

Alternate Energy Generating Opportunities in Pulp and Paper Mills



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Introduction

- Growing population and rapid economic development led to excessive consumption of fossil fuels which resulted in higher energy demand.
- But world is slowly shifting towards renewable energy sources like solar, wind, waste, biomass and hydro energy due to threats associated with fossil fuels such as emission of green house gases like CO₂ and N₂O.
- In the quest for alternate renewable energy sources, pulp and paper mills offers various feasible platforms for producing bioenergy as paper mills are based on lignocellulosic biomass.
- Pulp and paper mills are highly energy consuming, high energy prices and stringent environment rules have triggered scientists to look for the potential of pulp and paper industries in production of renewable energy.

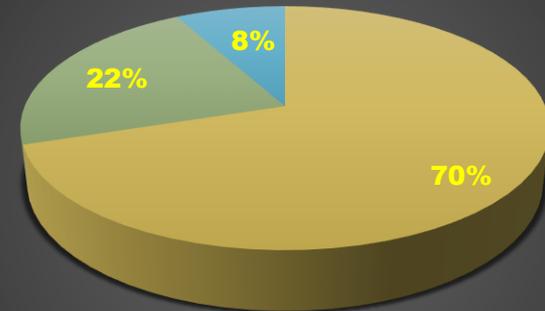
Introduction

- There are various feedstocks in a paper mill for energy generation such as biomass containing cellulose and hemicellulose; waste biomass such as residues of wood/bark, screening rejects and pith; black liquor containing lignin and organic compounds; effluent containing organic-rich wastewater, sludge etc.
- Biorefinery integrated with a paper mill is one such approach that can be implemented for converting biomass into various biofuels such as solids (lignin, pellets, and charcoal), gaseous (syngas, biogas, biomethane, and hydrogen) and liquid (bio-oil, Fischer Tropsch fuels, bioethanol, and biodiesel).
- The biorefinery concept can also be associated with combined heat and power (CHP) generating systems available in pulp and paper mills which utilize biomass such as bark, pith, and chipping waste for generating steam, energy, and biofuels.
- Agro-based paper mills offer huge potential for generating alternative bioenergy through combustion in chemical recovery boilers, gasification, biomethanation, and anaerobic treatment of spent pulping liquor.

Indian Paper Industry

- With 6-7 % average annual growth rate, paper consumption is expected to reach 30 million tonnes per annum by FY 2026-27 largely driven by emphasis on education and literacy.
- Indian Paper & Pulp Market was valued at US\$ 11.48 Billion in 2021, and is expected to reach US\$ 31.41 Billion by 2029, at a CAGR of 13.4% during forecast period.
- Per capita consumption is likely to increase to 17 kg as India's expected population would be 144 crores by 2025.

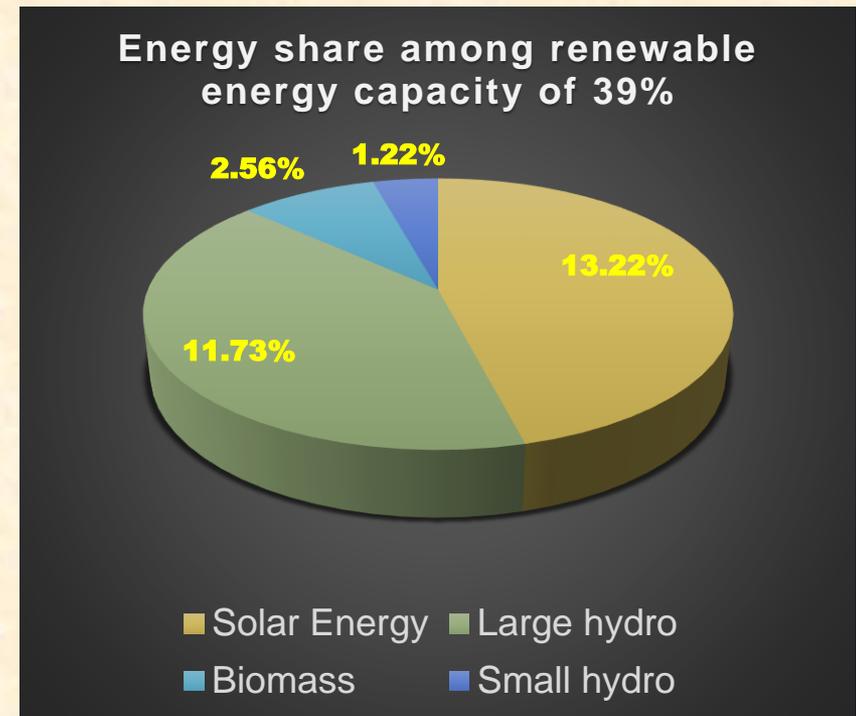
Current Cellulose fibre Sources



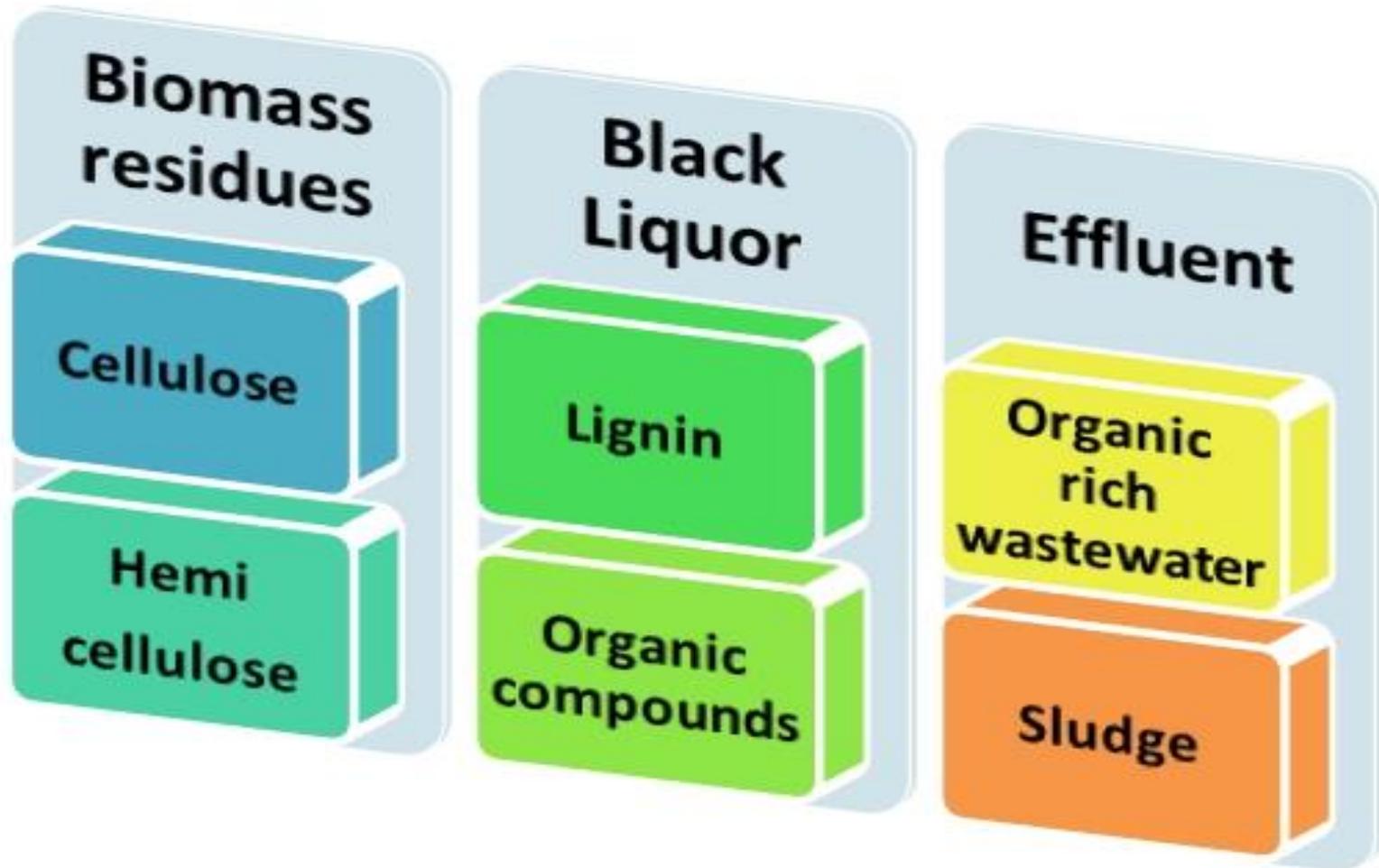
- Recycled/waste Paper based
- Wood based
- Non Wood/Agro Residue based

Energy Scenario in India

- Indian is strongly coal dependent country and frequently imports fossil fuels.
- More than 80% of India's energy requirement is fulfilled by coal and oil.
- According to MNRE data of Q1 2022 India's renewable energy capacity shares 39 % of total installed capacity.
- Typical steam and electricity consumptions of Indian paper mills are 11 to 15 tonnes and 1300 to 1700 kwh per tonne of paper production.



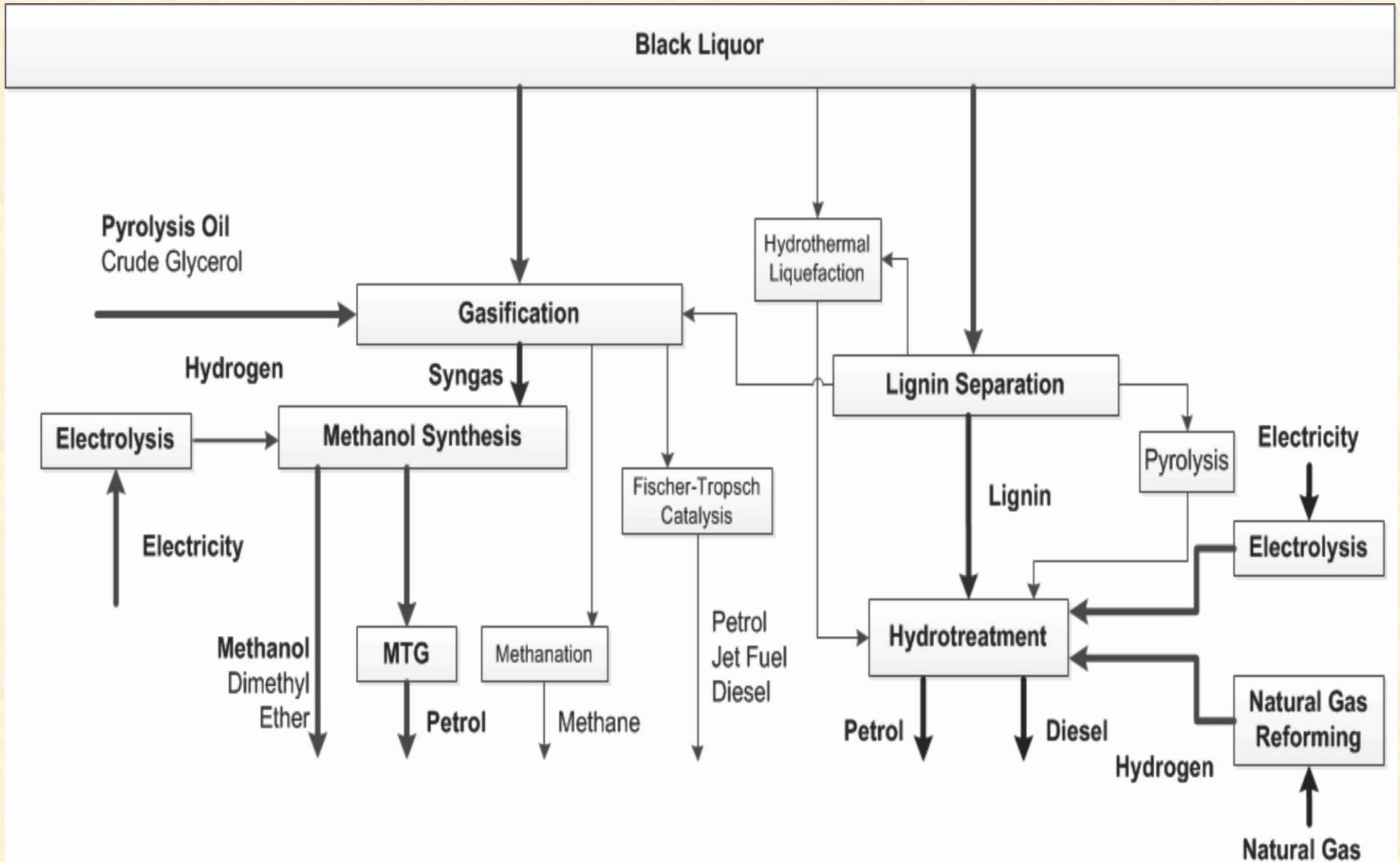
Feedstocks in Paper Mills for Energy Generation



Renewable Energy from Black Liquor

- Black liquor is a good source of green energy in terms of chemicals and organics present in it.
- In chemical recovery boiler, steam is generated through heat energy liberated by the combustion of black liquor. This steam is fed to a turbo generator to produce green electricity for fulfilling the mill's energy requirements.
- Black liquor can also be utilized for the production of hydrogen through the electrolysis process and alkali lignin separated during the process can use for producing green fuels.
- Black liquor subjected to gasification followed by methanol synthesis, methanation and fischer tropsch catalysis can give methanol dimethyl ether, petrol, methane, jet fuels and diesel etc.

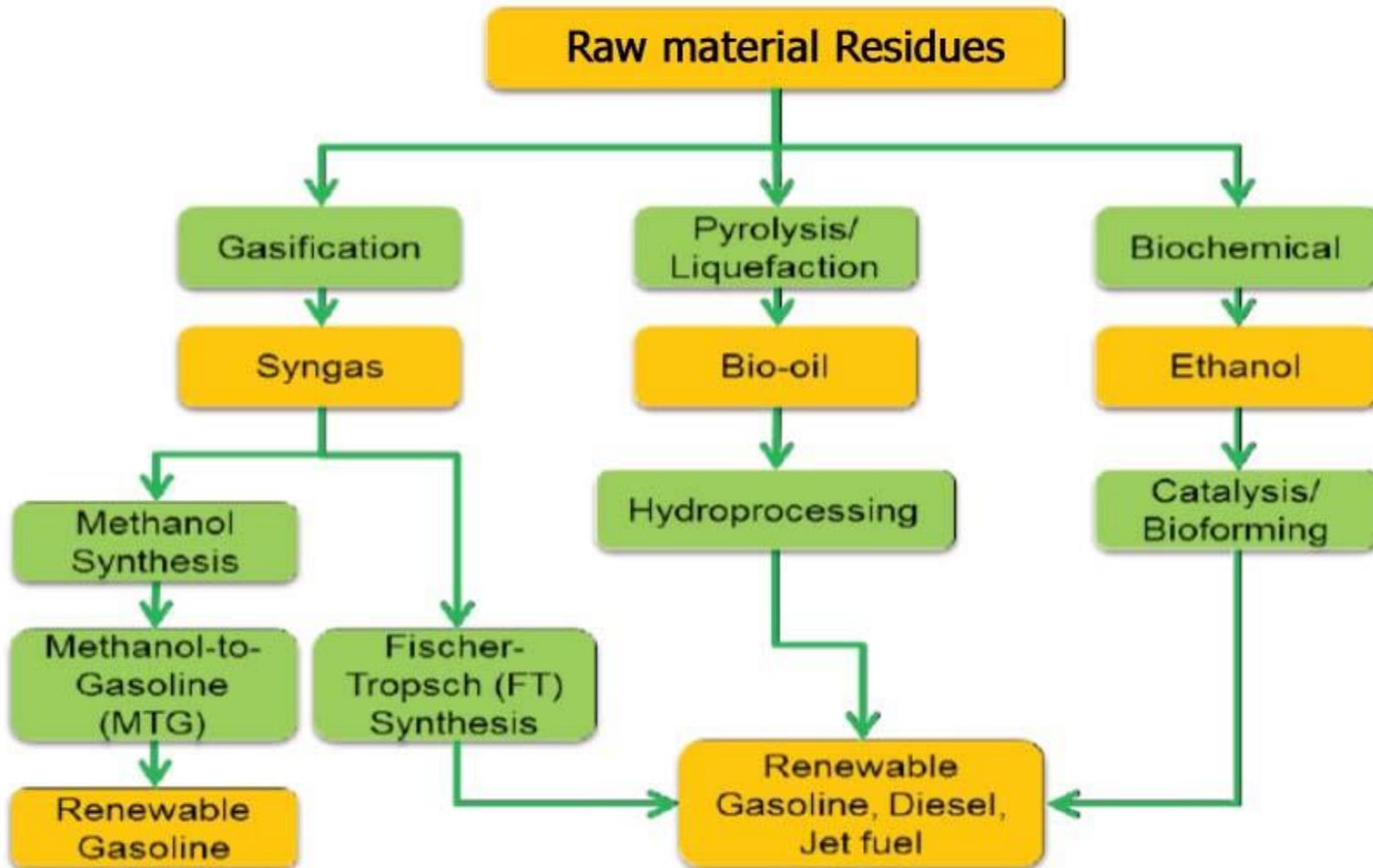
Renewable Energy from Black Liquor



Renewable Energy from Biomass Residues

- Biomass is a good source of carbon available other than fossil fuels.
- There are various sources of biomass residues available in pulp and paper industries such as bark, pith, rejects, spent liquor, and wastewater sludge.
- Biomass residues can be subjected to treatment processes such as gasification, pyrolysis/liquefaction, and biochemical conversion for producing renewable gasoline, diesel, and jet fuel.
- Hydrolysis of biomass residues followed by fermentation produces biofuels like ethanol.

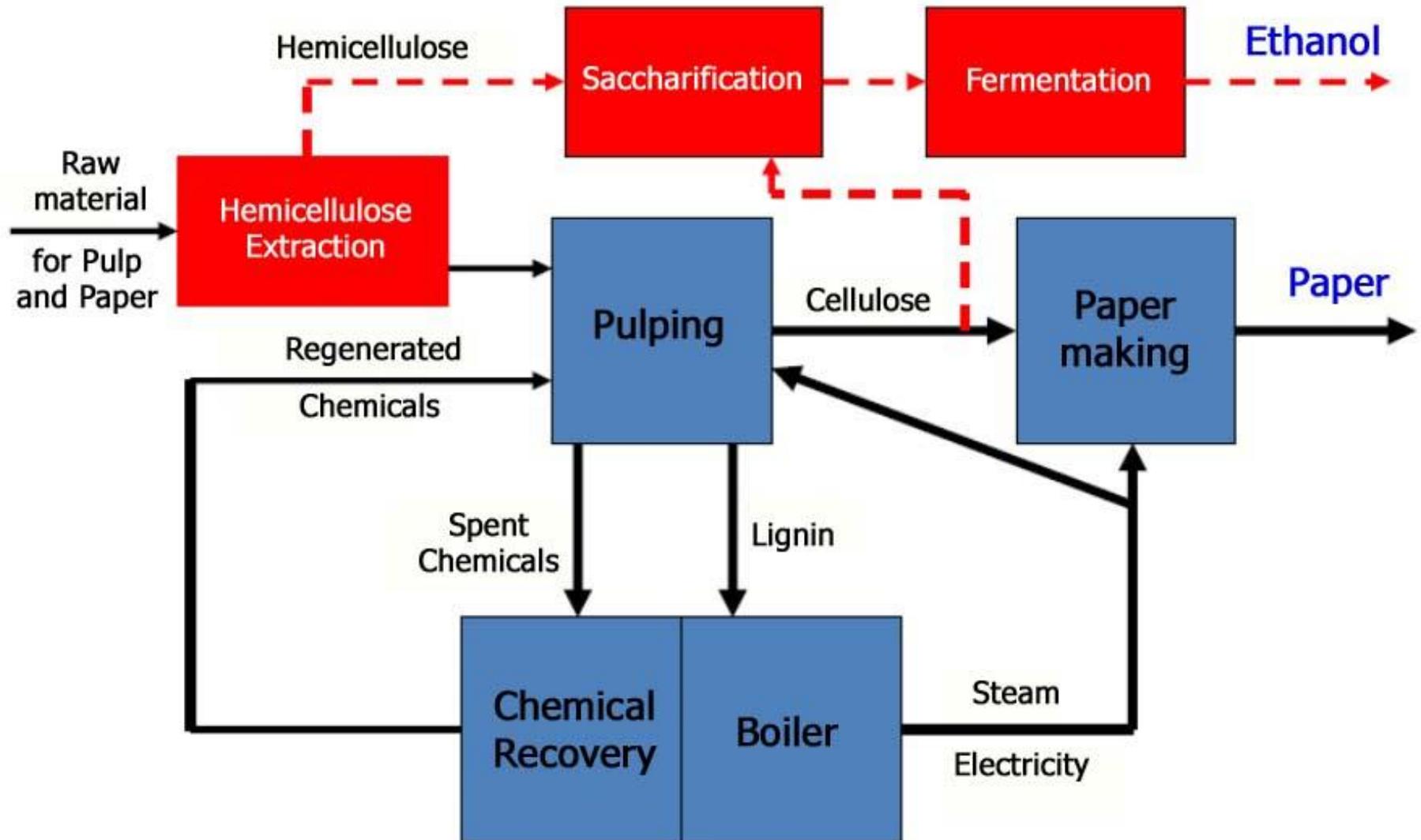
Renewable Energy from Biomass Residues



Renewable Energy from Hemicellulose

- Raw materials such as wood, bagasse, and wheat straw contain hemicellulose which can be utilized for producing green energy.
- Hemicellulose is extracted from raw materials first and then the extracted hemicellulose is subjected to saccharification followed by fermentation which ultimately produces ethanol.
- Produced ethanol can be used for blending with gasoline.

Renewable Energy from Hemicellulose



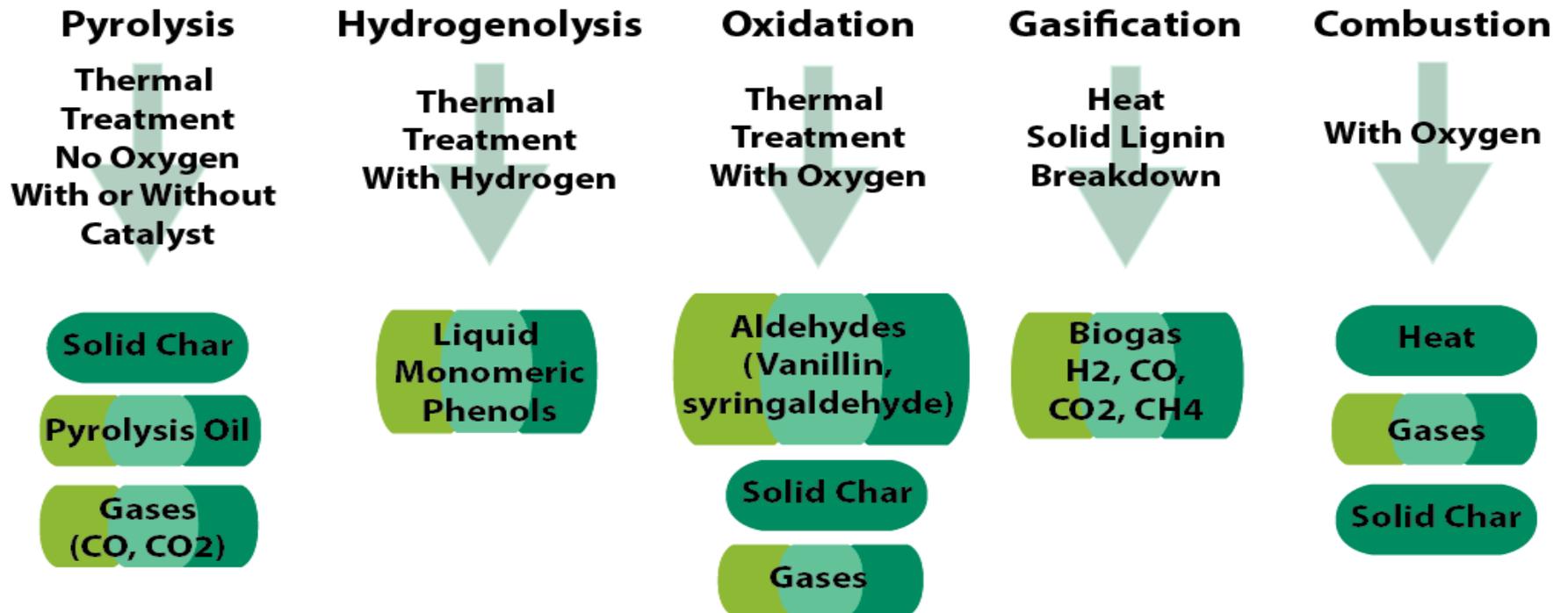
Renewable Energy from Lignin

- Lignin is aromatic in nature and it has huge potential to produce biochemicals, biofuels, and bioelectricity.
- Lignin is separated from black liquor by alkali and acidic procedures and separated lignin can be subjected to treatment processes such as pyrolysis, hydrogenolysis, oxidation, gasification, and combustion for producing a spectrum of renewable energy sources.
- Pyrolysis of lignin gives solid char, pyro-oil, and gases (CO, CO₂).
- Gasification of lignin gives syngas which can be further converted to methanol, ethanol, dimethyl ether, light gases, and Fischer Tropsch biofuels.

Renewable Energy from Lignin

Lignin

Treatment Methods and Products



Biochemicals



Biofuels



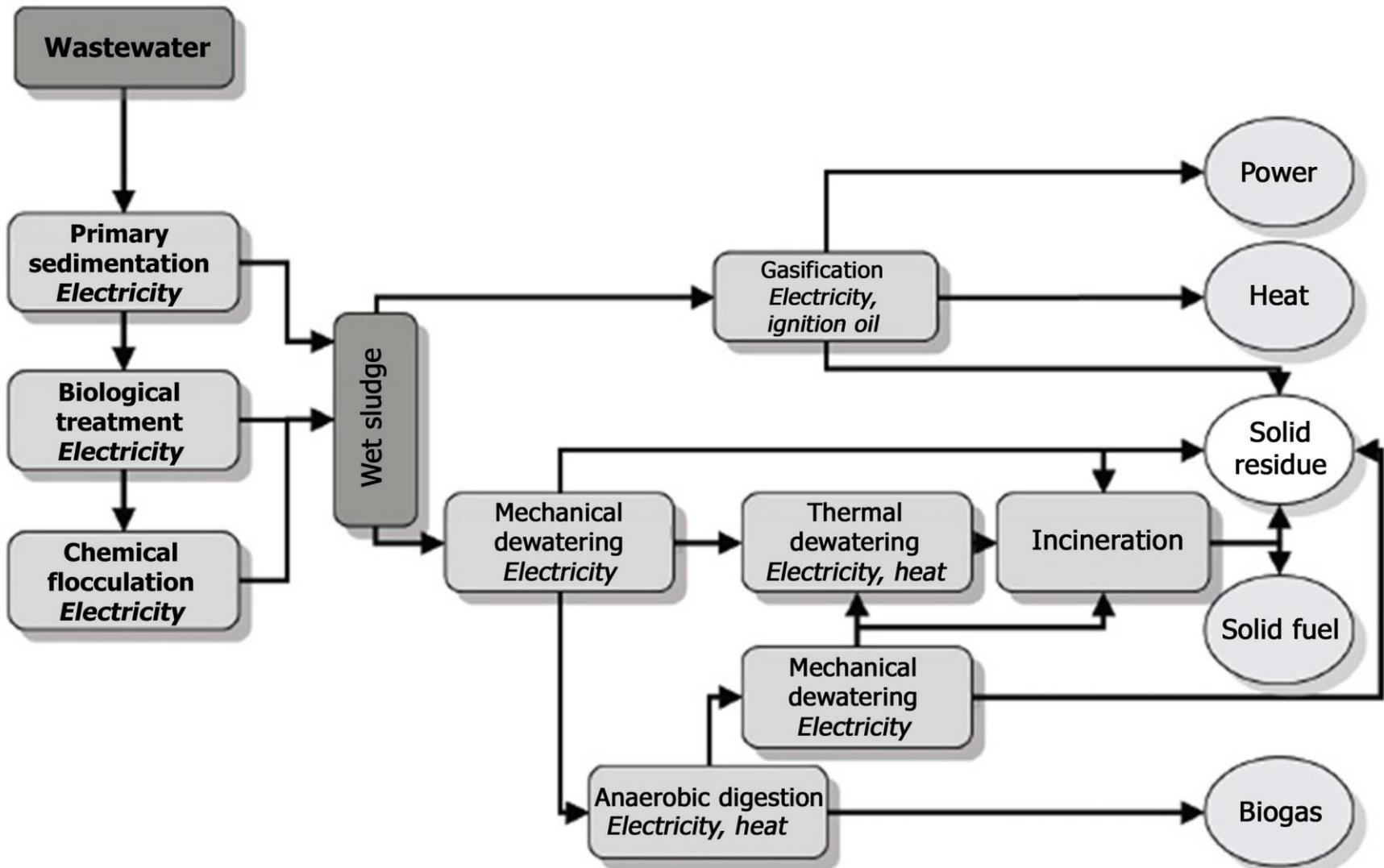
Bioelectricity



Renewable Energy from Waste Water Sludge

- Pulp and paper sludge is low in nitrogen content and high in carbon content which makes it highly suitable for anaerobic digestion after dewatering to produce biogas which can be purified to biomethane.
- The incineration of sludge after the dewatering process gives solid residue and solid fuel.
- Treatment of wastewater and sludge from the paper mill not only reduces the pollution load but also helps to recover renewable energy in terms of solid, gas, and liquid fuels.

Renewable Energy from Waste Water Sludge



Conclusion and Implication

- The pulp and paper mills have full potential to produce renewable energy and it is the right time to visualize them as biorefinery keeping in view the future energy demand.
- Future generation of renewable energy from pulp and paper mills, however, depends on the level of production and the technologies employed at mills.
- The pulp and paper mills will have to be re-purposed for the production of biomass based renewable energy.
- Integrating pulp and paper mills to renewable energy production facilities in addition to paper will enhance the profitability and hence the socio, economic, energy and environmental condition of country.
- It is concluded that adoption of processes like fractionation, pyrolysis, gasification, fermentation, hydrolysis etc. can make pulp and paper industry more sustainable and will further enhance the sustainable development goals defined by United Nation through circular economy approach.

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