BioCarbUpgrade – Upgrading biocarbon for sustainable metallurgical industries

Newsletter 1-2024

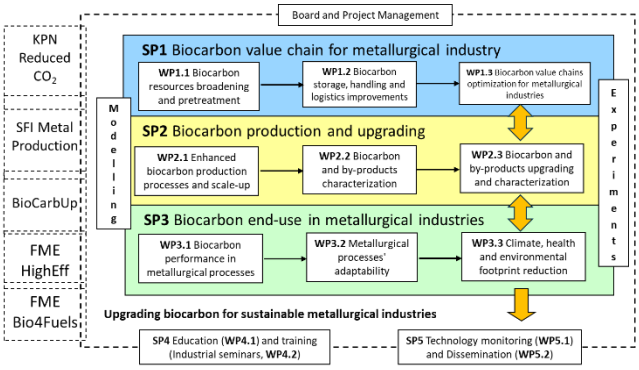
Introduction

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

The sub-objectives are:

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

The Work Breakdown Structure of BioCarbUpgrade is:



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

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

The BioCarbUpgrade consortium

SINTEF Energy Research will lead the project and will focus on biomass and biocarbon (BC) upgrading, BC production, process and plant upscaling, and dissemination to industry, authorities and the general public. NIBIO will lead the biomass resource activities. SINTEF ER will lead the biomass and BC upgrading activities and the BC production activities, assisted by University of Hawaii, Research Centre for Natural Sciences in Hungary, and Luleå University of Technology. SINTEF Industry will focus on the use of BC and bio-binder in metallurgical industry. NTNU will supervise the PhD and Master candidates and lead the research on the value chain assessments. The industrial partners include large and central industrial players in the metallurgical industry area in Norway (Elkem, Eramet Norway, Hydro) as well as their interest organisation Eyde Cluster, the biomass

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

supplier Norsk Biobrensel and the pyrolysis plant owners and operators OBIO and WAI Environmental Solutions, and they will contribute with finances and their extensive industrial knowledge generated through their commercial activities towards or within metallurgical industry. The constellation of project partners is complementary and strong, bringing together leading research organisations within the field and major industrial players.

Project background

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

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

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

Project overview

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

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

Biocarbon value chain for metallurgical industry - SP1

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

Biocarbon production and upgrading - SP2

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

Biocarbon end-use in metallurgical industries - SP3

The main objectives of SP3 are 1) Sustainability assessment of value chain performance of existing and improved metallurgical processes and connected systems for different metallurgical industries in Norway, 2) Assessment of the future role of woody biomass for reductants and materials in the Norwegian metallurgical industry within the context of progress towards the UN SDGs, and 3) Increasing expertise

throughout the biocarbon value chains for the metallurgical industries.
SP3 leader: Research Scientist Gøril Jahrsengene, SINTEF Industry

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

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

Progress in 2024

In 2024 the focus has been 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, and the PhD study on Advancing LCA Methods and Applications for a Sustainable Bioeconomy Transition.

BioCarbUpgrade event at Hydro Årdal

The second BioCarbUpgrade workshop and SC meeting was arranged at Hydro Årdal on 19-20 March 2024. In the meeting, the project and its activities were presented and discussed. The meeting was hosted by Hydro, who also arranged a tour of their facilities.

Workshop participants visiting the facilities at Hydro Årdal.

PhD work

The BioCarbUpgrade PhD position within value chain analysis (Advancing LCA Methods and Applications for a Sustainable Bioeconomy Transition) has been filled. The selected candidate is 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 three master students have been recruited connected to his PhD topic, each working towards one 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.

BioCarbUp in Journal of Thermal Analysis and Calorimetry

One BioCarbUpgrade work has been published in Journal of Thermal Analysis and Calorimetry:
Bence Babinszki, István Sándor Czirok, Robert Johnson, Zoltán Sebestyén, Emma Jakab, Liang Wang, Scott Turn, Øyvind Skreiberg, Zsuzsanna Czégény (2024). Volatile matter characterization of birch biochar produced under pressurized conditions. The abstract is given below.

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

BioCarbUpgrade in Chemical Engineering Transactions

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

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

BioCarbUpgrade in Chemical Engineering Transactions

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

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

BioCarbUpgrade in COM 2023 proceedings

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

"During industrial production of ferroalloys (FeMn/SiMn) and silicon (Si), carbon materials are used as the main reductants. The selection of carbon materials affects energy consumption, operational stability, and ultimately the yield and quality of the final product. Substituting fossil carbon with biocarbon as

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

BioCarbUpgrade in COM 2023 proceedings

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

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

BioCarbUp in Energy & Fuels

One BioCarbUpgrade associated work in the predecessor project BioCarbUp has been published in Energy & Fuels:
Przemyslaw Maziarka, Norbert Kienzl, Alba Dieguez-Alonso, Wolter Prins, Pablo J. Arauzo, Øyvind Skreiberg, Andrés Anca-Couce, Joan J. Manyà, Frederik Ronsse (2024). Part 2─Tailoring of Pyrolytic Char Properties with a Single Particle CFD Model with a Focus on the Impact of Shrinking, Vapor Cracking, and Char Permeability. The abstract is given below.

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

but a non-negligible effect on the soot formation, especially at 840 °C. The results indicate a need for further improvement of the primary degradation model to increase the accuracy of the effect of soot formation on the char structure."

BioCarbUp in Fuel

One BioCarbUpgrade associated work in the predecessor project BioCarbUp has been published in Fuel:
Tien Duc Luu, Jingyuan Zhang, Jan W. Gärtner, Shiqi Meng, Andreas Kronenburg, Tian Li, Terese Løvås, Oliver T. Stein (2024). Single particle conversion of woody biomass using fully-resolved and Euler–Lagrange coarse-graining approaches. The abstract is given below.

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

BioCarbUp in Journal of Thermal Analysis and Calorimetry

One BioCarbUpgrade associated work in the predecessor project BioCarbUp has been published in Journal of Thermal Analysis and Calorimetry:
Gábor Várhegyi (2024). Can varying activation energy be determined reliably from thermogravimetric experiments? The abstract is given below.

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

BioCarbUp in Energy & Fuels

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

"Studies into transient plastic phase biochar (TPPB) were conducted to compare how feedstock, moisture, acetic acid addition, and reaction time impacted the formation of TPPB and mechanical properties. Our results show that pyrolysis conditions sufficient for TPPB formation from birch wood do not lead to TPPB formation from spruce, cellulose (paper plates), or rice straw. However, TPPB formation was possible with spruce and rice straw with the addition of water to the initial material. Plasticized biochar and

non-plasticized biochar (NTPPB) produced from spruce and rice straw were compared in terms of the charcoal yield, proximate analysis (fixed carbon content), and mechanical properties of pelletized particles. Despite observing only minimal differences in the charcoal yields and fixed carbon contents between TPPB and NTPPB, the tensile strengths of biochar and biocarbon pellets [calcined at 900 °C (N_2)] were substantially improved with TPPB. Biocarbon pellets produced from spruce TPPB and rice straw TPPB were 5× and 1.5× stronger than the NTPPB counterparts. Adding 75 wt % H_2O to birch (nominal 8% moisture content) resulted in biocarbon with nearly 10 times higher tensile strength, despite both biocarbon materials being produced from a birch TPPB precursor. Birch biochars produced with shorter reaction times produced biocarbon pellets with nearly 3× higher tensile strength. Lastly, measured tensile (39 MPa) and compressive (188 MPa) strength values obtained from finely ground birch TPPB samples constitute one of the strongest biocarbon materials reported to date and would have sufficient mechanical strength to serve as a direct substitute for petroleum carbon anodes without any binder. These results demonstrate that plasticized biochar can be produced from a variety of different feedstocks and increasing their water content along with reducing the reaction time improves the mechanical properties of the biocarbon formed from the plasticized biochar intermediate."

BioCarbUp in Journal of Thermal Analysis and Calorimetry

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

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

BioCarbUp in Sustainable Chemistry & Engineering

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

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

BioCarbUp in Journal of Thermal Analysis and Calorimetry

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

"The gasification kinetics of chars forming from biomass materials was studied by kinetic equations of type dX/dt = A f(X) exp(−E/(RT)) where X is the conversion of the sample, A is the pre-exponential

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

BioCarbUp in Fuel

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

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

BioCarbUp in TMS 2023: Advances in Pyrometallurgy

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

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

BioCarbUp in TMS 2023: Advances in Pyrometallurgy

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

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

BioCarbUp in International Journal of Heat and Mass Transfer

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

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

BioCarbUp at Pyro2024

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

BioCarbUp results summarized in SINTEF blog and in a project handbook

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

BioCarbUp at JTACC 2023

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

behaviour and volatile matter composition of biocarbon products.

BioCarbUpgrade at the 62nd Annual Conference of Metallurgists

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

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

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

BioCarbUpgrade 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.

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

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

BioCarbUpgrade publications

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 Skreiberg, 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 Skreiberg (2023). A critical review on self-heating and self-ignition of biocarbon. Chemical Engineering Transactions 105:271-276.

Liang Wang, Øyvind Skreiberg (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 CO_2 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 Skreiberg (2023). A critical review on self-heating and self-ignition of biocarbon. E2DT, 22-25 October 2023, Palermo, Italy.

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

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

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

Sethulakshmy Jayakumari, Gøril Jahrsengene, Michal Ksiazek, Eli Ringdalen (2023). Investigations on CO_2 reactivity and Thermal Strength of Carbon Sources for Ferroalloy and Silicon Production. The 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 Skreiberg (2023). Upgrading biocarbon for sustainable metallurgical industries. EERA Bioenergy News 19, July 2023, p. 13.

BioCarbUp publications:

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. 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.

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 Skreiberg, 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 Skreiberg, 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 Skreiberg, Nicholas Smith-Hanssen, Sethulakshmy Jayakumari, Stein Rørvik, Gøril Jahrsengene, Scott Turn (2023). Investigation of gasification reactivity and properties of biocarbon at high temperature in a mixture of CO/CO_2. 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 Kőhalmi, 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 CO_2 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.

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 CO_2 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 granted funding

An application for 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 and was granted funding from the Research Council of Norway in June. 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.

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 now, after being in operation for more than three years, become a standalone organisation, i.e. no longer being only a project within the Norwegian Bioenergy Association (NoBio). 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. At the annual meeting of Norsk Biokullnettverk in January 2023, Øyvind Skreiberg presented results from the BioCarbUp project. All in all, the foundation of the network has been a timely one, serving its purpose. For more info about the network: https://www.biokull.info/ and the news page here, where you can find many interesting news from the biochar area, including regarding a new 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 was the main initiator of the Nordic Biochar Network. As a part of the network activities, conferences and webinars have been arranged, e.g. the recent Biochar Summit. 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)

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 has changed to EBI, i.e. with an increased industrial and European focus. An interesting article on Production quantities and C-sink potential of EBC-certified Biochar in 2023 is 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. Prosess21

provided their input to the work with a Report to the Storting (white paper) regarding how to reach the national climate goals for 2030. An interesting report, with respect to possible future use and priorities regarding biomass based materials in the Norwegian process industry, Biobasert Prosessindustri, is now finalized by one of the Prosess21 expert groups, 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 and BioMet joint workshop

BioCarbUpgrade and BioMet had a joint workshop on April 16th, 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 Sustainable Carbon Cycles initiative

FME Sustainable Carbon Cycles was a Centre for Environmentally Friendly Energy Research (FME) initiative. If funded, the centre would promote a sustainable valorisation of all biomass resources combining energy with utilisation of by- or co-products for materials and carbon storage applications.
A sketch application was submitted 10 May 2023 and the full application was submitted 15 November 2023, with several of the BioCarbUpgrade partners as participants. The decision regarding funding was announced in June. The competition was very strong, and the proposal did not receive funding. In any case, the initiative and its many partners clearly highlights the importance of the topic and the interest from a broad range of research, industrial and public actors. Øyvind Skreiberg and Michael Becidan from SINTEF Energy Research headed the initiative.
However, a FME targeted at the metallurgical industry was funded, the FME ZeMe - Zero Emissions Metal Production, which is very good news for the metallurgical industry and its fellow FME partners.

Recent events

Biochar Summit 2023, 12-15 June, Helsingborg, Sweden. https://www.biochar-summit.eu/

3rd Journal of Thermal Analysis and Calorimetry Conference 20–23 June 2023, Balatonfüred, Hungary. https://akcongress.com/jtacc/

The 62nd Annual Conference of Metallurgists, August 21-24, 2023, Fairmont Royal York, Toronto, Canada. https://metsoc.org/events-posts/the-62nd-annual-conference-of-metallurgists-com-2023/

E2DT, 22-25 October 2023, Palermo, Italy. https://www.aidic.it/e2dt2023/

ICSOBA 2023, 5-9 November 2023, Dubai, UAE. https://icsoba.org/2023/

Nordic Flame Days 2023, 29-30 November 2023, Trondheim, Norway, https://www.combustioninstitute.org/ci-event/nordic-flame-days-2023/

TMS 2024 Annual Meeting & Exhibition, Orlando, Florida, USA, 3-7 March 2024, https://www.tms.org/AnnualMeeting/TMS2024

IConBM2024, International Conference on BIOMASS 19-22 May 2024 Palermo, Italy, https://www.aidic.it/iconbm2024/

24th International Symposium on Analytical and Applied Pyrolysis, 19-23 May 2024, Beijing, China. http://pyro2024.yiyum.com

EUBCE 2024, 24-27 June 2024, Marseille, France, https://www.eubce.com/

Upcoming events

The 40th International Symposium of the Combustion Institute, 21-26 July 2024, Milan Italy, https://www.combustionsymposia.org/2024/

INFACON 2024, 18-22 September, Beijing, China, https://www.infacon17.net/

TMS 2025 Annual Meeting & Exhibit, 23-27 March 2025, Las Vegas, USA, https://www.tms.org/TMS2025

Links (click on the links or logos to get there)
BioCarbUp
BioCarb+
KPN reduced CO_2
Prosess21
SKOG22
Energi21
Norsk Biokullnettverk
Nordic Biochar Network