Bio4Fuels

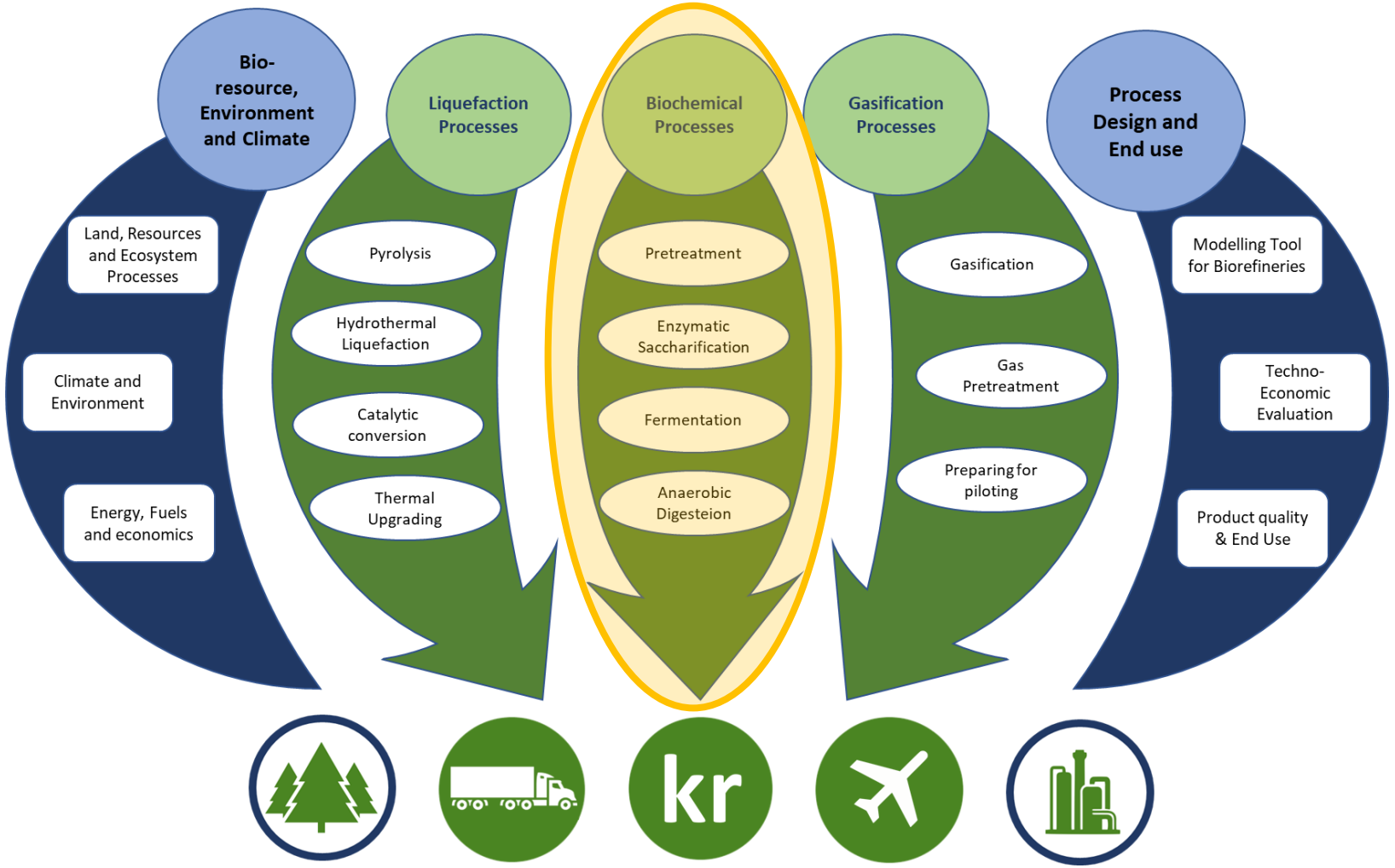
Norwegian Centre for Sustainable Bio-Based Fuel and Energy

SP3 - Work Plans 2021

Virtual Bio4Fuels Days – Nov 19, 2020

Anikó Várnai

SP3 The ‘Biochemical processes’ value chain



SP3 – Contact with industry
Work Packages and associated primary stakeholders in SP3

WP3.1 Pretreatment and fractionation – *Michaela Tanase-Opedal, RISE-PFI*

- **Norske Skog, St1, Borregaard**

WP3.2 Enzymatic saccharification – *Anikó Várnai, NMBU*

- **St1, Borregaard, Novozymes**

WP3.3 Fermentation – *Alexander Wentzel, SINTEF*

- **St1, Borregaard, Novozymes**

WP3.4 Anaerobic digestion and gas upgrading – *Michał Sposób, NIBIO*

- **ZEG Power, Oslo EGE, Biokraft, CAMBI**

Outline

- Takeaway points from the Midterm Evaluation – Aspects we have explored at SP level during 2020
- SP3 ‘The Biochemical processes’ value chain
  - Value chain perspective
    - ***Mapping of input/output streams connecting WPs***
    - ***Identification of potential value-added products***
  - Contact with industry
    - ***Mapping of direct contact at WP and product level***
- Work Plans in brief for 2021
- Innovation

New directions – SP3-relevant takeaway messages from the SWOT analysis

- "**Weeknesses**":
  - "**weak horizontal communication** (maybe of less importance)"; "**Integration across value chains challenging**"
  - "**Poor link between different parts of the value chains**"; "**Collaboration with Bio4Fuels members of different WPs** could be strengthen"; "often too much focus on individual WP activities, **more focus on cross WP activities** needed"
  - "Complex technology conversion routes and small amount of resources on each route. **Industrial partner engagement in the technology development is limited.**"
  - "**too little resources used on non energy applications** and, consequently, **lack of integrated thinking**."
  - "Despite of the restructuring into value chains, which helped a lot, **the spread of very different technologies** is still a challenge with respect to **potential new solutions across different value chains**."
- "**Opportunities**":
  - "increased interest in **advanced biofuels**"
  - "Integration of Bio4Fuels with **biorefinery research that is not focused on energy** could have great positive effects."
- **"Threats"**:
  - "There is a general lack of progress in commercial implementation nationally and internationally. This can be a major showstopper if the projects that are in the pipeline for start up in 2021 are not realized"

New directions – SP3-relevant takeaway messages from the SWOT analysis

- "**Weeknesses**":
  - **Communications: Connecting WPs** at value chain level and across value chains
  - **Contact with industrial partners: Better engagement at WP and product level**
  - **Integrated thinking:** Identification of complete value chains from raw material to product
- "**Opportunities**":
  - **Target materials:** Advanced biofuels and **value-added** non-fuel **products**
- **"Threats"**:
  - **Industry-relevant research:** Engagement of industrial partners in R&D; demonstration-scale trials
- **Some notes:**
  - Communication: SP3 participated with highlights from 3 WPs in the Summer 2020 and from 2 WPs in the Autumn 2020 Newsletters.
  - One of our technology developments (WP3.2) have been tried at demonstration scale at Borregaard's facilities and another technology (WP3.3) is currently developed with St1's involvement.

SP3 The biochemical value chain – From raw material to product

Nordic biomass

Norske Skog Skogn

Norske Skog St1 Borregaard

WP3.1 Pretreatment and fractionation — RISE-PFI

3.1-2 Pretreatment liquor

St1 Borregaard

3.1-1 Pretreated biomass

Enzymes

Novozymes

Borregaard St1 Novozymes

WP3.2 Enzymatic saccharification — NMBU

3.2-2 Lignin-rich residue

St1 Borregaard

3.2-1 Sugar-rich hydrolysate

Enzymes

3.1-1 PT Biomass

Borregaard St1

WP3.3 Fermentation — SINTEF

WP3.3 Fermentation, oleaginous — NMBU

3.3-4 Solid fermentation residue

ZEG Power Oslo EGE BioKraft CAMBI

WP3.4 AD and gas upgrading — NIBIO

3.4-2 Solid residue

St1 Umoe

3.3.1 Ethanol

3.3.2 Advanced fuels (e.g. Butanol)

3.3.3 Microbial oil

ZEG Power Oslo EGE

3.4.1 Biogas

2.3.1 Biooil

WP2.3 Thermochemical upgrading

WP5.2 Techno-economic evaluation

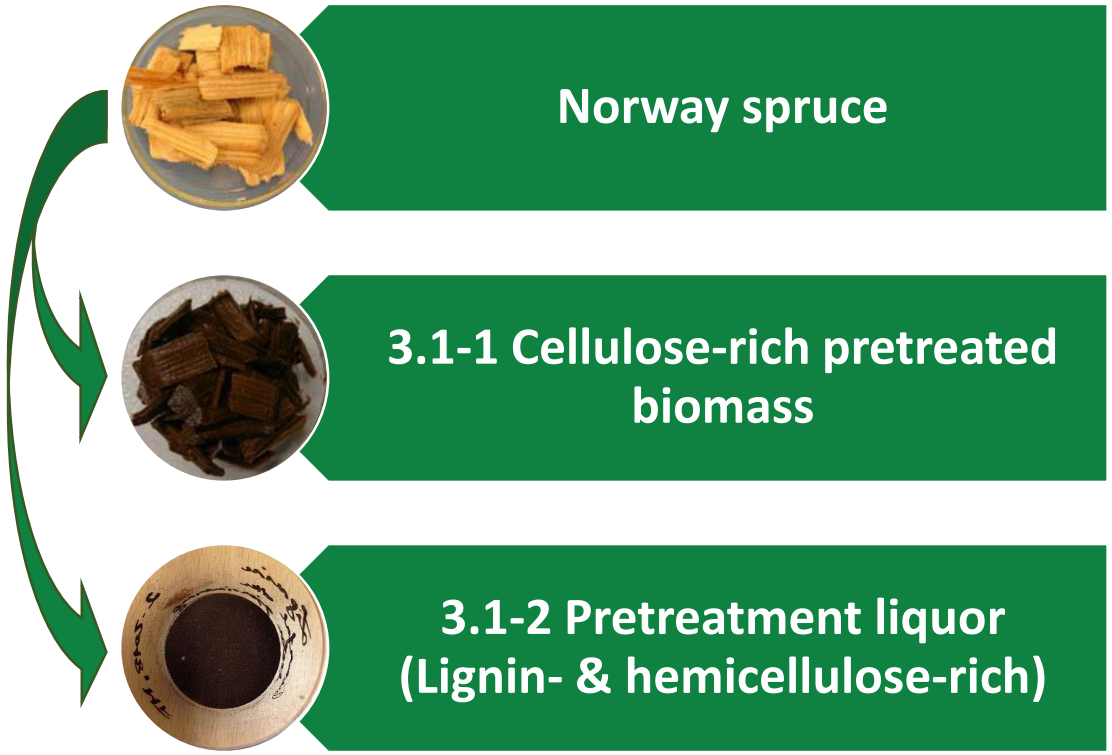
WP2.1 Pyrolysis

WP4.1 Gasification

Focus on mapping…

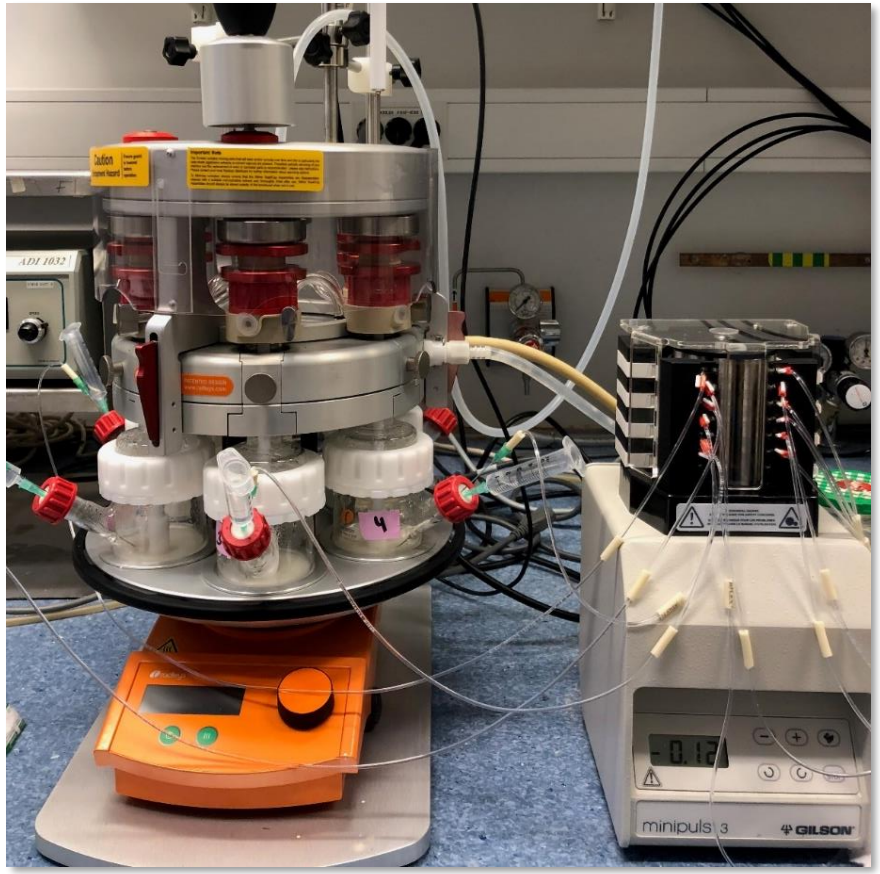
- Input/output streams **connecting WPs**
- Potential **value-added products**
- **Contact with industry** at WP and product level

WP3.1 Pretreatment and fractionation – Work Plan 2021



- Cooperate with downstream activities in technology development
  - **WP3.2-4:** Send liquid and solid fractions generated with the optimized pretreatment process
  - **WP5.2:** Provide data to the techno-economic assessment
- Investigate the possibility of **value-added products from organosolv lignin**
- Investigate the possibility to use an organosolv technology to produce cellulose-, hemicellulose- and/or lignin-based aviation fuels.

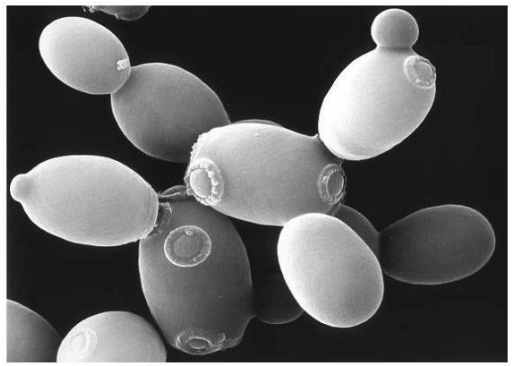
WP3.2 Enzymatic saccharification – Work Plan 2021



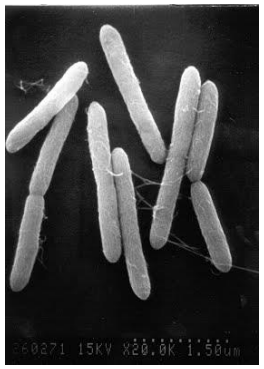
- Follow up cross-WP activities; produce samples for linked WPs (WP3.1, 3.3, 3.4) to strengthen interaction within SP3 and with WP2.4
- Assess the saccharification potential of organosolv-treated spruce from WP3.1-Pretreatment (PFI) using Cellic CTec2 and the importance of specific monocomponent enzymes.
- Test the efficiency of H_2O_2 feeding to activate LPMOs during SSF of pretreated biomass using cellulases and ethanol- or lactic acid-fermenting bacteria.

WP3.3 Fermentation – Work Plan 2021

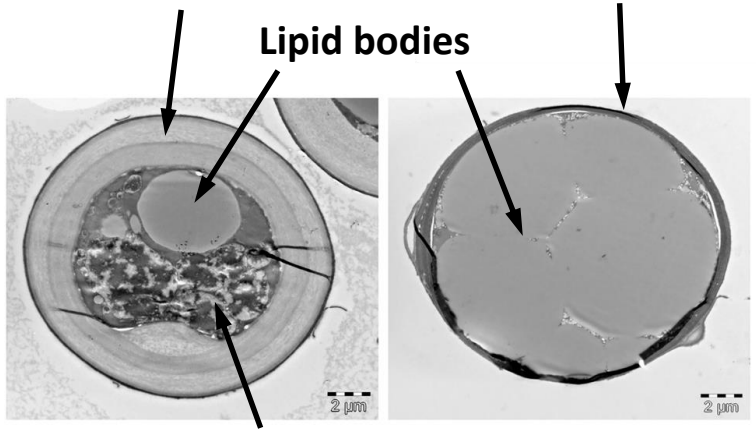
Fermenting yeast



Anaerobic bacteria

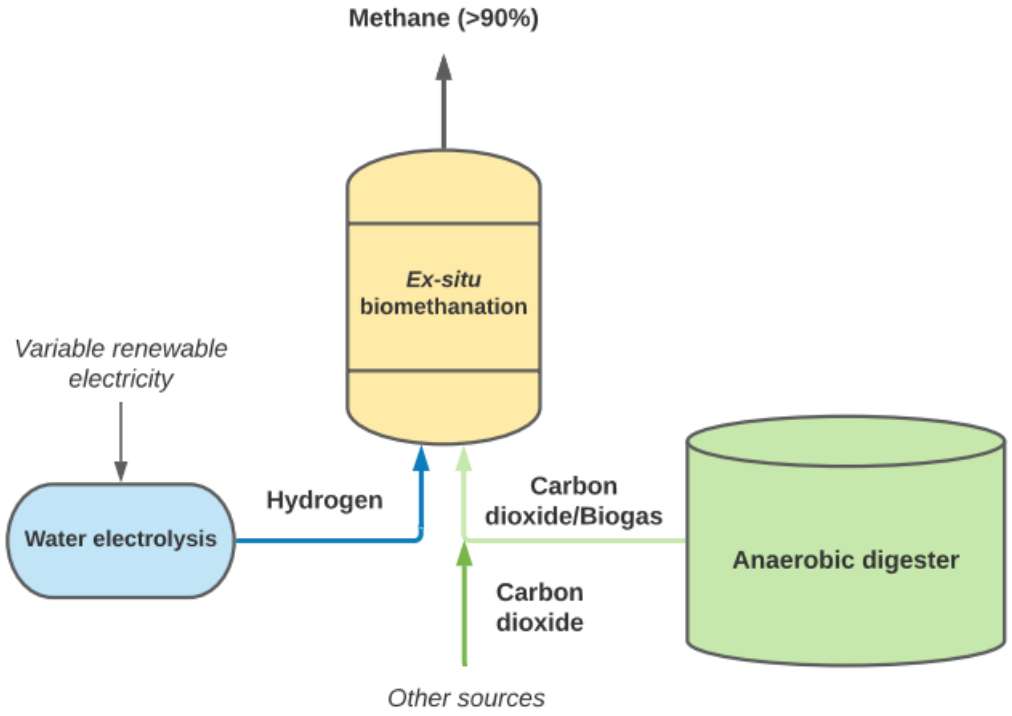


Oleaginous fungus



- Follow up on the activities of **SSF using organosolv-pretreated substrates from WP3.1** for ethanol production at SINTEF
- Follow up on the activities of **SSF using St1 and Borregaard substrates with Novozymes enzymes** at SINTEF to assess yeast tolerance to the pretreated biomass and strain adaptation to the substrate.
- Follow up on the joint activity of **SSF** using NMBU's **oleaginous fungi for improved production of lipids, chitin, and chitosan**.
- Use of **thermophilic organisms selected based on** their **potential** as producers and cultivability **for solvent and alcohols production** using biomass hydrolysates and SSF approaches.

WP3.4 Anaerobic digestion and gas upgrading – Work Plan 2021



***Ex-situ* biomethanation**

- Study the integration of the **SER process in** different **biorefinery concepts** (gasification & pyrolysis routes) in **collaboration with ZEG Power and other FME partners**
- Evaluate the potential of the **SER process to upgrade side streams generated in all three value chains** (e.g., pyrolysis gases, gasification syngas, alcohols, DME, and diverse residues).
- Assess **new substrates from other WPs for increased biogas production** (**WP3.1**, pretreatment liquor; **3.2**, saccharification residue; **3.3**, waste cell biomass; **2.2**: condensate from pyrolysis)
- Hydrogen injection in ***ex-situ* biomethanation** for **increased biological methane production**
- **Employ a postdoctoral researcher** at NMBU

SER: Sorption-Enhanced Reforming

Innovation in SP3

WP3.1	• Novel pre-treatment technology for producing high yield fermentable sugars and high-quality lignin from Norway spruce
WP3.2	• Identification of enzymes crucial for efficient softwood biomass processing – improved enzyme cocktails • Better understanding on how to activate enzymes for efficient biomass processing • More efficient process designs, reaching lower process costs
WP3.3	• Co-production of biopolymers and lipids by fungal fermentation of lignocellulose hydrolysates and solid substrates using SSF. • Establishment of thermophilic bacterial platform for (higher) alcohol/ester production • Optimization of the SSF process using industrial yeast for ethanol production
WP3.4	• Biological CO_2 capture and increased methane concentration adding H_2 to biogas processes • Biological CO_2 capture and increased methane concentration using electricity directly in biogas processes • Combining pyrolysis or gasification, and SER with biogas processes • Cost efficient hydrogen and CO_2 production from raw biogas using SER technology • Improved biofuel production efficiency using SER integration

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