GASIFICATION AND IT'S APPLICATION

CL 304 - CHEMICAL PROCESS TECHNOLOGY

PRESENTED BY GROUP 17

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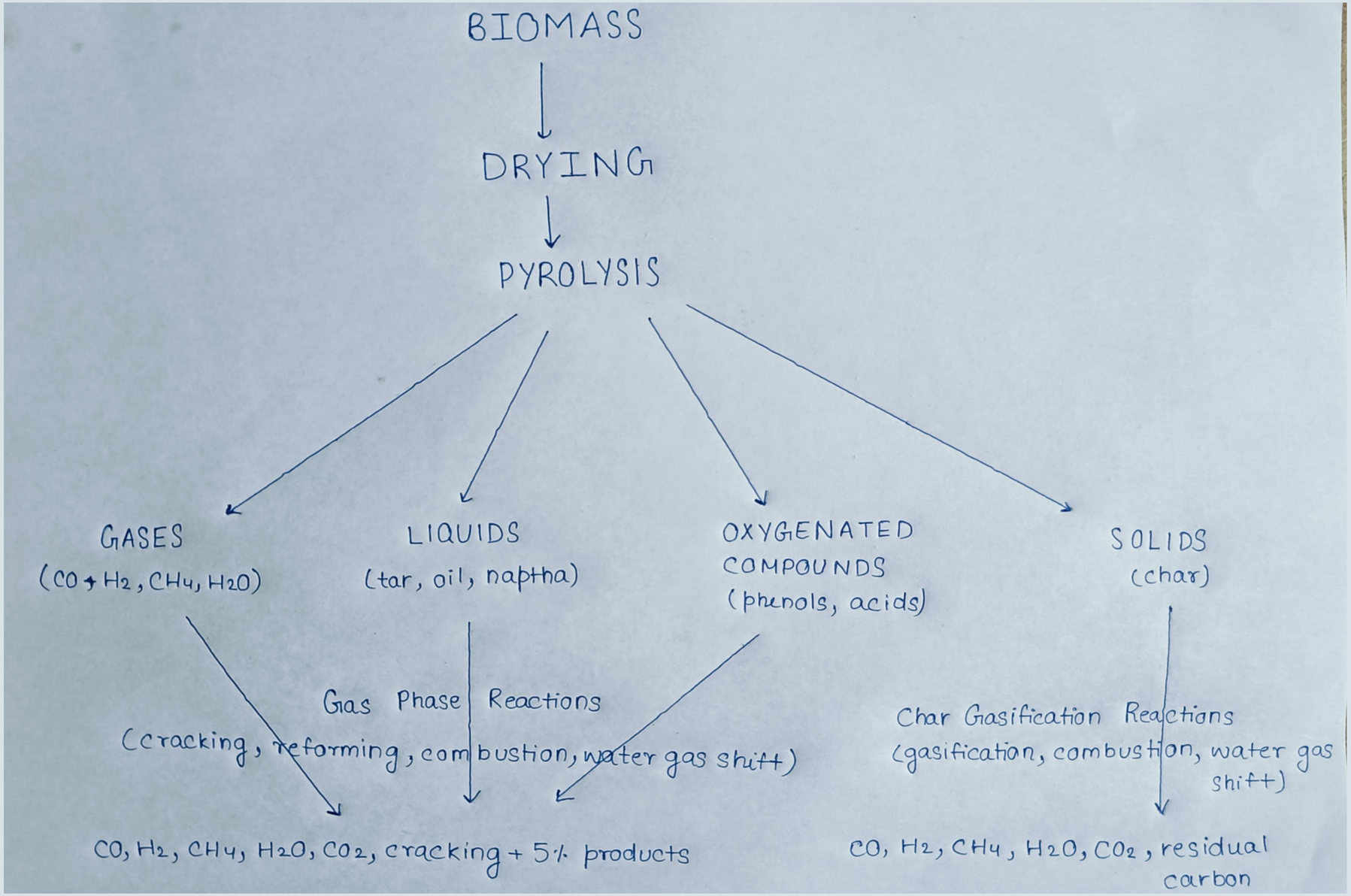
GASIFICATION

The process of gasification involves reacting carbonaceous materials, such as coal, or biomass, at high temperatures with controlled oxygen to produce syngas. CO and H_2-rich syngas can be used directly as fuel to produce CH_4, H_2, or synthetic fuel.

- 1830
  First Commercial application of Gasification
- 1920
  Gasification was used to produce synthetic chemicals
- 1945
  Heavy vehicles were powered by gasification systems

STEPS INVOLVED IN GASIFICATION



CHEMISTRY OF GASIFICATION

CARBONATION

$C + CO_2 \leftrightarrow 2CO + 172\ kJ/mol$
(BODOUGUARD)

$C + H_2O \leftrightarrow CO + H_2 + 131\ kJ/mol$
(WATER GAS)

$C + 2H_2 \leftrightarrow CH_4 - 72.8\ kJ/mol$
(HYDROGASIFICATION)

$C + \frac{1}{2} O_2 \rightarrow CO - 111\ kJ/mol$

OXIDATION

$C + O_2 \rightarrow CO_2 - 394\ kJ/mol$

$CO + \frac{1}{2} O_2 \rightarrow CO_2 - 284\ kJ/mol$

$CH_4 + 2O_2 \leftrightarrow CO_2 + 2H_2O - 803\ kJ/mol$

$H_2 + \frac{1}{2} O_2 \rightarrow H_2O - 242\ kJ/mol$

WATER-GAS SHIFT

$CO + H_2O \leftrightarrow CO + H_2 - 41.2\ kJ/mol$

METHANATION

$2CO + 2H_2 \rightarrow CH_4 + CO_2 - 247\ kJ/mol$

$CO + 3H_2 \leftrightarrow CH_4 + H_2O - 206\ kJ/mol$

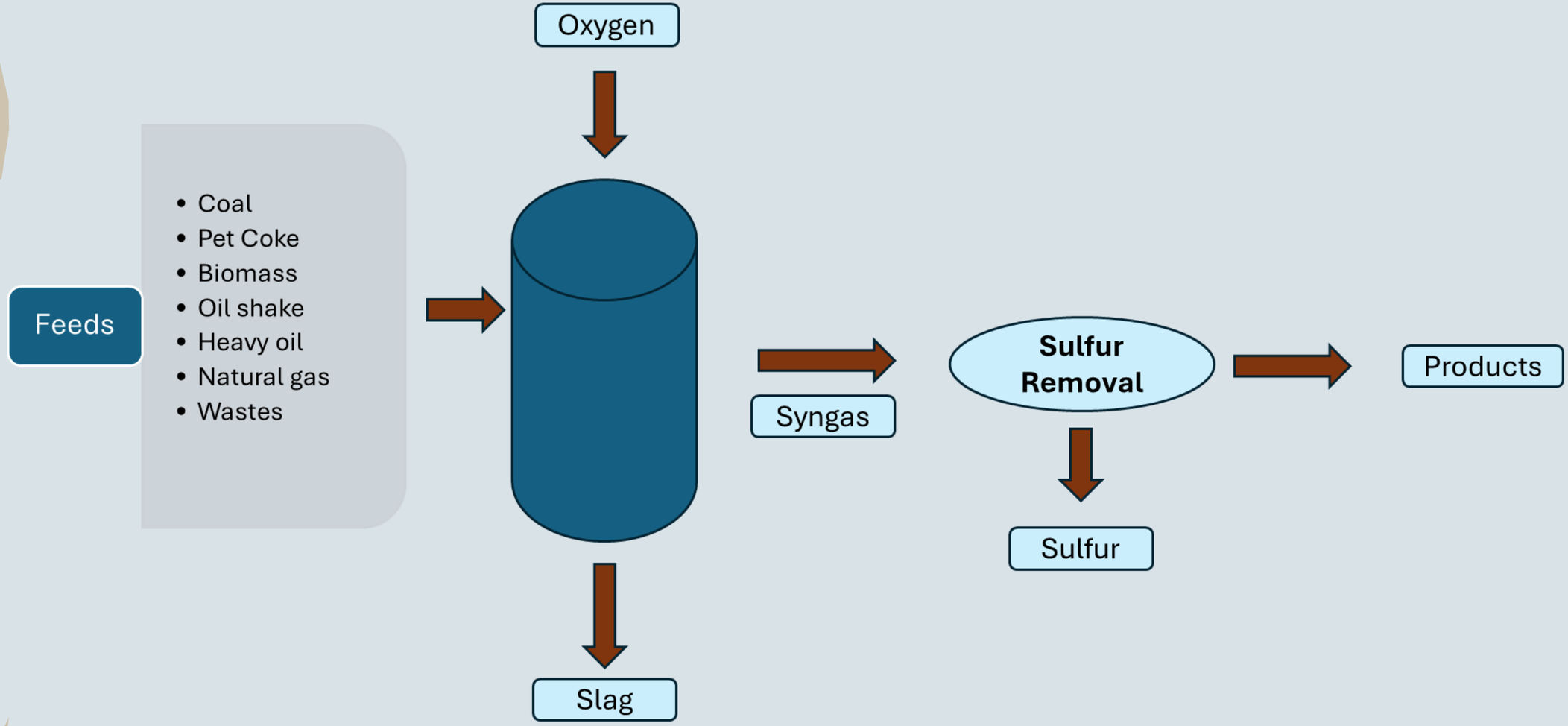
$CO_2 + 4H_2 \rightarrow CH_4 + 2H_2O - 165\ kJ/mol$

STEAM REFORMING

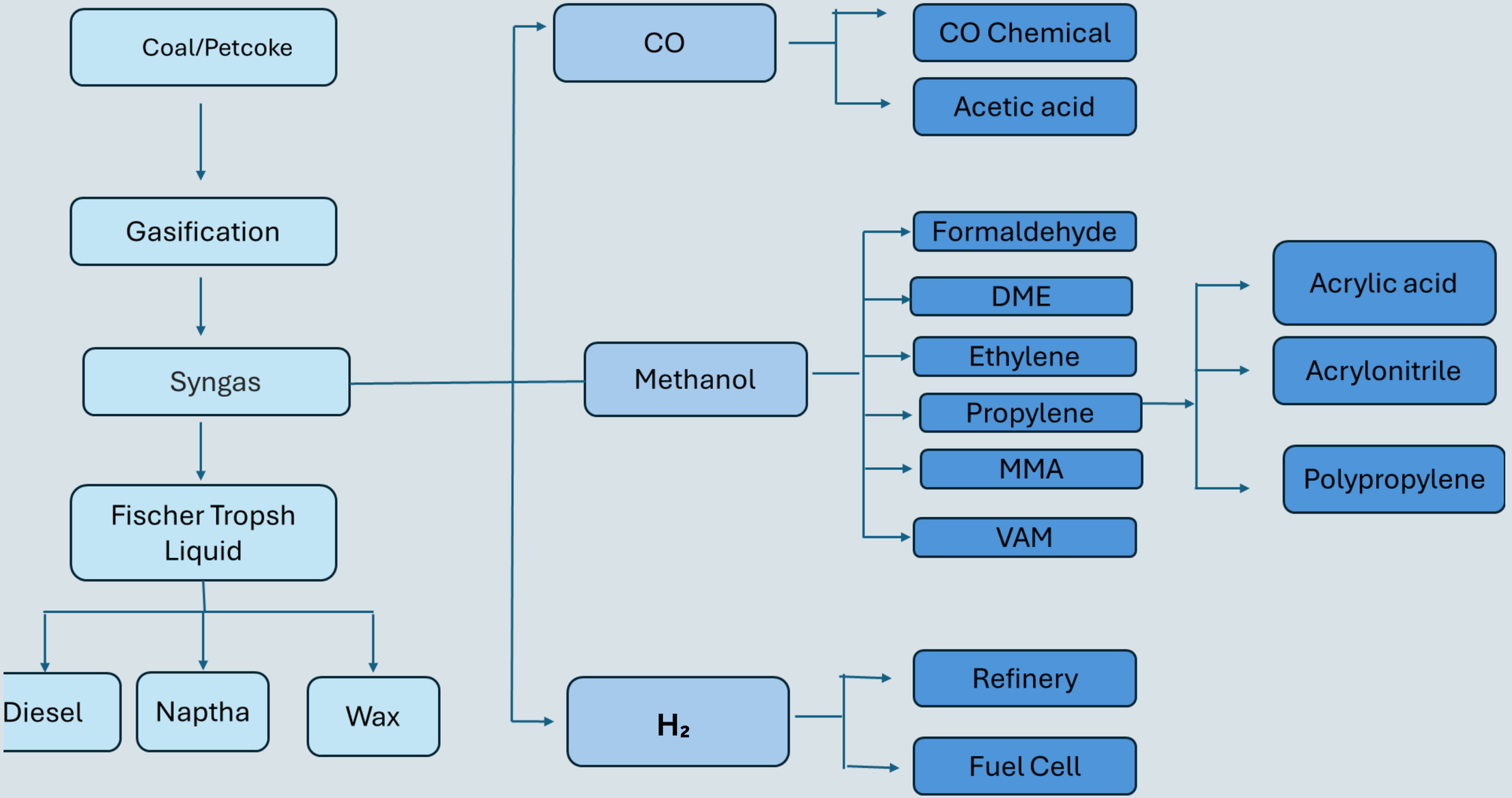
$CH_4 + H_2O \leftrightarrow CO + 3H_2 + 206\ kJ/mol$

$CH_4 + \frac{1}{2} O_2 \rightarrow CO + 2H_2 - 36\ kJ/mol$

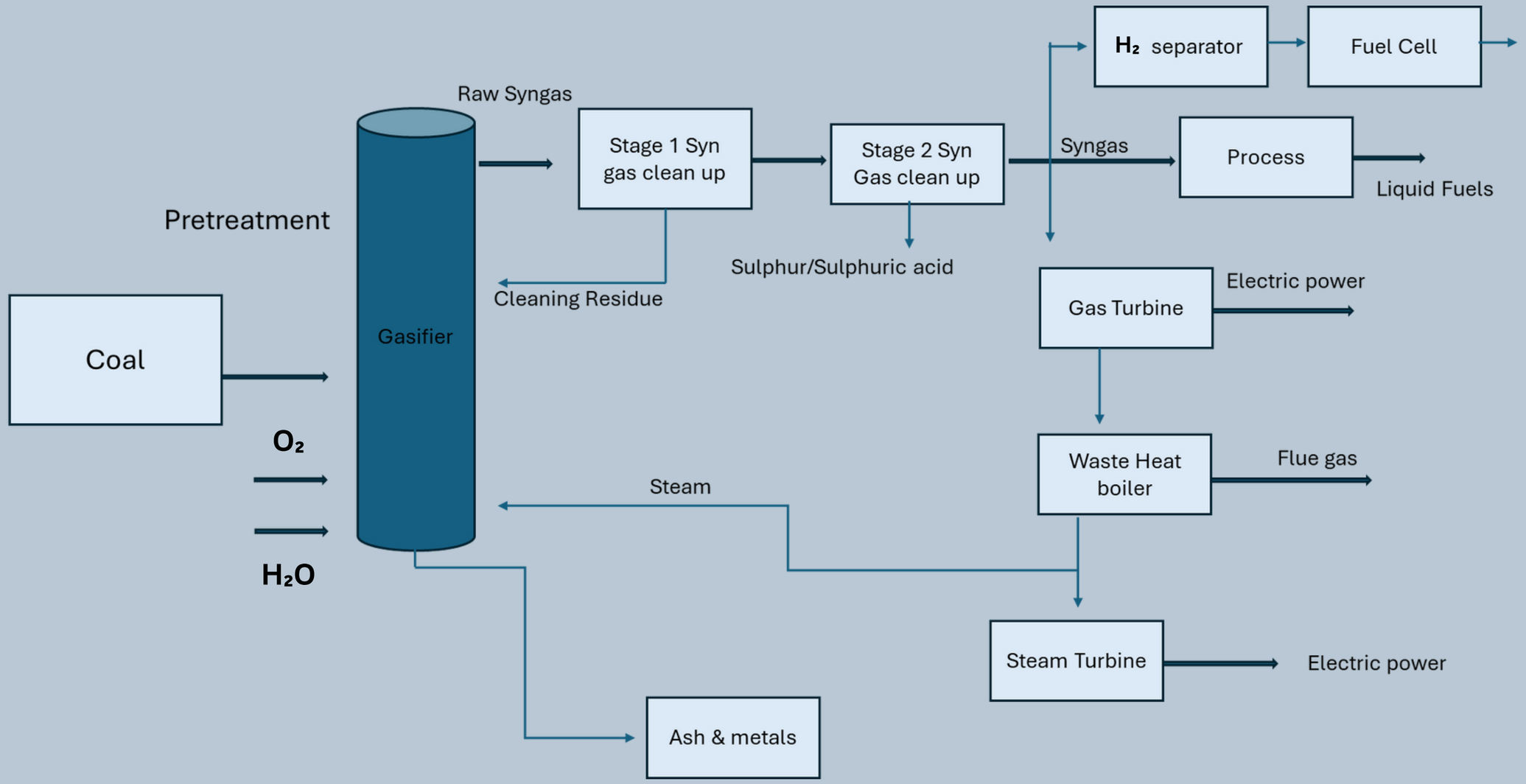
FEEDSTOCKS


Oxygen
Feeds
Coal
Pet Coke
Biomass
Oil shake
Heavy oil
Natural gas
Wastes
Syngas
Sulfur Removal
Products
Sulfur
Slag

GASIFICATION PRODUCTS



FLOW SHEET AND UTILIZATION SCHEME OF GASIFICATION PRODUCTS



COAL GASIFICATION

- Coal gasification is a process of converting coal into a gaseous fuel.
- The resulting gas mixture, known as syngas or synthesis gas, primarily consists of H_2, CO, and CH_4, along with smaller amounts of other gases such as CO_2 and N_2.
- Sulphur is utilised in the production of sulfuric acid, and ammonia is often used in fertiliser production.
- Coke, coal tar, sulphur, and ammonia all are by-products of syngas production. Coke is a smokeless fuel that is also used to make water gas as well as producer gas.

UNDERGROUND COAL GASIFICATION

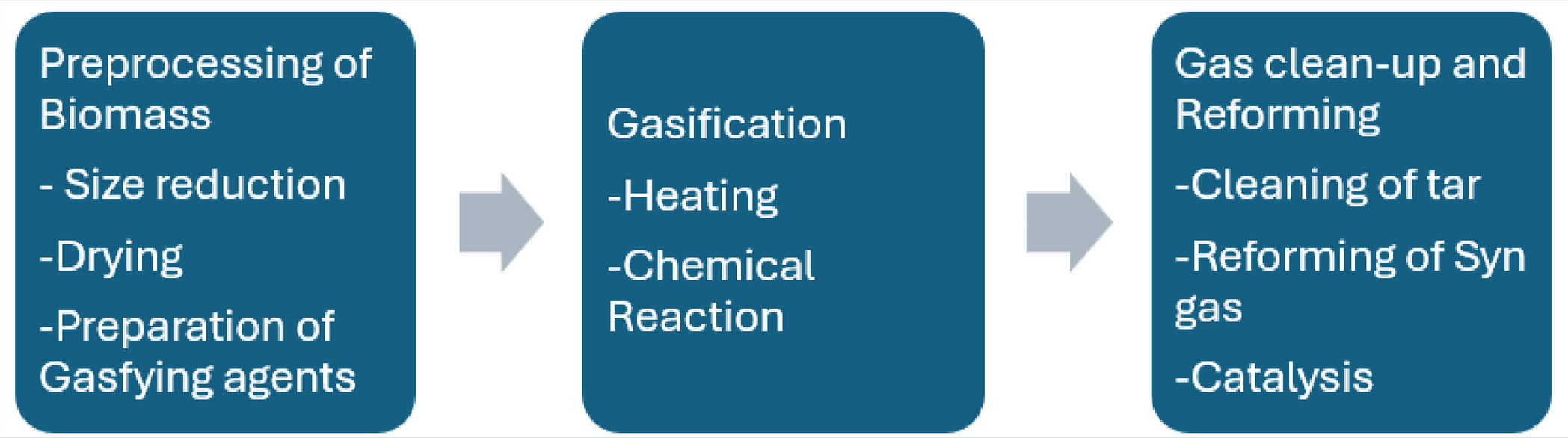
- Underground Coal Gasification (UGC) is an industrial process conducted in unmined coal seams. It involves injecting a gaseous oxidizing agent, such as oxygen or air, into the coal steam and extracting the resulting product gas through surface-drilled production gas wells.
- Under the process of UGC, gasification of coal happens in situ by controlled burning
- About 350 m^3 of gas can be produced per tonne of coal
- By-products of significant commercial value will be hydrocarbons, phenols, anhydrous NH_3

BIOMASS GASIFICATION

- It is a process of converting solid biomass into a gaseous combustion fuel (called producer gas) through a sequence of thermochemical processes.
- The gas contains various percentages of CO, H_2, CH_4, CO_2 and N_2 depending on the quality of the fuel used in gasification
- Parameters which have significant impact on product quality -
    - Feedstock type ,quality and moisture content
    - Particle size and density
    - Catalyst
    - Sorbent to Biomass Ratio
    - Air equivalence Ratio

MECHANISM OF GASIFICATION

The mechanism of gasification involves several thermochemical reactions that occur as a carbonaceous feedstock (such as coal, biomass, or waste) is converted into a gaseous mixture known as syngas or synthesis gas. The gasification process typically proceeds through several steps:



UPSTREAM PROCESSING

Upstream processing involves the preparation and pretreatment of the feedstock before it enters the gasification reactor.

Size Reduction and Drying

- Size reduced to obtain appropriate for gasification process . Converted into suitable form , such as slurry or powder ,as per requirements.
- Dried to attain optimal moistures levels.
- Smaller particles result in more CH_4, C_2H_4 and CO and lesser CO_2

Densification

- Required due to low biomass density.
- Compressing biomass makes handling and storage easier .
- Enhancing the homogeneity of feedstock input into gasifier

Storage and Handling

- Feedstocks need proper handling and storage to maintain its quality and prevent degradation

DOWNSTREAM PROCESSING

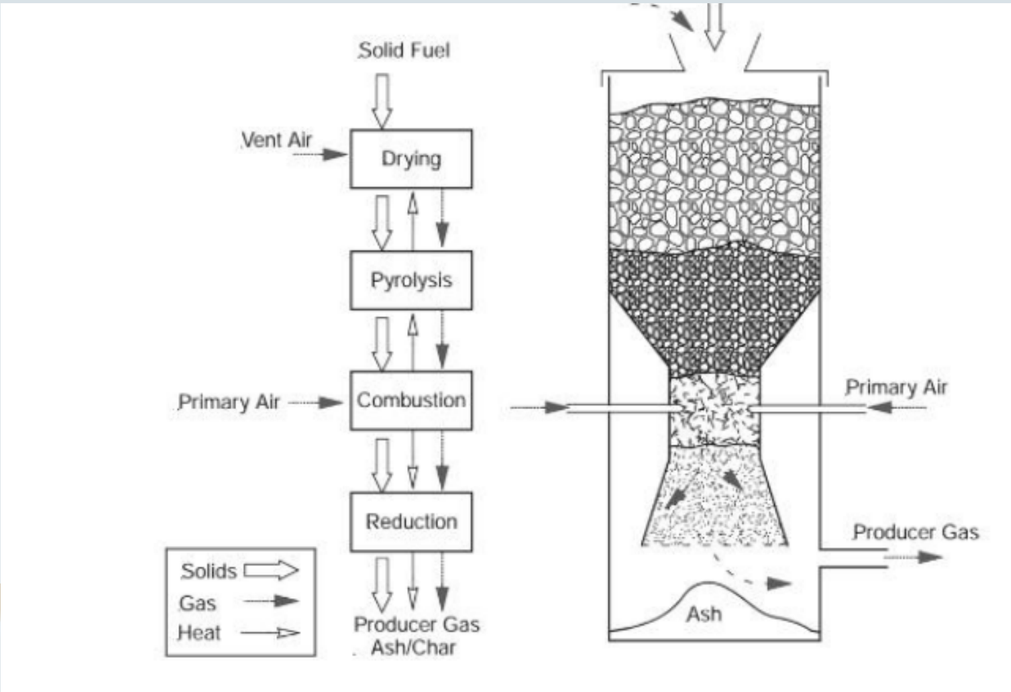
- Gaseous product are purified to fulfil quality standards. This includes operations such as filtration ,scrubbing and catalytic conversion to remove pollutants such as tar ,sulfur compounds and particles matter

- Downstream process starts with cooling the syngas to a suitable temperature range with heat exchangers or quenching system .

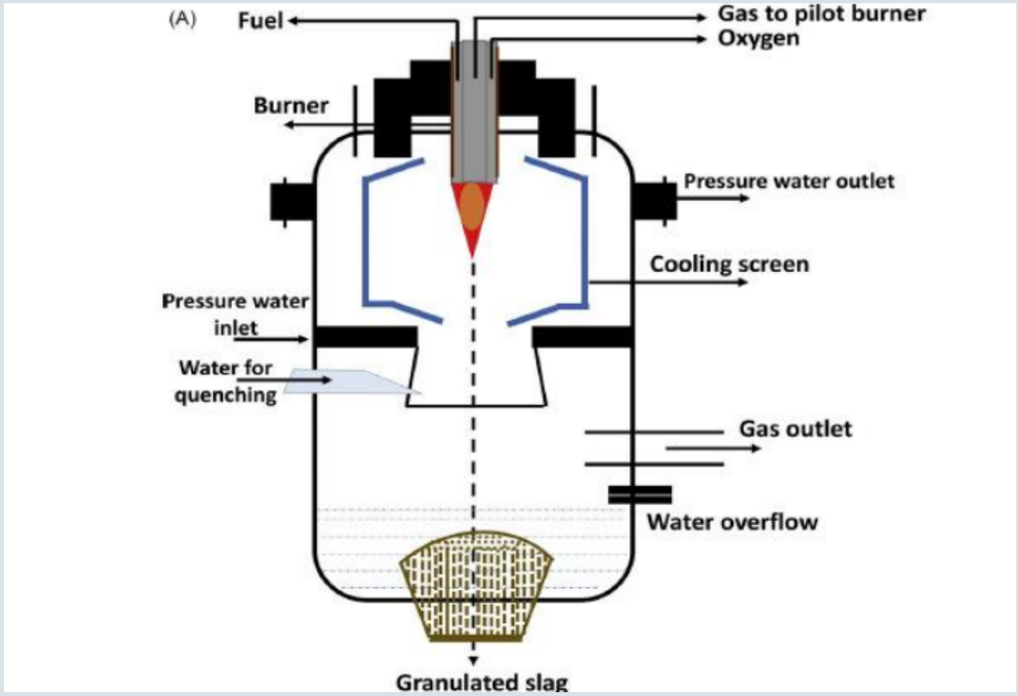
- Pollutants and their removal technique:
  - Sulfur compounds removal : Adsorption, Absorption or catalytic conversion
  - Acid gas: Scrubbing and Chemical Reactions
  - Tar: Scrubbing, Catalytic Cracking and Filtration

TYPES OF GASIFIER

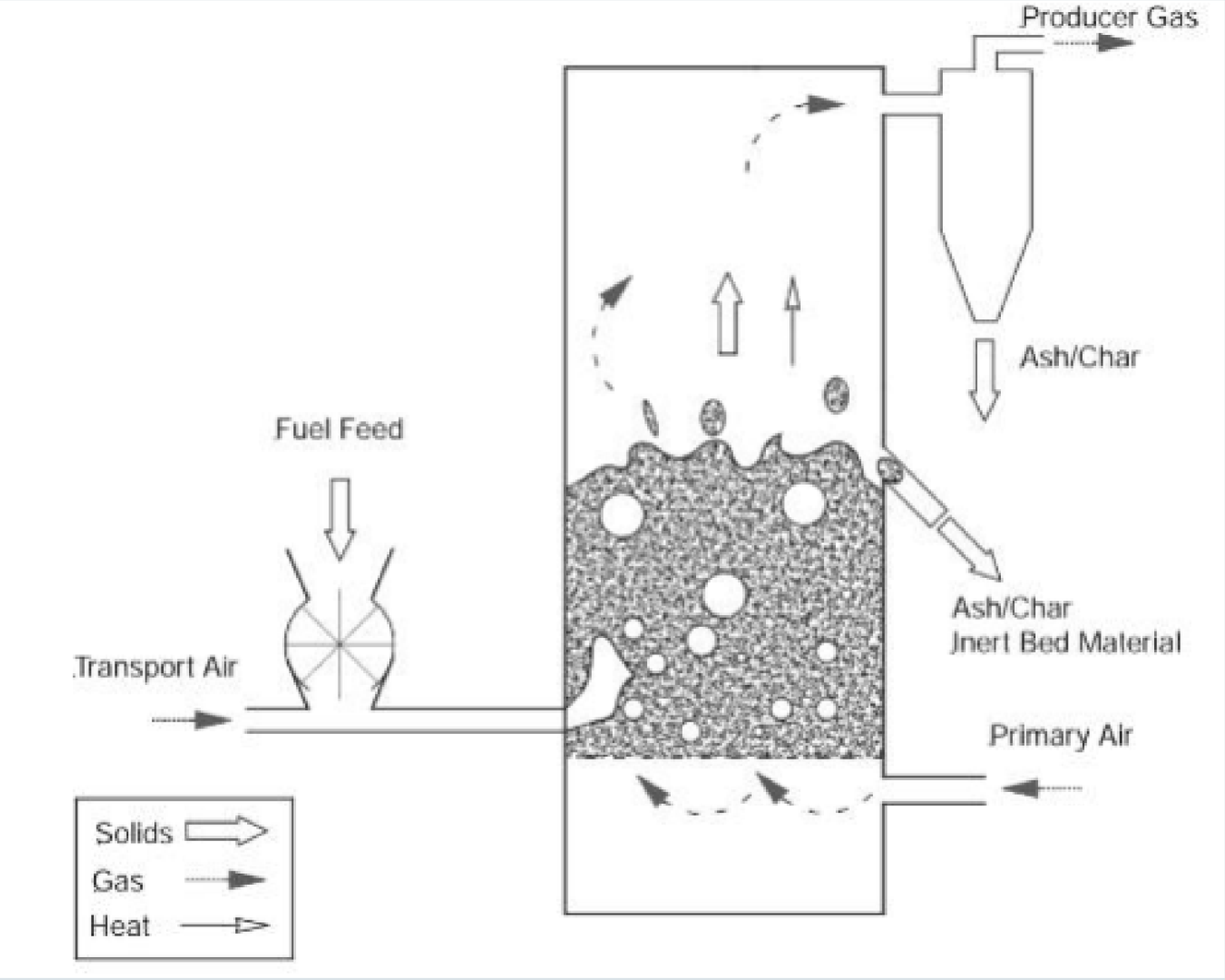
DOWNDRAFT GASIFIER



ENTRAINED FLOW GASIFIER



FLUIDISED BED GASIFIER



It is used to convert prepared waste into clean fuel gas. Bed material is suspended in a liquid-like form. Air is injected at the bottom through a distributor.

Improved version of fixed bed gasifier.Maximum temperature between 800-900 ℃ ,less than the fixed bed system

Have no distinct reaction zones and drying , pyrolysis and gasification occurs simultaneously.

APPLICATIONS

Cogeneration of Thermal energy with Power

Biomass gasification commonly aims for power generation, with increasing interest in co-generating heat and power. Gasification offers higher electrical efficiency compared to combustion. Researchers explore strategies like integrating gas and steam turbines,thereby achieving efficiencies up to 46% for coal and 32% for biomass gasification.

Producer gas driven Internal Combustion engine

Gasification technology enables the conversion of biomass or other feedstocks into syngas, which serves as a fuel for power generation in IC engines. Syngas, which is blended with air and fed into the cylinders of the IC engine for combustion.

APPLICATIONS

Fertlizier and Bio-Char production

Gasification produces nutrient-rich ash for fertilizer, while un-gasified char, known as bio-char, enhances soil fertility and carbon sequestration. This sustainable approach supports agriculture by improving nutrient retention and reducing environmental impact.

Carbon Capture Utilization

Gasification enables carbon capture by extracting carbon dioxide from biomass feedstock. The CO_2 can then be utilized in various ways, such as for industrial purposes like chemical synthesis and enhanced oil recovery, contributing to environmental sustainability and resource optimization.

ENVIRONMENTAL IMPACTS

Emission of PM, Nitrogen Oxide, Sulphur Dioxide

These pollutants can contribute to air pollution, leading to respiratory issues and other health problems for nearby communities. Incomplete combustion or improper waste management in gasification facilities can result in the release of harmful compounds like dioxins and volatile organic compounds

Ecological Consequences

Biomass feedstock cultivation for gasification may lead to land use changes, deforestation, and habitat destruction, posing threats to biodiversity and ecosystem stability. Clearing land for biomass crops can also result in soil erosion, loss of wildlife habitat, and disruption of local ecosystems. Additionally, transportation of biomass feedstocks to gasification facilities can contribute to carbon emissions and other environmental impacts

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THANK YOU