



**INSTITUTO  
DOM LUIZ**



# Syngas Biorefinery

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**Ciências  
ULisboa**

# Converting Biomass to Energy

Biomass sources for energy include:



## Wood and wood processing wastes

Firewood, wood pellets, wood chips, lumber/furniture mill sawdust and waste and black liquor from pulp and paper mills



## Biogenic materials in municipal solid waste

Paper, cotton, wool products, food, yard and wood wastes



## Agricultural crops and waste materials


Corn, soybeans, sugar cane, switchgrass, woody plants, algae and crop/food processing residues



## Animal manure and human sewage

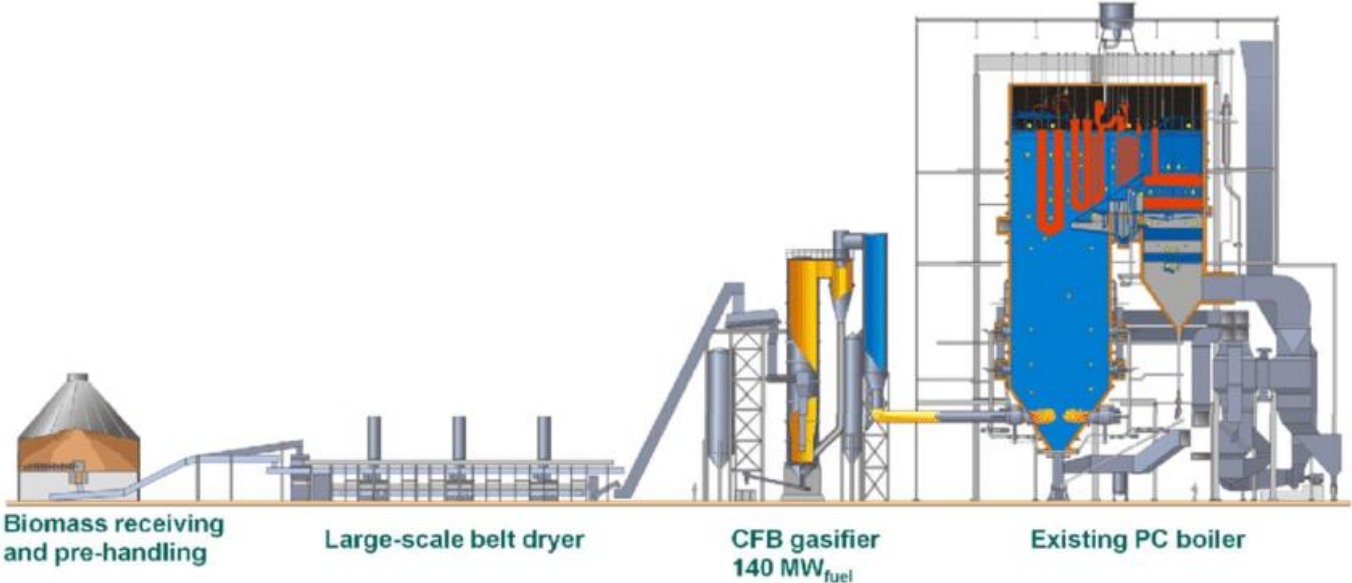
# Thermochemical Biomass Valorization

## Gasification

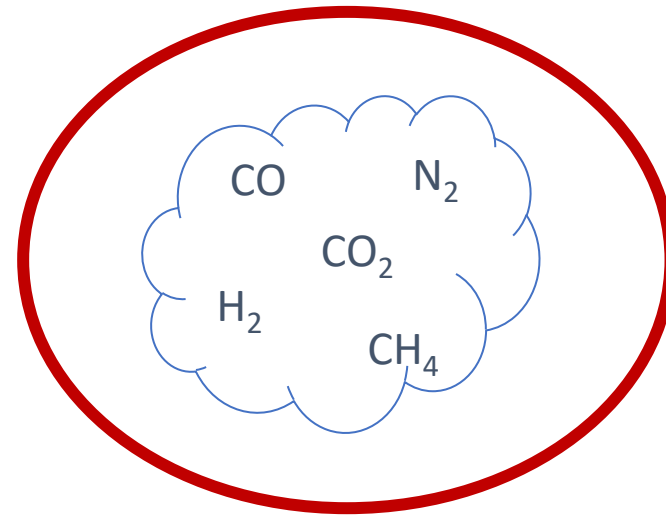
 Organic residues



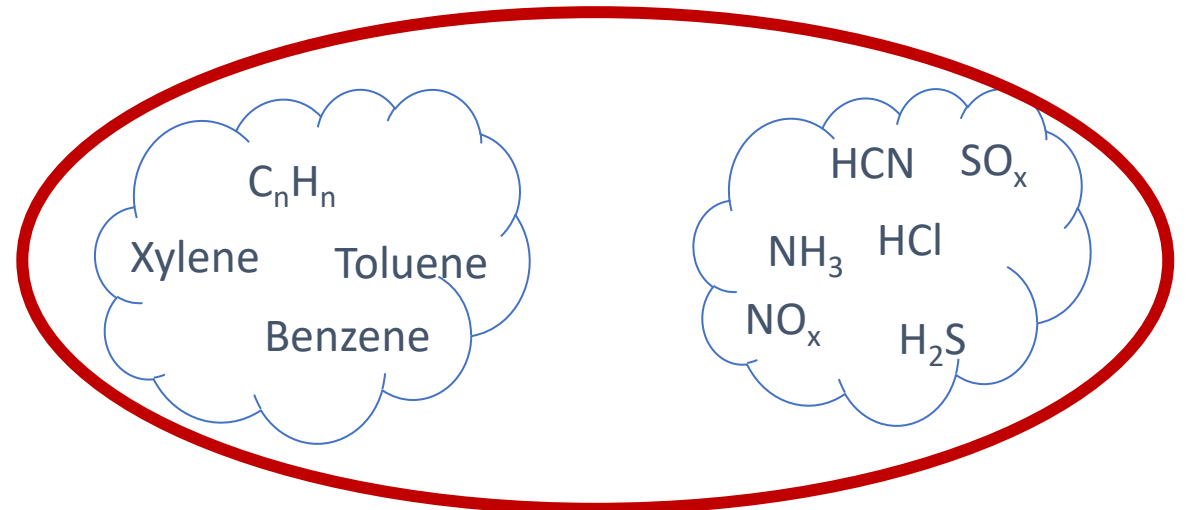
 Electricity



# Syngas



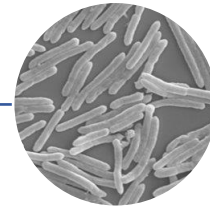
**Main  
components**



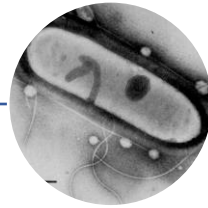
**Hydrocarbons and  
inorganic compounds**

# Syngas Fermenting Microorganisms

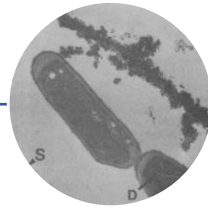
Most used  
microorganisms  
for syngas  
fermentation



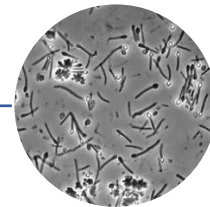
*Clostridium  
carboxydivorans*



*Clostridium  
ljungdahlii*



*Butyribacterium  
methylotrophicum*



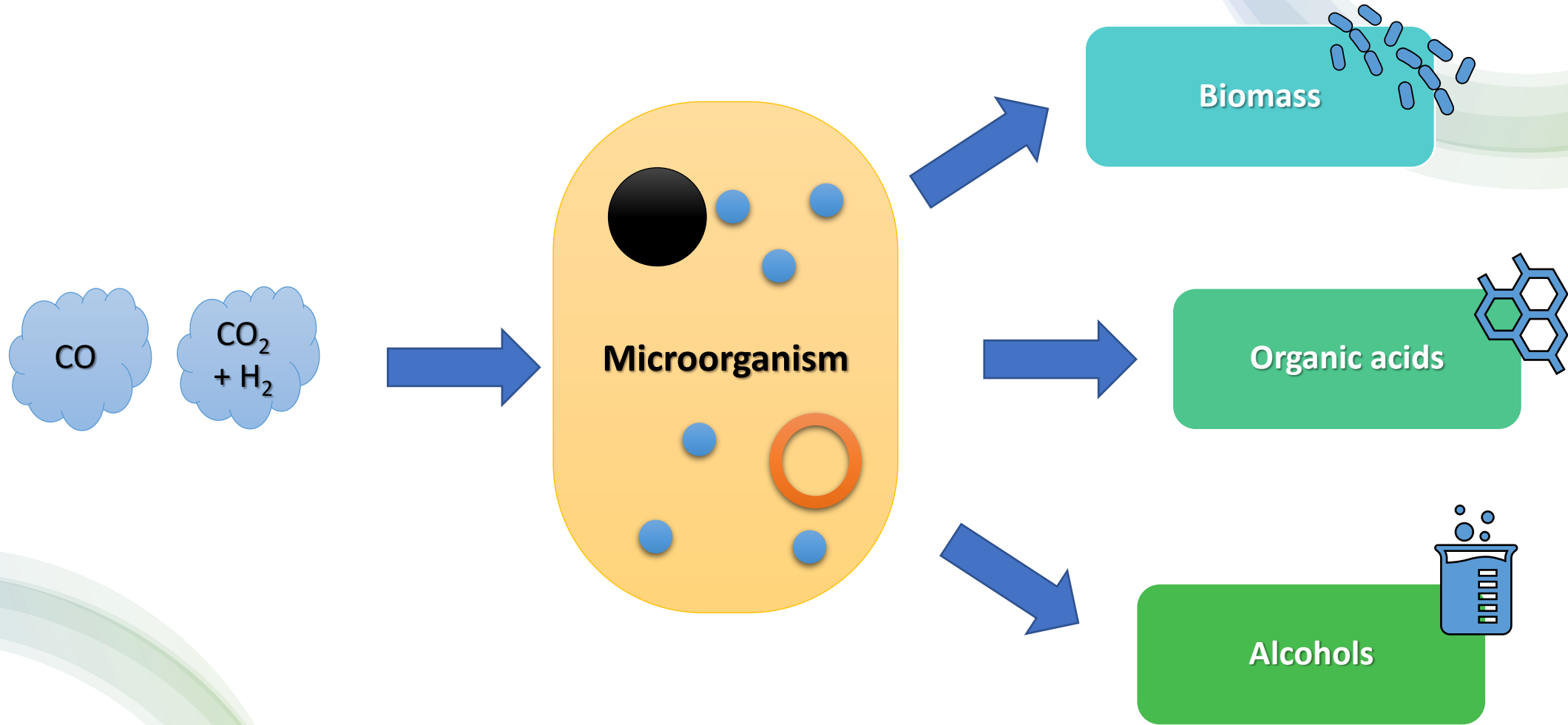
*Morella  
thermoacetica*

Ethanol

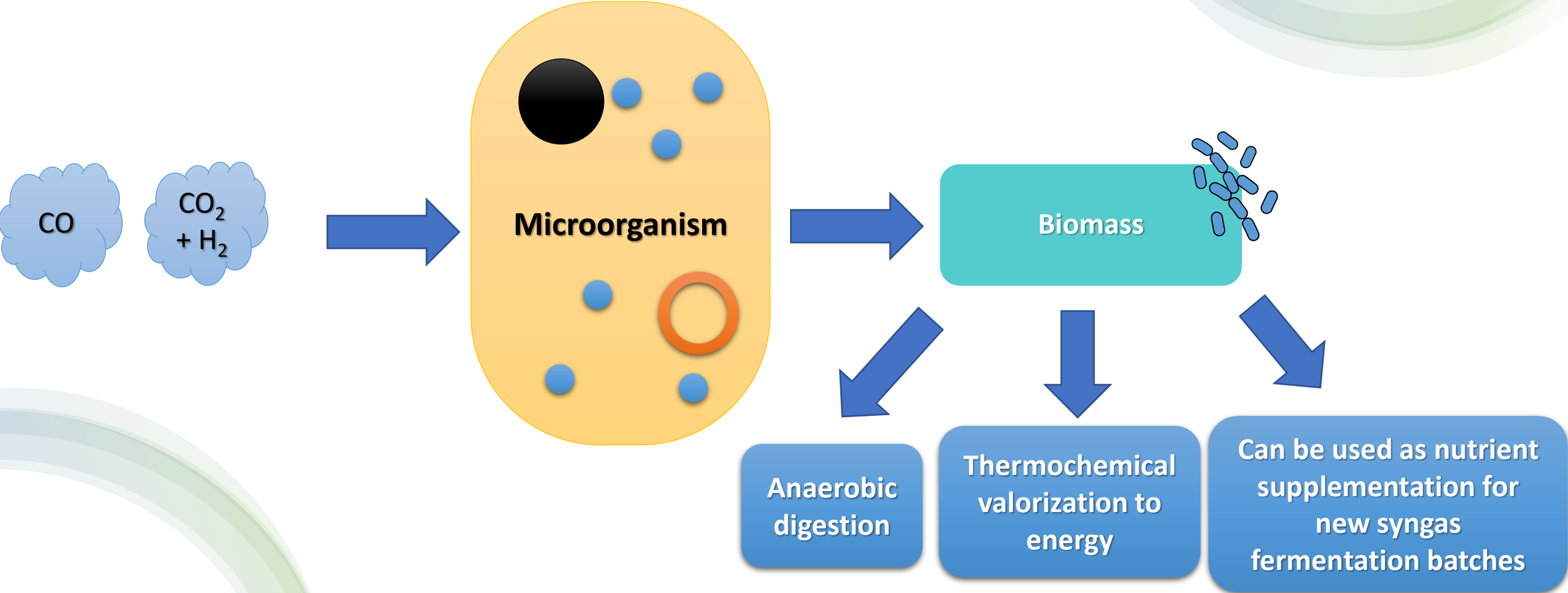
Organic acids:

- Acetic acid
- Butyric acid

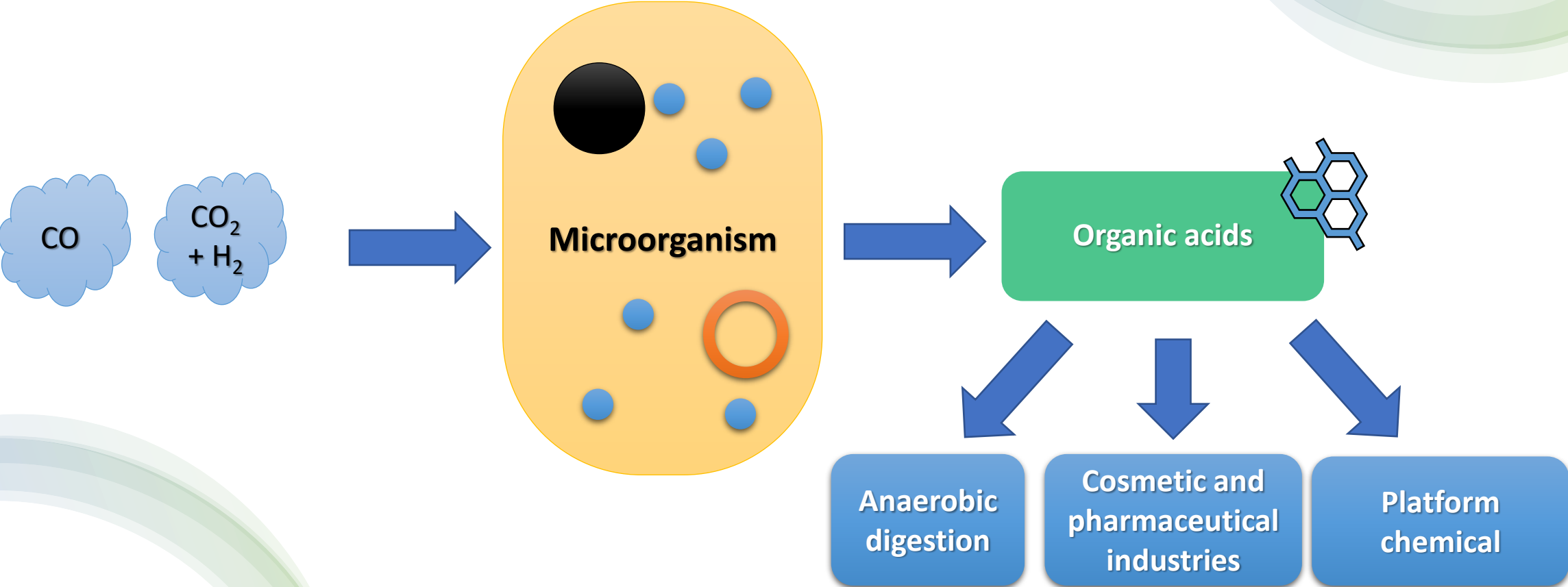
# Syngas Fermentation



# Syngas Fermentation: Product Valorization

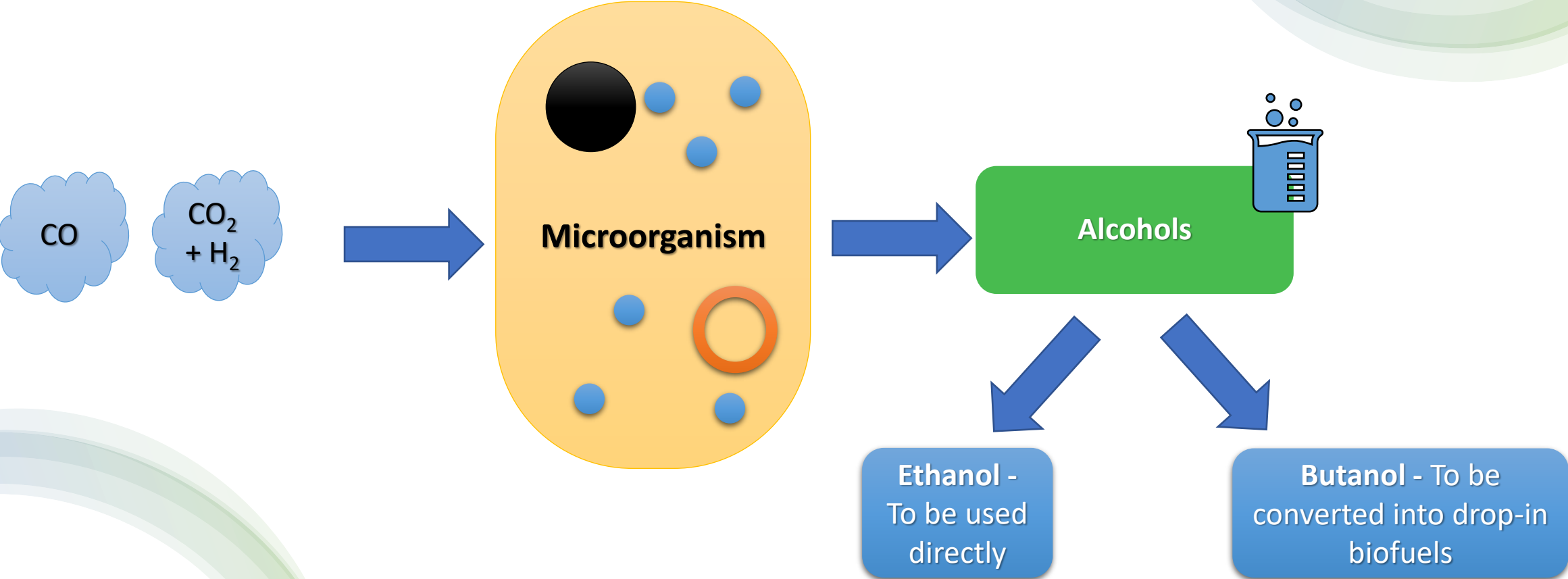


# Syngas Fermentation: Product Valorization





# Syngas Fermentation: Product Valorization



# Other Applications

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This technology can be applied on any carbon rich gas streams from:

- Cement and concrete factories
- Metallurgy
- Power plants
- Furnaces

# Syngas Fermentation

## Advantages

- Reduce carbon emissions
  - Conversion of pollutant gases into biofuels
- Not dependent of high temperatures or expensive metal catalysts
- Brings further value to the overall process due to high added value byproducts
- Great potential for adaptation to other gas producing technologies

## Bottlenecks

- Mass transference issues
  - Low solubility of the main syngas components on the liquid fraction
  - Optimization of bioreactor design
- Tests with “real” syngas
  - Influence of impurities on the cells
  - Optimization of fermentation parameters
- Low Technological Readiness Level (TRL)
  - Gasification and pyrolysis are already implemented at an industrial level

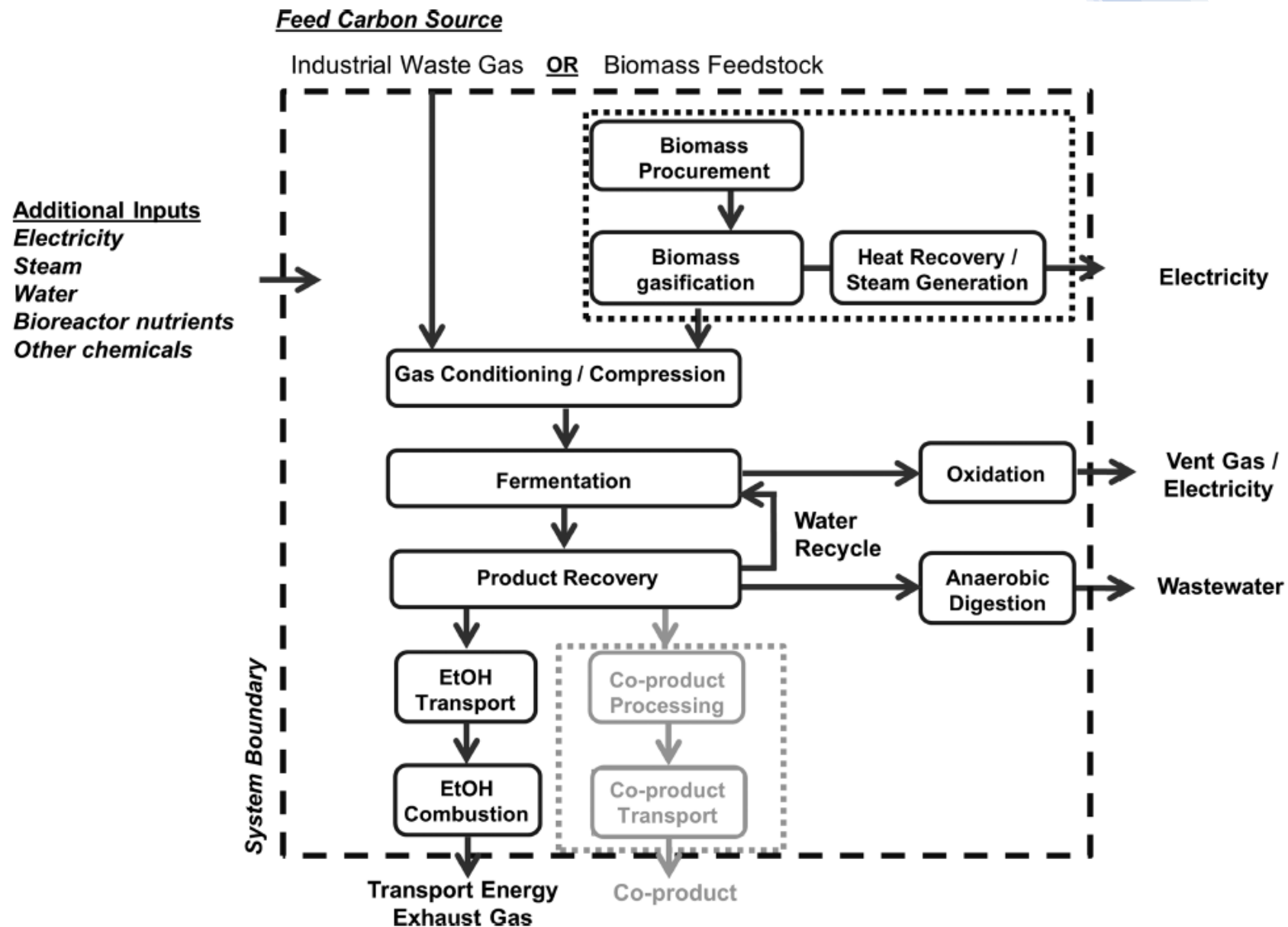


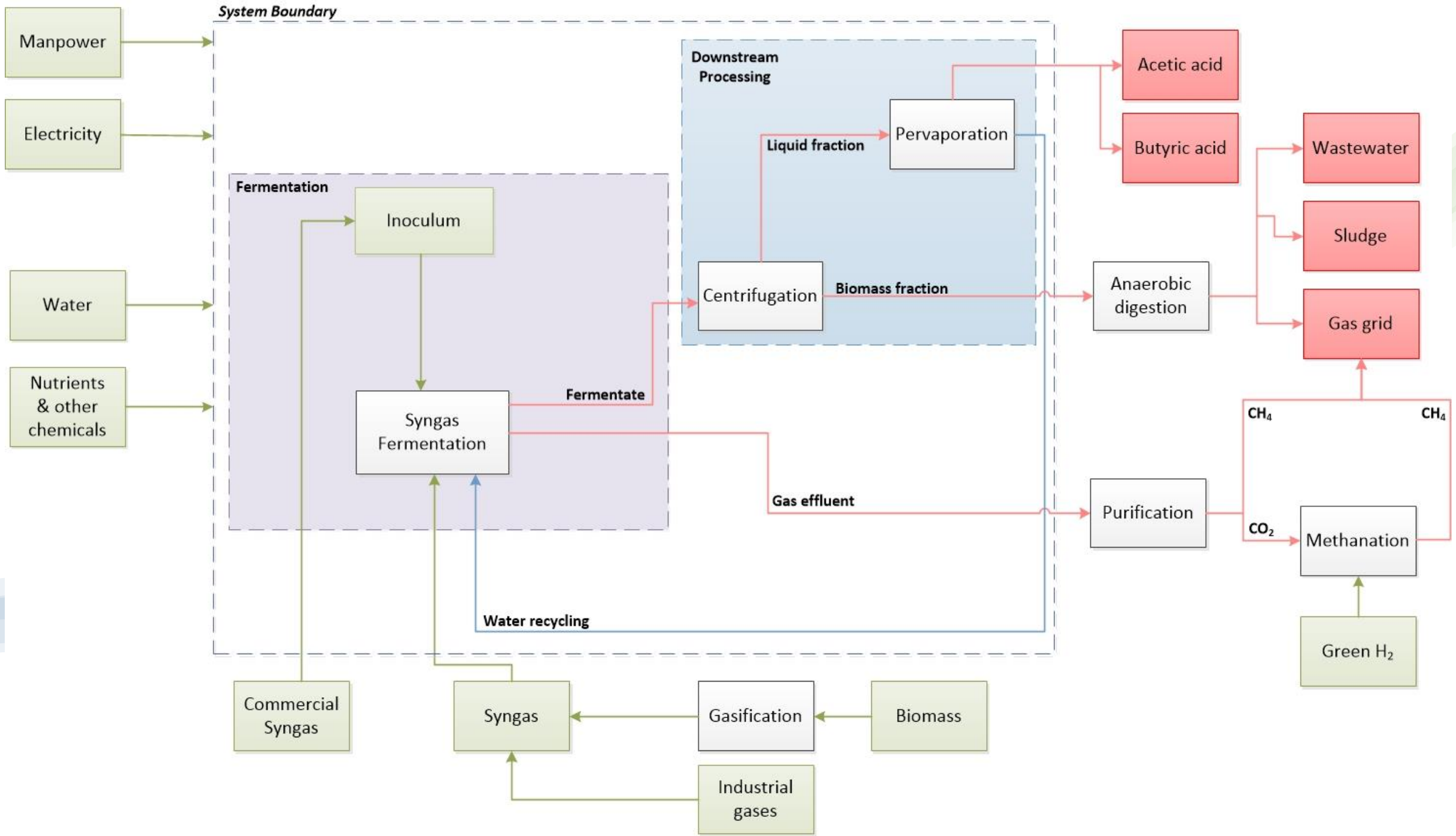


# Integrated Biorefinery - LCA



# Integrated Biorefinery - LCA







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# Thank you for your attention!

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