BIO4ENERGY

Annual report 2021

www.bio4energy.se

Introduction – overview of 2021

The Bio4Energy year of 2021 began as the previous year ended, with limited possibilities to meet physically, but with ample opportunities to practice creative forms of travel-free meetings. For us as researchers, we have encountered challenges related to recruitment and procurement of new equipment and instruments, both of which have seen serious delays during the pandemic. Nevertheless, 2021 has seen more people active in Bio4Energy than the previous couple of years, which is of course positive – without our researchers, no Bio4Energy!

2021 also marked the start of some changes, in particular in how the strategic funds are managed. New procedures are meant to make those means more predictable and the process both more manageable and more transparent. Fifteen new collaborative strategic projects addressing new and important avenues of research thus started in 2021.

Finally, we closed the year with a long-awaited physical researchers' meeting in Skellefteå in December, with inspiring presentations from several of our young researchers, as well as from Skellefteå kommun and RISE. We conclude that biorefinery research is a continued hot topic!

The year in numbers

Figure 1 summarises a few of Bio4Energy's output and achievements of 2021 in numbers.

People are our most valuable assets! After a few initial ramp-up years when Bio4Energy started in 2010, the number of researchers involved in Bio4Energy has been relatively stable at around 200 persons. 2021 saw a slight positive increase compared to the previous years.

PhD degrees are one way we contribute directly to society and industry – through providing competence for the future. The 13 defended PhD theses of 2021 mark our second highest since the start of Bio4Energy.

Publications is how most our research is disseminated. Of the 168 published peer-reviewed journal papers in 2021, at least 25% are a direct result of cross-platform collaboration, involving researchers from two or more of the seven Bio4Energy research platforms.

Alliance partners and *academic partners* represent national and international collaborations, a central part of Bio4Energy's operations. Both of those started to pick up in 2021 after a dip during the first year of the pandemic.

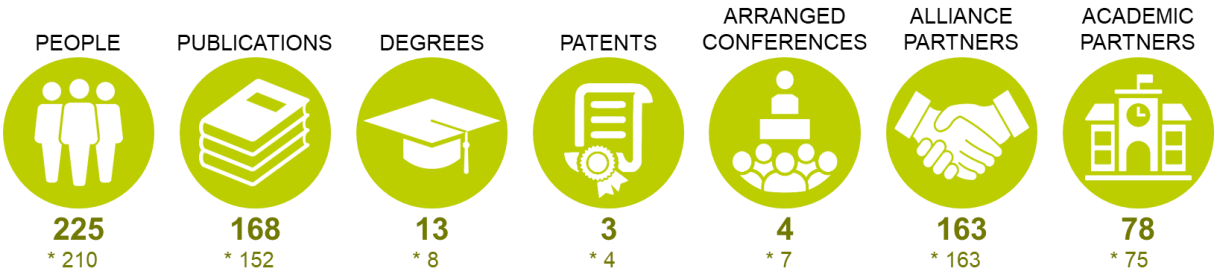


*Figure 1. Key numbers for Bio4Energy 2021. Numbers marked with * are average values for the period 2016-2021. 'Degrees' here represents PhD degrees. 'Alliance partners' represents our external collaboration partners from industry, society and institutes, and 'Academic partners' our external collaborations with academic departments outside Bio4Energy.*

P1 Systems Analysis and Bioeconomy

- Investigation of how to combine biofuel production for road and aviation with CCS and CCU from a combined carbon, cost and climate perspective. The full benefits of BECCS and BECCU were found to be contingent on the timely deployment of biofuel pathways that are not currently in commercial operation, in particular pathways based on gasification or hydrotreatment of forest residues. BECCS enables production of climate positive aviation biofuels at relatively low cost.
- Hydrogen production from electrolysis in almost fully renewable electricity system was investigated, and the role of thermal power and hydropower as flexibility sources. 29 different weather years were studied. Electrolyser utilisation above 60% on average was always achieved, but the inter-annual variability of hydrogen production was substantial. Thermal and hydro power reduce variability but risk causing emissions and hydropeaking.
- The spatially explicit localisation model BeWhere Sweden was soft-linked to two different forest market models to analyse the effects of increased competition for forest biomass resulting from introduction of large-scale biorefineries.
- Investigation of integrated CO_2 separation and CO_2 conversion to produce chemicals, such as CO and alcohols, where electricity is used as power of conversion.
- Integration/combination of CO_2 capture and compression linked to CCS was evaluated, to improve process efficiency.
- Investigation on how to combine chemical production with H_2 electrolysis to improve the process efficiency was initiated.
- Exploration on how to use bio-based materials to develop components (anodes and electrolytes) of batteries was started.
- Further development of theoretical models to improve the calculation speed and prediction capacity, which is highly beneficial for screening of novel liquid materials.
- Scientific progress in applying life cycle assessment (LCA) methodology at laboratory scale processes.
- Strategic collaboration with Holmen initiated, on proposal on climate change mitigation through intelligent forest management and forest biomass use.
- Several LCA studies have been performed in collaboration with other Bio4Energy platforms, including assessment of forest-based biofuels for arctic marine shipping, novel methanol production from woody biomass, membrane production and organosolv-based lignin production.
- Bio4Energy funding was used as seed funding for a new project within the Interreg Botnia Atlantica programme, "Added value from Logging residues".

The SysAnaBio platform

Biorefineries are inherently interconnected with existing industrial infrastructures and other sectors of the economy, and the related scientific-technological challenges are multifaceted and requires a multi-disciplinary perspective.
In this platform, holistic and comprehensive methodological systems analysis approaches are used to address technological, economic, and social challenges and opportunities related to the development of biorefineries.

P2 Forest-Based Feedstocks

- New genetic engineering methods were reported in *Populus* trees to 1) increase aspen tree growth based on tests both in the greenhouse and in a five-year field trial, 2) prolong time for fibre expansion during wood formation, 3) improve the overall saccharification yields, and 4) reduce adhesion of wood fibres. As an example, field-grown, transgenic hybrid aspen trees with lower acetyl content in wood were shown to display increased saccharification glucose yields especially in reaction conditions without pretreatment. The results also demonstrated the importance of reducing wood acetylation specifically in the woody tissues to avoid trade-offs in biomass productivity.
- Chemical and mathematical modelling methods revealed that wood fibers reach their final length by combining both diffuse and tip growth and targeted release of cell adhesion between the neighbouring fibres.
- Cross-platform collaboration discovered that oxidative nanofiber fibrillation of aspen wood is negatively influenced by low lignin content and high cellulose crystallinity.
- The Biopolymer Analytical Platform (BAP), dedicated to research on cell walls of terrestrial and aquatic plants and biopolymer materials, expanded its activities towards several new users. BAP is a central facility for several Bio4Energy platforms and recipient of Bio4Energy funding. BAP has also been accepted as a KBC platform and recipient of KBC financial support.
- Industrial collaboration projects were initiated to investigate the effect of alternative forest harvesting methods and organic nutrients on ectomycorrhizal establishment and soil biodiversity.
- Technological breakthroughs involved near-infrared modelling and deep learning algorithms to quantify the extent of tension wood in aspen wood and resin and fatty acids in spruce wood, a machine learning method for spruce genome wide association study, first X-ray images (3D microtomography) in live poplar stems, microfluidics methods to analyse mechanical properties of live wood samples, and fluorescence-lifetime imaging microscopy (FLIM) method for wood high-resolution chemotyping.
- The platform developed into a European hub for translatomics (global protein translation analytics) in plant stress research. Visitors from Finland, Spain, the Netherlands, USA and Uppsala were received to perform translatomic analyses and preparation of collaborative publications.
- Collaborative projects within and between the Bio4Energy platforms on X-ray microtomography as well as forest tree breeding contributed to new funding in the form of Novo Nordisk Emerging investigator grant (Establishment of trees with high-yield and high-quality wood fibers for more sustainable improved feedstock, 12 Mkr), and from Swedish Foundation for Strategic Research (SSF) (Landscape Breeding: A new paradigm in forest tree management, 25 Mkr).

The ForFeed platform

Feedstock is the basis of all other platforms, and optimised feedstock will influence the whole value chain. Research on feedstock production systems contributes to increased wood yield and allows engineering of wood characteristics. Within this platform, genetic and molecular control of properties that are important for feedstock biorefining are investigated, as well as how these properties are governed by environment and management practices.

P3 Feedstock Pre-Processing

- Flexible supercapacitors were created from egg-shell membranes coated with a composite of activated Norway spruce bark carbon and polypyrrole.
- Wood powders were produced in one step – from fresh pine logs to powder - using a novel multi-blade shaft mill. The resulting particles size was to 80-95% <1.0 mm, and a 40% higher aspect ratio was obtained compared to by hammer-milling.
- Edible *Pleurotus ostreatus* mushrooms were cultivated with cellulose fibre reject as growing substrate. The fruit bodies had good nutritional values and low contents of heavy metals.
- Co-combustion of sewage sludge and wheat straw produced phosphorus-rich ash particles with open pores that soil water may readily permeate and support direct interaction between the inner surfaces of ash particles and the fine roots of many plant species.
- Contrary to the general understanding, the hemicellulose content (mannan and xylan) was proven a more significant factor than the lignin content for predicting optimum process conditions in high-quality biomass pellet production.
- Slow pyrolysis or low-temperature gasification of softwood bark and forest residues produced char with four times higher K and P concentrations than fossil coal and coke. This may restrict the use of the charcoal in the steel industry since K and P reduce the strength of iron ore pellets in blast furnaces, impede the gas flow, negatively impact refractory materials, promote the formation of scaffolds, and give rise to increased consumption of the reducing agent.
- Problems in the dosing of mannitol powders in medicine manufacturing were shown to be due to changes in the mannitol particles' surface plasticity and contact area, as a result of interaction effects from temperature, humidity, and conditioning period.
- Activated carbons from Norway spruce bark were shown effective as adsorbents of pharmaceuticals and dyes.
- Bio4Energy has been instrumental for a number of externally funded research projects, with funding from VINNOVA, the Swedish Energy Agency, the Swedish Board of Agriculture, among others.
- Several Erasmus Mundus MSc student exchanges have been enabled by Bio4Energy, as well as a student interplatform project, as an initiating task for potential collaboration with the large French/European project BioTfueL

The FeedPro platform

Forest-based lignocelluloses are characterised by their structural and chemical diversity. Expertise in advanced feedstock characterisation and design and evaluation of tailored pre-processing technologies is critical for accelerating the development of biorefinery processes and products. This platform addresses challenges and opportunities caused by biomass heterogeneity, through research on characterisation, separation, and modification of bio-based materials.

P4 Thermochemical Conversion Technologies

- Bio4Gasification (B4G) is a node in the large competence centre SFC (Swedish Gasification Centre) in which many researchers from the platform have participated and contributed during the last 10 years. SFC ended in 2021 and was concluded successful for generating new world-leading knowledge in the area, and for extensive competence build-up. Many interesting results are still being published also after the Centre's closing.
- A method for detection of gaseous phosphorus oxides by broadband mid-infrared absorption spectroscopy was developed. Real-time in situ detection of POx, P_4O_6 and P_4O_{10} in combustion and gasification applications will enable new mechanistic understanding of release and reactions of P in the gas phase. This information is important for the development of novel concepts for ash design and utilization.
- The experimentally difficult to assess rheological properties of slag from molten biomass ash have been studied in detail by molecular dynamics simulations.
- The previously developed optical technique for in situ quantification of K, KOH and KCl was used to map K species in laboratory flames and pilot-scale reactors, as well as to validate numerical models for the release of K from biomass particles during combustion.
- Ash-quicklime interactions have been studied together with industrial partners, aiming to find new possibilities for large scale coal replacements. Work is ongoing to evaluate and compare different fuel types.
- Several new publications about methods to control the reactivity of biochar, which is an extremely important property for the process of replacing fossil coal in the steel industry. Researchers from the platform also developed a simulation model that can predict self-heating during post-production storage. It can be used to mitigate and control fire hazard risks in large-scale biochar production plants.
- Methods for quantitative chemical imaging of gaseous K, KOH and KCl with high time-resolution have been developed. These sophisticated tools can be used to generate fundamental mechanistic understanding targeting the K reactions close to burning particles as well as the rapid secondary reactions.
- Pilot-scale gasification experiments have contributed to improved understanding of methane production and connections between methane and soot formation during entrained flow gasification of solid biomass particles. The measurements highlight the advantages of using laser-based sensors for fast *in situ* detection and constitute an important step towards maximizing the process efficiency.

The ThermoChem platform

Through thermochemical conversion processes, widely different types of biomass can be converted into advanced fuels and chemicals. The overall challenge for this platform involves generating the fundamental understanding needed to support the technical development of thermochemical conversion of forest-based biomass, side streams, recycled fibres, underutilised fractions, and to make the corresponding technologies competitive to those for fossil fuels.

P5 Biopolymers and Biochemical Conversion Technologies

- A new project was launched with support from the Swedish Research Council and will focus on oxidoreductases from white-rot fungi. Oxidoreductases are involved in lignin biodegradation, but, more recently, their role in biodegradation of ligno-cellulosic polysaccharides, particularly cellulose, has also drawn attention. In addition to that, the possibility to utilise oxidoreductases as catalysts in oxygen-scavenging lignin-based paperboard coatings was further investigated using industrial lignosulfonate preparations from Domsjö Fabriker in Örnsköldsvik.
- A project on production of biopolymers from quinoa stalks using halotolerant bacteria received support from the Swedish International Development Cooperation Agency: "Biopolymers from quinoa residues using halotolerant bacterial isolates from the Bolivian Altiplano". The project engages researchers and students at Umeå University and Universidad Mayor de San Andrés in Bolivia.
- The research on combined production of mushroom and biofuels was included in the top 100 innovative research projects with potential for industrial implementation, and it was granted the Sparbanksstiftelsen Norrland's Award for Sustainable Innovations. The research is a collaboration with researchers in the FeedPro platform.
- A project that will investigate a new approach for microbial analysis in the pulp and paper industry was launched together with RISE Processum and industrial collaboration partners. The project addresses problems with microbial contaminants in pulp and paper processes and in packaging products.
- Research within the platform resulted in a new patent about preparation of hybrid biogels combining cellulose nanofibrils and alginate from the same raw material, viz. brown seaweed. The hybrid biogel has suitable rheological properties to be useful for example in 3D-printing.
- The upgrade of the organosolv reactor to a continuous system for biomass pretreatment and fractionation started. This new system will be one of 17 European pilot lines within the Horizon-2020 project BIOMAC, where technologies and solutions utilising nano-enabled bio-based materials will be upscaled and prepared for market applications. The BIOMAC pilot lines will cover the whole value chain for biomass valorisation and aims to offer an innovation system for small and medium-sized enterprises or industry, to develop production of bio-based nanomaterials. Our pilot line will be an important tool for Bio4Energy to further strengthen our position regarding pretreatment and fractionation of lignocellulosic biomass. More information here.

The BioPolChem platform

This platform focuses on bio-based polymers for advanced and sustainable materials, and conversion processes that involve microorganisms and enzymes. Both conventional forest-industrial processes and products, e.g. cellulose and cellulose derivatives, and novel polymeric bio-based materials are included. Exploitation of the inherent characteristics of the raw materials is central, incorporating the sustainability aspect to reduce, recycle, and reuse.

P6 Chemical Catalysis and Separation Technologies

- The first industrially relevant zeolite membranes for gas separations were developed and tested. The highly CO_2 permeable zeolite membranes of chabazite type were of an industrially relevant size, and were shown to perform exceptionally well at industrially relevant conditions, i.e. for a feed of humid gas.
- We also succeeded in the development of so-called DDR zeolite membranes in the form of small membrane discs with exceptionally high CO_2 permeability and CO_2/CH_4 selectivity, a world record by far.
- The since long ongoing development of zeolite catalysts received additional financial support from the Swedish Energy Agency for a project entitled Methanol-to-jet, in collaboration with researchers in the SysAnaBio platform.
- Unprecedented catalyst activity and stability of Mizoroki-Heck reaction in a continuous packed bed reactor over a Supported Ionic Liquid Catalyst was unravelled, which can potentially revolutionise the industrially important Heck reaction. Another reusable and active catalyst for the Mizoroki-Heck reaction was also developed.
- The environmental impact of polymeric membrane production was evaluated using LCA, in collaboration with the SysAnaBio platform.
- In electrochemistry, NiCo nanoneedles on 3D carbon nanotubes/carbon foam electrode as an efficient bi-functional catalyst for electro-oxidation of water and methanol was demonstrated.
- Developed new technology for integrated, metal free synthesis of glycidol and dimethyl carbonate from glycerol derived 1,3-dichloro-2-propanol via CO_2 capture.
- Membrane distillation applying, e.g., electrospun nanofiber membranes is an attractive option for desalination. Within the platform, mixed matrix membranes have been developed and successfully demonstrated for DCMD (direct contact membrane distillation), confirming their suitability for long-term desalination in remote areas and emergency situations. Also poly(vinylidene fluoride-co-hexa-fluoro propylene) membranes were demonstrated as non-toxic and environ-mentally safe for DCMD application.
- We proposed membrane distillation crystallizer to achieve zero liquid discharge (ZLD) in the pulping and papermaking industry application. The composite membrane's performances were evaluated using high saline RO brine and the concentrated salt solution was further extracted and analysed to show the membranes' potential to achieve ZLD.
- Efficient and sustainable energy storage systems are critical for our modern life, and excellent performance lithium-ion batteries (LIBs) are extensively employed in portable electronics and electric vehicles (EVs). Challenges related to, e.g., safety risks and battery performance limit the future and more widespread usage of LIBs. Researchers from the platform have during the year published several LIB related reviews regarding membranes and binders.

The CatSep Platform

In order to make biorefineries successful, it is essential to develop suitable catalysts and energy lean separation technologies. The focus of this platform is fundamental research on novel integrated catalysis and separation processes designed for application in forest and other lignocellulosic-based biorefineries, encompassing both thermochemical and biochemical routes to fuels and chemicals.

P7 Environment and Nutrient Recycling

- Concerning recovery of elements from ash fractions the chemical structure, reaction pathways and mobility of the macronutrients phosphorus and potassium in fuel particles during conversion have been elucidated. The resulting ash and slag formed were characterized in-depth regarding formed crystals and particle morphology with synchrotron-based X-ray tomography which has advanced our understanding of potential nutrient recycling from such particles.
- Platform researchers are active in introducing synchrotron-based measurements to an industrial partner working on sustainable biostimulants as funded by VINNOVA.
- A new project related to microalgal cell wall has been started within the platform. The new project includes a post-doctoral researcher financed by the Kempe foundation and a new instrument to break algal cell walls, financed by the Carl Trygger Foundation. The idea with this project is to study the algal cell wall and factors that influence its characteristics.
- Knowledge gained through activities within the platform resulted in a major collaborative project related to phosphorus recovery funded by the Swedish Energy Agency. The project will focus on novel energy and resource-efficient value chains through co-combustion of straw fuels and sludge, and involves several industrial partners as well as three Bio4Energy platforms (EnviroNut, ThermoChem, and SysAnaBio).
- New collaboration about seaweed characterisation initiated between the platform and several different researchers from the Northern periphery and Arctic region.
- The collaborative Bio4Energy project financed by the strategic means about the use of ashes as a fertiliser in lakes and in combination with microalgae as biofertilizer has been concluded. The results were very promising with the generation of biofertilizers for aquatic and terrestrial environment.

The EnviroNut platform

One of the key challenges when introducing new biorefinery concepts is to develop sustainable and resource-efficient utilisation routes of forestry biomass, industrial residues and organic waste streams, including closing the loops of nutrients and minerals, as well as minimising the potential environmental and health impacts. This platform aims at advancing the understanding related to critical research questions on the environmental aspects of sustainable forestry, bioenergy and biorefinery processes.

New strategic projects

Twenty per cent of all funding to Bio4Energy is set aside as **Strategic Funds** used to create synergies and explore and address new and important avenues of research.

Our strategic projects:

- Concern high-quality research dedicated to the biorefinery field;
- Involve collaboration between research and development platforms and research groups;
- Are targeted at finding solutions to global problems and strengthening the development and competitiveness of Sweden and Swedish industry and;
- Support young Bio4Energy researchers in a critical phase of their academic career.

In the 2021 call for **targeted strategic funds (2022-2023)**, ten 2-year projects were granted, according to below.

Valorization of biogenic carbon emissions for biotechnological production of green energy storage chemicals.
Io Antonopoulou (LTU, P5), Joakim Lundgren (LTU, P1), 709 kSEK tot.

Development of energy-efficient processing technology of wood biomass into nanofibers and biocomposites through the use of fungal pretreated substrates accessing the sustainability goals.
Kristiina Oksman (LTU, P5), Shaojun Xiong (SLU, P3), Ulrika Rova (LTU, P5), 1100 kSEK tot.

Waste2Plastic – Production of bioplastic from algal biomass generated on wastewater.
Christiane Funk (UmU, P5), David Agar (SLU, P1), Lalie Kossatz (RISE Processum), Björn Alriksson (RISE Processum), 560 kSEK tot.

Preparing and assessing porous liquid for carbon dioxide separation.
Xiaoyan Ji (LTU, P6), Naser Tavajohi (UmU, P6), 855 kSEK tot.

Environmentally friendly L-arginine separation by use of biomimicry.
Nils Skoglund (UmU, P7), Torgny Näsholm (SLU, P7), 900 kSEK tot.

Electrochemical pyrolysis of spruce needles.
Torbjörn Lestander (SLU, P3), Jyri-Pekka Mikkola (UmU, P6), Magnus Rudolfsson (SLU, P3), Gopinathan Manavalan (UmU, P6), 956 kSEK tot.

Evaluation of field-grown aspens with modified lignin, pectin and xylan by biochemical conversion technologies and comprehensive productivity analysis.
Ewa Mellerowicz (SLU, P2), Leif Jönsson UmU, P5), Benedicte Albrectsen (UmU, P2), 1616 kSEK tot.

Relation of wood structure and chemistry to nanocellulose extraction and properties.
Totte Niittylä (SLU, P2), Linn Berglund (LTU, P5), Gerhard Scheepers (RISE, P2), 1906 kSEK tot.

Improvement of LCA and economic methodology for upscaling biofuel and biomaterial production.
Dimitris Athanassiadis (SLU, P1), Mats Tysklind (UmU, P1), Tommy Lundgren (SLU, P1), Robert Lundmark (LTU, P1), 732 kSEK tot.

Paving the road for introducing renewable energy carriers in large industries.
Markus Broström (UmU, P4), Kentaro Umeki (LTU, P4), Andrea Toffolo (LTU, P1), Henrik Wiinikka (RISE, P4), 1681 kSEK tot.

Bio4Energy graduate school

During 2021, Bio4Energy had 75 active PhD students engaged in our research. The **Bio4Energy Graduate School** contains two courses for PhD students and early career researchers. The courses reflect the strength of the Bio4Energy cluster, with its unique layout of research and development covering the biorefinery value chain. At the end of the year, preparations started for a post-pandemic restart of the graduate school's most popular and acclaimed course "Biorefinery Pilot Research", with several new elements. The course will be given early in 2022.

In the context of the continued pandemic-related challenges during the year, we are proud to be able to state that in 2021, 13 Bio4Energy students defended their doctoral theses – the second highest number since the start in 2010!

PhD theses

Elina Bryngemark, Dept. of Social Sciences, Technology and Arts, LTU (P1)
"The Economics of Biofuel Development: Policy Incentives and Market Impacts".
Main supervisor: Patrik Söderholm.

Anne Buender, Dept. of Forest Genetics and Plant Physiology, SLU (P2)
"The biology and properties of wood for nanocellulose production".
Main supervisor: Totte Niittylä.

Thai Bui Quoc, Dept. of Chemistry, UmU (P6)
"Development of nitrogen-containing materials for capture and catalytic conversion of carbon dioxide to value-added chemicals".
Main supervisor: Jyri-Pekka Mikkola.

Feng Chen, Dept. of Forest Biomaterials and Technology, SLU (P3)
"Combined production of edible mushrooms and biofuels from lignocellulosic residues".
Main supervisor: Shaojun Xiong.

Evgeniy Donev, Dept. of Forest Genetics and Plant Physiology, SLU (P2)
"Modification of forest trees by genetic engineering. From design to the field".
Main supervisor: Ewa Mellerowicz.

Dimitrios Ilanidis, Dept. of Chemistry, UmU (P5)
"Biochemical conversion of biomass: Hydrothermal pretreatment, by-product formation, conditioning, enzymatic saccharification, and fermentability".
Main supervisor: Leif J. Jönsson.

Katharina Fürsatz, Technische Universität Wien, Institut für Verfahrenstechnik, Umwelttechnik und Technische Biowissenschaften (P7)
"Interactions between Fuel Ash from Residues and K-Feldspar Bed Material and their Significance for Fluidised Bed Thermal Conversion Systems".
Main supervisor: Nils Skoglund.

Simon Jonasson, Dept. of Engineering Sciences and Mathematics, LTU (P5)
"The effect of wood properties on oxidative isolation of cellulose nanofibrils and characterization of networks".
Main supervisor: Kristiina Oksman.

Carl Nolander, Dept. of Social Sciences, Technology and Arts, LTU (P1)
"Carbon Sink or Energy Source: Economic perspectives on future uses of forest resources in Sweden".
Main supervisor: Robert Lundmark.

Elias Olofsson, Dept. of Social Sciences, Technology and Arts, LTU (P1)
"Spatial forest resource competition: an economic study: How increased competition and production flexibility affect woody feedstock markets".
Main supervisor: Robert Lundmark.

Aekjuthon Phounglamcheik, Dept. of Engineering Sciences and Mathematics, LTU (P4)
"Bio-coal for the sustainable industry: A scientific approach to optimizing production, storage, and usages".
Main supervisor: Kentaro Umeki.

Kavitha Shanmugam, Dept. of Chemistry, UmU (P1)
"Circularity Assessment of Water and Waste in Cities - A Proposed Framework for Sustainable Performance Evaluation using LCA and LCC".
Main supervisor: Venkata Krishna Kumar Upadhyayula.

Jonas Zetterholm, Dept. of Engineering Sciences and Mathematics, LTU (P1)
"Evaluation of emerging forest-industry integrated biorefineries: Exploring strategies for robust performance in face of future uncertainties".
Main supervisor: Elisabeth Wetterlund.

Licentiate thesis

Chinedu Nwachukwu, Dept. of Engineering Sciences and Mathematics LTU (P1)
"Utilising forest biomass in iron and steel production: investigating supply chain and competition aspects".
Main supervisor: Elisabeth Wetterlund.

In memoriam

Chinedu Nwachukwu passed away sadly and unexpectedly in September 2021, when giving birth to her baby son.

She will be greatly missed by friends and colleagues within Bio4Energy and at LTU.

Media and outreach

During 2021, the work with a new website started. The new website will have a completely new look and be more adapted to Swedish conditions.

The research enabled by Bio4Energy has continued to generate substantial visibility during the year. A few examples:

- Doctoral student Atanu Kumar Das was interviewed by Swedish Radio P1 on his research on management of solid healthcare waste during the Covid-19 pandemic.
- Rikard Gebart participated in roundtable discussions on green hydrogen in Europe. Participants were stakeholders from politics, industry and academia from Germany, Norway, Finland, Denmark and Sweden.
- Field work activities in Bureå within the SGI/Tuffo-funded project SafeSed received substantial media attention. In the project, remediation of sediments contaminated with organic contaminants originating from e.g. sawmills, wood pre-treatment sites, and pulp and paper mills, will be assessed both in lab-scale and field trials using the novel technique (Sorbent Polymer Extraction and Remediation System).
- Bio4Energy news on a project on turning inedible quinoa residues into bio-based products, including critical capacity building, to strengthen Bolivian economy generated significant attention. The project involves Bio4Energy researchers Carlos Martín and Leif J. Jönsson.

Bio4Energy news have also been addressed by both specialist press within our sector and general press. A few examples are Infrasverige.se, Industrie Mag, Dagens Industri, Svenska Dagbladet, Hydrogen View, and Metaller och Gruvor.

Awards and commissions of trust

The research on combined production of mushroom and biofuels was included in the top 100 innovative research projects with potential for industrial implementation. The research was also granted the Sparbanks-stiftelsen Norrland's Award for Sustainable Innovations. The research is a collaboration between researchers in the FeedPro and BioPolChem platforms.

Shaojun Xiong (FeedPro platform) was also on the Venture Cup's Top-20 list for the concept "Sustainable mushroom cultivation."

Jessica Timmerfors (previously in Bio4Energy Graduate School, the BioPolChem platform and UmU Industrial Doctoral School for Research and Innovation) received the Gunnar Sundblad Young Researcher´s Award 2021 (400,000 kr) for her doctoral thesis on investigation of forest-industrial wood chipping using modern methods and techniques leading to increased possibilities to utilize feedstocks from forestry more efficiently.

Carlos Martín (BioPolChem platform) was awarded a Professorship in Biomass and Bioresources Utilization at Inland Norway University of Applied Sciences.

Shiyu Geng (BioPolChem platform) received the Royal Skyttean Society's award for young researchers for the use of nanotechnology in materials science with a focus on creating new nanostructured composites for new types of packaging and for the development of bio-based carbon nanomaterials that can be used in future energy storage units and in carbon capture. From the jury's motivation:

"Her research has shown very interesting results, including that these materials can be used as electrode materials for energy storage and as carbon dioxide traps. She has also developed bionano composites with extremely high mechanical properties through excellent dispersion and orientation."

PhD graduate, Aekjuthon Phounglamcheik (ThermoChem platform), received a Young Researcher's Best Presentation Award at 7th International Symposium on Gasification and its Applications.

Nils Skoglund (EnviroNut platform) was elected as Chair of Swedish Flame Research Committee including board membership of the International Flame Research Foundation, aiming to strengthen recovery within thermal conversion. Skoglund was appointed as responsible for Bioenergy contributions to the Max IV Strategic Roadmap 2030 including hosting workshops. The document will be finalised in 2022.

Bio4Energy's researchers also hold a large number of commissions of trust, and act as members on various boards and committees. Examples include the Scientific Council of Centre for Business and Policy Studies (SNS), the European Federation of Chemical Engineering (EFCE), IEA Bioenergy, the prestigious Selection Committee for the Marcus Wallenberg Price, the MAX IV reference group, the European Federation of Chemical Engineering (EFCE), the European Union COST action EUAlgae, and several of the program counsels and boards for the Swedish Energy Agency's research programs.

Bio4Energy in new centres

Center for Hydrogen Energy Systems Sweden - CH2ESS

CH2ESS is a research and knowledge initiative at Luleå University of Technology with a focus on hydrogen use in industrial processes and energy systems, in close collaboration with Swedish industry. Hydrogen is a key to a fossil-free energy system and B4E researchers are involved and secures that development in Sweden through groundbreaking research and skills supply.

CH2ESS engages B4E researchers from ThermoChem, SysAnaBio and BioPolChem platforms.

Contact: Joakim Lundgren (SysAnaBio).

Trees For Me, TFM (Centre of excellence for fast growing deciduous TREES–sustainable FORest, Material, and Energy)

TFM is a new competence centre financed by the Swedish Energy Agency. The centre focuses on production and processing of fast-growing broadleaves (birch, aspen, poplar and hybrid aspen) for sustainable forests, materials and energy. 50 partner organisations representing academic and research institutes, and the enterprise and public sectors will collaborate in the centre.

TFM engages B4E researchers from ForFeed, ThermoChem and SysAnaBio platforms.

Contact: Henrik Böhlenius (ForFeed), Marcus Öhman (ThermoChem), Elisabeth Wetterlund (SysAnaBio)

CESTAP (Competence Center for Sustainable Turbine Fuels for Aviation and Power Production)

CESTAP is also a new competence centre financed by the Swedish Energy Agency. Focus is on development of new fuel production routes and fossil-free fuels, and to work on potential modifications of turbine engines for e.g. aviation and power production. CESTAP engages over 30 organisations from academia, research institutes and relevant industrial sectors throughout the value chain.

CESTAP engages B4E researchers from CatSep and SysAnaBio platforms.

Contact: Jonas Hedlund (CatSep), Elisabeth Wetterlund (SysAnaBio)

Bio4Energy Advisory Board

During 2021, we welcomed several new members to our Advisory Board. We had two digital meetings during the year, and look forward to finally meeting physically in 2022.

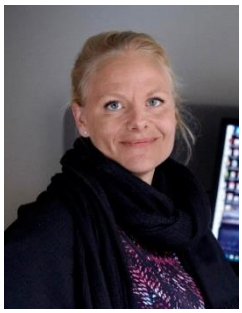
Peter Axegård
C-Green Technology AB
CTO

Charlotte Bengtsson
Skogforsk
CEO

Erik Dotzauer
Stockholm Exergi
Policy expert

Ann-Britt Edfast
Edfast & Wallén
konsult

Björn Fredriksson-Möller
St1 Biogas
Senior specialist



Johanna Mossberg
RISE
VP Biorefinery & Energy

Torgny Persson
Swedish Forest Industries
R&I director

Björn Sundberg
Stora Enso
VP Forest R&D

Linda Werner
St1
Head of Future Upstream

Martin Wimby
Valmet
Recovery business unit