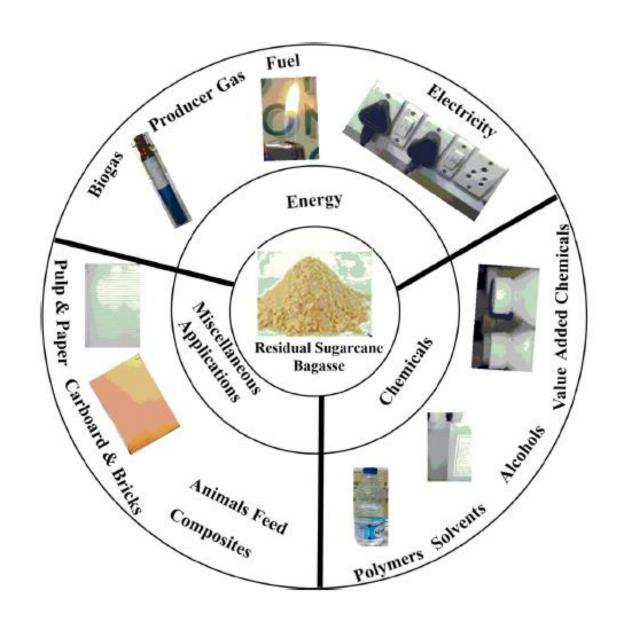
PHYSICO-CHEMICAL CONVERSION OF BIOMASS



HYDROTHERMAL CONVERSION OF BIOMASS



OPTIONS WITH SUGARCANE BAGASSE

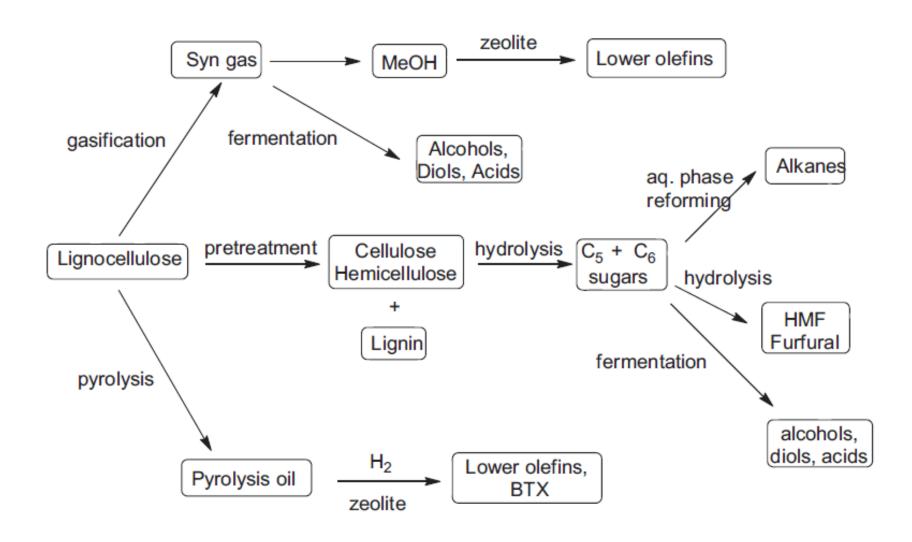


CHEMICALS FROM FOOD WASTE

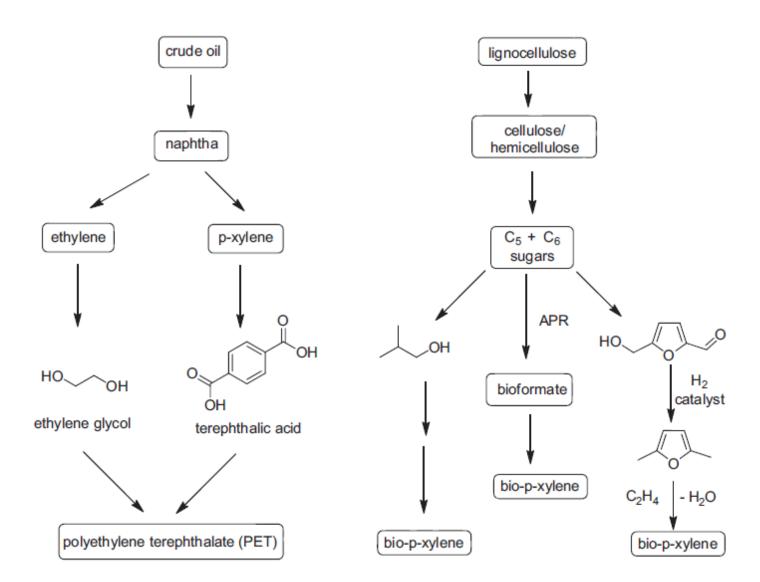
Antioxidant biomaterial hydrolysis extraction/ microwave distillation **Essential oil Biochemicals and** (limonene) nanoporous materials fermentation H₃C **Nutraceuticals** Enzyme

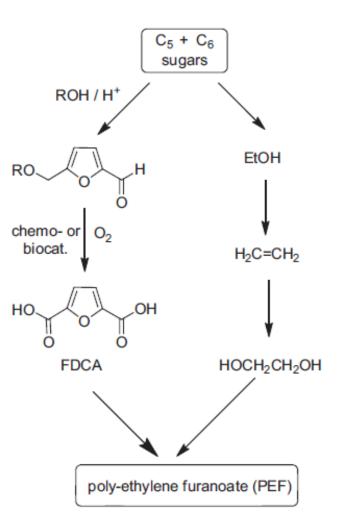
Solvent (ethanol)

CONVERSION OF LIGNOCELLULOSIC BIOMASS

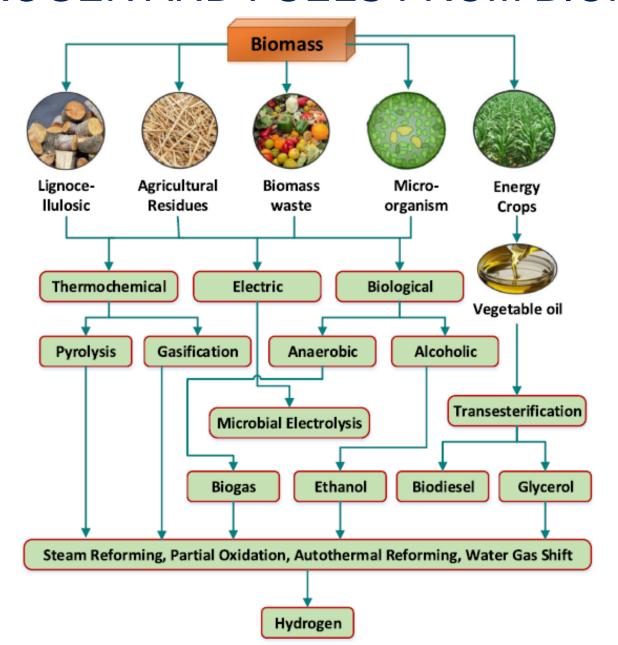


BIO-PET AND BIO-PEF

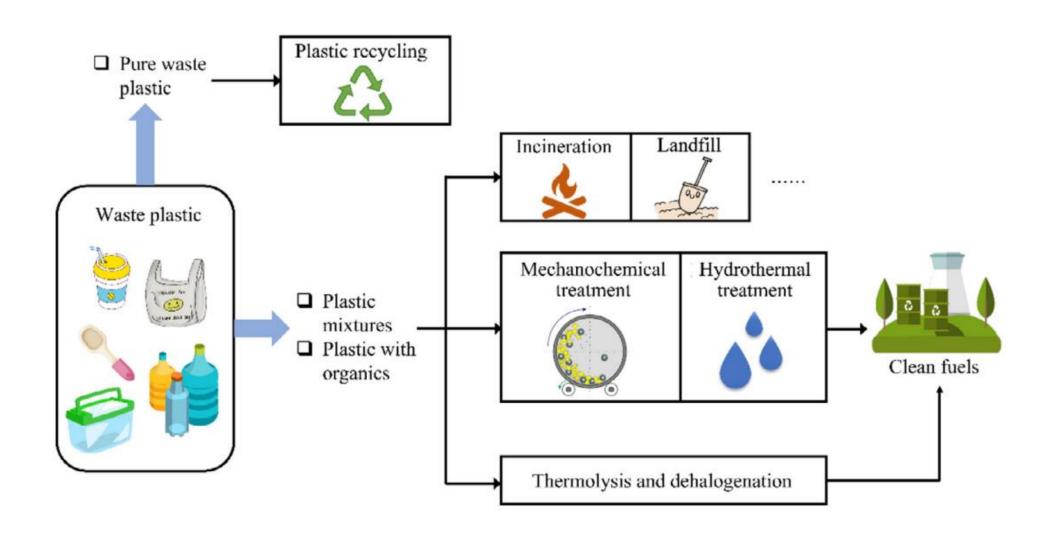


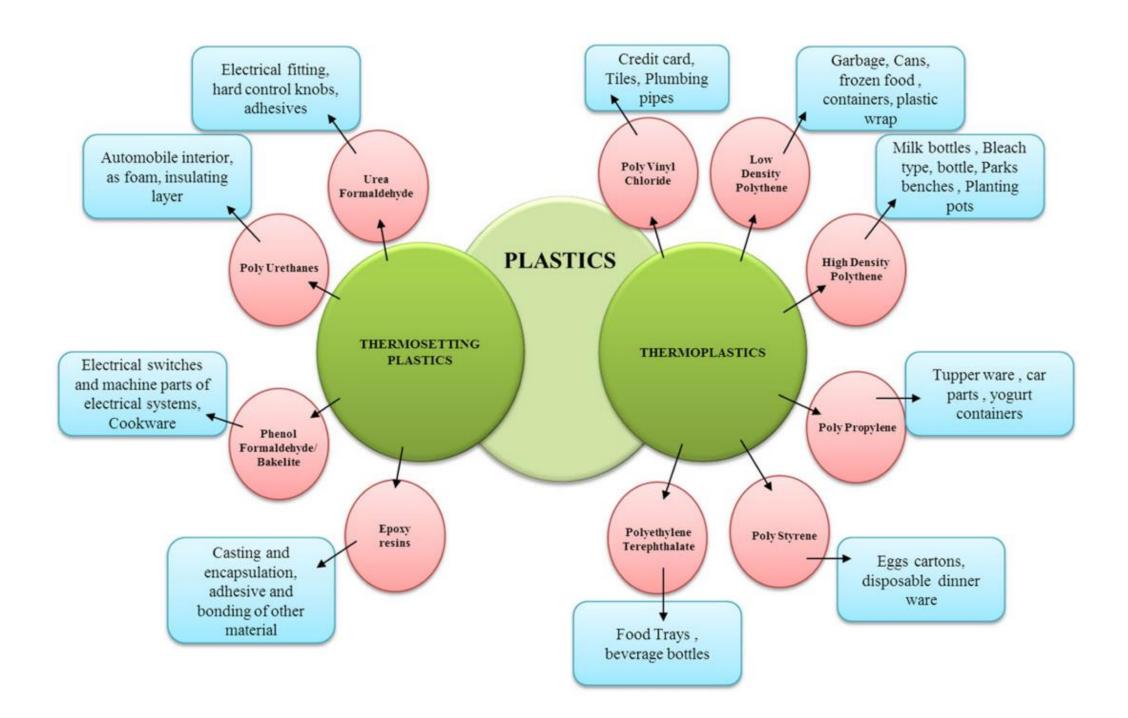


HYDROGEN AND FUELS FROM BIOMASS

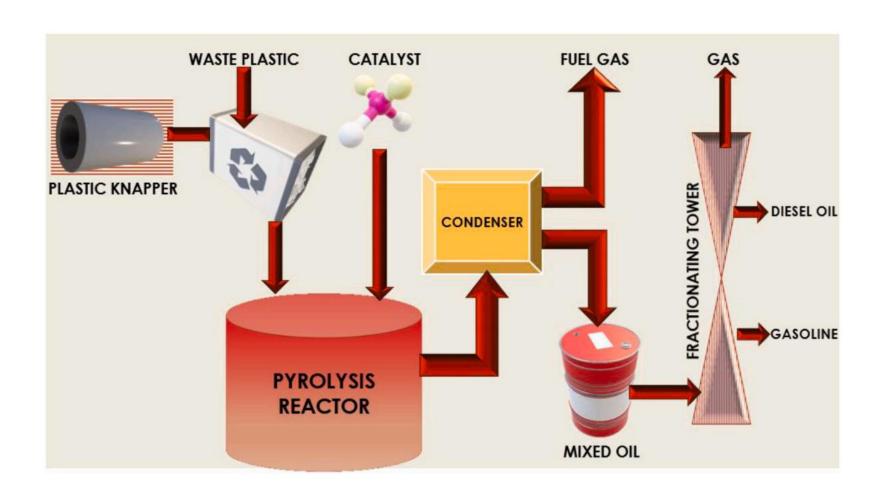


EXAMPLE – 3. PLASTIC WASTE

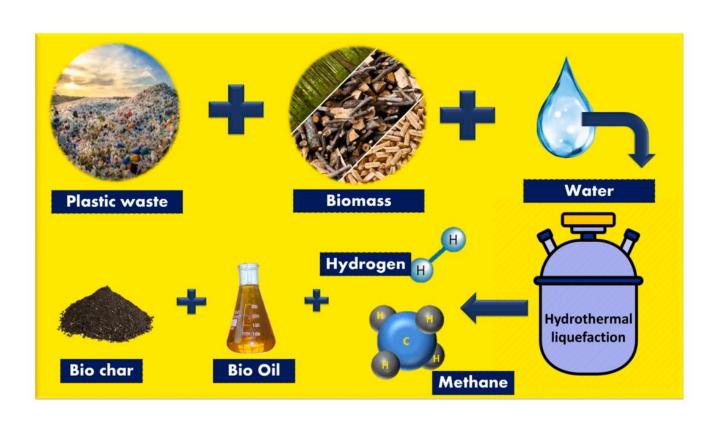


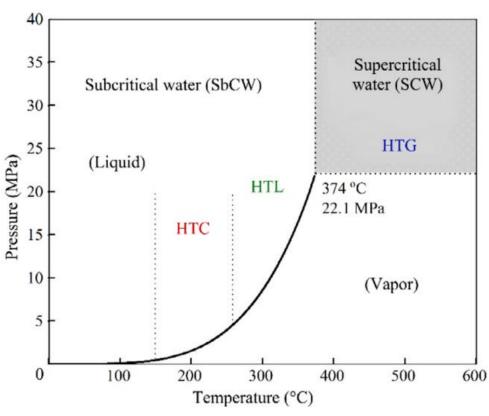


PYROLYSIS OF PLASTIC WASTE

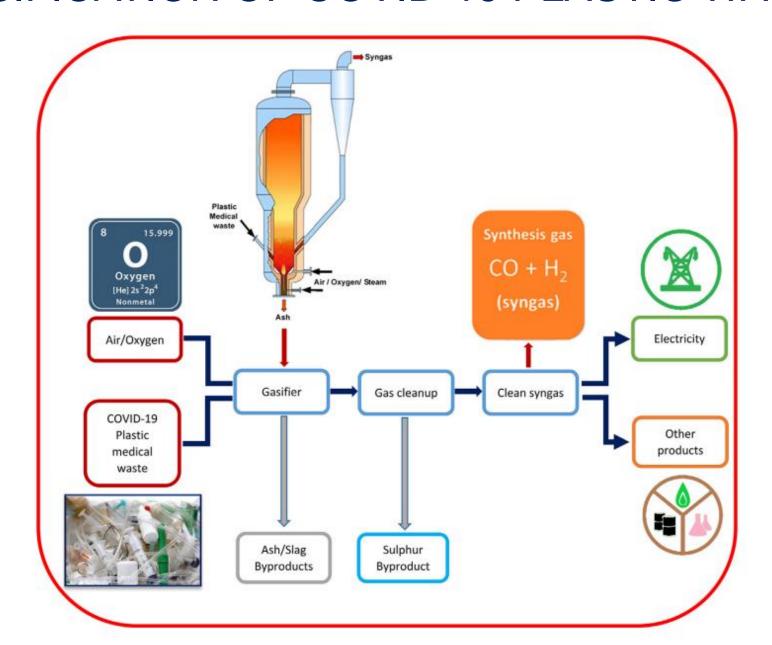


HYDROTHERMAL LIQUEFACTION OF PLASTIC WASTE

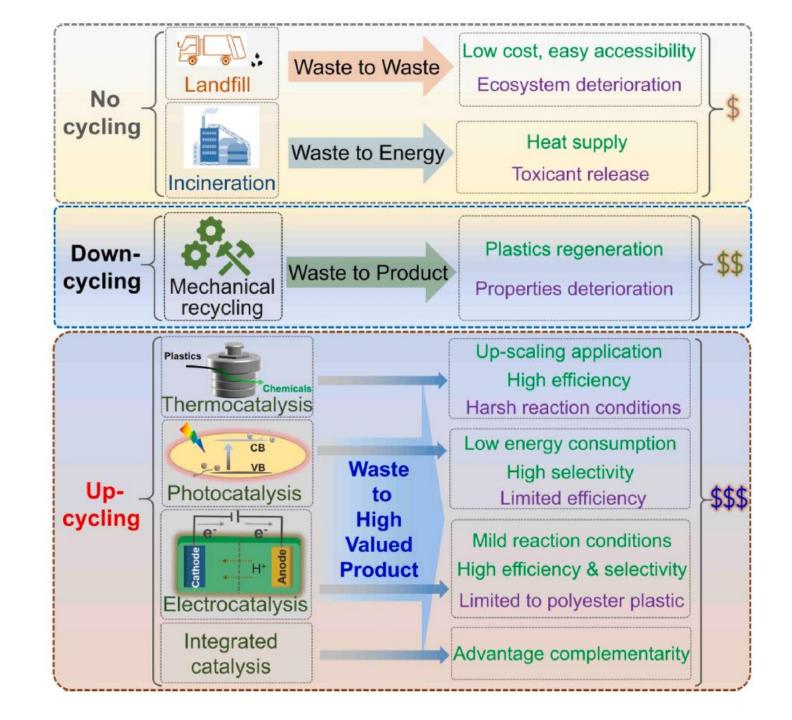




GASIFICATION OF COVID-19 PLASTIC WASTE

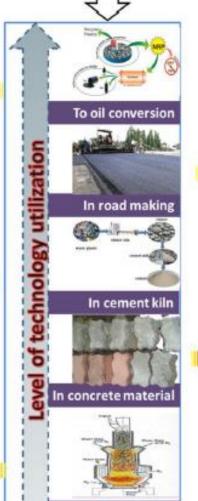


S



Advantages High energy efficiency, stability, high heating value Stable engine performance Production of by-products of various potential applications Reducing of unsaturated hydrocarbons Employing cheaper catalyst Design consideration in engine (optimum blend, delayed ignition, Higher heat release rate and increased Nox) Ensures complete destruction of waste Advantages No requirement of design modification, processing Thermal substitution rate of industry can be increased Waste collection and transportation senes strategy to the cement kiln Paying and buying options for user and producer ssues Advantages Can treat heterogeneous polymers with limited scope of pre-treatment Greater process flexibility

Emerging practices For plastic waste management



Gasification

Better binding between aggregates and bitumen

Resistance to deformation under extreme climate and water induced damage

Reduction in Gross phase separation under quiescent conditions

Lighter weight than competing products Improved reliability and sustainability Resistant to chemical, water and impact Excellent thermal and electrical insulation properties

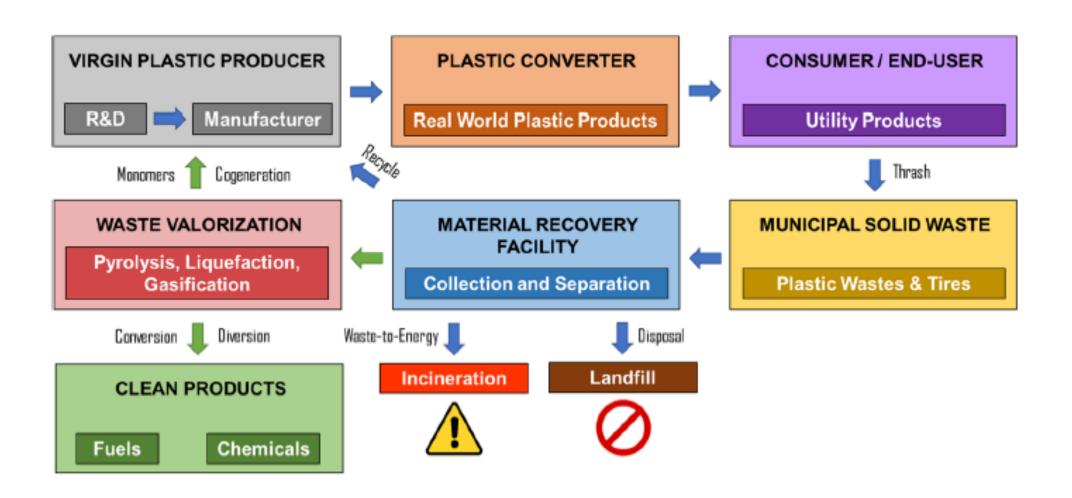
Lower manufacturing and shipping cost

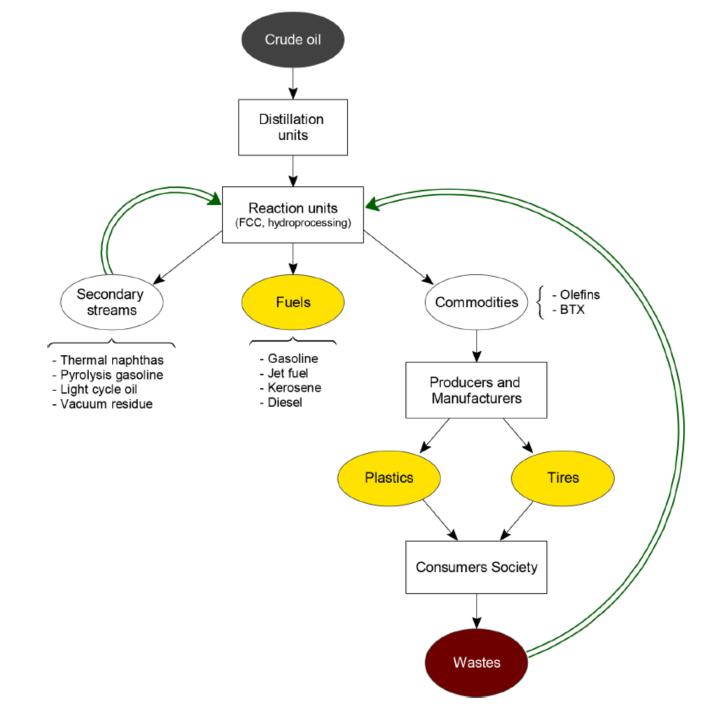
Workable Plastic proportion for optimum concrete quality

Boost durability, strength, fatigue

Development of appropriate equipment and product optimization

CIRCULAR ECONOMY FOR PLASTIC WASTE MANAGEMENT



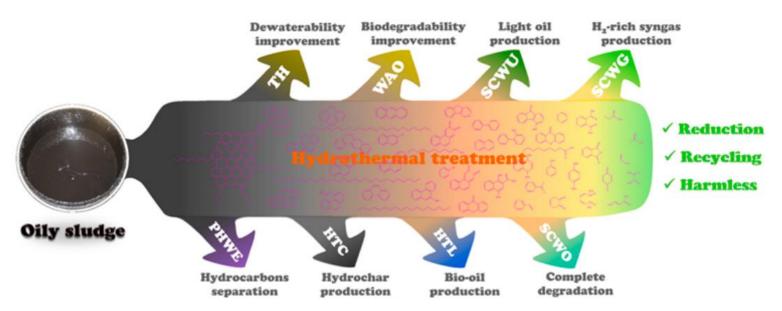


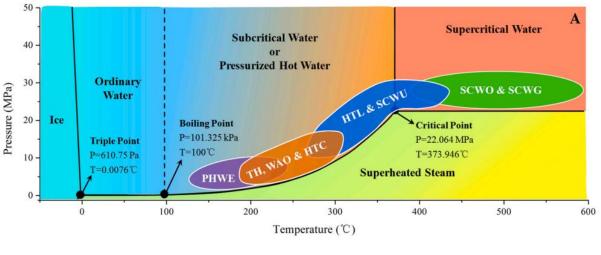
Ш SLUD Ш WAST 4. EXAMPL

Sludge Valorization

· Carbon resource Biodegradable plastics Resource recovery · Nitrogen and phosphorus recovery resource recovery Struvite CH, fuel · Gas pollutants removal · Liquid pollutants removal Sludge based including antibiotics. heavy metals, dyes, adsorbents phenolic compounds, fluoride Sludge based adsorbents · Wastewater treatment Bioflocculants · Heavy metal removal · Pulp effluent treatment Bioflocculants Sludge Sludge brick manufacturing Sludge cement construction · Sludge ceramsite Sludge brick Sludge ceramsite materials Sludge cement · Accelerating plant growth · Improving moisture Crop fertilizer Sludge retention Vegetable Fertilizer · Increasing organic matter composting in the soil Sludge · Improving erosion control composting Flower fertilizer Turf fertilizer Incineration Thermal Pyrolysis valorization Gasification Gas fuels

HYDROTHERMAL CONVERSION OF OILY SLUDGE

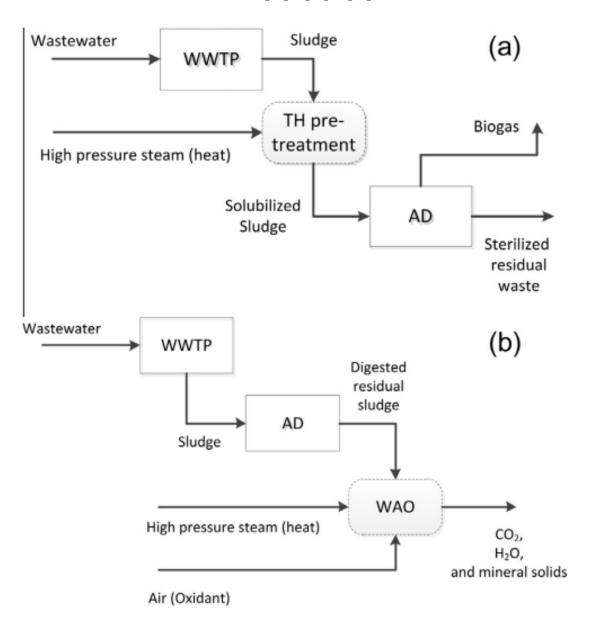




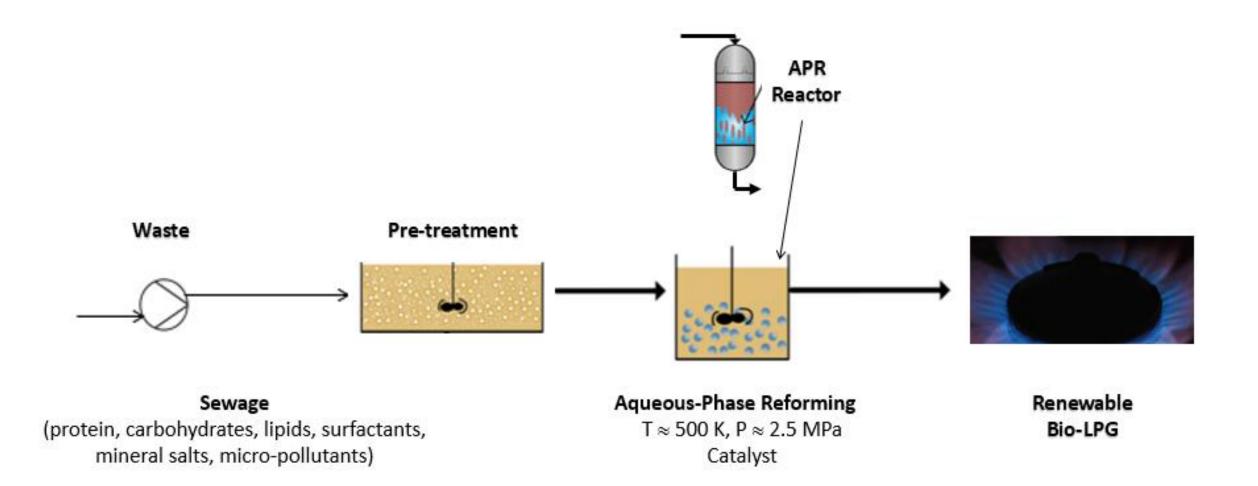
50MPa

5MPa

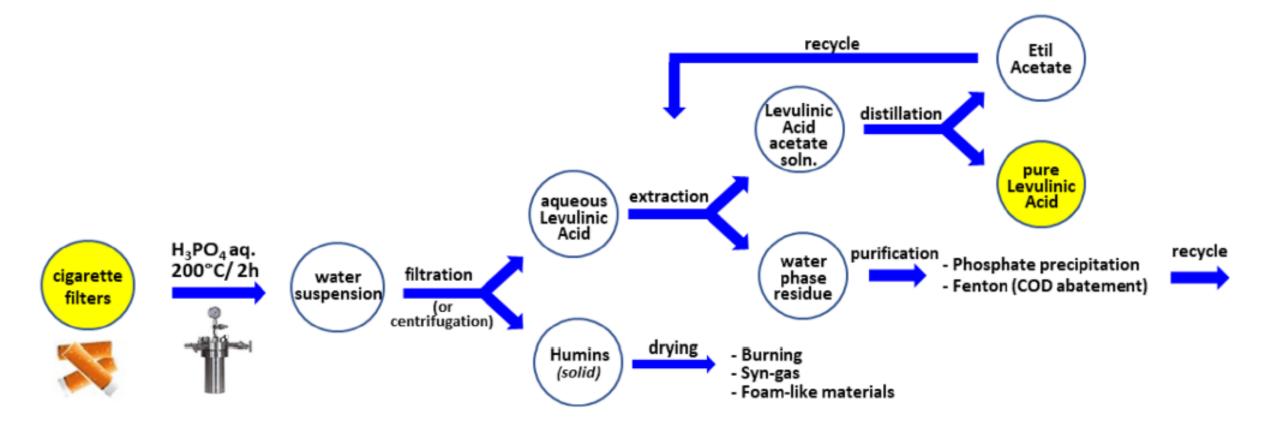
THERMAL HYDROLYSIS / WET OXIDATION OF SLUDGE IN WWTP



AQUEOUS-PHASE REFORMING OF SEWAGE SLUDGE

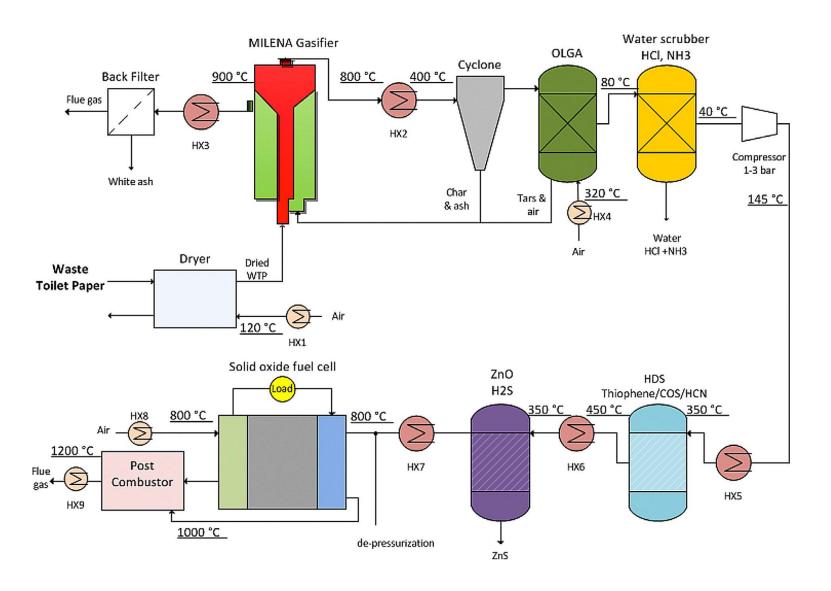


EXAMPLE – 5. MUNICIPAL PAPER WASTE



https://doi.org/10.1038/s41598-021-95361-4

EXAMPLE – 6. WASTE TOILET PAPER



THANK YOU