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Gasification to 2G Biofuels:

A sustainable energy solution

What are biofuels?







A range of fuels with biological origin (biomass)

Can be →
- Gaseous (Biogas, Syngas)
- Liquid (Biodiesel, Bioethanol)
- Solid (Biochars)


Biomass conversion technologies are used today for:

- Heat supply
- Power production

} Combined heat-power (CHP)

- Synthetic fuel production

Why biofuels?

Shifting of global dependence from fossil fuels to renewable energy production technologies towards the establishment of:

- favorable environmental conditions
- sustainable economy

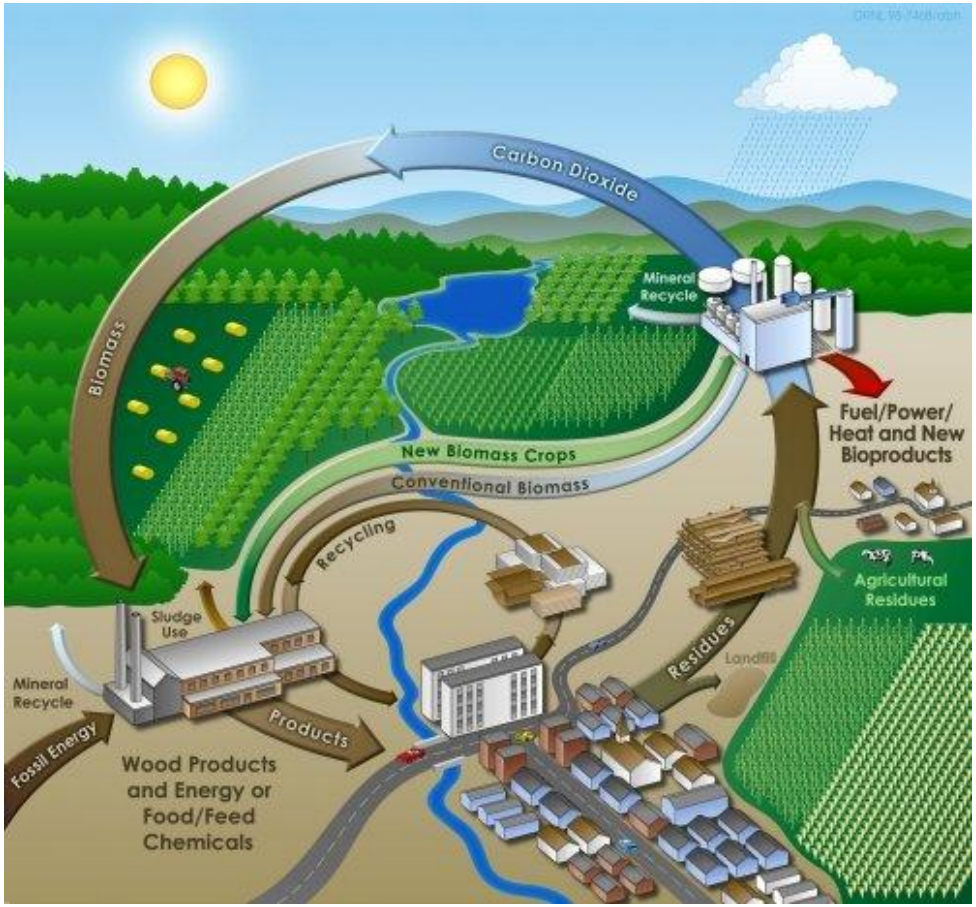
Biofuels production was stimulated

- low cost energy production
- agricultural sector stimulation
- greenhouse gas (GHG) emissions reduction
- vast global availability and biodiversity of biomass

Climate concerns and energy security → Biofuels production boost

CO_2 cycle

Biofuels are a "carbon neutral" energy source:



Plants use CO_2 to grow and produce biomass

↓

Biomass is converted to biofuels and used for power generation

↓

The CO_2 emitted from the use of biofuels is utilized by plants to create new biomass

Sources of Biofuels







Biofuels can be mainly produced from:

- Agricultural crops
- Vegetable oils
- Animal fat

} 1st Generation

- Agricultural residues
- Forest residues
- Wastes

} 2nd Generation

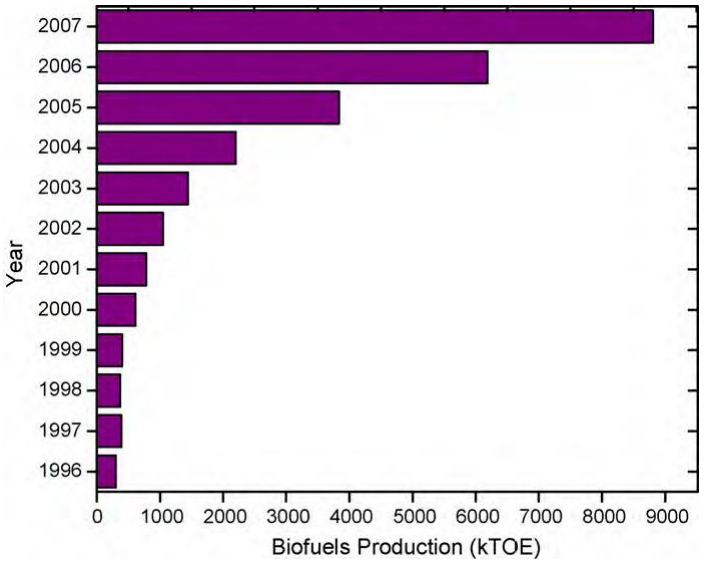
- Algae

3rd Generation

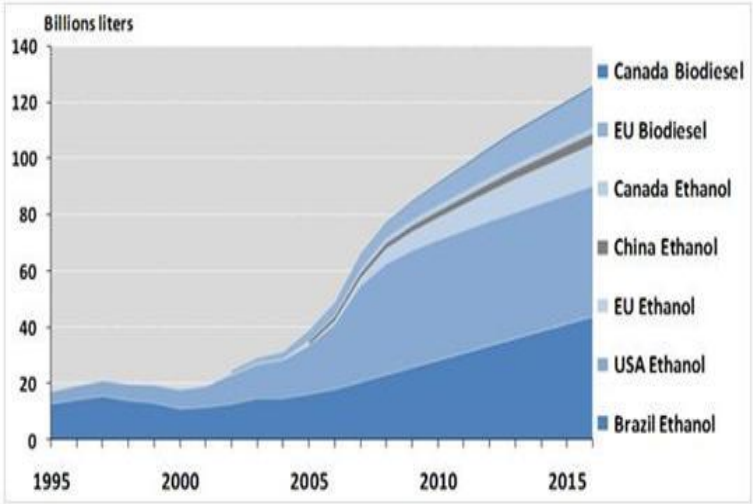



Biofuels production

Biofuels in Europe present an exponential increase in production over the years



Source: Eurostat



Source: www.oecd.com

Global biofuel production levels and future projection

Sustainability







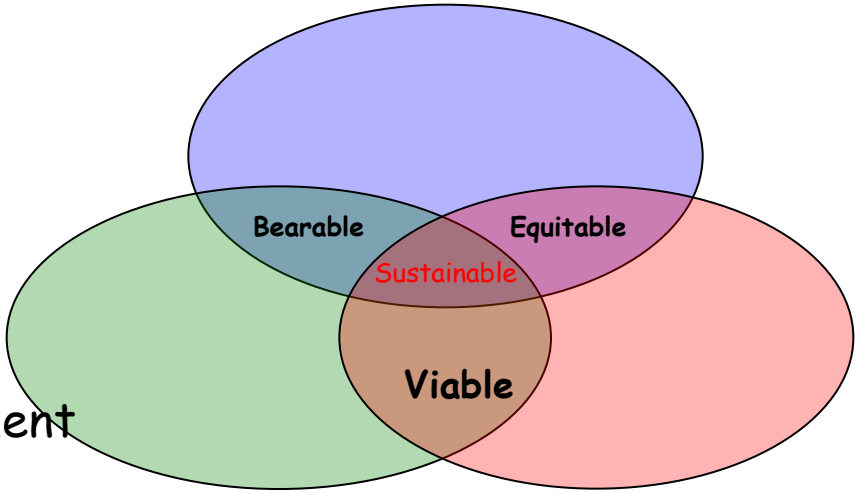
Sustainability: The capacity to endure

Modern processes revolve around 3 major sectors:

Society

Economy

Environment



Excelling in all 3 sectors is what makes a process sustainable

From 1st to 2nd Generation Biofuels





Initially, the source of biofuels was the "useful" part of the plantations such as grains or seeds

Soon a competition was developed between the biofuels and the food industries over

a) raw materials availability

b) market imbalance

This led to the shifting of interest towards 2nd generation biofuels from lignocellulosic residues and wastes

Towards 2nd Generation Biofuels







2nd generation biofuels offer the same benefits with their predecessors plus the possibility of waste management

They are sustainable by nature:

a) Socially acceptable (exploitation of useless materials)

b) Environmentally friendly (CO_2 neutral)

c) Economically viable (waste management + process optimization)

Production of 2nd Generation Biofuels

Biomass can be converted to 2nd generation biofuels though 2 different pathways:

a) Thermochemical

Gasification unit for syngas production

b) Biochemical

E. Coli producing biodiesel

Based on old but rigorously tested technologies
easily applicable

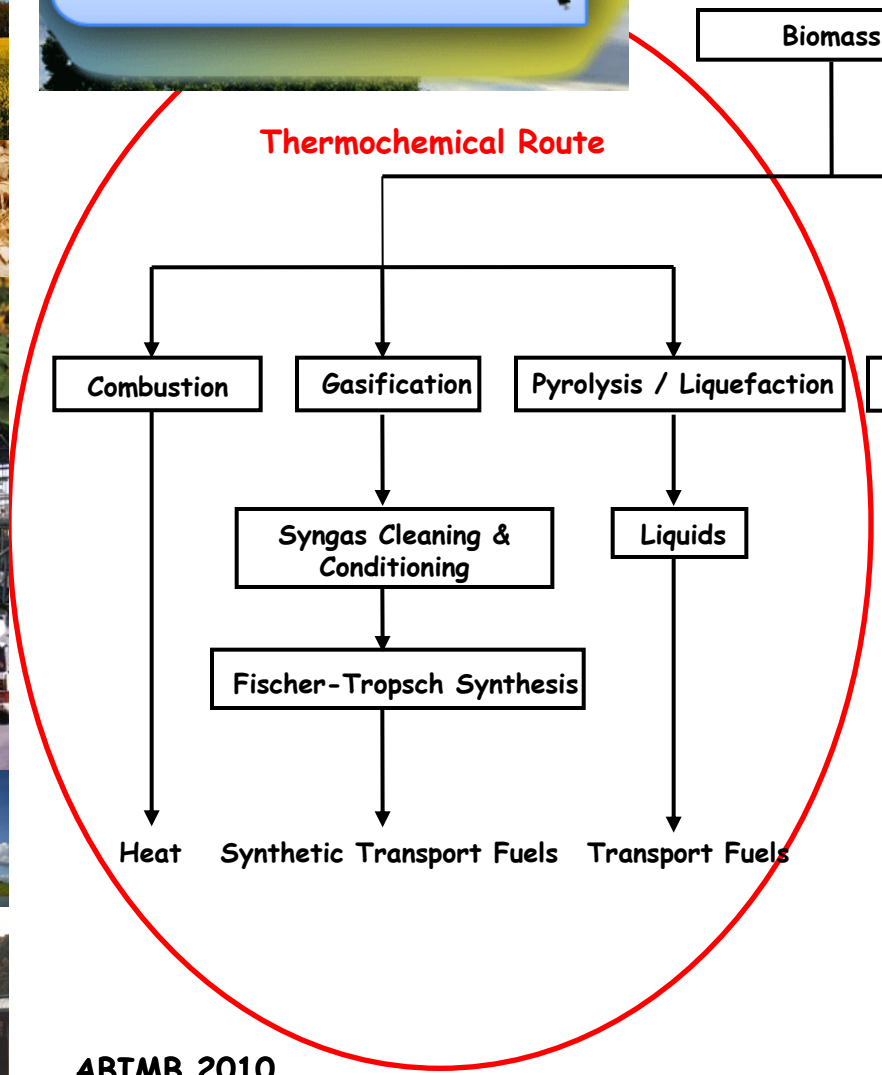
Promising with lots of optimization potential
still less prone to commercialization

Conversion Routes







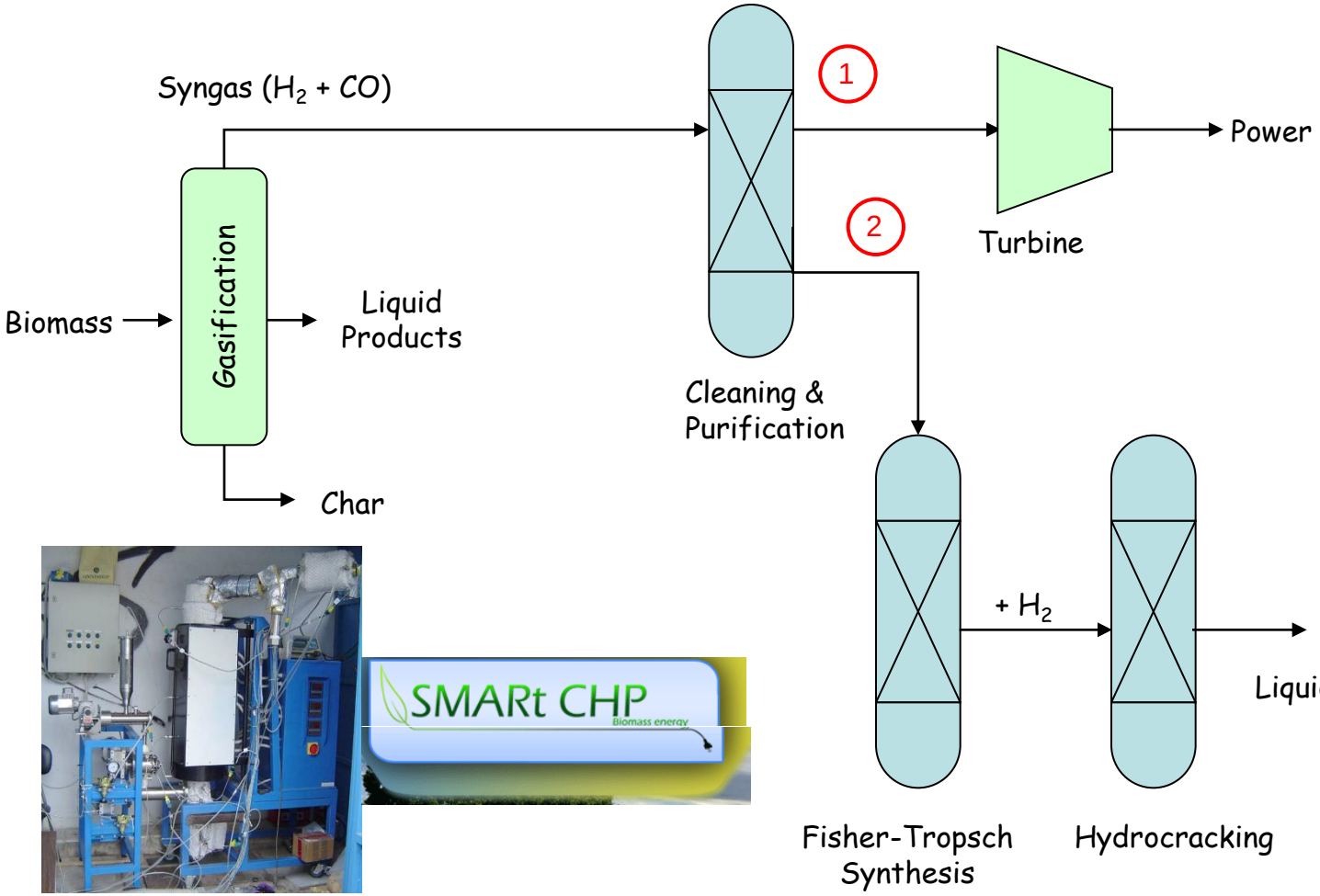


Thermochemical Conversion



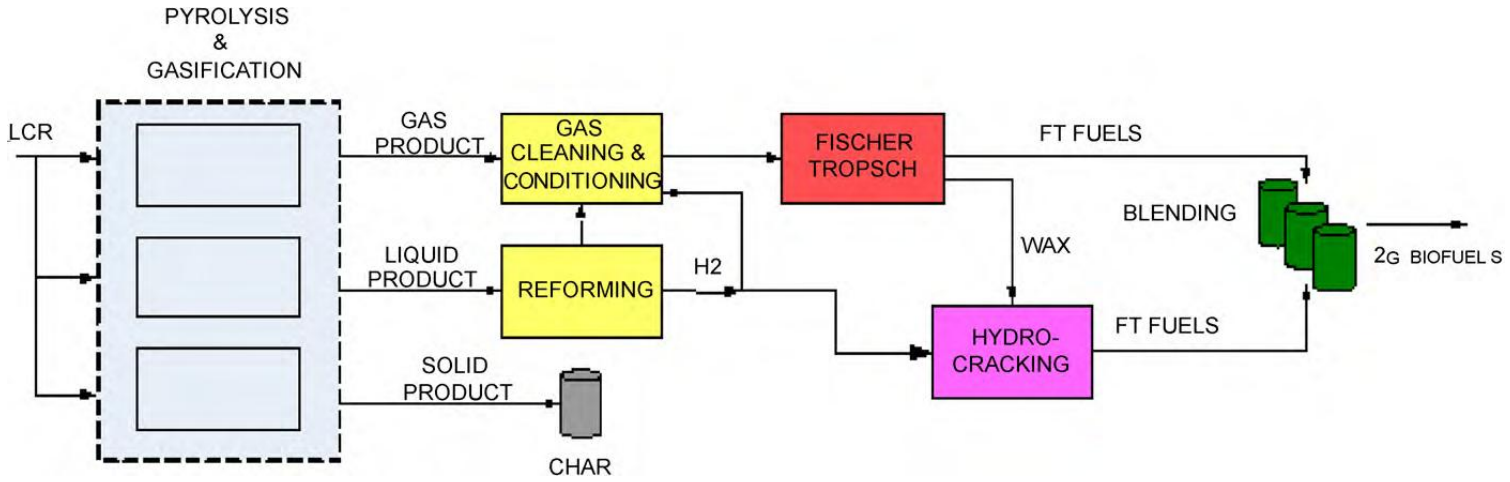






Pilot Fluidized Bed Gasification Unit ($5kW_{th}$)

Optimal Design Strategy



In general, optimal design involves the solution of the following problem:

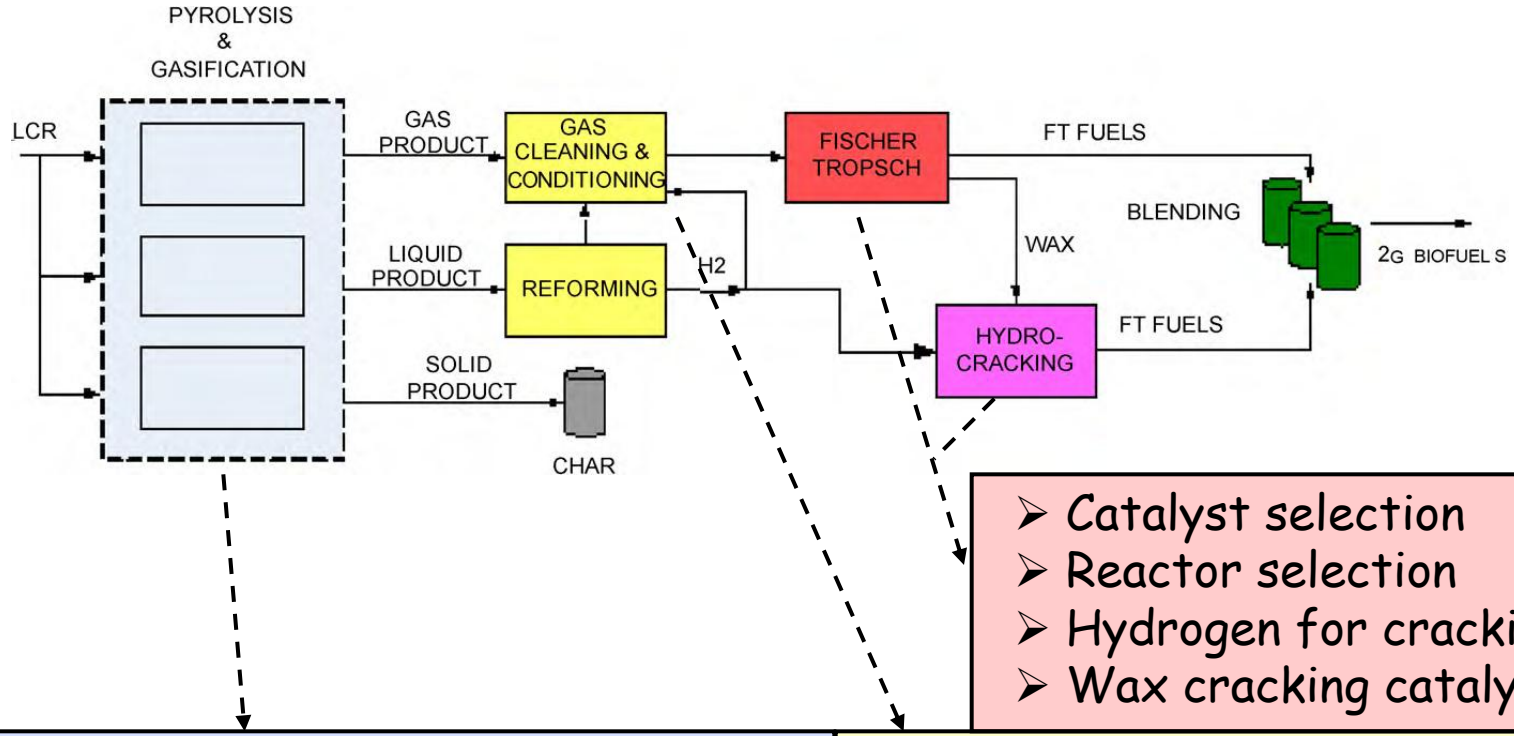
Min $f(\mathbf{x},e)$ where f an objective function

s.t. $g(\mathbf{x},e) = 0$ x the vector of design variables

$h(\mathbf{x},e) \leq 0$ e the vector of model parameters

$\mathbf{x}^l \leq \mathbf{x} \leq \mathbf{x}^u$

Optimal Design Strategy



- Catalyst selection
- Reactor selection
- Hydrogen for cracking
- Wax cracking catalysts

- Type of gasifier
- Use of air or H_2O
- Selection of catalysts to promote tar cracking
- Desirable H_2/CO ratio

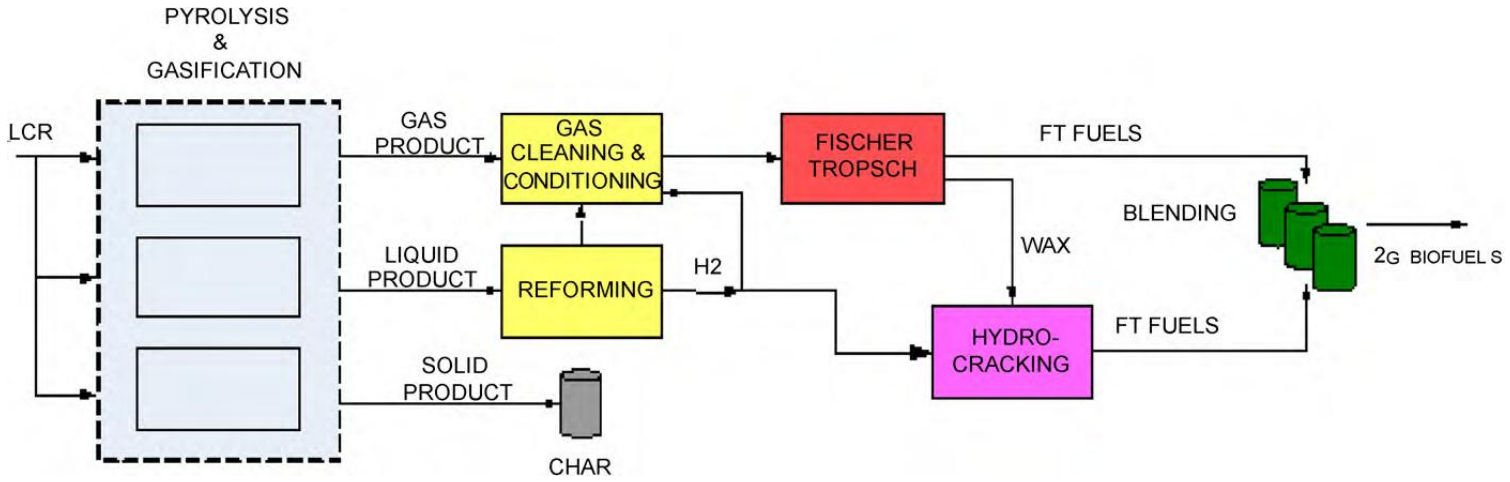
- Hot/Cold cleaning
- Filter selection
- Sorbent / membrane selection
- Cleaning specifications

Optimal Design Strategy





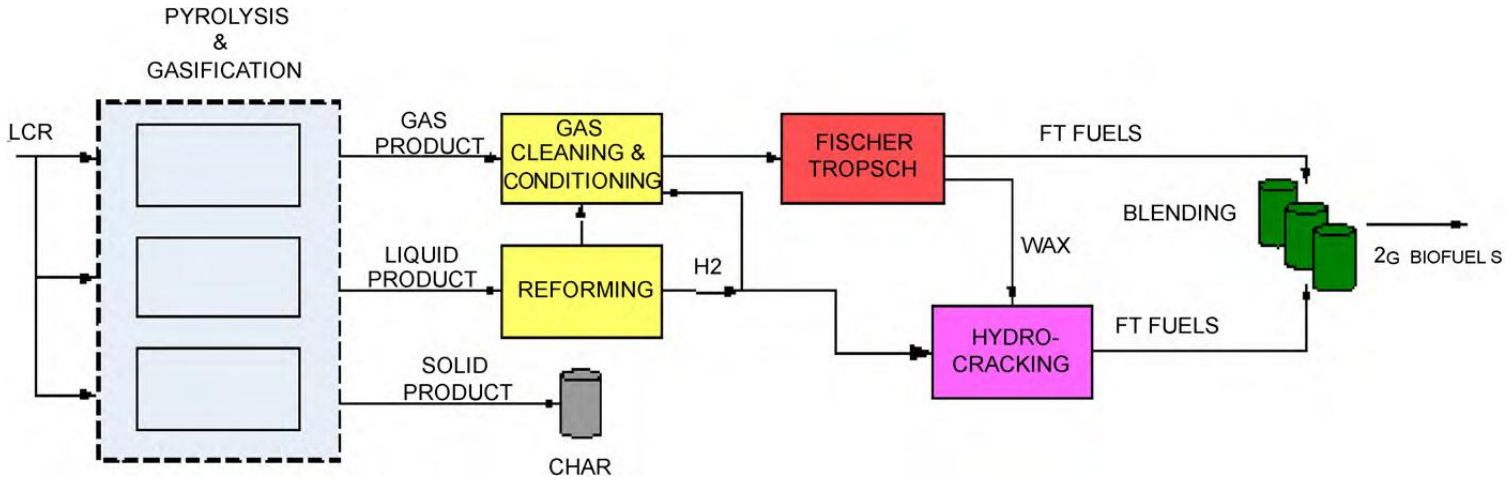




Due to the multiple interactions between the processing steps:

- Important decisions concerning major parameters must be taken
- Process integration (material and heat) must be considered
- Process modeling tools are necessary for the exploitation of all the possible interactions

Process integration possibilities



Process integration possibilities include:

- Tar cracking inside the gasifier
- Use of a liquid reforming step
- F-T wax hydrocraking & blending of the product with biofuels
- Use of H_2 from reforming in wax cracking reactor

Conclusions







The aim of this presentation was to:

- Show the use of biofuels and their key production technologies
- Indicate their role as a sustainable energy technology
- Point out the need for "green" energy alternatives
- Stress the need for efficient design of biofuel processes and demonstrate the complexity

Thank you for your attention!