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BIOCODE: Towards a novel and sustainable biorefinery concept based on green technologies for main commercial grain crop residues

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What is BIOCODE?

- A **sequential fractionation concept** based on **extraction pretreatment** (minor components) followed by **hydrothermal destructuration** (major components) will be developed and **integrated with conversion techniques** based on**:**
  - **Organosolv – Fermentation** (hemicellulose valorisation)
  - **Deep eutectic solvents** (cellulose valorisation) and,
  - **Hydrothermal carbonisation** (lignin valorisation).

- The concept is envisioned to enable flexible and **multifeedstock processing in smallscale units**.

- All processing is **based on green chemistry or techniques** with the sustainability, carbon footprint and economic potential evaluated.

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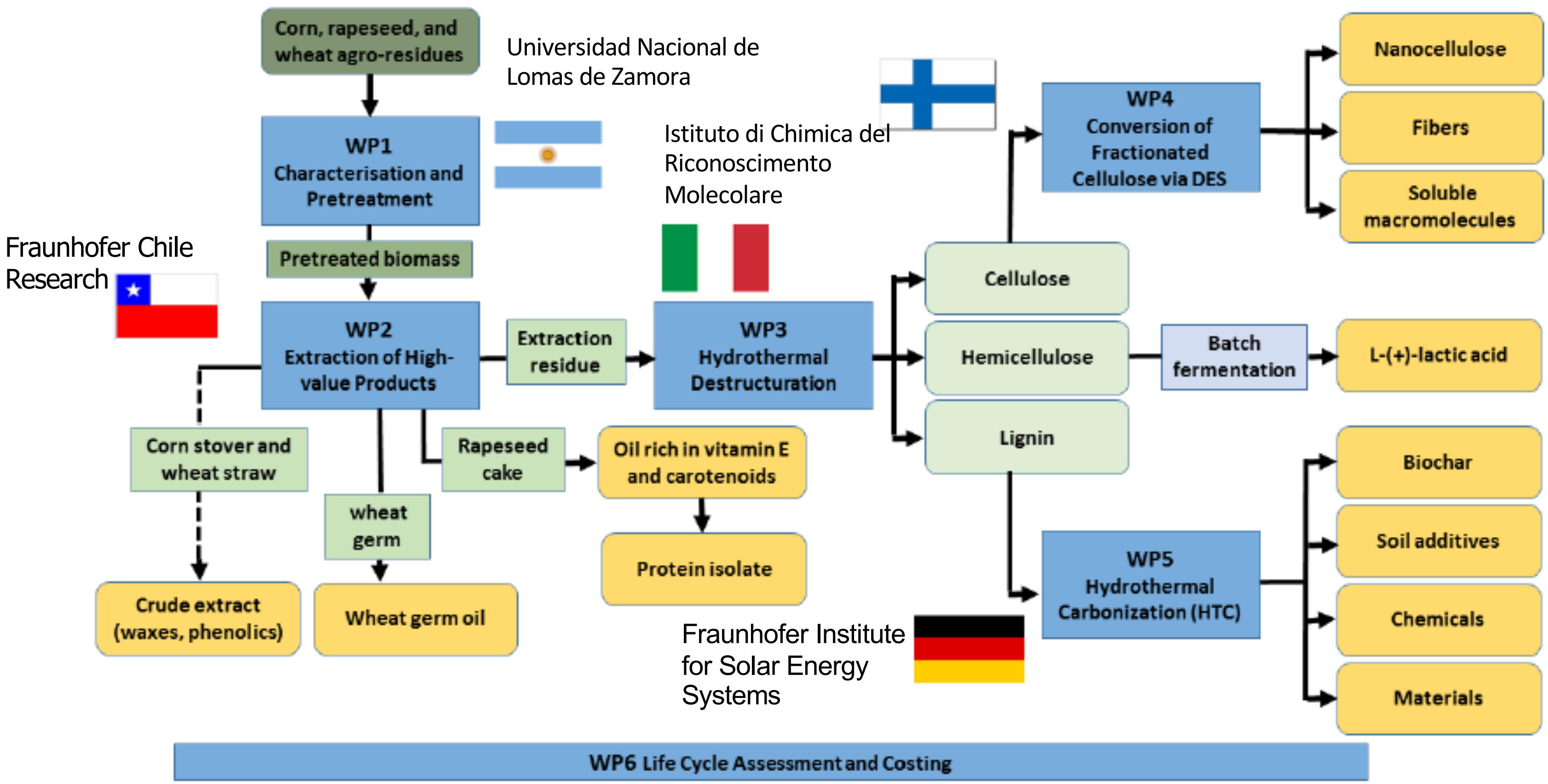
What is BIOCODE?

Project structure



BIOCODE assessment structure

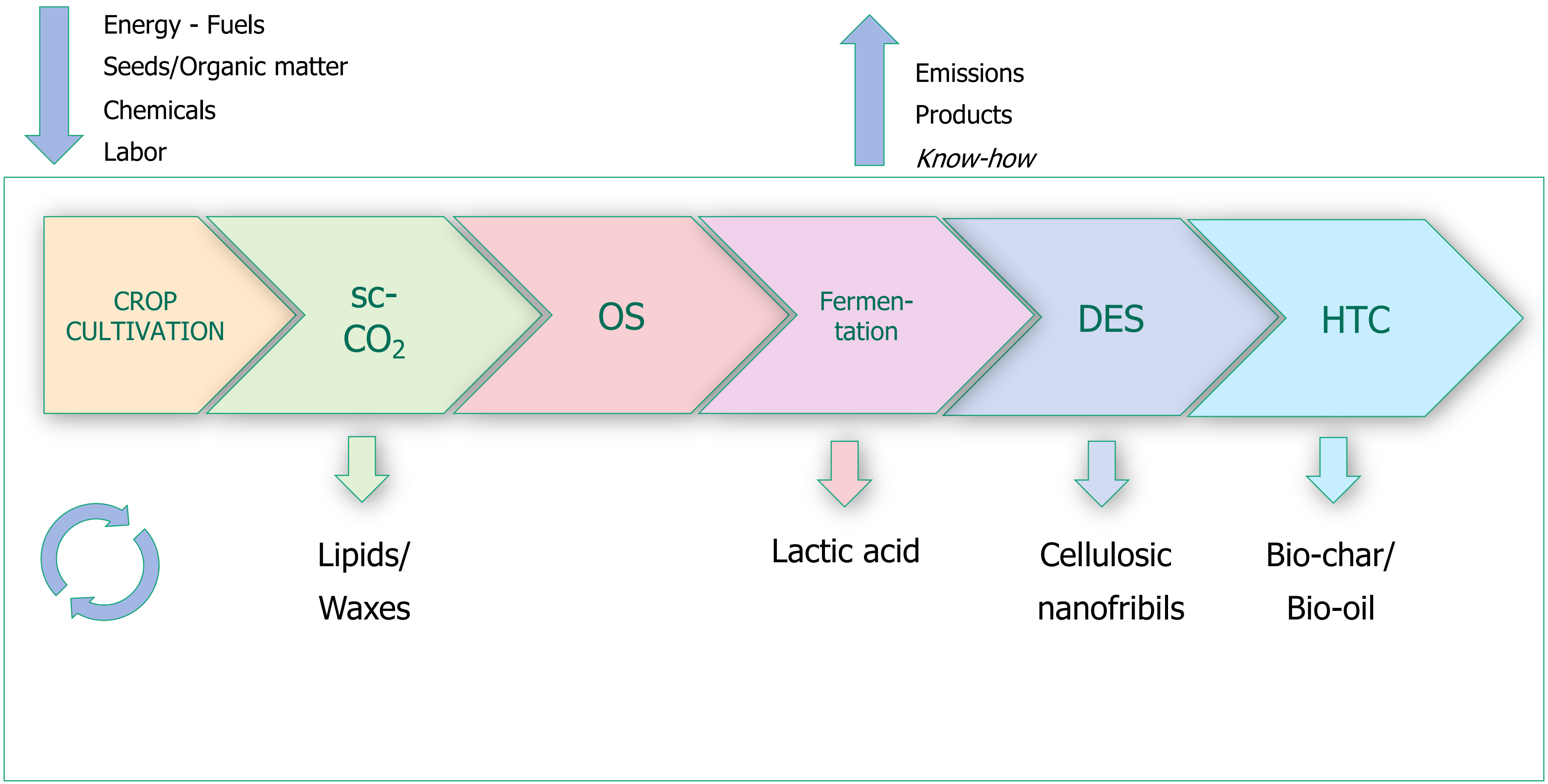
- Process definitions
  - Boundary
  - Products
  - Flow diagrams
  - Set conditions/parameters (experimental)
  - Mass and Energy balances
  - Economic context

Project impacts

- Economic
- Environmental
- Social

- Results validation (iterations within the partners)

Process definitions



Process scheme

WP-1 Crop selection and conditioning (UNLZ) – Dr. César López

- Most prominent commercial crops residues
- Crop variety selection
- Homogenisation and conditioning (10% Humidity, chopped, milled and vacuum packed)
  - Conditioning treatment: Higher material density → Enhance economic viability

Rapeseed

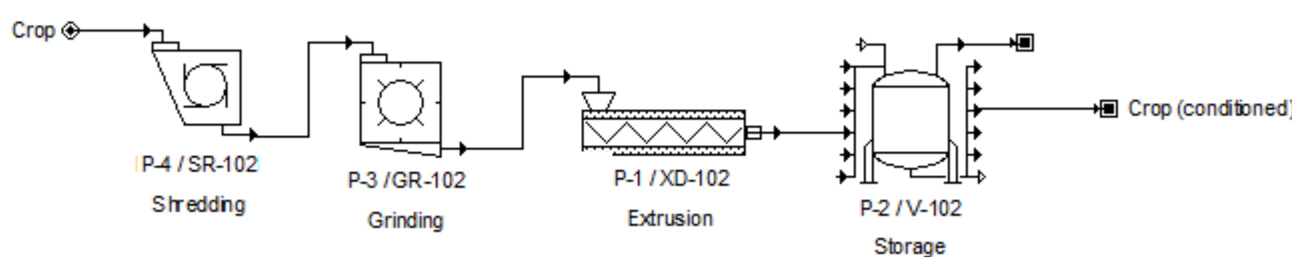
Wheat straw

Corn stover

Wheat germ

Best genotypes **WHEAT**

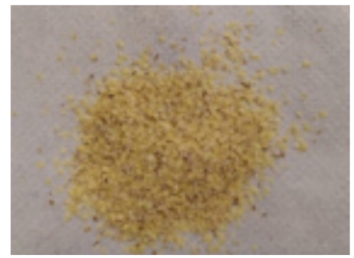
Up to 2.4 ton/ha of cell+Hcell and 1.4 ton/ha of lignin



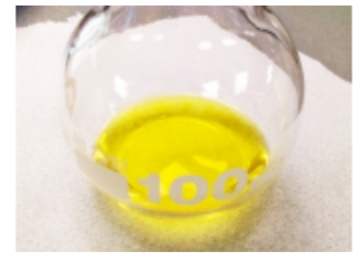
Process scheme

WP2- CO_2 Supercritical extraction/Lipids recovery (FCR) – Dr. Freddy Urrego / Dr. Franko Restovic

- Calculation base: 1.5 ton raw material per batch
- Sc-CO_2 parameters
  - Pressure: 300 – 400 bar
  - Temp.: 40 – 90ºC
  - Time: 5.3 – 13.2 h
  - up to 100 kg CO_2/kg raw material

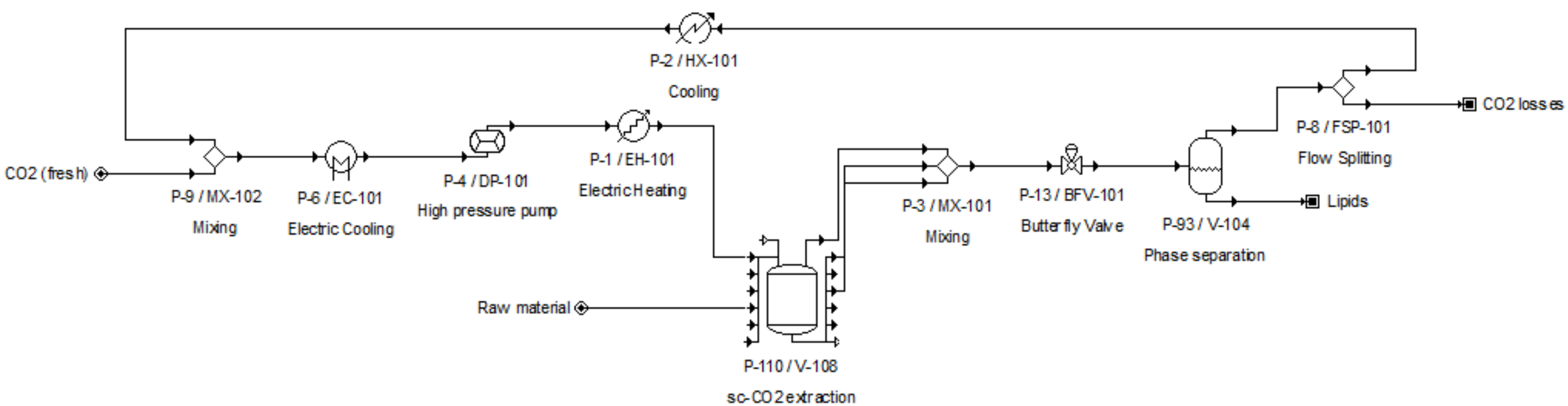


Raw material before sc-CO_2



Lipids recovered after sc-CO_2

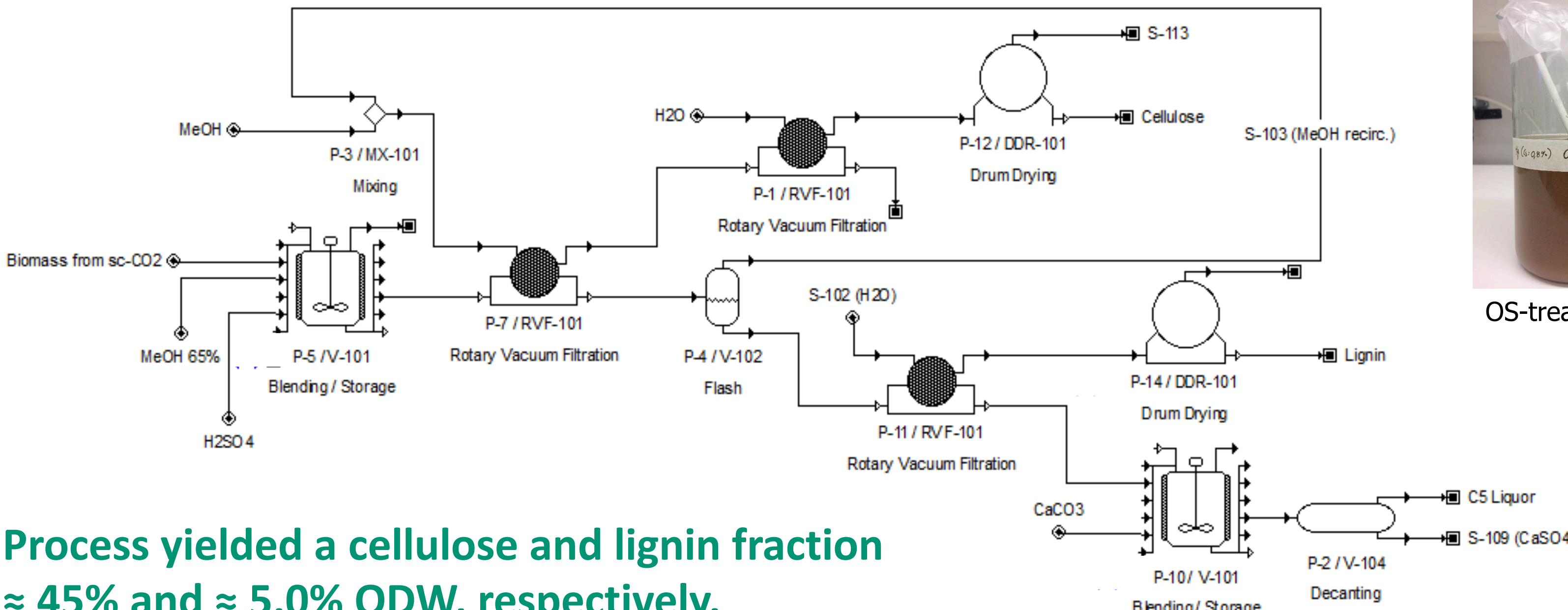
Wax/Lipids recovery 2.0 – 3.0% ODW

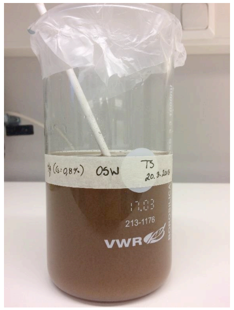


Process scheme

WP3- Organosolv fractionation (ICRM) – Dr. Gianluca Ottolina / Pierfrancesco Ricci

- OS parameters
  - Biomass: 10% w/v
  - Time: 40 min
  - Temp.: 165ºC
  - Pressure: 4 bar
  - MeOH: 65% v/v
  - H_2SO_4 : 2.5% w/w





OS-treated lignin

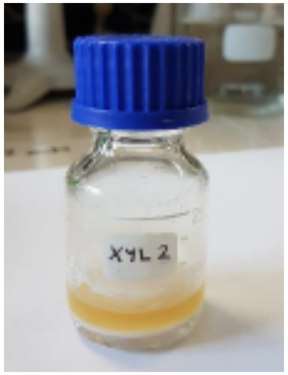
Process yielded a cellulose and lignin fraction ≈ 45% and ≈ 5.0% ODW, respectively.

Process scheme

WP3- C5 liquor fermentation/Acid lactid production (ICRM)

- Fermentation parameters
  - *Bacillus coagulans* XZL4
  - Sugar concentration 100 g/L
  - Yeast extract 10 g/L
  - $CaCO_3$ 60 g/L
  - Temp.: 50ºC
  - Agitation: 130 RPM
  - Time: 144 h

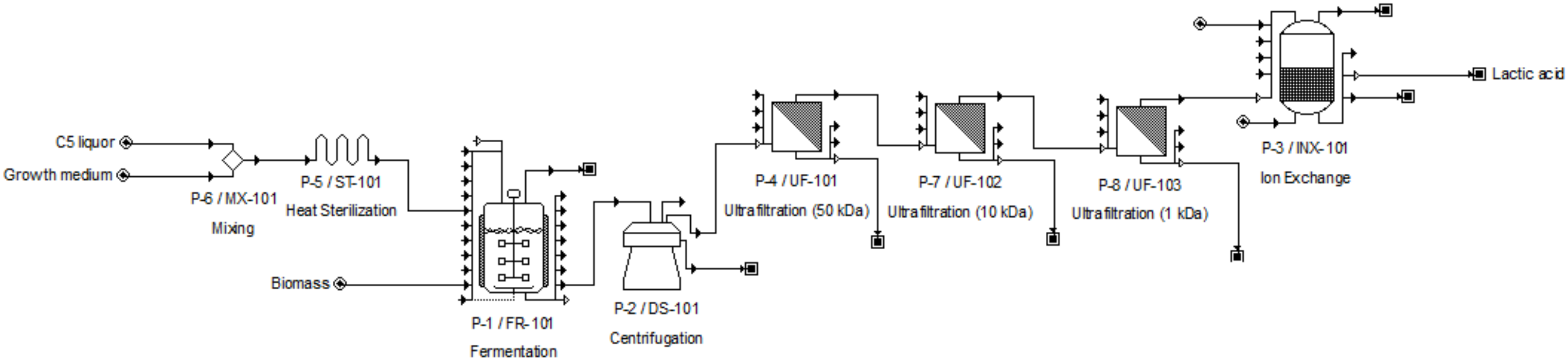
Sugar	%
Glu	12.3
Xyl	83.7
Gal	1.9
Ara	2.1



Fermentation broth

Xylose equivalents by DNS Assay in C5-black liquor: 5.28 g/L

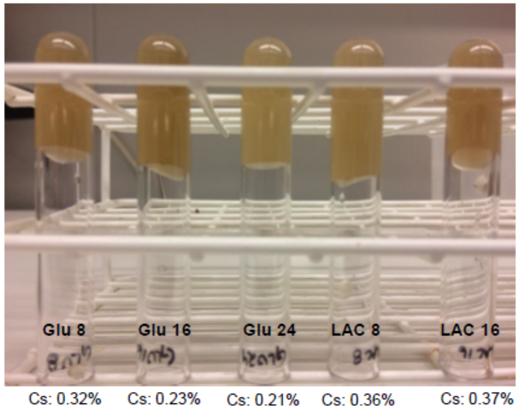
Lactic acid yield up to 0.9 g/g sugar



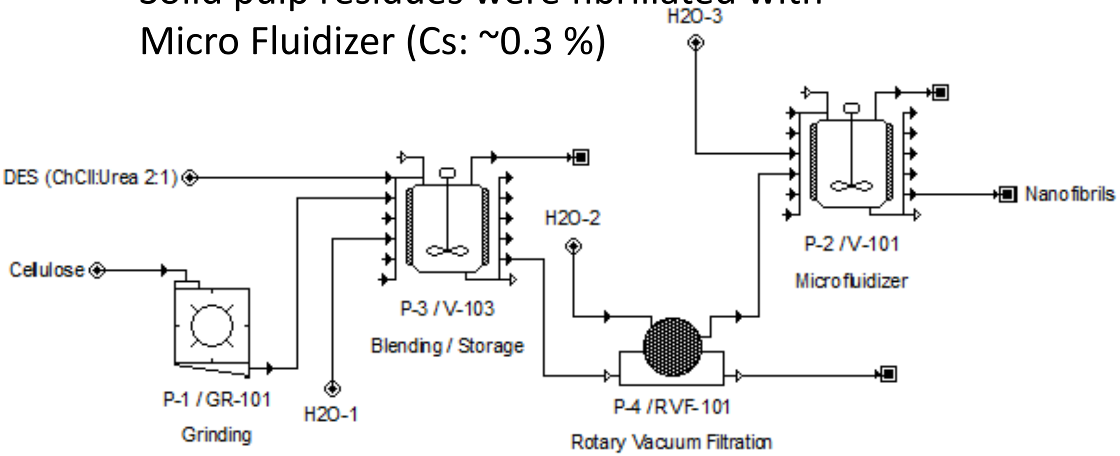
Process scheme

WP4- Cellulose DES treatment/Nanofibrils synthesis (Univ. Oulo) –
Dr. Henrikki Liimatainen / Dr. Terhi Suopajärvi

- DES parameters
  - Choline chloride-Urea (2:1)
  - Temp. 100ºC
  - Time: 2 h
  - Cs: 2%
  - Solid pulp residues were fibrillated with Micro Fluidizer (Cs: ~0.3 %)



Cellulose pulp after fibrillation

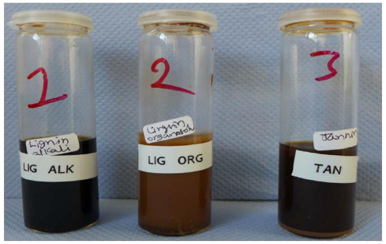


Best results were obtained with tensile strengths in the range of 92.0–99.2 MPa.

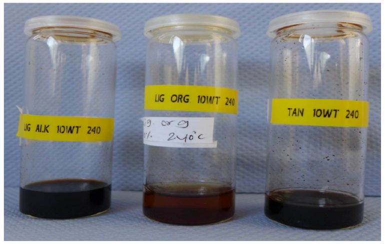
Process scheme

WP5- Hydrothermal carbonisation/Biochar production (Fh-ISE) – Dr. Monika Bosilj / Dr. Robin White

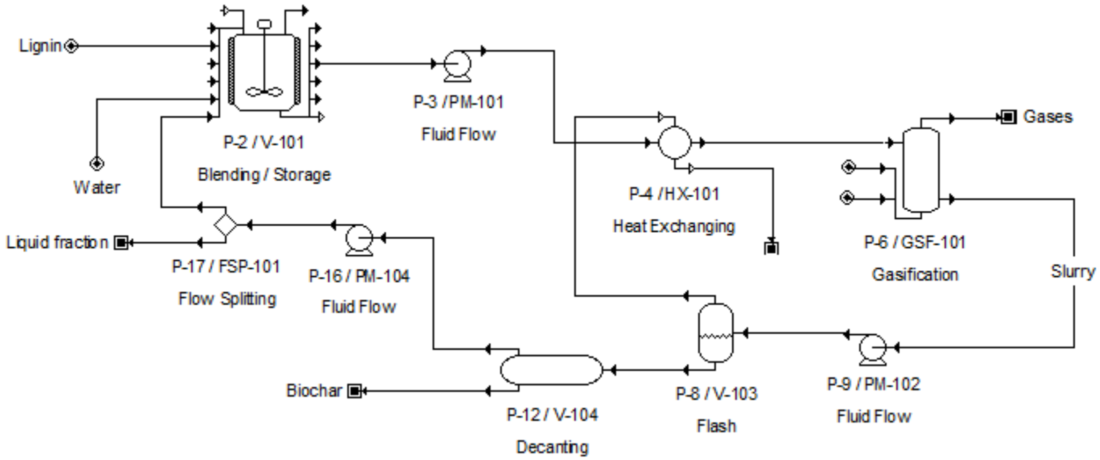
- HTC parameters
  - Temp.: 160 – 240ºC
  - Pressure: autogeneous – 50 bar (N_2)
  - Time: 1 – 24 h
  - Catalyst- a mineral base, TiN/NDC



Dissolved lignin before HTC



Liquid fraction after HTC



Biochar yield ≈ 65%

HTC-240ºC, only C and O were detected

Main conclusión from experimental stage

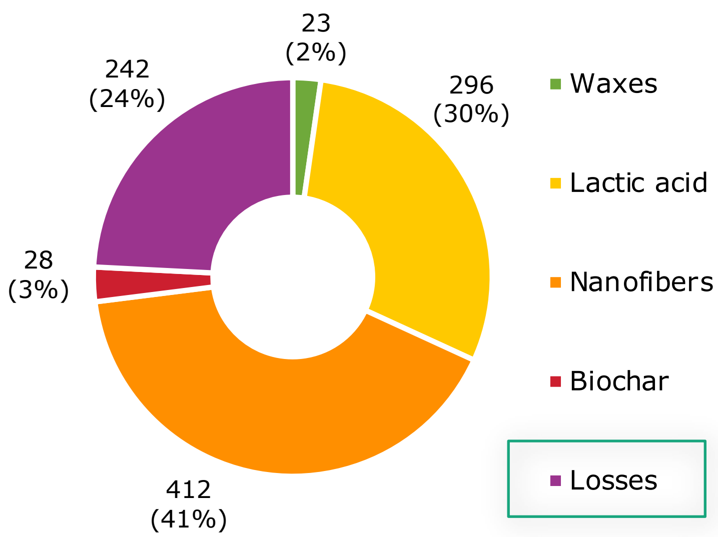
- **Technically,** application of the biorefinery concept on these selected lignocellulosic biomasses **is favourable** under the proposed conditions.

On-going research

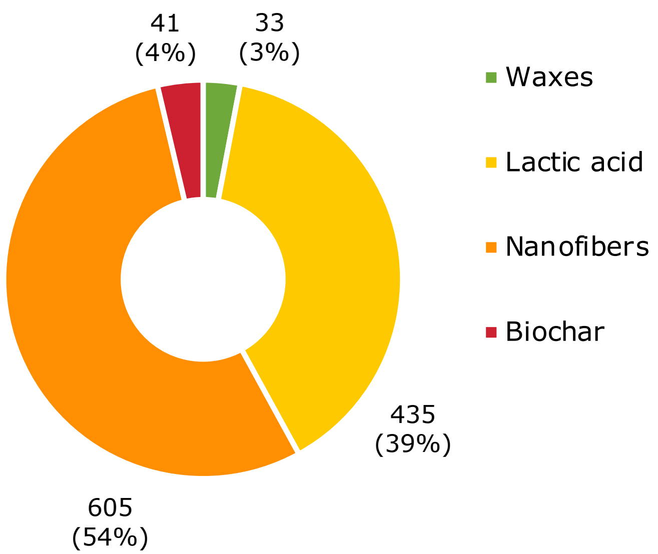
- Economics/LCA by Fraunhofer ISE + Partners
- Feasibility of lignocellulosic biorefinery scheme
  - Mass & Energy Balances
  - Models "tunning"

BIOCODE - Preliminar Mass Balance

Products (kg/ton crop)



Product yield (ton/yr)



IDENTIFICATION OF LOSSES

Process conditions?

Emissions?

Possibilities of valorisation?

→ Is this worthy?

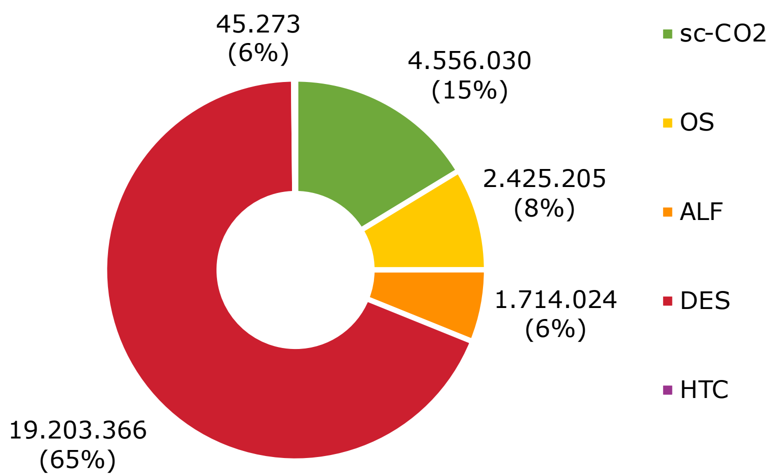
How to select the main product?

The one with the…

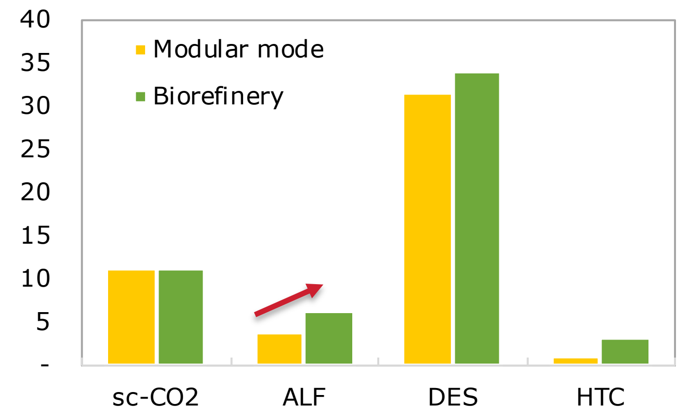
- higher profits?
- minor environmental footprint?

BIOCODE - Preliminar Economic Data

Operating costs ($/yr)



Unit production cost ($/kg)



OS costs needs to be absorb
by the final products

Costs depending on:

- Equipment selection
- Processing configuration
- Scaling-up economy

All processes are economically sustainable?

Can the biorefinery scheme survive if one module fails?

Acknowledgments

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Robin White

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María Eugenia Martínez


training
Capacity
industries
simulations
computing
Firstly
Chilean
number
host
major
development
solutions
strategies
extensive
salmon
fish
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expertise
Systems
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Chile
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