Optimal plant locations and sizes for straw-based BtL-plants in Austria, using a spatially explicit mixed-integer programming model

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Biomass is regarded as hopeful raw material in the search for alternatives to fossil fuels. Currently implemented large-scale installations concentrate on the processing of easily exploitable plant substances, such as oil, sugar or starch. The result is a direct form of competition to human consumption. This should be eliminated through second-generation systems, which focus on lignocellulosic plant compounds like straw or wood residues. In particular, straw from local arable land, in comparison to other available agricultural residues, offers significant advantages, such as the ability to harvest them in a storable condition. One way to use this energy source is the Biomass-to-Liquid (BtL) system. It represent a multi-stage process and gasifies and synthesizes the straw to the desired type of fuel. To increase transportability, scientific research deals with a de-centrally organized approach where the BtL production occurs in two temporally and spatially separate processes. In the first manufacturing process, the so-called (rapid) pyrolysis of the raw material, an intermediate product (slurry) is generated. This liquid black mass has a higher energy density and therefore a higher transportability than the organic residual mass. In the second process, the slurry is synthesized to BtL-fuel. The aim of the present work is to determine the minimum processing cost structure of BtL production, based on the available quantity of straw in Austria and taking into account de-central processing options.

Taking account of the existing competition for straw among BtL production, litter in animal husbandry and fired heating plants, two scenarios are formed. The first scenario is based on a virtually non-existent form of competition whereas in the second scenario the competitive situation exists. The estimated total amount of available straw for Austria therefore differs within the scenarios and is 1,7 and 1 million tons respectively.
The present problem of location and capacity planning of BtL-plants in Austria is reflected in the case of a local processing network as a warehouse location problem, with two distribution levels and an aim to minimize overall production costs. For economic analysis the manufacturing process is divided into two temporally and spatially separate processes. We use the regional level of districts and each district in Austria is at the same time supplier of the raw material, as well as a possible location for pyrolysis and synthesis plants. Each location can be realized in 10 different sizes and 10 capacity levels. In total, there are 100 possible plant formations for each realized location. However, just one pyrolysis and/or synthesis plant on each location can be realized.

The results in both scenarios show an absolute cost advantage of de-central processing concept. The plants are locally realized in arable areas. In the two scenarios 19 and 12 pyrolysis plants with an average processing amount of 91,930 and 86,667 tons of straw respectively are realized. In the second processing process, the synthesis occurs in both scenarios at a central location in the eastern part of Austria. The location and capacity planning model shows that a local processing network for BtL production is an efficient way of reducing overall costs. These cost reductions merely result from the local pre-processing of low transportation worthy commodities, such as straw, into slurry, thereby reducing transportation costs.