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# An Evaluation of Sludge-to-Energy Recovery Methods

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# Outline

- Overview
- Pre-Processing
- Anaerobic Digestion
- Combustion
- Pyrolysis
- Gasification
- Conclusion

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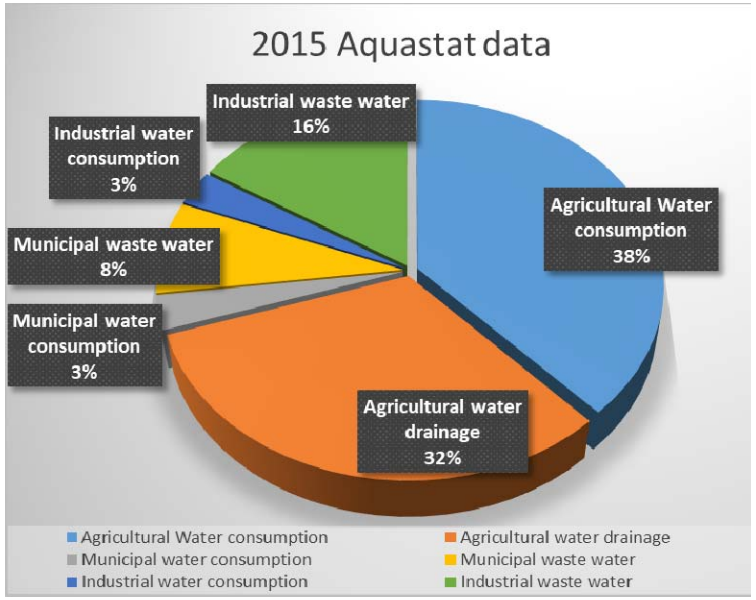
# Sewage Sludge…. Waste or Resource?

# What is Sewage Sludge

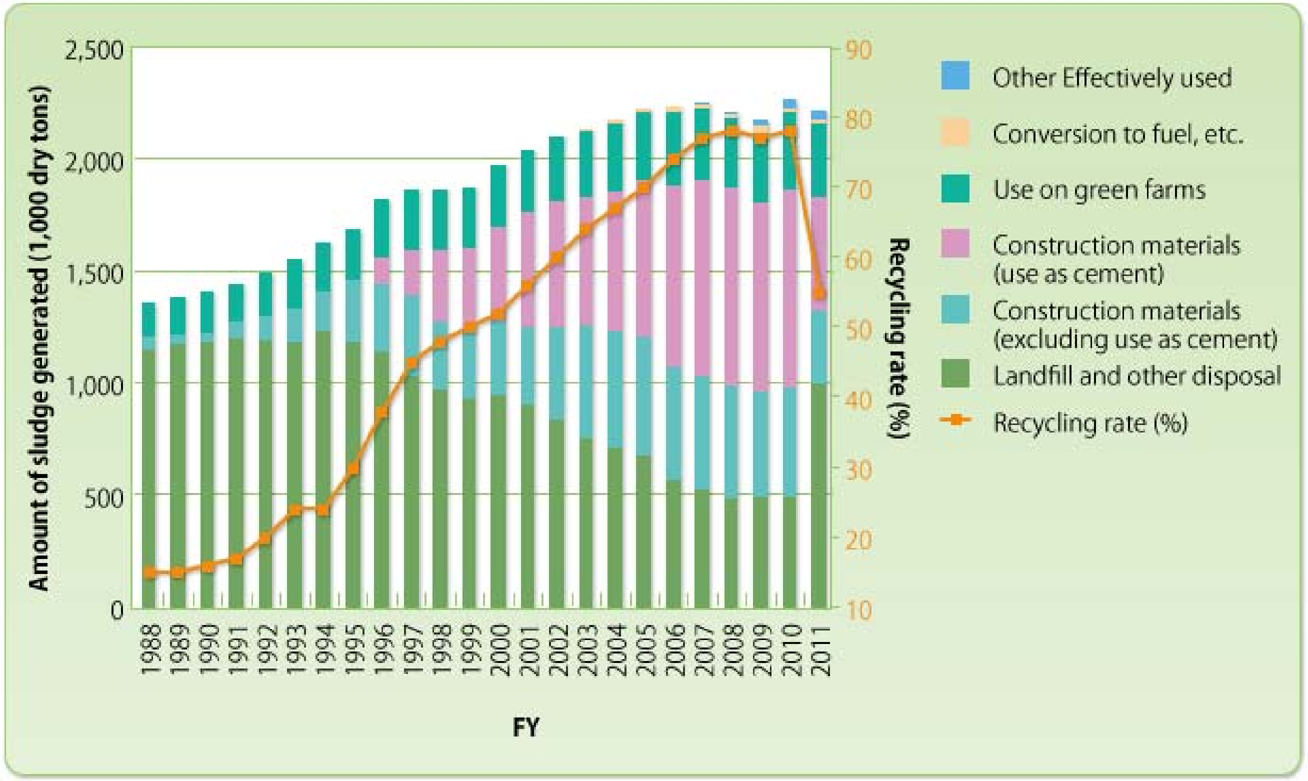



Global water use

Waste Water treatment Facility

Sewage Sludge

# Sewage Sludge Use




**Treated Sludge can be used for various agricultural, construction or energy applications. However, landfilling and incineration remains prominent.**

# Why Sludge – to - Energy

## So, What are the drawbacks to “sewage sludge“ present use?

- Growing waste management issues
- Hindering policies and regulations for carbon disposals
- Increasing price of disposal
- Wastage of potential resource
- Pollutants considerations

Landfill or Buried dumping

Incineration

Dumping into Water bodies

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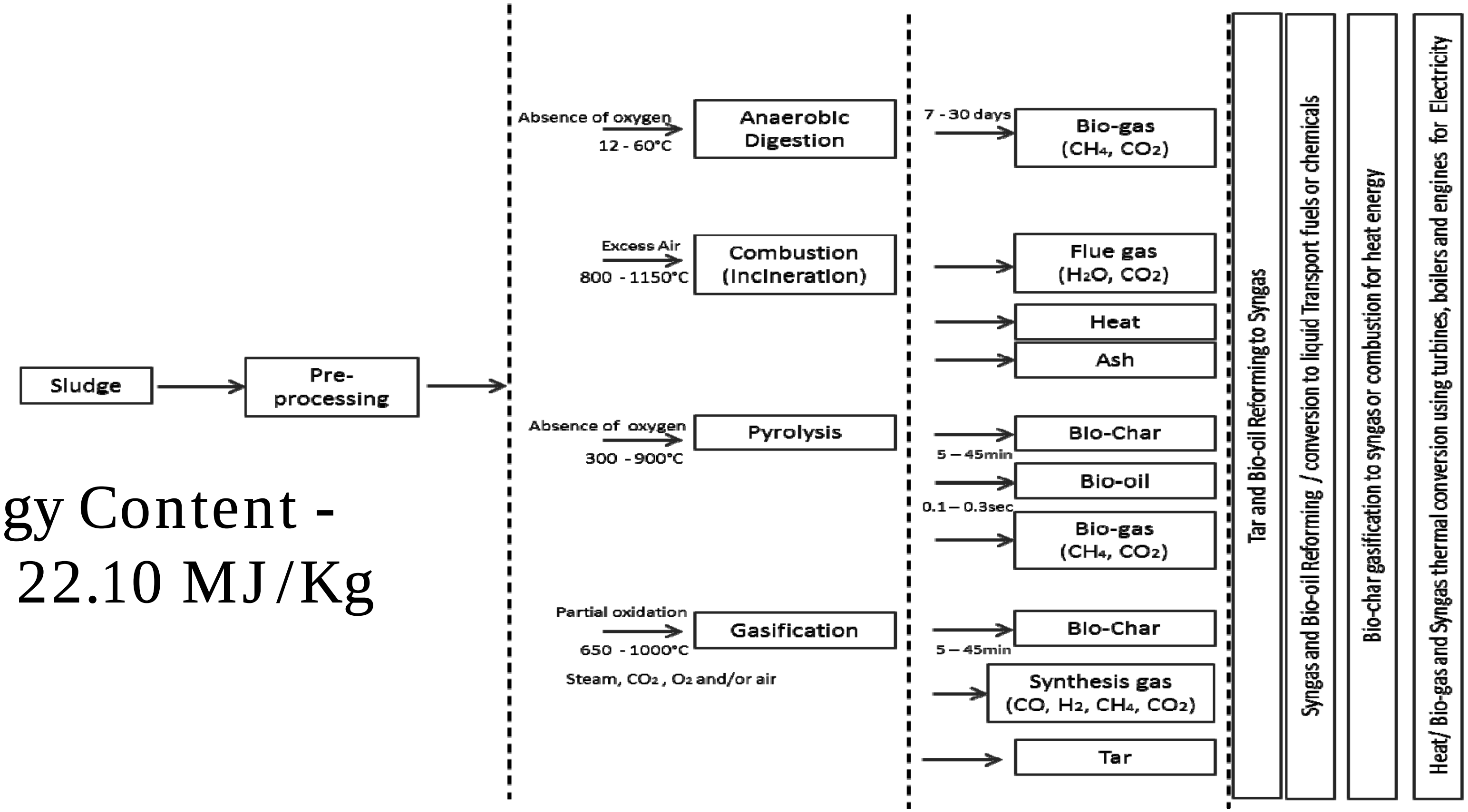
# Energy Recovery from Sludge

# Sludge - to - Energy Recovery Methodss




Energy Content -
11.10 – 22.10 MJ/Kg

First principle of circular economy: “Waste is either a resource, food, energy *or money*……
“*zero* waste and pollution”

# Pre-Processing of Sludge

## Sludge thickening, dewatering and drying process

Sludge Thickening – similar to sedimentary tanks for increasing solid contents by removal of some liquid fraction

Sludge Dewatering – Use of mechanical or chemical assisted system to reduce water content

Sludge Drying – Use of thermal treatment to obtain granular sludge that can be easily handled

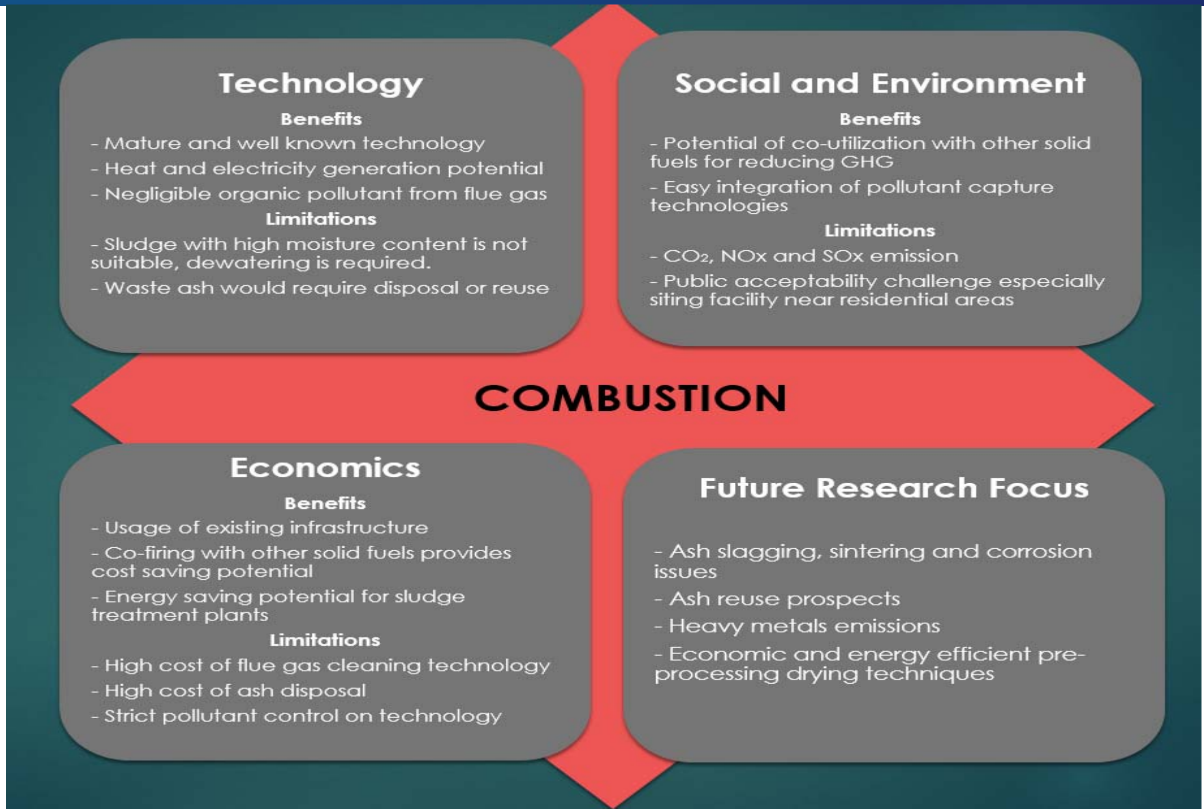
# Anaerobic Digestion

- Biological process for biogas production
- Globally accepted and technologically mature.
- Biogas (60 – 70% methane)
- Energy content of biogas 13 – 21 MJ/kg³
- Potential to offset 50% energy requirement
  Risk of non-utilisation or flaring of biogas
- Profitability dependent on scale
- Improvement of digestion rate
- Enhancement of biogas yield and quality


**Current research focussed on various chemical, mechanical and thermal pre-treatment methods to enhance digestion rate and yield.**

# Combustion

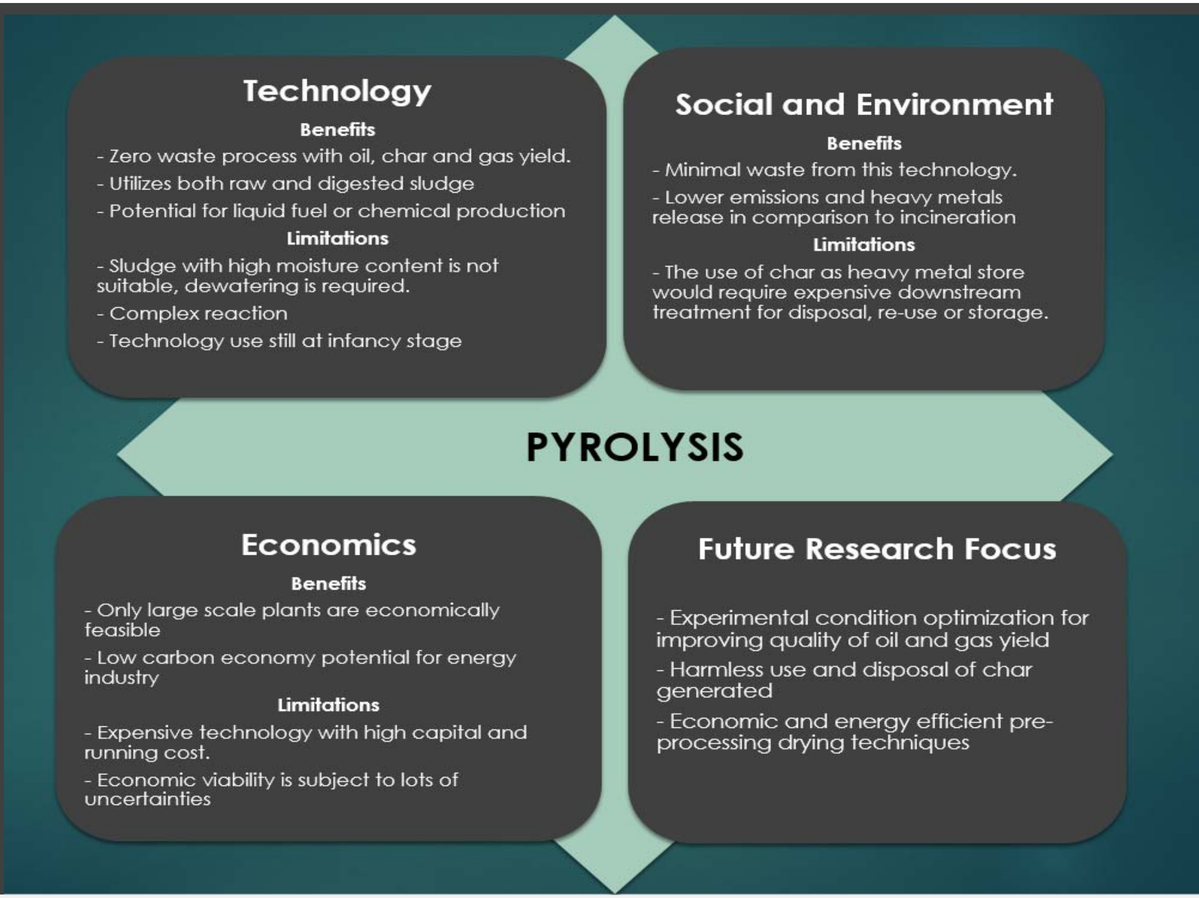
- High temperature oxidation for heat and electricity generation
- Technologically mature process
- Flue gas cleaning facility
- Operation challenges – moisture and ash content
- Moisture = inefficiency and low heating value
- Ash slagging = inefficiency and reactor maintenance
- C0-utilization with coal or biomass




**Current research focussed on pre-treatments, optimisation of combustion parameters, catalysts usage, minimisation of pollutants formation, and heavy metals retention in ash to improve combustion suitability and minimise deterrent factors.**

# Pyrolysis

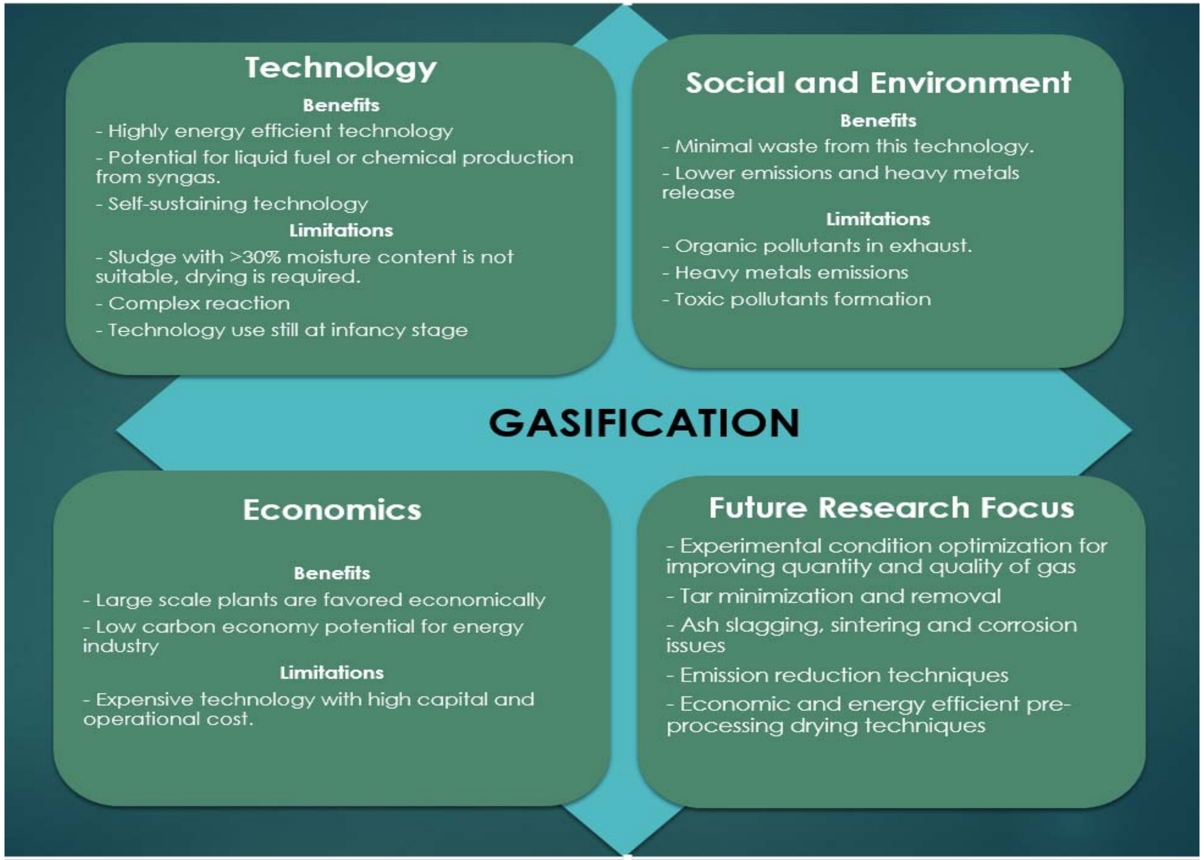
- Inert atmosphere thermal decomposition for bio-oil, char and gas.
- Not a technologically mature process
- Bio-oil with ~ 33 MJ/Kg heating value
- Negligible pollutant and heavy metal emission
- Operation challenges – moisture and char content
- Moisture = inefficiency, low oil quality.
- Char = Ash catalytic cracking, disposal or use in circular economy




**Current research focussed on pre-treatments, optimisation of pyrolysis parameters to enhance bio-oil and gas yield, catalysts, minimisation of pollutants or heavy metals emission, downstream use of yields to ensure profitability and efficiency of technology.**

# Gasification

- Partially oxidized thermal decomposition for gaseous yield.
- Not a technologically mature process
- Synthesis gas with ~ 4 – 12 MJ/$m^3$
- Pollutants formation – $H_2S$, $NH_3$, $SO_x$ & $NO_x$
- Moisture = inefficiency, tar formation.
- Ash = clinker formation, heavy metal emissions, disposal or use




**Current research focussed on pre-treatments, optimisation of gasifier parameters to enhance syngas and $H_2$ yield, catalysts and minimisation of tar, pollutants and heavy metals emission to ensure profitability and efficiency of technology.**

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# Concluding Remarks

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- Environmental limitations of sludge disposal requires its use as a resource
- Further work in sludge characterization, co-utilization of sludge, operating condition optimization required.
- High moisture and ash content are the main obstacle.
- Use of catalysts, coupling of various technologies and co-use of sludge with other fuel types are high potential routes for future commercial scale-up.
- In-depth feasibility, technical, economic, social and life cycle assessment required for establishing suitability in the low carbon circular economy.

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# Questions???