Hydrothermal Liquefaction:

A Possible Solution To Alberta's Greenhouse Gas Emissions Crisis

UNIVERSITY OF CALGARY


Jay Upadhyaya
Mechanical Engineering


Chau Le
Natural Sciences


Chijindu Ubani
Natural Sciences


Brian Kim
Natural Sciences


Manvirpal Ghotra
Chemical Engineering

CESAR CANADIAN ENERGY SYSTEMS ANALYSIS RESEARCH

Correspondence:
jupadhya@ucalgary.ca

INTRODUCTION

Alberta's large freight transportation sector consumes 358 PJ/yr and emits 39 $MtCO_2e/yr$, primarily associated with the combustion of diesel fuel [3]. Making drop-in fuels from the 490 PJ/yr of residual biomass produced by Alberta's forestry and agricultural sectors provides one of the few low carbon alternatives for the freight transportation sector [3]. Hydrothermal liquefaction (HTL) of residual biomass is a promising technology that generates an energy rich bio-crude (40 MJ/kg) from residual biomass, which can either be used directly as a marine fuel or be refined to bio-based diesel [4]. This study generates scenario models for HTL production of Alberta's biomass resources to assess the impact on the diesel market in Alberta, the marine market in BC and the systems level greenhouse gas (GHG) emissions.

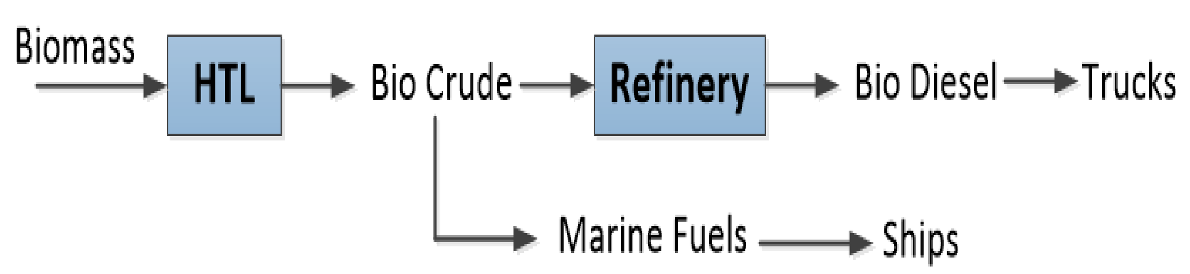


Fig 1. HTL Flow Diagram

METHODS

Assumptions for Scenarios:

- 8 years decay rate of trees
- 50% Carbon content in trees
- 0.4% forest harvested per year
- 50% of Agriculture land harvested per year
- 90% refinery efficiency
- Access to 80% of total forestry residual biomass and 100% of agricultural residual biomass
- Saturate 50% of BC marine bio-crude demand

Conversion factors were obtained from Steeper Energy [4] and whatIf Technologies [3].
Scenario models were created using Canadian Energy System Simulator (CanESS).

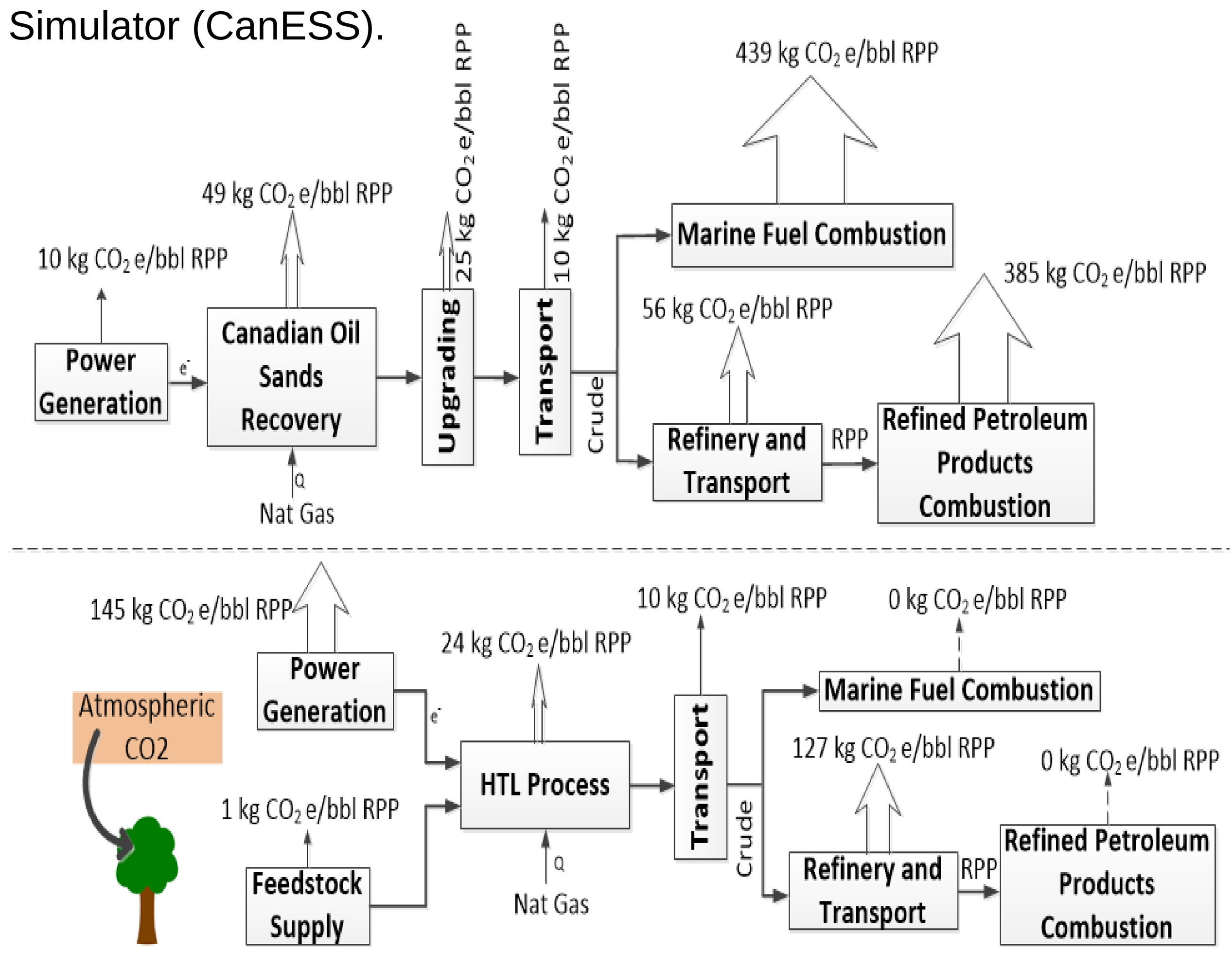
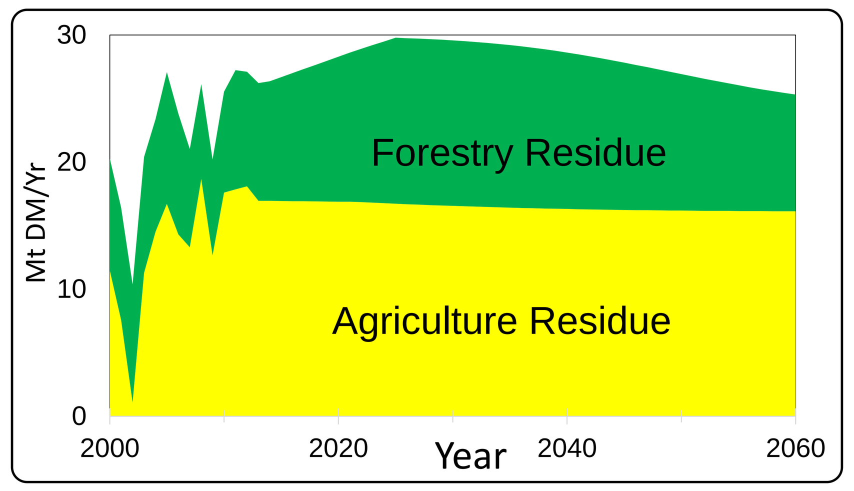


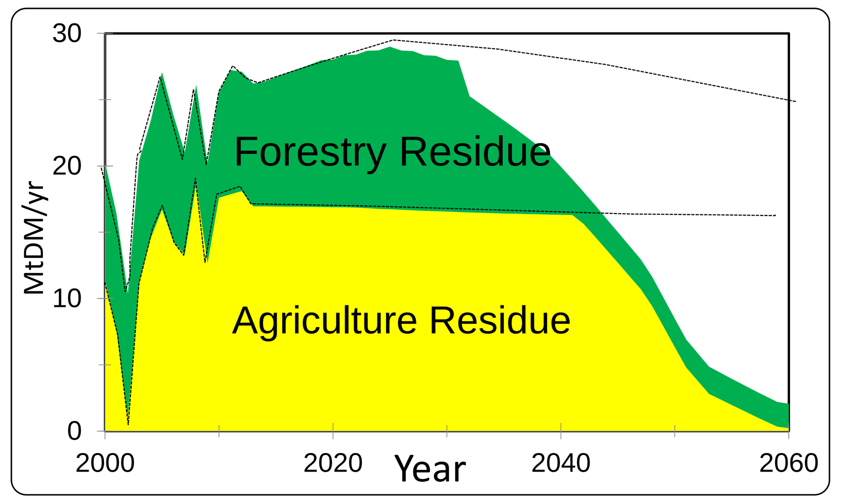
Fig 2. CO_2 Emissions from SAGD and HTL Processes

RESULTS

REFERENCE | ALTERNATIVE

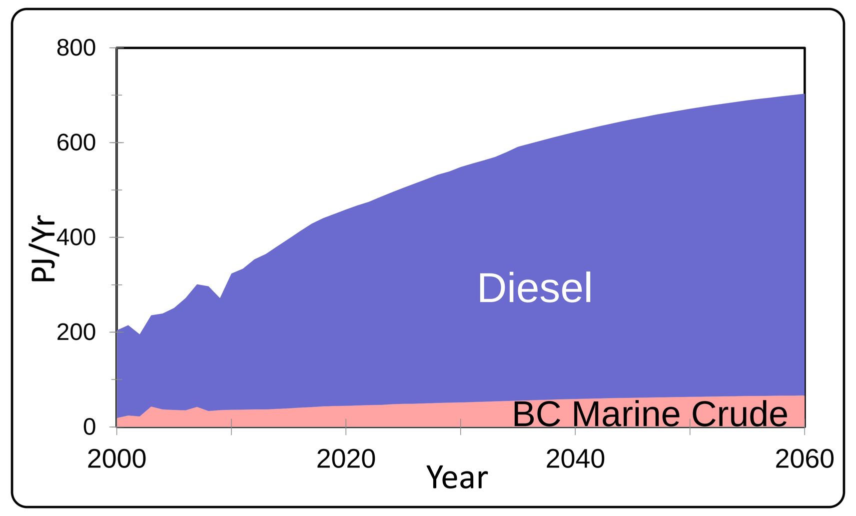
A. Amount of Residual Biomass in AB
Reference amount of biomass in AB compared with the amount of biomass after HTL implementation

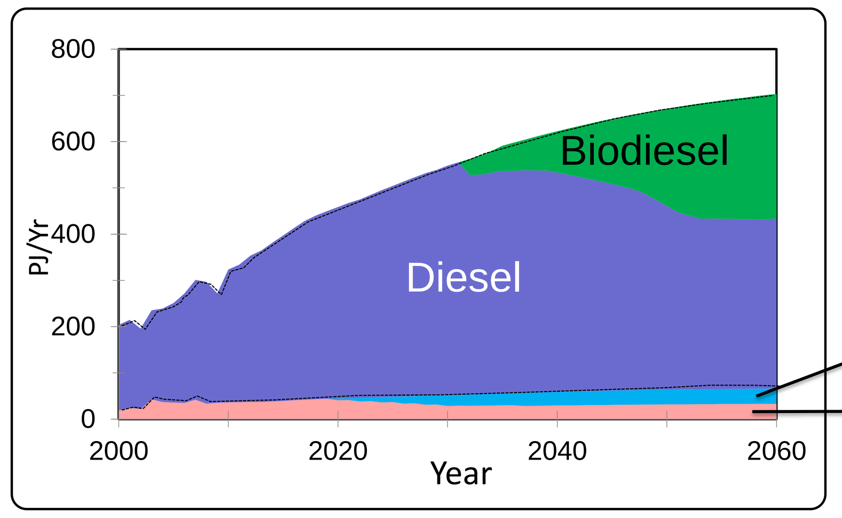




- 27-30 MtDM/yr of biomass is consumed by HTL in 2060 compared to the reference scenario

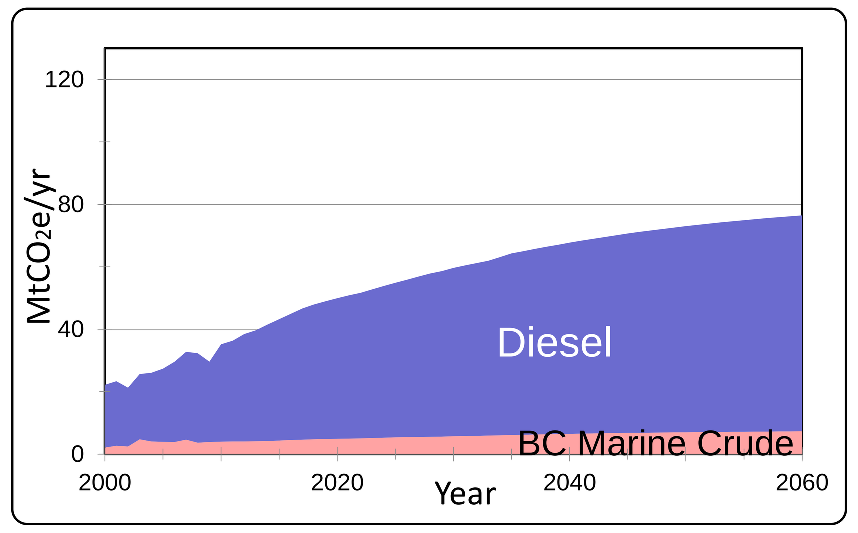
B. Freight Fuels Demand in AB and BC marine market
Comparing the reference scenario demand for diesel and BC marine Crude to the alternative demand after HTL implementation

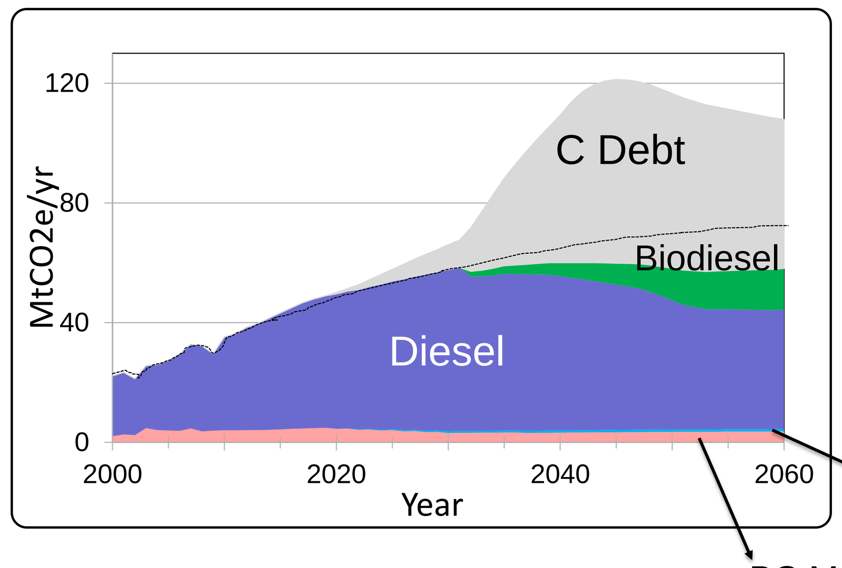




- 43% of diesel demand is met by HTL in 2060
- 50% of BC Marine Crude demand is met by HTL in 2060

C. Carbon Dioxide Emissions
Comparing reference CO_2 emissions from diesel and BC marine crude to the alternative CO_2 emission after implementing HTL technology in AB





- Additional 50 $MtCO_2e/yr$ is released by HTL from C-sink
- 43% reduction in CO_2 emissions from diesel by 2060
- HTL process releases 5.4 $MtCO_2e/yr$ by 2060

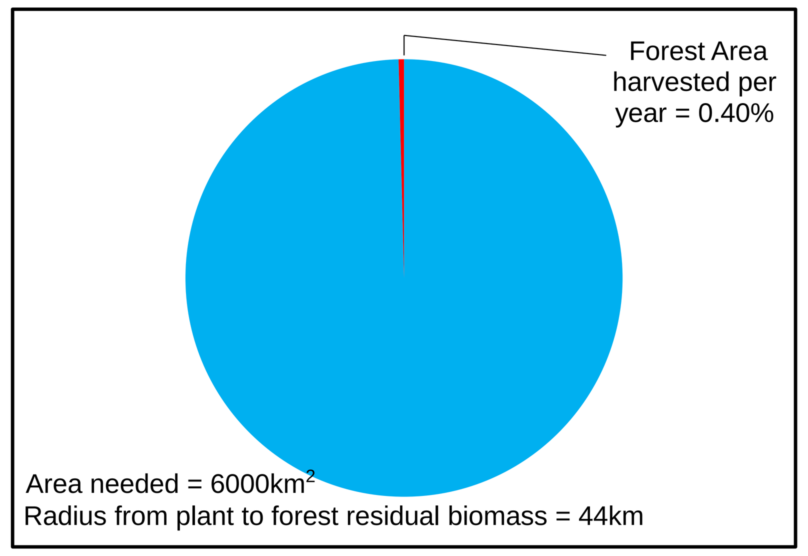


Fig 3 (a). Forest Area Needed for a Plant

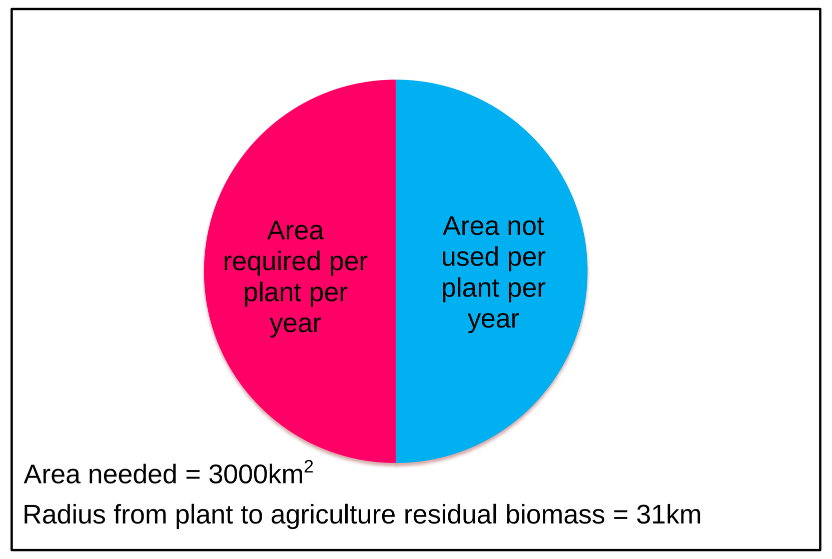


Fig 3 (b). Agriculture Area Needed for a Plant

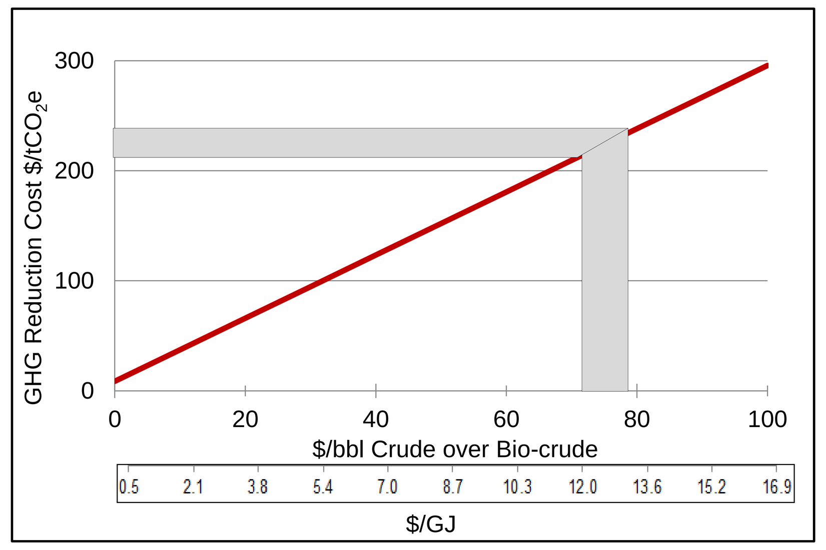


Fig. 4. Carbon tax needed to make HTL viable in AB

NOTE: Black dotted line represent reference scenario projections

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DISCUSSION

From our projections, HTL technology was able to capture 43% (254PJ/yr) of the total diesel demand and 50% (33PJ/yr) of the total marine fuel demand in BC by 2060. This led to a 43% (31$MtCO_2e/yr$) reduction of CO_2 emissions from SAGD in 2060. However an additional 50$MtCO_2e/yr$ was released from HTL. This increase in CO_2 emission was solely due to the utilization of carbon sinks (in this case forestry biomass) as fuel for HTL and not from the HTL process itself as the process is very efficient (about 77% efficiency)[4]. This creates a Carbon debt on land. In a sense, this is the penalty we pay for using forestry biomass.
HTL is a fairly new technology and as a result the cost is fairly high with an O&M cost of about $40 million/yr [4].
In order to make this technology viable and competitive at the current price of crude ($44-$50/bbl), price on carbon emissions will need to be about $230/tCO_2e$.

CONCLUSIONS

HTL technology has the potential to reduce CO_2 emissions from SAGD by about 43% (31$MtCO_2e/yr$) by 2060. That said, the cost of the technology and the utilization of carbon sinks through the use of forestry biomass leads to a carbon debt that poses a serious threat to this technology as this releases additional 50$MtCO_2e/yr$. To tackle this issue of Carbon debt we recommend the following policies:

- Improvement in the efficiency of HTL process. As quite a bit of CO_2 is released from refining bio-crude and from the electricity needed to run the HTL process
- More research and development on HTL technology as it is a fairly new technology
- Better and sustainable forest management practices have to be implemented if this technology is to be pursued
- Lastly, we recommend focusing on the BC Marine market as CO_2 saved (127kg/bbl) from not refining bio-crude can help reduce the carbon debt we pay. However, this is limited by the size of BC marine market

In order to make this technology feasible and competitive in the current AB market they have to be a price on CO_2 emissions of about $230/tCO_2e$

ACKNOWLEDGEMENTS

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