



Newsletter 1-2016

Progress in 2016

In 2016 focus is on further studies connected to the resource base, carbonization experiments under different conditions, biocarbon combustion and gasification reactivity and techno-economic studies connected to biocarbon production and use.

In 2015 focus was on further work connected to the resource base, biocarbon production and logistics, as well as biocarbon end use properties.

In 2014 focus was on startup of the project and the planned activities and deliverables for 2014. Various studies were started connected to the resource base and costs of these, fuel properties, feeding solutions, carbonization technologies and biocarbon conversion applications. The PhD position on modelling of biocarbon production was also announced, and filled.

BioCarb+ at IConBM 2016

Two BioCarb+ abstracts were accepted for submission of full papers for presentation at the 2nd International Conference on Biomass, 19-22 June 2016, Giardini Naxos-Taormina, Sicily, Italy. The accepted abstract titles are:

- 1) CO₂ reactivity assessment of woody biomass biocarbons for metallurgical purposes
- 2) Value chain analysis of biocarbon utilisation in residential pellet stoves

The conference is ongoing right now, and swiftly publication in Chemical Engineering Transactions is expected.

BioCarb+ at 24th European Biomass Conference & Exhibition

Four BioCarb+ works were presented at the 24th EUBCE conference in Amsterdam, 6-9 June 2016:

- 1) Bio-carbonization process integration for high quality energy carriers: charcoal, biomethane, biocrude, and biofertilizer
- 2) Carbon Yield Predictions in Biochar Based on Stochastic Reactor Modelling
- 3) Reactivity assessment of biocarbons for metallurgical purposes
- 4) Energy efficiency, environmental aspects and cost-efficiency of small-scale biocarbon conversion applications – value chain analysis

BioCarb+ at Pyro 2016

Two BioCarb+ works were presented at the 21st International Symposium on Analytical and Applied Pyrolysis, 9-12 May 2016, Nancy, France.

- 1) Stochastic reactor modelling for biomass pyrolysis
- 2) Towards the maximum theoretical yields of charcoal from biomass pyrolysis

BioCarb+ in Energy & Fuels

A manuscript entitled "[Combustion Characteristics of Biomass Charcoal Produced at Different Carbonization Conditions: A Kinetic Study](#)" has been published in Energy & Fuels. The abstract is given below.

"The combustion properties of spruce chars and spruce forest residue chars were studied in the kinetic regime by a series of thermogravimetric analysis (TGA) experiments. The work aimed at establishing how the pressure of the char preparation affects the reactivity with oxygen. Parts of the chars were prepared from a thin layer of biomass in inert gas flow at atmospheric pressure and 0.8 MPa. Other chars were formed in a pressurized reactor by a flash carbonization method [Antal, M. J., Jr.; Mochidzuki, K.; Paredes, L. S. Flash carbonization of biomass. Ind. Eng. Chem. Res. 2003, 42 (16), 3690–3699, DOI: 10.1021/ie0301839]. Despite the differences in the preparation, remarkable similarities were observed in the combustion behavior of the samples. The kinetics of the char burnoff was described by assuming three partial reactions. A total of 18 experiments at three different temperature programs were evaluated by the

method of least squares to obtain dependable kinetic model variants. A common activation energy of 150 kJ/mol gave a reasonable description for the three partial reactions in all experiments."

This work is a key work in the efforts on combustion characterization of biomass charcoal produced at different carbonization conditions.

Remembering Michael Jerry Antal, Jr.

Prof. Michael Jerry Antal, Jr. sadly passed away October 21, 2015. He was a key research partner in BioCarb+ and a great colleague and friend through decades of many of us. His contribution to the scientific community really stood out from the crowd. He will be greatly missed, but never forgotten.

At the above mentioned Pyro 2016 conference, a Soirée in honour of Prof. Antal was arranged, and now an Energy & Fuels manuscript entitled "[From "Sirups" to Biocarbons: A 30 Year Research Cooperation for Better Biomass Utilization with Michael J. Antal, Jr](#)" has been published.

Presentations from the soirée are available at the [Pyro 2016 website](#).

Also a special issue in Energy & Fuels in the honor of Prof. Antal is in progress. Three BioCarb+ manuscript have been submitted to this special issue.

Scott Turn joins the BioCarb+ team

Dr. Scott Turn from the University of Hawaii (UH) joins the BioCarb+ team, as responsible for their contributions to the BioCarb+ project. The UH contributions will be concentrated on high yield fixed carbon charcoal production at pressurized conditions. A PhD candidate, Maider Legarra, will be part financed by BioCarb+.

BioCarb+ students

A number of students have been or are connected to BioCarb+. In 2014 two students (**Charissa Higashi** and **Kathryn Hu**) from Hawaii, **USA**, visited Trondheim during the summer. In 2015 a summer student from **Norway** (**Benedicte Hovd**) financed by BioCarb+ within the SINTEF summer job program was working with aspects connected to biocarbon CO₂ reactivity. This work was continued by a master student (**Hau-Huu Bui**) from **Vietnam** and a project student (**Maria Zabalo Alonso**) from **Spain**. Also in 2015, a PhD student from **Hungary** (**Eszter Barta-Rajnai**) visited Trondheim Aug-Sept, as well as an

assistant professor (**Zsolt Barta**) from Hungary in September. A master student from **Belgium** (**Sam van Wesenbeeck**) at University of Hawaii worked in the BioCarb+ project and there is also a link to a PhD student from Spain (**Maider Legarra**) at University of Hawaii, who now is part financed by BioCarb+. In 2016 Maria Zabalo Alonso is continuing with her master thesis within BioCarb+, **Przemyslaw Maziarka** from **Poland** is carrying out his master thesis work within BioCarb+, also connected to CO₂ reactivity of biocarbons, and **Maciej Olszewski** from Poland is carrying out his master thesis connected to techno-economics of biocarbon production. Also in 2016 a summer student from Norway, **Nicolai Alsaker**, is financed by BioCarb+, working with CO₂ reactivity of densified biocarbon. In addition the BioCarb+ PhD student from **Germany** (**Kathrin Weber**) is continuing her work. Connected to her work, **David Lüdecke** from Germany is carrying out his master thesis. Hence, a very significant educational activity is connected to BioCarb+.

Industrial charcoal production in Norway to become a reality?

Elkem, one of the industrial partners in BioCarb+, is together with Treklyngen, Avinor and Vardar now carrying out an innovation project called **Norwegian Wood**. The aim is to create an industrial value chain producing both biocarbon, biooil and heat. The first step is a feasibility study. More info is given [here](#).

New publications

Liang Wang, Benedicte Hovd, Hau-Huu Bui, Aasgeir Valderhaug, Therese, Videm Buø, Rolf Gunnar Birkeland, Øyvind Skreiberg, Khanh-Quang Tran (2016). CO₂ reactivity assessment of woody biomass biocarbons for metallurgical purposes. IConBM, 19-22 June 2016, Sicily, Italy.

Rajesh S. Kempegowda, Zsolt Barta, Øyvind Skreiberg, Liang Wang (2016). Value chain analysis of biocarbon utilisation in residential pellet stoves. IConBM, 19-22 June 2016, Sicily, Italy.

Rajesh S. Kempegowda, Øyvind Skreiberg, Khanh-Quang Tran, Pagandai V. Pannir Selvam (2016). Bio-carbonization process integration for high quality energy carriers: charcoal, biomethane, biocrude, and biofertilizer. 24th European Biomass Conference and Exhibition (**EUBCE**), 6-9 June 2016, Amsterdam, The Netherlands.

Kathrin Weber, Tian Li, Terese Løvås (2016). Carbon Yield Predictions in Biochar Based on Stochastic Reactor Modelling. 24th EUBCE.

Liang Wang, Hau-Huu Bui, Benedicte Hovd, Aasgeir Valderhaug, Therese Videm Buø, Rolf Gunnar Birkeland, Øyvind Skreiberg, Khanh-Quang Tran (2016). Reactivity assessment of biocarbons for metallurgical purposes. 24th EUBCE.

Rajesh S. Kempegowda, Zsolt Barta, Øyvind Skreiberg, Liang Wang (2016). Energy efficiency, environmental aspects and cost-efficiency of small-scale biocarbon conversion applications – value chain analysis. 24th EUBCE.

Hau-Huu Bui, Liang Wang, Khanh-Quang Tran, Øyvind Skreiberg, Apanee Luengnaruemitchai (2016). CO₂ Gasification of Norwegian Charcoals Prepared at Different Pressures. Proceedings of The Petroleum and Petrochemical College International Symposium, Chulalongkorn University, 24 May 2016, Bangkok, Thailand.

Khanh-Quang Tran, Hau-Huu Bui, Apanee Luengnaruemitchai, Liang Wang, Øyvind Skreiberg (2016). [Isothermal and non-isothermal kinetic study on CO₂ gasification of torrefied forest residues](#). Biomass and Bioenergy 91(Aug 2016):175-185.

Kathrin Weber, Tian Li, Terese Løvås, Lars Seidel, Cathleen Perlman, Fabian Mauss (2016). Stochastic reactor modelling for biomass pyrolysis. **Pyro 2016** (21st International Symposium on Analytical and Applied Pyrolysis), 9-12 May 2016, Nancy, France.

Morten Grønli, Liang Wang, Øyvind Skreiberg (2016). Towards the maximum theoretical yields of charcoal from biomass pyrolysis. Pyro 2016.

Charissa Rachelle Mika Higashi (2016). A study on the theory, generation, and retention of charcoal quality by thermochemical equilibrium calculations, efficient microcrystalline cellulose carbonization, thermogravimetry, and psychrometric experiments. University of Hawaii Master thesis. Supervisor: Michael J. Antal, Jr.

Liang Wang, Gábor Várhegyi, Øyvind Skreiberg, Tian Li, Morten Grønli, Michael J. Antal, Jr. (2016). [Combustion Characteristics of Biomass Charcoal Produced at Different Carbonization Conditions: A Kinetic Study](#). Energy & Fuels 30(4):3186-3197.

Hau-Huu Bui (2016). CO₂ gasification of charcoals produced from Norwegian stem wood and forest residues. Chulalongkorn University Master Thesis. Main supervisor:

Apanee Luengnaruemitchai, Co-supervisors: Khanh-Quang Tran, Liang Wang, Øyvind Skreiberg

Sam Van Wesenbeeck, Charissa Higashi, Maider Legarra, Liang Wang, Michael Jerry Antal Jr (2016). [Biomass pyrolysis in sealed vessels. Fixed-carbon yields from Avicel cellulose that realize the theoretical "limit"!](#). Energy & Fuels 30(1):480-491.

Maria Zabalo Alonso (2015). Use of charcoal as reductant in metallurgical industry. NTNU Project thesis. Main supervisor: Khanh-Quang Tran, Co-supervisors: Liang Wang, Øyvind Skreiberg

Sam Van Wesenbeeck (2015). Charcoal in a nutshell: Biocarbon production from cellulose, Norwegian wood, Macademia nutshells and sewage sludge. University of Hawaii Master thesis. Supervisor: Michael J. Antal, Jr.

Benedicte Hovd (2015). Biocarbon for energy - Biocarbon CO₂ reactivity. SINTEF Summer Job Project report. Supervisors: Liang Wang, Øyvind Skreiberg

Øyvind Skreiberg (2015). [BioCarb+ Verdikjeden for biokarbon: Fra biomasse til energi](#). Bioenergidagene 2016, 18-19 November 2015, Gardermoen, Norway.

Øyvind Skreiberg (2015). [BioCarb+](#). Presented in the session "Grensesprengende forskning" at Energiforskningskonferansen, 21 May 2015, Oslo, Norway.

Liang Wang, Gábor Várhegyi, Øyvind Skreiberg, Morten G. Grønli, Michael J. Antal, Jr. (2015). [Combustion Characteristics of Biomass Charcoal Produced at Different Carbonization Conditions](#). Proceedings of 23rd European Biomass Conference and Exhibition (**EUBCE**), 1-4 June 2015, Vienna, Austria, pp. 1196-1199.

Liang Wang, Charissa Higashi, Øyvind Skreiberg, Morten G. Grønli, Michael J. Antal, Jr. (2015). [Charcoal Production from Forest Residues](#). Proceedings of 23rd EUBCE, pp. 1184-1187.

Liang Wang, Kathryn Hu, Charissa Higashi, Øyvind Skreiberg, Viktor Myrvågnes, Morten G. Grønli, Michael J. Antal, Jr., Gábor Várhegyi (2015). [Effect of Storage Time and Conditions on Biomass Charcoal Properties](#). Proceedings of 23rd EUBCE, pp. 1180-1183.

Liang Wang, Øyvind Skreiberg, Morten G. Grønli, Michael J. Antal, Jr. (2014). Thermogravimetric studies of charcoal formation from cellulose under different pyrolysis conditions. AIChE Annual Meeting in Atlanta, GA, 16 - 21 November, 2014.

BioCarb+ in the media

Lars Martin Hjorthol, Øyvind Skreiberg (2014). Lopwood and brushwood make high-grade charcoal. [Gemini](#).

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

Other news

IEA Task 32 Biomass Combustion and Co-firing

An [IEA Bioenergy Task 32](#) meeting was arranged in Switzerland in connection with the [20th ETH-Conference on Combustion Generated Nanoparticles](#), 13-16 June. This was the first meeting in the new triennium (2016-18). For more information about IEA Bioenergy Task 32 activities, see this [newsletter](#), and for IEA Bioenergy news, see this [newsletter](#).

EERA Bioenergy - Stationary Bioenergy

The effort this year has been focused on arranging workshops in Brussels connected to issue papers, on bioenergy and biofuels, and coordination of efforts to establish joint EU proposals. For more info on EERA Bioenergy, visit the [website](#), and see the [newsletters](#).

RHC technology platform

The activity level of the [RHC platform](#) is picking up, after a period where new financing solutions have been sought and the originally planned strategy documents have been delivered. The "new" European Technology and **Innovation** Platform on Renewable Heating & Cooling (RHC-ETIP) brings together stakeholders from the biomass, geothermal and solar thermal sector - including related industries such as District Heating and Cooling, Thermal Energy Storage, Hybrid Systems and Heat Pumps - to define a common Research, Development and Innovation strategy for increasing the use of renewable energy technologies for heating and cooling. Two workshops will be arranged 27 and 28 June. The first one is an [industry workshop](#) while the second one is a [technology workshop](#). The aim is to support to key activities of the RHC-ETIP and to discuss the successful contribution of the RHC-sector to the fifth dimension of the Energy Union.

See the RHC [newsletters](#) for other news.

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

[BioCarb+](#)

[SKOG22](#)

[Energi21](#)

[Renewable Heating and Cooling platform](#)

[EERA Bioenergy](#)

[IEA Task32 Biomass Combustion and Cofiring](#)

