

BioCarbUpgrade – Upgrading biocarbon for sustainable metallurgical industries



Newsletter 2-2025

Progress in 2025

In 2025 the focus has been on assessing different enhanced carbonisation experiments (in two atmospheric and one pressurised pyrolysis reactor) and characteristics of the products, and upgraded feedstocks and biocarbons, as well as on storage and logistics of biocarbon. 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 the PhD candidate has now published one manuscript and submitted another one.

BioCarbUpgrade event in Trondheim

The fifth BioCarbUpgrade workshop and SC meeting was arranged in Trondheim, hosted by SINTEF Industry, on 29-30 October 2025. In the meeting, the project and its activities were presented and discussed. During the meeting a tour of the SINTEF Industry laboratory facilities was arranged.



Workshop participants visiting the SINTEF Industry laboratory facilities. 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 first manuscript and submitted another one - "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".

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 CO₂-equivalents per tonne of alloy (mean \pm 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 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

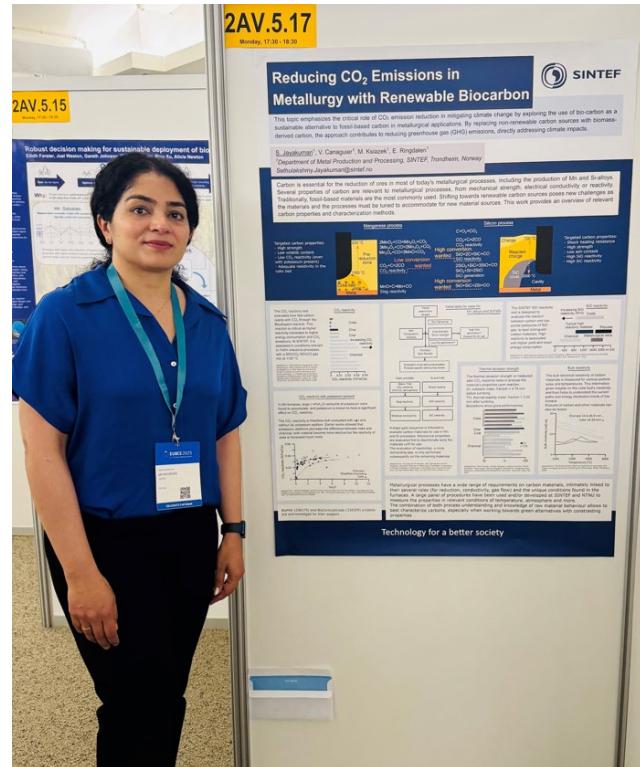
A BioCarbUpgrade work was presented at ICheaP17, Florence, Italy, 29 June - 2 July 2025:

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 CO₂ 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, Wiśla, 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.

News briefs from the last year

Production, Upgrading & Industry News

January 2025

Vow Green Metals & Outokumpu Supply Agreement. Vow Green Metals signed a definitive 3-year supply agreement with stainless steel giant Outokumpu. This contract secures the offtake for a significant portion of the production from the Hønefoss plant, validating the commercial demand for Norwegian biocarbon in the European high-end steel market. [Read more](#)

Elkem Carbon Fiskaa Refurbishment Completed. Elkem completed the major refurbishment of its baking furnace at the Fiskaa plant in Kristiansand. The upgrade includes new handling systems specifically designed for biocarbon blends, allowing the plant to increase its bio-share in electrode paste production without compromising mechanical stability. [Read more](#)

February 2025

Eramet Launches "eraLow" Manganese Alloys. Eramet officially branded its low-carbon manganese alloys as "eraLow," aimed at the premium green steel market. The product line heavily relies on the "bio-reduction" strategy (substituting fossil coke with biocarbon) currently being piloted at their Norwegian plants in Sauda and Kvinesdal. [Read more](#)

Vow Green Metals Accelerates Viken Park Pre-Study. Following successful feasibility studies, Vow Green Metals entered the final pre-study phase for its large-scale plant at Viken Park. The facility targets a production capacity of 30,000 tons and is designed to act in industrial symbiosis with other tenants, utilizing excess heat and bio-oil byproducts. [Read more](#)

March 2025

Wacker Chemicals Norway Signs Import Deal. To meet immediate decarbonization goals while domestic production scales up, Wacker Chemicals Norway signed a long-term agreement to import high-grade biocarbon. This move highlights the current "volume gap" where demand for green reductants in the silicon industry exceeds local Norwegian supply. [Read more](#)

Fesil Rana Increases Bio-Share. The Fesil ferroalloy plant in Mo i Rana reported reaching a new milestone

of 25% biocarbon substitution in two of its furnaces. The achievement was attributed to a new sourcing strategy for locally densified charcoal that better withstands the physical pressure of the burden. [Read more](#)

April 2025

Elkem Launches Recycled Silicones for Label Industry. Elkem introduced a new range of recycled silicone products, demonstrating circularity in the downstream value chain. This reduces the total carbon footprint of their products, complementing upstream efforts to use biocarbon in the initial smelting process to meet customer "Scope 3" reduction targets. [Read more](#)

Washington Mills Advanced Biocarbon Trials. The silicon carbide producer Washington Mills, located in Orkanger, reported advanced trials replacing petroleum coke with biocarbon. This substitution is critical for reducing the high SOx emissions associated with traditional petcoke, addressing both local air quality and global climate goals. [Read more](#)

May 2025

Elkem AGM Reaffirms 50% Biocarbon Goal. At its Annual General Meeting, Elkem's shareholders approved the continued strategic focus on the "Climate Roadmap." This includes the ambitious target of reaching 50% biocarbon in the raw material mix globally by 2030, despite the short-term financial headwinds caused by high Norwegian energy prices. [Read more](#)

Tizir Titanium & Iron Biocarbon Tests. The Tizir smelter in Tyssedal announced positive results from its latest campaign using biocarbon in the pre-reduction process of ilmenite. The trials confirmed that biocarbon could replace coal without negatively affecting the quality of the titanium slag or the high-purity iron byproduct.

June 2025

Hydro Tests Green Hydrogen in Casthouse. Norsk Hydro successfully tested green hydrogen in a melting furnace at its Høyanger recycling plant. This pilot proves that hydrogen can replace natural gas in the casthouse, offering a fossil-free heat source that complements the decarbonization of the electrolysis process itself. [Read more](#)

Arbaflame Expands Transatlantic Pellet Trade. Arbaflame celebrated increased export volumes of its steam-treated "black pellets" to North America. The success of these logistics proves the viability of Arbaflame's pellets as a global commodity, relevant

for Norwegian smelters looking to import high-quality, water-resistant biocarbon that can be stored outside. [Read more](#)

July 2025

HitecVision Acquires Majority of Vow Green Metals. Private equity firm HitecVision completed the acquisition of a majority stake in Vow Green Metals. This injection of capital and industrial expertise is intended to move Vow's project portfolio from "planning" to "construction," significantly de-risking the supply chain for major customers like Elkem. [Read more](#)

August 2025

Eramet Launches Sauda CCS Pilot. Eramet Norway commissioned its carbon capture pilot plant at the Sauda manganese smelter. The unit is designed to capture 70% of flue gas emissions, a critical percentage that allows the plant to reach net-zero when combined with a ~30% switch to biocarbon reductants. [Read more](#)

Norwegian Hydrogen & GreenIron Partnership. Norwegian Hydrogen and GreenIron signed an agreement to co-locate hydrogen production and direct reduction iron (DRI) plants. This partnership aims to produce fossil-free iron using hydrogen instead of coal, representing a radical technological alternative to biocarbon-based reduction for the steel industry. [Read more](#)

September 2025

Siva Invests in Hønefoss Infrastructure. State enterprise Siva invested NOK 152 million to acquire the factory buildings for Vow Green Metals' Hønefoss plant. This leaseback model reduces Vow's capital expenditure, allowing them to focus funds on the pyrolysis technology itself rather than real estate, accelerating the plant's completion. [Read more](#)

Elkem Unlocks Silicone Recycling Pathway. Elkem announced a breakthrough in mechanical recycling for silicone rubber. This innovation reinforces their circular economy strategy, reducing the volume of new silicon metal (and thus biocarbon/coal reductants) required to meet market demand, effectively lowering the biocarbon intensity per unit of utility. [Read more](#)

October 2025

Elkem Curtails Production Due to Power Prices. Citing high power prices and weak market demand, Elkem temporarily curtailed ferrosilicon production at its Norwegian plants. This event underscores the economic fragility of the transition: high operating

costs currently limit the financial headroom needed to pay "green premiums" for biocarbon. [Read more](#)

Finnfjord & Carbon Recycling International Update. Finnfjord AS reported continued progress on integrating the world's largest commercial CO₂-to-methanol plant. The facility uses furnace gas and biocarbon synergies to lower the carbon footprint of ferrosilicon, serving as a flagship example of CCU (Carbon Capture and Utilization) in the Nordics. [Read more](#)

November 2025

Hydro Roadmap: Biomethane at Sunndal. Norsk Hydro updated its net-zero roadmap, revealing that it has replaced 70% of natural gas with biomethane in the casthouse at Sunndal. This demonstrates that biocarbon (in gas form) is effectively decarbonizing the heating processes downstream of the electrolysis cells. [Read more](#)

Standard Bio AS High-Density Briquettes. Standard Bio AS reported significant progress in their densification technology, producing biocarbon briquettes with higher mechanical strength. This breakthrough addresses the "fines" issue, where biocarbon typically crumbles in large furnaces, and is a key enabler for higher substitution rates. [Read more](#)

December 2025

Vow Green Metals Hønefoss Hot Commissioning. By year-end 2025, Vow Green Metals reported that its Hønefoss Phase 1 plant was in the final stages of "hot commissioning." The plant represents the first industrial-scale proof of the concept in Norway, setting the stage for the larger Viken Park facility to follow in 2026/27. [Read more](#)

Vow Green Metals becomes Arbion Industries. Vow Green Metals changes its name to Arbion Industries, marking a new chapter that reflects the company's ambition of scaling operations and becoming a leading European producer of biocarbon, building an integrated industrial platform for biocarbon production. [Read more](#)

Implementation, Research & Innovations & Funding

January 2025

FME ZeMe Official Kick-Off (Jan 15). The "Zero Emission Metal Production" (ZeMe) research centre held its official opening in Trondheim. With a budget spanning eight years, the centre coordinates over 30 partners to solve specific technical barriers in

substituting coal with biocarbon and integrating hydrogen in metal production processes. [Read more](#)

Enova's New 2025-2028 Mandate Starts. The Norwegian Ministry of Climate and Environment implemented a new four-year steering agreement for Enova. The revised mandate pivots funding criteria more aggressively toward "market development" for immature value chains, directly benefitting high-capex biocarbon projects that previously struggled to meet energy-efficiency metrics. [Read more](#)

Hafslund Celsio CCS Project Resumed. After cost-related delays, the full-scale CCS project at the Klemetsrud waste-to-energy plant was fully resumed. This revitalizes the "Longship" value chain, ensuring that the Northern Lights storage infrastructure—critical for future metallurgical CCS projects—will be operational on schedule. [Read more](#)

February 2025

Northern Lights "Ship 2" Arrives. The second CO₂ transport ship for the Northern Lights project, *Northern Pathfinder*, arrived for bunkering trials. This logistical milestone confirms the readiness of the transport value chain that Norwegian smelters will rely on for offloading captured process emissions that biocarbon alone cannot eliminate. [Read more](#)

IFE Launches "Bio-Battery" Project. The Institute for Energy Technology (IFE) launched a new research project exploring the use of hard carbon derived from Norwegian spruce in sodium-ion batteries. This innovation could create a high-value secondary market for biocarbon producers, improving the overall economics of the sector. [Read more](#)

March 2025

SINTEF "EnergyProSafe" Project Launch. SINTEF launched the "EnergyProSafe" project (2025–2028) to address safety risks such as self-heating and explosion in biocarbon storage and transport. Solving these safety hurdles is a prerequisite for insurance and large-scale logistics of "new fuels" in the industry. [Read more](#)

NTNU Doctoral Defense on Biocarbon Reactivity. A pivotal PhD defense at NTNU provided new models for predicting how different biocarbon types react in submerged arc furnaces. The research offers a "selection tool" for metallurgists to match specific wood species to specific alloy production requirements, reducing trial-and-error costs. [Read more](#)

April 2025

Biocarbon in Metallurgy Conference (Apr 8-9). Held in Poland with strong Norwegian leadership from SINTEF/NTNU, this conference concluded that "Volume, not Technology" is now the primary barrier to 2030 adoption. The event served as a key forum for aligning European research agendas with industrial reality. [Read more](#)

Green Platform "Circ-Bio" Interim Results. The ongoing Green Platform project "Circ-Bio" released interim results showing that pre-treatment of demolition wood can reduce contaminants to levels acceptable for ferrosilicon production. This opens up a vast, low-cost feedstock reserve that avoids competition with the pulp and paper industry. [Read more](#)

May 2025

Eyde Cluster Visits Returkraft CCU Pilot. The Eyde Cluster organized industry visits to the Returkraft waste-to-energy Carbon Capture and Utilization (CCU) pilot. The transfer of knowledge from waste incineration to the metallurgical process industry is crucial for plants like Glencore Nikkelverk and Elkem Carbon to implement similar capture technologies. [Read more](#)

June 2025

BioCarbUpgrade Project Results. SINTEF's "BioCarbUpgrade" project released findings on using "bio-binders" to improve the mechanical strength of biocarbon pellets. This research directly tackles the "fines generation" issue in furnaces, which has historically limited biocarbon substitution to lower percentages. [Read more](#)

NIBIO Report on Biochar Stability. NIBIO published critical research urging a "100-year stability" framework rather than "eternal" storage for biochar. This scientific input impacts how biocarbon credits are calculated and verified for the metallurgical industry's carbon accounting. [Read more](#)

July 2025

European Innovation Scoreboard 2025. The 2025 Scoreboard classified Norway as a "Strong Innovator," highlighting effective public-private partnerships like FME ZeMe. However, it noted a gap in scaling up hardware innovations, validating the need for instruments like the EU Innovation Fund to bridge the "valley of death" for biocarbon plants. [Read more](#)

Elkem Wins EU ETS Free Allowance Appeal. The Norwegian Ministry of Climate and Environment ruled in favor of Elkem regarding a complaint on the allocation of free EU ETS quotas. This regulatory win

secures millions in value for Elkem, preserving capital that can be reinvested in decarbonization projects. [Read more](#)

August 2025

Elkem Awarded NOK 33M for Recycled Products.

Innovation Norway awarded Elkem NOK 33 million to develop low-emission products for the automotive and construction industries. The project focuses on using recycled silicon and biocarbon to lower the embedded carbon, meeting stricter procurement standards. [Read more](#)

Research Council "Blue Carbon" Call. A new transnational call opened focusing on "Blue Carbon Ecosystems," funding research into algae and marine biomass. This represents a long-term strategic pivot to find alternative biomass sources for industry, relieving pressure on forestry. [Read more](#)

September 2025

SMA Mineral Receives Enova Support. SMA Mineral received significant funding to build a new lime plant in Mo Industrial Park. The plant utilizes new technology that allows for biocarbon integration and electrification, showcasing Enova's support for industrial pilots. [Read more](#)

Alcoa Mosjøen Biocarbon Pilot Update. Alcoa continued testing biocarbon anodes at its Mosjøen smelter, reporting mixed results on mechanical stability. The ongoing research highlights the difficulty of replacing calcined petroleum coke in the electrolysis part of aluminium production compared to the reduction part of silicon production. [Read more](#)

October 2025

Beyonder Battery Anode Research. Beyonder progressed in using biocarbon from sawdust for battery anodes. While not metallurgical reduction, this innovation creates high-value off-take competition for the same sawdust resources that smelters rely on for biocarbon production. [Read more](#)

Norwegian Catapult Centre Tests. New biocarbon pelletizing technologies were verified at the Sustainable Energy Catapult Centre. The centre provides a testing ground for small-scale biocarbon producers to prove their product quality before engaging with major smelters like Elkem or Hydro. [Read more](#)

November 2025

Vow Green Metals Wins €26.2M EU Grant. Vow Green Metals was awarded EUR 26.2 million from the EU Innovation Fund to finance its second large-scale

biocarbon plant at Viken Park. This grant is a critical validation of the technology and provides the non-dilutive equity needed to trigger final investment decisions. [Read more](#)

LanzaTech & Eramet Win €40M EU Grant. The EU Innovation Fund awarded €40 million to LanzaTech for a facility in Porsgrunn that will convert Eramet's furnace off-gases into ethanol. This CCU breakthrough turns pollution into a valuable product, offering a second revenue stream for the smelter. [Read more](#)

December 2025

Enova Launches Floating Wind Call. Enova launched a NOK 2 billion call for floating wind projects. This is critical for the long-term "electrification + biocarbon" strategy of coastal smelters, which require vast amounts of new renewable power to replace fossil energy in heating processes. [Read more](#)

Green Platform Awards Announced. The Research Council of Norway announced the 2025 winners of the "Green Platform" funding. Several projects focused on "circular bioeconomy" were awarded grants, specifically targeting the logistics cost reduction of transporting forest residues to industrial hubs. [Read more](#)

Policy, Regulations & Market Framework

January 2025

EU ETS Maritime Full Effect (Jan 1). Shipping officially entered the EU ETS, raising logistics costs for imported biomass and biocarbon. This policy shift significantly improves the relative competitiveness of locally sourced Norwegian biocarbon compared to imports from the Americas or Asia that require deep-sea transport. [Read more](#)

FuelEU Maritime Regulation Starts. This regulation mandates lower GHG intensity in shipping fuels, creating a new market for biocarbon by-products (bio-oils) as maritime fuel. This regulatory pull improves the overall project economics for biocarbon producers by valorizing the liquid fraction of pyrolysis. [Read more](#)

February 2025

EU "Clean Industrial Deal" Launched. The European Commission launched the "Clean Industrial Deal" to accelerate industrial decarbonization. For Norway, this strengthens the framework for Carbon Contracts for Difference (CCfDs) and provides new funding avenues for projects combining biocarbon and CCS. [Read more](#)

March 2025

National Inventory Document Released. The Norwegian Environment Agency's annual GHG inventory report identified the metallurgical industry as the primary remaining source of land-based emissions. The report explicitly pointed to biocarbon substitution as the most "technology-ready" lever for immediate emission cuts before 2030. [Read more](#)

April 2025

IMO Net-Zero Framework Approved The IMO approved new net-zero regulations effective from 2027. This signals future cost increases for international shipping, further encouraging Norwegian industry to shorten their supply chains and rely on domestic or regional biomass sources. [Read more](#)

May 2025

Nordic Council Bioeconomy Report. A report from the Nordic Council highlighted a "biomass deficit" in the region, urging cross-border cooperation on forestry. The report warned that competition between energy (heating) and industry (reduction) for wood fibre is intensifying, requiring clearer prioritization policies. [Read more](#)

June 2025

Revised Waste Regulations for Wood. Norwegian authorities updated waste regulations to clarify the definition of "waste wood." This regulatory easing facilitates the use of demolition wood as a raw material for biocarbon production without requiring complex waste processing permits, unlocking new feedstock volumes. [Read more](#)

July 2025

Bioenergy Europe Calls for EUDR Simplification. A coalition including Bioenergy Europe called for urgent simplification of the EU Deforestation Regulation (EUDR). Norwegian industry supported this, as complex tracing requirements for wood chips threaten to bottle-neck the supply of biomass for biocarbon production. [Read more](#)

Norway's "Climate Action Plan" Status. The government's updated status report confirmed that biocarbon remains the single largest "technology-ready" lever for reducing process emissions in the metallurgical sector by 2030, reinforcing its central place in national climate strategy. [Read more](#)

August 2025

Norsk Industri CBAM Position Paper. The Federation of Norwegian Industries published a

position paper demanding that the EU CBAM (Carbon Border Adjustment Mechanism) include "downstream products." Without this, Norwegian alloy producers fear their low-carbon metal will be undercut by cheap, high-carbon finished goods imported from Asia. [Read more](#)

September 2025

Statskog Biomass Strategy. State-owned Statskog released a strategy to prioritize industrial wood access over raw export. This policy shift aims to ensure that Norwegian forest resources contribute to domestic value creation (biocarbon/industry) rather than being exported as raw logs. [Read more](#)

Standard Norway Biocarbon Standards Drafted. New national standards for "Industrial Biocarbon" were drafted to unify trading specifications. These standards provide a common language for moisture, fixed carbon, and density, facilitating smoother trade between producers (forestry) and consumers (metallurgy). [Read more](#)

October 2025

National Budget 2026: CO₂ Tax Hike. The proposed 2026 budget included a sharp increase in the CO₂ tax for non-ETS sectors. This impacts the transport and forestry sectors, potentially increasing the cost of biomass logistics but also incentivizing the switch to zero-emission transport solutions. [Read more](#)

November 2025

EU Safeguard Measures Exempt Norway. The EU Commission announced new safeguard measures on ferroalloy imports but explicitly exempted Norway (EEA). This decision protects market access for Norwegian producers, ensuring their low-carbon products do not face the same tariffs as high-carbon Asian competitors. [Read more](#)

Other news

Historical agreement in Denmark

10 billion Danish kroner will towards 2045 be made available for global warming abatement efforts in the Danish agricultural sector, which includes a CO₂ tax from 2030 on greenhouse gas emissions from livestock and a significant focus on biocarbon production and the utilization of biocarbon for different global warming abatement purposes. [Read more here](#).

Carbon Removal Certification Framework (CRCF)

"On 10 April 2024, the European Parliament adopted the provisional agreement on the Carbon Removals

and Carbon Farming (CRCF) Regulation, which created the first EU-wide voluntary framework for certifying carbon removals, carbon farming and carbon storage in products across Europe. By establishing EU quality criteria and laying down monitoring and reporting processes, the CRCF Regulation will facilitate investment in innovative carbon removal technologies, as well as sustainable carbon farming solutions, while addressing greenwashing." Read more [here](#).

KSP-K EnergyProSafe has started

A 4-years knowledge building project (KSP-K) connected to energy production and safety aspects in the biocarbon value chains for the metallurgical industries was applied for in March 2024 and was granted funding from the Research Council of Norway in June 2024. The project had its kick-off meeting 5 June 2025 and its first ordinary consortium gathering in November 2025. 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 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 is a member of its board. Also the BioCarbUpgrade industry partners Elkem, Norsk Hydro and OBIO 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 10-11 June 2025: [Biochar Summit](#), in collaboration with Biochar Europe. The next Biochar Summit will be arranged 10-11 June 2026 in Vienna. 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 Prosessteknologi](#), 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](#).

For more info about Prosess21:

<https://www.prosess21.no/>

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.

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 has now been established and the kick-off meeting was arranged January 14.

A conference co-organised by ZeMe, [Biocarbon in metallurgy](#), was arranged in Wiśla in Poland 8-9 April, with the BioCarbUpgrade project as one of the contributors. A new conference is planned 22-23 April 2026, in Kraków, Poland.

Recent events

INFACON 2024, 18-22 September, Beijing, China.

<https://www.infacon17.net/> (triennial)

Biochar IV, 18-23 May 2025, Santa Marta, Colombia.

<https://engconf.us/conferences/materials-science-including-nanotechnology/bio-char-iv/> (biennial)

EUBCE 2025, 9-12 June 2025, Valencia, Spain.

<https://www.eubce.com/>

The Biochar Summit 2025, June 10-11, 2025, Brussels, Belgium. <https://www.biochar-industry.com/2024/save-the-date-the-biochar-summit-2025/>

ICHEAP17, 17th International Conference on Chemical and Process Engineering 29 June - 2 July 2025, Florence, Italy. <https://www.aidic.it/icheap17/> (biennial)

E2DT, Palermo, Italy, 12-15 October, 2025.

<https://www.aidic.it/e2dt2025/> (biennial)

ICSOBA 2025, 26 - 31 October 2025, Nanning, China. <https://icsoba.org/2025/>

Upcoming 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.

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)



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)



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

[BioCarbUp](#)

[BioCarb+](#)

[KPN reduced CO₂](#)

[Prosess21](#)

[SKOG22](#)

[Energi21](#)

[Norsk Biokullnettverk](#)

[Nordic Biochar Network](#)



Project information and past achievements

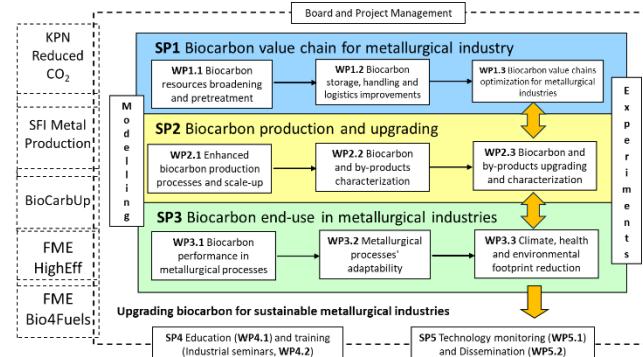
About the project

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/>
SEI Metal Production: <https://www.ntnu.edu/metro>

FME HighEFF: Centre for an Energy Efficient and Competitive Industry for the Future. <http://www.higheff.no>

for the future, <http://www.mgchem.no>
KPN Reduced CO₂ emissions from metal production,
<https://www.sintef.no/en/projects/reduced-co2-reduced-co2-emissions-in-metal-production/>

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 CO₂ footprint of the metallurgical industry. The roadmap targets a 43% reduction of CO₂ 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 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 apolloabetulins 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 Skreberg (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 Skreberg (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 CO₂ 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 CO₂ 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 CO₂ 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 CO₂ 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 CO₂ reactivity and the results from investigations of various carbon materials are presented and discussed. Studies show that charcoal has the highest CO₂ reactivity due to its physical and chemical properties. In addition, the effect of alkalis in charcoal on CO₂ 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 CO₂ 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 $31 \pm 15 \text{ kg/m}^3$, and the porosity was $1.8 \pm 1.1 \text{ vol \%}$. 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 $2.8 \pm 1.1 \text{ wt \%}$, for the condensable fraction $6.5 \pm 3.3 \text{ wt \%}$, and for the pyrolysis gas $4.1 \pm 1.9 \text{ wt \%}$. 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, a . 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 (N₂)] 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 % H₂O 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 \$\text{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 \$\text{CO}/\text{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 N₂. 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' CO₂ 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/CO₂ and SiO gas reactivity test, K-impregnation and CH₄-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 Ringdal (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 CO₂-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 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 Skreiber, Karl Oskar Pires Bjørgen, Zoltán Sebestyén, Zsuzsanna Czégény, Jørn Bakken. Production and characterization of biocarbon under different conditions.

BioCarbUpgrade at Pyro2024

Two BioCarbUpgrade 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 Skreiber. Study on Slow Pyrolysis of Spruce, Pine and Birch Bark.

2) Bence Babinszki, Zoltán Sebestyén, Emma Jakab, Liang Wang, Øyvind Skreiber, 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 Skreiber. A critical review on self-heating and self-ignition of biocarbon.

2) Liang Wang, Øyvind Skreiber. 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 CO₂ 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 BioCarbUpgrade 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, Liang Wang, Scott Turn, Øyvind Skreiber. Biocarbons produced under pressurized conditions: characterisation of the volatiles.

2) Bence Babinszki, Zoltán Sebestyén, Emma Jakab, Luca Köhalmi, János Bozi, Gábor Várhegyi, Liang Wang, Øyvind Skreiber, 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 Skreiber. [Biochar: Renewable carbon from biomass for the metallurgical industry](#). SINTEF blog 20 February 2023.

Øyvind Skreiber. [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 Skreiber, 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.

Publication list

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](#). Environmental Impact Assessment Review 117, 108204.

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. LCM 2025, 9-12 September 2025, Palermo, Italy.

Øyvind Skreiberg. [SLCFs: What are short-lived climate forcers and how do they affect the climate?](#) SINTEF blog 8 August 2025.

Liang Wang, Øyvind Skreiberg (2025). [EnergyProSafe – Improving energy production and safety in biocarbon value chains, and BioCarbUpgrade](#). EERA Bioenergy News 23, p. 8, 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](#). Chemical Engineering Transactions 117:175-180.

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. ICheaP17, 29 June - 2 July 2025, Florence, Italy.

Sethulakshmy Jayakumari, Vincent Canaguier, Michal Ksiazek, Eli Ringdalen (2025). Reducing CO₂ emissions in metallurgy with renewable biocarbon. EUBCE 2025, 9-12 June 2025, Valencia, Spain.

Bence Babinszki, Zsuzsanna Czégény, Liang Wang, Øyvind Skreiberg, Jørn Bakken (2025). Characterization of liquid by-products from pyrolysis of birch, spruce and pine bark. Biochar IV, 18-23 May 2025, Santa Marta, Colombia.

Liang Wang, Jørn Bakken, Øyvind Skreiberg, Zsuzsanna Czégény, Bence Babinszki (2025). Production of Biocarbon from Untreated and Leached Birch, Spruce and Pine Bark. Biochar IV, 18-23 May 2025, Santa Marta, Colombia.

Marvin Werra (2025). Life-cycle assessment of Ferromanganese production using biocarbon as reductant and carbon capture and storage. Biocarbon in Metallurgy 2025, 8-9 April 2025, Wiśla, Poland.

Simen Gjølsjø (2025). The wood resources in Europe and Scandinavia. Biocarbon in Metallurgy 2025, 8-9 April 2025, Wiśla, Poland.

Hans Kristian Bugge Tørset (2025). Charcoal for Low-Carbon SilicoManganese Production in Gabon - Quantifying Sustainable Potentials with Life Cycle Assessment and Land Cover Analysis. Master's thesis in Energy and Environmental Engineering, NTNU.

Zsuzsanna Czégény, István Sándor Czirok, Gergő Szabó, Zoltán Sebestyén, Bence Babinszki, Liang Wang, Øyvind Skreiberg (2025). Water Leaching of Wood Barks for Biocarbon Production. ACS Spring meeting 2025, 23-27 March, San Diego, USA.

Bence Babinszki, Zoltán Sebestyén, Emma Jakab, István Sándor Czirok, Liang Wang, Øyvind Skreiberg, Zsuzsanna Czégény (2025). [Impact of water leaching of biomass on the composition of torrefaction condensates](#). Journal of Analytical and Applied Pyrolysis 189, 107092.

Gøril Jahrsengene (2024). Decarbonization of Metallurgical Industries – Research Approaches and Opportunities in Norway. Seminar series at University of Hawaii at Manoa, 4 October 2024, Honolulu, USA.

Sethulakshmy Jayakumari, Michal Ksiazek (2024). [Fines Generation and Strength of Various Carbon Materials Used in the Ferroalloy Industries](#). Proceedings of Silicon for the chemical and solar industry XVII, Trondheim, 10-12 September 2024.

Liang Wang, Øyvind Skreiberg, Karl Oskar Pires Bjørgen, Zoltán Sebestyén, Zsuzsanna Czégény, Jørn Bakken (2024). Production and characterization of biocarbon under different conditions. Impacts of Fuel Quality 2024, 2-6 September 2024, Garmisch-Partenkirchen, Germany.

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](#). Journal of Thermal Analysis and Calorimetry, <https://doi.org/10.1007/s10973-024-13381-4>.

Liang Wang, Jørn Bakken, Zsuzsanna Czégény, Øyvind Skreiberg (2024). Study on Slow Pyrolysis of Spruce, Pine and Birch Bark. 24th International Symposium on Analytical and Applied Pyrolysis, 19-23 May 2024, Beijing, China.

Bence Babinszki, Zoltán Sebestyén, Emma Jakab, Liang Wang, Øyvind Skreiberg, Zsuzsanna Czégény (2024). Comparative study on the composition of condensates, the liquid by-products of biomass torrefaction. 24th International Symposium on Analytical and Applied Pyrolysis, 19-23 May 2024, Beijing, China.

Liang Wang, Øyvind Skreiber, Robert L. Johnson, Zhang Yang, Alba Dieguez-Alonso, Scott Turn, Kentaro Umeki (2023). Production, Characterization and Conversion of Biocarbon under Different Conditions. Nordic Flame Days 2023, 28-30 November, Trondheim, Norway.

Liang Wang, Øyvind Skreiber (2023). [A critical review on self-heating and self-ignition of biocarbon](#). Chemical Engineering Transactions 105:271-276.

Liang Wang, Øyvind Skreiber (2023). [Evaluation of water leaching on properties of woody biomass for biocarbon production](#). Chemical Engineering Transactions 105:277-282.

Sethulakshmy Jayakumari, Gøril Jahrsengene, Michal Ksiazek, Eli Ringdalen (2023). [Investigations on CO₂ reactivity and Thermal Strength of Carbon Sources for Ferroalloy and Silicon Production](#). Proceedings of The 62nd Conference of Metallurgists, COM 2023, pp. 1009-1018.

Gøril Jahrsengene, Sethulakshmy Jayakumari, Ida Kero, Eli Ringdalen (2023). [Sustainable Metal Production – Use of Biocarbon and the Concern of Dusting](#). Proceedings of The 62nd Conference of Metallurgists, COM 2023, pp. 1001-1007.

Liang Wang, Øyvind Skreiber (2023). A critical review on self-heating and self-ignition of biocarbon. E2DT, 22-25 October 2023, Palermo, Italy.

Liang Wang, Øyvind Skreiber (2023). Evaluation of water leaching on properties of woody biomass for biocarbon production. E2DT, 22-25 October 2023, Palermo, Italy.

Øyvind Skreiber (2023). KPN BioCarbUp & KSP BioCarbUpgrade - Hovedresultater. Eramet metallurgisk møte, 13 september 2023, Trondheim.

Gøril Jahrsengene (2023). Sustainable Metal Production – Use of biobased materials. CaNAI Summer School, August 28-30, Laval University, Quebec, Canada.

Sethulakshmy Jayakumari, Gøril Jahrsengene, Michal Ksiazek, Eli Ringdalen (2023). Investigations on CO₂ reactivity and Thermal Strength of Carbon Sources for Ferroalloy and Silicon Production. The 62nd Annual Conference of Metallurgists, August 21-24, 2023, Fairmont Royal York, Toronto, Canada.

Gøril Jahrsengene, Sethulakshmy Jayakumari, Ida Kero, Eli Ringdalen (2023). Sustainable Metal Production – Use of Biocarbon and the Concern of Dusting. The 62nd Annual Conference of Metallurgists, August 21-24, 2023, Fairmont Royal York, Toronto, Canada.

Øyvind Skreiber (2023). [Upgrading biocarbon for sustainable metallurgical industries](#). EERA Bioenergy News 19, July 2023, p. 13.

BioCarbUp publications:

Kyle Anthony Castillo, Robert L. Johnson, Christian Jayme Castillo, Liang Wang, Øyvind Skreiber, Scott Turn (2025).

[Experimental Optimization of Pellet Tensile Strength from Spruce Biochar Produced at Elevated Pressure](#). Energy & Fuels 39:1668-1678.

Jingyuan Zhang, Corinna Netzer, Tian Li, Terese Løvås (2024). [A novel model for solid fuel combustion with particle migration](#). Proceedings of the Combustion Institute 40, 105575.

Przemyslaw Maziarka, Norbert Kienzl, Alba Dieguez-Alonso, Wolter Prins, Pablo J. Arauzo, Øyvind Skreiber, 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](#). Energy Fuels 38:9772-9793.

Gábor Várhegyi (2024). [Can varying activation energy be determined reliably from thermogravimetric experiments?](#) Journal of Thermal Analysis and Calorimetry. <https://doi.org/10.1007/s10973-024-13261-x>

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](#). Fuel 368, 131600.

Kyle Anthony A. Castillo (2023). An experimental investigation of transient plastic phase biochar: reactor conditions and biochar properties. University of Hawai'i at Mānoa Master Thesis.

Jingyuan Zhang, Tian Li, Corinna Netzer, Terese Løvås (2023). A novel porous media approach for the simulation of biomass combustion in a fixed-bed. Nordic Flame Days 2023, Trondheim, Norway, 28-30 November 2023.

Gábor Várhegyi (2023). [Problems with the determination of activation energy as function of the reacted fraction from thermoanalytical experiments](#). Journal of Thermal Analysis and Calorimetry. <https://doi.org/10.1007/s10973-023-12559-6>

Robert L. Johnson, Kyle Castillo, Christian Castillo, Liang Wang, Øyvind Skreiber, Scott Q. Turn (2023). Use of Plasticized Biochar Intermediate for Producing Biocarbons with Improved Mechanical Properties. Biochar III: Production, Characterization and Applications, 17-22 September 2023, Tomar, Portugal.

Robert L. Johnson, Kyle Castillo, Christian Castillo, Cassidy Hihara, Quang-Vu Bach, Liang Wang, Øyvind Skreiber, Scott Turn (2023). [Biocarbon Production via Plasticized Biochar: Role of Feedstock, Water Content, Catalysts, and Reaction Time](#). Energy & Fuels 37:15808-15821.

Liang Wang, Øyvind Skreiber, 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/CO₂](#). Fuel 346, 128233.

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](#). ACS Sustainable Chemistry & Engineering 11, 5845-5857.

Zsuzsanna Czégény, I.S. Czirok, Robert Johnson, Zoltán Sebestyén, Bence Babinszki, Emma Jakab, Liang Wang, Scott Turn, Øyvind Skreiberg (2023). Biocarbons produced under pressurized conditions: characterisation of the volatiles. JTACC, 20–23 June 2023, Balatonfüred, Hungary.

Bence Babinszki, Zoltán Sebestyén, Emma Jakab, Luca Köhalmi, János Bozi, Gábor Várhegyi, Liang Wang, Øyvind Skreiberg, Zsuzsanna Czégény (2023). The effect of pyrolysis conditions on yield, thermal behaviour and volatile matter composition of biocarbon products. JTACC, 20–23 June 2023, Balatonfüred, Hungary.

Gábor Várhegyi, Liang Wang, Øyvind Skreiberg (2023). [Kinetics of the CO₂ gasification of woods, torrefied woods, and wood chars. Least squares evaluations by empirical models](#). Journal of Thermal Analysis and Calorimetry. <https://doi.org/10.1007/s10973-023-12151-y>.

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](#). TMS 2023: Advances in Pyrometallurgy pp. 179–197.

Nicholas Smith-Hanssen, Gøril Jahrsengene, Eli Ringdalen (2023). [Biocarbon Materials in Metallurgical Processes—Investigation of Critical Properties](#). TMS 2023: Advances in Pyrometallurgy pp. 165–177.

Jingyuan Zhang, Tian Li, Henrik Ström, Boyao Wang, Terese Løvås (2023). [A novel coupling method for unresolved CFD-DEM modeling](#). International Journal of Heat and Mass Transfer 203, 123817.

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.

Øyvind Skreiberg (2023). BioCarbUp - Optimalisering av biokarbon verdikjeden for en bærekraftig metallurgisk industri. Norsk Biokullnettverk årskonferanse, 11-12 januar 2023, Stavanger.

Øyvind Skreiberg (2022). [The Contribution of Biomass to Reduce Global Warming](#). EERA Bioenergy News 18, December 2022, pp. 5-6.