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DESIGN OF WOOD BIOMASS SUPPLY CHAINS

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In an extremely unstable world, an efficient management of energy resources and environment is crucial for a bright future.

Societies are each day more convinced of the necessity to change the paradigm of consumption of energy resources. The vast majorities of these resources are non-renewable and not environmentally friendly and have soaring prices that may lead to the collapse of world economies, because they are too dependent on these resources. In order to change the current situation, the vast majority of countries are focusing on increase consumption of renewable and environmentally friendly energies to allow a reduction of the dependence on fossil energy and emissions of greenhouse gases.

There are several types of renewable energy sources such as the wind, hydro, solar, geothermal, wave and biomass. This work deals with one of them, the biomass, and particularly woody biomass. According to EN 14588 or EN 14891-1 “woody biomass is biomass from trees, bushes and shrubs. This definition includes forest and plantation wood, wood processing industry by-products and residues, and used wood”.

The wood biomass is a clean and renewable energy because it has a carbon neutral cycle. The trees capture CO_2 from the atmosphere. After burning the resources of the trees the CO_2 is released back into the atmosphere. This cycle repeats successively. For this reason, the burning of biomass does not cause more emissions of greenhouse gases..

Beyond the environmental benefits, the harvest of forest resources allow the cleaning of forests, reducing fire risk and the proportions of them, as well as the economic development of rural areas.

The wood biomass after transformed can be included in various economic activities, such as: in the production of derivatives timber products, for heating, for electricity generation, or in the transport sector.

To be profitable the business of biomass it is necessary to optimize the supply chain, from the collection of raw materials until the end-user. Transport costs account for about 50% of total costs, in some cases can reach 65%. The correct definition of the links in the supply chain and the optimal planning of the flow of materials is crucial in order to meet demand at the desired time while minimizing total costs.

In this work we consider a company that collects the material in the forest and deliveries it to the customer after transforming the raw material in wood chips (subrectangular shaped pieces with a defined particle size produced by mechanical treatment with, usually, knives).

The company's aim is to deliver the quantity of products desired by customers at the desired time, minimizing the total cost of the supply chain.

The supply chain is formed by harvest areas in forests (that serve as suppliers), customers and may have intermediate warehouses.

In the forest the collection of forest resources is made and then resources are stored in the local or are transformed in wood chip. If the material is processed, the resulting products are transported to the customers or to the intermediate warehouses.

In this sector of the activity supply and demand is seasonal, varying throughout the year due to climatic variations. Because of this seasonality the use of inventories is more important for a good level of service than in other types of supply chains.

The intermediate warehouses serve to improve supply and demand coordination, particularly relevant when seasonality of both supply and demand are an important issue and to better manage wood chips and transportation operations. The stores can accommodate resources not chipped, as well as chipped material, and they can also be used to carry out processment operations.

The customers receive the resources already processed in order to meet their demands.

One important aspect of the problem is the optimal management and good planning of equipment and human resources involved in the tasks of collecting, processing of forest resources, transportation and storage.

For tackling all these aspects of the supply chain design, an integer programming model that supports tactical and operational decisions was developed. The model allows the minimization of all the costs involved.

For a given planning horizon discretized in time periods, the model addresses the following tactical decisions (middle term):

- Use or not the intermediate warehouses;
- Installation or not of the fixed chipper at each warehouse

In terms of operational decisions (short term), the model considers the following decisions:

- Planning of transportation between the different links in the chain;
- The location where the chipping is done (in the forest or in the warehouse);
- Planning the use of mobile machines chipping.
- The quantities to be stored at all time periods, in the different warehouses.
- Which supply areas should be used;

We tested our model in a set of small and medium sized instances (the larger one has 12 numbers of time periods, 12 harvest areas, 3 warehouses and 4 clients) with a general purpose solver. A good solution (measured by the difference between the cost of the solution and a lower bound) was reached quickly (in minutes) for all tested instances.

To obtain good solutions in reasonable amounts of time for larger instances, we intend to combine decomposition techniques (in particular, column generation) and (local search based) metaheuristics.

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