BioCarb+ Enabling the biocarbon value chain for energy

Newsletter 1-2014

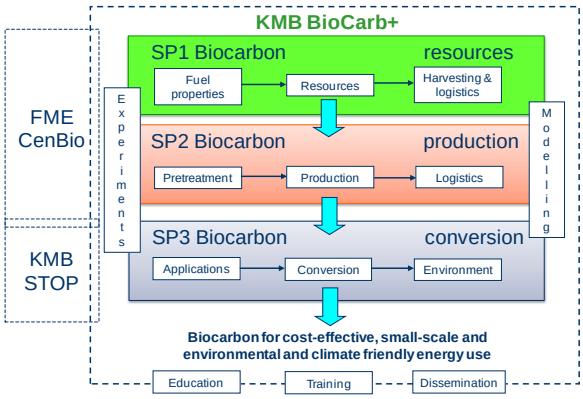
Introduction

The overall objective of BioCarb+ is development of new strategies for use of low-grade biomass, pulpwood and energy wood resources for biocarbon (BC) production for raw material for industrial applications (reduction agent / metallurgical coke) and conversion for energy purposes. The sub-objectives are:

- New or improved biomass harvesting and logistics solutions, with special attention to forest residues, but also pulpwood and energy wood (including hardwood), and their properties
- New or improved biocarbon production solutions through development or improvement of biomass pretreatment methods, biocarbon production processes and applications and biocarbon logistics solutions
- New or improved biocarbon conversion solutions through development or improvement of biocarbon conversion applications with focus on high energy efficiency and low emissions, and biocarbon properties for industrial applications
- Efficient utilisation of by-products from the biocarbon production process to improve overall economy and improve sustainability (CO_2-footprint) of biocarbon production and utilisation
- 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 where applicable

The anticipated results of the project are reduced harvesting and logistics costs for low-grade biomass resources, maximised BC yield and quality in the BC production process and maximised energy efficiency and minimised emissions in the BC end-use applications.

The Work Breakdown Structure of BioCarb+ is:



BioCarb+ will run for four years (2014-2017) and has a total budget of 20 million NOK which is 80% financed by the Research Council of Norway through the ENERGIX program and 20% financed by the industrial partners.

The BioCarb+ consortium

The project consortium covers all the necessary aspects, from resources to end-use, and includes large and central industrial players in the bioenergy area in Norway.

SINTEF Energy Research leads the project and will focus on the thermal side (BC production and conversion) and participate in many scientific activities. NTNU (Norwegian University of Science and Technology) will supervise the PhD candidate and participate in selected scientific activities. NFLI (Norwegian Forest and Landscape Institute) will focus on the biomass supply side of the project including resource assessment, supply cost estimations and optimal allocation in a competitive environment. HNEI (Hawaii Natural Energy Institute) is a renowned US educational and research institution, with cutting edge competence in the BC field through Prof. Michael J. Antal, Jr. He will be co-supervisor of the PhD candidate and will participate in selected scientific activities. Prof. Antal is also the inventor of the patented HNEI Flash Carbonization™ Demonstration Reactor, the cutting edge carbonization technology of today.

The industrial partners will contribute with finances and their extensive industrial knowledge generated through their

- a Knowledge-building Project for Industry (KPN) co-funded by the Research Council of Norway through the ENERGIX-programme.
Contact: oyvind.skreiberg@sintef.no

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commercial activities within forestry (AT Biovarme as part of AT Skog), fuel supply (Norsk Biobrensel), energy production (AT Biovarme) and BC as a reductant for Si, SiC and Mn production (Elkem, Eyde-nettverket, Saint Gobain Ceramic Materials, Eramet Norway, Alcoa Norway).

The constellation of project partners is very strong, bringing together leading research organisations within the field and major industrial players, in the whole BC chain from the resource side to the end-use side. The project has HNEI as a very strong international research partner, and will also expand the existing collaborative ties with Gabor Varhegyi, Hungarian Academy of Sciences and University of Naples. Together this will ensure an optimum project output.

What is biocarbon?

Biocarbon is often called charcoal and is as such familiar to most people, as it is frequently used for cooking or barbequing. Even though charcoal is preferred before wood for these purposes, these combustion processes are far from optimal compared to what is possible in optimum combustion applications for charcoal as powder, briquettes or pellets.

Biocarbon results from a thermal conversion process in which the virgin biomass, e.g. wood, is heated to a certain temperature, losing a major part of its volatile content and, hence, increasing the relative carbon and fixed carbon content. The thermal treatment results in a product that has lost the fibrous structure of the virgin biomass and which can be used directly as a reductant in metallurgical industry or for cooking and barbecuing, or it can be easily and energy efficiently crushed to powder and if wished for further compressed into briquettes or pellets.

Biocarbon is NOT the same as torrefied material. Torrefaction is a lower temperature thermal process with the aim of upgrading a virgin biomass to a torrefied material, which also can be easily crushed to powder and turned into pellets. These pellets can then cost-efficiently be transported over long distances for the use mainly in large-scale cofiring plants, replacing coal, in powder burners.

Hence, biocarbon is a more refined and versatile product than torrefied material, and with the best fuel qualities that a biomass based solid fuel can have, and with many possible alternative uses.

Why biocarbon?

Biocarbon has many qualities and areas of use, as a fuel or for other purposes. Biocarbon is the optimum solid biomass fuel. It

- gives the most stable combustion conditions with the least emission variations and can easily and energy efficiently be crushed to small and close to spherical particles
- gives the highest heating value
- gives the highest energy density (mass, and volume when compressed) and bulk density (when compressed)
- gives the highest fixed carbon content
- has a high reactivity
- takes up very little water
- do not degrade bacteriologically during storage
- gives reduced logistics costs when compressed (transport and storage)
- gives reduced bioenergy plant investment needs

Compared to fossil coal biocarbon has:
- lower N, S and metal, e.g. Hg, contents
- lower ash content

and last but not least, it is renewables based.

The biocarbon fuel can be used as e.g. peak load fuel in existing bioenergy plants, as a substitute fuel for oil boilers, as quality fuel for high efficiency and low emission small-scale heating appliances, and in general for abating operational problems in bioenergy plants.

Solid biomass fuel quality ladder

1. Carbonized (slow to moderate heating rate pyrolysis)
2. Torrefied (slow and mild pyrolysis)
3. Mechanically upgraded (e.g. pellets, briquettes, powder)
4. Untreated (e.g. dry wood chips, wood logs)
5. Low quality biomass (e.g. wet wood chips, GROT, straw)
6. Waste (e.g. MSW)

(GROT is the Norwegian acronym for branches and treetops)

In the metallurgical industry biocarbon is a preferred reductant from a properties point of view in the production of e.g. silicon (Si), silicon carbide (SiC) and manganese (Mn). E.g. Si is used in the solar cell industry for production of solar cell panels. For solar cells one unit biomass energy in, gives around one thousand units of electricity out during the lifetime of a solar cell. This is indirect bioelectricity.

Finally, biocarbon can be used for different other purposes, e.g. as active carbon for cleaning/purification purposes or as soil productivity enhancer.

For all uses of biocarbon there will be optimum biocarbon production conditions that produce the best or the preferred biocarbon quality for the specific use. This optimum can also depend on the properties of the virgin biomass.

BioCarb+ deliverables

In the first year of BioCarb+ focus will be on initial theoretical and experimental studies that will form the foundation for the succeeding studies to be carried out.

In addition to the Norwegian BioCarb+ partners, Prof. Michael J. Antal, Jr. from the Hawaii Natural Energy Institute at the University of Hawaii at Manoa as a BioCarb+ research partner will contribute to or lead the work on several deliverables. He is recognized as a world-renowned authority in the biocarbon area.

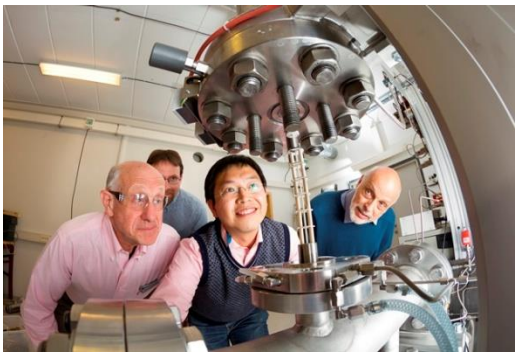
Dr. Gabor Varhegyi, formerly a research professor and group leader at the Hungarian Academy of Sciences and now an independent researcher, is actively involved in BioCarb+ as a collaborative partner. He has extensive knowledge and experience on the reactivity and kinetics of biomass and will be involved in such studies also in BioCarb+.

PhD position announced

The PhD position within "Biocarbon production modelling" has been announced at jobbnorge. A large number of applications have been received and the applicant evaluation process is ongoing. A co-operation with the University of Naples through Prof. Colomba Di Blasi, a collaborative partner in BioCarb+, is planned connected to carbonization reactor modelling.

HP-TGA operative

The latest addition to the SINTEF/NTNU thermal laboratory, a high-pressure thermogravimetric analyzer (HP-TGA) is now installed in the laboratory and will be used extensively in BioCarb+. The HP-TGA enables studying carbonization also at pressurized conditions, which significantly can increase both the biocarbon and fixed carbon yields. The TGA is financed by CenBio (Bioenergy Innovation Centre) investment funds given by the Research Council of Norway.



An international team in front of the HP-TGA. From the left: Michael J. Antal, Jr. from Hawaii, assistant BioCarb+ project leader Liang Wang from China and SINTEF and Gabor Varhegyi from Hungary. BioCarb+ project leader Øyvind Skreiberg from Norway and SINTEF in the background. Photo: Thor Nielsen

Two Hawaii students in Trondheim

Two students, Charissa Higashi (graduate student) and Kathryn Hu (undergraduate student), from the University of Hawaii at Manoa is visiting SINTEF/NTNU this summer and will be linked to biocarbon activities. Their stay is financed by the National Science Foundation (NSF) in USA through the EAGER project of Prof. Michael J. Antal, Jr. They are succeeding Roland Considine and Gregory Patric Specht, whose stays contributed to two Energy & Fuels publications leading to the establishment of BioCarb+.

Collaboration with Hungarian Academy of Sciences

The Hungarian Academy of Sciences (HAS), a collaborative partner in BioCarb+, will carry out a study connected to BioCarb+ aiming at revealing the reasons for the ageing process sometimes occurring during long term storage of biocarbon. HAS has advanced experimental equipment for the purpose, a so-called Py-GC-MS analyzer, and extensive experience in using this. Emma Jakab and Zsuzsanna Czégény at HAS will be leading this work.

New publications

BioCarb+ in the media

Lars Martin Hjorthol, Øyvind Skreiberg (2014). Kvist og kvas blir edelt kull. Gemini. Reproduced on forskning.no, Aftenposten nett and Adresseavisen nett.

Pre-BioCarb+ publications in CenBio

Liang Wang, Øyvind Skreiberg, Morten G. Grønli, Gregory Patric Specht, Michael J. Antal, Jr. (2013). Is elevated pressure required to achieve a high fixed-carbon yield of charcoal from biomass? Part 2: The importance of particle size. *Energy & Fuels* 27(4):2146-2156.

Øyvind Skreiberg, Morten G. Grønli, Michael J. Antal, Jr. (2013). The smart biofuels of the future. *Biofuels* 4(2):159-161.

Michael J. Antal, Jr., Liang Wang, Øyvind Skreiberg, Morten G. Grønli (2013). Is Elevated Pressure Required to Achieve a High Fixed-Carbon Yield of Charcoal from Biomass? The Importance of Particle Size. *International Symposium* held at Osaka University, Japan at the 18th March 2013.

Liang Wang, Øyvind Skreiberg, Morten G. Grønli and Michael J. Antal, Jr. (2013). Attainment of High Fixed-Carbon Yields from Biomass. *2nd Nordic Biochar Seminar* in Helsinki, Finland, 14-15 February 2013.

Liang Wang, Øyvind Skreiberg, Morten G. Grønli, Michael J. Antal, Jr. (2012). Is Elevated Pressure Required to Achieve a High Fixed-Carbon Yield of Charcoal From Biomass? *AIChE Annual Meeting* in Pittsburgh, PA, 28 October - 2 November, 2012.

Michael J. Antal, Jr., Liang Wang, Øyvind Skreiberg, Morten G. Grønli (2012). Fundamentals of biocarbon production and utilization. *CenBio days 2012*, 18-19 January, Ås, Norway.

Liang Wang, Marta Trninic, Øyvind Skreiberg, Morten G. Grønli, Roland Considine, Michael J. Antal, Jr. (2011). Is elevated pressure required to achieve a high fixed-carbon yield of charcoal from biomass? Part 1: Round-robin results for three different corncob materials. *Energy & Fuels* 25(7):3251-3265.

Other news

SKOG22 with biocarbon as a suggested priority area

SKOG22 shall produce a broad and common strategy for research, development, innovation and knowledge dissemination within the forest based value chains. A targeted, complete and coordinated national R&D effort shall contribute to increased competiveness for the forest based value chains.

Biocarbon is suggested to be specifically mentioned in this strategy as an area of future importance and with a need for further R&D efforts.

AIChE annual meeting in Atlanta 16-21 November

A BioCarb+ connected presentation with the title "Thermogravimetric studies of charcoal formation from cellulose under different pyrolysis conditions" will be given at the annual meeting of the American Institute of Chemical Engineers in Atlanta, USA. This is a joint SINTEF, NTNU and HNEI presentation.

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

BioCarb+
SKOG22
Energi21
Renewable Heating and Cooling technology platform
EERA Bioenergy
IEA Task32 Biomass Combustion and Cofiring

The future is in our hands. Photo: Thor Nielsen