Bio4Fuels

Norwegian Centre for Sustainable Bio-Based Fuel and Energy

HIGHLIGHTS
FROM
2020

Enabling sustainable biofuels production in Norway

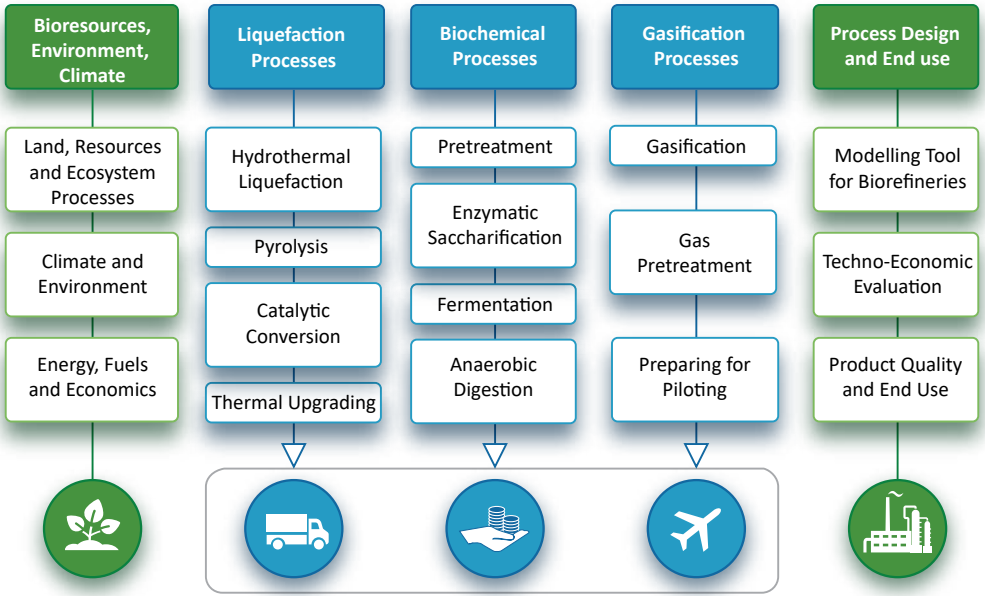
Contents

Front page photo: Roar Ree Kirkevold/Magasinet Skog

Photo: Volvo Truck Corporation

Bio4Fuels value chains

From sustainable biomass resources to economic production of advanced biofuels

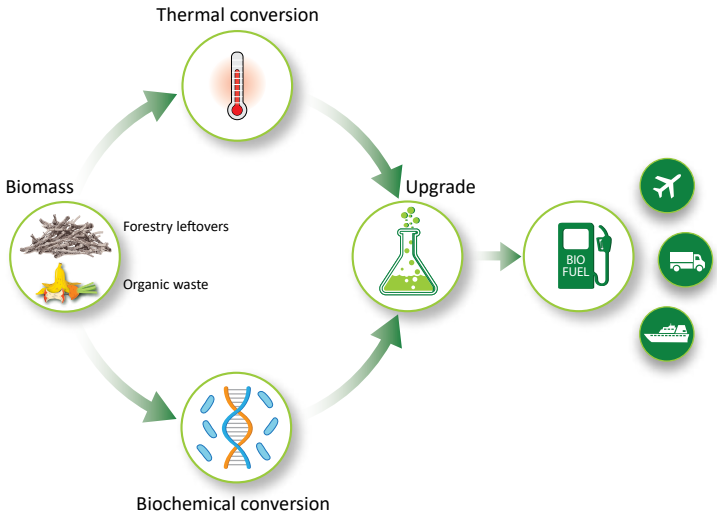


What is Bio4Fuels?

The Bio4Fuels FME Centre's goal is to contribute to the reduction of climate gas emissions from the transport sector. We aim to enable a sustainable production of biofuels in Norway based on low-grade woody biomass and agricultural waste.

Bio4Fuels also addresses issues regarding viable commercial production of advanced biofuels from sustainable biomass, with the ambition to improve the technologies and economics of processes for converting biomass to advanced biofuels, investigate the sustainability and impact of large-scale use of low-grade biomass, and to evaluate and design the process concepts and testing quality of the biofuels for the engines used today.

The prospects for advanced biofuel production in Norway have increased significantly through the activities of key Bio4Fuels stakeholders since the establishment of Bio4Fuels in 2017.



From the chair of the board and centre leader

Like everywhere the world over, the Bio4Fuels Centre had to make major adjustments to its activities and operations during most of 2020. Our research partners were able to switch over to a flexible combination of virtual operation while keeping as much of the core experimental activities going, and our virtual meetings have given new opportunities and alternatives for flexibility in participation. In this way we have still been able to generate interesting results and to a large extent follow our plans, despite a tumultuous year.

In parallel with this, the European Green Deal, the Norwegian Green Platform, the IEA Net Zero 2050 and the Norwegian Climate White paper have intensified society's and industry's awareness of the critical importance of renewables. This emphasizes the importance of Bio4Fuels research on advanced biofuels as a means of reducing emissions in key areas of the transport sector.

2020 also marked the completion and successful defence of the first Bio4Fuels-funded PhD.

As we approach the halfway milestone for the operation of Bio4Fuels, the Centre management has, with the support of the research institutions and stakeholders, prepared and delivered the required documentation for the Research Council's midterm evaluation of Bio4Fuels. The evaluation part of this work underlined the escalating importance of our research activities towards realizing the ambitions of the green transition, with many of our processes and expertise developed in the Centre being relevant for the wider bioeconomy.

Ingo Machenbach, Statkraft
Chair of the Board

Duncan Akporiaye, SINTEF
Centre leader

Reseach activities - Selected highlights

Bio4Fuels article in Nature Sustainability: Abandoned cropland should produce biofuels

More biofuels are needed to counteract climate change. But producing them shouldn't diminish food production or wilderness areas. The solution may be to grow more grass on recently abandoned cropland.

Title: 'The land–energy–water nexus of global bioenergy potentials from abandoned cropland'

Authors: Jan Sandstad Næss, Otavio Cavalett and Francesco Cherubini

From the article abstract: Bioenergy is a key option in climate change mitigation scenarios. Growing perennial grasses on recently abandoned cropland is a near-term strategy for gradual bioenergy deployment with reduced risks for food security and the environment. However, the extent of global abandoned cropland, bioenergy potentials and management requirements are unclear.

Bioenergy potentials are 6–39 exajoules per year (11–68 per cent of today's bioenergy demand), depending on multiple local and management factors. About 20 exajoules per year can be achieved by increasing today's global cropland area and water use by 3 and 8 per cent, respectively, and without production inside biodiversity hotspots or irrigation in water-scarce areas.
Read the full article in Nature Sustainability:
https://www.nature.com/articles/s41893-020-00680-5


Photo: Shutterstock

State-of-the-art hydrothermal liquefaction pilot system

SINTEF Energy Research has invested in a continuous lab-scale HTL mini-pilot system. For Bio4fuels, this helps with the studies of the suitability of different Norwegian sourced feedstock, producing biocrude samples for the upgrading tasks

Liquefication Processes Hydrothermal liquefaction (HTL) is a thermochemical process that takes advantage of the water in the feedstock, at process conditions where the heat of evaporation for water is avoided and hence pre-drying is not necessary. This makes the process very interesting for high moisture feedstock such as organic residues and sludges. The technology uses high pressures and temperatures where the water is at sub-or supercritical state.

Through the Norwegian national infrastructure project, NorBioLab2, SINTEF Energy Research has invested in a continuous lab-scale HTL mini-pilot system, with a capacity of maximum 2 L/h slurry feed and is able to operate at state-of-the-art conditions, i.e. up to 500 °C and 350 bar.

The reactor is built with a research focus, for studying operational issues, such as fate of inorganics, corrosion, and the effect of depressurization on those. The system has the possibility to include stress loaded corrosion samples for material and weld testing under real HTL environment.

SINTEF Energy's lab-scale HTL mini-pilot system

Production of fungal lipids and biopolymers through Simultaneous Saccharification and Fermentation (SSF)

A new co-production process, developed in Bio4Fuels, holds promise when it comes to its application to transform cellulosic residual biomass from biorefineries to higher value products.

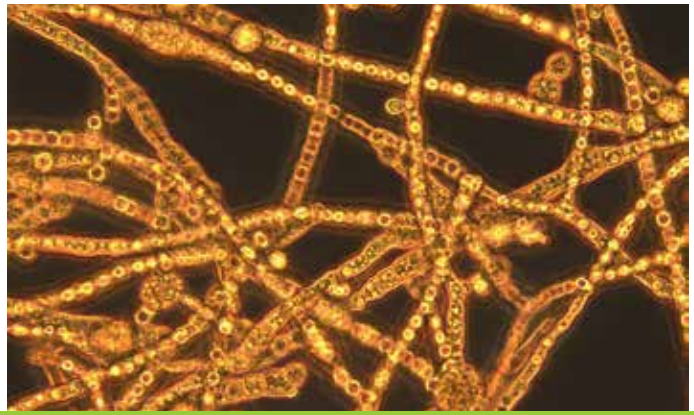
Mucor circinelloidesis a dimorphic fungus capable of accumulating large amounts of intracellular neutral lipids (triacylglycerates) as a potential feedstock for biodiesel production. It also offers a diverse spectrum of other products through fungal fermentation e.g. organic acids, amino acids, enzymes, antibiotics, chitosan and biomass with significant nutritional value.

Bio4Fuels research includes working to establish scalable bioconversion of lignocellulose materials into lipid rich fungal biomass with focus on the concomitant production of other metabolites (chitin and chitosan, and polyphosphate).

Separated Hydrolysis and Fermentation – SHF is a conventional method where the hydrolysis of the biomass is carried out ahead of the fermentation process. In SSF, the enzymes that catalyse the hydrolysis of polysaccharides into sugars, and the microorganisms that are fermenting the latter into higher value products, are used at the same time. Therefore, the sugar production and utilization occur simultaneously.

The fungus showed good growth and lipid accumulation activity during SSF fermentation using pulp from Borregaard's BALI™ process

Mucor circinelloides hyp containing lipid bodies



Technical and economical evaluation through lab-scale pilot plant

A lab-scale pilot plant gives Bio4Fuels researchers valuable insight into the fermentation from lignocellulose derived sugars to butanol and butyric acid – which can be further developed into an additive for aviation fuel.

Technical and economical evaluation covers the bridge between fundamental science and commercial opportunities. The objective is to gather sufficient information from all partners in a given process and value chain. Based on this information the researchers design and model a process to determine its characteristic dimensions which are used to develop a basis for capital and operation costs.

The researchers are currently doing an assessment of fermentation from lignocellulose derived sugars to butanol and butyric acid. The value chain consists of a pre-treatment where woody material is converted to sugars. These are fermented in two parallel continuous fermenters and recovered. Subsequently, the sugars are esterified to butyl-butyrate - which can be used as an additive to aviation fuel.

A lab-scale pilot plant has been built in recent years, by resources from the IndNor project EcoLodge and FME Bio4Fuels. The results from the lab-scale pilot plant give valuable insight into the performance of the process and complement available data and demonstrate the feasibility of the process, and the most capital extensive units are identified. Given this information, the researchers can now investigate how to restructure the process to improve the performance and reduce projected operational or capital costs at the same time.

...pilot plant demonstrate the feasibility of the process

Industrial activities

Heading for full-scale production
- Initiatives in Norway

Some of our partners

Enzymatic Saccharification - Borregaard and Novozymes

Bio4Fuels works in close collaboration with partners Novozymes and Borregaard to improve the efficiency of today's state-of-the-art enzyme blends in depolymerizing softwood-type feedstocks, which are in abundance in Norway.

One of the targets is to develop an industrial setup to improve the efficiency of commercial cellulase blends by harnessing the action of oxidative enzymes called LPMOs (lytic polysaccharide monooxygenases) in a more efficient way than it is done in current industrial processes.

The novel process is based on a recent scientific breakthrough at NMBU by a team led by professor Vincent Eijsink, and proves that LPMOs can utilize hydrogen peroxide much more efficiently than oxygen to break down cellulose.

Recently, the team successfully implemented this recently developed industrial setup at demonstration scale at the NMBU team and Borregaard published the results of the demonstration-scale saccharification study using H_2O_2 supply that was carried out at Borregaard's Demo Unit in a joint publication in the journal of "Biofuels, Bioproducts and Biorefining"

These experiments represent the first ever demonstration of this revolutionary technology at such scale.

Borregaard's Demo Unit in Sarpsborg. Photo: Martin Lersch, Borregaard.

Avinor and Sustainable Aviation Fuel (SAF)

A major advantage of biofuels is that they can be blended directly into fossil-based aviation fuel without adaptations to aircraft engines or distribution systems.

Biofuel was certified for use in civil aviation in 2009. Since then, the development of various technologies for producing jet biofuels has accelerated. In January 2016, Avinor Oslo Airport, in collaboration with AirBP, Neste, SkyNRG, Lufthansa Group, KLM and SAS, was the world's first international airport to blend biofuel into the regular fuel supply system and to offer biofuels to all airlines refuelling at the airport.

From 2020, it is required that 0.5 per cent of all aviation fuel sold in Norway must be advanced biofuels (except for the Norwegian Armed Forces). Norway is the first country in the world to introduce this kind of requirement. The Norwegian parliament's goal is that 30 per cent of aviation fuel in Norway in 2030 will be advanced biofuel.

Together with the airlines and NHO Luftfart, Avinor has explored the possibility of establishing large-scale production of biofuels for aviation based on local biomass. Analyses show that in Norway, it is primarily forestry that will be able to contribute these quantities in a sustainable way. Airlines SAS, Widerøe, Norwegian, have along with Avinor, Norwegian Confederation of Trade Unions (LO) and the Federation of Norwegian Aviation Industries (NHO Luftfart) set a common emissions target, and a roadmap to achieve the goal of Norwegian aviation being fossil free by 2050, meaning that as of 2050, fossil fuels will not be used for scheduled flights in and from Norway.

Photo: Avinor

The city of Oslo, Agency of Waste Management (Renovasjons- og energigjenvinningsetaten (REG)) – and buses running on food waste

REG collects and ensures safe treatment of around 17,000 tonnes of household waste per year. The food waste becomes biogas and biofertilizer, the plastic waste is converted into new plastic products and the residual waste is incinerated and becomes environmentally friendly electricity and district heating.

The Agency of Waste Management (REG) is an agency in the municipality of Oslo with the responsibility for collecting and handling household waste for Oslo's residents. Romerike biogas plant (RBA), treats food waste from Oslo's households, but also receives livestock manure and some other biomasses.

The biogas from the plant is upgraded in the gas plant to liquefied biogas (LBG) and is a CO_2-neutral fuel for buses and other transport. Biofertilizer is a nutrient-rich fertilizer product for agriculture.

Biogas is produced by decomposing organic material without access to oxygen and is the most climate-friendly biofuel on the market. The biogas from RBA has a climate benefit of approx. 91 %, compared to diesel. If the climate benefit for biofertilizer is included, the climate benefit is over 100 % - i.e., a carbon-negative value chain. The biogas is currently used on buses and renovation vehicles in Oslo and on heavy transport. The biogas produced at the RBA plant replaces approx. 2.5 million liters of diesel per year.

Photo: REG

Eirik Ogner Jåstad
Bio4Fuels PhD candidate

The First Bio4Fuels Candidate

Woody biofuels can cut greenhouse emissions by a quarter

There are enough natural resources to meet the demands for biofuels. And with the increase in market prices, the forestry sector stands to gain.

In his doctoral dissertation, Eirik Ogner Jåstad investigates the potential and sustainability of the production of biofuels and bioenergy from Nordic forest resources. Jåstad has determined how the forest and energy sector will adapt to the production of biofuels and bioheat and showed that the feasibility of biofuels production from woody biomass is strongly influenced by the development of the international market prices.

The Nordic economy depends on the export of goods, including from the forest industry. Although this has been heavily reduced in the last century, today making up three per cent of the total Nordic economy. However, the shift from fossil fuel-based energy to a more renewable energy system makes it possible for the forest industry to reclaim its position.

Large-scale biofuels production from the forest will lower greenhouse gas emission by up to 27 per cent.

Eirik Ogner Jåstad's doctoral dissertation is part of the Bio4Fuels centre at the Norwegian University of Life Sciences (NMBU). Based on his models, there are enough forest resources in the Northern countries to fulfill the demand for the generation of renewable biofuels, heat, and electricity.

Photo: Roar Ree Kirkevold/Magasinet Skog

Bio4Fuels outreach in 2020

Bio4Fuels days

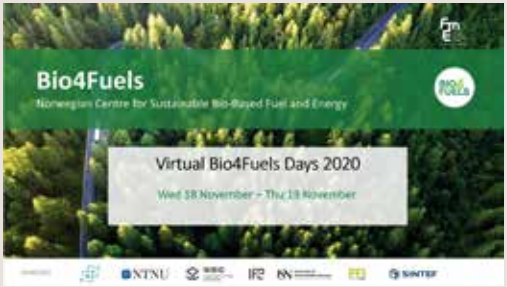
Date: 18-19 November
Topics: Working towards a climate-neutral 2050

This year's Bio4Fuels Days 2020 was held as an online seminar, gathering 80 researchers, industry specialists and policymakers. The purpose of the seminar was to share insight, challenges and recent developments within the production and use of advanced biofuels.

The first day of the seminar had an international perspective, with presentations from Bio4Fuels' stakeholders and invited speakers. Day two was an internal seminar for Bio4Fuels' partners.

A major contributor to the emission of greenhouse gases is the use of fossil fuels in the transport sector. The EU's European Green Deal aims for the sector to be climate-neutral in 2050, and to achieve this goal a sustainable biofuel industry needs to be established. The demonstration and scale-up of novel processes for production of advanced biofuels is essential.

The new demonstration plant of Silv Green Fuel was presented by Statkra Senior Engineer and Bio4Fue air of the Board Ingo Machenbach. Other presenters were St1, Norwegian University of Life Sciences, Imperial College London, Avinor, and RTI International, all highlighting different aspects of biofuels and their importance for achieving future goals of reducing greenhouse gas.



Bio4Fuels webinars

Date: 6 May
Topic: Norsk skogsektor mot 2050

Date: 12 June
Topic: Biodrivstoff som klimatiltak i Norge mot 2030

Date: 23 October
Topic: Skape grønne verdier – refleksjoner sett fra Norske Skog

External workshops

Date: 6 July
Topic: e-EUBCE event on "Incorporating *Efficient Bioenergy in Industry"*

Date: 25 November
Topic: German Biomass Research *Center's forum on Hydrothermal Processes*

Date: 2 September
Topic: "Pellets – en trussel mot klimaet?" *The Norwegian Academy of Science and letters*

Date: 9 September
Topic: "Decarbonisation of Transport – Light Duty Vehicles". *The Norwegian Academy of Science and letters*

For Bio4Fuels scientific publications from 2020, see the annual report: https://www.nmbu.no/en/services/centers/bio4fuels/news/node/40424

Photo: Roar Ree Kirkevold/Magasinet Skog

Bio4Fuels organization

Management and leaders

Biochemical Conversion — SP 3

Mihaela Tanase Opedal, RISE PFI
Aniko Varnai, NMBU
Alexander Wentzel, SINTEF
Michał Sposób, NIBIO

SP 2 — **Liquefaction Processes**

Judit Sandquist, SINTEF
Kai Toven, RISE PFI
Roman Tschentscher, SINTEF
De Chen, NTNU

Gasification Processes — SP 4

Morten Seljesko, SINTEF
Edd Blekkan, NTNU
Klaus Jens, USN

SP 1 — **Bio-resource, Environment and Climate**

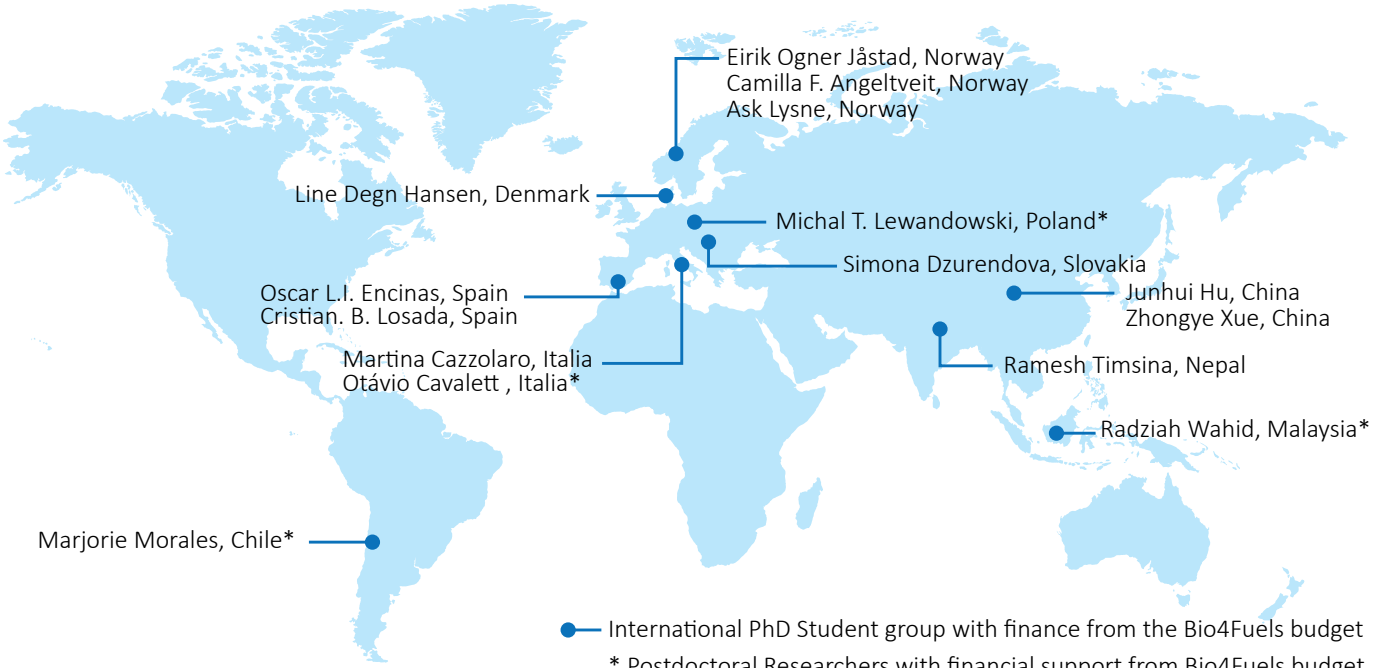
Francesco Cherubini, NTNU
Rasmus Astrup , NIBIO
Torjus Bolkesjø, NMBU

Process Design and End Use — SP 5

Bernd Wittgens, SINTEF
Heinz Preisig, NTNU
Terese Løvås, NTNU

Management and Staff

Duncan Apkoriaye, SINTEF
Svein Jarle Horn, NMBU
Odd Jarle Skjelhaugen, NMBU
Janne Beate Utåker, NMBU
Ann-Solveig Hofseth, NMBU
Bente Paulson, NMBU
Liv Axelsen, SINTEF


Eirik Ogner Jåstad, Norway
Camilla F. Angeltveit, Norway
Ask Lysne, Norway
Line Degn Hansen, Denmark
Michal T. Lewandowski, Poland*
Simona Dzurendova, Slovakia
Oscar L.I. Encinas, Spain
Cristian. B. Losada, Spain
Junhui Hu, China
Zhongye Xue, China
Martina Cazzolaro, Italia
Otávio Cavalett , Italia*
Ramesh Timsina, Nepal
Radziah Wahid, Malaysia*
Marjorie Morales, Chile*
International PhD Student group with finance from the Bio4Fuels budget
* Postdoctoral Researchers with financial support from Bio4Fuels budget

Bio4Fuels Industrial and public stakeholders

BIORESOURCE OWNERS

BIOFUEL AND BIOCHEMICAL PRODUCERS

TECH./KNOWLEDGE PROVIDERS, NORWEGIAN

TECH./KNOWLEDGE PROVIDERS, INTERNATIONAL

BIOFUELS DISTRIBUTORS AND END USERS

TRADE ORGANIZATIONS

GOVERNMENT AND STATE PARTNERS

Authors: Duncan Akporiaye, Svein Jarle Horn, Bente Poulson, Ann-Solveig Hofseth, Odd Jarle Skjelhaugen, Janne Beate Utåker.
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