

Hydrofaction[®]

A Leading Technology
for the Efficient Conversion
of Sustainable Biomass
into Renewable Transportation Fuels

Perry Toms, CEO

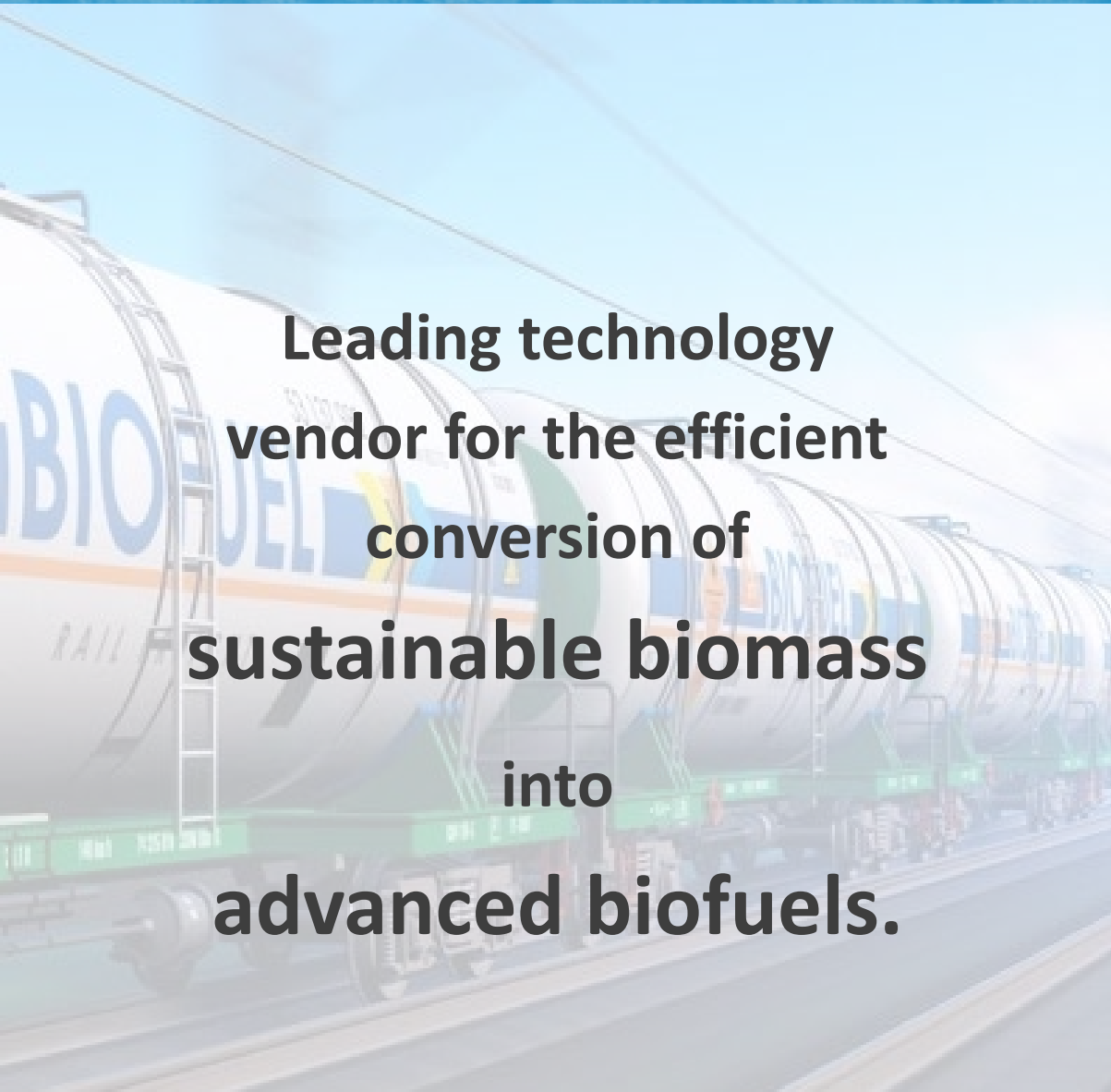
pt@steeperenergy.com

19 November 2019 - Brussels








EXPERT WORKSHOP

Potential of Hydrothermal
Liquefaction (HTL) routes
for biofuel production

A photograph of a train with several white tankers. The tankers have "BIOFUEL" written on them in large blue letters. The train is moving along tracks, and the background is a clear blue sky.


**Leading technology
vendor for the efficient
conversion of
sustainable biomass
into
advanced biofuels.**


Hydrofaction®


-  A **proven** thermochemical process
-  **Cost-effectively** converts biomass residues to bio-crude oil and advanced biofuels
-  **Significant** reductions of GHG emissions compared to fossil and bio-technologies
-  **Validated** by industry, governments and granting authorities
-  **Ideal** solution for wet lignocellulosic biomass and bio-organic wastes

- Developed, piloted and proved Hydrofaction® (30 patents granted; 100+ pending) over past 8 years.
- Hydrofaction® efficiently converts wet biomass into **renewable crude oil & finished fuels**.
- Hydrofaction® is being demonstrated/commercialized to large-scale on large-scale aggregated lignocellulosic feedstocks with market leaders
- Interface with petroleum and petro-chemical companies to pave pathway to distribution/customers
- Next steps:
 - Own pathway from biomass feedstocks to petrol-pump
 - Identify disruptive market opportunities for fast penetration leading to quick feedback and optimization (Moore's Law) e.g.: pay to destroy bio-organic wastes such as **sewage sludge**

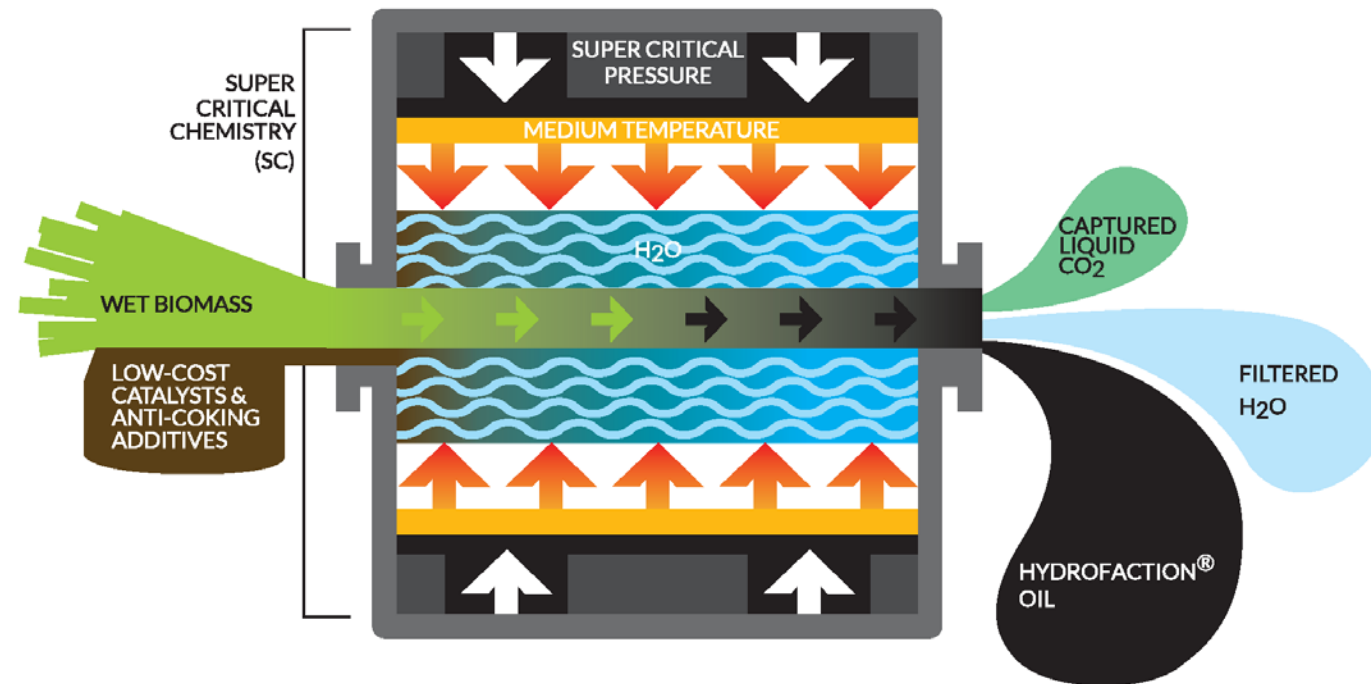
Hydrofaction®





 Proprietary take on **hydrothermal liquefaction (HTL)** optimized for higher yields of bio-fuels

 Transformation via **supercritical chemistry** ($\pm 400^{\circ}\text{C}$ and ± 330 bar) converting low-energy biomass into advanced bio-fuels

 **Renewable Hydrofaction® Oil** is similar to petroleum crude oil in composition and energy density

The US DOE recognizes **HTL** as being an exceptionally cost and resource efficient technology for production of biofuels with the greatest potential GHG mitigation for heavy transport



-  Sustainability (fuel versus food; land use change; culture; biodiversity)
-  Advanced biofuels: reducing carbon intensity of heavy transport (electrification or low energy-density fuels are a poor option)
-  Desire and commitment by fibre/agri-industries to enter biofuel market
-  Organic waste management (sewage, municipal, manure, and others)



Advanced Biofuels – can they make a real difference?

100 M odt/y¹
750,000 bpd



400 M odt/y²
3,000,000 bpd



Availability: **1.9B** odt/y of “non-food” non
“merchantable”⁴ biomass residuals

200 M odt/y³
1,500,000 bpd



Production: **14M** bpd of Hydrofaction[®] Oil or **32%** of
the world’s total transportation fuel demand



Reductions: accounts for over **14%** of global total GHG
emissions reductions target of limiting global warming
to 2°C by 2030, which needs to be 25% lower than
2017⁶

1. Canada Report on Bioenergy 2010, <http://www.bioenergytrade.org/downloads/canadareportonbioenergy2010sept152010.pdf>
2. US EIA “Billion-ton study”, http://www1.eere.energy.gov/bioenergy/pdfs/billion_ton_update.pdf
3. EUBIA 2015 & Monforti et al. 2015, https://gallery.mailchimp.com/6518403df5fe7c761f9d31bfd/files/EUROPEAN_BIOMASS_RESIDUES_EUBIA.pdf & <http://www.sciencedirect.com/science/article/pii/S1364032114010855>
4. IEA Sustainable Production of Second-Generation Biofuels, https://www.iea.org/publications/freepublications/publication/second_generation_biofuels.pdf
5. IEA, 2013 http://203.117.10.102/media/news_pdfs/WEO2012_Singapore_Fatih_Birol.pdf
6. <https://www.ipcc.ch/site/assets/uploads/2018/12/UNEP-1.pdf>



Clean Fuel Standard (CFS)

Overall objective is to achieve 30 million tonnes of annual reductions in greenhouse gas emissions by 2030. Liquid fuel class regulations come into force in Jan 2022.

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

Greenhouse Gas Reduction Act + Renewable Low Carbon Fuel Requirements Regulation, e.g. E5, B4; fuel suppliers must progressively decrease the average carbon intensity of their fuels to achieve a 10% reduction in 2020 relative to 2010.



Renewable Fuel Standard (FRS2)

Increase the volume of renewable fuel required to be blended into transportation fuel to 36 billion gallons by 2022.

Renewable Identification Numbers (RINs)

California Low Carbon Fuel Standard (LCFS)



Goal: Reduce carbon intensity of transportation fuel pool by at least 20% by 2030.





Renewable Energy – Recast to 2030 (RED II)

Overall target for Renewable Energy Sources consumption by 2030 has been raised to 32%. A transport sub-target has been introduced by co-legislators in the final agreement: Member States must require fuel suppliers to supply a minimum of 14% of the energy consumed in road and rail transport by 2030 as renewable energy.

 Silva Green Fuel: JV between Norway's **Statkraft** and Sweden's **Södra**:

-  Woody residue to renewable diesel, jet and marine fuels
-  Evaluated **40** technology pathways before choosing Hydrofaction®

Commercialization in two phases:

-  Phase 1: **€ 50+ M** industrial scale demonstration plant at Tofte, Norway
-  Phase 2: Commercial facility capable of producing **2,000 BPD or 100,000 Fuel Tonnes per Annum** (capex: \cong € 200+ M)






Statkraft





SÖDRA

Highly Attractive Market

 **Evolving regulatory standards** compromise use of anaerobic digestion:

-  biosolids disposal,
-  nutrient recovery and
-  landfill control


 **Public concerns on contaminants**


-  Pharmaceuticals (endocrine-disruptors)
-  Micro-plastics

 **Growing population** taxing the capacity for existing biosolids infrastructure

 **Rising costs** for water and sewage fees

Hydrofaction® Competitive Advantages

 Gate fees from **negative cost feedstocks** enable positive economic returns from urban-scale Hydrofaction® plants

 Hydrofaction® is an ideal **solution** for **wet** primary and secondary sludges

 Steeper team has a **strong background** with HTL for sewage

 **Demo-Scale Forestry = Commercial-Scale Sewage**, validating both market solutions with Silva demonstration project



-  Most efficient thermochemical platform to convert waste/low-value biomass into biocrude
 - ✓ Proven chemistry with strong enforceable IP position
 - ✓ Recognized and validated by industry, government and authorized third parties

-  Convert sewage biosolids/sludge into renewable transportation fuels
 - ✓ Solves growing waste management issues
 - ✓ Marine fuels plus upgrading to drop-in fuels

-  Hydrofaction® Demonstration-scale Projects facilitate market adoption
 - ✓ Norway woody biomass Demo Project proves path to large-scale advanced biofuel production
 - ✓ Tofte Demo is equivalent to commercial-scale for: urban bio-organic wastes and remote location energy projects...
 - ✓ De-risks technology scale-up and provides for optimization and technology advances

-  Proven chemistry and implementation offers substantial GHG reductions in transport fuels