Assessment of likely Technology Maturation pathways used to produce biojet from forest residues (The ATM project)

BOEING

NORAM

UBC

SkyNRG

BOMBARDIER
the evolution of mobility

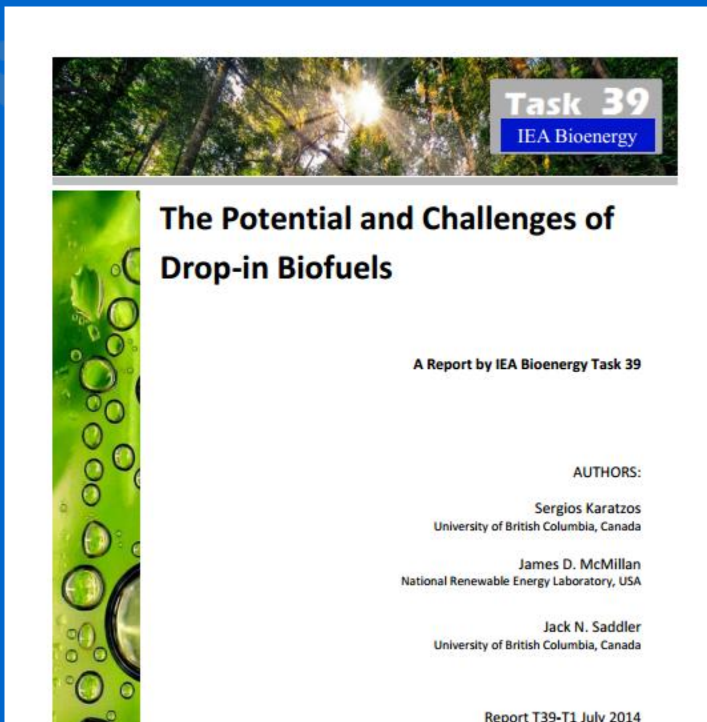
WESTJET

GARDN
Green Aviation
Research & Development
Network

Drop-in biofuels reports (2014 & 2019)

www.Task39.org

2014


Task 39
IEA Bioenergy

The Potential and Challenges of Drop-in Biofuels

A Report by IEA Bioenergy Task 39

AUTHORS:

Sergios Karatzos
University of British Columbia, Canada

James D. McMillan
National Renewable Energy Laboratory, USA

Jack N. Saddler
University of British Columbia, Canada

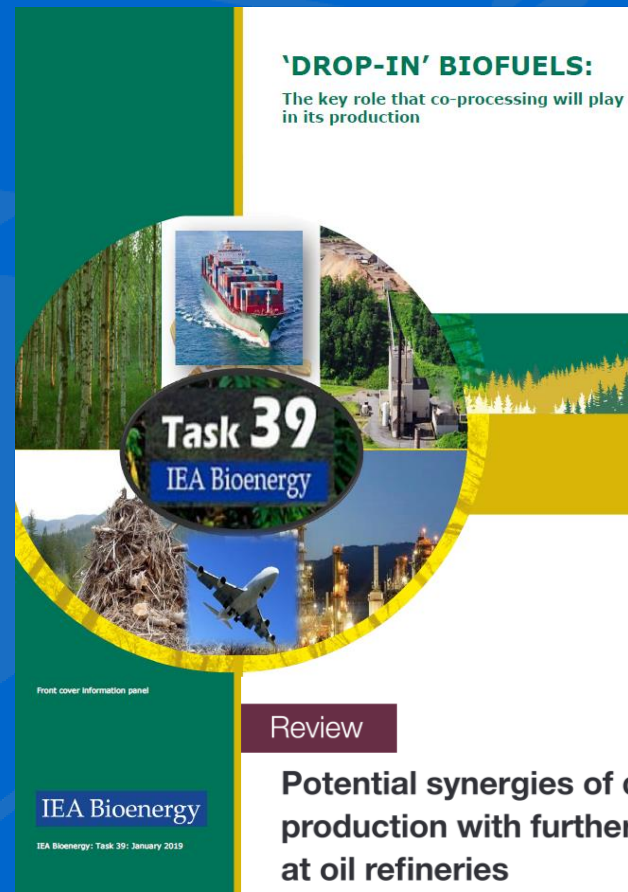
Report T39-T1 July 2014

Review — Biofpr (Biofuels Bioproducts & Biorefining)

Drop-in biofuel production via conventional (lipid/fatty acid) and advanced (biomass) routes. Part I

Sergios Karatzos and J. Susan van Dyk, IEA Bioenergy Task 39 and Forest Products Biotechnology/Bioenergy Group, University of British Columbia, Vancouver, BC, Canada
James D. McMillan, IEA Bioenergy Task 39 and National Renewable Energy Laboratory, Denver, Colorado
Jack Saddler, IEA Bioenergy Task 39 and Forest Products Biotechnology/Bioenergy Group, University of British Columbia, Vancouver, BC, Canada

2019


'DROP-IN' BIOFUELS:

The key role that co-processing will play in its production

Task 39
IEA Bioenergy

Front cover information panel

IEA Bioenergy

IEA Bioenergy: Task 39: January 2019

Review — Biofpr (Biofuels Bioproducts & Biorefining)

Potential synergies of drop-in biofuel production with further co-processing at oil refineries

Susan van Dyk, IEA Bioenergy, Task 39 and Forest Products Biotechnology/Bioenergy Group, University of British Columbia, Vancouver, British Columbia, Canada
Jianping Su, Forest Products Biotechnology/Bioenergy Group, University of British Columbia, Vancouver, British Columbia, Canada
James D. McMillan, IEA Bioenergy, Task 39 and National Bioenergy Center, National Renewable Energy Laboratory, Golden, CO
Jack (John) Saddler, IEA Bioenergy, Task 39 and Forest Products Biotechnology/Bioenergy Group, University of British Columbia, Vancouver, British Columbia, Canada

Received November 20, 2018; revised December 20, 2018; accepted January 2, 2019
View online at Wiley Online Library (wileyonlinelibrary.com);
DOI: 10.1002/bbb.1974; ***Biofuels, Bioprod. Bioref.*** **(2019)**

Main challenges of different technologies identified in 2014 report

- Oleochemical
  - Feedstock cost, availability, sustainability
- Pyrolysis & HTL (direct thermochemical liquefaction)
  - Hydrogen demand
  - Hydrotreating catalyst – cost and lifespan
- Gasification
  - Capital / scale
  - Syngas conditioning
- Biochemical
  - Low productivity
  - Valuable intermediates

ATM Project -
Assessing the potential of direct thermochemical liquefaction technologies for biojet production

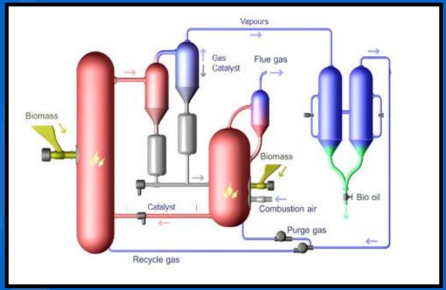
- Source biocrude from different technology providers (3)
- Upgrading of biocrudes (biogenic feedstocks/bio-oils?)
- Characterization of biojet & other fractions
- Feedstock supply chain logistics and feasibility;
- Life cycle assessment;
- Biocrude production process performance and techno-economics;
- Demonstration plant concept and design
- Policy environment and recommendations

Biocrude Upgrading approaches

- CanmetEnergy-Ottawa
  - Co-processing strategy – blending biocrude (18%) with furnace fuel oil before hydrotreating (C14 analysis used)
  - Proprietary MoS_2 dispersed catalyst
- Pacific Northwest National Laboratory
  - "Dedicated" hydrotreating of biocrudes one or two-stage upgrading
  - Commercial Ni-Mo sulfide based hydrotreating catalyst

Sources of biocrudes

- Fast pyrolysis bio-oil/biocrude
  - Challenges: High oxygen, high TAN, unstable
  - BTG, Netherlands (small commercial & optimized)
- Catalytic pyrolysis biocrude

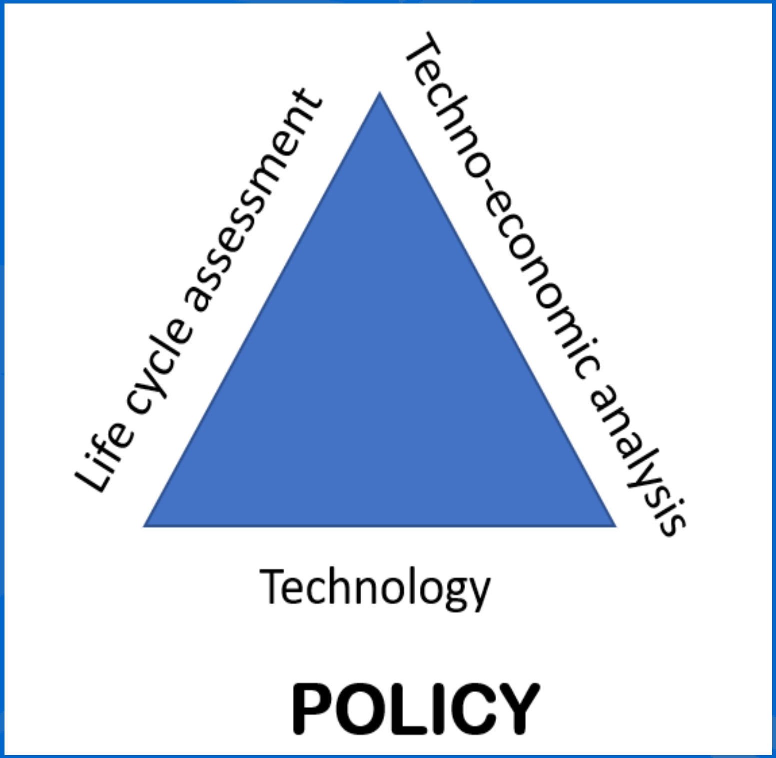


  - Lower oxygen & stable but low yields
  - VTT, Finland (pilot, not optimized)
- Hydrothermal liquefaction biocrude
  - Lower oxygen, stable & wet feedstock
  - Supercritical (<10% O_2) vs <u>subcritical</u> (>10% O_2)
  - Aarhus University, Denmark (pilot, not optimized)

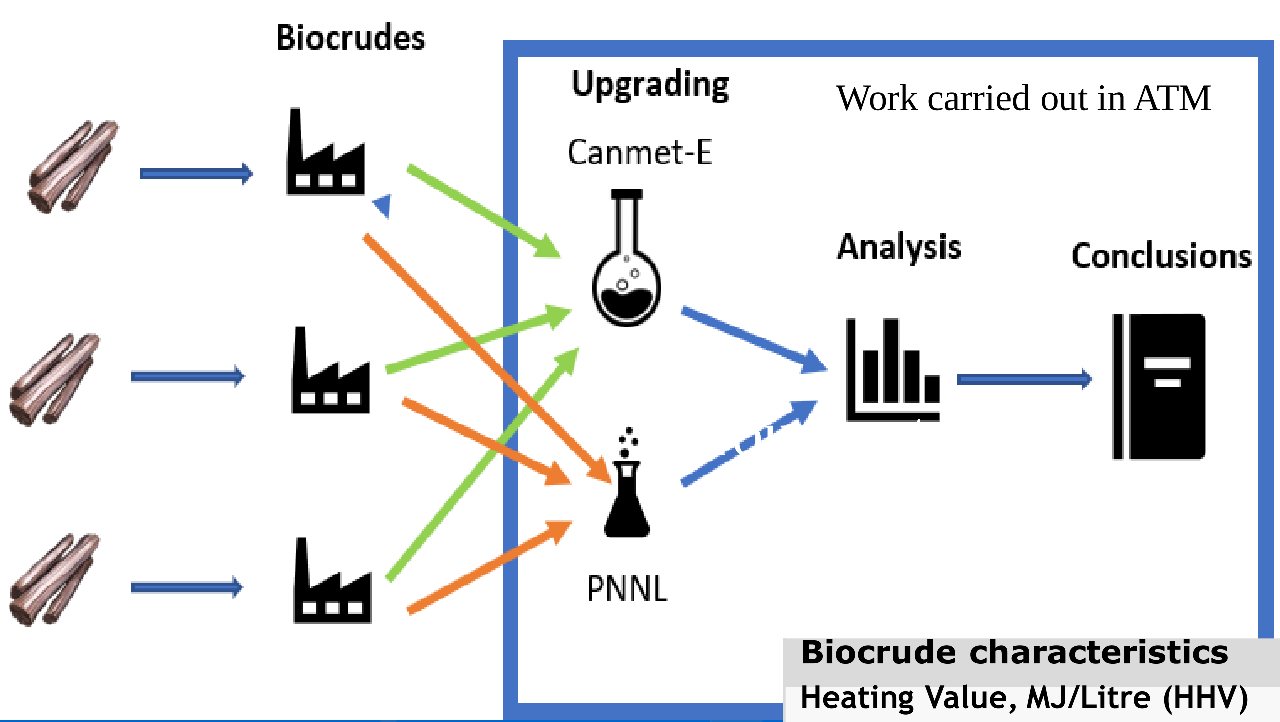
Key components of ATM Project

- Integrated analysis of technical, techno-economic and life cycle factors, within the current policy framework in British Columbia.

- Note:Most projects consider only technical or technical & economic viability



Simple flow diagram of the project



Composition and Source of HTL biocrude: Aarhus University, using Subcritical conditions

Biocrude characteristics	
Heating Value, MJ/Litre (HHV)	35.87
Density, g/litre	1,120
Carbon fraction %	78.2
Sulphur fraction %	0
Hydrogen fraction %	7.2
Oxygen fraction %	14.5
Aromaticity, %	60.9
Ash Content, wt %	0.61
pH	4.53
Pour point, ºC	33
Solids, wt%	0.5
TAN, mg KOH/g	28.6
Water content, wt %	5.6

Composition of biocrudes

Parameter	Fast pyrolysis	Catalytic pyrolysis	HTL
Heating Value, MJ/Litre (HHV)	21.52	32.3	35.87
Density, g/litre	1,197	1,168	1,120
Aromaticity, %	42.9	63.9	60.9
pH	2.66	3	4.53
Pour point, °C	-36	-6	33
TAN, mg KOH/g	125	82.6	28.6
Water content, wt %	25.7	7.6	5.6

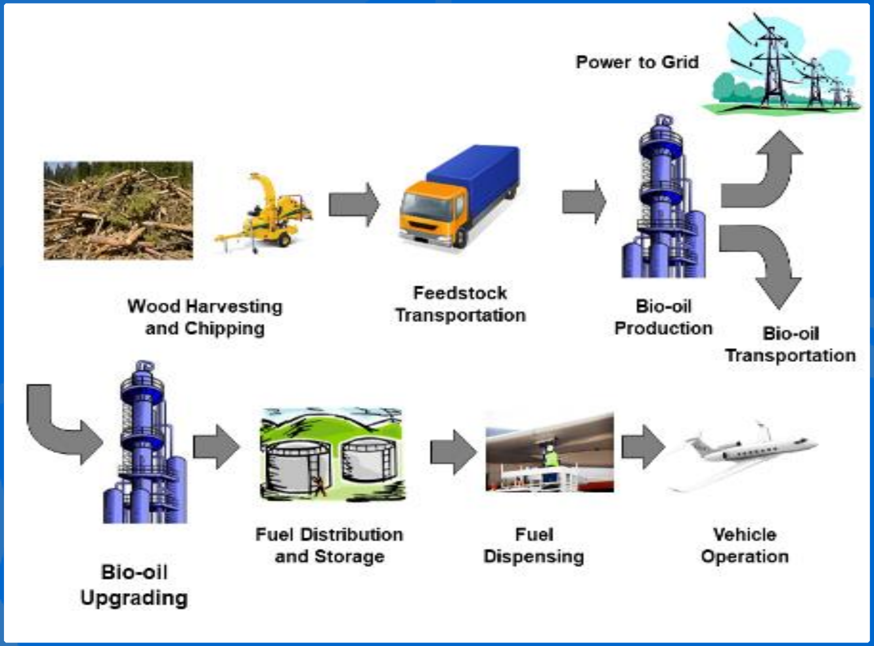
Upgrading of HTL biocrude

- Upgrading of HTL biocrude was demonstrated to be technically feasible, resulting in a “biocrude” with low oxygen levels and from which multiple fuel products were obtained (naphtha, jet fuel, diesel, heavy fuel oil)
- A significant jet fraction was produced (29.8% Canmet and 22.9% PNNL)
- The fuel fractions were analysed with a specific focus on the jet fraction.
- The quality of the jet fractions met most of the general ASTM D7566 specifications. With further optimization very likely that all standards could be met

NB – Yield results from Canmet coprocessing upgrading were based on biogenic fraction only

Life cycle analysis (GHGenius)

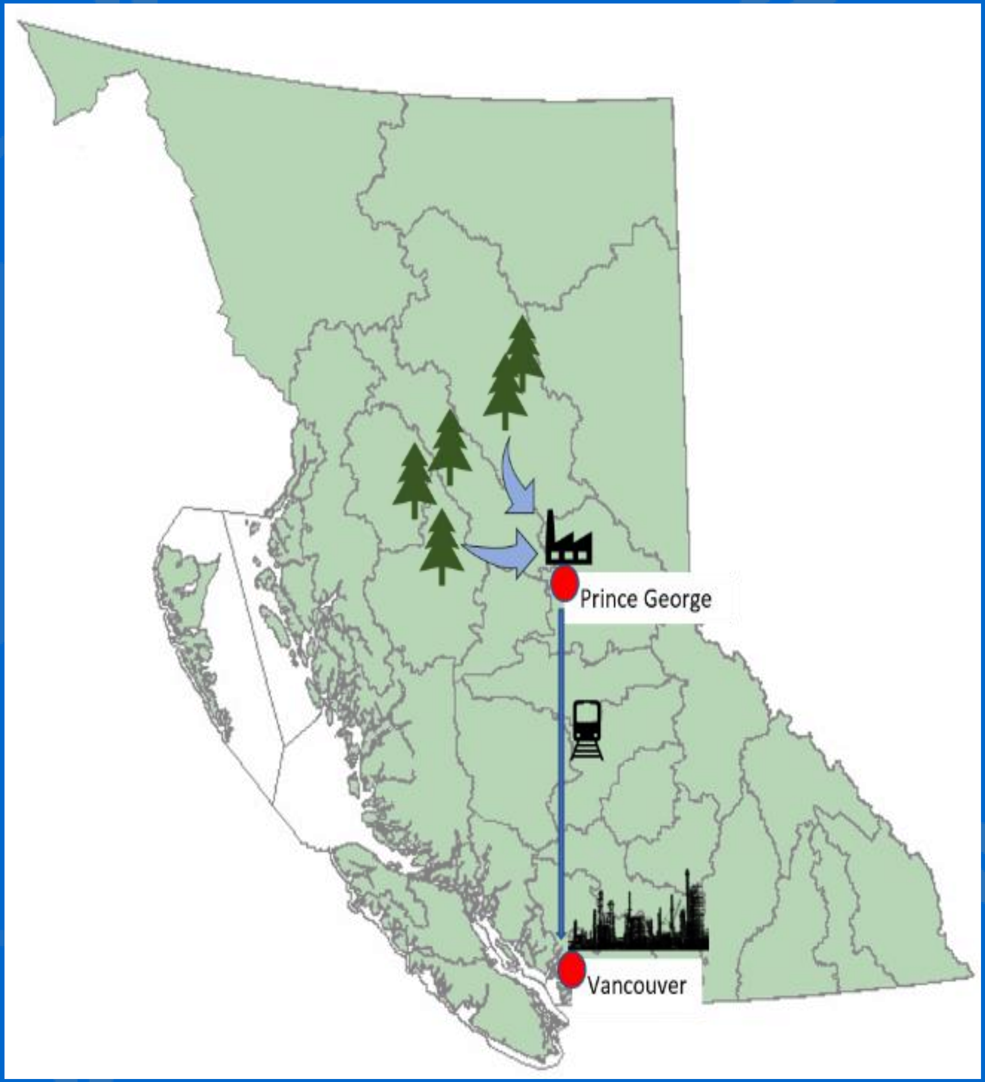
- PNNL upgrade: -51% (optimized -71.3% based on demo design)
- Canmet upgrade: -5.4%
- Further optimization of the HTL pathway with dedicated hydrotreating, based on a possible demonstration facility of 200 bbl/day, could deliver emission reductions of 71.3%.
- Key factors influencing potential emission reductions are:
  - co-products and
  - hydrogen consumption.



Hypothetical Supply chain for ATM Project

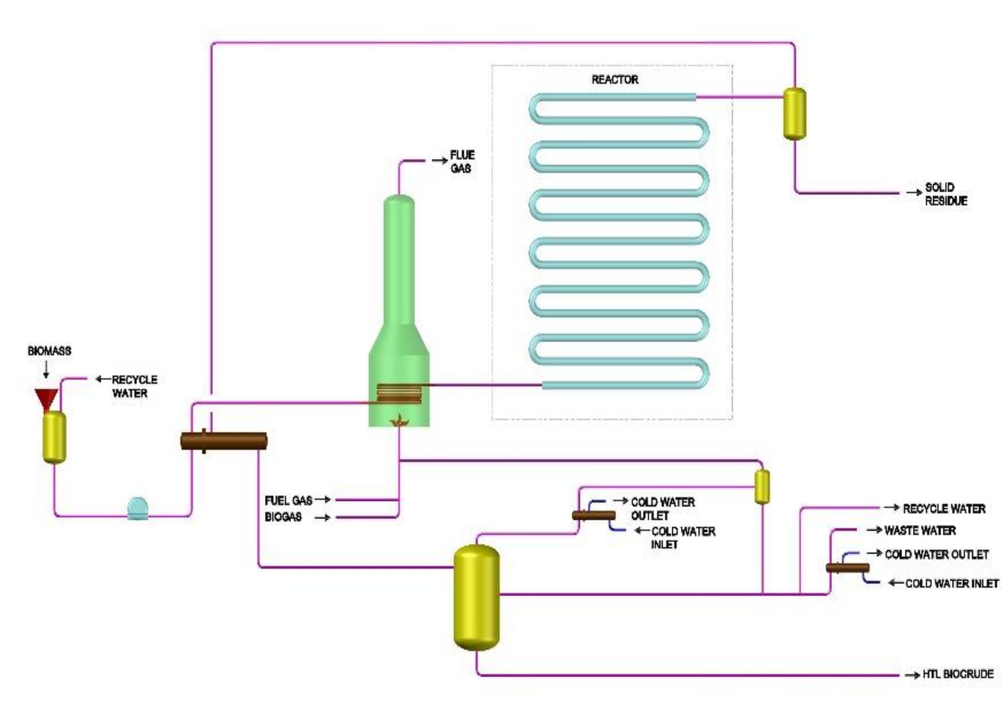
Biomass availability was assessed based on the current volumes within a 100 km radius of the proposed biocrude facility in BC.

Sufficient feedstock was available at an average cost of $80CAN per oven dry tonne delivered to the biorefinery gate.



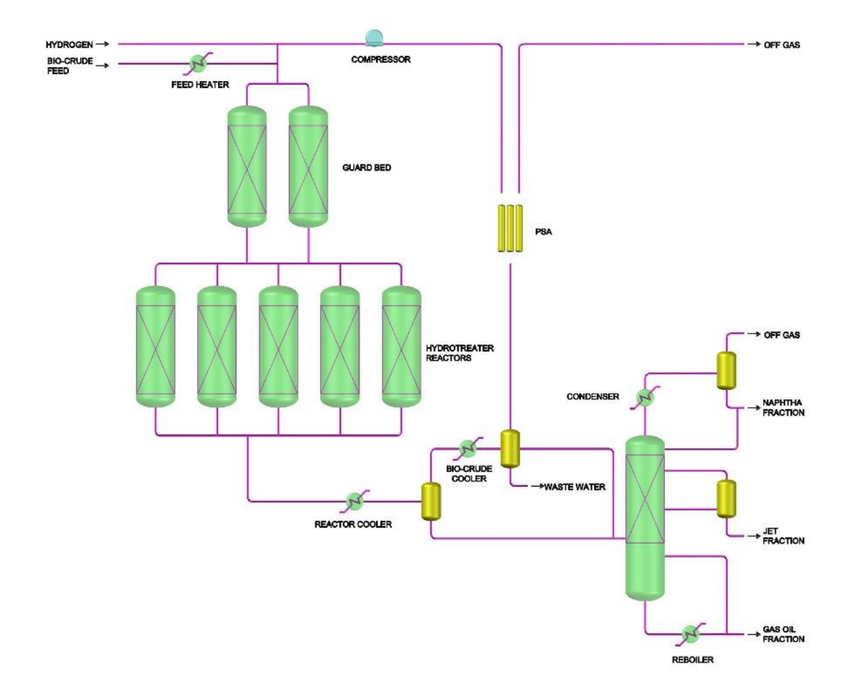
Engineering flow sheets (Class 5) of HTL pathway

Biocrude production assumed near to feedstock supply and transported to upgrading facility



Waste water treatment adds significantly to CAPEX

Hydrotreatment co-located with refinery



ATM/HTL biocrude upgrading - Key conclusions (full report at www.Task39.org)

- Biojet fuel successfully produced from HTL biocrude via the two upgrading pathways
- The Biojet fraction meets the majority of general ASTM specifications
- Possible emission reductions of up to 71.3% are possible
- Techno-economic assessment was reasonable compared to other potential biojet fuel pathways (e.g. alcohol to jet, HEFA biojet, FT biojet, sugar to biojet)
- HTL biocrudes were more stable, less corrosive, had a higher energy density and were “conducive” to one stage hydroprocessing
- However, “Nature” of the feedstock needs further study

Acknowledgements & Questions?

- Project partners – Boeing, Noram Engineering, SkyNRG, Westjet, Air Canada, Bombardier
- UBC team (Susan van Dyk, Jianping Su, Mahmood Ebadian)
- Funders – Boeing, GARDN
- Canmet, PNNL
- Don O’Connor (S&T^2 Consultants)
- Michael Lakeman (Boeing)
- Biocrude suppliers – VTT; BTG; Aarhus University (Ib Johannsen & Patrick Biller)