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Hydrofaction®

Advanced Biofuels Technology Ready for Commercial Deployment

2024

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A global leader in converting sustainable biomass to drop-in advanced biofuels

Danish-Canadian company with offices in Calgary, Canada and locations in Denmark

Hydrofaction® biocrude upgrading facility in Calgary and demonstration facility in Tofte, Norway

Proven & highly optimized hydrothermal liquefaction (HTL) process called Hydrofaction®

High conversion rate of low-value biomass to biocrude, upgradable to advanced biofuels and chemicals at existing refineries

Significantly **reduces carbon intensity** of transport fuels (diesel, jet, marine) when compared to fossil fuels

Hydrofaction® can process many different feedstocks, but Steeper Energy is focused on the conversion of **forestry and agricultural residues**

A Cost Effective Advanced Biofuel Pathway

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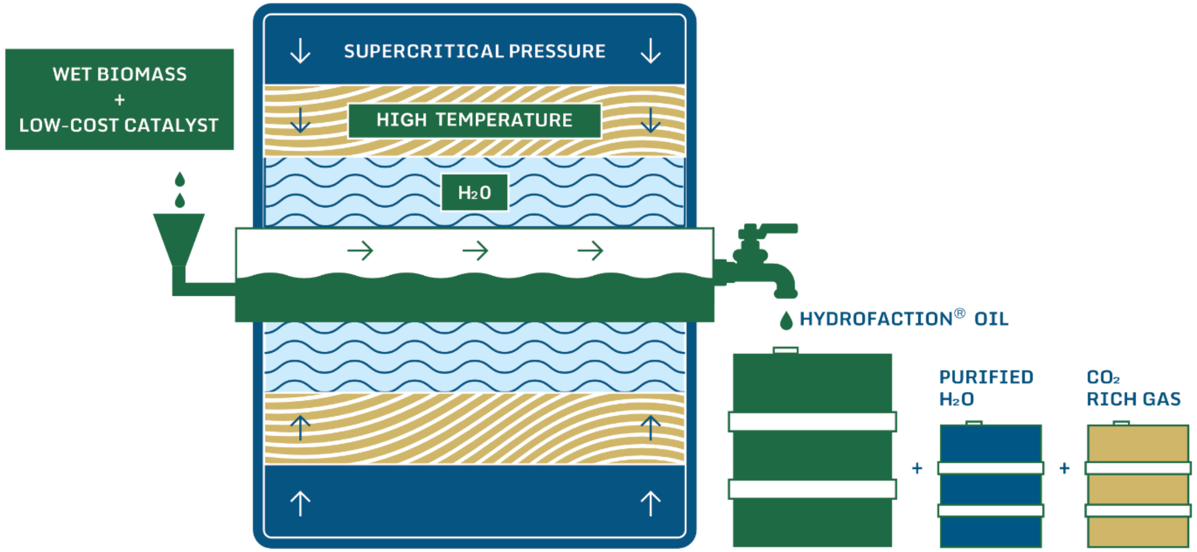
Hydrofaction® is a cost-effective, low carbon intensity, fossil fuel alternative process

- Hydrofaction® achieves an industry-leading 45% biomass-to-oil conversion on a mass basis, and up to 85% of the biomass input energy is recovered in the biocrude
- Hydrofaction® biocrude similarities to fossil crude means less refining is required
- Makes use of existing petroleum infrastructure
- Ideally suited for multiple types of wet waste feedstocks, as no drying is required
- Addresses key issues with sustainable feedstocks (fuel versus food; land use change; biodiversity)
- Pathway to carbon negative liquid long-haul transport fuels

Hydrofaction®

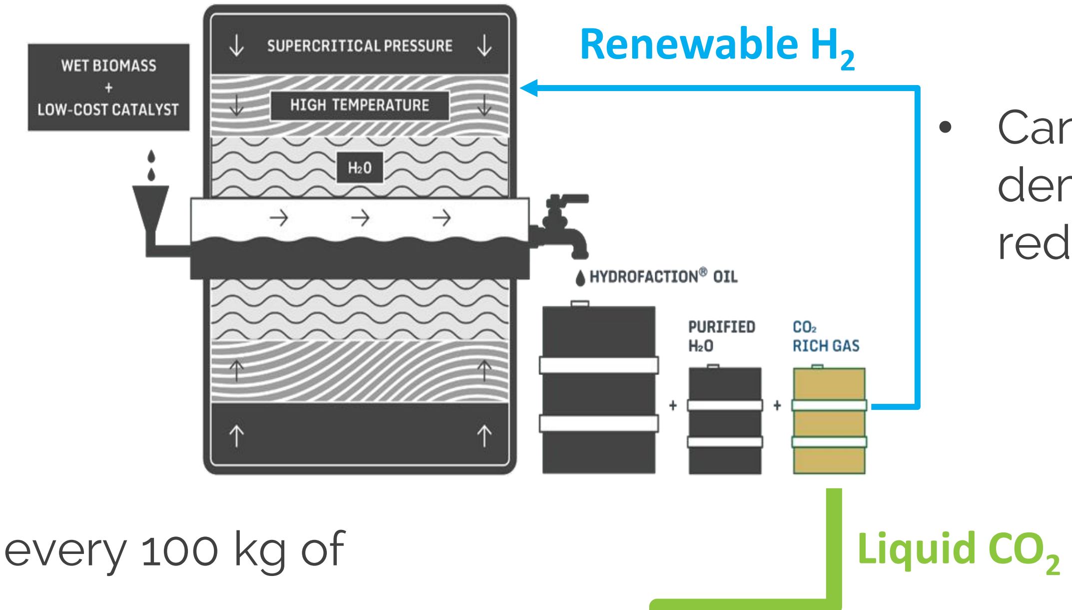
- Proven and optimized hydrothermal liquefaction (HTL) for higher yields
- Supercritical chemistry (~400°C and ~330 bar)
- High energy efficiency (no pre-drying) and highest biomass conversion in the market
- Hydrofaction® Oil has:
  - Low oxygen content
  - High thermal stability
  - High energy density (close to crude oil)
- Ultra Low-Carbon fuels with potential to become Carbon Negative through Carbon Capture, Utilization and Storage (CCUS)

Hydrofaction® is a highly optimized version of HTL, with an industry leading feedstock to biocrude conversion rate



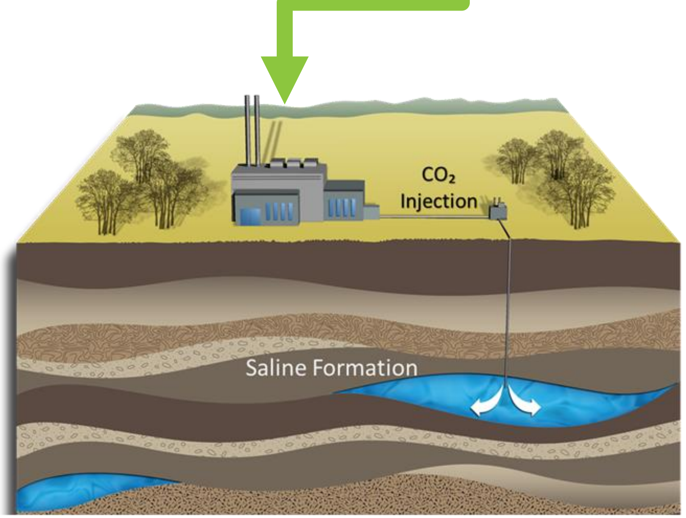
Byproducts: Renewable H_2 & Liquid CO_2

Hydrofaction® produces renewable H_2, which can be used in upgrading or sold, and liquid CO_2, for use in industry or permanent sequestration

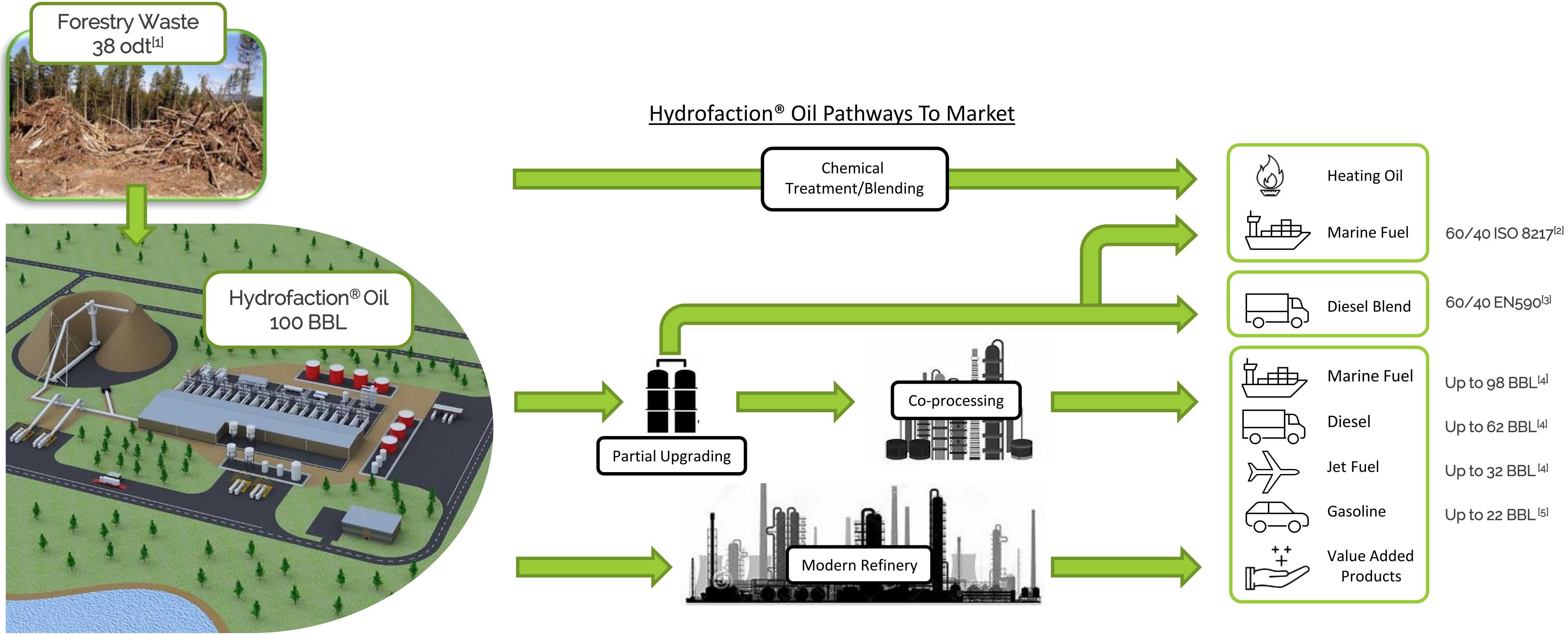


- Can support upgrading demands to further reduce CI score

- Production: 80-90 kg of liquid CO_2 from every 100 kg of Hydrofaction® Oil produced
- Potential markets:
  1. permanently sequestered
  2. used to offset existing consumptions
  3. used in the production of e-fuels



Hydrofaction® Oil to Fuels



[1] Dry forestry waste to show yield. The process does not require drying
[2] 60 vol% blend of partially upgraded Hydrofaction® Oil and 40 vol% RMG 180 marine fuel oil meets ISO 8217 specification
[3] 60 vol% blend of Hydrofaction® renewable diesel fraction with 40 vol% fossil diesel meets EN590 ultra-low sulfur diesel specification
[4] Maximum upgrading scenarios for producing marine biofuels, renewable diesel, and jet fuel in various proportions
[5] Gasoline as a secondary fuel product in some of the scenarios with production ranging from 12 BBL to 22 BBL

Hydrofaction® Oil Properties

Derived from forestry residue

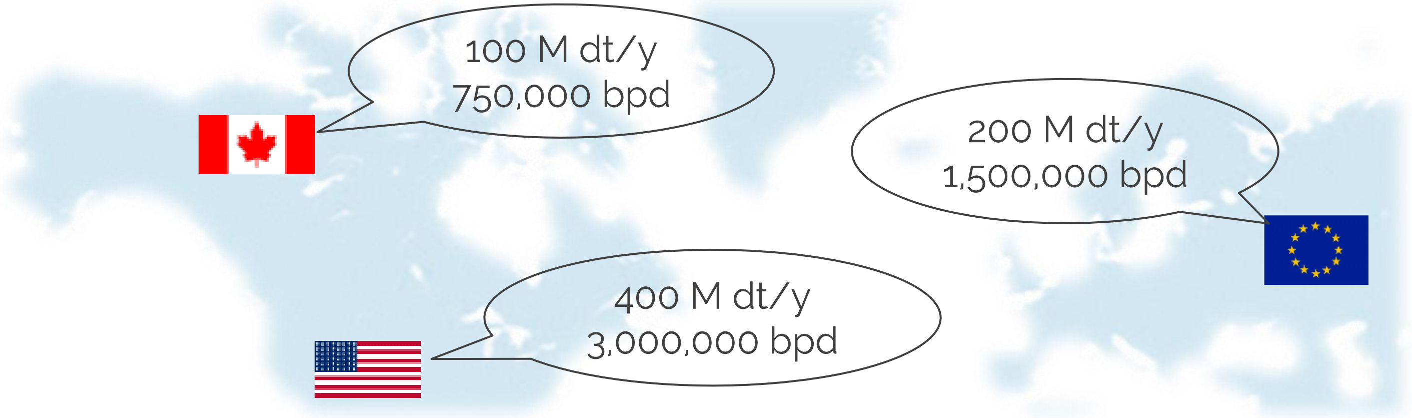
Test	Method	Result
Water Content	ASTM D4377 (Mod)	0.18 wt.%
Ash	ASTM D482 (Mod)	0.1 wt.%
Micro carbon residue	ASTM D4530	17.08 wt.%
TAN	ASTM D664A	33.19 mg KOH/g oil
High Heating Value - HHV [daf*]	ASTM D240	38.14 MJ/Kg
Density @ 15.6°C	ASTM D4052	1043 kg/m^3
Kinematic Viscosity @ 40°C	ASTM D445	772.6 cSt
Elemental analysis (daf)		
Carbon	ASTM D5291	80.90 wt.%
Hydrogen	ASTM D5291	9.15 wt.%
Nitrogen	ASTM D5291	0.25 wt.%
Sulfur	ASTM D1552	146 ppm
Oxygen	By difference	9.69 wt.%
H/C	Calculated	1.35 molar ratio
Pour point	ASTM D97	-33 °C
Flash Point	ASTM D3828B	74 °C
Fuel fractions		
Naphtha (IBP-190°C)	ASTM D7169	5.9 %
Jet fuel fraction (190–260°C)	ASTM D7169	11.3 %
Heavy middle distillates (260–343°C)	ASTM D7169	23.3 %
Heavy gas oils (343-550°C)	ASTM D7169	39.9 %
Residue (550+)	ASTM D7169	19.5 %

* daf: dry ash free

Global Hydrofaction® Potential

Estimated global residual biomass availability:

1.9B dry tonnes (dt) annually of non-food, non-merchantable, forestry and agriculture biomass residues…



7,000
Hydrofaction® plants could be built

14M bpd
Hydrofaction® Oil could be produced

19%
of 2019 Global Oil Demand

~15%
of the annual reduction target for 2030 global GHG emissions could be achieved

1. US Dept. of Energy, 2016, "2016 Billion-ton report", https://www.energy.gov/sites/default/files/2016/12/f34/2016_billion_ton_report_12.2.16_0.pdf
2. NRCAN, 2010, "Canada Report on Bioenergy", http://www.cancarb.ca/pdfs/pubs/NRCAN%20canada-report-on-bioenergy-2010-sept-15-2010.pdf
3. EC Directorate General for Energy Directorate C1 – Renewables and CCS Policy, 2017, "Sustainable and optimal use of biomass for energy in the EU beyond 2020", https://energy.ec.europa.eu/system/files/2017-06/biosustain_annexes_final_0.pdf
4. IEA, 2010, "Sustainable Production of Second-Generation Biofuels", https://www.oecd.org/berlin/44567743.pdf
5. IEA, 2021, "Net Zero by 2050: A roadmap for the global energy sector." https://www.iea.org/reports/net-zero-by-2050
6. UN Environment, Emissions Gap Report 2022, https://www.unep.org/resources/emissions-gap-report-2022
7. Global GHG emissions reductions assume an annual reduction of 15 GtCO2e is required to limit global warming to 2˚C by 2030

Regulatory Drivers

Clean Fuel Regulations (CFS)

Goal: Reduce the carbon intensity of fuels used in Canada by ~15% by 2030.

British Columbia-Low Carbon Fuel Standard (BC-LCFS)

Goal: Reduce the carbon intensity of fuels used in British Columbia by 30% by 2030.

Renewable Fuel Standard (RFS2)

Goal: Increase the volume of renewable fuel required to be blended into transportation fuels

California Low Carbon Fuel Standard (LCFS)

Goal: Reduce the carbon intensity of transportation fuel pool in California by at least 20% by 2030

Oregon Clean Fuels Program (CFP)

Goal: Reduce the carbon intensity of transportation fuel pool in Oregon by 37% by 2035

Revised Directive EU/2023/2413 (RED III)

Overall target for renewable energy sources consumption by 2030 has been raised to 42.5%. Countries could choose from a binding target of a 14.5% reduction of GHG intensity in transport from the use of renewables or a binding share of at least 29% of renewables within the final consumption of energy in the transport sector by 2030

Hydrofaction® maximizes North American and European incentives for low-carbon intensity transport fuels

Incentives improve project economics bridging the time required for Hydrofaction® to become fully optimized leading to reduced cost of production

Milestones

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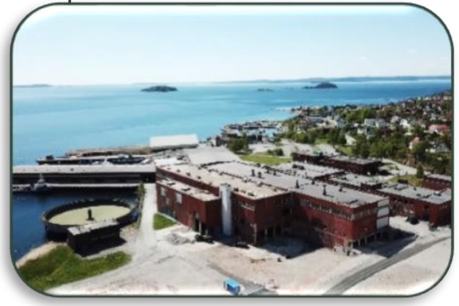
2011
Dr. Steen Iversen, and Perry Toms, established Steeper Energy

2013
Steeper Energy's Continuous Bench Scale (CBS) pilot plant installed at the Aalborg University, DK

2016
5000 operating hours reached at CBS; Hydrofaction® Oil production proven to be repeatable and reliable

2016-2017
Silva Green Fuel (Statkraft) licenses Hydrofaction® to build 30 BPD industrial-scale demonstration plant in Tofte, Norway as a precursor to a 2000 BPD plant



2017-2019
CBS undergoes first upgrades and optimizations

2018-2019
Upgrading of Hydrofaction® Oil to on-spec diesel and marine fuel achieved; co-processing routes externally validated

2018-2020
Steeper and SGF advance the design of sub-systems, contract key suppliers and begin construction of industrial-scale Demo Plant

2020
Advanced Biofuels Center (ABC) established in Calgary, Canada for demonstrating pathways to finished fuels with select commercial end users

November 2021
Commissioning and start-up of Silva Green Fuel industrial-scale Demo Plant

2020-2021
CBS undergoes reactor upgrade. Proprietary pump is commissioned

2023-2024
Commercial MOUs and agreements

Growing IP portfolio of 25 patent families, with over 200 patents granted internationally

Commercial Demonstration

Strategic Partner

Silva Green Fuel, Steeper's first commercial licensee, chose to invest in Hydrofaction® after extensive diligence on ~40 competing technologies

Phase I: Demo Plant

Constructed in 2021

A € 50M Demo Plant with capacity of 30 BPD converting forestry residues to renewable biocrude

Engineering Verification

We are currently in the process of having Steeper's commercial plant capital costs and engineering verified

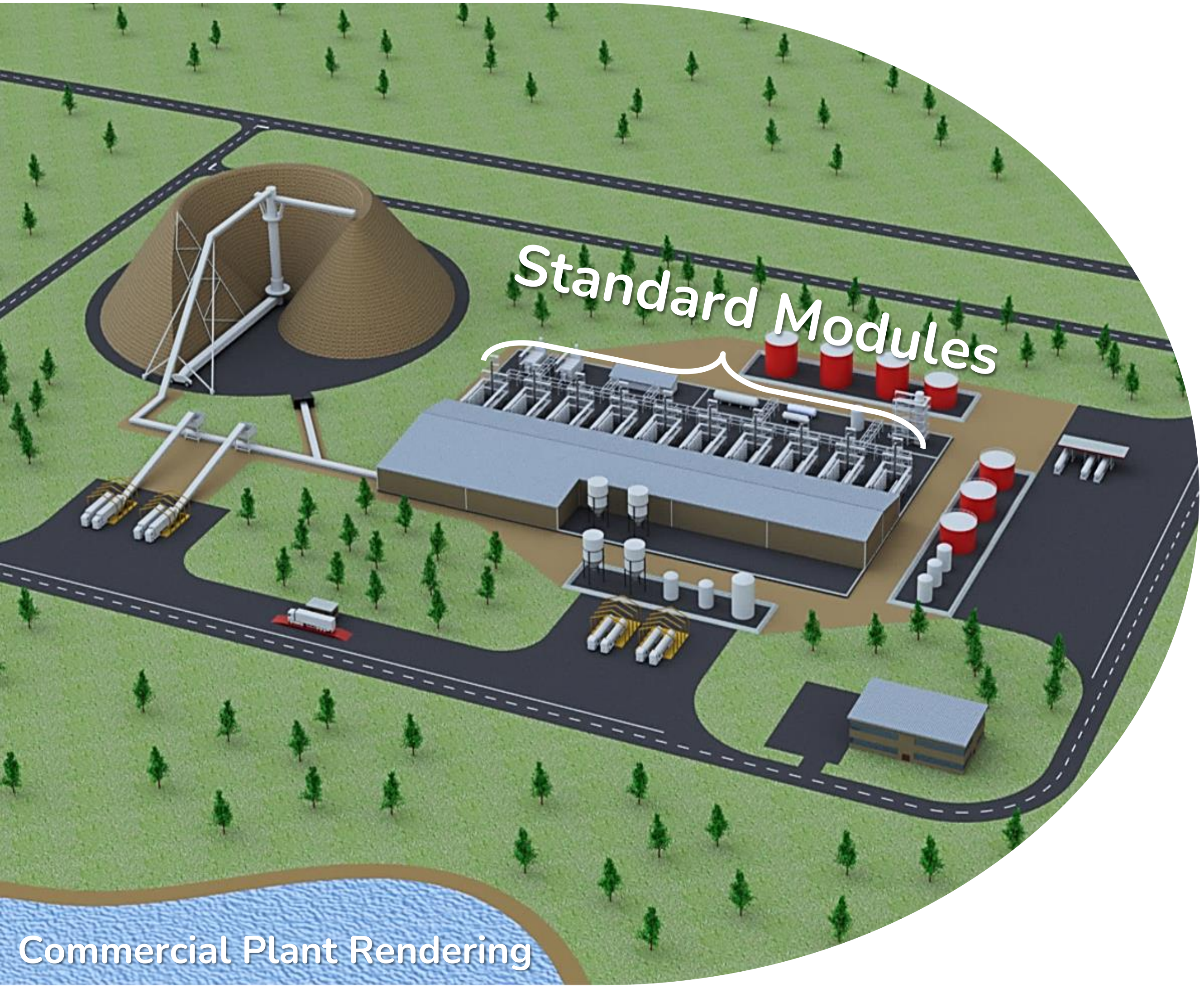
Operations

Construction of Phase I completed in 2021 with continuous improvement and operation through 2024. Phase II to follow

Phase II: Commercial Plant

Average production of 2,000 BPD or 125,000 Fuel Tonnes per Annum

Standard Modular Plant Design



Hydrofaction® plants are designed on a philosophy of standard capacity modules which are replicated to the appropriate plant scale

This design methodology delivers consistency, replicability, and redundancy, which leads to high availability

Controlled, repeatable engineering, manufacturing, and regulatory approval processes leads to rapid plant deployment

Modular design reduces on-site construction costs and moves sub-components to a controlled manufacturing environment, which yields quality, cost-effectiveness, and reduced risk

Biocrude to Finished Fuels

In addition to biocrude production, Steeper is advancing upgrading and co-processing pathways to ensure Hydrofaction® Oil's integration into existing energy infrastructure

Advanced Biofuels Centre

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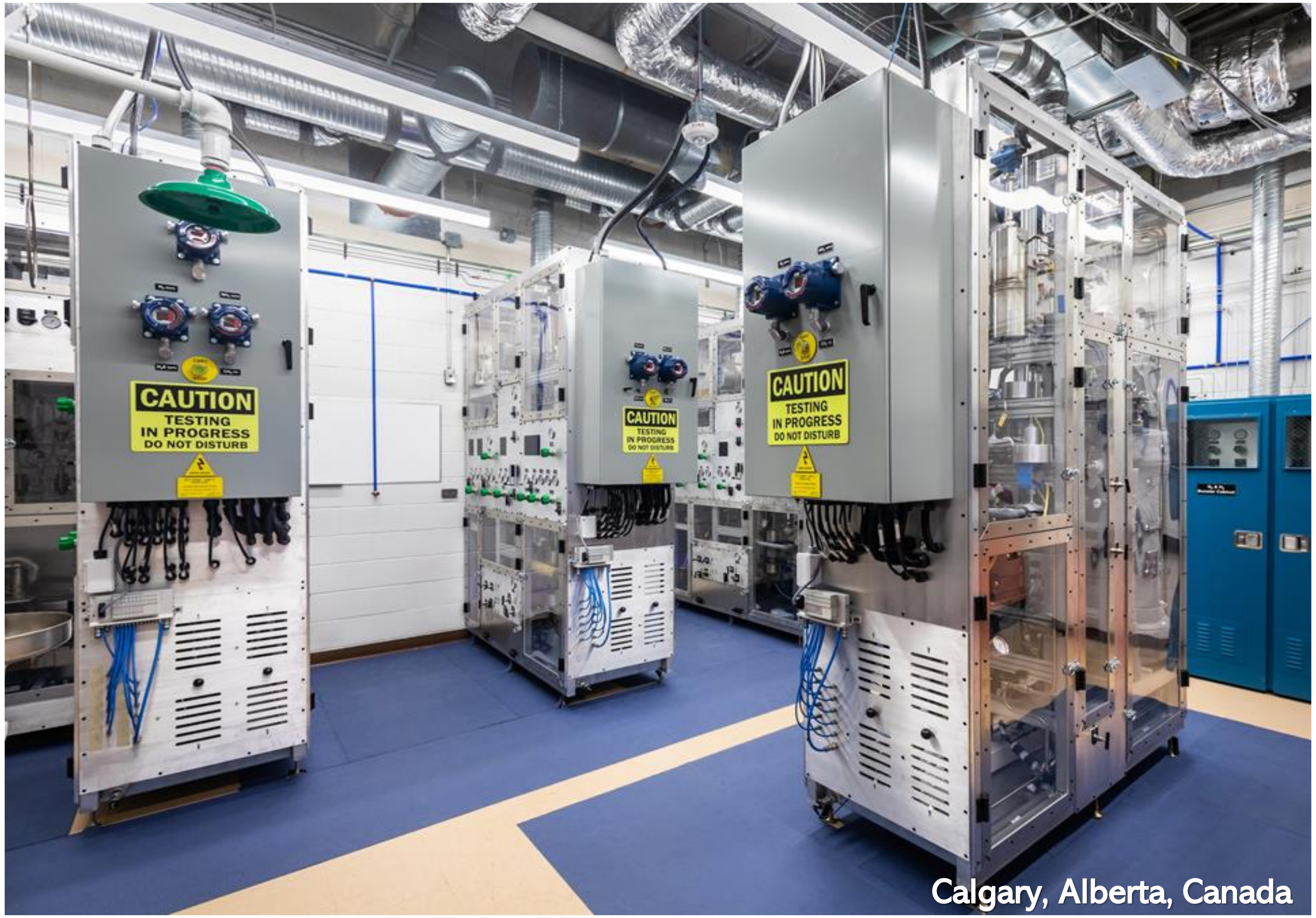
Defining the value of Hydrofaction® Oil

- Advancing biocrude stability, blending, and compatibility
- Utilizing in-situ renewable H_2
- Demonstrating refinery integration
- Developing techno-economic pathways to renewable fuels
- Delivering flexibility in commercial design for Hydrofaction® licensees

This highly specialized laboratory is enhancing Steeper's upgrading and refinery co-processing capabilities



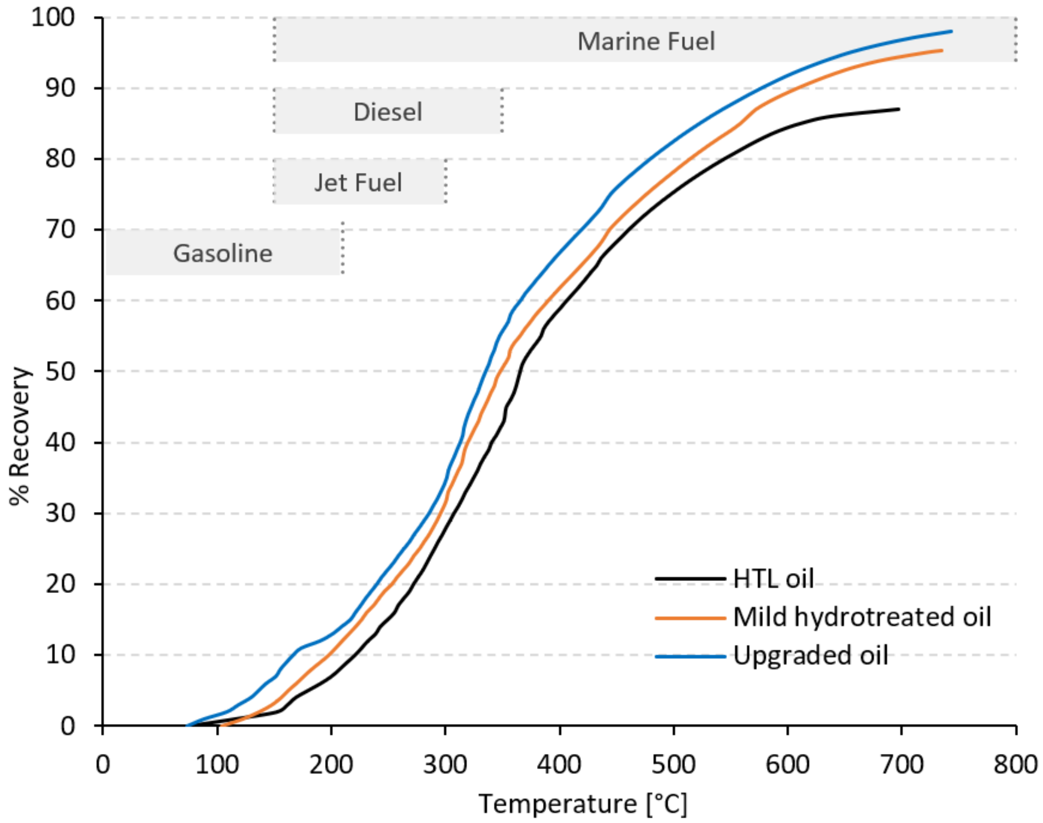
Calgary, Alberta, Canada

Hydrofaction® Oil: Upgrading

The physicochemical properties of the Hydrofaction® Oil significantly improved after hydrotreating using **commercial sulphided catalysts**.

Test	Method	HTL oil	Mild hydrotreated oil	Upgraded oil
Campaigns results*				
Water yield [wt.%]	-	-	5.8	1.2
Gas yield [wt.%]	-	-	3.4	1.0
Liquid hydrocarbon yield [wt.%]	-	-	90.8	97.8
Hydrogen consumption [wt.%]	-	-	1.4	0.5
Product characterization				
Nitrogen [wt.%, daf]	ASTM D4629	0.25	0.19	0.13
Sulfur [wt.%, daf]	ASTM D5453, D6667	0.02	0.02	0.01
Oxygen [wt.%, daf]	by difference	9.69	3.89	1.68
H/C Molar Ratio	calculated	1.35	1.51	1.56
HHV - daf [MJ/kg]	ASTM D240	38	43	44
Ash [ppm]	ASTM D482 (Mod)	915	689	<10
Micro carbon residue [wt.%]	ASTM D4530	17	9.18	6.80
Water Content [wt.%]	ASTM D4377 (Mod)	0.18	0.06	<0.1
Density @ 25°C [kg/m^3]	ASTM D4052/D5002	1036	966	939
Viscosity @ 25°C [cSt]	ASTM D445	4458	181	37
TAN [mg KOH/g oil]	ASTM D664A	32	<0.1	<0.1

daf: dry ash free
Mild hydrotreated oil: 330°C, 100 bar, 0.5 h^{-1} (WHSV), 1000 v/v (H_2-to-oil ratio)
Upgraded oil: 370°C, 100 bar, 0.5 h^{-1} (WHSV), 1000 v/v (H_2-to-oil ratio)
* The values for water yield, gas yield, liquid hydrocarbon yield and hydrogen consumption apply to the product from the previous stage. For upgraded oil, the information under mild hydrotreated oil would need to be combined with those under upgraded oil when determining the pathway from Hydrofaction® oil to upgraded oil.



Boiling point distribution curves determined by simulated distillation for renewable crude oil, partial upgraded and upgraded oil.

GHG Emissions Reductions

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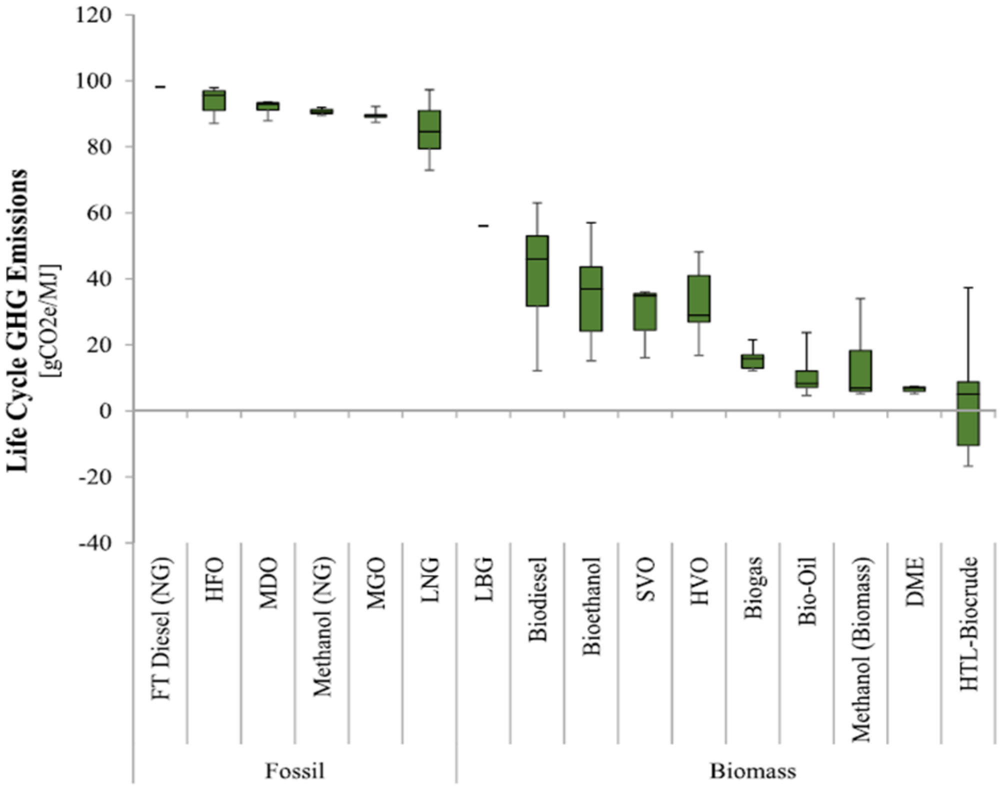
A 2000 BPD Hydrofaction® Plant reduces 437,000 t CO_2e annually.

Emissions Source	gCO_2e/MJ
Biofuel preparation, utilities, catalysts, transport	10
Energy Usage	4
Drop-in Biofuel End-Use Combustion	3
Waste wood combustion avoidance	-17
Project Emissions	**0**
Baseline Fossil Fuel Comparator	94
GHG Emissions Reduction	**100%**
Further Reduction Potential	**gCO_2e/MJ**
CO_2 Sequestration, Low Grade Heat Production, and Other Optimisations	-30
Total GHG Emissions Reductions possibilities	**>132%**

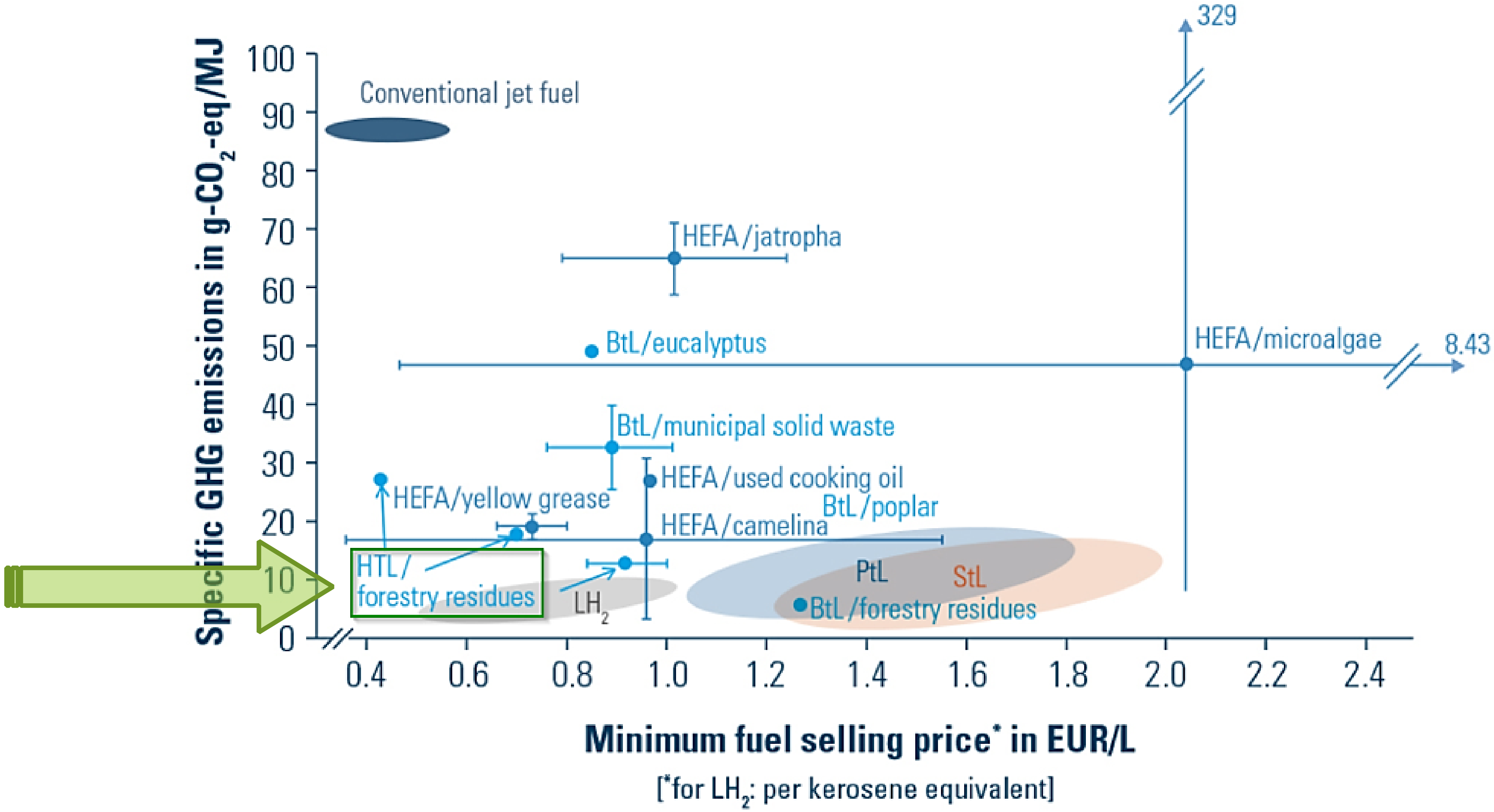


Source: Foretich, Anthony, et al. "Challenges and opportunities for alternative fuels in the maritime sector." Maritime Transport Research, vol 2, Aug. 2021,

More than 100% GHG reductions possible through CCUS and Power-to-X using liquid CO_2 from process

Carbon Efficient and Cost Competitive

Hydrofaction® is a carbon-efficient and cost-competitive advanced biofuels solution for producing globally relevant volumes of heavy and long-haul transport fuels



Source: https://www.bauhaus-luftfahrt.net/en/topthema/hy-shair/

Global Leader in HTL Technology

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Commercial adoption

Scale-up

Fuel Offtakers Signed MOU 2022

Commercial Plants 2025

Demo Plant 2021

Testing and Refinery Partners

Advanced Biofuels Center 2020

Pilot Plant 2013

Industry validation

Knowledge transfer

Leveraging Pilot, Demo, and HTL Expertise, Steeper brings a solution that stimulates cross-industry collaboration, job creation, and cleantech growth

TOM Capital

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- TOM Capital (TOM) is the majority shareholder of Steeper Energy and is a Calgary-based Private Equity firm. TOM has been an investor in Steeper Energy since 2012
- TOM Capital owns businesses in Canada and the US spanning manufacturing, technology, consumer products, real estate development, retail real estate, and financial services
- TOM's founders have been involved in creating businesses that in a number of instances have become highly valued public companies. TOM Capital has a long-term investment horizon with a focus on driving significant enterprise value appreciation over time
- The team at TOM is focused on the most strategic dimensions of portfolio companies. Steeper's president and two board members are staff of TOM. Other TOM employees participate in strategic initiatives as required

TOM Capital Management Inc.

Summary of Hydrofaction®

Steeper Energy has arguably the most advanced HTL-based renewable fuels technology and is positioned for rapid commercialization and tremendous growth

- Industrial Demo Plant
- Pilot Plant >8000 hours
- Robust project pipeline
- Capital costs and engineering in the process of being verified

Commercial Readiness

- Feedstock flexible
- Common catalysts
- Redundancy in design

Simplicity & Robustness

- 45% conversion on a mass basis
- Up to 85% energy recovery. No pre-drying required
- High heating value and low oxygen content

Process Efficiency

- Hydrofaction® Oil is chemically similar to petroleum
- Compatible with refineries and existing infrastructure

Petro-equivalency

- Clean discharge water
- Organics recycling maximizes yield and minimizes waste

Minimal Effluent & Waste Streams

- Process gas rich in H_2 and CO_2
- Renewable H_2 export possible
- Biogenic CO_2 capture-ready

Renewable H_2 & CO_2 Capture

- >200 patents granted
- >25 patent families
- Extensive know-how spanning Hydrofaction® and upgrading

Strong IP Protection

- Carbon-negative technology
- Access to regulatory incentives

Sustainability