



# Life cycle analysis using Argonne GREET model of algae based biofuels produced utilizing flash hydrolysis process



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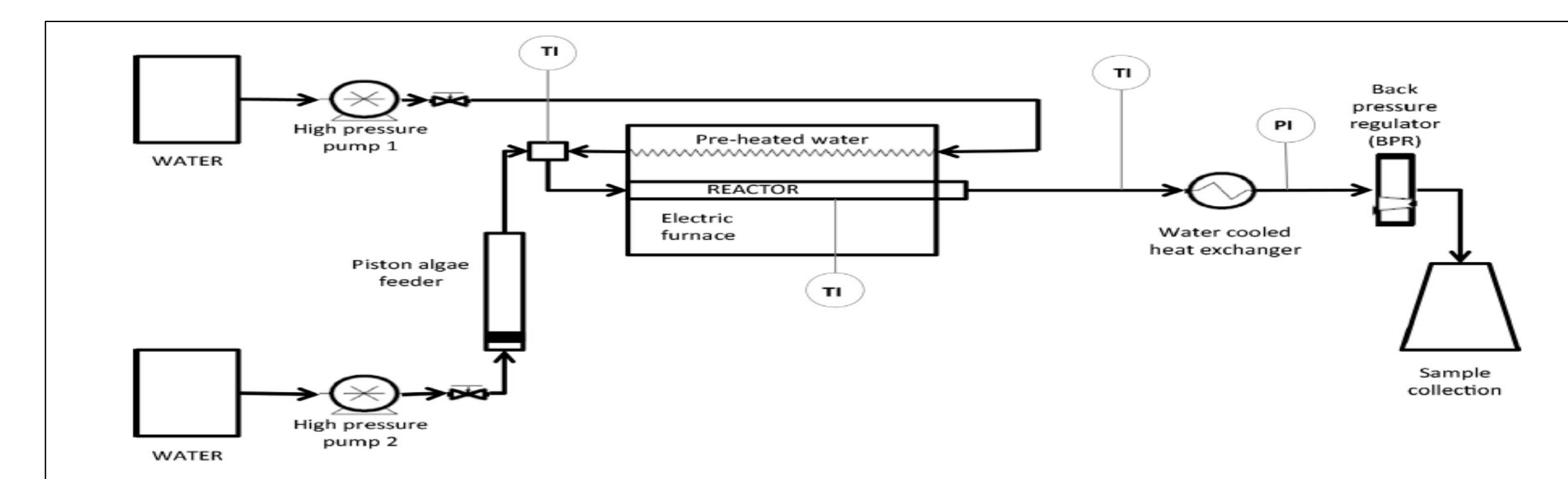
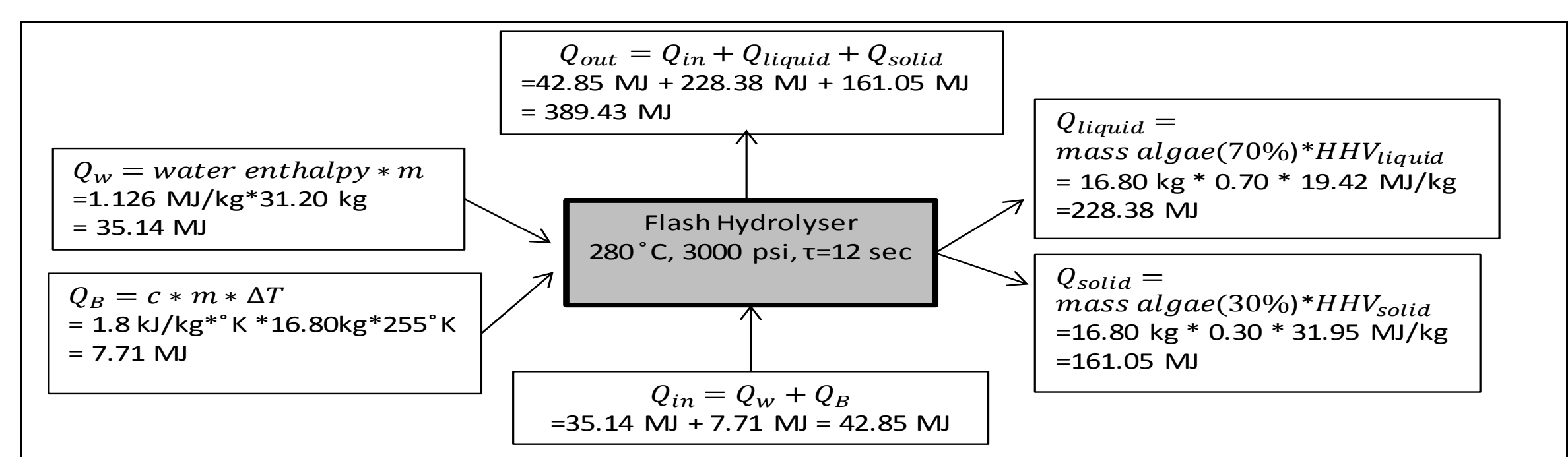
## Abstract

Traditional processing methods of algae to biofuels require dewatering after harvesting of the algae before the lipids can be extracted. This is typically the most energy intensive and therefore the most expensive step. Old Dominion University has successfully utilized a flash hydrolysis process where proteins are solubilized into the liquid phase of product and the remainder lipid-rich, low nitrogen product is separated into a solid phase. The GREET model was used to quantify the LCA from WTW production of biodiesel, renewable gasoline, and renewable diesel II utilizing the flash hydrolysis process. Results were compared with existing model simulations from their algae Harmonization study and algae HTL study and also with existing conventional petroleum based reformulated gasoline (RFG) and conventional petroleum based low-sulfur diesel (LSD) LCA's.

## Introduction

- Argonne National Laboratory has developed the Algae Process Description (APD) to be used in conjunction with the Greenhouse Gases, Regulated Emissions, and Energy Use in Transportation (GREET) modeling system.
- Covers all 5 life cycle stages:
  1. Feedstock cultivation,
  2. Feedstock transport,
  3. Biofuel production,
  4. Biofuel transport, and
  5. Biofuel end use in vehicles.
- Feedstock cultivation and biofuel production have key stages which interact through the APD:
  1. Nutrient consumption and recycling,
  2. biomass harvesting and drying
  3. Oil extraction
  4. Conversion of oil to fuel
- GREET outputs include total energy use, fossil fuels, natural gas use, coal use, petroleum use and carbon dioxide equivalent green house gases (GHG's).
- Two existing and published models for well-to-wheels algae biofuel production exist, the harmonization study and the hydrothermal liquefaction study (HTL).
- The complete life cycle analysis (LCA) was completed in accordance with ISO 14040:2006 and ISO 14044:2006.
  - Functional unit based on 1 mmBtu of fuel production
  - Comparisons include:
    - ODU algae process biodiesel vs. harmonization biodiesel vs. HTL biodiesel vs. petroleum diesel
    - ODU algae process renewable diesel II vs. harmonization renewable diesel II vs. HTL renewable diesel II vs. petroleum diesel
    - ODU algae process renewable gasoline vs. harmonization renewable gasoline vs. HTL renewable gasoline vs. petroleum gasoline

## Methods & Materials



## Results



## Conclusions

- All algae oil extraction techniques used in the simulations present in this study produce cleaner and greener transportation fuel.
- The biodiesel simulation was closest to achieving total energy consumption equal to its conventional fuel counterpart. This is due to the biodiesel blend only consisting of 20% biofuel. The total energy btu/mmbtu values were 112% for HTL, 133% for the ODU flash hydrolysis, and 138% for the harmonization study when compared to conventional diesel.
- The renewable diesel II simulation had total energy btu/mmbtu values of 147% for HTL, 258% for the ODU flash hydrolysis, and 286% for the harmonization study when compared to conventional diesel.
- The renewable gasoline simulation had total energy btu/mmbtu values of 147% for HTL, 251% for the ODU flash hydrolysis, and 280% for the harmonization study when compared to conventional diesel.
- The energy recovery in the flash hydrolysis process when cooling the subcritical water from 280 °C to 99 °C saves close to 26 MJ per hour. Additional energy savings may be able to be gained by preheating incoming flash hydrolysis water with the 99 °C water through a heat exchanger.
- The liquid phase of the flash hydrolysis process was not evaluated as a coproduct. This is 70% of the reactor product and is rich in proteins and nutrients. Future evaluation of this product in terms of market value may allow for offsetting of costs within the algae processing life cycle.
- Local algae cultivation may be more efficient depending on local growing conditions.

## References

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## Acknowledgements

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- Argonne National Laboratory