Bio4Fuels

Norwegian Centre for Sustainable Bio-Based Fuel and Energy

Autumn 2022

From Bio4Fuels Management

Bio4Fuels Days 2022: 16 -17 November

- 16 November
  - Open International Meeting
    - IEA Bioenergy
    - European Biogas Association
    - Johnson Matthey
    - Biozin
    - Silva Green Fuel
- 17 November
  - Bio4Fuels Partners Only
    - New FME
    - Industry Input
    - Work Plans 2023-2024

- Find more information
- Register for the event

Equinor's Refinery at Mongstad. Photo: Øyvind Hagen, Equinor

From Bio4Fuels Management

Energi21 - National strategy for research and innovation within new climate friendly energy technology

- An update of the Energi21 strategy report was initiated in 2021
- Bio4Fuels was active in providing input within the area of bioenergy
- The final report was published June 2022
  - Role of advanced biofuels is outlined
  - Role and competence of FME Bio4Fuels indicated
  - Set of concrete recommendations for research and infrastructure strategy given.
- Read more here (English)
- Download the strategy report (Norwegian)

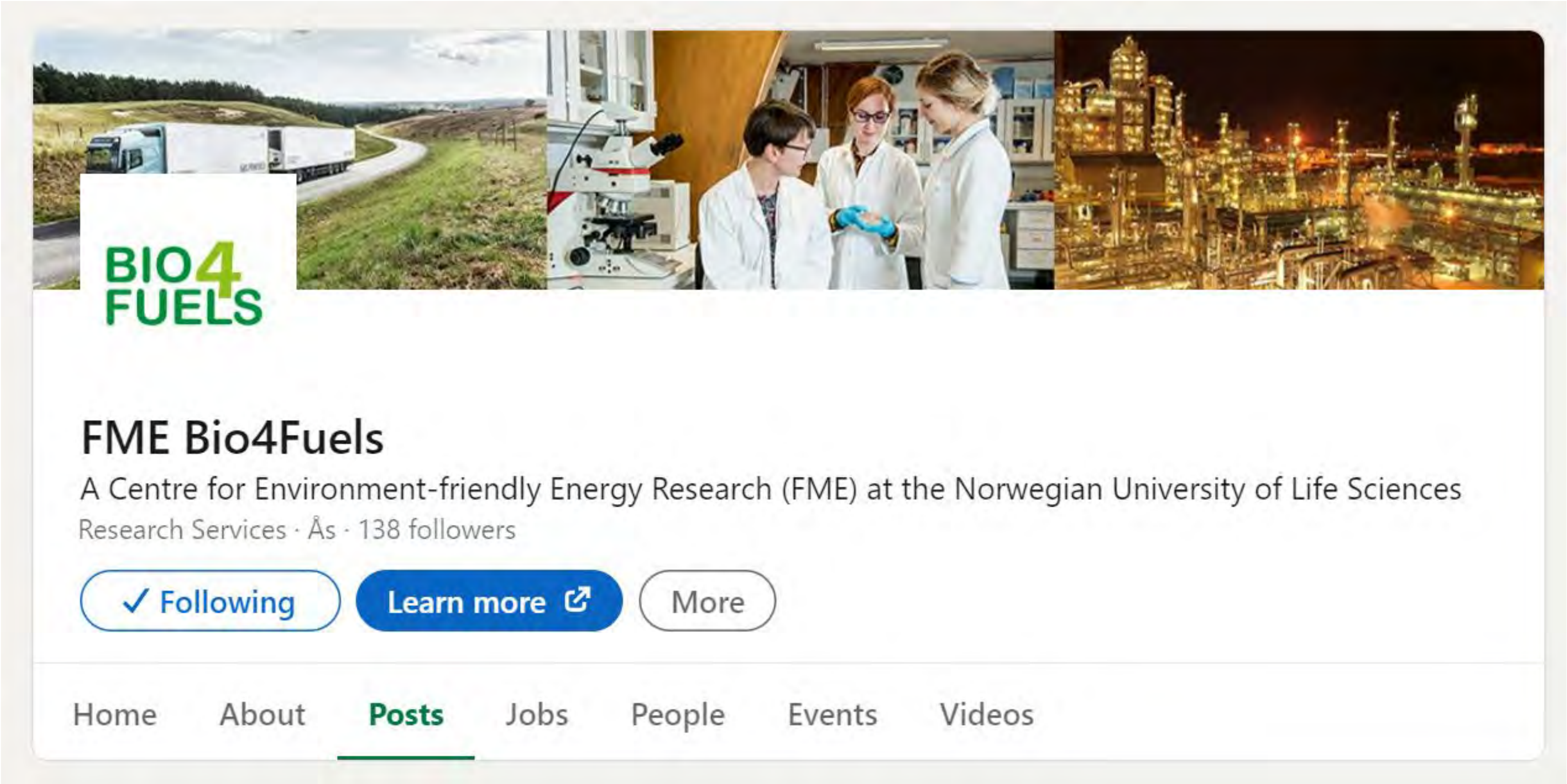
Photo: Pixel & Co

From Bio4Fuels Management

Follow us on LinkedIn

Did you know that we are on LinkedIn? We share our own news and those we find relevant for our followers.

Remember to tag us @ FME Bio4Fuels when you have something you think we should see.



From Bio4Fuels Management

Research visit at the University of California Davis by PhD student Camilla Angeltveit

NMBU PhD student Camilla Angeltveit is currently on a three months research visit to Professor Tina Jeoh's lab at UC Davis.

She is performing real-time measurements of enzymatic cellulose degradation using a biosensor.

The aim is to get a better understanding of the synergistic relationship between cellulases and LPMOs.

From Bio4Fuels Management

Successful Centre Status meeting at Ersgard

6 – 7 September 2022

- Meeting for WP leaders and PhD students
- Status and plans from all Bio4Fuels Sub Projects
    - Major achievements so far in Bio4Fuels
    - Status of activities for 2022
    - Proposed plans for 2023 - 2024
- Input to a vision for a new FME
    - Group work
    - Presentations and discussion
- @Ersgard farm in Stjørdal

Photo: Grete Sørebø, Ersgard

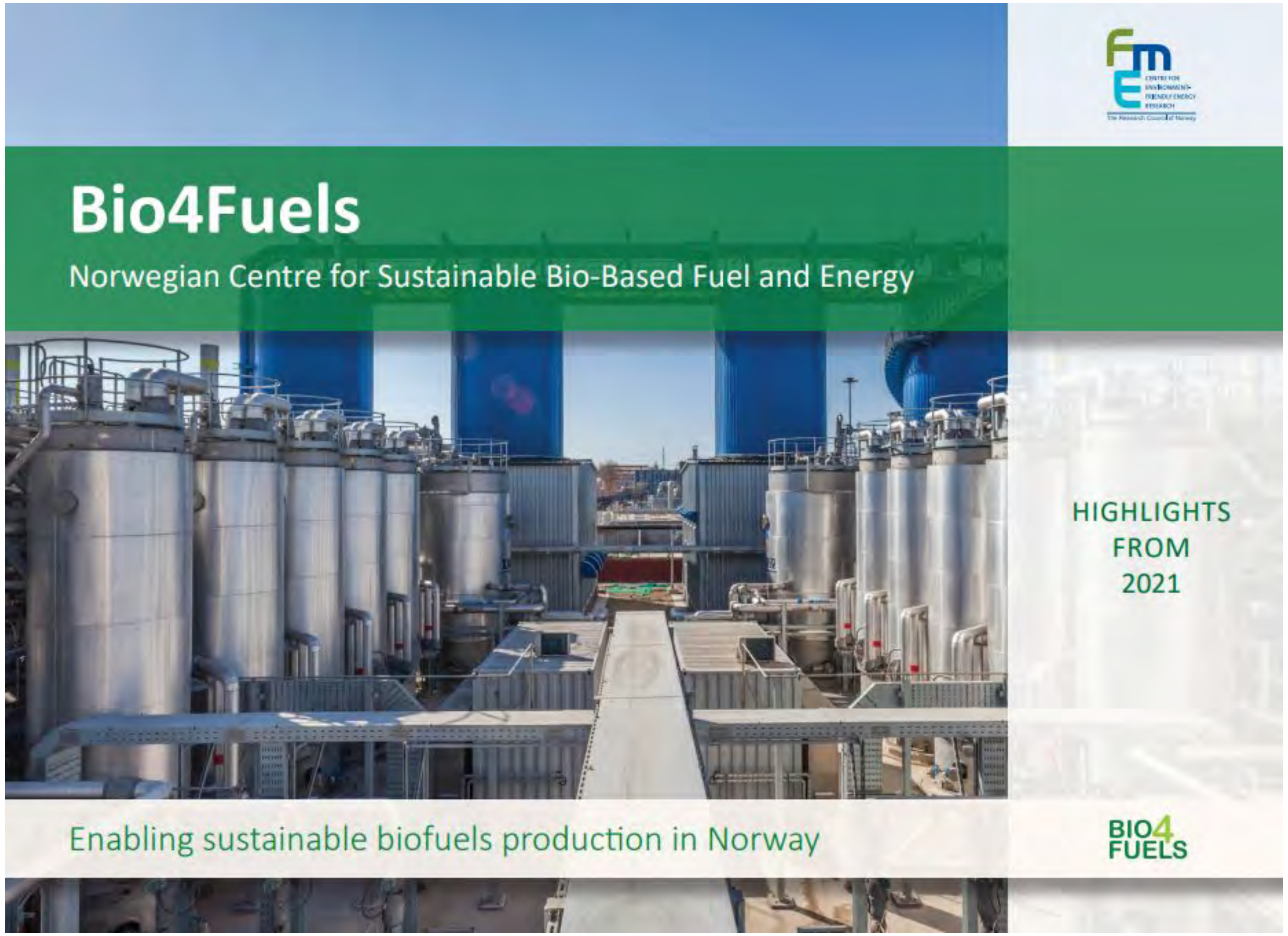
From Bio4Fuels Management

Highlights from 2021

In addition to the annual report, Bio4Fuels produces a shorter brochure version. The Highlights from 2021 was printed before the summer and distributed within the network.

Please contact fme.bio4fuels@nmbu.no if you would like a copy but have not yet received one.

Both reports can also be found on our web site.



From Bio4Fuels Management

Final Report f3

f3 (fossil free fuels) is a large Swedish Knowledge Centre for Renewable Transportation Fuels, with Chalmers in Gothenburg as the coordinator.

f3 started its research program in 2018 and ended on 30 June 2022.

f3 is now run as an important network. It is very relevant for Bio4Fuels.

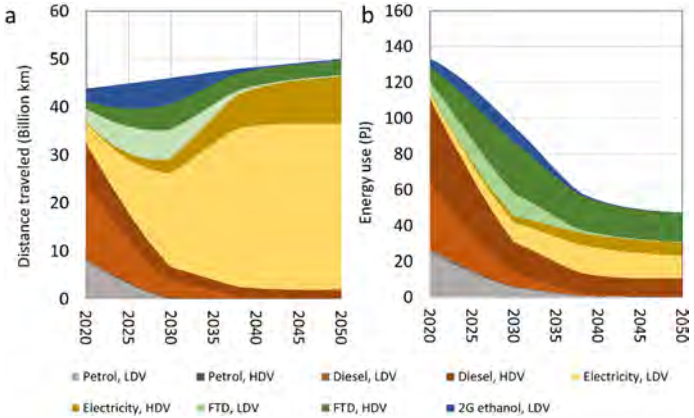
The full report (Swedish) can be found on the right side of the article on our web site.

Autumn newsletter WP1.2

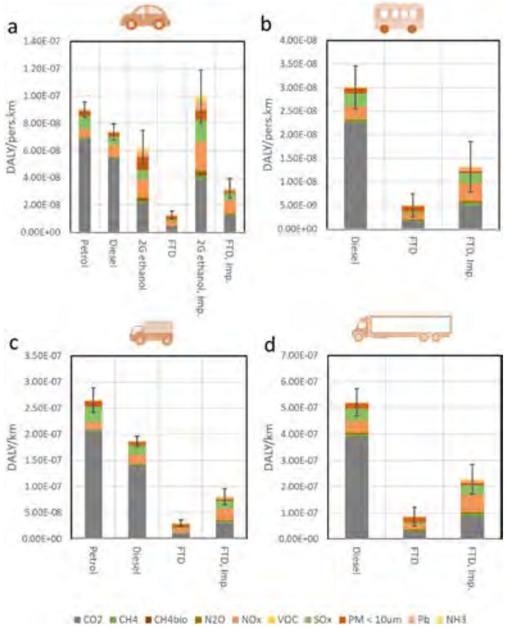
Unraveling the role of biofuels in road transport under rapid electrification

- Biofuels have been the predominant option for climate change mitigation in road transport for decades, but the recent expansion of electric vehicles may question this role
- We model the energy use and life-cycle emissions of road transport activities until 2050 in Norway, a country with a rapid growth in vehicle electrification
- Mitigation from biofuels peaks in 2030 at 3.1 ± 0.45 $MtCO_2$eq. year^{-1} (30% of today's road transport emissions), and impacts on human health decrease
- The largest emission savings are achieved from biofuels in trucks, buses and vans
- Integrated strategies combining high electrification rates of the vehicle fleet with targeted applications of biofuels can increase the mitigation of road transport emissions.

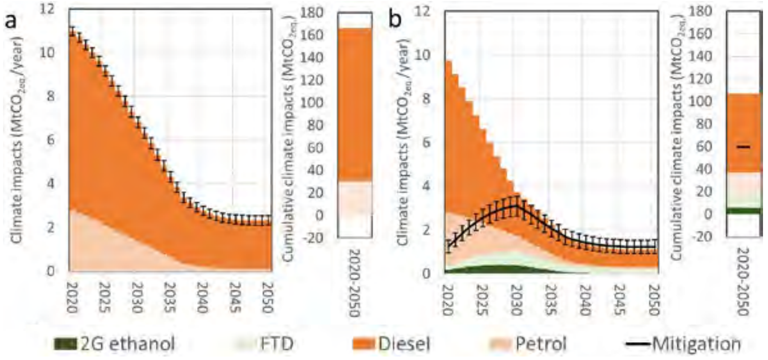
Future road traffic activity (a) and energy use (b) in Norway'



Human health impacts



Future climate impacts from road transport without (a) and with (b) biofuels



Full paper available at: https://onlinelibrary.wiley.com/doi/10.1002/bbb.2395

Autumn newsletter WP2.2

Summer student on hydrothermal liquefaction

WP2.2 had a summer student working on the continuous hydrothermal liquefaction experimental campaign during June-August 2022.

Preliminary results show, in agreement with the batch results, that bark addition did not reduce the oil yields.

Due to technical problems, many of the experiments could not be performed, hence the results are not conclusive.

The troubleshooting will continue in 2022 and the experiments are planned to be finished in 2022-23.

The results were presented at the Summer student conference at SINTEF Energy Research August 17, Trondheim

Last year's results were published in Chemical Engineering Transactions Vol 92, 2022, DOI: 10.3303/CET2292017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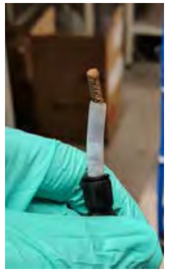
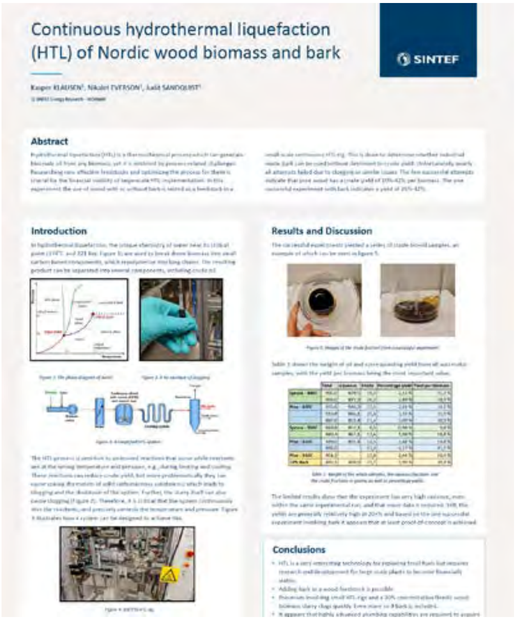
Hydrothermal Liquefaction of Bark-containing Nordic Biomass

Judit Sandquist*, Nikalet Everson, Asmira Delic, Maria N.P. Olsen
SINTEF Energy Research, Postboks 4761 Torgarden, Trondheim, Norway
Judit.Sandquist@sintef.no



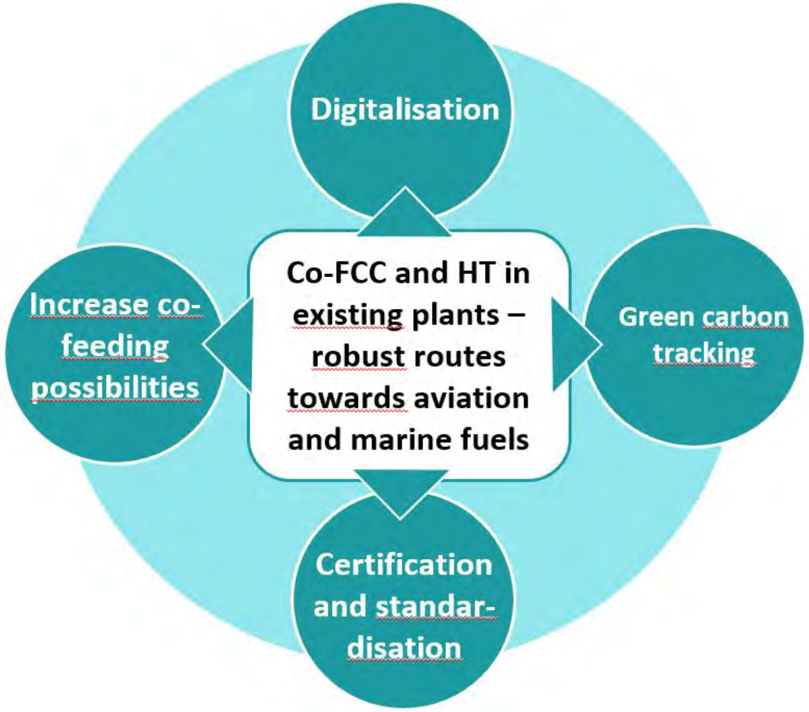


Autumn newsletter WP2.3

New EU-project: REFOLUTION

Refinery integration, scale-up and certification for aviation and marine biofuels production

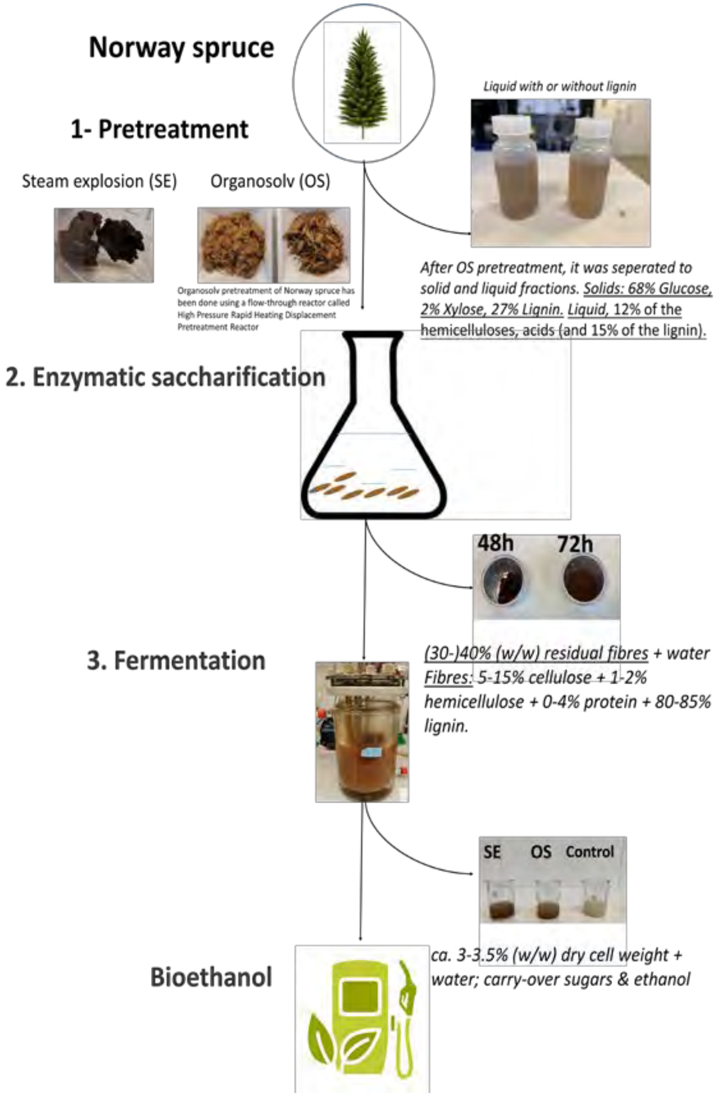
- **Challenge**: Unlock the full potential of advanced biofuels production in Europe from European Refineries.
- **Collaboration**: European consortium with expertise from the entire value chain and strong commitment from industry to maximise exploitation of results.
- **Impact**: Increasing cost-effectiveness of the production of advanced biofuels, while enhancing sustainability in a circularity approach, and preparing market up-take in EU.



This project has received funding from the European Union's Horizon Europe research and innovation programme under grant agreement nr 101096780.

Autumn newsletter SP3

Presentation of the collaborative work to NBC 2022

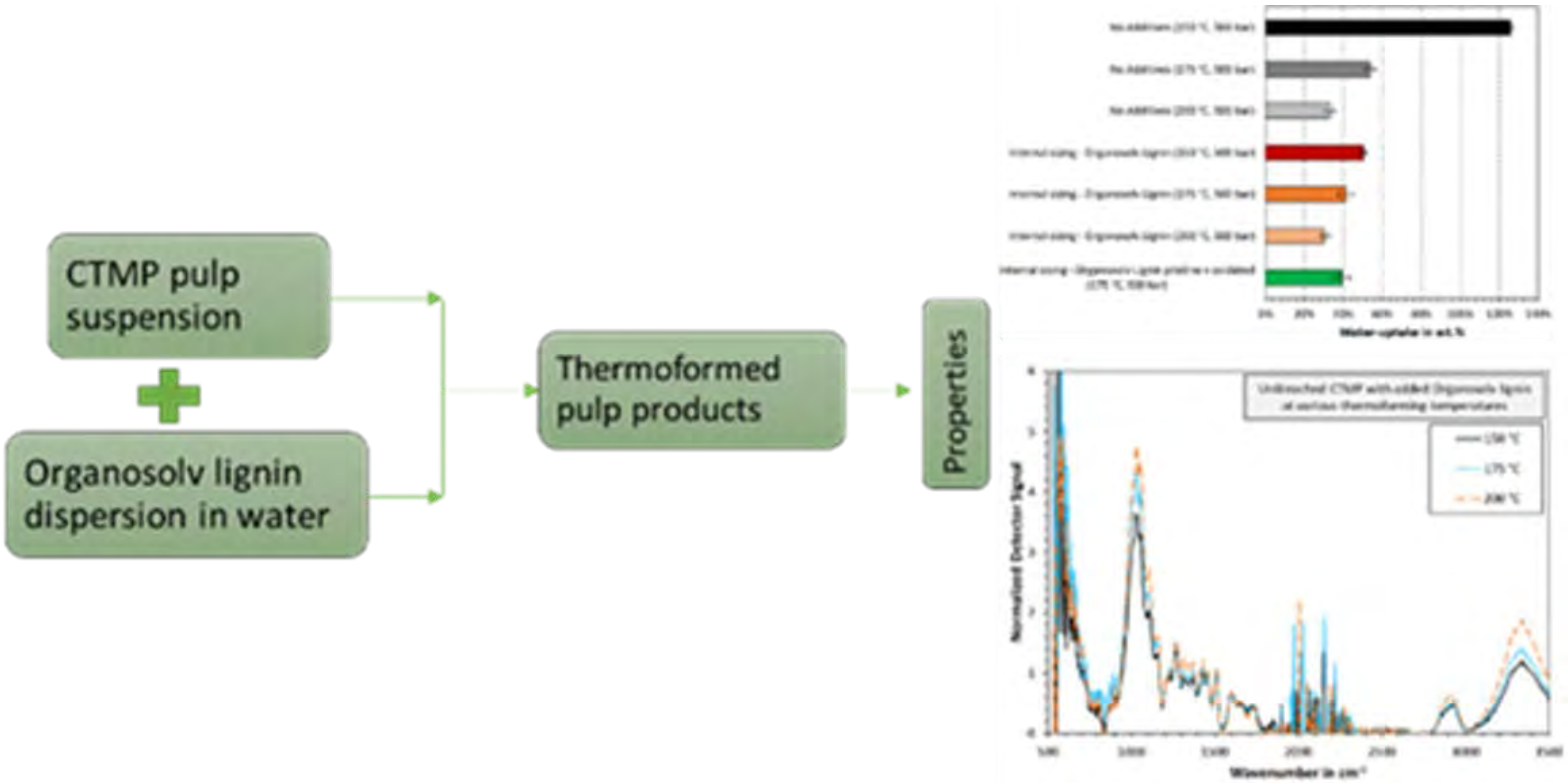


Nordic Biogas Conference

Autumn newsletter WP3.1

Preatreatment and fractionation

- Organosolv lignin used as an internal sizing agent for thermoformed pulp products
- Mihaela Tanase-Opedal and Jost Ruwoldt, 2022: Organosolv lignin as green sizing agent for thermoformed pulp products, send to *ACS Omega.*
- Mihaela Tanase-Opedal and Jost Ruwoldt, 2022: Sustainable lignin polymer in thermoformed fibre products, accepted as Oral presentation at Nordic Wood Biorefinery Conference, Finland, 25-27 October 2022.



Autumn newsletter WP3.1

Organosolv lignin used as an internal sizing agent for thermoformed pulp products

In recent years, the environmental demands, and a shift towards a sustainable and economically biorefinery have focused on valorization of entire biomass, both pulp-products and value-added products to reduce their environmental footprint. The concept of using fiber materials and polymers from the biomass to thermoformed fiber products is interesting, since the product would be completely based on renewable resources.

In our study we therefore tested in-house produced organosolv lignin as a sizing additive to prepare thermoformed pulp products. The addition of organosolv lignin decreased the wettability and swelling of the thermoformed product. These results are due to the distribution of organosolv lignin on the surface, filling in the pores and cavities, and providing a tighter fit within the thermoformed materials. In conclusion, the results from our study encourage the use of organosolv lignin as sizing additive to thermoformed products, which can improve water resistance to be used in sustainable packaging applications.

Autumn newsletter WP3.3

Simultaneous saccharification and fermentation of lignocellulose biomass by filamentous fungi

Research activity of Faculty of Science and Technology, NMBU

The use of thermophilic strains of fungi allowed us to simplify the trade-off between optimal conditions for enzymatic hydrolysis and microbial lipid accumulation. With higher temperatures the simultaneous saccharification and fermentation (SSF) process is more efficient in releasing sugars for lipid conversion, resulting in better economical viability.

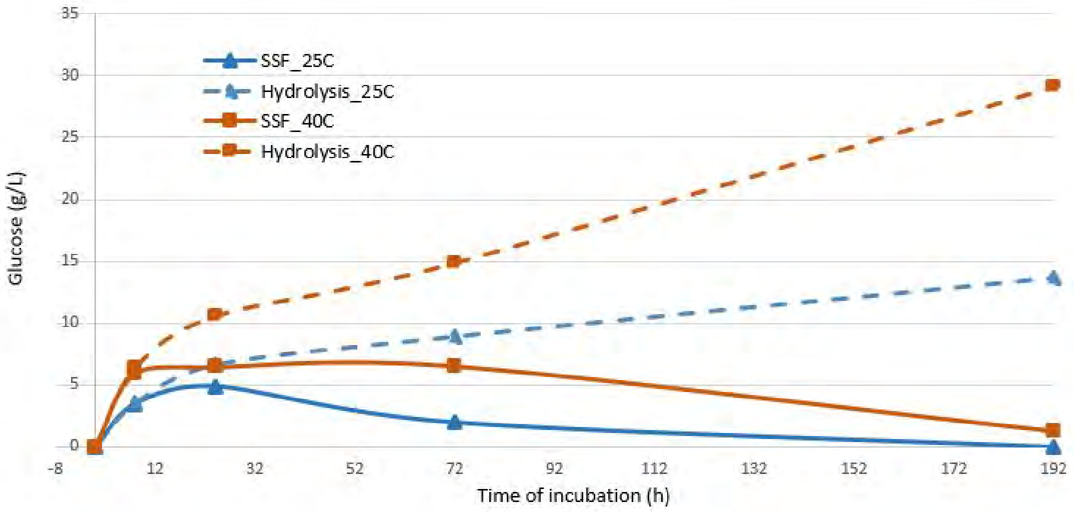


Fig. 1: Glucose production by enzymatic hydrolysis of lignocellulose biomass (dash lines) and releasing/consumption balance in SSF with thermophilic fungus (straight lines) at 25°C (blue) and 40°C (orange) along the incubation time. Higher temperature makes hydrolysis faster, thus providing more glucose for the fungal lipid production.

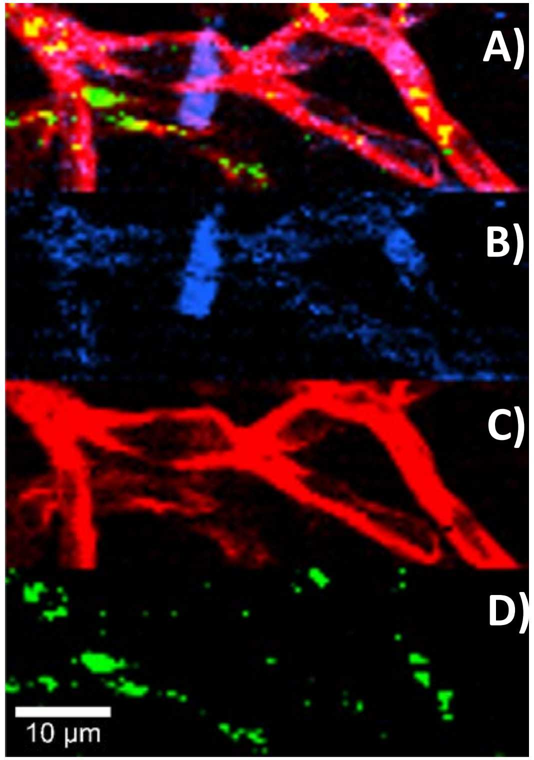


Fig. 2: Raman microspectroscopy imaging allows tracking of the status of lipid accumulation in a complex mixture of fungal biomass and cellulose material. A) Fungal hyphae with lipid bodies intertwined with cellulose fibers (composite Image) B) Cellulose signals (blue) C) Fungal hyphae (red) D) Lipid bodies (green).

Autumn newsletter WP3.3

Mixotrophic gas fermentation using sugar-based Feedstocks

Research activity of SINTEF Industry

Applying C1 feedstocks to mixotrophic fermentation can boost carbon utilisation and product output. Specific gas-fermenting bacteria (acetogens) are capable of utilising both substrates simultaneously to improve carbon yields. Combining existing sugar-based substrates, with synthesis gas could be a pivotal game-changer with regards to consolidating and valorising waste feedstocks.

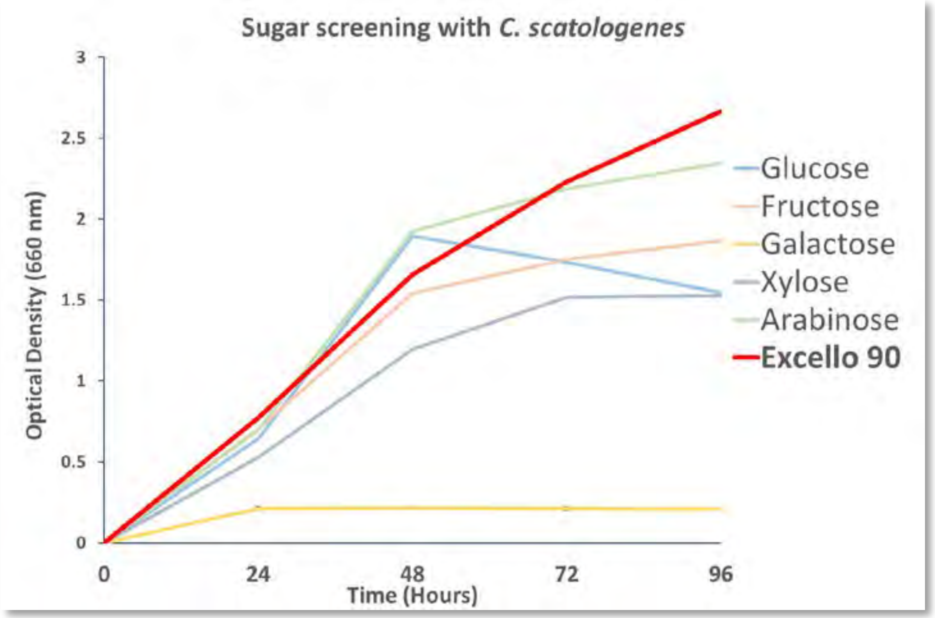
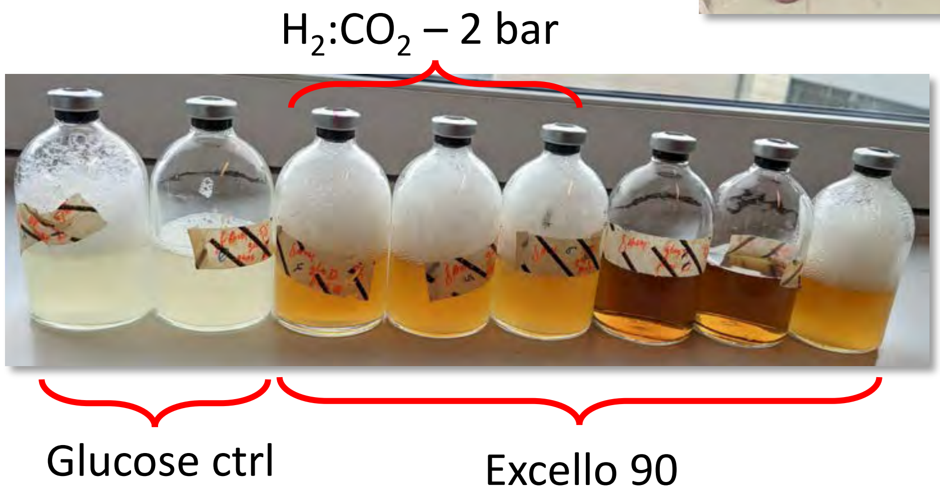


Fig. 1: *Clostridium scatologenes*, a strictly-anaerobic bacterium, was grown on several different sugars, including Excello 90, a by-product from Borregaard's BALI process. Early results have demonstrated that despite containing a high level of impurities, Excello 90 is a suitable feedstock for *C. scatologenes*, in terms of growth and fermentative performance.

Fig. 2: To apply a 80:20 mixture of H_2:CO_2 into serum flasks, a gas-exchanger is needed (right). This instrument allows for precise application of different gases into serum flasks and enables the assessment of carbon utilisation via product formation/gas consumption. (Below), a preliminary experiment showing favourable gas consumption with Excello 90 as the sugar substrate supplement. Particularly good growth is observed in the presence of Excello 90 and H_2:CO_2 gas.



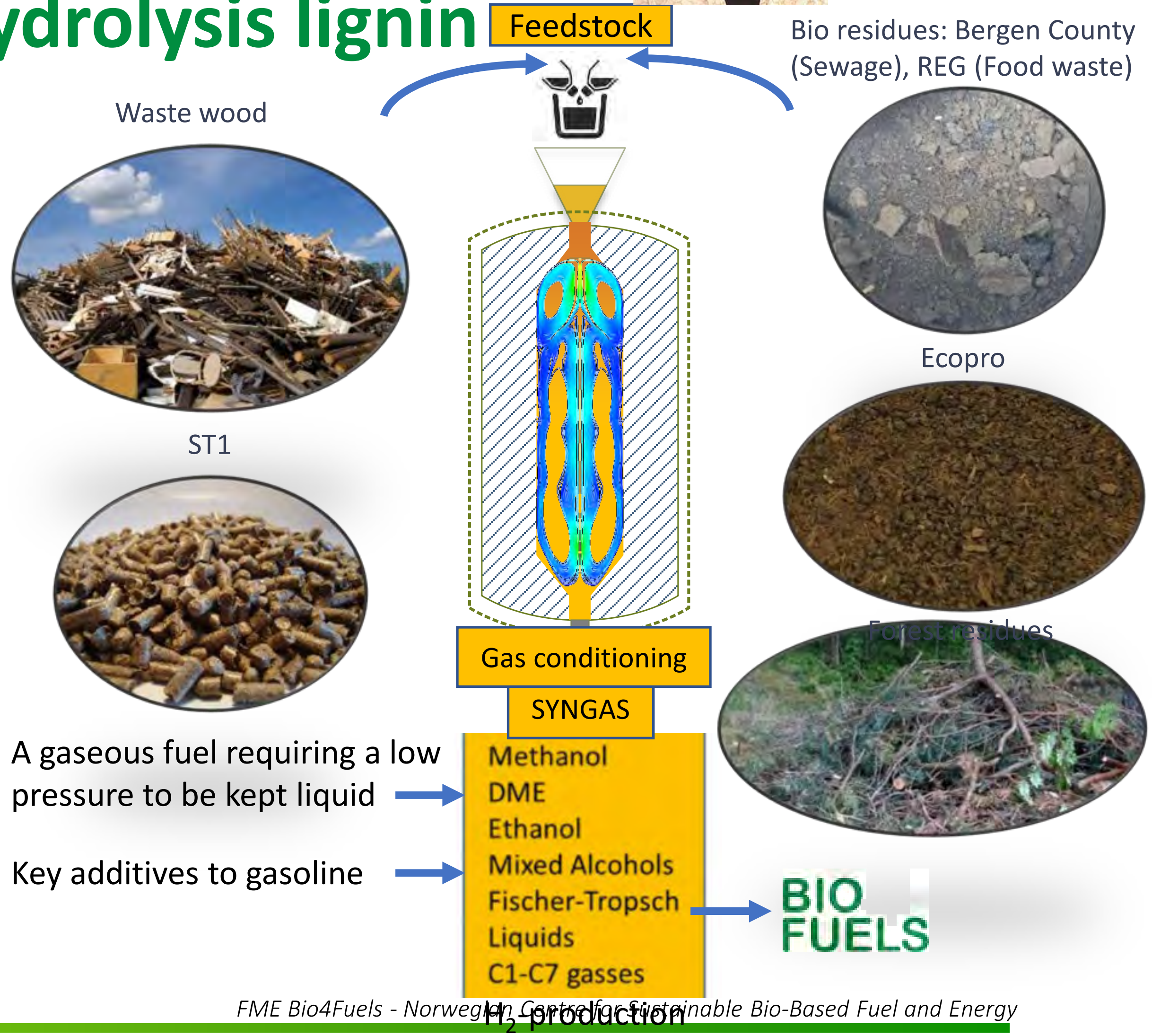
Autumn newsletter WP4.1

Entrained flow reactor performance on the gasification of St1 Cellunolix® hydrolysis lignin

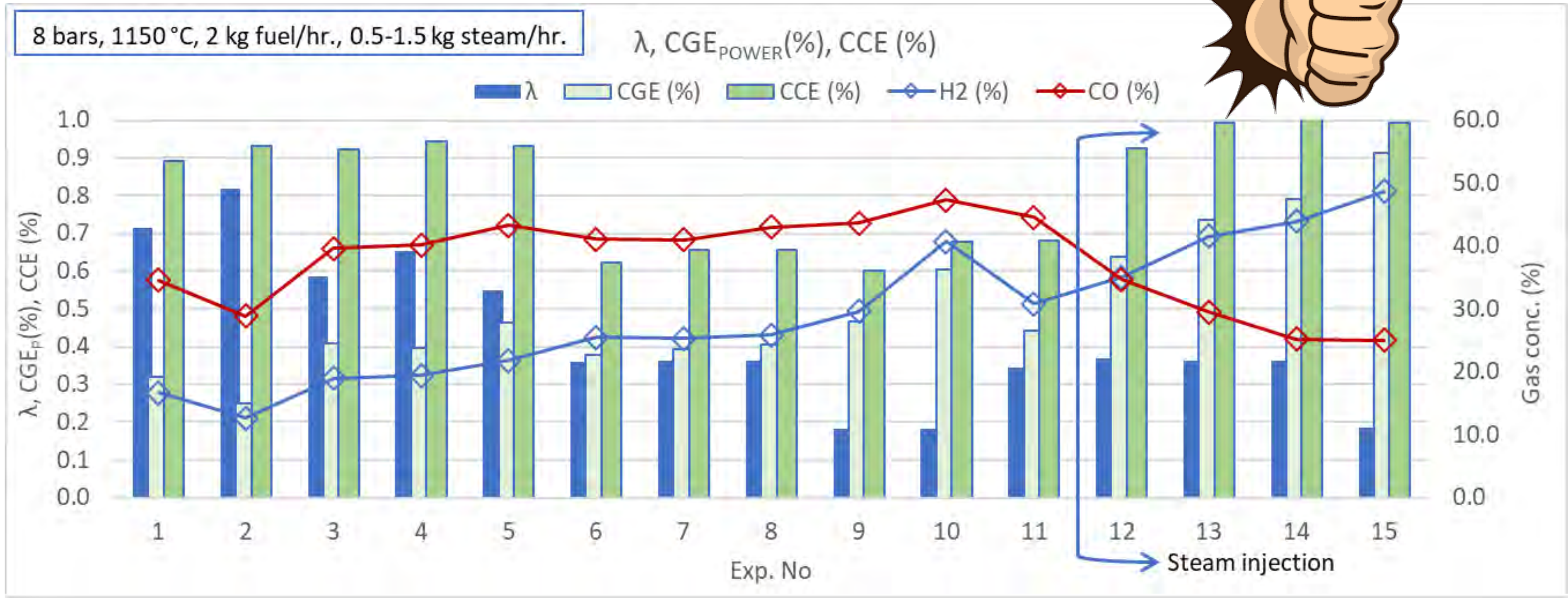
Identifying future fuels

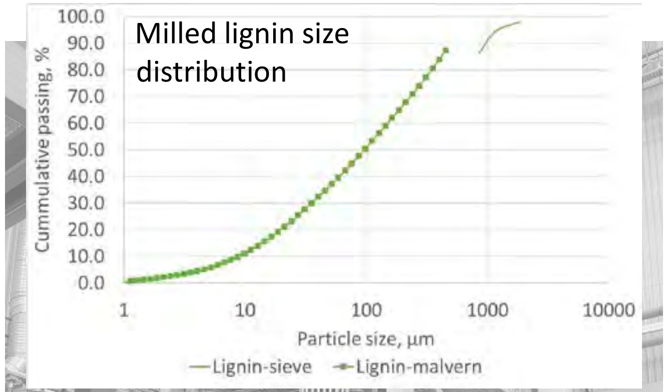
Feedstock as a mixture of waste wood, primary forest residues and various bio residues from i.e. biogas production (food, MSW sewage, animal waste and other biodegradable wastes)

- About **600 000 ton annual bio residues** prod. in Norway used for farming purposes (N_2-, P+, plastic-)*
- About **3 700 000 solid m^3 of primary forest residues** annually available in Norway
- Waste wood from households and industrial activities is the third largest waste stream in Norway with an annual generation of about **800 000 tons**
- St1 Cellunolix® hydrolysis lignin prod. about **15 000 tons dry annually****** (mainly Finland)



Entrained flow reactor performance on the gasification of St1 Cellunolix® hydrolysis lignin






10-20 kW EF gasifier at SINTEF Energy

Small-scale gasification of St1 milled Cellunolix® hydrolysis lignin pellets in a 10-20 kW pilot-scale entrained flow gasifier with a reactor temp. of 1160 ˚C, 12 kW fuel input, p= 8 bars w/O_2 as gasifier agent, λ = 0.2-0.6 including steam injection (1-2 kg/hr)

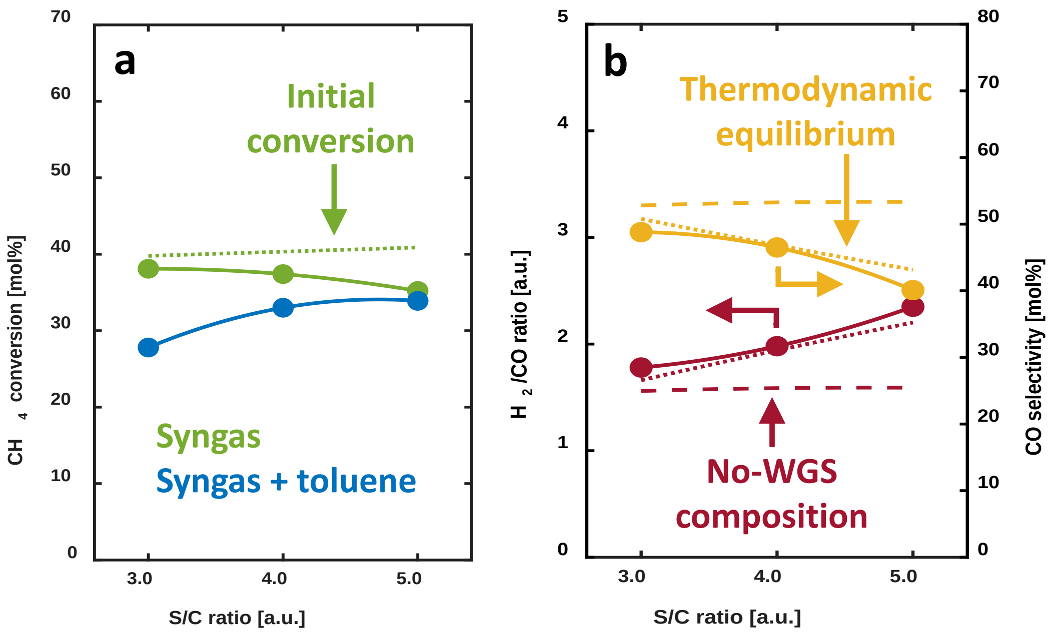
- Successful gasification of lignin showing the effect of steam on the H_2/CO ratio
- Finally submitted paper on reactor scaling
- Working on common publication with USN/WP4.3

Autumn newsletter WP4.2

Steam Reforming of Biomass Gasification Tar

- Experimental model studies on catalytic steam reforming of biomass gasification tar in progress
- Effects of key operating conditions and Ni-Co/Mg(Al)O catalyst synthesis parameters currently investigated
- Tar compounds are completely converted, methane is more difficult to convert
- Preliminary results suggest optimum steam/temperature window minimizing deactivation by coke formation and sintering
- Efficient H_2/CO ratio adjustment by simultaneous WGS equilibration demonstrated in model environment
- Figure shows results at 700 °C with toluene as model tar compound added to syngas (10 g/m^3).

Contact: Ask Lysne; ask.lysne@ntnu.no



Initial and final (TOS: 8 hours) CH_4 conversion (a) in pure syngas and tar model (toluene: 10 g/Nm^3) environment (temperature: 700 °C, GHSV: 85000 NmL/g_{cat}min, catalyst: 20-20 wt% Ni-Co/Mg(Al)O). Final H_2/CO ratio and CO selectivity (b) in tar model environment (same conditions). Calculated theoretical no-WGS composition indicated.

Lysne, A. et al., *Chem. Eng. Trans.* **2022,** *92*, 37-42.

Autumn newsletter WP4.2

Phosphorus deactivation of Co-based catalysts for Fischer-Tropsch synthesis

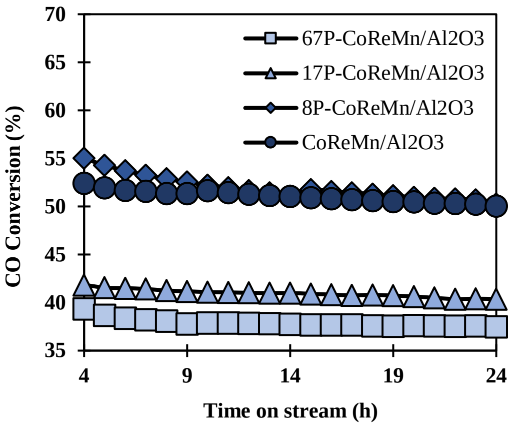
Syngas produced by biomass gasification contains several potential poisons for Fischer-Tropsch catalysts. This work was focused on the effect of increased loading of phosphorus on a cobalt-based catalyst. The work was presented at the Nordic Symposium of Catalysis 2022.

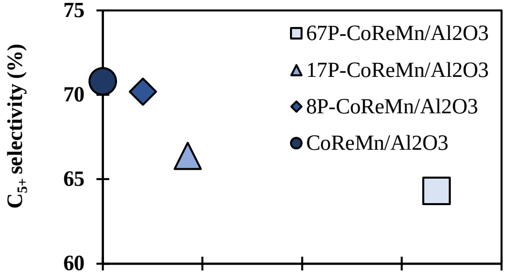
The results showed that below 800 ppm of phosphorus, the catalyst performance in terms of activity (STY, bottom left figure) was not significantly affected. However, above this threshold, the effect of phosphorus was noticeable with a significant decrease in intrinsic activity.

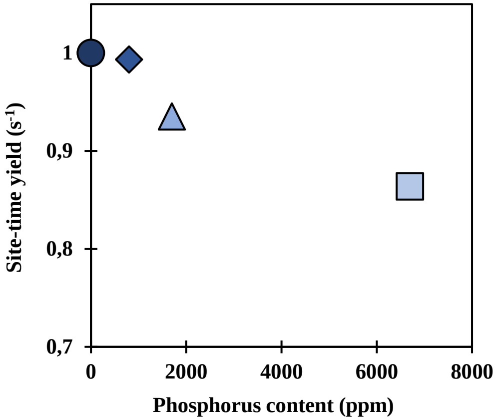
However, the selectivity was affected in all poisoned catalysts. The product distribution shifted towards less valuable products as methane.

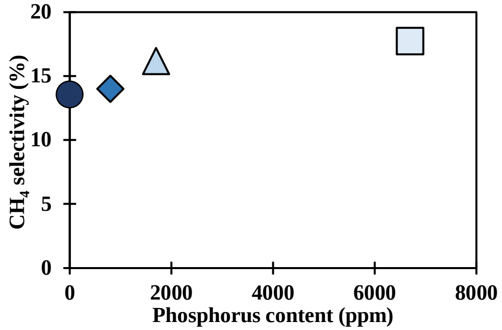
This implies that syngas cleaning and conditioning must take into account the presence of phosphorous from the biomass.

Contact: Oscar Luis Ivanez Encinas,
oscar.l.i.encinas@ntnu.no









Catalysts: 15%Co, 3,75%Mn, 0,5% Re on Al_2O_3

No addition:	CoReMn/Al_2O_3
With 800ppm P:	8P-CoReMn/Al_2O_3
With 1700 ppm P:	17P-CoReMn/Al_2O_3
With 6700 ppm P:	67P-CoReMn/Al_2O_3

Autumn newsletter WP4.3

International conferences in modelling

Phd student Nastaran A, Samani has participated at two conferences in simulation and modelling. The topic of the conference papers where simulations of the bubbling fluidised bed gasification reactor at USN.

At the 10th Vienna International Conference on Mathematical Modelling MATHMOD 2022,Vienna Austria, 27–29 July 2022 she presented the paper

- Evaluating the impacts of temperature on a bubbling fluidized bed biomass gasification using CPFD simulation model

At the 63rd International Conference of Scandinavian Simulation Society, SIMS 2022, Trondheim 20-21 September 2022, she presented the paper

- Eulerian-Lagrangian simulation of air-steam biomass gasification in a bubbling fluidized bed gasifier

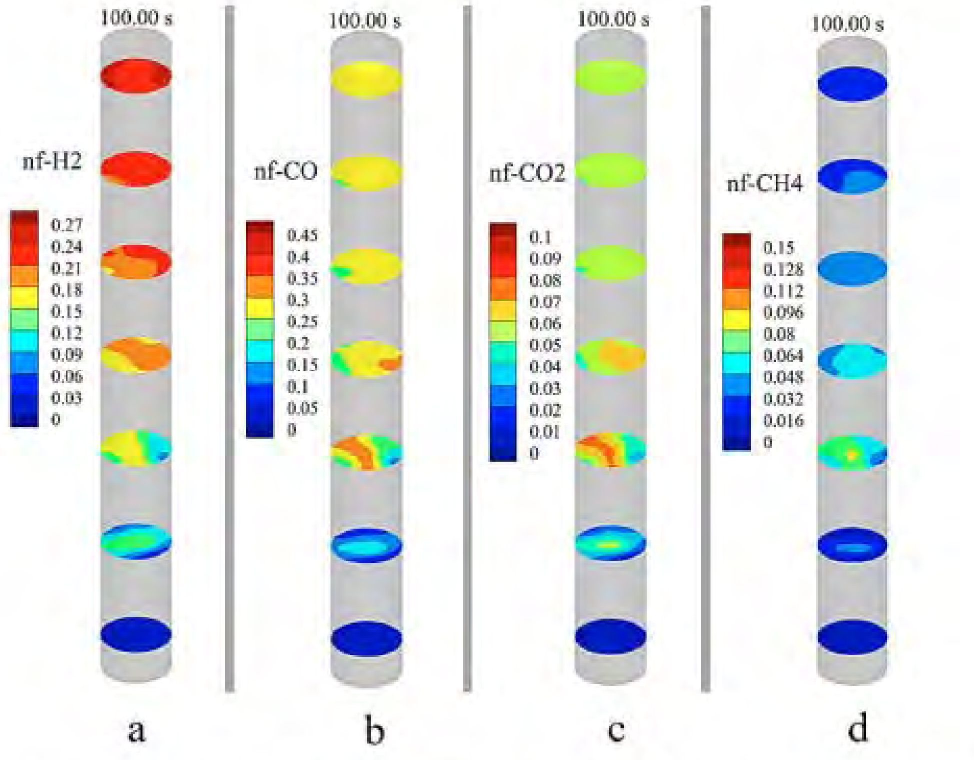
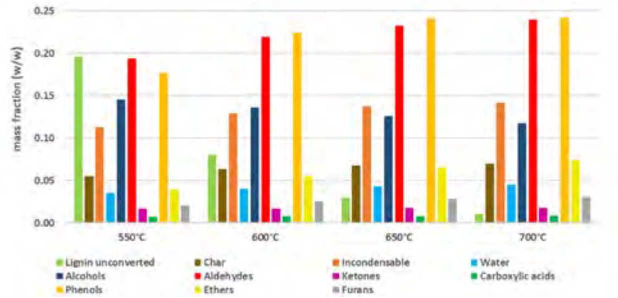


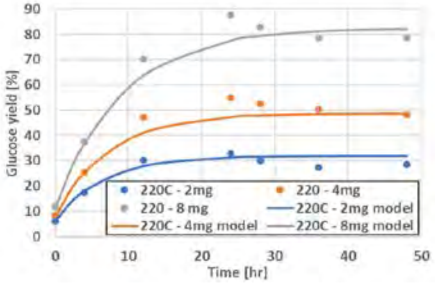
Fig. 5. Mole fraction of product gas a) H_2, b) CO, c) CO_2 and d) CH_4 at levels in the reactor at T=1200 K for wood chips

Autumn newsletter WP5.1

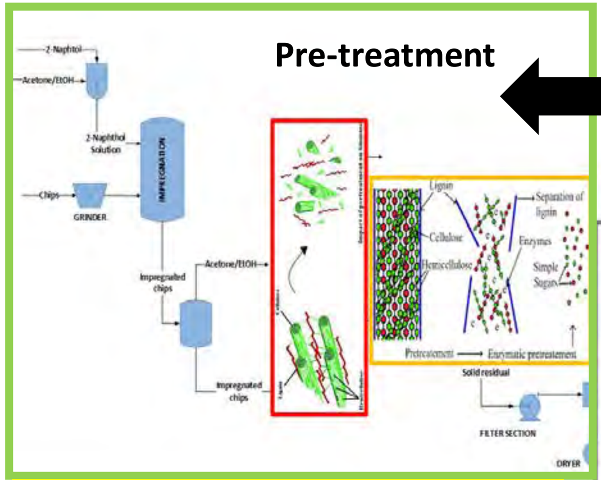
Modelling of Two-steps Pyrolysis Process

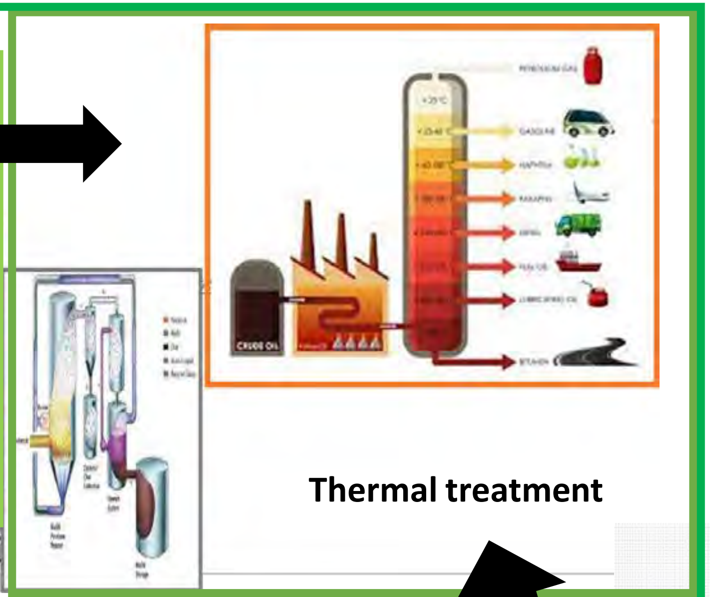

(1) PYROLYSIS MODEL





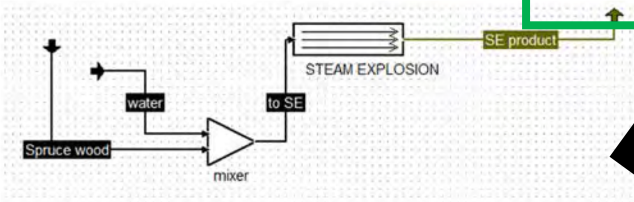
(1) SACCHARIFICATION DATA-DRIVEN MODEL



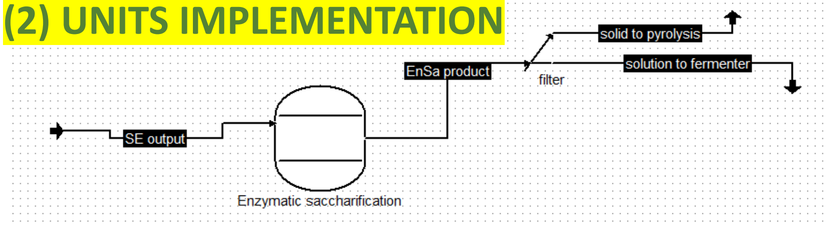


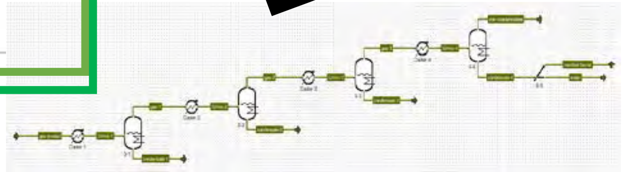
(3) SUB-SECTIONS SIMULATION

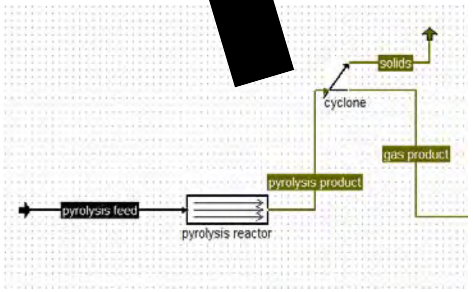
(4) BIOREFINERY FULL PROCESS



(2) UNITS IMPLEMENTATION







(2) UNITS IMPLEMENTATION

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fme.bio4fuels@nmbu.no