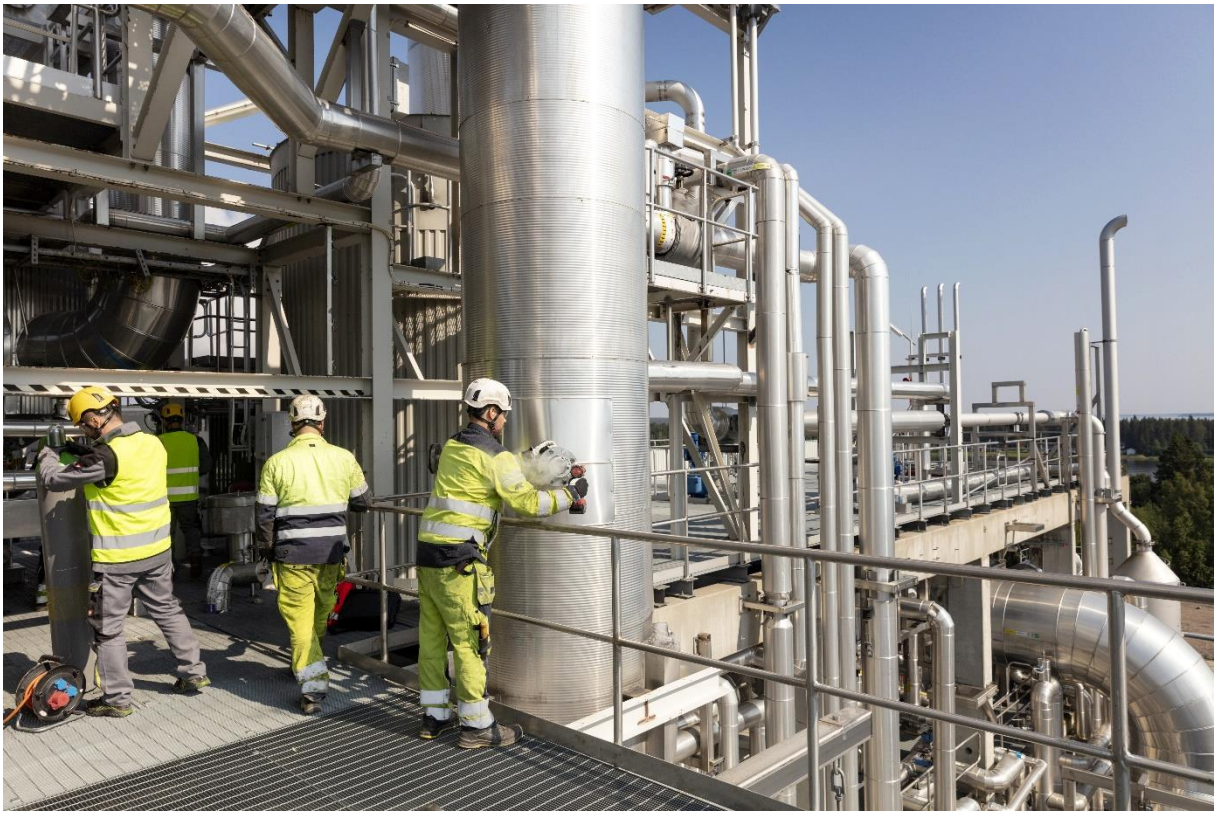
BIO4ENERGY

Annual report 2024



www.bio4energy.se

BIO4ENERGY

Bio4Energy – a strategic research environment

Bio4Energy is a Strategic Research Environment funded through the Swedish Government's investment in high-quality research in 24 strategic research areas. Our research focuses on biorefineries for sustainable production of renewable energy carriers, chemicals and materials.

Partners are Umeå University (UMU), Luleå University of Technology (LTU), the Swedish University of Agricultural Sciences (SLU), RISE Research Institutes of Sweden and Processum.

Bio4Energy's research is at the international forefront and covers the entire value chain: From residual biomass feedstocks to end-products in the form of advanced biofuels, bio-based materials, and "green" chemicals. Our vision is to create environmentally friendly and sustainable technologies; alternatives to today's petrol-based systems.

Bio4Energy researchers collaborate with academia, research institutes and industry worldwide. The researchers are active in education and competence supply at undergraduate, advanced and doctoral levels. The research environment has been in operation since 2010 and involves over 200 researchers. Close to 150 PhD students have graduated from Bio4Energy, and over 180 postdocs have refined their researcher skills within our environment. Our research has resulted in around 2000 peer-reviewed scientific publications and more than 60 patent applications.

Management and coordination

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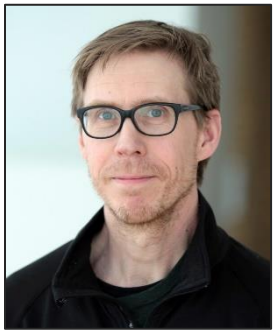

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Introduction – overview of 2024

The year of 2024 has continued to be a year of war and unrest in the surrounding world, and at the same time alarming reports indicate that we will not meet the global 1.5-degree climate target with current climate policy. Meanwhile, in Sweden the industry's green transition continues – but with several terminations or delays. Bio4Energy's research is largely motivated by the challenge of finding sustainable solutions for the climate, environment and society. We also now see an increasing significance of much of our research. Two notable areas are (1) energy security, where bioenergy is an important and inevitable part of the energy mix – both in terms of bio-based heat and power production and for production of bio-electro-fuels and -chemicals, and (2) the development of domestically sourced materials and products, such as fertilisers, polymeric materials and "green" steel.

We are thus happy to be able to continue contributing to education, research and innovation within this critical area.

The year in numbers

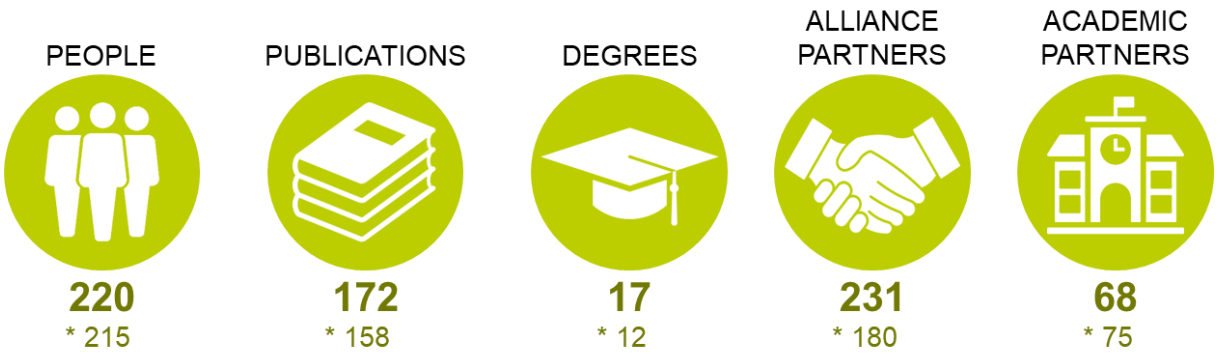
The figure below summarises a few of Bio4Energy's achievements of 2024 in numbers.

People are our most valuable assets! Over the past decade, the number of researchers involved in Bio4Energy has remained relatively stable at around 220 persons.

PhD degrees are one of the ways in which we contribute directly to society and industry – through providing competence for the future. 2024 marked an exceptionally high number of graduated PhDs – second best ever for Bio4Energy!

Publications is how most our research is disseminated. Of the 172 published peer-reviewed scientific journal papers in 2024, at least 25 are a direct result of cross-platform collaborations, which means that researchers from two or more of the Bio4Energy research platforms have been involved.

Alliance partners and *academic partners* represent national and international collaborations, a central part of Bio4Energy's operations. After a few slower years during the pandemic, our number of non-academic collaborations hit a new all-time high in 2024.



***Key numbers for Bio4Energy 2024**. Numbers marked with * are average values for the period 2016-2024. '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.*

Research highlights from the platforms

Bio4Energy is organised into seven research platforms, each with its own special focus in the biorefinery value chain, as shown in the figure to the right.

The following pages are dedicated to highlights from the seven platforms during 2024, with brief descriptions of the scope of each platform.

Particular focus is here placed on new scientific results and achievements – or in short, we here give to you the quick flyover and a selection of insights from the 172 scientific papers published during 2024.

P1 Systems Analysis and Bioeconomy (SysAnaBio)

Biorefineries are inherently interconnected with existing industrial infrastructures and other sectors of the economy, and the related scientific-technological challenges are multifaceted and require 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.

Platform leader: Robert Lundmark, LTU, robert.lundmark@ltu.se

- Showed in full-scale trials that there is a significant difference in pellet quality and storage properties depending on whether the pellets are produced from sawdust of small- or large-diameter pine trees. Pellets made from sawdust of large-diameter pine logs had lower quality and exhibited more issues with self-heating during storage, compared to pellets made from small-diameter pine logs.
- Demonstrated that the production of forest-based biofuels for marine shipping has strong potential and brings several socio-economic benefits alongside environmental advantages. From an economic perspective, both short- and long-term sustainability benefits were identified. By replacing imported fossil fuels, Swedish shipping can reduce operational costs and generate added economic value domestically.

- Explored different sewage sludge treatment scenarios and showed how the economic feasibility of advanced sludge treatment technologies (e.g., co-combustion and hydrothermal carbonization, HTC), depends heavily on energy prices, fertilizer markets, and financial support. Co-combustion with potassium-rich agricultural biomass can improve cost-efficiency but requires high heat prices and nearby biomass resources to remain viable. HTC can offer cost savings by reducing disposal costs and enabling recovery of phosphorus but may penalize electricity production. Collaborative sludge management between neighboring facilities can enhance phosphorus recovery and investment viability. Ultimately, leveraging local infrastructure and site-specific conditions is key to ensuring that sludge treatment strategies are both economically and environmentally sustainable.
- Presented a novel framework based on advanced data analysis techniques to identify key operational factors behind boiler failures. The method combined Principal Component Analysis (PCA), *k*-means clustering and Deep Embedded Clustering (DEC). The findings can support improved operation and help extend the lifespan of boilers.
- Examined the potential impacts of increased woody biomass demand in the Swedish iron and steel industry, particularly in relation to regional prices and resource allocation. The analysis focused on the use of biomass to replace fossil fuels in two highly energy-intensive processes: pellet induration and carburization in hydrogen-based direct reduced iron (DRI). Results from different demand scenarios showed that greater biomass use could lead to significant price increases, especially for forest residues and industrial by-products, potentially creating competition with other sectors. The findings highlight the importance of long-term supply strategies and coordinated policy efforts to ensure biomass availability, recognizing that biomass and hydrogen play complementary rather than competing roles in Sweden's transition to fossil-free steel.

P2 Forest-Based Feedstocks (ForFeed)

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.

Platform leader: Hannele Tuominen, SLU, hannele.tuominen@slu.se

- Established new experimental fields in Alnarp, SLU, for testing genetically modified trees under strict regulatory compliance, supervised by the Swedish Board of Agriculture. The first trials were initiated to investigate how changes in wood chemistry, specifically lignin composition and callose content, affect tree performance under field conditions over the coming five years.
- Performed whole-genome resequencing of Scots pine (*Pinus sylvestris* L.) and developed a 50K SNP (single nucleotide polymorphism) genotyping array for use in breeding and selection of superior pine trees. In parallel, novel regulators of lignin content and composition were discovered in aspen (*Populus tremula*) through genome-wide association studies, providing potential genetic markers for early detection of beneficial wood properties in angiosperm trees.

- Identified that genetic models which account for population structure yield more reliable results. This has practical relevance for forest breeding, where inaccurate selection can result in costly outcomes.
- Established an optimal thinning regime for hybrid poplar (*Populus maximowiczii × P. trichocarpa*, clone OP42) in a long-term trial in southern Sweden. Among four tested treatments, a procedure that comprised of 1100 stems per hectare resulted in the highest biomass production eleven years after thinning.
- Found that planting position had the strongest impact on both seedling performance and fungal community composition in Norway spruce and Scots pine. Fertilization with ammonium nitrate increased seedling mortality, while arginine phosphate enhanced root growth.
- Provided evidence for the existence of a secondary wall sensing mechanism in woody tissues that adjusts xylan composition. This mechanism guarantees sustained, or even increased, tree growth and productivity in response to external stresses such as drought.
- Created near-infrared (NIR) models for predicting wood chemical and physical properties in microscopic sections of both young and fully mature aspen trees, and showed that these models enable fast assessment of traits such as wood chemistry and reaction wood formation, even in regions beyond the scanned section.
- Identified, through microdialysis-facilitated metabolite harvest and metabolomics analysis, that two strains of the same ectomycorrhizal fungus (*Pisolithus microcarpus),* differing in their compatibility with their host (*Eucalyptus grandis),* produce different metabolite profiles during symbiosis. The more compatible strain released a root-like metabolome, while the less compatible strain (forming fewer mycorrhiza) produced chemically divergent compounds, likely triggering plant defense responses.
- Demonstrated that subcritical extraction of matrix compounds from wood improves enzymatic saccharification, enabling more efficient conversion of biomass to fermentable sugars.
- Developed high-throughput methods for analyzing isolated wood cells. An AI-based system was created to characterize wood fiber macerates from light-microscopy images. A workflow was also developed to improve cell wall regeneration in wood protoplasts, enabling studies of adhesion mechanisms in developing xylem cells.

Maxime Chantreau *measures chlorophyll content in hybrid aspen trees using a Dualex sensor at the UPSC phenotyping platform. (***top***, photo by Hannele Tuominen).*

*Hybrid aspen trees on their way to be planted in the field in Alnarp. (***bottom***, photo by Hannele Tuominen)*

- Identified a mechanism by which tannin modification during ectomycorrhizal interaction contributes to pectin remodeling in plant cell walls, with implications for plant–microbe communication and cell wall dynamics.
- Produced a transcriptome atlas covering both zygotic and somatic embryogenesis in Norway spruce, providing a valuable resource for developmental and genetic research in conifer species.
- Discovered that redirection of auxin fluxes plays a central role in coordinating apical and lateral growth in trees, contributing to balanced biomass allocation.
- Identified that nitrate, unlike other nitrogen sources, has a distinct effect on tree growth and lignin accumulation, offering new insights into nutrient–growth interactions.
- Produced a chromosome-scale genome assembly and population genetics resource for *Populus tremula*, enabling large-scale studies in genetics, breeding and adaptation.

P3 Feedstock Pre-Processing (FeedPro)

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.

Platform leader: Mikael Thyrel, SLU, mikael.thyrel@slu.se

- Applied advanced characterisation techniques to improve phosphorus recovery from biochar and ash. Experiments performed at the DanMAX beamline (MAX IV, Sweden) used PXRD with area detector to determine the chemical structure and spatial distribution of phosphorus.
- Deep learning was used to improve the segmentation of X-ray microtomography images of phosphorus-rich ash particles, a key step in optimizing their recycling for nutrient recovery. A U-Net model trained on manual input significantly outperformed traditional methods, enabling accurate identification of material and pore structures. This approach provided detailed insights into porosity, particle wall thickness, and surface area, overcoming challenges in manual segmentation and enhancing the efficiency of ash analysis.
- Tested microwave-exfoliated few-layered graphene (meFLG) as a cathode material for aluminium batteries. The material showed stable discharge capacities of approximately 100 mAh/g over 500 cycles. Initial irreversible capacities due to side reactions with electrolyte species decreased at higher current rates. The results highlight the influence of oxygen and sulphur impurities and suggest that their removal could enhance meFLG performance.
- Demonstrated that steam explosion preconditioning improves the production of activated carbon from softwood bark for dye removal in wastewater treatment. The best-performing carbon, obtained through steam explosion and pyrolysis at 600 °C, reached a surface area of 1308 m^2/g and removed over 70% of synthetic dyes from wastewater. The process improves carbon structure and adsorption capacity, offering a sustainable option for industrial wastewater treatment.

P4 Thermochemical Conversion Technologies (ThermoChem)

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.

Platform leader: Markus Broström, UMU, markus.brostrom@umu.se

- Conducted the first documented oxy-fuel combustion of biomass in a 100 kW down-fired pulverised combustor, accompanied by in situ measurements of gaseous potassium (K), potassium hydroxide (KOH), and potassium chloride (KCl). These measurements provide valuable insights into alkali behaviour under oxy-fuel conditions.
- Developed a wide-field imaging technique for gaseous K, KOH, and KCl with detection limits below parts-per-million, 20 ms temporal resolution, and 0.13 mm spatial resolution over a 4 × 16 mm field. The method enables detailed analysis of reaction kinetics in biomass combustion.
- Explained refractory corrosion mechanisms in biofuel-fired lime kilns through laboratory studies and confirmed the findings in full-scale operation. The results showed that slag from biomass ash penetrates refractory linings more extensively than coal ash, causing microstructural degradation and accelerated wear.
- Multiple studies advanced oxygen-enriched combustion concepts aimed at generating CO_2-rich flue gas streams for future carbon capture and storage (CCS) and carbon-negative applications.

P5 Biopolymers & Biochemical Conversion Technologies (BioPolChem)

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.

Platform leader: Leif Jönsson, UMU, leif.jonsson@umu.se

- Developed a process for bacterial nanocellulose (BNC) production using *Komagataeibacter sucrofermentans* with ethylene glycol (EG), disodium terephthalate (TPA), PET monomers, and glucose as carbon sources. Higher BNC yields were achieved with EG compared to glucose and TPA. Raman spectroscopy revealed molecular differences, indicating EG as the preferred carbon source.
- Demonstrated the applicability of the organosolv fractionation process for the fractionation of marginally used halophyte biomass, which allowed to expand the portfolio of available feedstocks for biorefinery processes.

- Adapted an established organosolv fractionation process, originally developed for lignocellulosic biomass, for efficient fractionation of mixed waste textiles.
- Developed and scaled up an enzyme-assisted process for enrichment and purification of biogenic CO_2 from industrial flue gases. Five microbial carbonic anhydrases were selected based on their stability under high temperatures, alkaline conditions, and exposure to NO_x and SO_x. Small-scale optimization assessed solvent concentration, temperature, and enzyme load, followed by ten repeated absorption–desorption cycles to evaluate long-term catalytic performance. Scaling up to 25 L enabled treatment of 9000 L flue gas, yielding a high-purity CO_2 (>91%) stream, which was compressed and shipped to project partners in Germany (UFZ) for conversion into CO_2-based chemicals, supporting valorization of off-gas emissions from bio-based industries.
- Produced a new cellulose derivative, veratryl cellulose, using a biobased substituent derived from white-rot fungal degradation of biomass.
- Enabled bioelectrochemical conversion of CO_2 into formate and hydrogen by novel formate dehydrogenases. Ten novel enzymes were identified and screened for their ability to convert CO_2 to formate and to release H_2 and CO_2 from formate, offering potential as renewable, fossil-free chemical and energy carriers.
- Demonstrated successful and energy-efficient fibrillation of wood-based spent mushroom substrate using a non-toxic process with environmental benefits. The fibrillated material was further developed, showing potential for future use in sustainable packaging applications.
- Successfully developed forest-based wound dressings and conducted pre-clinical testing as a step toward market introduction.

Large scale flue gas (obtained from SunPine) treatment for shipping to our EU project VIVALDI partner. A proud achievement from the BioPolChem platform, as it was a challenge to scale up and collect the flue gas, with significant custom-made designs to be implemented
(photo by Tomas Bergman)

P6 Chemical Catalysis and Separation Technologies (CatSep)

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.

Platform leader: Jonas Hedlund, LTU, jonas.hedlund@ltu.se

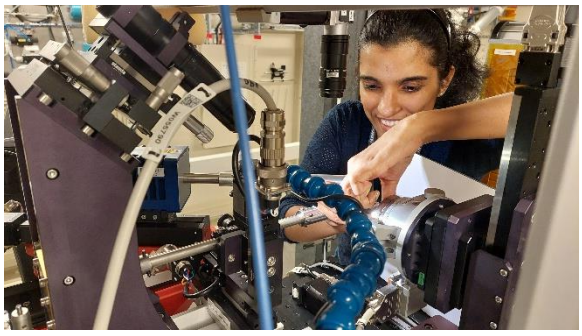
- Achieved exceptional CO_2/CH_4 selectivity and CO_2 permeability in DDR-type zeolite membranes at low temperatures. These properties open up the potential for biogas upgrading systems with near-zero methane loss, contributing to more efficient and climate-friendly biomethane production.
- Developed solid polymer electrolytes for lithium metal batteries with stable cycling performance beyond 1100 cycles. The new electrolytes support long-term operation and high-voltage compatibility, contributing to the development of more durable and energy-dense battery systems

P7 Environment and Nutrient Recycling (EnviroNut)

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.

Platform leader: Nils Skoglund, UMU, nils.skoglund@umu.se

- Conducted what is believed to be the first ever combined synchrotron-based X-ray diffraction and computed tomography (XRD-CT) analysis of phosphorus-rich ash fractions and biochars at the DanMAX beamline, MAX IV Laboratory. This approach enabled spatially resolved identification of crystalline phases at 20 µm resolution. Supported by AI-based image analysis, this method enhances 3D structural interpretation and facilitates integration with complementary in-house analytical techniques.



*New EnviroNut PhD student **Jeenu Jegy** during her first beam time at MAX IV to collect XRD-CT data. (photo by Nils Skoglund)*

- Studied metal uptake by algae in laboratory-scale experiments using different ash types in natural lake waters. The results provide insight into inter-actions between ash-derived substances and aquatic environments, supporting future applications in nutrient recycling.
- Demonstrated an efficient thermochemical synthesis route for a common phosphate phase found in phosphorus-rich ashes and biochars. This enables further studies on trace element inclusion and competition, with implications for the use of these materials in plant-related applications.

New projects supported through Strategic Funds

Twenty percent 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 2024 call for **free strategic funds (2025)**, six 1-year projects were granted, according to below (main applicants underlined).

Climate positive hydrogen production through catalytic and non-catalytic methane pyrolysis: Focus on bulk chemical carbon products

Henrik Wiinikka (LTU, P4), Nils Skoglund (UMU, P7), Joakim Lundgren (LTU, P1), Fredrik Weiland (RISE, P4), Hoda Shafaghat (RISE, P4)

A novel biorefinery merging 2nd and 3rd generation feedstocks for fuels, biochemicals, and materials

Katerina Hruzova (LTU, P5), Francesco Gentili (SLU, P7), Tomas Gustafsson (RISE Processum)

Life after Deck? – The cascading potential of thermally modified wood

David Agar (SLU, P1), Junko Takahashi-Schmidt (SLU, P2), Shaojun Xiong (SLU, P3), Markus Broström (UMU, P4), Sef Meens Eriksson (UMU, P1), Pooja Dixit (RISE Processum)

Bio-based aromatic chemicals from lignin via electro-chemical depolymerization and conversion

Xiaoyan Ji (LTU, P6), Leif Jönsson (UMU. P5), Sandra Winestrand (UMU, P5), Ola Sundman (UMU, P5), Shubhankar Bhattacharyya (RISE Processum), Chandani Singh (RISE Processum)

Use of spent zeolite membranes for microfiltration of biorefinery streams

Liang Yu (LTU, P6), Linn Berglund (LTU, P5), Linda Sandström (RISE, P4)

Biochar from waste streams - potential for use as soil improvement and for sustainable nutrient recycling

Anna Strandberg (UMU, P3), Kentaro Umeki (LTU, P4), Christoffer Boman (UMU, P7), Mirva Niinipuu (RISE, P4)

Bio4Energy Graduate School

The **Bio4Energy Graduate School** currently comprises three courses for PhD students and early career scientists. During 2024 the graduate school offered the courses "Biorefinery Pilot Research" and "Systems' Perspectives on Biomass Resources", which attracted 15 and 19 PhD students, respectively.

During 2024, Bio4Energy had around 70 active PhD students. 17 doctoral and three licentiate theses were defended in 2024. Big congratulations to you all!

PhD theses

Marzieh Bagheri, LTU, Energy Engineering (P1)
Sewage sludge treatment scenarios: Techno-economic analyses of energy and phosphorus recovery focusing on implementation challenges
Main supervisor: Elisabeth Wetterlund

Felix Barbut, SLU, Dept. of Forest Genetics and Plant Physiology (P2)
Unraveling the role of Xylan in the integrity of secondary cell walls: Insights from Arabidopsis and Aspen
Main supervisor: Ewa Mellerowicz

Andreas Averheim, SLU, Dept. of Forest Biomaterials and Technology (P3)
Steam explosion technology for the valorization of softwood bark
Main supervisor: Mikael Thyrel

Marcelo Dal Belo Takehara, LTU, Energy Engineering (P4)
Pulverized biomass combustion and gasification: Experimental study of the effects of acoustic forcing on flame and fuel conversion
Main supervisor: Rikard Gebart

Nikolaos Papafilippou, LTU, Energy Engineering (P4)
CFD Modelling of hydrogen rich biomass syngas combustion
Main supervisor: Rikard Gebart

Karin Sandström, UMU, Dept. of Applied Physics and Electronics (P4)
Effects of impurities on phase equilibrium in quicklime and cement clinker production
Main supervisor: Markus Broström

Ali Valizadeh, LTU, Energy Engineering (P4)
Role of surface morphology on bed particle layer formation during thermal conversion of woody biomass in fluidized beds
Main supervisor: Marcus Öhman

Katerina Hruzova, LTU, Biochemical Process Engineering (P5)
Potential of organosolv lignin nanoparticles as a sustainable flotation reagent: Towards a Low-Carbon Footprint Mining Industry
Main supervisor: Ulrika Rova

Petter Paulsen Thoresen, LTU, Biochemical Process Engineering (P5)
Structure and property oriented organosolv lignin extraction
Main supervisor: Leonidas Matsakas

Martin Plöhn, UMU, Dept. of Chemistry (P5)
Revealing the potential of Nordic microalgae: Turning waste streams into resources
Main supervisor: Christiane Funk

Luisa Rosenstock Völtz, LTU, Wood and Bionanocomposites (P5)
Use of co-rotating extrusion process for the development of resource-efficient biocomposites
Main supervisor: Kristiina Oksman

Olivia Spain, UMU, Dept. of Chemistry (P5)
Guardians of green gold: Exploring microalgal cell walls and their significance in industrial processing
Main supervisor: Christiane Funk

Chaojun Tang, UMU, Dept. of Chemistry (P5)
Investigations of the importance of the redox environment in LPMO-supported bioconversion of pretreated lignocellulose
Main supervisor: Leif Jönsson

Fangfang Li, LTU, Energy Engineering (P6)
CO_2 electrochemical reduction in ionic liquid/deep eutectic solvent-based systems: Technology development to process evaluation
Main supervisor: Xiaoyan Ji

Sofie Björklund, UMU, Dept. of Chemistry (P7)
Exploring the occurrence, distribution and transport of per- and polyfluoroalkyl substances in waste-to-energy plant
Main supervisor: Stina Jansson

Calle Niemi, SLU, Dept. of Forest Biomaterials and Technology (P7)
Biochemical and spectral Characterization of micro and macroalgae
Main supervisor: Francesco Gentili

Carla Pérez Morales, UMU, Dept. of Chemistry (P7)
Hydrothermal carbonization of digested sewage sludge and microalgae biomass: phosphorus and energy recovery
Main supervisor: Stina Jansson

Licentiate thesis

Samarthkumar Pachchigar, LTU, Energy Engineering (P4)
Ash transformation during thermochemical conversion of agricultural biomass in entrained flow conditions
Main supervisor: Marcus Öhman

Sahar Foorginezhad, LTU, Energy Engineering (P6)
CO_2 capture through integration of aqueous and immobilized deep eutectic solvents
Main supervisor: Xiaoyan Ji

Haiman Hu, LTU, Energy Engineering (P6)
Confining ionic liquids to develop high-performance quasi-solid-state composite electrolytes
Main supervisor: Xiaoyan Ji

A series of dissertation "nailing" ceremonies: *Ali Valizadeh (***top left***, photo by Samarthkumar Pachchigar), Felix Barbut (***top right***, photo by Hannele Tuominen), Marzieh Bagheri (***bottom left***, photo by Zeenat Farooq), Martin Plöhn (***bottom center***, photo unknown), and Chaojun Tang (***bottom right***, photo unknown)*

Communication and outreach activities

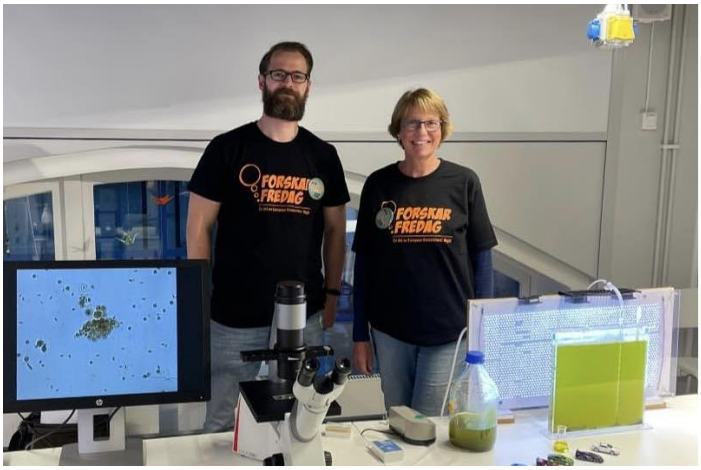
Bio4Energy's external communication in 2024 continued through the main channels of official website and newsletters.

Communication efforts highlighted strong scientific results, personal achievements within the research community, and Bio4Energy's role as a partner in Sweden's bioeconomy development. Topics that received notable attention in news and media during the year include:

- Sustainable aviation fuels and challenges to large-scale production.
- Forest-based wound care materials.
- Bioplastics from algae and wastewater.
- Circular approaches to textile and biocomposite materials.
- Enzyme-based CO_2 capture and purification.

Bio4Energy also communicates research findings through other outreach activities. A few examples from 2024 are:

- Nils Skoglund (P7) participated in two outreach activities: a RISE Processum workshop on scaling up biobased solutions in Umeå, and a presentation in Boden on phosphorus recovery from ashes, using results from the Bio4Energy ReASH project.
- Alyssa Göransson (P1) participated in the Stockholm International Youth Science Seminar (SIYSS) during Nobel Week 2024. She presented research on industrial transformation to an audience of secondary school students and took part in a round-table discussion on "Shaping Tomorrow: Diversity and STEM for Global Solutions".
- Elisabeth Wetterlund (P1) contributed to a Formas-supported article highlighting key results from the finalized SMACK project, focusing on circular economy approaches to sewage sludge management.
- Anna Strandberg (P7) was invited as a speaker to the UTRI workshop in Umeå in November 2024, sharing insights from ongoing Bio4Energy research.
- Linn Berglund created a social media video in collaboration with Skogsindustrierna for the *next.gen.bioinnovators* initiative, introducing the potential of nanocellulose to younger audiences
- RISE Processum and BioPolChem researchers participated in organizing the *Nordic Wood Biorefinery Conference 2024* (Örnsköldsvik, Sweden) and the *11th Workshop on Cellulose, Regenerated Cellulose and Cellulose Derivatives* (Karlstad, Sweden).



Martin Plöhn *and* ***Christiane Funk*** *representing Bio4Energy during ForskarFredag at Umeå University – Sweden's part of the European Researchers' Night, aimed primarily at school children and young people to spark curiosity about science and research (***left***).*

Liang Yu *(CatSep platform) delivers a highly appreciated oral presentation at EuroMembrane 2024 in Prague, highlighting over 30 years of research at Luleå University of Technology on ultra-thin zeolite membranes (***right***).*

New equipment and research infrastructure

- A new laboratory was completed within the Bio4Energy research environment. It features dedicated sections for material synthesis (P7), laser spectroscopy (P4), and thermal synthesis (P3, P4). This new facility enables researchers to carry out more advanced studies on nutrient-carrying materials, with a particular focus on the circular use of phosphorus.
- The lab also supports new experimental setups using tunable diode laser spectroscopy, allowing for more precise gas-phase measurements. In addition, the facility can be used for the preparation of biochar materials, contributing to research on sustainable resource use and environmental technology.
- A high-temperature X-ray diffraction (HT-XRD) hot stage was added to the MAXS X-ray platform at Umeå University in 2024, co-funded by Bio4Energy.

Awards and new commissions of trust

- Linn Berglund and Kristiina Oksman (BioPolChem) were awarded Luleå University of Technology's Innovator of the year prize for their outstanding work with bio-based materials that have the potential to revolutionize both healthcare and industry. The prize is awarded by Nordea's Norrlandsstiftelse.
- Linn Berglund also received the Young Researcher's Award from the Gunnar Sundblad Research Foundation 2024.
- SLU Forest Faculty award for the best PhD course granted for the Wood Biology and Biotechnology course organized by Ewa Mellerowicz (ForFeed).
- Maria Pettersson (SysAnaBio) has been appointed by the government as new member of the Swedish Climate Policy Council. Maria is Professor of Environmental and Natural Resources Law at LTU and joined the SysAnaBio platform in 2024.
- Kristiina Oksman (BioPolChem) has been elected as a new member of the Swedish Research Council's Scientific Council for Natural and Engineering Sciences.

***Linn Berglund** and **Kristiina Oksman,** winners of the Innovator of the Year prize (photo by Tomas Bergman).*

Bio4Energy Advisory Board

During 2024, we had two meetings with Bio4Energy's external Advisory Board:

- A digital meeting in January, on the theme "Bio-based fertilizers and recycling of ash"
- A physical meeting in September at RISE Processum in Örnsköldsvik, on the theme "Research and innovation for the bioeconomy of the future"

In addition to presentations from several Bio4Energy researchers from different platforms and from our Advisory Board members, the meetings also included addresses from invited external presenters.

During the September meeting in Örnsköldsvik, we also had the chance to visit the new pilot and demonstration facilities, which are part of RISE Bioeconomy Arena. Big thanks to RISE Processum for hosting the meeting!

Bio4Energy Advisory Board *and managers visiting RISE Processum in Örnsköldsvik for the summer meeting in September 2024.*

Advisory Board members 2024

During the year, we welcomed new Advisory Board member Urban Svensson from Perstorp

Peter Axegård
FineCell
CEO

Charlotte Bengtsson
Skogforsk
CEO

Erik Dotzauer
Stockholm Exergi
Policy expert

Ann-Britt Edfast
Edfast & Wallén
Consultant

Björn Fredriksson-Möller
Öresundskraft
(formerly at St1 Biogas)

Anna Karlberg
Stora Enso
VP Forest R&D

Torgny Persson
Swedish Forest Industries
R&I director

Urban Svensson
Perstorp
Director Procurement

Linda Werner
St1
Head of Future Upstream

Martin Wimby
Valmet Recovery Business Unit
Technology Director