Optimal localisation of second generation biofuel production – the role of process integration in system studies

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Introduction

Ambitious targets for renewable energy in transport boost interest in second generation biofuels, in particular in forest rich regions such as Sweden. Large plant capacities and feedstock competition makes geographic localisation important. Integration with other industries provides an opportunity for efficient resource utilisation, but also puts additional requirements on the choice of locations.

BeWhere

- Techno-economic geographically explicit optimisation model
- Analysis of optimal locations and properties of bioenergy conversion facilities
- Previous studies have been made on regional, national and European levels, with different levels of detail in the modelling

Objective

This project's aim is to develop the BeWhere Sweden model.

The model will be used for extensive systems analysis of various bioenergy and biofuel scenarios, and to identify locations that are robust to boundary condition variations, in particular regarding energy market prices, policy instruments, investment costs and feedstock competition.

BeWhere model development:

- Detailed modelling of process integration with existing energy systems, in particular forest industry
- Detailed modelling of flows of biomass feedstock
- Possible integration with BeWhere Europe model

Model description

BeWhere Sweden (Figure 1) is based on mixed integer linear programming (MILP). The model minimises the total cost of the studied system, including supply chain costs and costs associated with emitting fossil CO_2. Different biofuel production technologies are considered, based on both gasification and fermentation. The model determines the optimal number, types and locations of biofuel plants.

Different scenarios for biofuel demand, energy market conditions, policies and feedstock availability are applied, in order to identify robust solutions.

Process integration

Different industries, e.g. the pulp and paper industry, and district heating systems are considered as potential biofuel plant sites. The energy balance of each plant site, including temperature levels of heat needed and how that heat demand is satisfied today, is considered explicitly.

All potential biofuel plants are dimensioned so their heat surplus fit the site specific heat demand of the industries and district heating systems, thereby decreasing the total use of fuel in the system.

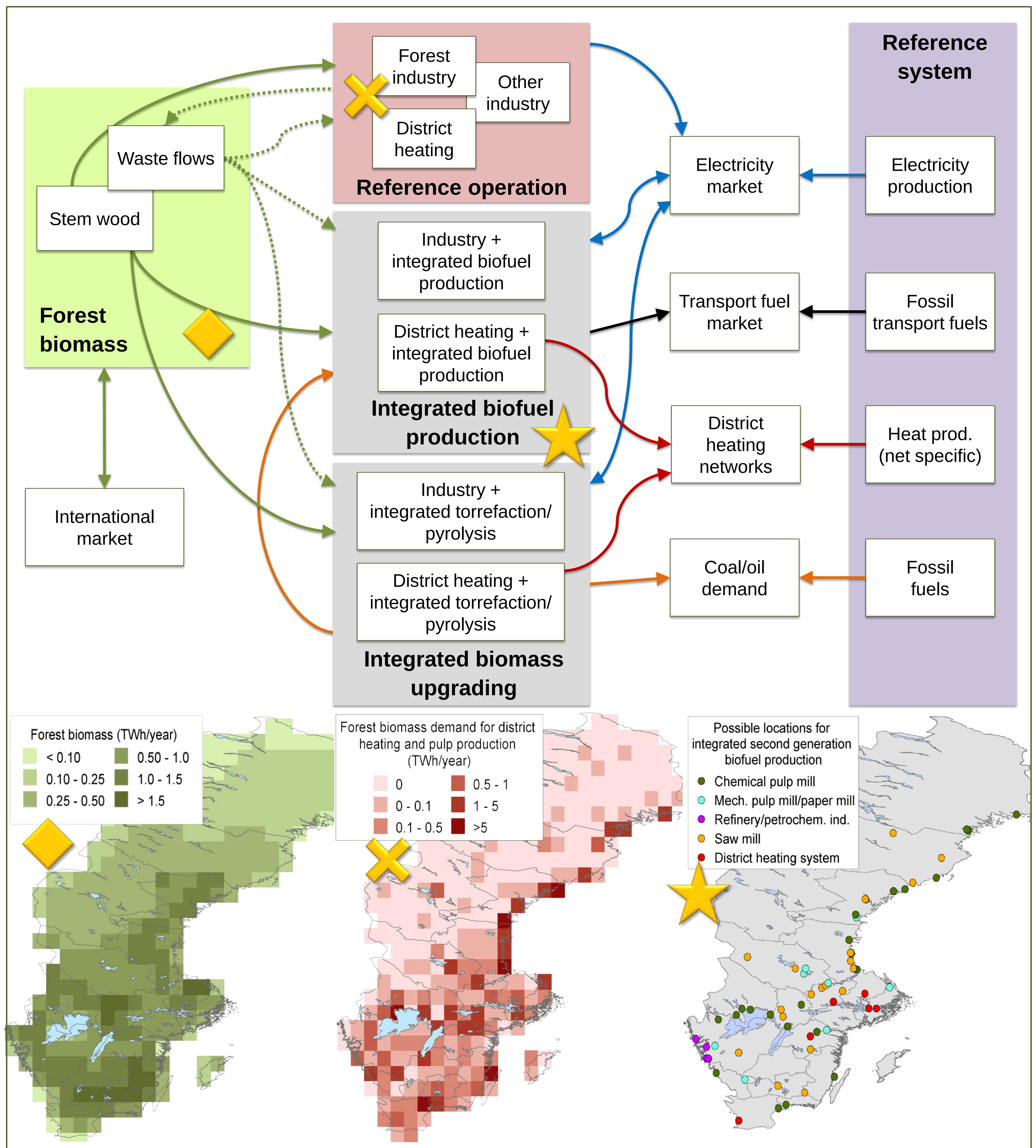

Figure 1. Schematic overview of BeWhere Sweden and visualisation of selected key input data.

Results

Model runs are made using different targets for the use of second generation biofuel in transport, under various boundary conditions. In Figure 2 results for a biofuel target of 6 TWh per year (ca 7% of total transport fuel demand) are shown. The figure shows the optimal locations and types of new biofuel plants, the feedstock origin, and where the produced biofuel is used. Two cases are shown – one where black liquor gasification (BLG) is considered (top) and one where it is not (bottom).

The preliminary results show that BLG with DME production is the preferred production technology. This is due to the high biomass-to-biofuel conversion efficiency and the high degree of process integration. If BLG is not considered, more plants and a larger amount of biomass are needed to fulfil the same biofuel target. The resulting biofuel production cost is almost doubled when BLG is not considered. However, with a higher dispersion of plants, the total transport distances of both biomass and biofuel become considerably shorter.

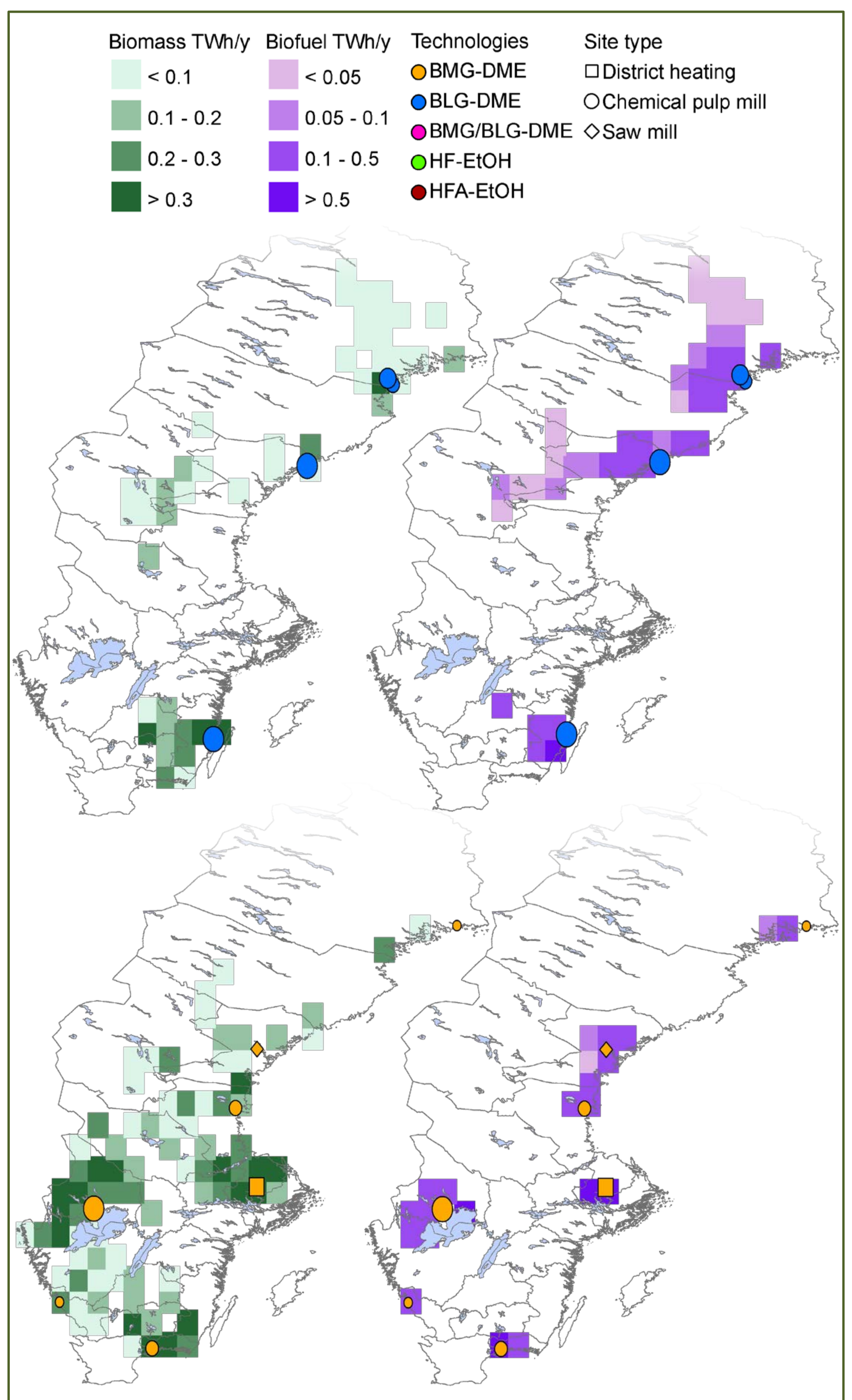

Figure 2. Results for a second generation biofuel target of 6 TWh/y, with BLG considered (top) and with BLG not considered (bottom). Biomass used to produce biofuel (left) and biofuel use (right) are shown.

The marker shapes indicate site type, the colours biofuel production technology, and the sizes biofuel production in each plant.

Summary

Aggregated modelling studies of broadly introduced second generation biofuels typically make generalised assumptions about production integration and excess heat utilisation.

Here detailed bottom-up studies of integrated biofuel production are introduced into a top-down model and taken to a higher system level.

BeWhere Sweden will be a useful decision support tool for energy and transport system studies, and can complement and add value to results from other, more aggregated energy system models.

More information

BeWhere Sweden: www.liu.se/bewhere

BeWhere: www.iiasa.ac.at/bewhere

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