Thermal Treatment

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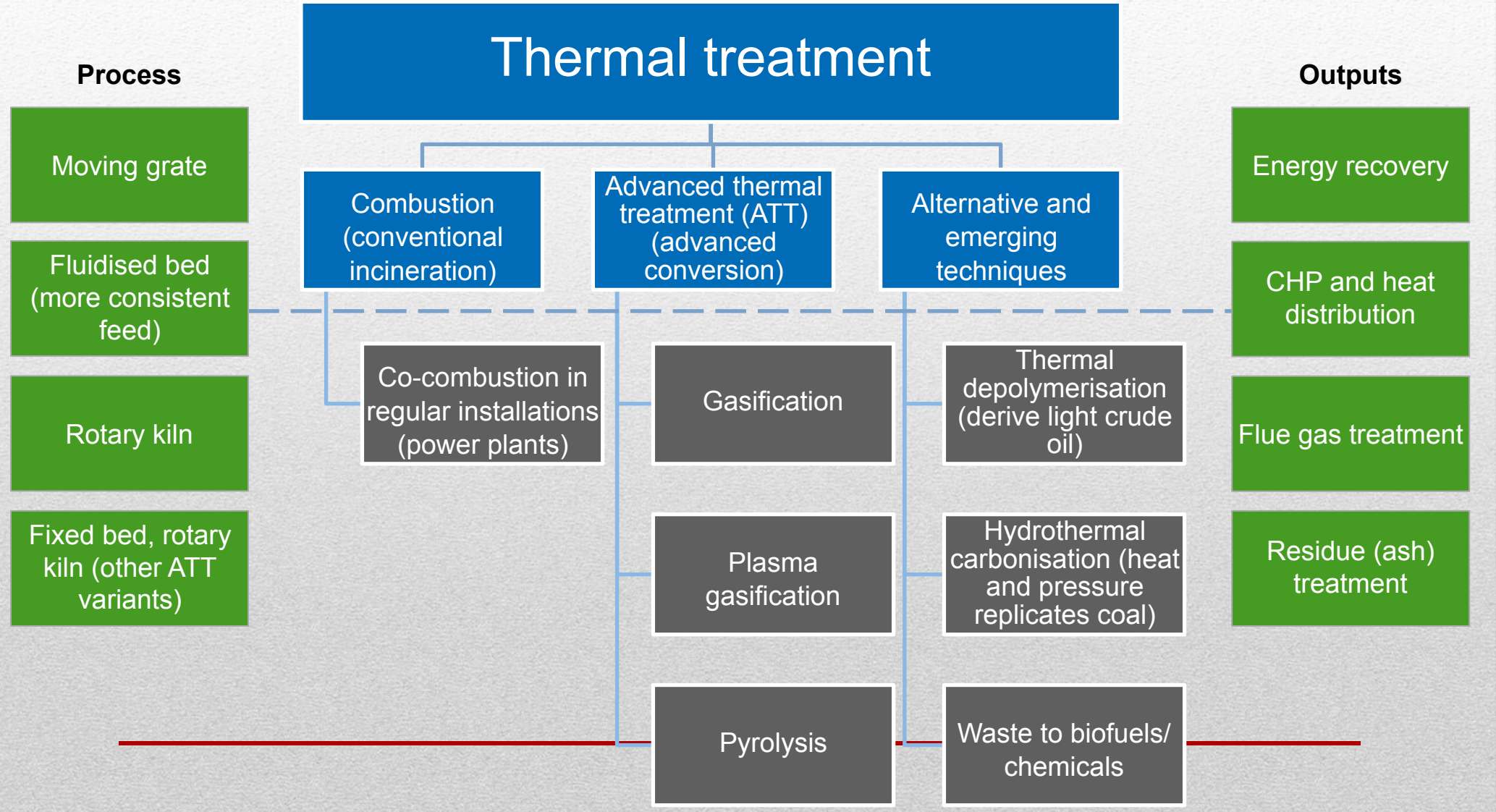
Introduction: Thermal treatment

- Technologies using high temperatures to treat waste (or RDF)
- Commonly involves thermal combustion (oxidation)
  - Reduces waste to ash (MSW c. 30% of input)
  - Facilitates energy recovery as electricity and heat
- Alternative advanced ‘conversion’ technologies (ACT)
  - Advanced thermal treatment (ATT)
  - Most common gasification (limited O_2) and pyrolysis (no O_2)
  - Convert waste into intermediate products (fuels, chemicals)

Thermal Treatment Technologies



Thermal Treatment: Combustion

- Combustion (incineration) – burning waste to recover energy

Combustion in a furnace at high temperatures (European Directive 850°C for at least 2 seconds)

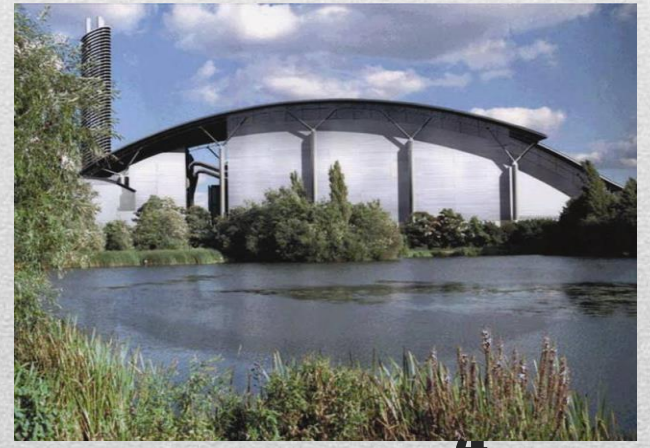
Energy in waste converted to heat (hot gases)

Gases pass to a boiler (option integrated furnace-boiler)

Heat transferred into hot water to produce superheated steam

Steam generates electricity via a turbine

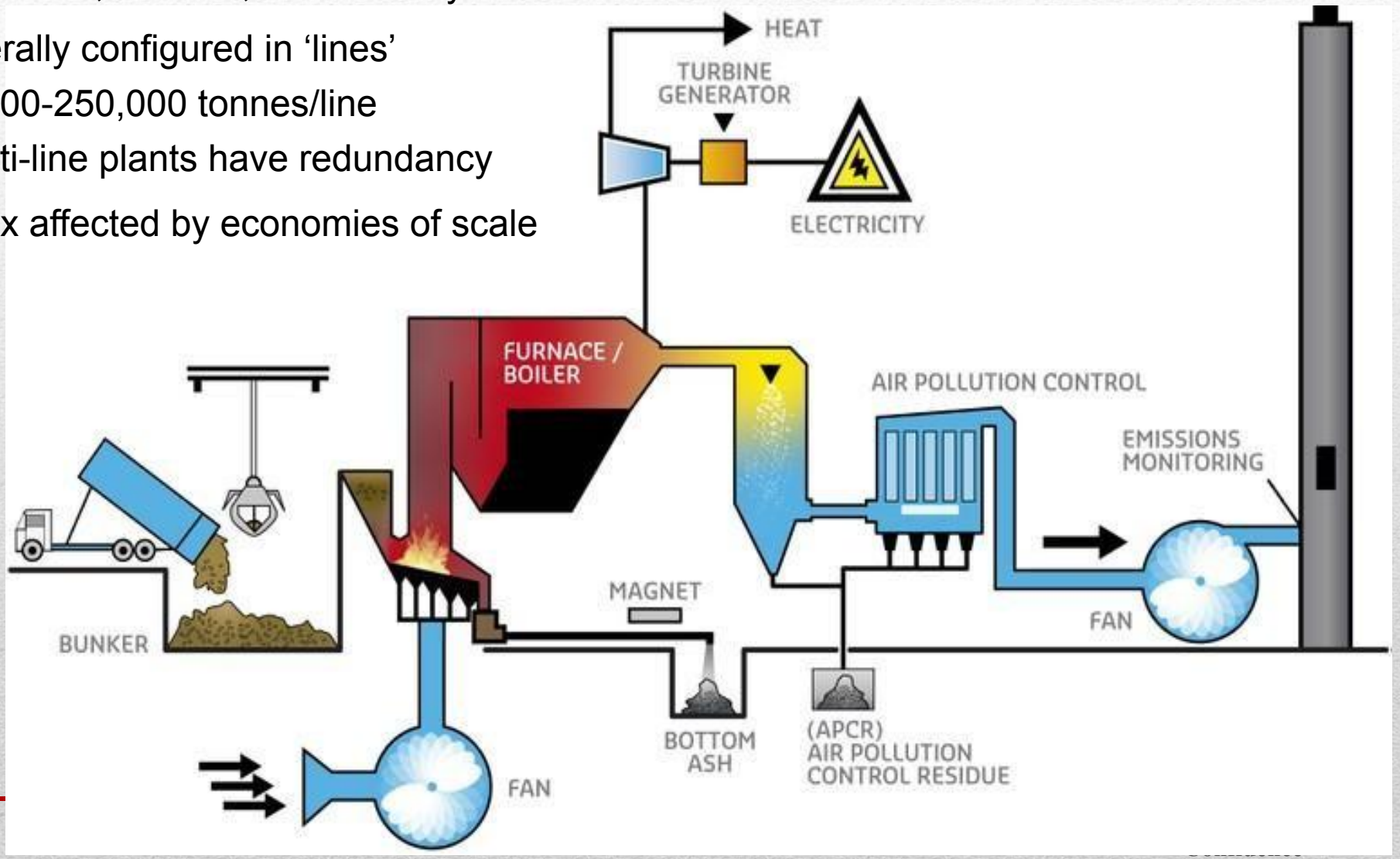
Heat recovered in CHP (Combined Heat and Power) mode



- Outputs
  - Bottom ash – commonly recovered (metals & aggregate)
  - Air pollution control residues – landfilled (hazardous)
- Co-combustion (power plant) as secondary fuel
  - ✓ Economic and carbon savings
  - ✗ Incineration Directive compliance

Direct Combustion – Schematic

- Scale c. 50,000-750,000 tonnes/year
- Generally configured in ‘lines’
  - c. 200-250,000 tonnes/line
  - Multi-line plants have redundancy
- Capex affected by economies of scale



Combustion – Advantages and Disadvantages

Advantages

- Renewable energy
- Established, mature, reliable
- Widely deployed
- Fully enclosed
- Significant experience on wide range of feedstocks
- Process multiple fuels
- Tolerant of fluctuations in fuel quality and composition
- Destroy biodegradable content
- Reduce volume 70-95%
- Potential high efficiency CHP (50-60%)
- Option for cooling (CHP plus absorption chiller) = CCHP

Disadvantages

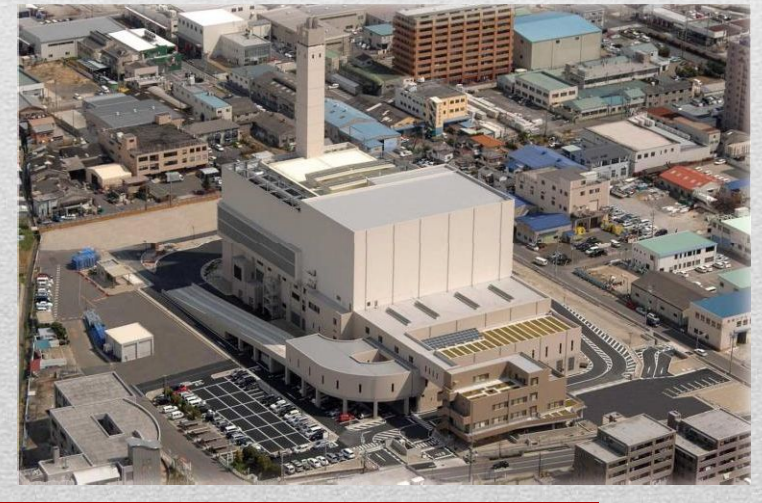
- May limit recycling initiatives
- Feedstock security
- Requires sophisticated gas cleaning, monitoring, control (high Capex)
- APCr is hazardous waste
- Electrical efficiency c. 20-30%
- Poor public image & acceptance
- Potential political and planning challenge
- Heat customers need to be close

Advanced Thermal Treatment

Treatment	*Oxygen Level*	*Energy Form*
Energy from Waste (Incineration)	Excess of Oxygen	Heat, Electricity
(Incineration)	Oxygen	y
Gasification	Limited Oxygen	Gas, Char
n	Oxyge	
Pyrolysis	Absence of Oxygen	Gas, Char, Liquid (Oil)
s	Oxygen	Char,

Thermal Treatment: Gasification

- Partial oxidation (combustion) in low oxygen atmosphere
  - O_2 lower than required to combust
- Successful schemes often use homogeneous wastes
- Waste reacts chemically
  - Degrades into chemical compounds
  - Forms synthesis gas ('syngas')
  - Mixture of CO_2, H, CO, CH_4, and steam
- Syngas leaving the reactor chamber can be:
  - Combusted immediately
  - Quenched & cleaned for fuel gas for power generation
- Syngas can be used in higher efficiency generating plant
  - e.g. gas engines or gas turbines
  - Gas must be good enough quality
  - Gas cleaning likely to be required
  - Technical challenge to maintain engines

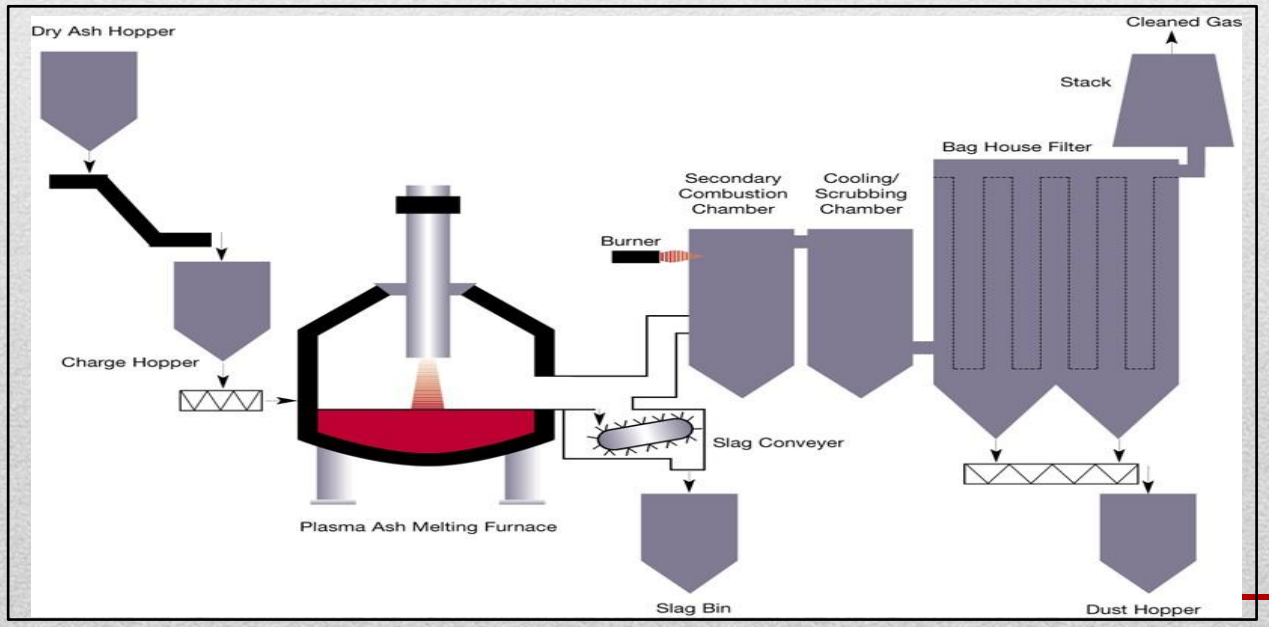


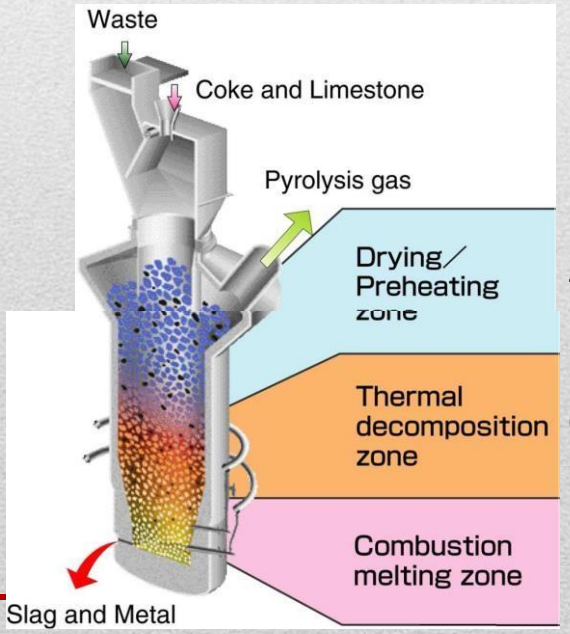
- In principal may be lower air emissions than conventional WtE

Thermal Treatment: Gasification

- Many variants, core variants include:

Plasma gasification	**2-stage gasification**	**Direct melting systems**
Very high temperature	1 gasification – 2 combustion	No pre-treatment, range of waste
Cleaner syngas	Require pre-treatment	Coke and limestone addition
Energy intensive	Efficiency < conventional WtE	Energy intensive
Limited references	Some references	Many references (Japan)





Gasification – Advantages and Disadvantages

Advantages

- Allows use of efficient power generating technologies (reciprocating engines and gas turbines)
- Low NOx & SOx emissions due to process occurring in a low oxygen environment
- Better volume reduction than combustion or pyrolysis
- Variants vitrify heavy metals in 'inert' slag
- Seen as advanced alternative to incineration – more acceptance
- May realise lower emissions
- Some variants treat wide range of waste

- Significant technical residual risk in gas cleaning for power production
- Limited feedstock variability (depends on variant)
- Some limitations on type and mix of feedstock to ensure syngas has high CV
- Limited experience operating gasifiers with MSW
- Reciprocating engines and gas turbines very sensitive to syngas contaminants
- High profile project failures may impact financial backing
- Higher Capex than conventional WtE tonne-for-tonne

Disadvantages

Thermal Treatment: Pyrolysis

- Thermal degradation in absence of oxygen
  - Organics and some inorganics (e.g. tyres)
  - Can accept liquid fuels
  - Mature for fossil fuels but limited for waste fuel
  - Successes primarily tyres and woodchip
- Pyrolysis converts feedstock into three outputs:
  - Fuel gas (syngas)
  - Char (or biochar)
  - Liquid fuel (pyrolysis oil or bio-oil)
  - Fast (flash) or slow variants define products
    - Flash can derive speciality chemicals
  - Plasma pyrolysis converts high CV waste (plastics) to diesel
    - Reverses plastic production process – challenging
    - Gases – condensed to distillate – refined to diesel
  - Syngas can use higher efficiency generating plant
    - Proportion of feedstock energy content fuels the process

Advanced Thermal Treatment: Outputs and Applications