BioBoost

Biomass based energy intermediates boosting biofuel production

Publishable Summary

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A large part of renewable energy in Europe is produced from biomass. To increase the share of biomass conversion pathways which are energy efficient, economic and flexible in feedstock are needed. The BioBoost project (Biomass based energy intermediates boosting biofuel production) aims at making a substantial improvement towards increasing the efficiency of the use of biomass and organic residues in the future. The project focuses on de-central conversion of biomass to optimised, high energy density carriers, which can be utilised either directly in small scale combined heat and power (CHP) plants or in large scale applications for the synthesis of transportation fuel and chemicals. Mainly, dry as well as wet residual biomass and wastes are used as feedstock for conversion. Due to their secondary nature, this feedstock has the potential for high environmental sustainability, and in the case of straw, it may even strengthen food production than competing to it. However, perennial, ligno-cellulosic energy crops and forest residues are included as a possibility to compensate the seasonal occurrence of for example straw. These types of biomass are converted by means of fuel flexible thermo-chemical processes such as fast pyrolysis, catalytic pyrolysis and hydrothermal carbonization (HTC) to produce stable intermediate energy carriers in the form of bio-oil, -coal or -slurry. These can be utilized separately or in different combinations. For straw, as an example, the energy density of the carrier can be increased by a factor of 10 to 15, enabling economic long range transportation from several regionally distributed conversion plants to few central large scale gasification plants for bio-fuel production.

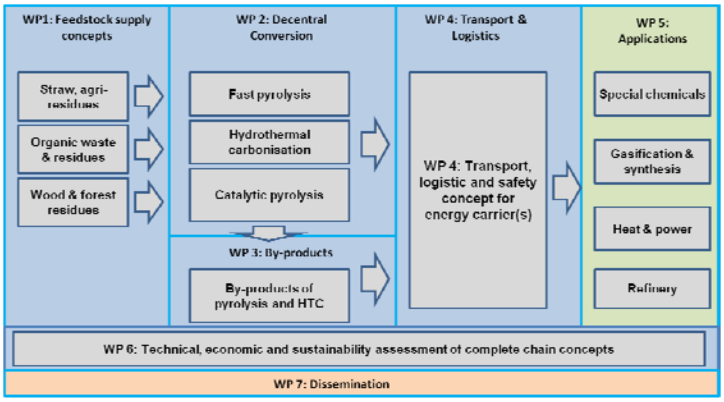

Figure 1: Overview

A logistic model of the supply chain taking into account de-central and central conversion scenarios with different types of energy carriers is set up and validated allowing the determination of costs, the number and location of de-central and central sites. A techno-economic and environmental assessment of the value chains supports the optimisation of products and allows for comparison of the processes under consideration and to other conversion routes. The application of energy carriers is investigated in applications of heat and power production, synthetic fuels & chemicals and as bio-crude for refineries. Coordinated by the Karlsruhe Institute of Technology thirteen partners from industry, universities and research institutions take part in the collaborative project, contributing to 7 work packages.

The BioBoost project has finished after 42 months duration and achieved the envisaged results.

The feedstock potential for a large variety of different agricultural residues and organic wastes was investigated earlier and published on the website. Lately the data were prepared for publication and presentation on a GIS server which can be accessed via the BioBoost homepage. In P3 the Geoportal was completed, presenting the analysis of the biomass potential in the EU-27 with their possible use for energy purposes. Estimates were made for spatial unit's NUTS-3. The Web application allows interactive browsing the spatial data presenting density and technical potential of the all kinds modeled biomass types. An interactive map is based on the Web browser on the visitor side (client side), when releasing data (i.e., the server side [server-side]).

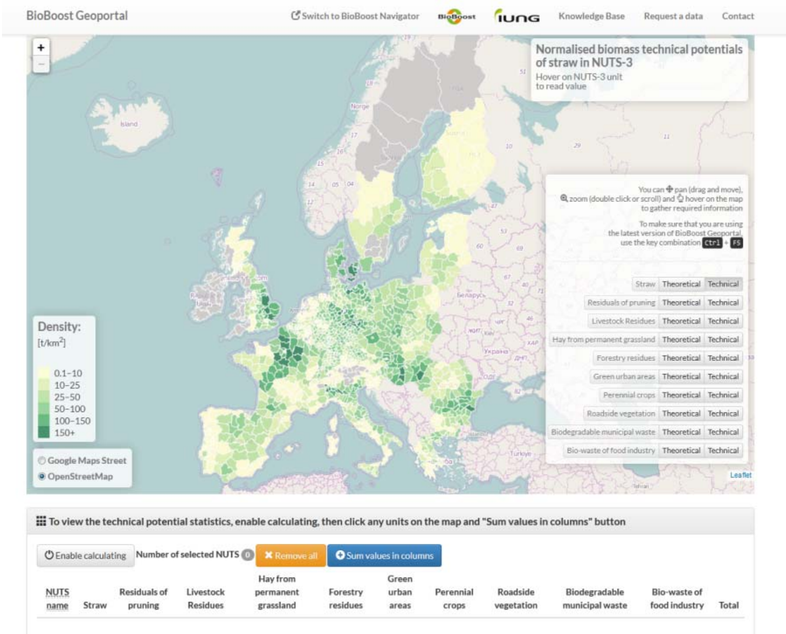

Figure 2: BioBoost GEO Portal

The main emphasis of work package 2 was on hydrothermal carbonisation (HTC), the thermal pyrolysis and catalytic pyrolysis pathways. In thermal pyrolysis the work focused on the investigations on mixing of pumpable and flowable slurries, stability and storing, the production of alternative non-flowable energy carriers in form of pastes, char properties, and the flammability of pyrolysis oils. A fuel concept with regards to energy carrier use in entrained flow gasifiers (bioliq® concept) was developed. Based on this work the following three forms of energy carriers were selected as the most promising: (1) Organic condensate (+ ash from combustion of biomass), (2) Slurry of aqueous condensate + char, (3) “All-in-one”-slurry of the three product fractions: Aqueous condensate, organic condensate, char. The energy carriers from options (1) and (2) were produced in KIT and conditioned in a way that enables use in gasification. The option (3) was not yet technically feasible due to stability problems and further research is necessary on this energy carrier.

For the catalytic fast pyrolysis (CFP) pathway two new alumina based catalysts (synthesized and scaled up by Grace) were tested on pilot scale in addition to the three others already tested. These catalysts show high activity, one being the most active off all tested. With this very active catalyst O2 content up to 8% in catalytic oil was produced but at low oil yields (11%wt). Both alumina catalyst show higher coke selectivity compared to ZSM-5 based catalysts. Moreover, long term CFP test of 100 hrs was carried in CERTH pilot plant unit out in order to investigate the deposition rate of the biomass ash metals on the catalyst during biomass catalytic pyrolysis process. It was found that deposition rate of various ash metals can be between 55-90% depending on the metal. The effect of catalyst deactivation during the long test on the catalyst performance was also determined.

For hydrothermal carbonisation a completely new feedstock was tested for its technical and economic feasibility from lab scale to industry scale: organic municipal waste. Compared to other feedstocks evaluated in the project (brewery spent grains, horse manure) organic municipal waste produced best results in terms of carbon content among others. Heating values are close to brown coal. Besides optimising process parameters for carbonisation, AVA-CO2 developed and optimised the whole process from feedstock feeding to separation of slurry, drying of coal and filtering of process water. Also logistics and storing conditions have been evaluated for three types of coal: dust, pellets and cakes. Safety data sheets for all three types of coal have been developed. The overall lifecycle assessment proves economic viability for HTC coal out of organic municipal waste, partly due to the gate fee, which has available for the disposal of this waste stream.

Workpackage 3 focused on the separation and extraction of by-products from the thermal conversion processes. As the concentration of HMF in HTC process water is too low for a separation, a new process of coupling HTC with HMF-production was suggested: The process water of HMF production was used for HTC coal production. The first results are very promising. In regard of this, the application of HMF, as substitute of a part of formaldehyde for resin production is very important (Chimar). Here HMF was more reactive than formaldehyde, which caused problems by the used method designed for the application of pure formaldehyde. Here further studies are necessary.

A logistics model was developed in work package 4 to optimize biomass and energy carrier transportation and to identify optimum locations for de-central and central plants. The results are: (1) a complete logistics model describing possible modes of storage, handling and transport for biomass and energy carrier intermediates including all data for costs and CO2 emissions, (2) a risk assessment for the logistics model identifying the most relevant risk factors and possible steps for risk mitigation (3) a simulation model implemented as a software tool that supports analysis on a regional level (NUTS3) for the whole value chain from biomass acquisition at the field to utilization of the final products, and (4) an optimization software module - wrapping the simulation model - which can be used to identify optimal de-central and central processing plant locations and capacities based on regional conditions such as feedstock availability, road/rail infrastructure and price level.

Within in P3 the focus of efforts has been the validation and refinement of the logistics model and the simulation model as well as improvement of the optimization software module to facilitate the identification of optimized scenarios. The risk assessment for logistics has been extended and refined. Several refinements and improvements to the simulation model and the optimization module have been made based on preliminary optimization results. The data and code for the simulation model has been validated and finalized for the scenario optimization (data freeze and code freeze).

During the last year, WP5 undertook further combustion tests with HTC coal produced from biological waste. Regarding the use of liquid energy carriers, pyrolysis oil combustion with a FLOX(R) burner was tested. The possibilities and cost effects for the adaption of existing boilers to burn bio-char have been analyzed. The applicability of different energy carriers to a refinery set up including the use of existing refinery units for upgrading of catalytic pyrolysis oil was evaluated. Due to improved properties of catalytic pyrolysis over thermal pyrolysis oil, focus was set on the upgrading of CP oil. The energy carrier use for gasification was studied. An integrated process to phenol and biofuels has been designed and examined within the BioBoost framework.

During the last 12 month work package 6 concentrated on fine tuning of the economic assessment, the environmental assessment and the application of the logistic model for the investigation of market implementation.

The dissemination and exploitation of the results were a focus of all partners towards the end of the project. The scientific community was addressed with scientific papers and presentations and the BioBoost navigator to present data along the different production chains has become available at the website. Additionally, the industrial stakeholders were informed on technologies and latest developments by 3 one day workshops taking place in Greece (October 2014), in Linz (Austria, February 2015) and in Geleen (The Netherlands, July 2015). Workshops had a good attendance between 30 -70 persons from local and regional stakeholders and industry. The interest was focused on the use of forest and agricultural residues for sustainable bioenergy and fuels.

The conclusions and recommendations of the project were presented to the policy stakeholders at a policy workshop held together with the ´SECTOR project on 16 June 2015 in Brussels as well as in a technology workshop on 17th June in Brussels.

Highlights of the project activities have been documented in a film for TV stations which is available on the website. Scientific information of feedstock potentials in EU-28 and the properties of several utilisation pathways are online available at the navigator on the project website.

Project website address: www.bioboost.eu

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05 EnBW Energie Baden-Württemberg AG (ENBW)

Deutsches Zentrum fuer Luft- und Raumfahrt (DLR, Third party to EnBW)

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08 Instytut Uprawy Nawozenia I Gleboznawstwa, Panstwowy Instytut Badawczy (IUNG)

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