Life cycle assessment of the biofuel production from lignocellulosic biomass in a hydrothermal liquefaction – aqueous phase reforming integrated biorefinery

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Could biofuel be a possible solution for the decarbonization of trucking, shipping and aviation?

WET biomass

BIOCRUDE

Aqueous phase

Gas phase

Solid phase

Needs valorization! Because of low concentration of carbon (0.4-2 wt C%) and expensive wastewater treatment

Needs upgrade! Because of high heteroatoms content

Catalytic hydrogenation: need of GREEN hydrogen
Aqueous phase reforming (APR)

APR is a catalytic reaction able to **produce** hydrogen starting from oxygenated hydrocarbons dissolved in water, working at **mild pressure and temperature** directly in the liquid aqueous phase.
Methodology

Our feedstocks

Corn stover (CS)

Generally left on the field after corn harvesting as soil nutrient

RESIDUE

Lignin-rich stream (LRS)

By-product of a 2nd generation bioethanol plant

No value → WASTE
Methodology

Integration of HTL and APR

Fresh feed

Feed → HTL → Bio-crude

Gas phase

HTL → Bio-fuel

External H₂

H₂

APR

Aqueous phase

Recycle

Purge
Are we sure that it is environmentally sustainable?

**Life Cycle Assessment**
ISO 14040 and 14044

LCA is an objective tool for analyzing and quantifying the environmental consequences of products (services) during all their life-cycle, from the extraction of raw materials, through industrial production, including the use phase and the end-of-life disposal.
Methodology

LCA of biofuel from CS

Functional unit: 1 MJ of biofuel

System boundaries:
Methodology

LCA of biofuel from LRS

**Functional unit:** 1 MJ of biofuel

**System boundaries:**
Methodology

Different ways to assess biogenic carbon

- **“0/0 approach”:** neither the uptake nor the release of biogenic carbon is considered in the calculation of impacts for the global warming potential.

- **“–1/+1 approach”:** the uptake of biogenic CO₂ carbon is considered an environmental credit, while the release is considered an environment burden, with the same impact factor of fossil carbon.

- **Dynamic approaches** based on time-dependent characterization factors.
Impact results

**Global warming potential**

0.06 kg CO₂ eq. for LRS
0.05 kg CO₂ eq. for CS

**Fossil resource depletion**

0.68 MJ for LRS
0.68 MJ for CS
Impact results

**Acidification potential**
- 474 mg SO2 eq. for LRS
- 709 mg SO2 eq. for CS

**Eutrophication potential**
- 23 mg PO4 for LRS
- 69 mg PO4 for CS
Sensitivity analysis

The non-biogenic nature of biomass

The cumulative GWP increased from 59.7 to 114.6 g CO2 eq./MJ biofuel (+92%)

The cumulative GWP increased from 50.3 to 99.9 g CO2 eq./MJ biofuel (+98%)
LCA GWP results

Comparison of global warming potential between HTL-APR and alternative biotecnologies (1 MJ) and HTL-APR (base) and HTL-APR (hydropower).

GWP results (g CO₂ eq./MJ):
- HTL-APR (base)
- HTL-APR (hydropower)
- Fermentation
- Gasification
- Pyrolysis
- Fossil diesel

Bars show GWP results with different technologies.
THANK YOU
FOR YOUR ATTENTION

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