# *BIOFUEL DEVELOPMENT AND THE COMPETITION FOR FOREST RAW MATERIALS: A PARTIAL EQUILIBRIUM ANALYSIS OF SWEDEN*

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## Overview

In order to reach the renewable energy policy targets in the transport sector, second generation (2G) biofuels produced from forest raw materials (e.g. harvesting residues) can be cornerstones. Still, in many countries, these raw materials are currently used as inputs in the heat and power (HP) sector and, not least, in the forest industries (pulp and paper plants and sawmills). Forest biomass is a scarce resource, and it is essential to understand how these sectors would be affected by an increased penetration of 2G biofuels. In this respect, Sweden represents an interesting case study due to its well-developed forest industries and mature HP sector involving intense use of forest biomass. The technological experiences and a well-developed infrastructure also make Sweden a suitable country for future 2G biofuel production. This study investigates price development and resource allocation in the Swedish forest raw materials market in the presence of substantial increases in domestic 2G biofuel production.

## Methods

To study price formation and resource allocation and the Swedish forest raw material markets, a national partial equilibrium forest sector model is used, namely the so-called Swedish Forest Sector Trade Model (SFSTM) II, developed by Lestander (2011) and Carlsson (2011). The model includes forest owners' supply of raw material, production of, and demand for, forest industry products (e.g. sawnwood, paper and particle board) as well as heat and power generation. The modeling structure builds on the same structure of demand, supply and trade as the global GTM (Kallio 1987) and the EFI-GTM (Kallio, Moiseyev et al. 2004) models, as well as the Norwegian forest sector model NTMII (Bolkesjø 2004). In this paper, SFSTM II is updated to the new base year 2016, and extended with a 2G biofuel module to address the impacts of such production. Scenarios between 5 and 30 TWh of 2G biofuel (Bio-SNG) production are assessed.

In the presence of an increased demand for forest biomass, at least two market effects can be expected: a *competition effect* and a *by-product effect* (Lauri, Forsell et al. 2017). The competition effect is the increased competition for raw materials under a constrained biomass supply. This causes feedstock prices to increase, but by different magnitudes depending on the supply situation for various feedstock. The by-product effect refers to the synergy effect between the forest industries producing by-products and sectors demanding by-products, e.g., plants producing heat or 2G biofuels. When such plants demand more by-products (e.g., wood chips, sawdust, etc.), the prices of by-products increase, in turn generating higher returns to the plant owners supplying these. In addition, this creates an incentive to increase the production of the main product, something that in turn generates more by-products. In other words, whereas the competition effect leads to feedstock price increases, the by-product effect can mitigate such a price rise by inducing an increase in the supply of by-products. Using the SFSTM II, the impact of these effects can be studied.

The model includes national regional data on harvest levels, production of, and demand for, forest industry products, HP energy and 2G biofuels. Forest raw materials and products can be traded between the national regions, as well as with a region representing the rest of the world. Data is mainly gathered from The Swedish Foresty Agency, The Swedish National Forest Inventory, Sweden Statisics and the The Food and Agriculture Organization. Import levels of raw materials are constrained to 2016 import levels to reflect a development with increasing forest raw material prices in the rest of the world due to a assumed increase in world demand for 2G biofuels. This constraint is relaxed in a sensitivity analysis, in which a 20% increase in imports is allowed in addition to 2016 imports levels.

## Results

The simulation results show increasing forest industry by-product (i.e., sawdust, wood chips and bark) prices, not least in the high-production scenarios (20-30 TWh). The HP sector becomes less profitable in the presence of increased 2G biofuel production due to increasing feedstock prices, but is not shown to substitute biomass for fossil fuels. The competition for sawdust increases the most, and is re-allocated from the HP sector to Bio-SNG production. The HP sector is covering up the feedstock shortage with harvesting residues, which is made possible due to increased roundwood harvest (the by-product effect). Moreover, the fiberboard and particleboard industry eventually shut down due to higher input prices (the competition effect). The exit of fiberboard and particleboard production leads to increased pulpwood exports. This model result is in line with the historical trend of an expanding HP sector using more and more bioenergy at the expensive of the board industry in Sweden (SFA 2014, FAO Statistics 2018). For 30 TWh of Bio-SNG production, sawlog harvests increase by 8 million $m^3f$ (27 %).

Regardless of whether import levels remain at 2016 levels, or increase by 20%, the general production patterns in the Swedish forest raw materials market will remain stable. Yet, a delay in events is expected; the increase in sawdust and harvesting residue prices are delayed, and so is the board industries' reduced production. Moreover, increased imports leads to lower harvest of roundwood as well as harvesting residues.

## Conclusions

Introducing 2G biofuel production increases feedstock prices, and two fiberboard industries eventually shut down, thus suggesting that the 2G biofuel demand targets lead to increased competition for the forest raw material. At the same time, though, there is also evidence of synergy effects between the sawmill sector and the use of forest raw material in the HP sector. Higher by-product prices spur sawmills to produce more sawnwood, something that in turn makes forest owners increase their harvest levels. Already in the 5 TWh Bio-SNG scenario, there is an increase in the harvest level, suggesting that the by-product effect kicks in from start. Moreover, in the 30 TWh Bio-SNG scenario, the average sawnwood price increases by a modest 0.9% due to increased returns on by-products. In addition to forest industry by-products, harvesting residues use increases with more intense roundwood harvest activities, and this will have a mitigating effect on prices in the forest raw material market. More harvesting residues can be used in the HP sector, and this helps dampen some of the upward pressure on the price of industry by-products.

At a general level, this paper has highlighted the importance of considering price formation in forest biomass markets when developing bioenergy and 2G biofuel policies. Depending on the policy design, synergies may be achieved as well as increased competition for raw material leading to industrial shutdowns.

## References


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