Hydrothermal gasification of seaweed: a promising technology to biofuels production

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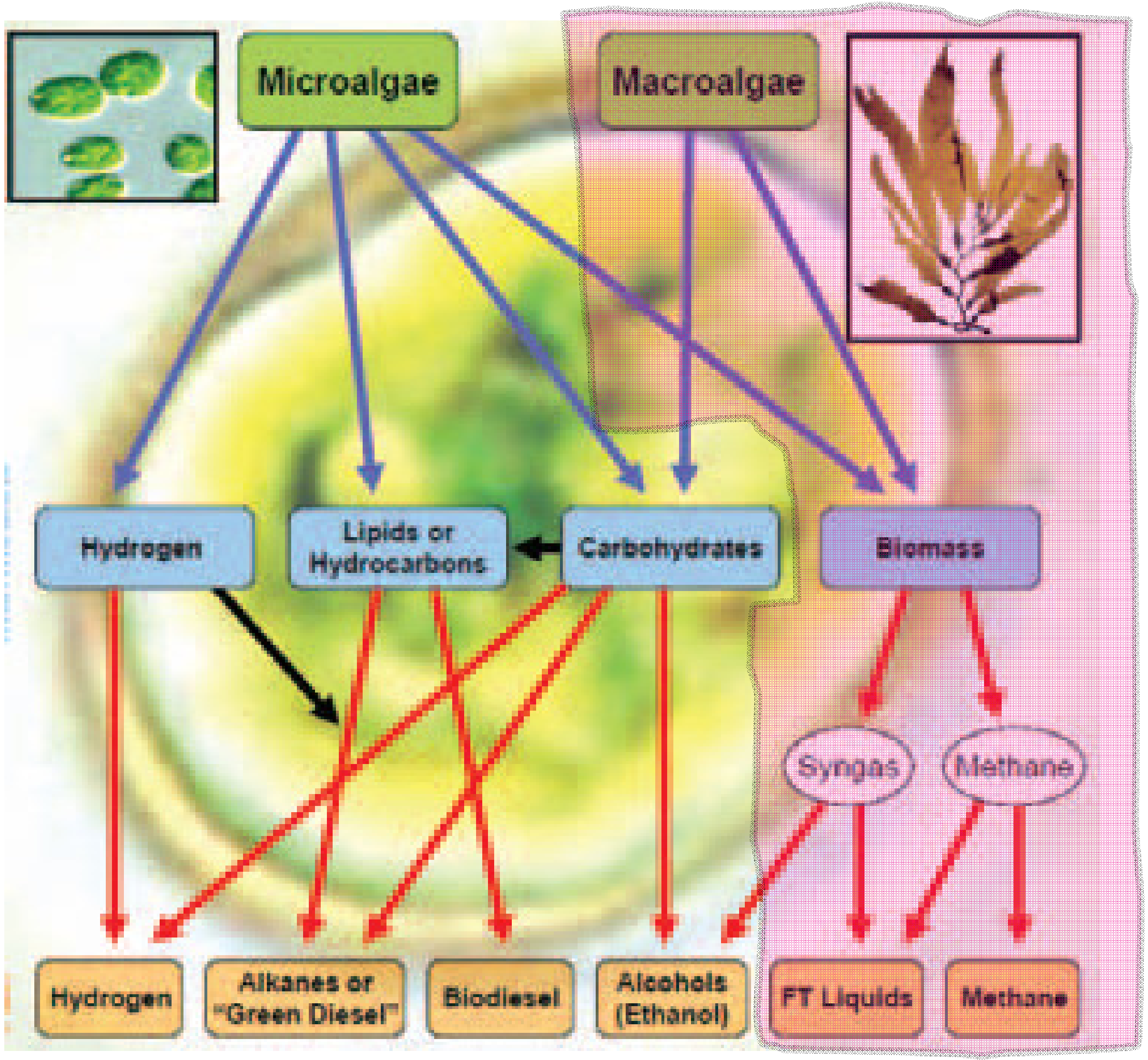
Adopted from University of Karachi, Pakistan

Algal bioenergy conversion routes

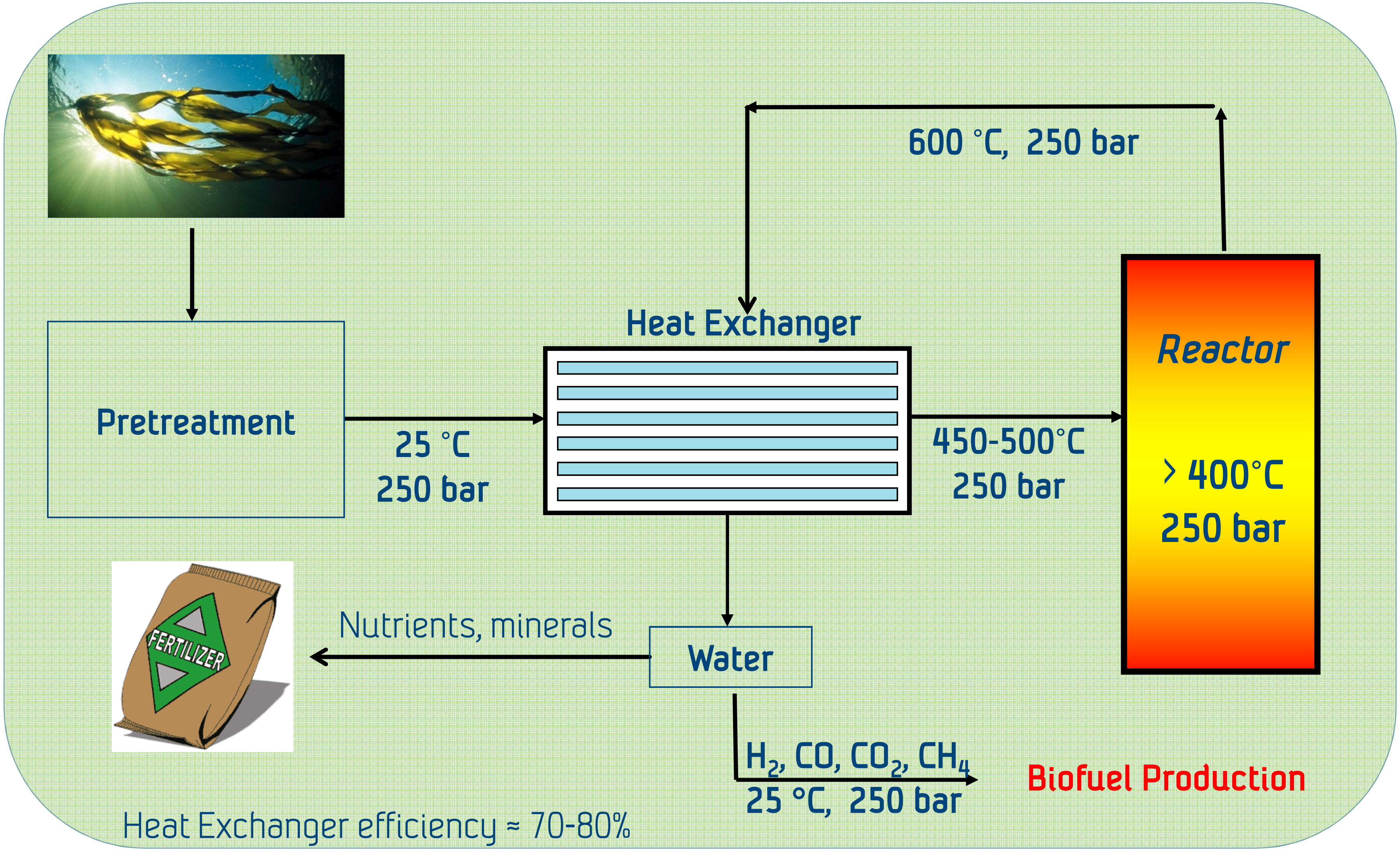


Darzins, A. 2009. The promises and challenges of algal derived biofuels

Why seaweed to biofuels?

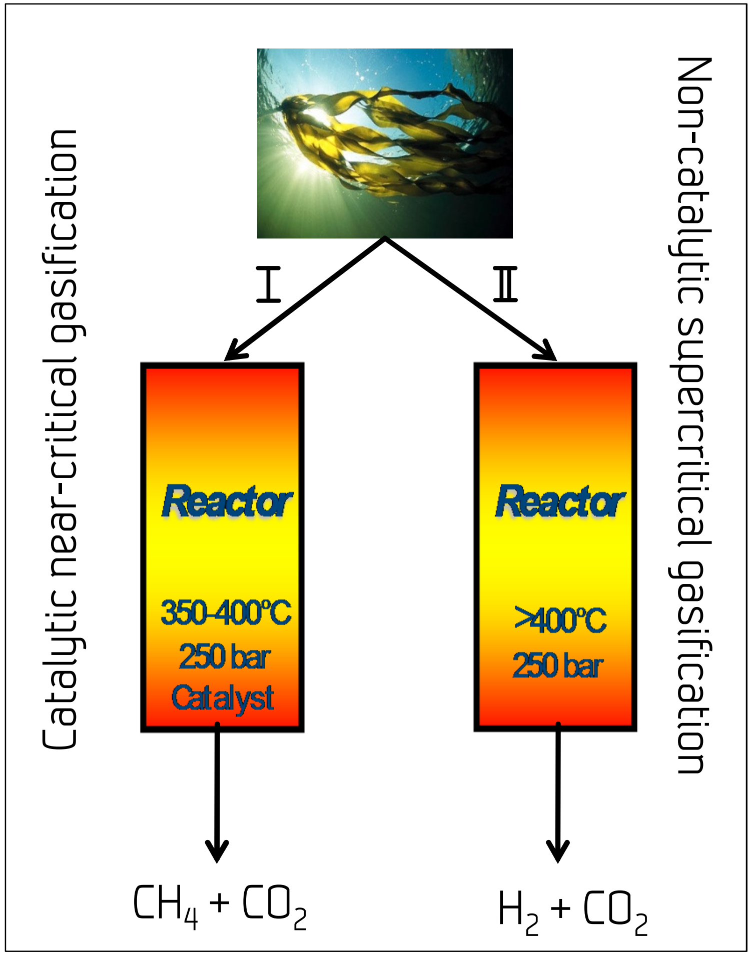
- No competition with food production or land use
- No need for fresh water
- Simple operation
- Recycling of nutrients – transferring P from seawater to land – eliminating P shortage on land if residues are used as fertilizer
- CO_2 removal from the seawater which is essential to protect the cold-water coral eco-system.
- Sea cleaning at fish farming facilities: Salmon needs high-N feed, but most of the N is emitted back to the water. Macroalgae grow faster when having access to N.
- Domestic grown biomass in Norway

Hydrothermal gasification of seaweed



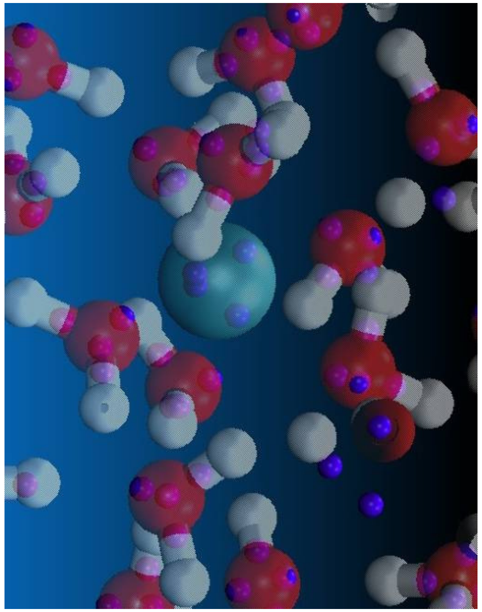
Types of hydrothermal gasification

- ***Catalytic near-critical gasification***
  - T~350-450°C: liquids phase or supercritical gasification
  - Heterogeneous catalyst
  - $C_xH_yO_z \rightarrow CH_4 + CO_2$
- ***Non-catalytic supercritical water gasification (SCWG)***
  - T~ 600-650 °C):
  - Non-catalytically
  - $C_xH_yO_z \rightarrow H_2 + CO_2$



Importance of water

- It is necessary in a rather high content as it acts as a **solvent**
- It is needed for the water-gas shift reaction, being a **reactant**
- It suppresses tar and coke formation by solvation and dilution
- It accelerates depolymerization of cellulose and hemicellulose by hydrolysis, breaking down the whole biomass structure very rapidly. It acts as a **catalyst**
- Under supercritical conditions, water is a good **medium** for free radical reactions, which are the ones required for forming gases



Biofuels, Bioprod. Bioref., 2 (2008) 415-437

Advantages

- **No drying** of wet biomass is needed. Therefore, the energy for water evaporation are not needed.
- Practically all carbon present in seaweed can be converted resulting in **high carbon conversion** rate .
- **Fast conversion** as compared to other routes
- **CO_2 is easily separated** from the gas product because it is much more soluble in water at high pressure and ambient temperature than CH_4 and H_2 → **gas phase with high heating value**

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Advantages

- The **product gas is pressurized** and that is very important for the downstream processes and CCS technologies.
- **High solubility** of the intermediates in the reaction medium **inhibits tar and coke formation** → high gas yields at relatively low temperatures
- Allows for **nutrients and/minerals recovery** → fertilizers
- The use of an efficient counter-current **high-pressure heat exchanger** between the feed streams and the reactor effluent can result in high thermal efficiencies, allowing us to process low energetic aqueous (waste-) streams

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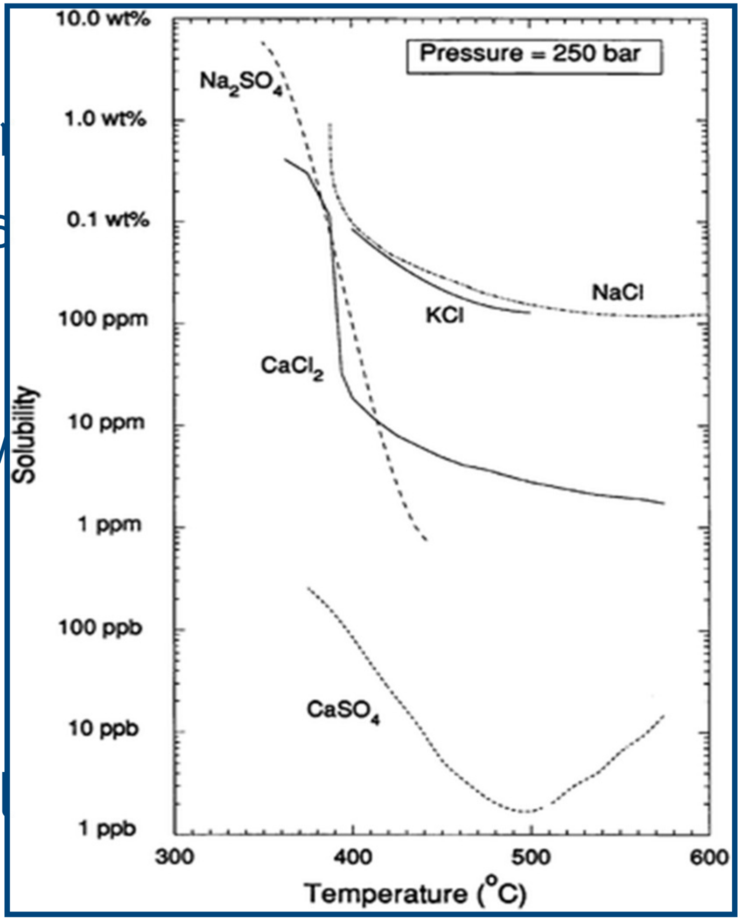
Challenges

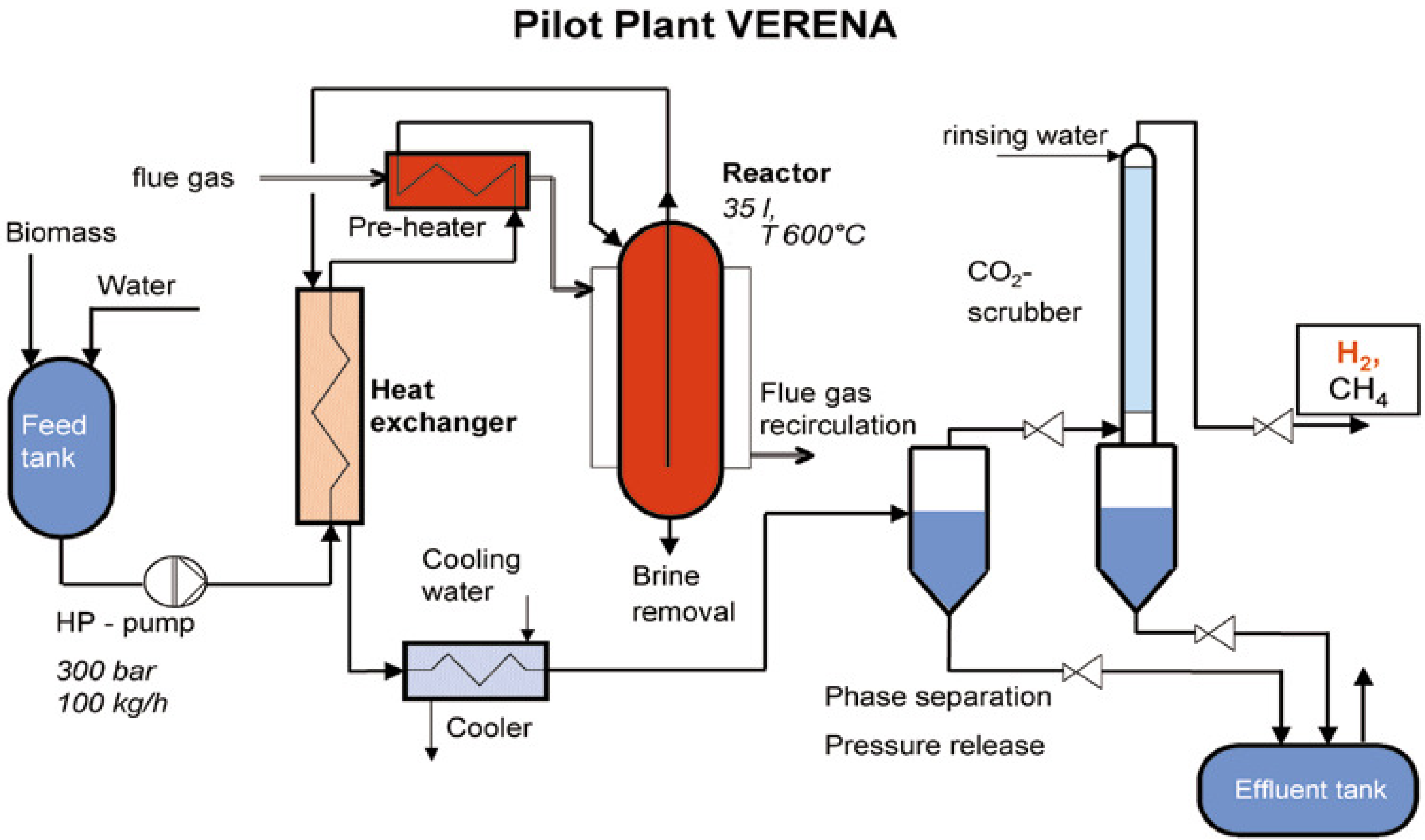
- **Corrosion** due to the high pressure
  - special alloys are required as a constr
  - The reactor walls may become cata interpretation of data
- **Deposition of char/coke** on the reactor w exchanger
- **Catalyst deactivation**
- **Salts precipitation** due to the low solubil



State-of the art

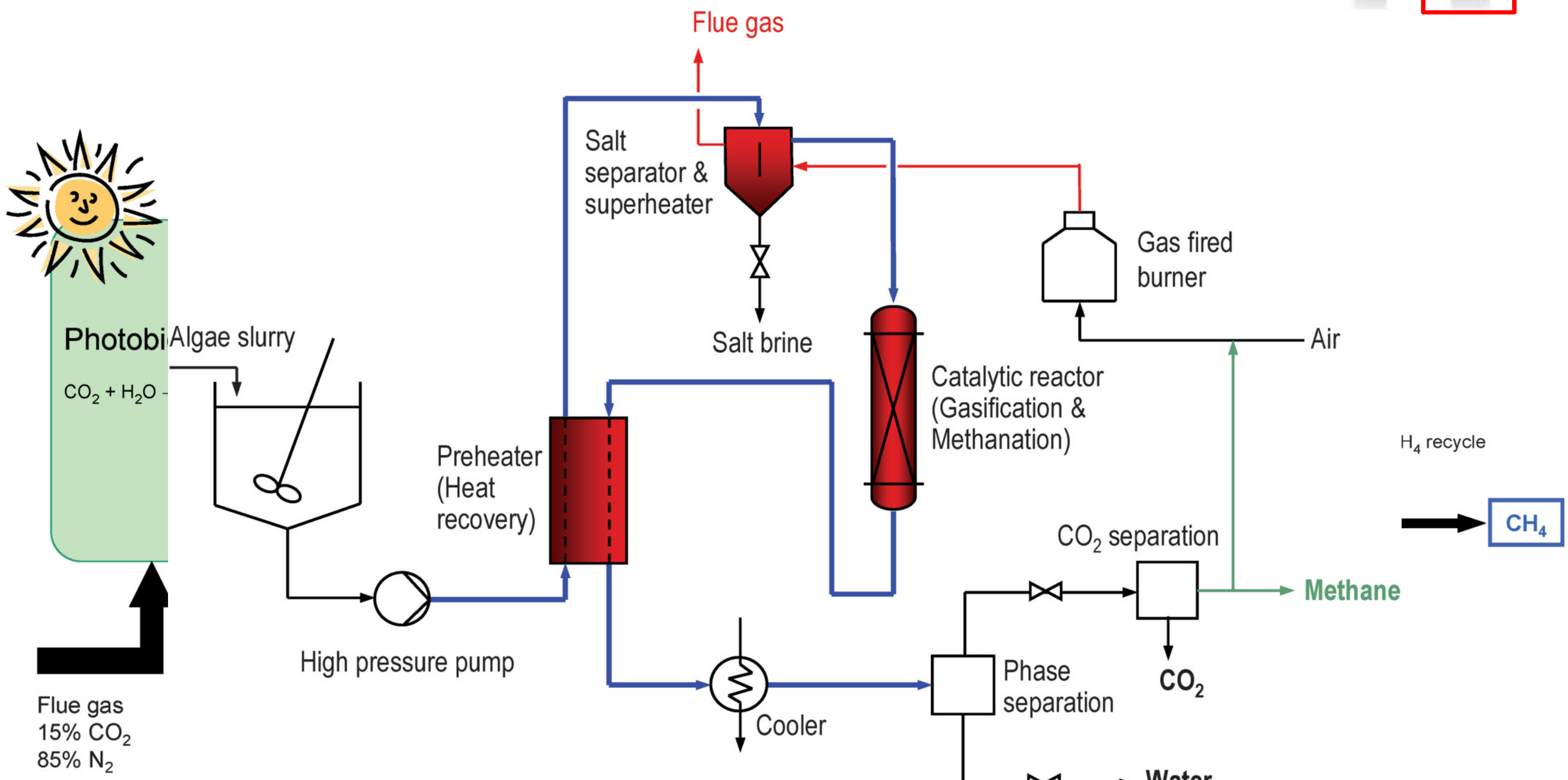
Feedstock	Location
Tabacco stalk, corn stalk, cotton stalk, sunflower stalk, corncob, oreganum stalk, chromium-tanned, waste and vegetable-tanned waste	Kalrsuhe (Germany)
Microalgae, glycerol	Twente University (The Netherlands)
Corn- and potato-starch gels, wood sawdust suspended in a cornstarch gel, potato wastes, bagasse	University of Hawaii (Hawaii)
Glucose	Korea Advanced Institute of Science and Technology (Korea), University of Twente (The Netherlands),
Cellulose, Xylan, Lignin	University of Tokyo (Japan)
Cellulose, starch, glucose, biomass waste	University of Leeds (UK)

Karlsruhe Institute of Technology - KIT



http://www.itc-cpv.kit.edu/downloads/boukis-flyer-verena.pdf

Paul-Scherrer Institute - PSI



Stucki et al. Energy and Environmental, 2009, 2, 535-541

Twente University

- Example of supercritical gasification (microalgae)

$$\xrightarrow[P \geq 220\ \text{bar}]{T \geq 374\ ^\circ C} H_2, CO, CO_2, CH_4, C_2\text{-}C_3$$

  - Composition of the product gas (% of DM)

	Algae
H_2	7
CO	22
CH_4	25
CO_2	26
C_2-C_3	20

T= 600 °C

P = 240 bar

Algae dry matter content = 7.3%

Carbon to gas conversion = 53%

Catalytic carbon to gas conversion ≈ 90%

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Adopted from University of Karachi, Pakistan