BioCarbUpgrade – Upgrading biocarbon for sustainable metallurgical industries

Newsletter 1-2026

Progress in 2026

In 2026, the last year of the project, the focus has been on final assessments of different enhanced carbonisation experiments (in two atmospheric and one pressurised pyrolysis reactor) and characteristics of the products, and upgraded feedstocks and biocarbons, storage and logistics of biocarbon, as well as extensive results publishing. Activities connected to the end-use in metallurgical industries have included assessing measurement methods for dust and fines generation, biocarbon reactivity testing and use of bio-binders in the production of anodes. The PhD study on Advancing LCA Methods and Applications for a Sustainable Bioeconomy Transition is progressing very well, and two manuscripts have been published.

BioCarbUpgrade event in Luleå

The sixth BioCarbUpgrade workshop and SC meeting was arranged in Luleå, hosted by Luleå University of Technology, on 11-13 May 2026. In the meeting, the project and its activities were presented and discussed. During the meeting a tour of the Harads Arctic Heat pyrolysis plant as well as the university laboratory facilities were arranged.

Workshop participants. LinkedIn post here.

PhD work

The BioCarbUpgrade PhD position within value chain analysis (Advancing LCA Methods and Applications for a Sustainable Bioeconomy Transition) was filled by Marvin Werra from Germany. He started his work September 2023 at Department of Energy and Process Engineering, NTNU, with Professor Francesco Cherubini as his main supervisor, and three co-supervisors as well.

Marvin's work is progressing very well and several master students have been recruited connected to his PhD topic, working towards each of the metallurgical partners in BioCarbUpgrade, which are very interested in the work and are actively contributing to provide information about their own processes and value chains as input to the PhD LCA work.

He has now published his two first manuscripts - "Life-cycle assessment of Ferromanganese production using biocarbon as reductant and carbon capture and storage" (LinkedIn post here) and "Life-cycle assessment and sustainable biomass potential of charcoal for low-emission Silico-Manganese alloy production in Gabon" (LinkedIn post here).

BioCarbUpgrade in Energy & Fuels

One BioCarbUpgrade work has been published in Energy & Fuels:

Yusuf Tolunay Kilic, Marcelo Takehara, Øyvind Skreiberg, Kentaro Umeki (2026). Selective Product Enhancement in Auger Reactor: Pyrolysis of Pine Bark Through In-Situ Recirculation of Pyrolysis Vapors. The abstract is given below.

"In biomass pyrolysis, final product selectivity is governed not only by major reaction conditions like temperature and heating rate but also by complex vapor–solid interactions and secondary reactions. Yet, the influence of internal flow configuration on pyrolysis vapor remains poorly understood in continuous pyrolysis systems. This study aims to evaluate how controlled vapor–solid interactions via changes in the vapor outlet port location affect the distribution and transformation of pyrolysis products. Experiments were performed in a continuous laboratory-scale

- a Knowledge-building Project for Industry (KSP-K) co-funded by the Research Council of Norway.
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SINTEF

auger reactor, processing pine bark at highest treatment temperatures (HTT) of 600, 700, and 800 °C. The reactor featured five independently heated zones and six selectable vapor outlet ports, enabling three vapor flow modes: parallel flow (PF, conventional cocurrent flow operation) and two counterflow (CF) configurations to systematically manipulate vapor–solid contact. Results showed that one of the CF configurations, where vapors passed through the coldest (the incoming) biomass zone before exiting, enhanced vapor condensation on incoming biomass and promoted secondary reactions, leading to up to a 15.5% relative increase in biochar yield compared to PF. The increase in biochar yield was accompanied by an increase in fixed carbon yield, and H_2 and CH_4 yields, indicating intensified thermal cracking and polymerization of pyrolysis vapors. In contrast, the CF configuration involving vapor recirculation without interaction with the coldest zone favored external condensation and achieved the highest bio-oil recovery. The PF configuration exhibited the lowest char yield and the highest unaccounted carbon fraction due to poor vapor condensation at elevated outlet temperatures. These findings demonstrate that the manipulation of vapor–solid interactions serves as a critical parameter for steering pyrolysis pathways toward targeted product enhancement, offering a scalable approach for optimizing biochar, gas, and bio-oil yields through in situ vapor recirculation.”

BioCarbUpgrade in Resources, Conservation & Recycling

One BioCarbUpgrade work has been published in Resources, Conservation & Recycling:
Marvin Werra, Hans Kristian Bugge Tørset, Ting Hua, Xiangping Hu, Laurent Joncourt, Thibault Cheisson, Marcos Djun Barbosa Watanabe, Øyvind Skreiberg, Francesco Cherubini (2026). Life-cycle assessment and sustainable supply potential of charcoal for low-emission silicomanganese production in Gabon. The abstract is given below.

“Silicomanganese (SiMn) is an important alloy in steelmaking. The production relies on metallurgical coke, causing hard-to-abate emissions. Replacing metallurgical coke with charcoal is a promising mitigation option, but its environmental impacts remain unclear. This study performs a comparative life-cycle assessment of charcoal substitution in SiMn production in Gabon and evaluates domestic biomass potential. The climate impact of conventional SiMn production is 3019 ± 142 kg CO_2-equivalents per tonne of alloy. Charcoal from rectangular masonry kilns reduces this impact by ~60% when replacing ~75% of coke during sintering and smelting. Terrestrial acidification, non-renewable energy use and human health impacts are reduced by 57%, 67% and 10%, respectively. Domestic charcoal demand can be met by establishing biomass plantations on recently abandoned cropland, with potential for surplus production, but areas are highly fragmented. Expansion into adjacent areas with relatively low value for ecosystem carbon storage and biodiversity can increase connectivity and improve logistics.”

BioCarbUpgrade in Biomass and Bioenergy

One BioCarbUpgrade work has been published in Biomass and Bioenergy:
Bence Babinszki, Liang Wang, Øyvind Skreiberg, Zoltán Sebestyén, István Sándor Czirok, Zsuzsanna Czégény (2026). Characterization of the pyrolysis condensates of birch, spruce and pine bark: Impact of water leaching on the composition. The abstract is given below.

“Biocarbon, produced via the pyrolysis of lignocellulosic biomass, is increasingly sought as a sustainable reductant in metallurgical industries. The production of biocarbon also generates significant amounts of condensable liquid by-products, which can be valuable materials subject to detailed characterization and proper upgrading. The current biocarbon production relies mainly on stem wood, but alternative biomass materials of sufficient quality, high availability, and low costs are needed. Bark, a major forestry residue, is a potential feedstock candidate for biocarbon production; however, its high mineral content is a drawback for several industrial applications.
In the present work, bark chips of birch, spruce, and pine wood were pyrolyzed in a fixed bed reactor collecting both solid and condensed liquid products. The amount of inorganic elements present in the barks was reduced by an industrially feasible static water leaching method. The chemical composition of the condensates of both leached and unleached bark samples were compared by using GC/MS analysis. A comparison of the composition of bark and stem wood condensates revealed that the summed organic content measured in the bark condensates was much less than that of stem wood. The analysis of bark condensates showed that the birch bark condensates had significantly higher acid content than the bark condensates of conifers, i.e., spruce and pine. The concentration of specific condensate components showed different changes depending on the leached feedstock type. The reduced mineral contents in the leached barks affected the thermal decomposition during pyrolysis, resulting in modest changes in condensate compositions.”

BioCarbUpgrade in Energy & Fuels

One BioCarbUpgrade work has been published in Energy & Fuels:

Robert L. Johnson, Magdalena Joka Yildiz, Grzegorz Świderski, Kamila Koronkiewicz, Cassidy Hihara, Kyle Castillo, Christian Castillo, Zhaoxi Zheng, S. Evelyn Lyu, Klaus Schmidt-Rohr, Liang Wang, Øyvind Skreiberg, Scott Q. Turn (2026). Role of wood composition in the Carbonization of Transient Plastic Phase Biochar. The abstract is given below.

"Transient plastic phase biochars (TPPB) produced from different woody feedstocks (birch, spruce, and eucalyptus) were investigated to understand underlying factors responsible for differences in mechanical performance of biocarbon produced from these materials. All TPPB materials were produced under identical constant pressure (12.4 MPa) using wet 1–2 mm particles (75 wt % H_2O addition) and reacted for 30 min at 320 °C under nitrogen gas. TPPB materials were analyzed using proximate analysis, thermogravimetric analysis (TGA), differential scanning calorimetry (DSC), FTIR, quantitative 13C NMR and GC-MS of solvent extracts. While the general properties of the TPPB chars were overall quite similar, several key differences provide insights into the different mechanical performance after conversion to biocarbon. Specifically, the TPPB from birch contained a high concentration of triterpenoid-rich extractives and their carbonization products, which are not present in the TPPB from either eucalyptus- or spruce-derived TPPB. Differences in the 13C NMR spectra and TGA thermograms reflect this additional component. Results from this study suggests that the superior mechanical performance of biocarbon produced from birch TPPB likely results from the triterpenoid-derived components acting as a plasticizing agent that alters the glass transition temperature of the material. This results in more interparticle bonding during calcination, increasing the mechanical strength of the resulting biocarbon."

BioCarbUpgrade in Chemical Engineering Transactions

One BioCarbUpgrade work has been published in Chemical Engineering Transactions:

Bence Babinszki, Liang Wang, Øyvind Skreiberg, Zoltán Sebestyén, István Sándor Czirok, Zsuzsanna Czégény. Effect of Feedstock Water Leaching and Thermal Treatment on the Pyrolysis Condensate of Pine Bark. The abstract is given below.

"There is a growing demand for biocarbon in metallurgical applications. While biocarbon is primarily produced from stem wood, it is crucial to diversify feedstock sources to ensure sustainability, high availability, and cost-efficiency. Pine bark, a significant forestry waste stream, represents a promising alternative. However, biocarbon production via pyrolysis generates significant condensable liquid by-products. Although often discarded, these condensates can become valuable resources through detailed characterization and upgrading. In this study, pine bark chips were pyrolyzed in a fixed-bed reactor. To mitigate the high inorganic content typical of bark, a portion of the feedstock underwent water leaching prior to pyrolysis. The impact of leaching on the resulting condensate composition was evaluated using gas chromatography/mass spectrometry (GC/MS) analysis. Since direct utilization of raw condensates is hindered by high water content, post-pyrolysis thermal treatments were applied to condensates from both leached and unleached samples. The thermal treatment of the condensate samples was performed in a muffle furnace at 140 and 160 °C for 2 hours. GC/MS analysis of the thermally treated condensates revealed that heating at 140 °C significantly enriched the organic content, evidenced by higher compound intensities compared to raw condensates. Treatment at 160 °C showed a similar trend but favored the retention of heavier compounds (e.g., levoglucosan) while significantly reducing highly volatile compounds (e.g., acetic acid). These findings provide critical data for the biocarbon industry, supporting the utilization of pine bark as a feedstock and offering strategies for the valorization of condensate by-products."

BioCarbUpgrade in Chemical Engineering Transactions

One BioCarbUpgrade work has been published in Chemical Engineering Transactions:

Liang Wang, Zsuzsanna Czégény, Yusuf Tolunay Kilic, Bence Babinszki, Robert L. Johnson, Kentaro Umeki, Øyvind Skreiberg, Scott Q. Turn. Characterisation of Biocarbon Produced from Untreated and Water-Leached Pine Bark. The abstract is given below.

"Leaching pine bark with deionized water effectively reduced its total ash content by removing a portion of the inorganic elements, particularly the water-soluble potassium (K) and sodium (Na). As a result, biocarbon derived from leached pine bark contained lower levels of both ash and carbon, compared to biocarbon derived from untreated pine bark. Inductively coupled plasma atomic emission spectroscopy (ICP-AES) confirmed that the content of total and individual inorganic elements in the leached bark biocarbon was considerably reduced relative to the untreated counterpart. X-ray diffraction (XRD) analysis identified calcium carbonate as the dominant mineral phase in both biocarbons; however, its peak intensity was notably weaker in the leached bark biocarbon, indicating a lower content of this mineral phase. Scanning electron microscopy coupled with energy-dispersive X-ray spectroscopy (SEM-EDS) revealed calcium-rich grains on the surface of the untreated bark biocarbon, which were largely absent in the leached bark biocarbon. Fourier transform infrared (FTIR) spectroscopy showed similar spectral profiles for both biocarbons, though the leached bark biocarbon exhibited reduced peak intensities corresponding to C=O and C–O–C stretching vibrations. This reduction is likely due to the removal of water-soluble extractives and polysaccharides during leaching, resulting in the formation of fewer oxygenated functional groups during carbonization and a reduced carbon content."

BioCarbUpgrade in Chemical Engineering Transactions

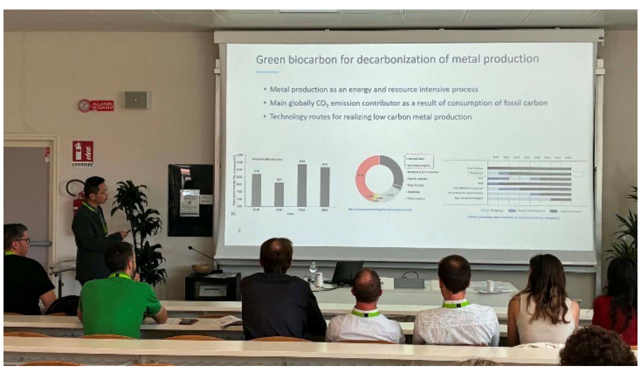
One BioCarbUpgrade work has been published in Chemical Engineering Transactions:
Liang Wang, Jørn Bakken, Øyvind Skreiberg. Study on self-heating of biocarbon at different surrounding temperatures. The abstract is given below.

"Metal production is a highly energy- and resource-intensive industry that relies heavily on carbon as both a reducing agent and an energy source. Biocarbon has been considered as a promising material to replace the conventional fossil carbon for metal production to reduce CO_2 footprints of metallurgical industry. However, in comparison to fossil carbon, the biocarbon has relatively high potential regarding self-heating and self-heating during storage, transportation and handling. The aim of this study is to investigate self-heating and self-ignition of biocarbon upon contact with synthetic air at low temperatures in the range of 140-250°C. The test self-heating and self-ignition of biocarbon powder was tested using a fixed bed reactor with controlling the surrounding temperature and adjusting flow of supplied air. Along one test, the emission of CO_2 and CO was monitored continuously. The self-heating and self-ignition of one biocarbon sample was tested under different temperatures at 180, 190, 200 and 250 °C with supplying of varied flow with 0.5 L/min, 1 L/min and 2 L/min. The results showed that temperature is a key factor that leading to self-heating of the studied material. For the test conducted at the temperatures below 200°C, no evident increase of temperature measured in the core of sample bed was detected. And no release of CO_2 and CO was monitored. For the test conducted at 200°C, the reactions started as the temperature is approaching this desired temperature, with slow release of CO_2 and CO and decrease of O_2. More intensive reactions took place and measured temperature increased dramatically during the first 15 minutes holding of the sample at 200°C, which was accompanied with intensive release of CO_2 and decrease of O_2. Afterwards, even with continuous supplying the synthetic air, only a slow increase of temperature measured from in core of sample bed was detected. During this stage, only the release of CO_2 and CO is rather stable, indicating smoldering combustion of the material. The findings for from this work indicate combination of temperature measurement and monitoring of gas emissions can be an important measure to identify self-heating and self-ignition of biocarbon. Alarm thresholds for biocarbon can be established based on such measurements, which helps to prevent and reduce risks related to self-heating and self-ignition of biocarbon along the value chain from production to final application"

BioCarbUpgrade at PYRO2026

Three BioCarbUpgrade works were presented at the 25th edition of the International Symposium on Analytical and Applied Pyrolysis, Pisa, Italy, 7-11 June 2026:
1) Zsuzsanna Czégény, István Sándor Czirok, Gergő Szabó, Zoltán Sebestyén, Bence Babinszki, Ágnes Móricz, Liang Wang, Øyvind Skreiberg. Water Leaching of Wood Barks for Biocarbon Production: Analysis of Extractives.
2) Zoltán Sebestyén, Bence Babinszki, Liang Wang, Øyvind Skreiberg, István Sándor Czirok, Zsuzsanna Czégény. Effect of Pre- and Post-Treatments on The Pyrolysis Condensate of Pine Bark.
3) Liang Wang, Jørn Bakken, Zsuzsanna Czégény, Yusuf Tolunay Kilic, Øyvind Skreiberg, Bence Babinszki, Robert Johnson, Kentaro Umeki, Scott Q Turn. Study on biocarbon produced from untreated and water leached bark.

Bence Babinszki, Zoltán Sebestyén, Zsuzsanna Czégény and Liang Wang in Pisa.



Liang Wang presenting at PYRO2026.

BioCarbUpgrade at IConBM 2026

Three BioCarbUpgrade works were presented at [IConBM 2026](), Bologna, Italy, 24-27 May 2026:

1) Bence Babinszki, Liang Wang, Øyvind Skreiberg, Zoltán Sebestyén, István Sándor Czirok, Zsuzsanna Czégény (2026). [Effect of Feedstock Water Leaching and Thermal Treatment on the Pyrolysis Condensate of Pine Bark]().

2) Liang Wang, Zsuzsanna Czégény, Yusuf Tolunay Kilic, Bence Babinszki, Robert L. Johnson, Kentaro Umeki, Øyvind Skreiberg, Scott Q. Turn (2026). [Characterisation of Biocarbon Produced from Untreated and Water-Leached Pine Bark]().

3) Liang Wang, Jørn Bakken, Øyvind Skreiberg (2026). [Study on self-heating of biocarbon at different surrounding temperatures]().

Liang Wang in front of his poster, together with Bence Babinszki, at IConBM 2026.

BioCarbUpgrade at Biochar Summit 2026

A BioCarbUpgrade work was presented at [Biochar Summit]() 2026, 10-11 June 2026, Vienna, Austria:
Marvin Werra, Hans Kristian Bugge Tørset, Ting Hua, Xiangping Hu, Laurent Joncourt, Thibault Cheisson, Marcos Djun Barbosa Watanabe, Øyvind Skreiberg, Francesco Cherubini. Charcoal as Reductant in Silicomanganese Production in Gabon: Life-Cycle Assessment and Biomass Supply Potential.

BioCarbUpgrade at LCIC 2026

A BioCarbUpgrade work was presented at [LCIC 2026](), Berlin, Germany, 1-3 July 2026:
Marvin Werra et al. The Bio-Economy in Ferromanganese Production: Environmental Impacts of Biocarbon and Carbon Capture and Storage Integration.

BioCarbUpgrade partners at Biocarbon in Metallurgy 2026

Attendance for [Biocarbon in Metallurgy]() 2026, 21-23 April 2026 in Krakow, Poland, was record high, including attendees and speakers from the

BioCarbUpgrade project partners. With speakers from Canada, Brazil, Australia and Europe the global community together was brought together to discuss biocarbon production and market, biocarbon use in metallurgical operations, focusing on application in the different sectors ferroalloys, aluminium and steel making. We are already looking forward to next year's event, 6-8 April 2027 in Krakow, Poland.

Lunch-seminars with TEKNA

In May, TEKNA, one of the unions and interest groups in Norway, arranged two lunch-seminars on use of biocarbon in metallurgical industries. One focused on aluminium and the speakers were Gøril Jahrsengene (SINTEF), Viktorija Tomkute (Hydro), and a representative from biocarbon producer Envigas AB. The other focused on ferroalloy production and had Sethulakshmy Jayakumari (SINTEF), Jon Rune Vetleseter (Elkem) and a representative from biocarbon producer Cruda. The seminars were in Norwegian (except Sethu's presentation), and both the stream and the questions asked can be found online.

News briefs from the last half year

Elkem Awarded NOK 87 Million by Enova for Biocarbon Scale-up

Date: April 28, 2026

Summary: Elkem received significant funding from Enova for a project running until 2028 to develop tailored industrial biocarbon solutions. The goal is to safely and efficiently increase the share of renewable carbon at Elkem's five Norwegian smelters, potentially reducing emissions by 0.5 million tonnes of CO_2 annually.

Source: Elkem Press Release

Elkem Sells Canadian Biocarbon Business to CHAR Tech to Secure European Supply

Date: April 20, 2026

Summary: Elkem announced the sale of its Saguenay biocarbon pilot facility to CHAR Tech. Crucially for Norway, this included a five-year, 62,500-tonne offtake agreement to secure a steady supply of biocarbon pellets for Elkem's Canadian and European (including Norwegian) smelting operations.

Source: Elkem Press Release

CHAR Tech Closes Acquisition of Elkem's Biocarbon Assets

Date: April 20, 2026

Summary: CHAR Tech officially confirmed the closing of the acquisition of Elkem's biocarbon assets. The release highlights the commercial upgrade of the facility to produce 15,000 tonnes per year, supporting heavy industrial decarbonization and ferrosilicon production.

Source: CHAR Tech Press Release

Biocarbon in Metallurgy 2026 Conference

Date: April 21–23, 2026

Summary: NTNU and SINTEF hosted the 4th edition of this major conference in Norway. It brought together industry and research representatives to discuss the availability, production, quality, and safe use of renewable biogenic feedstocks as low-emission reductants in the metallurgical industry.

Source: NTNU Event Page

Biochar as a Carbon Dioxide Removal Solution Webinar

Date: March 26, 2026

Summary: Coordinated by Gassnova, SINTEF Energy Research hosted a webinar based on their upcoming report on biochar. The session covered how converting biogenic carbon into a stable form enables fossil carbon substitution in metallurgical processes and materials.

Source: SINTEF Event Page

Eramet Advances "eraLow" Manganese Alloys with Biocarbon Testing

Date: May 29, 2026 (Latest update)

Summary: Eramet detailed ambitious projects at its Norwegian smelters to launch "eraLow," aiming for zero CO_2 Manganese Alloys. A core pillar of this initiative in 2026 is the industrial testing of biocarbon to replace fossil coke as a reductant, preparing for full-scale implementation.

Source: Eramet Product Page

Norwegian Industry Leaders Present at Biochar Summit 2026

Date: June 10–12, 2026

Summary: At the 2026 Biochar Summit, major Norwegian players discussed scaling and safety. Paal Jahre Nilsen from Norway's Vow ASA spoke on the industrial scaling of biochar production, while Odd Arne Fossan from Norsk Hydro presented technical and commercial perspectives on using biomaterials in aluminum production. A dedicated session also covered the safety and self-heating properties of biochar at sea.

Source: Biochar Summit Program

Applying Biomaterials to Anode Production

Date: April 23, 2026

Summary: At the "Biocarbon in Metallurgy 2026" conference hosted by NTNU (Norwegian University of Science and Technology), Norsk Hydro presented its ongoing research into biocarbon integration. Hydro's presentation specifically focused on the technical challenges and safety/performance considerations of applying biomaterials to anode production for the aluminum industry—a critical step in their roadmap toward low-carbon aluminum.

Source: Biocarbon in Metallurgy 2026 conference

Biocarbon Formulation Rollout and CBAM Strategy

Date: Early 2026

Summary: Headquartered in Norway, WAI Environmental Solutions updated its strategy to align with the EU's Carbon Border Adjustment Mechanism (CBAM), which began phasing in carbon certificate pricing for the metallurgical sector in 2026. To help industries transition smoothly, WAI announced the 2026 Phase I commissioning of its new biocarbon formulation plant, which produces customized, high-mechanical-strength biocarbon pellets designed to replace metallurgical coal in the steel, ferroalloy, and aluminum sectors with minimal dusting and no self-ignition issues.

Source: WAI Sustainability | WAI Biocarbon Formulation

The Path to Climate-Neutral Silicon at Holla

Date: 2026

Summary: Following their major 2025 contract to secure long-term biogenic carbon, Wacker's 2026 sustainability updates heavily featured their Holla plant in Norway. Wacker confirmed that the Holla site is utilizing 100% green hydroelectricity and is actively in the process of qualifying and integrating the biocarbon to replace hard coal in their electric arc furnaces. This is a foundational step in creating a climate-neutral value chain for their metallurgical-grade silicon.

Source: Wacker Sustainability News

Other news

KSP-K EnergyProSafe is progressing well

The 4-years knowledge building project (KSP-K) connected to energy production and safety aspects in the biocarbon value chains for the metallurgical industries that started in 2025 had its second ordinary consortium gathering in June 2026, and it is progressing well. The title of the project is Improving Energy Production and Safety in biocarbon value chains (EnergyProSafe). The project includes key actors within the metallurgical industry in Norway as well as from the areas of biocarbon production and fire safety solutions. Liang Wang from SINTEF Energy Research led the project initiative. More information, including newsletters, is available on the EnergyProSafe website.

Norsk Biokullnettverk

The "Norwegian Biochar Network" was founded in 2019. Its purpose is to gather actors from the biochar value chains in Norway. The network aims to promote biochar as an important part of the circular economy, and works towards Norwegian leadership in value creation connected to production and utilization of biochar. SINTEF Energy Research is a member in the network, and Øyvind Skreiberg was until recently a member of its board, now Kathrin Weber from SINTEF Energy Research is a new board member. Also several of the BioCarbUpgrade industry partners are members in the network. The network has attracted great interest and many members and has after being in operation as a project within the Norwegian Bioenergy Association (NoBio) for several years, now become a standalone organisation. As a part of the network activities, seminars, workshops and webinars have been arranged on different biochar topics and for different industries (e.g. the metallurgical industry), and the network is also active in making the biochar voice heard in the society and towards authorities. All in all, the foundation of the network has been a timely one, serving its purpose. For more info about the network, see here, where you can find many interesting news from the biochar area, including regarding a recent report on the possibilities for sustainable production and the markets for use of biochar in Norway.

Nordic Biochar Network

The Nordic Biochar Network was founded in 2019. It is a joint initiative of researchers in the Nordic countries to increase and spread knowledge about biochar. Research Scientist Kathrin Weber from SINTEF Energy Research is the president of the Nordic Biochar Network. As a part of the network activities, conferences and webinars have been arranged, e.g. a Biochar Summit in 2024, which was arranged again in 2025 and 10-11 June 2026 in Vienna: Biochar Summit, in collaboration with Biochar Europe. For more info about the network: https://www.nordicbiochar.org/

International Biochar Initiative

In addition to the Norwegian Biochar Network and the Nordic Biochar Network, the International Biochar Initiative (IBI) is a source of extensive information connected to the biochar field. Its mission is to provide a platform for fostering stakeholder collaboration, good industry practices, and environmental and ethical standards to support biochar systems that are safe and economically viable. IBI news are available here.

European Biochar Industry Consortium (EBI) has become Biochar Europe

Biochar Europe (the earlier EBI) is supporting the development of biochar applications and is a network of many industrial actors connected to biocarbon production and utilisation. Earlier Norsk Biokullnettverk had an active link to the International Biochar Initiative, but this changed to EBI (now Biochar Europe), i.e. with an increased industrial and European focus. A recent white paper on Biochar as the Key to a Climate-Neutral, Competitive & Resilient European Economy is available here. Interesting resources/news are available here.

Prosess21

Prosess21 is a forum established to strengthen the coordination between the competence environments in and connected to the process industry and the public actors. Prosess21 shall give strategic advices and recommendations on how to minimize emissions from the process industry while achieving sustainable growth. The metallurgical industry is a very important part of the Norwegian process industry. An interesting report, with respect to possible future use and priorities regarding biomass based materials in the Norwegian process industry is Biobasert Prosessindustri, as well as Ny prosessteknologi med redusert karbonavtrykk inkl. CCU. The Prosess21 main report, summarises the Prosess21 work.

A new Prosess21 chapter has now started, with a new mandate and a new steering group, see here. An interesting recent report is: Critical and Strategic Raw Materials in Norway: Positions and Potentials.

For more info about Prosess21: https://www.prosess21.no/

FME ZeMe

FME ZeMe (Zero Emissions Metal Production) is a Centre for Environment-friendly Energy Research (FME) targeted at the metallurgical industry, which received funding from the RCN in 2024. FME ZeMe had its kick-off meeting 14 January 2025.

A conference co-organised by ZeMe, Biocarbon in metallurgy, was arranged 22-23 April 2026, in Kraków, Poland, with several BioCarbUpgrade partners as contributors.

Recent events

TMS 2026 Annual Meeting & Exhibit, 15-19 March 2026, San Diego, USA. https://www.tms.org/TMS2026

Biocarbon in Metallurgy 2026, 22-23 April 2026, Kraków, Poland.

Tekna webinar: Biokarbon i norsk aluminiumsproduksjon, 19 mai 2026.

Tekna webinar: Biokarbon til silisium- og manganproduksjon, 20 mai 2026.

EUBCE 2026, 19-22 May 2026, The Hague, The Netherlands. https://www.eubce.com/

IConBM2026, International Conference on BIOMASS 24-27 May 2026 Bologna, Italy. https://www.aidic.it/iconbm2026/ (biennial)

25th International Symposium on Analytical and Applied Pyrolysis, 7-11 June 2026, Pisa, Italy. https://pyro26.dcci.unipi.it/ (biennial)

The Biochar Summit 2026, 10-11 June 2026, Vienna, Austria. https://www.biochareurope.eu/summit

12th Conference on Safety & Environment in Process & Power Industry and Fire Explosion,14-17 June 2026, Turin, Italy. https://www.aidic.it/cisap12fex26/index.php (biennial)

Upcoming events

The 41st International Symposium of the Combustion Institute, 26-31 July 2026, Kyoto, Japan. https://www.combustionsymposia.org/ (biennial)

The 65th Annual Conference of Metallurgy and Materials, August 17-20, 2026, Calgary, Alberta, Canada. https://com.metsoc.org/

Silicon for the chemical and solar industry XVIII, Kristiansand, 7-10 September 2026. https://www.ntnu.edu/si-conference (biennial)

Impacts of Fuel Quality 2026, 20-25 September 2026, Aspen, Utah, USA. https://fuelqualityimpact.org/news (biennial)

18th International Ferro-Alloys Congress (INFACON XVIII), Reykjavik, Iceland, 23–27 May 2027. https://www.ru.is/en/infacon18

Links (click on the links or logos to get there)

EnergyProSafe
BioCarbUp
BioCarb+
KPN reduced CO_2
Prosess21
SKOG22
Energi21
Norsk Biokullnettverk
Nordic Biochar Network

Project information and past achievements

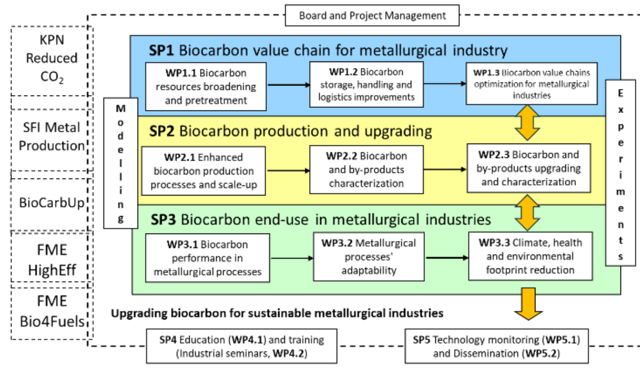
About the project

The overall objective of BioCarbUpgrade is sustainable biocarbon value chains for the metallurgical industries.

The sub-objectives are:

- Broadening of the biomass resource base for the specific metallurgical processes, including biomass pretreatment,
- Identifying enhanced biocarbon production processes and scale-up requirements of these to produce optimum yields and qualities,
- Developing methods for upgrading biocarbon and biooil to increase their suitability for the specific metallurgical processes,
- Sustainability assessment of value chain performance of existing and improved metallurgical processes and connected systems for different metallurgical industries in Norway,
- Assessment of the future role of woody biomass for reductants and materials in the Norwegian metallurgical industry within the context of progress towards the UN SDGs,
- Increasing expertise throughout the biocarbon value chains for the metallurgical industries,
- Education of highly skilled candidates within this area and training of industry partners,
- Monitoring of activities and state-of-the-art within this area and dissemination of knowledge to the industry partners, and other interested parties when applicable.

The Work Breakdown Structure of BioCarbUpgrade is:



BioCarbUpgrade management and work break down structure and project links and information flow.
BioCarbUp: Optimising the biocarbon value chain for sustainable metallurgical industry, https://www.sintef.no/projectweb/biocarbup/
SFI Metal Production, https://www.ntnu.edu/metpro
FME HighEFF: Centre for an Energy Efficient and Competitive Industry for the Future, http://www.higheff.no
KPN Reduced CO_2 emissions from metal production, https://www.sintef.no/en/projects/reduced-co2-reduced-co2-emissions-in-metal-production/
FME Bio4Fuels, https://www.nmbu.no/bio4fuels

BioCarbUpgrade will run for four years (2023-2026) and has a total cash budget of 18 million NOK. This is a Collaborative and Knowledge-building Project (KSP) funded by The Research Council of Norway and industry.

The BioCarbUpgrade consortium

SINTEF Energy Research will lead the project and will focus on biomass and biocarbon (BC) upgrading, BC production, process and plant upscaling, and dissemination to industry, authorities and the general public. NIBIO will lead the biomass resource activities. SINTEF ER will lead the biomass and BC upgrading activities and the BC production activities, assisted by University of Hawaii, Research Centre for Natural Sciences in Hungary, and Luleå University of Technology. SINTEF Industry will focus on the use of BC and bio-binder in metallurgical industry. NTNU will supervise the PhD and Master candidates and lead the research on the value chain assessments. The industrial partners include large and central industrial players in the metallurgical industry area in Norway (Elkem, Eramet Norway, Hydro) as well as their interest organisation Eyde Cluster, the biomass supplier Norsk Biobrensel and the pyrolysis plant owners and operators OBIO and WAI Environmental Solutions, and they will contribute with finances and their extensive industrial knowledge generated through their commercial activities towards or within metallurgical industry. The constellation of project partners is complementary and strong, bringing together leading research organisations within the field and major industrial players.

Project background

The theme of this project is biocarbon for sustainable metallurgical industries in response to the Research Council of Norway KSP-K call. It addresses the topic of environmentally friendly energy and its focus on long-term, sustainable development of the energy system, while supporting the transition to a zero-emission society and promoting competitive Norwegian business and industry. It is also directed towards the ENERGIX program plan and its focus on 1) sustainable utilisation and consumption of renewable energy resources - as biomass, 2) reduction of Norwegian and global emissions of greenhouse gases - from metallurgical industry, 3) enhancement of Norway's security of supply - through increased use of domestic biomass resources, 4) strengthened innovation in Norwegian trade and industry and the public sector - for the metallurgical value chains and 5) further development of Norwegian research and educational institutions to support innovation efforts in the metallurgical industry.

Bioenergy is important in Norway and the current national bioenergy strategy is influenced by e.g. Klimakur 2030, Klimameldingen, Bioøkonomistrategien, Energi21 and Skog22. Concurrently, the metallurgical industry in Norway seeks to substitute large amounts of biobased materials for fossil reductants and materials (packing coke and coal tar pitch) in their processes. The Norwegian Process Industry Roadmap - Combining growth and zero emissions by 2050, Industrimeldingen and Process21 lay the foundation for an accelerated utilization of Norwegian biomass resources that would reduce the CO_2 footprint of the metallurgical industry. The roadmap targets a 43% reduction of CO_2 by 2030 compared to 2005 levels. To enable this transformation, the whole biocarbon (BC) value chain for the metallurgical industry must be adapted and tuned to remove economic constraints, secure its sustainability, satisfy reductants and materials (RM) quality demands, and develop predictable (amount, quality and price), long-term biomass resource demand. Due to security of supply and sustainability, RM should preferably be produced from biomass resources that limit logistics and do not increase pressure on natural ecosystems beyond sustainable thresholds. BC as reductant in Norway is currently more prevalent in Si and FeSi production. Quality constraints limit BC use as reductant in Mn-alloy production and as packing coke in Al production and biooil use as bio-binder in anodes and Söderberg electrodes. Cost-efficient methods of upgrading biomass and/or BC and biooil to match the quality demands of the different metallurgical processes would remove barriers to adoption and drive costs toward those of the fossil reductants.

This project responds to the national strategies and the goals of the metallurgical industry by adapting and tuning the biobased reductants and materials (BRM) value chain to produce suitable and affordable BRM in a sustainable manner from a diversified biomass feedstock base.

Project overview

The project is divided into 5 subprojects (SP), each subproject is itself divided into several work packages (WP).

- Biocarbon value chain for metallurgical industry - SP1
- Biocarbon production and upgrading - SP2
- Biocarbon end-use in metallurgical industries - SP3
- Education and training - SP4
- Technology monitoring and dissemination - SP5

Biocarbon value chain for metallurgical industry - SP1

The main objective of SP1 is Broadening of the biomass resource base for the specific metallurgical processes, including biomass pretreatment.
SP1 leader: Professor Francesco Cherubini, NTNU

Biocarbon production and upgrading - SP2

The main objectives of SP2 are 1) Identifying enhanced biocarbon production processes and scale-up requirements of these to produce optimum yields and qualities, and 2) Developing methods for upgrading biocarbon and biooil to increase their suitability for the specific metallurgical processes.
SP2 leader: Research Scientist Liang Wang, SINTEF Energy Research

Biocarbon end-use in metallurgical industries - SP3

The main objectives of SP3 are 1) Sustainability assessment of value chain performance of existing and improved metallurgical processes and connected systems for different metallurgical industries in Norway, 2) Assessment of the future role of woody biomass for reductants and materials in the Norwegian metallurgical industry within the context of progress towards the UN SDGs, and 3) Increasing expertise throughout the biocarbon value chains for the metallurgical industries.
SP3 leader: Research Scientist Gøril Jahrsengene, SINTEF Industry

Education and training - SP4

The major objective of SP4 is Education of highly skilled candidates within this area and training of industry partners.
SP4 leader: Professor Francesco Cherubini, NTNU

Technology monitoring and dissemination - SP5
The major objective of SP5 is Monitoring of activities and state-of-the-art within this area and dissemination of knowledge to the industry partners, and other interested parties when applicable.
SP5 leader: Chief Scientist Øyvind Skreiberg, SINTEF Energy Research, who also is the BioCarbUpgrade project leader

Earlier progress

In **2024** the focus was on finalizing the studies connected to the broadening of the resource base in Norway for biocarbon production, execution of different enhanced carbonisation experiments and characterisation of the products, upgrading of feedstocks and biocarbon, storage and logistics of biocarbon, activities connected to the end-use in metallurgical industries, including arranging a joint workshop between BioCarbUpgrade and the sister knowledge building project BioMet on Biocarbon use in metallurgical industries: Identifying changes and challenges, a public workshop on bio-binders and the PhD study on Advancing LCA Methods and Applications for a Sustainable Bioeconomy Transition.
In **2023** the focus was on start-up of the project, studies connected to the broadening of the resource base in Norway for biocarbon production, planning and execution of enhanced carbonisation experiments and activities connected to the end-use in metallurgical industries, recruitment of the PhD candidate and dissemination from the project.

Earlier publications

BioCarbUpgrade in Environmental Impact Assessment Review

One BioCarbUpgrade work has been published in Environmental Impact Assessment Review:
Marvin Werra, Marcos Djun Barbosa Watanabe, Vedant Ballal, Teymur Gogiyev, Sten Yngve Larsen, Merete Tangstad, Øyvind Skreiberg, Francesco Cherubini (2025). Life-cycle assessment of ferromanganese production using biocarbon as reductant and carbon capture and storage. The abstract is given below.

"Ferromanganese (FeMn) is an essential alloy whose production relies on metallurgical coke as a reducing agent, leading to hard-to-abate carbon dioxide emissions. The use of biocarbon as an alternative reductant and carbon capture and storage (CCS) are key mitigation strategies of FeMn production, yet their environmental performances are still unexplored. This study evaluates the possible environmental co-benefits and trade-offs of replacing metallurgical coke with biocarbon, with and without CCS, in Norway. The climate impact of FeMn production is 2312 ± 110 kg CO_2-equivalents per tonne of alloy (mean ± 5th/95th percentiles). Emission reductions are about 57 ± 3.0 % at a full substitution rate and 29 ± 3.7 % at a more realistic substitution rate of 50 %. CCS alone can reduce emissions of 53 ± 4.8 %. The combination of biocarbon with CCS can achieve negative emissions when the biocarbon substitution is higher than 78 %. More efficient material and energy use throughout the value chain is key to maximise climate benefits. The main trade-offs can occur with terrestrial acidification and particulate matter formation, and are mostly due to biomass pyrolysis. A 50 % substitution of the metallurgical coke annually used for FeMn production in Norway requires around 25 % of currently unused forest residues, or 8 % of the today's wood harvest volume. Although some economic and technological barriers remain to be overcome, this study offers an initial quantification of the environmental implications that can be expected from a value chain perspective in connection to local resource availability and technical challenges."

BioCarbUpgrade in Chemical Engineering Transactions

One BioCarbUpgrade work has been published in Chemical Engineering Transactions:
Zsuzsanna Czégény, István Sándor Czirok, Gergő Szabó, Zoltán Sebestyén, Bence Babinszki, Emma Jakab, Liang Wang, Øyvind Skreiberg (2025). Water leaching of wood barks for biocarbon production. The abstract is given below.

"Water leaching of birch bark, pine bark and spruce bark performed at 25 and 60 °C with and without stirring was tested as a pretreatment method to reduce the inorganic content of the feedstock. The yields of the solid demineralized bark and the dry material content of the leachate were determined. The effect of water leaching on the properties of bark materials was assessed by inductively coupled plasma optical spectroscopy (ICP-OES), element composition analysis and thermogravimetry (TGA). The solid yield of water-leached bark samples was around 90 % for all three types of barks. The water leaching process removed significant amounts of organic material together with the inorganics. The C content of the water-leached samples decreased by 2-5 %, while the O content increased by 2-5 % comparing to the raw bark materials. Among the inorganic components, the concentrations of alkali ions (K, Na) decreased the most for all three types of bark. The leaching efficiency for Ca, K and Na was higher for birch bark comparing to pine bark and spruce bark. The effect of alkali ion removal and partial removal of the extractives is reflected on the thermal behaviour of the water-leached bark samples."

BioCarbUp in Energy & Fuels

One BioCarbUpgrade associated work in the predecessor project BioCarbUp has been published in Energy & Fuels:

Kyle Anthony Castillo, Robert L. Johnson, Christian Jayme Castillo, Liang Wang, Øyvind Skreiberg, Scott Turn (2025). [Experimental Optimization of Pellet Tensile Strength from Spruce Biochar Produced at Elevated Pressure](). The abstract is given below.

"Constant pressure (12.07 MPa) pyrolysis of woody spruce biomass was tested using a 2^K factorial design to evaluate the effects of independent variables, including reactor temperature, reaction time, biomass feedstock, biomass moisture content, and acetic acid content, on transient plastic phase (TPP) formation, fixed carbon yields, and ultimate tensile strengths of biochars. Two-factor interactions were also observed. Temperature had the greatest effect on fixed carbon yields and ultimate tensile strengths. Minimal differences in fixed carbon yields and ultimate tensile strengths occurred between TPP and non-TPP (NTPP) biochars produced under similar reaction conditions. Reaction conditions that led to improved ultimate tensile strength sacrificed fixed carbon yield. The spruce biochar sample with the highest measured pellet tensile strength, 4.36 ± 0.50 MPa, was formed at a temperature of 230 °C and a nominal moisture content of 113.85%."

BioCarbUpgrade in Proceedings of Silicon for the chemical and solar industry XVII

One BioCarbUpgrade work has been published in Proceedings of Silicon for the chemical and solar industry XVII, Trondheim, 10-12 September 2024:

Sethulakshmy Jayakumari, Michal Ksiazek (2024). [Fines Generation and Strength of Various Carbon Materials Used in the Ferroalloy Industries](). The abstract is given below.

"One of the challenges in utilizing renewable reductants in metallurgical processes is their fragility, which often leads to the generation of significant quantities of fine particles during transportation and storage. The amount of dust and fines produced is closely tied to the mechanical strength of the material. The strength of a given carbon material is critical to the industry both prior to its introduction into the furnace and during its operation within the furnace, as industrial furnaces are typically large and contain substantial amounts of raw materials. It is essential for carbon material to withstand the weight of the materials above, without crushing. If the carbon material is crushed, the resulting fines may lead to clogging and impede the upward flow of gas, thereby adversely affecting furnace operations. The interaction of a carbon material with gas and sudden temperature change upon entry into the furnace can lead to a change in its strength. High strength implies low amounts of dust and fines, while low strength implies the opposite. The mechanical strength of biomass can be enhanced through pelletizing or briquetting, thereby increasing the usable carbon yield in ferroalloy production. Mechanical strength can be evaluated using various methods such as tumble/abrasion, drop, and compression tests. Additionally, the ability of the reductant to withstand rapid heating can be evaluated to estimate the thermal shock strength. This study presents the strength of various carbon materials, including some biocarbon pellets used in the ferroalloy industries"

BioCarbUpgrade in Journal of Thermal Analysis and Calorimetry

One BioCarbUpgrade work has been published in Journal of Thermal Analysis and Calorimetry:

Bence Babinszki, István Sándor Czirok, Robert Johnson, Zoltán Sebestyén, Emma Jakab, Liang Wang, Scott Turn, Øyvind Skreiberg, Zsuzsanna Czégény (2024). [Volatile matter characterization of birch biochar produced under pressurized conditions](). The abstract is given below.

"The volatile matter (VM) content and composition of birch biochars produced at 320 °C under elevated pressure (0.1–11 MPa) and constant pressure or constant volume reactor conditions were characterized by thermogravimetry/mass spectrometry (TG/MS) and pyrolysis–gas chromatography/mass spectrometry (Py–GC/MS). Some of the thermal properties of the biochars and the composition of the VMs varied as a function of the maximal pressure applied during carbonization. The samples prepared at higher pressures released more volatiles up to 320 °C, while the maximal rate of thermal decomposition at around 440 °C showed decreasing tendency with the carbonization pressure. In terms of VM composition, the most apparent effect was the significant increase of the amounts of apoallobetulins from biochars prepared at elevated pressures, which were formed by dehydration, ring closure and rearrangement from the betulin content of birch. The change in the ratio of the evolved guaiacol and 4-methylguaiacol as well as that of syringol and 4-methylsyringol as a function of the maximal pressure of carbonization indicated a modification of the lignin decomposition mechanism."

BioCarbUpgrade in Chemical Engineering Transactions

One BioCarbUpgrade work has been published in Chemical Engineering Transactions:
Liang Wang, Øyvind Skreiberg (2023). [A critical review on self-heating and self-ignition of biocarbon](). The abstract is given below.

"Biocarbon is a promising alternative to replace fossil carbon as reductant for metal production with benefits to reduce greenhouse gas emissions and increase the sustainability of the metallurgical industry. As a carbon and energy intensive industry, a significant amount of biocarbon needs to be produced, handled, transported and stored for further utilization in metal production processes. Biocarbon is a reactive porous material and can undergo self-heating that is related to spontaneous exothermic reactions at low temperatures. The biocarbons can be produced from different biomass materials and under different conditions, and have various physical and chemical properties. The biocarbons with different properties have different tendency in terms of self-ignition and risk of fire. In addition, storage and transportation conditions play also important roles in causing the self-ignition of biocarbon, including gas atmosphere, temperature, heat and mass transfer to surroundings, humidity, etc. Several studies have been conducted to investigate reasons for causing biocarbon self-ignition, including conversion behaviour and mechanisms of biocarbon self-ignition and potential mitigation measures. The main objective of this review is to survey studies on the self-ignition of biocarbons by correlating them to biocarbon production and storage conditions and provide background information for safe transportation and storage of biocarbon."

BioCarbUpgrade in Chemical Engineering Transactions

One BioCarbUpgrade work has been published in Chemical Engineering Transactions:
Liang Wang, Øyvind Skreiberg (2023). [Evaluation of water leaching on properties of woody biomass for biocarbon production](). The abstract is given below.

"Biocarbon is an attractive option to replace fossil carbon for metal production with the benefits of reducing greenhouse gas emissions and CO_2 footprint. Nowadays, biocarbon is mainly produced from virgin wood through pyrolysis. As a carbon and energy-intensive industry, large amounts of biocarbon are needed in the metallurgical industry. With consideration of the increasing price of virgin wood and demands from other industries for this material source, it is necessary to broaden the biomass resource base. Woody biomasses with high carbon content and superior mechanical properties are still preferred for producing biocarbon. Therefore, various non-conventional woody biomasses are considered for biocarbon production, including forest residues, waste wood, etc. However, compared to virgin wood, the non-conventional woody biomasses often have high content of inorganic elements. During pyrolysis, the inorganic elements present in the feedstock might cause problems for the equipment and influence the reactions. A major fraction of the inorganic elements will remain in the produced biocarbon, which negatively affects the conversion of the biocarbon during metal production processes and some inorganic elements may influence the quality of the metal products as well. Demineralization is a process widely used for pretreatment of biomass materials that are rich in or contaminated with inorganic elements. Water leaching is still the most popular option as it is rather easy to conduct with low costs and fewer challenges for treating leachates. The objective of this paper was to compile and review the current literature concerning the demineralization of non-conventional woody biomasses through water leaching. The review revealed that leaching conditions (i.e., temperature and time) need to be carefully selected with consideration of the content and present form of the inorganic elements in different biomass materials. Moreover, the water leaching efficiency under given conditions is also related to the physical properties of the biomass material (i.e., particle size). In addition to the inorganic elements, the water leaching might also affect the organic composition (i.e., extractives) of the biomass materials. The properties of leached biomass materials should be characterized, which can be used for predicting the yield and quality of the produced biocarbon. Optimal water leaching procedures and conditions need to be identified and tested for maximizing the reduction of undesired inorganic elements and limiting the negative effect of properties of non-woody biomasses for biocarbon production."

BioCarbUpgrade in COM 2023 proceedings

One BioCarbUpgrade work has been published in Conference of Metallurgists proceedings:
Sethulakshmy Jayakumari, Gøril Jahrsengene, Michal Ksiazek, Eli Ringdalen (2023). [Investigations on CO_2 reactivity and Thermal Strength of Carbon Sources for Ferroalloy and Silicon Production](). The abstract is given below.

"During industrial production of ferroalloys (FeMn/SiMn) and silicon (Si), carbon materials are used as the main reductants. The selection of carbon materials affects energy consumption, operational stability, and ultimately the yield and quality of the final product. Substituting fossil carbon with biocarbon as reductants is meant to reduce the CO_2 footprint and is currently being investigated in the ferroalloy industry. The properties of various fossil reductants and charcoal and their impact on ferroalloy production have been investigated and are compared in this study. The "Boudouard reaction" which is the CO_2 reactivity of carbon results in an increase in carbon and energy consumption. Therefore, it is important to have knowledge about the reactivity of the chosen reductant and its impact. The reactivity is dependent on various factors, including physical properties and chemical composition. In this study, methods for studying CO_2 reactivity and the results from investigations of various carbon materials are presented and discussed. Studies show that charcoal has the highest CO_2 reactivity due to its physical and chemical properties. In addition, the effect of alkalis in charcoal on CO_2 reactivity is also addressed. The high amount of fines generated inside the ferroalloy furnace can reduce the charge permeability and have a negative effect on furnace operation. Thus, the thermal strength of the carbon materials is an important property for its use. Methods for studying thermal strength and fines generation and results from investigations of various carbon materials have been analysed and are presented and discussed. The lower thermal strength of charcoal compared to traditional fossil carbon sources may limit its use. But methods to mitigate this through the use of bio-coke are presented."

BioCarbUpgrade in COM 2023 proceedings

One BioCarbUpgrade work has been published in Conference of Metallurgists proceedings:
Gøril Jahrsengene, Sethulakshmy Jayakumari, Ida Kero, Eli Ringdalen (2023). [Sustainable Metal Production – Use of Biocarbon and the Concern of Dusting](). The abstract is given below.

"The silicon and ferroalloy industries in Norway have traditionally relied on fossil carbon products as reductants for their respective process. Efforts to reduce fossil CO_2 emissions by introducing biocarbon have already begun, and targets of 25–40% biocarbon use by 2030 have been set by various producers in Norway. An understanding of the effects of the physical properties of the carbon on the process must be obtained so that the transition can take place with minimal process interruptions. It is well documented that charcoal is more friable than traditional fossil carbons, particularly during transportation and handling. Major issues related to the fines generation are concerning material loss, effect of furnace performance, personal health and safety concerns by inhalation of particles, and possibility of dust explosions. The strength of unreacted material, the cold strength, can give good information about the dusting potential of a material; however, many methods exist for these evaluations. In this work, an overview of the raised issues concerning dusting, and methods to evaluate cold strength in relation to dusting, is included, as is some relevant comparisons between charcoals and traditional carbon sources with respect to tumbling strength."

BioCarbUp in Proceedings of the Combustion Institute

One BioCarbUpgrade associated work in the predecessor project BioCarbUp has been published in Proceedings of the Combustion Institute 40:
Jingyuan Zhang, Corinna Schulze-Netzer, Tian Li, Terese Løvås (2024). [A novel model for solid fuel combustion with particle migration](). The abstract is given below.

"Solid fuel conversion in a fixed-bed is a challenging modelling task due to different time and length scales and the importance of heat transfer mechanisms. The current study aims to propose a novel model that can capture all the main features of the conversion of fuel bed while maintaining a moderate computational cost. The model is based on the commonly applied porous media approach, which describes the solid phase using an Eulerian framework. A layered particle submodel with four types of solids, wet wood, dry wood, char, and ash, is implemented to account for different conversion stages. At each computational cell, a matrix is used to record the information on all the properties of the four types of solids, including the number and volume of particles. The model allows the exchange of particles between cells, thus capable of simulating the motion of the fuel bed during conversion, such as bed collapsing. In addition, the new model can efficiently calculate heat transfer between particles and particles and fluid in each computational cell. The proposed model is validated against a series of experiments on biomass conversion in a rectangular fixed-bed combustor operated in a counter-current mode with various air supply rates. Good agreement with experiments was found even at the limited combustion regime. With the overall low computational cost generated by the bed model, the proposed model framework has the potential to efficiently simulate a wide range of solid fuel conversion processes at a large scale, not only in fixed-beds but also in moving beds and rotary kilns."

BioCarbUp in Energy & Fuels

One BioCarbUpgrade associated work in the predecessor project BioCarbUp has been published in Energy & Fuels:

Przemyslaw Maziarka, Norbert Kienzl, Alba Dieguez-Alonso, Wolter Prins, Pablo J. Arauzo, Øyvind Skreiberg, Andrés Anca-Couce, Joan J. Manyà, Frederik Ronsse (2024). Part 2—Tailoring of Pyrolytic Char Properties with a Single Particle CFD Model with a Focus on the Impact of Shrinking, Vapor Cracking, and Char Permeability. The abstract is given below.

"The prediction of the structural properties of biobased carbonaceous materials of pyrolytic origin (chars) with only base feedstock properties and process conditions still poses a challenge that hinders char tailoring for novel applications. CFD modeling of single biomass particle conversion can help solve this issue since it allows for the quantification of relations between parameters that are difficult to measure. A model for char tailoring must include a validated representation of the structural changes coupled to all other relevant phenomena occurring during conversion. Part 2 of this study focuses on finding the description of the mentioned aspects to achieve the highest precision of prediction of the structural changes in char by a CFD model. The investigation in Part 2 is composed of three cases focused on accurate description and prediction of (1) bulk density and porosity, (2) secondary vapor reactions on yields and soot formation, and (3) permeability, as well as the outflux and conversion of evolved vapors. The experimental results from Part 1 and the literature data were used to find appropriate descriptions of phenomena and assess the accuracy of the model. The model results indicate that for both particle lengths (10 and 16 mm), a high accuracy of prediction of base structural parameters was achieved. The average prediction error for temperatures between 400 and 840 °C of bulk density was 31 ± 15 kg/m^3, and the porosity was 1.8 ± 1.1 vol %. The results also show a low error in the prediction of bulk product yields (dry basis) over the mentioned temperature range, which were: for char 2.8 ± 1.1 wt %, for the condensable fraction 6.5 ± 3.3 wt %, and for the pyrolysis gas 4.1 ± 1.9 wt %. The distribution of secondary char formation was found to be nonuniform below 500 °C. The changes in permeability had a minor influence on the vapor outflux but a non-negligible effect on the soot formation, especially at 840 °C. The results indicate a need for further improvement of the primary degradation model to increase the accuracy of the effect of soot formation on the char structure."

BioCarbUp in Fuel

One BioCarbUpgrade associated work in the predecessor project BioCarbUp has been published in Fuel:

Tien Duc Luu, Jingyuan Zhang, Jan W. Gärtner, Shiqi Meng, Andreas Kronenburg, Tian Li, Terese Løvås, Oliver T. Stein (2024). Single particle conversion of woody biomass using fully-resolved and Euler–Lagrange coarse-graining approaches. The abstract is given below.

"The conversion of woody biomass is studied by means of a layer-based model for thermally-thick biomass particles (Thunman et al. 2002, Ström et al. 2013). The model implementation is successfully validated against experiments that study particle conversion in a drop tube reactor. After this validation step, this work focuses on the well-known problem of grid dependence of two-phase numerical simulations using the standard Euler–Lagrange (EL) framework. This issue is addressed and quantified by comparing EL data that models the particle boundary layers to corresponding simulations which fully resolve these boundary layers (fully-resolved, FR, simulations). A comparison methodology for the conceptually different FR and EL approaches by extracting the heat transfer coefficient from the detailed FR simulations is proposed and confirms that the EL results are strongly grid-dependent. This issue is overcome by applying a set of coarse-graining methods for the EL framework. Two coarse-graining methods are evaluated, a previously suggested diffusion-based method (DBM) and a new approach based on moving averages referred to as MAM. It is shown that both DBM and MAM can successfully recover the detailed FR data for pure particle heating for a case where the grid size is half the particle diameter, i.e. when the standard EL method fails. Both coarse-graining methods also give improved results for an EL simulation that considers the more complex combined physics of particle heating, drying and devolatilisation, given that the CG model parameters that scale the corresponding CG interaction volumes are sufficiently large. Based on the available FR data, recommended model parameter ranges for DBM and MAM are provided as a function of normalised boundary layer thickness. The novel MAM approach is shown to be significantly more efficient than the DBM and therefore suitable for future EL simulations with multiple particles."

BioCarbUp in Journal of Thermal Analysis and Calorimetry

One BioCarbUpgrade associated work in the predecessor project BioCarbUp has been published in Journal of Thermal Analysis and Calorimetry:

Gábor Várhegyi (2024). Can varying activation energy be determined reliably from thermogravimetric experiments? The abstract is given below.

"Solutions of the general isoconversional kinetic equation were generated and compared assuming activation energies, E, which vary with the advance of the reaction, α. Series belonging to 4–5 heating rates were compared. TG curves simulated with highly varying activation energies could approximate well the curves simulated with first-order kinetics and constant E. This observation indicates that the information content of a series of TG curves at constant heating rates is not sufficient for the determination of activation energies that vary with the advance of the studied reactions. The problem proved to be smaller when differential curves were compared in the same way; the uncertainties decreased by factors 0.2–0.5. There is a standard procedure of ASTM International (ASTM E2958-19, 2019. https://doi.org/10.1520/E2958-21) that describes the estimation of E from experiments carried out at a specific modulated temperature program. The reliability of this procedure was also tested and found to be low, though not as low as that of the evaluation of TG curves at linear temperature programs with usual heating rates. The work continues and complements a recent study of the author (Várhegyi in J Therm Anal Calorim 148:12835–12843, 2023)."

BioCarbUp in Energy & Fuels

One BioCarbUpgrade associated work in the predecessor project BioCarbUp has been published in Energy & Fuels:
Robert L. Johnson, Kyle Castillo, Christian Castillo, Cassidy Hihara, Quang-Vu Bach, Liang Wang, Øyvind Skreiberg, Scott Turn (2023). Biocarbon Production via Plasticized Biochar: Role of Feedstock, Water Content, Catalysts, and Reaction Time. The abstract is given below.

"Studies into transient plastic phase biochar (TPPB) were conducted to compare how feedstock, moisture, acetic acid addition, and reaction time impacted the formation of TPPB and mechanical properties. Our results show that pyrolysis conditions sufficient for TPPB formation from birch wood do not lead to TPPB formation from spruce, cellulose (paper plates), or rice straw. However, TPPB formation was possible with spruce and rice straw with the addition of water to the initial material. Plasticized biochar and non-plasticized biochar (NTPPB) produced from spruce and rice straw were compared in terms of the charcoal yield, proximate analysis (fixed carbon content), and mechanical properties of pelletized particles. Despite observing only minimal differences in the charcoal yields and fixed carbon contents between TPPB and NTPPB, the tensile strengths of biochar and biocarbon pellets [calcined at 900 °C (N_2)] were substantially improved with TPPB. Biocarbon pellets produced from spruce TPPB and rice straw TPPB were 5× and 1.5× stronger than the NTPPB counterparts. Adding 75 wt % H_2O to birch (nominal 8% moisture content) resulted in biocarbon with nearly 10 times higher tensile strength, despite both biocarbon materials being produced from a birch TPPB precursor. Birch biochars produced with shorter reaction times produced biocarbon pellets with nearly 3× higher tensile strength. Lastly, measured tensile (39 MPa) and compressive (188 MPa) strength values obtained from finely ground birch TPPB samples constitute one of the strongest biocarbon materials reported to date and would have sufficient mechanical strength to serve as a direct substitute for petroleum carbon anodes without any binder. These results demonstrate that plasticized biochar can be produced from a variety of different feedstocks and increasing their water content along with reducing the reaction time improves the mechanical properties of the biocarbon formed from the plasticized biochar intermediate."

BioCarbUp in Journal of Thermal Analysis and Calorimetry

One BioCarbUpgrade associated work in the predecessor project BioCarbUp has been published in Journal of Thermal Analysis and Calorimetry:
Gábor Várhegyi (2023). Problems with the determination of activation energy as function of the reacted fraction from thermoanalytical experiments. The abstract is given below.

"The so-called compensation effect is well known between the activation energy, E, and the pre-exponential factor, A. The present work shows by examples that much higher compensation effects may arise when E and A vary with the reacted fraction. For this purpose, a set of five simulated experiments were constructed by first-order kinetics with E = 200 kJ mol^{-1} at a wide range of heating rates. These data were evaluated by the method of least squares assuming E and A as functions of the reacted fraction. Such E functions were found which highly differed from a constant E while described well the evaluated data. They included a linearly increasing E and several parabolic E functions. The observed effects may contribute to the contradictory kinetic parameters that were reported in the literature of the isoconversional ("model-free") studies. It was found that the compensation effects between E and A functions can be 8–11 times higher than between E and A values."

BioCarbUp in Sustainable Chemistry & Engineering

One BioCarbUpgrade associated work in the predecessor project BioCarbUp has been published in Sustainable Chemistry & Engineering:
Robert L. Johnson, Kyle Castillo, Christian Castillo, Liang Wang, Øyvind Skreiberg, Scott Q. Turn (2023). Use of Plasticized Biochar Intermediate for Producing Biocarbons with Improved Mechanical Properties. The abstract is given below.

"Slow pyrolysis of woody materials under elevated pressure was previously shown to result in macroscopic morphology changes, appearing as a solid that had experienced a molten phase, described as "transient plastic phase biochar" (TPPB). Experiments have been conducted to study the influence of process variables on the formation of TPPB. Results suggest TPPB formation is mediated through hydrolysis that allow for a molten phase to occur. Elevated pressure plays a key role by keeping water in the condensed phase. Despite drastic changes in material morphology, notable differences between TPPB and standard biochar (not TPPB or "NTPPB") were not detected using proximate analysis, solid state ^{13}C NMR, and helium pycnometry, indicating the material chemistry was minimally affected. Clear differences between the mechanical properties of the TPPB and NTPPB powders and pellets were shown using tabletability experiments. The utility of TPPB was then demonstrated by comparison of tensile and compression strengths of materials calcined (N_2) at (900 °C) to form transient plastic phase biocarbon (TPPC). The TPPB precursor resulted in a TPPC pellet with 10 times greater tensile (4.4 MPa) and compressive strength (17.6 MPa) and nearly two times greater density than carbon pellets produced from NTPPB."

BioCarbUp in Journal of Thermal Analysis and Calorimetry

One BioCarbUpgrade associated work in the predecessor project BioCarbUp has been published in Journal of Thermal Analysis and Calorimetry:
Gábor Várhegyi, Liang Wang, Øyvind Skreiberg (2023). Kinetics of the CO_2 gasification of woods, torrefied woods, and wood chars. The abstract is given below.

"The gasification kinetics of chars forming from biomass materials was studied by kinetic equations of type $dX/dt = A\ f(X)\ \exp(-E/(RT))$ where X is the conversion of the sample, A is the pre-exponential factor, E is the activation energy and f(X) is a suitable model function. The theoretically deduced f(X) models in the literature are rarely applicable for chars of biomass origin because of chemical and physical inhomogeneities and irregularities. Hence, empirical f(X) functions were determined by a method proposed four years ago (Várhegyi in Energy Fuels 33:2348–2358, 2019). The parameters of the models were obtained by the method of least squares. Thermogravimetric experiments from an earlier work were reevaluated to explore the possibilities of the approaches employed. The experiments belonged to untreated birch and spruce woods; torrefied woods; chars prepared at a higher temperature; and chars formed at high heating rates (ca. 1400 °C min^{-1}). Common kinetic features were found for the CO_2 gasification of the chars studied. The reliability of the results was carefully tested by evaluating smaller and larger groups of the experiments and comparing the results. The method proved to be suitable for the determination of realistic f(X), E, and A from single modulated experiments, too. The models described well the gasification of chars forming from different woods through a wide range of temperature programs and thermal pretreatments."

BioCarbUp in Fuel

One BioCarbUpgrade associated work in the predecessor project BioCarbUp has been published in Fuel:
Liang Wang, Øyvind Skreiberg, Nicholas Smith-Hanssen, Sethulakshmy Jayakumari, Stein Rørvik, Gøril Jahrsengene, Scott Turn (2023). Investigation of gasification reactivity and properties of biocarbon at high temperature in a mixture of CO/CO_2. The abstract is given below.

"Understanding the conversion behaviors of biocarbon under conditions relevant to industrial conditions is important to ensure proper and efficient utilization of the biocarbon for a dedicated metallurgical process. The present work studied the reactivity of biocarbon by using a Macro-TGA at 1100 °C in a gas mixture of CO_2 and CO to simulate the conditions in an industrial closed submerged arc manganese alloy furnace. The conversion residues from the Macro-TGA tests were collected for detailed characterization through a combination of different analytical techniques. Results showed that biocarbons produced under various conditions have different reactivities under the studied conditions. The biocarbon produced in an atmospheric fixed bed reactor with continuous purging of N_2 has the highest reactivity. Its fixed carbon loss started as the gas atmosphere shifted from the inert Ar to a mixture of CO and CO_2 at 1100 °C. And only 450 s was needed to reach a desired fixed-carbon loss of 20%. The high reactivity of the biocarbon is mainly related to its porous structure and high content of catalytic inorganic elements, which favor gasification reactions of the carbon matrix towards the surrounding gas atmosphere and consumption of carbon consequently. In contrast, biocarbon produced under constrained conditions and from wood pellets and steam exploded pellets have more compact appearance and dense structures. Significant fixed carbon loss for these biocarbons started 80–200 s later than that of the biocarbon produced at atmospheric conditions with purging of N_2. Additionally, it took longer time, 557–1167 s, for these biocarbons to realize the desired fixed-carbon loss. SEM-EDX analyses results revealed clear accumulation and aggregation of inorganic elements, mainly Ca, on the external surface of the residues from gasification of biocarbon produced in the fixed bed reactor with purging of N_2. It indicates more intensive migration and transformation of inorganic elements during gasification at this condition. This resulted in formation of a carbon matrix with more porous structure and active sites on the carbon surface, promoting the Boudouard reaction and conversion of carbon."

BioCarbUp in TMS 2023: Advances in Pyrometallurgy

One BioCarbUpgrade associated work in the predecessor project BioCarbUp has been published in TMS 2023: Advances in Pyrometallurgy:
Stein Rørvik, Nicholas Smith-Hanssen, Sethulakshmy Jayakumari, Liang Wang (2023). Characterizing Bio-carbon for Metallurgical Processes Using Micro X-ray Computed Tomography with High Temperature Experiments. The abstract is given below.

"An important path to the goal of reducing the metal producing industries' CO_2 footprint is to replace fossil carbon sources with bio-based carbon sources for the electrodes and reductant agents. Since the structure of bio-carbon is substantially different from fossil carbon, characterizing the bio-carbon structure and examining its behaviour during the relevant processes are important. Focusing on the silicon and ferroalloy industries in Norway, micro X-ray computed tomography (µCT) has been used to analyse and compare single grains of bio-carbon before and after various experimental procedures. These procedures consist of high-temperature treatment under different conditions for CO/CO_2 and SiO gas reactivity test, K-impregnation and CH_4-based carbon deposition. This paper shows examples on results from µCT measurements before and after the experiments, and describes briefly the data processing methods applied. The relevance to the experiments and industrial applications is also discussed."

BioCarbUp in TMS 2023: Advances in Pyrometallurgy

One BioCarbUpgrade associated work in the predecessor project BioCarbUp has been published in TMS 2023: Advances in Pyrometallurgy:
Nicholas Smith-Hanssen, Gøril Jahrsengene, Eli Ringdalen (2023). Biocarbon Materials in Metallurgical Processes—Investigation of Critical Properties. The abstract is given below.

"The silicon, ferroalloy and aluminum industries have mostly been dependent on fossil carbons for their respective process. However, efforts to reduce their fossil CO_2-emissions the switch to biocarbon has already begun and targets of 25 to 40 % biocarbon by 2030 have been set by various producers in Norway. To achieve this transformation a better understanding of the effects of physical properties of the carbon on the process must be obtained so that the transformation can occur with minimal process interruptions. For the silicon, ferrosilicon, and ferromanganese industries the effects of biocarbon reductants are the primary interest whereas for the aluminum industry use of biocarbon to replace packing coke used in anode baking is desired. In this work, an overview over relevant carbon properties and methods to characterize these are presented together with an evaluation of how these properties may affect the different processes when introducing biocarbon."

BioCarbUp in International Journal of Heat and Mass Transfer

One BioCarbUpgrade associated work in the predecessor project BioCarbUp has been published in International Journal of Heat and Mass Transfer:
Jingyuan Zhang, Tian Li, Henrik Ström, Boyao Wang, Terese Løvås (2023). A novel coupling method for unresolved CFD-DEM modeling. The abstract is given below.

"In CFD-DEM (computational fluid dynamics-discrete element method) simulations particles are considered Lagrangian point particles. The details of the flow near the particle surface are therefore not fully resolved. When the particle scale is larger than the resolved flow scale, the coupling between the CFD model and the DEM model is critical. An effective coupling scheme should minimize the risk of artificial influences on the results from choices of numerical parameters in implementations and consider efficiency and robustness. In this work, a novel coupling method is developed. The method includes both the smoothing of the particle data and the sampling of the gas phase quantities. The smoothing employs the diffusion-based method. The gas sampling method can reconstruct the filtered fluid quantities at the particle center. The sampling method is developed based on the diffusion-based method with higher efficiency. The new method avoids mesh searching and it can be easily implemented in parallel computing. The developed method is validated by the simulation of a forced convection experiment for a fixed bed with steel spheres. With the well-posed grid-independent coupling scheme, the simulation results are in good agreement with the experimental measurements. The coupling effects and the computational cost are discussed in detail."

BioCarbUpgrade at LCM 2025

A BioCarbUpgrade work was presented at LCM 2025, Palermo, Italy, 9-12 September 2025:

Marvin Werra, Marcos Djun Barbosa Watanabe, Vedant Ballal, Teymur Gogiyev, Sten Yngve Larsen, Merete Tangstad, Øyvind Skreiberg, Francesco Cherubini (2025). Life-cycle assessment of ferromanganese production using biocarbon as reductant and carbon capture and storage.

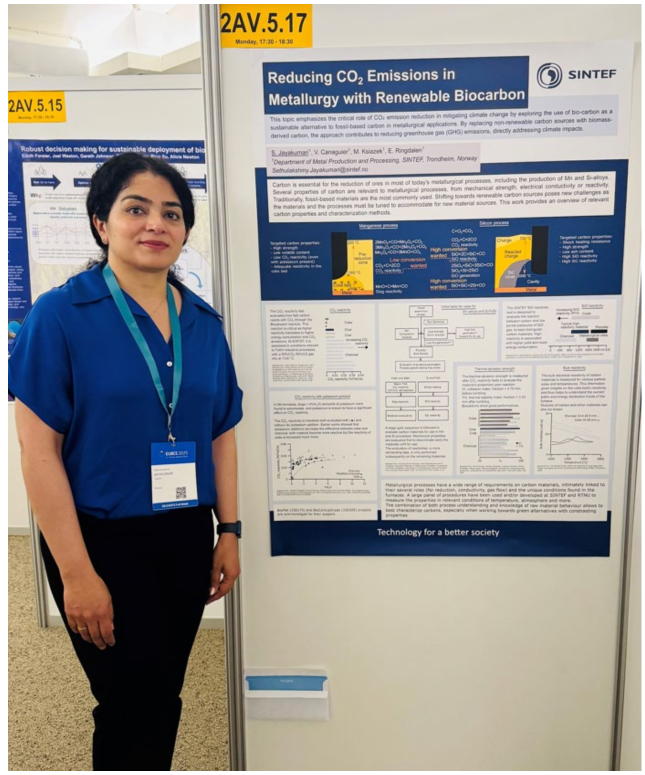
Marvin Werra at LCM 2025. LinkedIn post [here](#).

BioCarbUpgrade at ICheaP17

A BioCarbUpgrade work was presented at ICheaP17, Florence, Italy, 29 June - 2 July 2025:
Zsuzsanna Czégény, István Sándor Czirok, Gergő Szabó, Zoltán Sebestyén, Bence Babinszki, Emma Jakab, Liang Wang, Øyvind Skreiberg (2025). Water leaching of wood barks for biocarbon production.

BioCarbUpgrade at EUBCE 2025

A joint work between BioCarbUpgrade and BioMet was presented at EUBCE 2025, Valencia, Spain, 9-12 June 2025:
Sethulakshmy Jayakumari, Vincent Canaguier, Michal Ksiazek, Eli Ringdalen. Reducing CO_2 emissions in metallurgy with renewable biocarbon.



Sethulakshmy Jayakumari at her poster.

BioCarbUpgrade at Biochar IV

Two BioCarbUpgrade works have been presented at Biochar IV, Santa Marta, Colombia, 18-23 May 2025:
1) Bence Babinszki, Zsuzsanna Czégény, Liang Wang, Øyvind Skreiberg, Jørn Bakken. Characterization of liquid by-products from pyrolysis of birch, spruce and pine bark.
2) Liang Wang, Jørn Bakken, Øyvind Skreiberg, Zsuzsanna Czégény, Bence Babinszki. Production of Biocarbon from Untreated and Leached Birch, Spruce and Pine Bark.

BioCarbUpgrade at Biocarbon in Metallurgy 2025

One BioCarbUpgrade work and one BioCarbUpgrade connected work have been presented at Biocarbon in Metallurgy 2025, Wisła, Poland, 8-9 April 2025:
1) Marvin Werra. Life-cycle assessment of Ferromanganese production using biocarbon as reductant and carbon capture and storage.
2) Simen Gjølsjø. The wood resources in Europe and Scandinavia.

BioCarbUpgrade at ACS Spring meeting 2025

One BioCarbUpgrade work has been presented at ACS Spring meeting 2025, San Diego, USA, 23-27 March:

Zsuzsanna Czégény, István Sándor Czirok, Gergő Szabó, Zoltán Sebestyén, Bence Babinszki, Liang Wang, Øyvind Skreiberg. Water Leaching of Wood Barks for Biocarbon Production.

BioCarbUpgrade at Silicon for the chemical and solar industry XVII

One BioCarbUpgrade manuscript has been presented at Silicon for the chemical and solar industry XVII, Trondheim, 10-12 September 2024:
Sethulakshmy Jayakumari, Michal Ksiazek. Fines Generation and Strength of Various Carbon Materials Used in the Ferroalloy Industries.
The manuscript has been published in conference proceedings.

BioCarbUpgrade at Impacts of Fuel Quality 2024

One BioCarbUpgrade work has been presented at Impacts of Fuel Quality 2024, 2-6 September 2024, Garmisch-Partenkirchen, Germany:
Liang Wang, Øyvind Skreiberg, Karl Oskar Pires Bjørgen, Zoltán Sebestyén, Zsuzsanna Czégény, Jørn Bakken. Production and characterization of biocarbon under different conditions.

BioCarbUpgrade at Pyro2024

Two BioCarbUgrade works were presented at the 24th International Symposium on Analytical and Applied Pyrolysis (Pyro2024) 19-23 May 2024, Beijing, China:
1) Liang Wang, Jørn Bakken, Zsuzsanna Czégény, Øyvind Skreiberg. Study on Slow Pyrolysis of Spruce, Pine and Birch Bark.
2) Bence Babinszki, Zoltán Sebestyén, Emma Jakab, Liang Wang, Øyvind Skreiberg, Zsuzsanna Czégény. Comparative study on the composition of condensates, the liquid by-products of biomass torrefaction.

BioCarbUpgrade at the 2nd International Conference on Energy, Environment & Digital Transition

Two BioCarbUpgrade and BioCarbUp joint manuscripts have been presented at the 2nd International Conference on Energy, Environment & Digital Transition (E2DT), Palermo, Italy, 22-25 October 2023:
1) Liang Wang, Øyvind Skreiberg. A critical review on self-heating and self-ignition of biocarbon.
2) Liang Wang, Øyvind Skreiberg. Evaluation of water leaching on properties of woody biomass for biocarbon production.
The manuscripts have been published in conference proceedings.

BioCarbUpgrade at the 62nd Annual Conference of Metallurgists

Two BioCarbUpgrade and BioCarbUp joint manuscripts have been presented at the 62nd Annual Conference of Metallurgists, August 21-24, 2023, Fairmont Royal York, Toronto, Canada:
1) Sethulakshmy Jayakumari, Gøril Jahrsengene, Michal Ksiazek, Eli Ringdalen. Investigations on CO_2 reactivity and Thermal Strength of Carbon Sources for Ferroalloy and Silicon Production.
2) Gøril Jahrsengene, Sethulakshmy Jayakumari, Ida Kero, Eli Ringdalen. Sustainable Metal Production – Use of Biocarbon and the Concern of Dusting.
The manuscripts have been published in conference proceedings.

BioCarbUpgrade in EERA Bioenergy Newsletter

An article entitled "Upgrading biocarbon for sustainable metallurgical industries" presents BioCarbUpgrade in the July 2023 EERA (European Energy Research Alliance) Bioenergy newsletter.

BioCarbUp at JTACC 2023

Two BioCarbUgrade associated works in the predecessor project BioCarbUp were presented at 3rd Journal of Thermal Analysis and Calorimetry Conference 20–23 June 2023, Balatonfüred, Hungary:
1) Zsuzsanna Czégény, I.S. Czirok, Robert Johnson, Zoltán Sebestyén, Bence Babinszki, Emma Jakab, Lian Wang, Scott Turn, Øyvind Skreiberg. Biocarbons produced under pressurized conditions: characterisation of the volatiles.
2) Bence Babinszki, Zoltán Sebestyén, Emma Jakab, Luca Kőhalmi, János Bozi, Gábor Várhegyi, Liang Wang, Øyvind Skreiberg, Zsuzsanna Czégény. The effect of pyrolysis conditions on yield, thermal behaviour and volatile matter composition of biocarbon products.

BioCarbUp results summarized in SINTEF blog and in a project handbook

The BioCarbUpgrade predecessor project BioCarbUp has been summarised in a SINTEF blog:
Øyvind Skreiberg. Biochar: Renewable carbon from biomass for the metallurgical industry. SINTEF blog 20 February 2023.
Øyvind Skreiberg. Biokull: Fornybart karbon fra biomasse til metallurgisk industri. SINTEF blogg 17 januar 2023. (Norwegian version)
This adds on to the earlier published project handbook:
Øyvind Skreiberg, Liang Wang, Gøril Jahrsengene, Tian Li, Simen Gjølsjø (2022). Optimising the

biocarbon value chain for sustainable metallurgical industry - BioCarbUp handbook.

The Contribution of Biomass to Reduce Global Warming was elaborated on in EERA Bioenergy Newsletter

An article entitled "The Contribution of Biomass to Reduce Global Warming" was included in the December 2022 EERA (European Energy Research Alliance) Bioenergy newsletter. While the biomass contribution to energy production is very important, the contribution of biomass to cover different material needs is also important, e.g. for substitution of fossil reductants and materials in the metallurgical industry.

BioCarbUpgrade workshop on bio-binders

BioCarbUpgrade invited to a workshop November 5th 2024 called «Use of Bio-Binders for Metal Production». A total of 19 people met physically in Trondheim, and 42 unique users attended online. The attendees listened to relevant presentations and discussed the opportunity to utilize liquid biocarbon as binders for electrodes and pellets, and focusing on the HSE issues related to the new material. Presentations were held by a number of BioCarbUpgrade participants from SINTEF, Hydro and WAI Environmental Solutions, while other invited presentations were held by Envigas and KTH Royal Institute of Technology in Stockholm.

Workshop participants.

BioCarbUpgrade and BioMet joint workshop

BioCarbUpgrade and BioMet had a joint workshop on April 16th 2024, called «Biocarbon use in metallurgical industries: Identifying changes and challenges». A total of 27 people gathered physically (+22 digital) to better get to know each project, and to present and discuss the most important changes and challenges related to the use of biocarbon in the metallurgical industry. Øyvind Skreiberg and Gøril Jahrsengene had a joint presentation about BioCarbUpgrade, Gang Xin (WAI ES) and Einar Stuve (OBIO) presented from the biocarbon producer side, and representatives from the industry partners Elkem and Eramet also presented their perspective.

Workshop participants.

Publication list

Marvin Werra, Hans Kristian Bugge Tørset, Ting Hua, Xiangping Hu, Laurent Joncourt, Thibault Cheisson, Marcos Djun Barbosa Watanabe, Øyvind Skreiberg, Francesco Cherubini (2026). Charcoal as Reductant in Silicomanganese Production in Gabon: Life-Cycle Assessment and Biomass Supply Potential. Biochar Summit 2026, 10-11 June 2026, Vienna, Austria.

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Liang Wang, Jørn Bakken, Zsuzsanna Czégény, Yusuf Tolunay Kilic, Øyvind Skreiberg, Bence Babinszki, Robert Johnson, Kentaro Umeki, Scott Q Turn (2026). Study on biocarbon produced from untreated and water leached bark. 25th International Symposium on Analytical and Applied Pyrolysis 7-11 June 2026, Pisa, Italy.

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