# An agent-based model of an energy wood market in a Swiss region

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**Abstract.** The amount of available energy wood on a given market at a given point in time is limited not only by natural restrictions but also set by the specific decision making of the market participants such as foresters, saw mills or heating providers. A systematic investigation of the underlying mechanisms and structure of energy wood markets is yet still missing. This study presents a conceptual model depicting a Swiss region's energy wood market where actors are modelled as bounded-rational agents. The model was developed applying a first version of the MAIA-methodology (Ghorbani et al. 2010).

**Keywords:** agent-based modelling, abm, forestry, forest management, energy wood market, renewable energy sources

## 1 Introduction

Depending on the tree species of each tree to be harvested between 10% and 50% of the total wood mass consists of branches and leaves otherwise not useable as high-quality round wood. This lower quality wood can generally be chopped and sold as energy wood to heat producers or as pulpwood to the chemical industry. Whether and how much energy wood is offered on the market has thus partially been a function of the round wood production. As oil prices increase and heating providers switch to renewable energy sources, energy wood becomes a more valuable energy source leading to an enlivened competition between consumers thereof.
Energy wood is sold by foresters, forest owners or commercial forestry companies to heating providers, reaching from small household heating systems to big commercial plants. This happens both on a spot market as well as on a long-term contractual basis with contracts typically lasting from 10 to 20 years. Energy wood prices are often partially bound to fluctuations of the oil price and are well-known throughout the market.
Foresters and non-industrial private forest owners as the ones to make decisions on when and where to harvest trees are assumed to be motivated not solely by profit

maximization goals but also by other utility maximization goals "such as aesthetics, recreation and wildlife habitat" (Beach et al. 2005). Traditional social bounds as well as these non-financial motivational factors significantly determine the market actors' relations. Furthermore, forestry in Switzerland is coined by small and medium forest parcel sizes, private and local community ownership and to a significant degree by a mountainous terrain. Compared to the good's intrinsic value transport costs are high, leading to local supply/demand-structures.

By building an agent-based model (ABM), the authors wanted to come to a better understanding of the factors influencing the availability of energy wood on the market. Questions to be addressed were: Which agents get which amount of energy wood at what price? Do changes in foresters' and forest owners' value systems, e.g. a stronger commercial orientation at the loss of traditional social bounds, lead to an increase or decrease in the available amount of energy wood on the market? Can incentives be found to increase the overall available amount of energy wood on the market?
A first version of an agent-based model (ABM) of an energy wood market still relying on standard microeconomic assumptions was implemented by Olschewski et al. (2009). The model was able to reproduce plausible market results. An advanced version of the model based on refined domain knowledge is presented hereby.

## 2 The model

At first, domain knowledge concerning the Swiss energy wood market was gathered through expert interviews. Then a conceptual model was specified. The MAIA-methodology supports the meta-model concepts of a *physical structure*, a *collective structure*, a *constitutional structure*, an *operational structure* and an *evaluation structure* (Ghorbani et al. 2010).

Belonging to the constitutional structure, market participants were modelled as *roles*. Each role is attributed some *objectives*, *subobjectives*, *institutions* (consisting of formal/informal prohibitions, permissions and obligations for this role), *rights* (what a role is allowed to do), *information* (the type of information it has access to), *resources* (monetary, natural and other resources this role can decree on) etc. During the simulation run a role must be taken up by an individual agent who enacts it (*role enacting agent*, REA). It is possible for an agent to enact several roles.
Four categories of relevant roles were identified: 1. Suppliers of energy wood: foresters and private forest owners. 2. Consumers of energy wood: small private energy wood consumers, public wood fuel consumers (municipalities), commercial energy wood consumers, district heating network operators and pulpwood consumers. 3. Intermediates able to act both as suppliers and consumers of energy wood: forestry companies, bundling organizations, sawmills. 4. Others: small private heat consumers.
Resources being traded on the market belong to the physical structure. They include money, energy wood, round wood and heat/energy.

From the static model structure, so called *action situations* (AS) as part of the dynamic *operational structure* were derived. An AS simply describes a relatively independent process partaking in the model run, e.g. an interaction of REAs. All ASs must be brought into a logical order that can be sequentially processed. Important ASs identified were the following:

1. Market entry and exit of certain REAs: Each round, a few heat consumer REAs make a decision on whether to install a wood energy heating system (market entry) or replace an existing one with alternative energy sources (market exit).
2. Industrial round wood market run: Sawmill REAs buy roundwood either directly from foresters or forest owners or indirectly from intermediates, namely forestry companies or bundling organizations.
3. Energy wood market run: In a first phase, all energy wood consumer REAs try to either buy energy wood from corresponding suppliers (directly or through intermediates) on a spot market or, if long-term contracts have run out, set up new contracts. A single consumer REA cannot combine both trading modes at the same time, but, once run out of contracts, it can switch from one trading mode to another between rounds. In a second phase, all intermediates try to buy energy wood from direct suppliers (foresters or forest owners).
4. Harvest and thinning activities: Foresters and forest owners carry out harvesting and forest maintenance activities or outsource them to forestry companies.

This conceptual model has been validated in several expert workshops.

## 3 Outlook

A first version of the advanced model has recently been implemented in Java. Domain knowledge is partially encoded in an OWL-ontology. Currently, the model implementation is being validated and the model behaviour inspected. A systematic analysis of relevant model parameters is planned to be performed in the near future using a cluster computer.

## References


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