BL2F

Biofuel Co-production at Pulp Mill by Novel HTL Technology

Heat-to-Fuel, 27th April 2022, Vienna

BL2F

Transforming Black Liquor to Biofuel

This project has received funding from the European Union Grant Number 884111

The BL2F Project

Black Liquor to Fuel (BL2F) is a H2020 project that will transform **Black Liquor** into a new, clean biofuel for aviation and shipping

12 partners

8 countries

36 months

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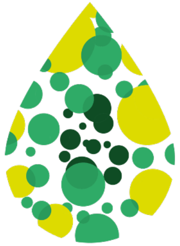
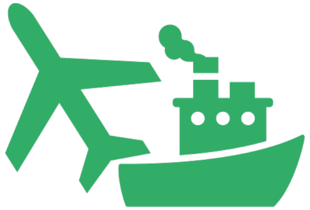
Project Goals



Create a high-quality drop-in biofuel



Decrease carbon emissions from aviation and shipping

Decrease the use of fossil fuels

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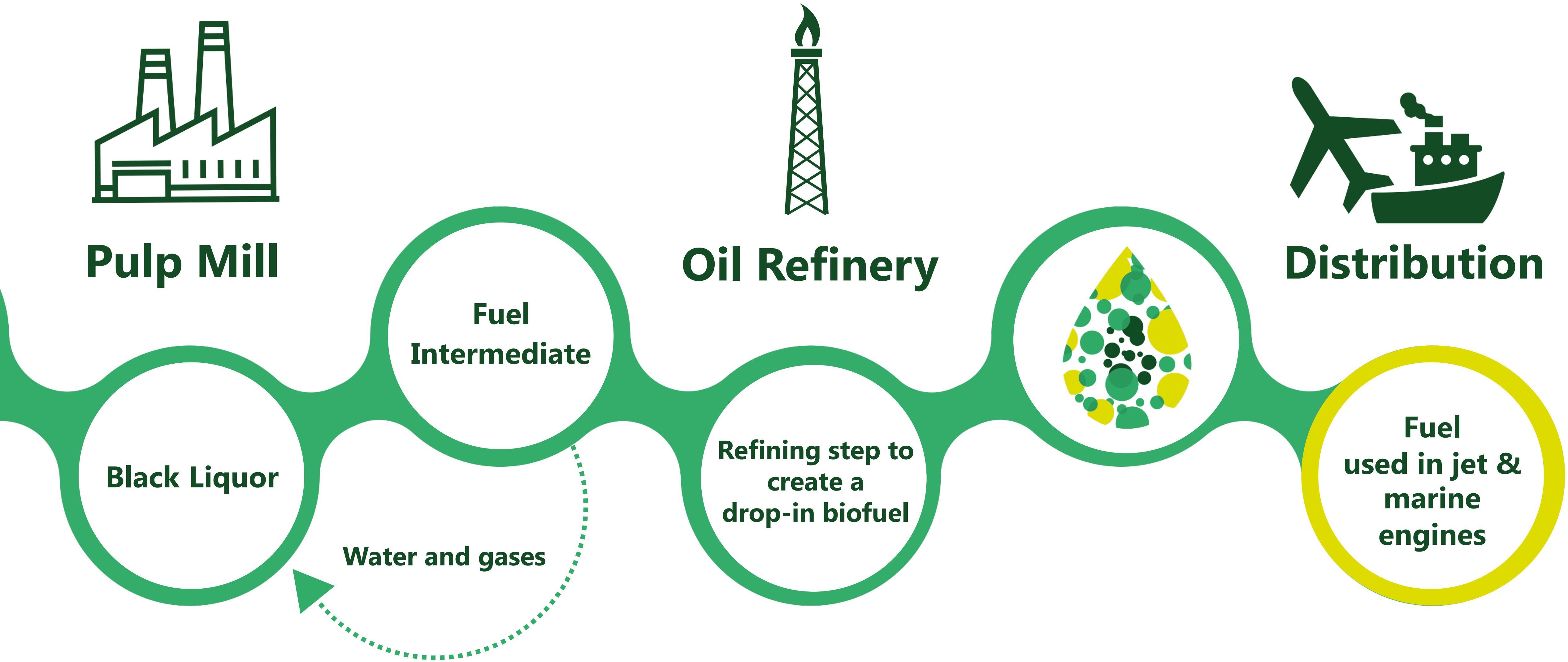
The BL2F Process



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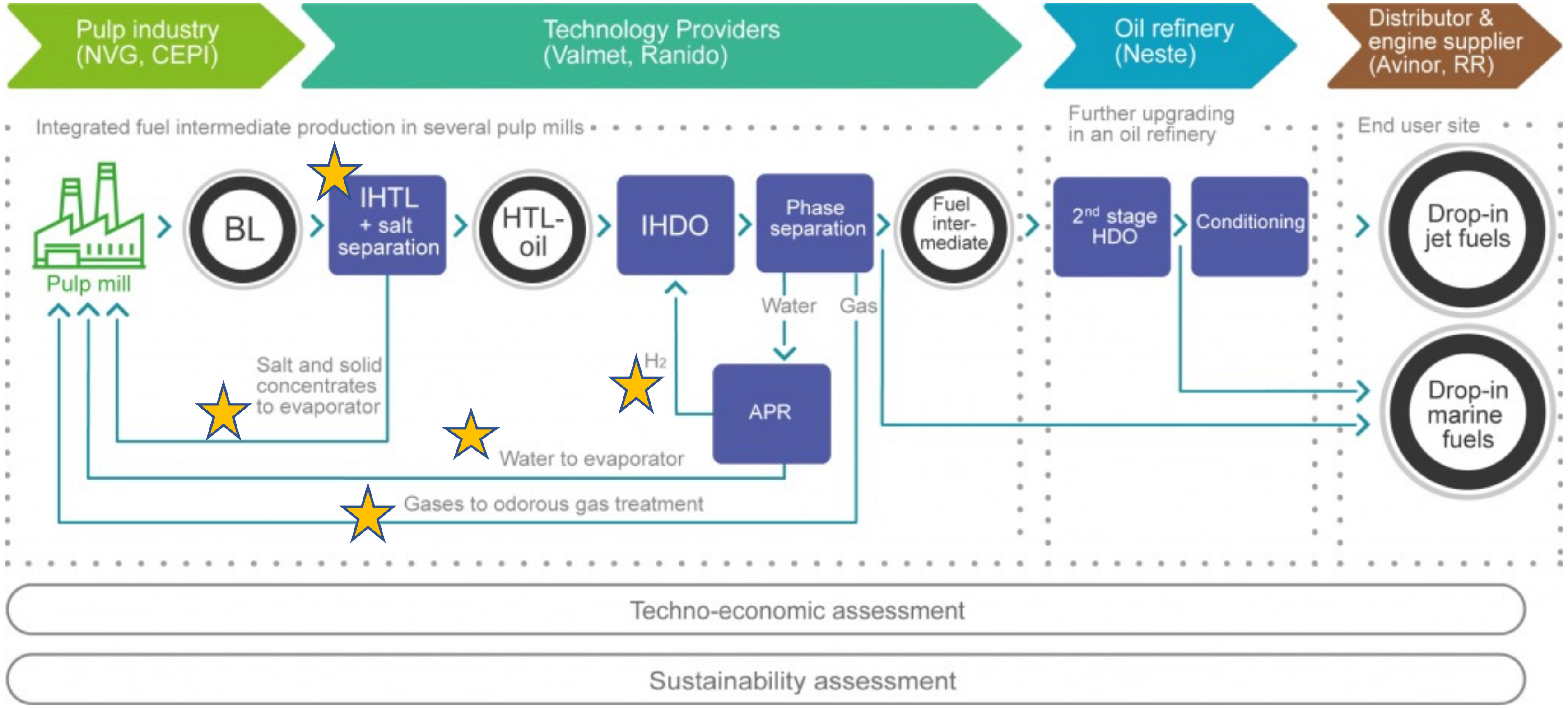
The BL2F Value-Chain



1. Salt separation
2. Solids/salt handling
3. Water handling
4. Gas handling
5. Hydrogen production

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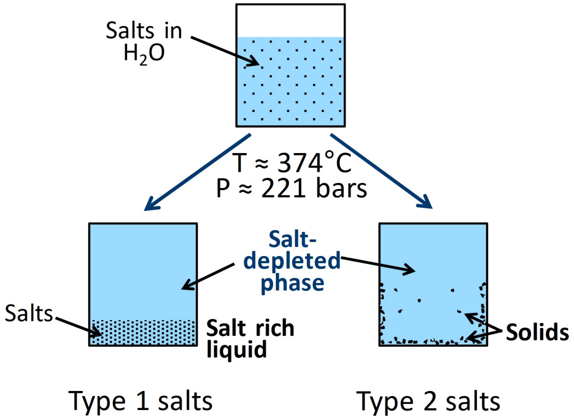
Salt Separation Integrated-HTL

- Salts have limited solubility in supercritical water
- Salts 1 and 2 behave differently
- Black liquor contains both types



Ions	HO^-	Cl^-	CO_3^{2-}	SO_4^{2-}
Mg^{2+}	2	1	2	2
Ca^{2+}	2	1	2	2
Na^+	1	1	2	2
K^+	1	1	1	2

Lappalainen, Jukka, David Baudouin, Ursel Hornung, Julia Schuler, Kristian Melin, Saša Bjelić, Frédéric Vogel, Jukka Konttinen, and Tero Joronen. "Sub-and Supercritical Water Liquefaction of Kraft Lignin and Black Liquor Derived Lignin." *Energies* 13, no. 13 (2020): 3309

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Financial Estimate of Pulp Mill Integration

Integration to a pulp mill

- Abundant and Pumpable feedstock
- Homogenous quality
- Thermal integration (steam system of recovery boiler)
- Evaporator for preheating/ concentration
- Solids, water and gas handling
- Existing operation and maintenance personnel

Biomass conversion technology		IHTL	HTL
Technology development level		R&D	
Plant size	1000t/a	150	180
O&M	M€/1000t	0.40	0.22
Investment	M€/1000t	0.73	2.00
Total	M€/1000t	1.23	2.22

45 % saving

- Ong et al. Co-liquefaction of BL and Radiate Pine
  Cost of ~ 0.7 €/L
- Funkerbusch et al. at large Kraft pulp, excess lignin feedstock
  - **Cost of ~ 0.4 €/L**

Lappalainen, Jukka, David Baudouin, Ursel Hornung, Julia Schuler, Kristian Melin, Saša Bjelić, Frédéric Vogel, Jukka Konttinen, and Tero Joronen. "Sub-and Supercritical Water Liquefaction of Kraft Lignin and Black Liquor Derived Lignin." *Energies* 13, no. 13 (2020): 3309

Ong, Benjamin HY, et al. "A Kraft Mill-Integrated Hydrothermal Liquefaction Process for Liquid Fuel Co-Production." *Processes* 8.10 (2020): 1216

Funkenbusch, LiLu T., Michael E. Mullins, Lennart Vamling, Tallal Belkhieri, Nattapol Srettiwat, Olumide Winjobi, David R. Shonnard, and Tony N. Rogers. "Technoeconomic assessment of hydrothermal liquefaction oil from lignin with catalytic upgrading for renewable fuel and chemical production." *Wiley Interdisciplinary Reviews: Energy and Environment* 8, no. 1 (2019): e319

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Reactor Design at Tampere University

Objective:

- Effective HTL reaction
- Simultaneous removal of salts

Requirement:

- Uniform temperature distribution
- Sufficient residence time

Design challenges:

- Wall heat transfer not effective because of thickness of the reactor walls
- Plugging of reactor due to crystallization of Type-2 salts
- Products extraction

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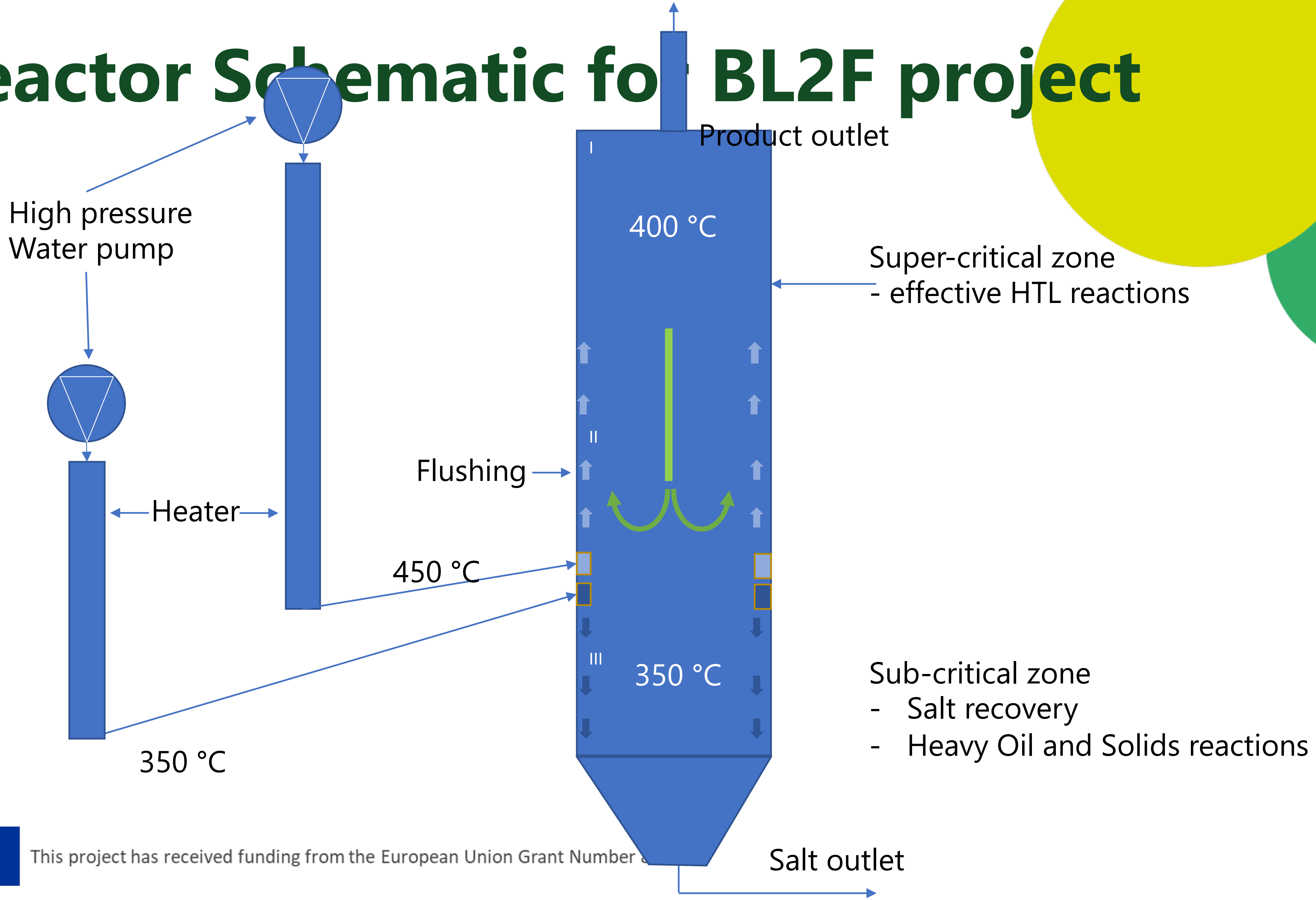
Reactor Schematic for BL2F project



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HTL facility developed at Tampere University – BL2F and other HTL facilities

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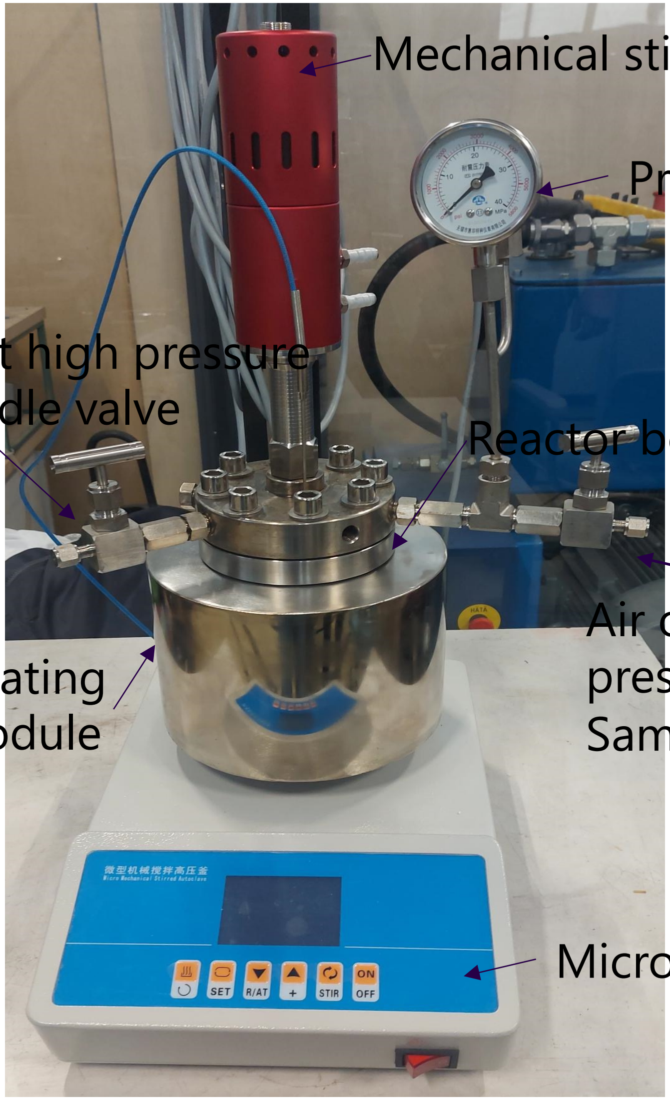
Batch Reactor Facility



Specifications	Value
Volume	500 ml
Kettle Material	SS 304
Operating Temperature	450 °C
Working maximum pressure	0-35 Mpa
Stir Method	Mechanical stirring
Manufacturer	Ollital Technology

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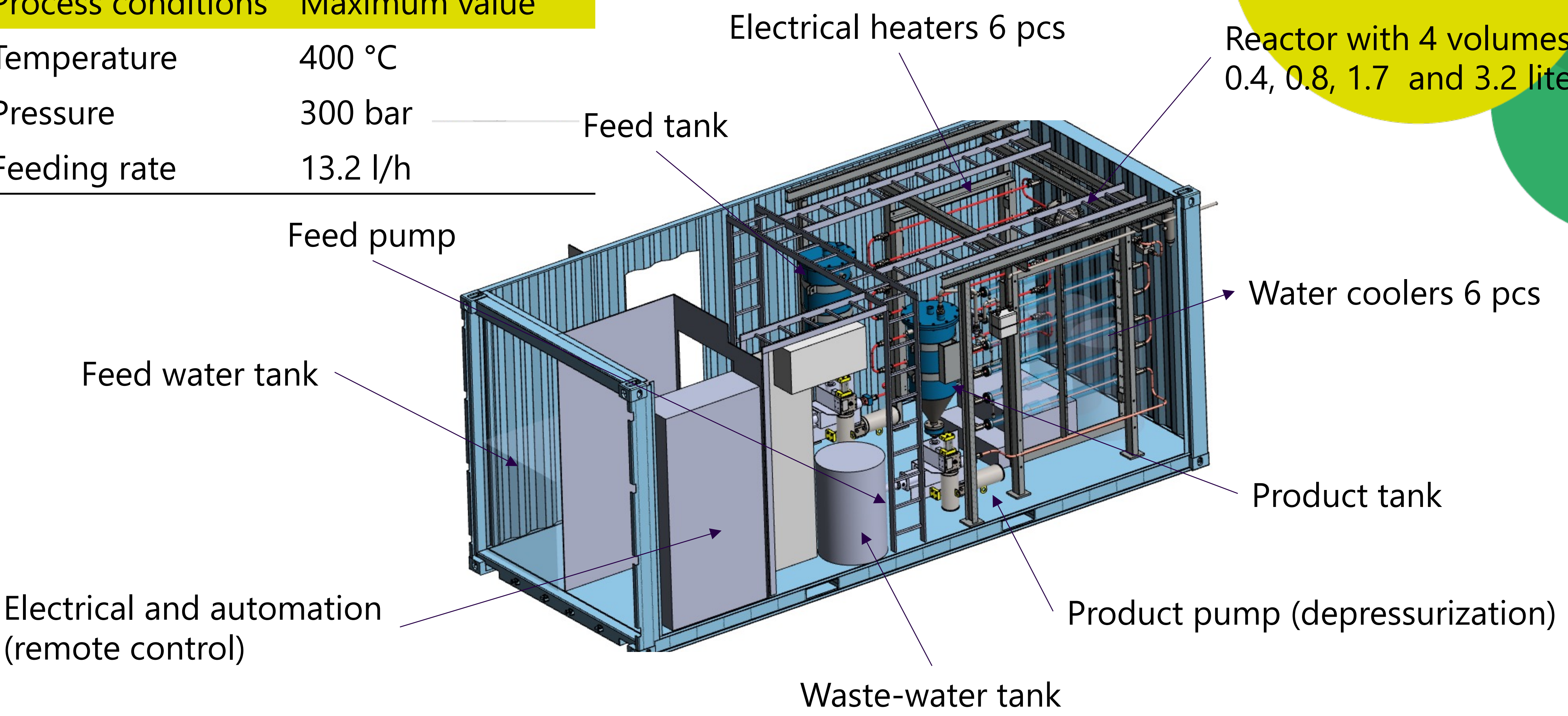
Continuous Reactor Facility - EHTA

Process conditions	Maximum value
Temperature	400 °C
Pressure	300 bar
Feeding rate	13.2 l/h



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EHTA process

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First result from our Continuous experiments

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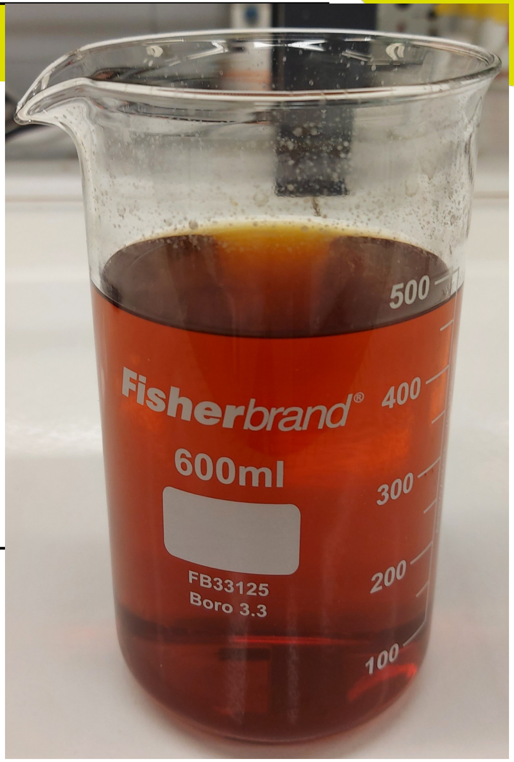
First product from Continuous EHTA facility

Specification	Value
Feedstock	Biowaste
Feedstock particle diameter	<500 µm
Feedstock concentration	10 wt%
Temperature	350 °C
Pressure	220 bar
Residence time	15 min



Bio-crude from
EHTA test equipment

Aqueous phase after
biocrude separation

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Analysis of HTL product and feedstock

Elemental analysis of Lignin, Biocrude and Hydrochar

Sample	N	C	H	S	O	Ash	HHV*
Lignin	0.47	53.64	5.8	4.85	35.4	0.08	29.556
Hydrochar	0.25	48.4	3.208	0.972	21.44	25.72	23.14
Biocrude	0.412	80.247	7.135	1.127	**8.88**	2.3	**37.52**

*Higher heating values (HHV) were calculated according to Boie's formula:
HHV = 0.3516 C +1.16225 H + 0.1109 O + 0.0628 N

TOC analysis of Aqueous phase

Sample	TOC	TC	LC
Aqueous phase	24600	32820	8214

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BL2F Partners:

Tampere University

Brunel University London

KIT Karlsruhe Institute of Technology

SINTEF

PAUL SCHERRER INSTITUT PSI

VTT

THE NAVIGATOR COMPANY

Valmet

NESTE

Ranido

LGi sustainable innovation

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Thank you!

Get in touch with the project:

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