The Biomass Production and its Technical Background in Hungary

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Abstract:
Hungary's total stock biomass is about 350-360 million tons, which represents nearly two-thirds of the total renewable energy resources of our country. The majority of this biomass is wood-based. Only about one sixth of the feasible resources have been hitherto harnessed. The future possibilities in biomass production can be attained by plantations (energy plantations), among which the ones cultivating trees are called energy tree plantations. Over many hundreds of thousands of hectares of such stands are expected to be planted in Hungary in the near future.
Planting of such huge volumes can only be carried out at a scheduled rate when applying the appropriate type of machinery and cultivation technology.
Because the technologies required on energy tree plantations differ substantially from the equipment used at traditional forests, machine development is unavoidable.
In our research and development we have defined and systematized the actions and the corresponding machinery for the cultivation technology of energy tree-plantations.
We have establised if a technological step needs machine developments or better the design of completely new machine prototypes. Respecting several technological parameters (e.g. planted woods species, area size, etc.) we have proposed different production lines for the cultivation technology of short- and long-rotation energy tree plantations and for the underwood level of flood plain forests taking into account machine upkeep and operational costs.
We have proposed strategies (using the Building Block Concept) for the development of different prototypes of a cutting machine (16 different approaches) to establish machinery lines for various cultivation technologies.
The results are utilized continuously both in practice and in university education. Following innovative research-development activities the automation of cutting and harvesting can be achieved. Regarding our domestic cutting machine development a licencing procedure has also been started.

Keywords: renewable energy, biomass, energy plantations, research-development, deployment of wood plantation, nursing, harvesting, machinery development, cutting machine, harvesting machine

1 Introduction

Hungary plans to increase the ratio of renewables in energy production up to 14,65% by the year of 2020. The country's renewable energy utilization action plan sets the effective exploitation of the domestic biomass potential as an important target. The future possibilities in biomass production are attained by plantations (energy plantations), among which the ones cultivating trees are called energy tree plantations. These can be either

⇒ short-rotation energy tree plantations (characteristics: 1 - 2 (3) years of rotation; relatively thin (1-5 (10) cm) stem diameter; one-step harvesting with eg. a mobile chipper);

⇒ long-rotation (roundwood-producing) energy tree plantations (characteristics: 3-5 (10) years of rotation; thicker stems (10-15 (20) cm diameter); usually multi-step harvesting).

From the standpoint of energetics, significant importance can be attributed to the following resources too:

⇒ The underwood level of flood plain forests, which provides wood with a quality similar to that of short-rotation (thin stem producing) energy tree plantations. These stands are row-independent for not having been afforested artificially;

⇒ The felling byproducts of regular forests. The collection of these byproducts has not yet been solved satisfyingly, however.

The development of machinery improving the energetic utilization of wood also involves the establishment of complex equipment (site preparation machines, cultivators, planters, machines for tending, harvesting and winding up the plantation) for the use with short rotation (thin stem producing) forests. The mechanization of these tasks has not yet been solved satisfactorily up today, synchronized equipment needs to be installed in these fields. These lines of machines could be optimized partly from machines developed in Hungary, partly from adaptations. The development of machines aiming at the energetic utilization of wood is also reasoned by the past years' dynamic domestic increase in the energetic use of woody biomasses, especially in power plants.

Short rotation energy forest plantations can be established at those sites of good quality soil which are suitable for plantation agriculture, yet there is a low demand (or overproduction) for the crops that could be grown or there is an incertitude in the production (possibility of inland waters or flood damage, etc.), therefore these lands are not used for the field growing of plants any more, but instead, they will be suitable for dendromass production.

The cultivation technologies of short rotation energy forests depend on various factors (e.g. species, size of the plantation, regional conditions, available power machines and engines, factors influencing logistics) which should be well considered before choosing the most suitable technology.

For the establishment of short rotation energy forests at agricultural sites generally such cuttings are used which reproduce naturally and have a good root striking and recovering ability: they sprout easily from the stump and have a large current growth even at young age. Most suitable for these purposes are cuttings with the length of 15-25 cm. The size of the cuttings (most of all, the diameter) depends primarily from the properties of the species to be planted. The diameter can vary between 0,8-2,5 cm. Planting design can be single-row or twin-row arrangement. This will also influence mechanization. In the case of single-row planting (row spacing: 1,5-2,8 m; stem spacing: 0,4-1,0 m) and twin-row planting (row spacing: 2,0-2,8 m; spacing of twin-rows: 0,6-0,8 m; stem spacing: 0,4-1,0 m).

The nursing works on the plantation are very important too, mainly in the first year because of the weed contol and the nutriment supply. It is very important that the costs of harvesting related on gross expenditures represent about 50-80% of the overall production costs, that is low harvesting costs and the choice of the optimal harvesting methods are key factors. The afore-mentioned facts reason the significance of the proper choice of the machines and equipment used on energy tree plantations. This is the scope of the present research work.

2 Description of research methodology, aims of research

There are huge possibilities in Hungary for the future use of renewable energy resources since primarily from biomass there is a great bigger potential available than the amount utilized at present. *(Figure 1).*

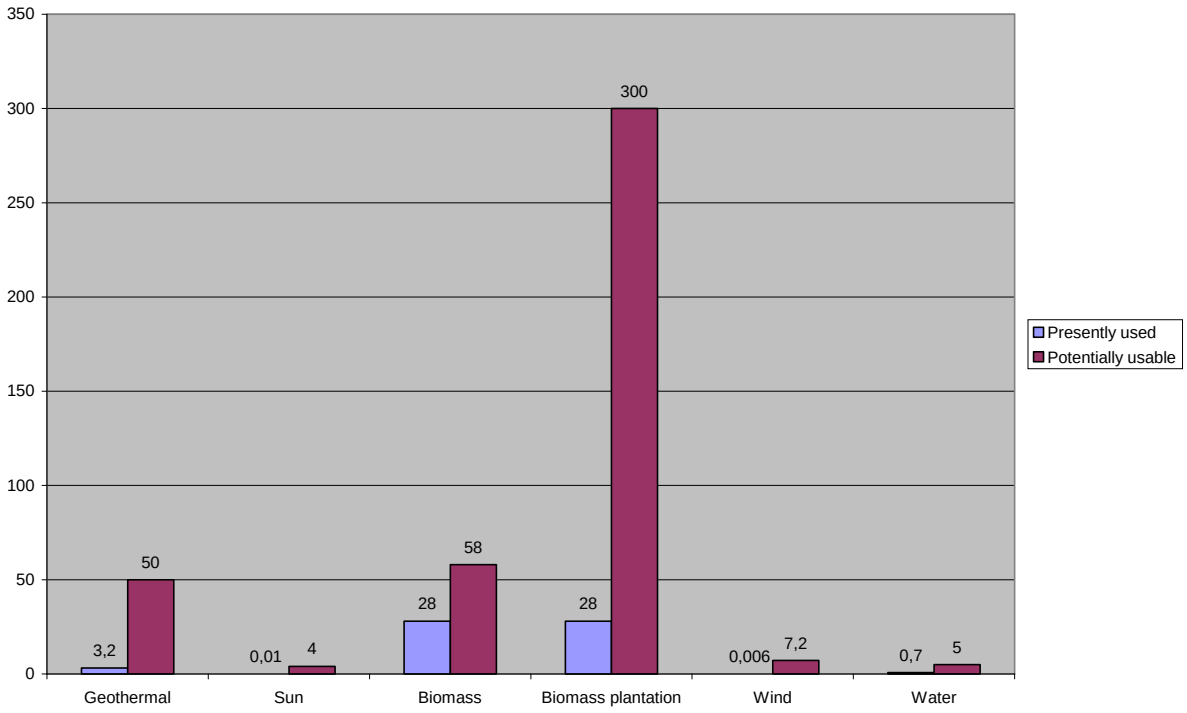

Figure 1: Renewable energy resources in Hungary [PJ/year]

Figure 2 summarizes the different types of biomass and their relative proportion in Hungary.

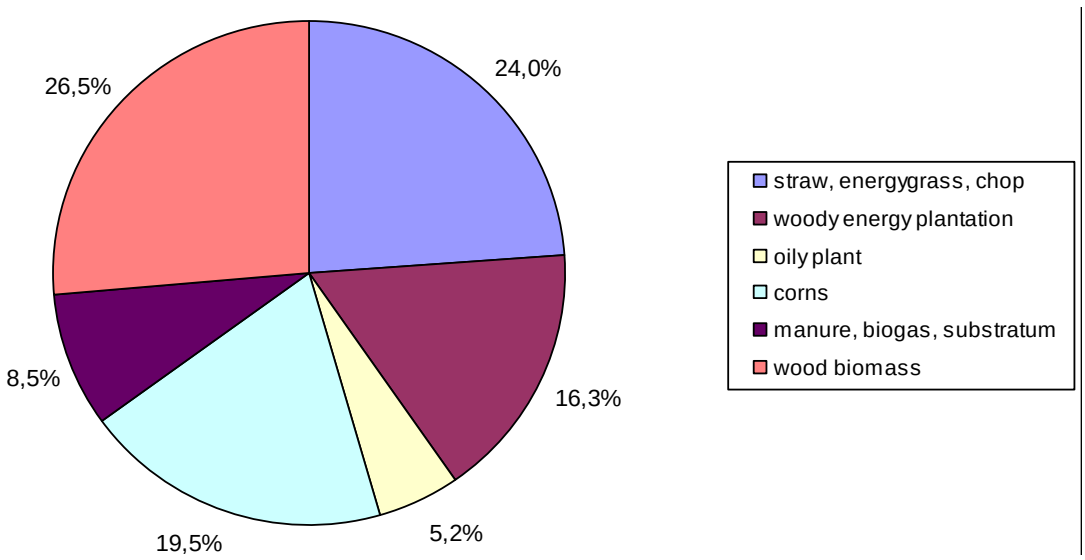

Figure 2: Types and proportion of biomass in Hungary [%]

Figure 2 shows that woody energy plantations take an important place in the national biomass production and this is what reasons the significance of the present research.

In our research and development activity we have defined and systematized the actions and the corresponding machinery for the cultivation technology of energy tree-plantations. This is summarized in the Table 1.

Table 1. The actions and the corresponding machinery required in the cultivation technology of energy tree-planting

Action	Aim and characteristics of the action	Machinery
Site-preparation:	Making the surface suitable for the preparation of the soil	
- landscaping	Elimination of ground irregularities	Push blade
- bushwhacking	Cutting out bushes and shrubs	Stem crusher
- chemical weed control	Clearing away non-woody plants	Sprayer
Preparation of the soil	Implementing optimal physical state for the soil	
- deep ploughing (25–50 cm)	Rotation of the soil	Deep plough, subsoiler
- deep turning (50–70 cm)	Rotation of the soil	Trench plough
- ground surface finishing	Pounding of clods, grading the surface of the soil	Tiller, land plane, harrow
Sowing	Sowing black locust seeds	Sower
Planting of saplings	Planting saplings of black locust and domestic poplar species.	Tree-planting machine
Propagation by cuttings	Propagation of hybrid poplar clones and willow by cuttings, besides the plantation of hybrid poplar clones and willow by canes	Cutting machine, sapling-planting machine, hole-digger
Cultivation:	Ensuring optimal conditions for the species of the energy tree-plant	
- mechanical soil tending	Loosening of the soil, weed control	Tiller, cultivator, forestry soil loosener
- mechanical weed control	Weed control	Stem crusher
- chemical weed control	Weed control, destruction of insects	Sprayer, grouting machine
Harvesting:	Production of chips suitable for combustion	
- one-step harvesting	Production of wood chips by mobile chipping	Mobile chipper
- multi-step harvesting	Chipping by one of the following series of actions: - felling-chipping, - felling-harvesting-chipping, - felling-bunching-transport of bunches-chipping	Brushcutter, chainsaw, feller, harvester, buncher, chipper, hydraulic crane trailer,
Transport of wood chips	Transport of the chips between the production site and the power plant	Lorry, trailer
Transport of bunches	Transport of the bunches between the production site and the chipping site	Hydraulic crane trailer, forestry truck, trailer
Winding up the plantation:	Making the site suitable for the field growing of plants.	
- grubbing	Rooting up of tree trunks	Chock grapple, stem chipper
- root cutting	Cutting out of the roots	Root cutter
- trench ploughing (50–70 cm)	Ploughing up the soil	Trench plough
- finishing of the ground surface	Pounding of clods, grading the surface of the soil	Tiller, land plane, harrow

We have concluded that regarding the actions of the cultivation technology of energy tree plantations site-preparation, preparation of soil, sowing, planting of saplings, cultivation, transport of wood chips, transport of bunches and winding up the plantation can all be accomplished using the appropriate and subsistent agricultural and forestry machinery. It is necessary however that the right type and scale of machinery, fitting best the requirements be chosen. Essential developments need to be realized in the mechanization of the propagation and harvesting.

Aims of the research

Proposing suitable and optimal types of machines for the different-sized energy plantations for the tasks of establishing, nursing, harvesting and winding up the plantations, namely:

⇒ planting and harvesting machinery line for short-rotation energy tree plantations,
⇒ planting and harvesting machinery line for long-rotation energy tree plantations,
⇒ planting and harvesting machinery line for the underwood level of flood plain forests.

3 Results

The results of the research and the machinery development have been as follows:

⇒ Optimization of the machinery technology of energy tree plantations (University of West Hungary - Institute of Forest and Environmental Techniques, Ministry of Rural Development - Hungarian Institute of Agricultural Engineering, Bagodi Mezőgép Kft.);
⇒ Development of machines for planting energy tree plantations (Bagodi Mezőgép Kft., University of West Hungary - Institute of Forest and Environmental Techniques, Ministry of Rural Development - Hungarian Institute of Agricultural Engineering).

The goal was to design an ideal planting machinery and to develop an optimal planting technology for it. The following machine setups are proposed as the result of our research and development work:

⇒ Single-row conventional till-seed-drill planting machine without a feeder;
⇒ Multirow (double-row or three-row) conventional till-seed-drill planting machine without a feeder;
⇒ Twin-row (one row pair) conventional till-seed-drill planting machine without a feeder;
⇒ Twin-row (multiple: two or three row pairs) conventional till-seed-drill planting machine without a feeder;
⇒ Single-row conventional till-seed-drill planting machine with semi-automatic (rotating) feeder system;
⇒ Multirow (double-row or three-row) conventional till-seed-drill planting machine with semi-automatic (rotating) feeder system;
⇒ Twin-row (one row pair) conventional till-seed-drill planting machine with semi-automatic (rotating) feeder system;
⇒ Twin-row (two or three row pairs) conventional till-seed-drill planting machine with semi-automatic (rotating) feeder system;
⇒ Single-row planting machine with semi-automatic (push-type) feeder system;
⇒ Double-row planting machine with semi-automatic (push-type) feeder system (*Figure 3.*);
⇒ Twin-row planting machine with semi-automatic (push-type) feeder system;
⇒ Single-row conventional till-seed-drill planting machine with automatic feeder system;

Figure 3: Machinery for planting energy tree plantations (double-row planting machine with semi-automatic (push-type) feeder system)

⇒ Development of machinery for tending energy tree plantations (Figure 4.) (University of West - Hungary Institute of Forest and Environmental Techniques, Huniper Kft.).

The goal was to build a prototype of a machine which is suitable for the protection of energy tree plantations and other afforestations against grub damage.

Figure 4: Injecting machine for plantation tending

⇒ Development of machinery for plantation harvesting (Optigép Kft.).

During the two-step plantation harvesting process the stems are first separated from the stump and piled up behind the tractor using a OG-FD type felling machine (*Figure5.*) then the stems are chipped with a trailed EA-F type wood chipper. Both the OG-FD and the EA-F can handle stems with a diameter up to 15 cm. They can be driven by an engine with a minimum power output of 57 kW (80 HP). The average particle size of the wood chips produced by the EA-F is 3-5 cm.

When using the OPTI-VFA type energy tree harvesting machine (*Figure 6.*) a single step harvesting process is carried out. This involves the felling of the stems with a maximum diameter of 10 cm from the stump and processing them to the chipping equipment of the machine. After chipping the product can be loaded on trucks. The minimum power requirement of the machinery is 132 kW (180 HP). Row distance can be set to 1.5 m and 2.4 m. The average particle size is 5-6 cm. The average speed of the machine is 2-3 km/h.

Figure 5-6: OG-FD type felling machine; OPTI-VFA type felling and chipping machine

⇒ Development of machinery for harvesting the underwood level of flood plain forests. (Bagodi Mezőgép Kft., University of West Hungary - Institute of Forest and Environmental Techniques, Ministry of Rural Development - Hungarian Institute of Agricultural Engineering).

The proper treatment of the underwood level of flood plain forests requires the development of such a harvester which is row-independent. Suitably these types of machines will be equipped with a swinging-knife cutter, a screw-type gatherer and a drum-type chipper *(Figure 7-8)*.

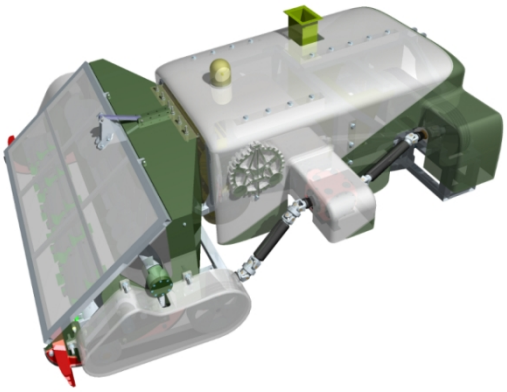

Figure 7: Row-independent harvester

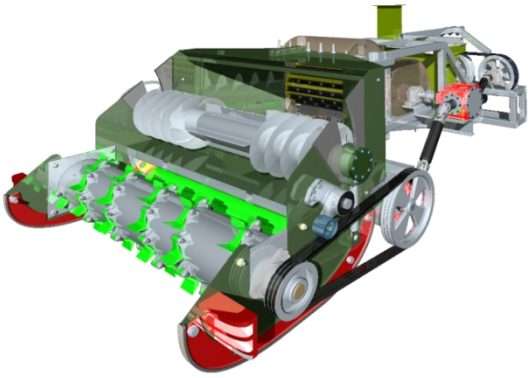

Figure 8: swinging-knife cutter, a screw-type gatherer and a drum-type chipper

⇒ Development of a wood chipper (Figure 9.) (Metripond M. 93 Kft., University of West Hungary - Institute of Forest and Environmental Techniques).

This part of our research focused on the development of a machine with low power consumption which is primarily suitable for handling the amounts of fuel wood generally processed in small farms. Nevertheless this gear will be also utilisable in the harvesting processes of short-rotation (thin stem producing) tree plantations.

Figure 9: Wood chipper

⇒ Development of a felling-bunching machine (Hevesgép Kft., Károly Róbert College).

The result of this development was the prototype of a machine which is utilizable in the first step of the multi-step harvesting of short-rotation (thin stem producing) plantations.

⇒ Development of a bunching machine (Figure 10.) (KEFAG Kft., private companies).

The aim of this development was to create the prototype of an equipment which is primarily suitable to handle the branch material left back at the felling site. Besides of that it will be applicable in the harvesting processes of small-size short rotation (this stem producing) plantations.

Figure 10: Bunching equipment

⇒ Development of a multifunctional (collecting, chipping, compacting) machine (University of West Hungary - Institute of Forest and Environmental Techniques, IKR),

The aim of this part of the research was to establish the prototype of a forestry superstructure which can be mounted on to the BPT-220 type tandem drive trailer frame manufactured by the IKR Kft.

⇒ Development of a machine for collecting the branch material left back at the felling site (Figure 11.) (University of West Hungary - Institute of Forest and Environmental Techniques, KEFAG Kiskunsági Erdészeti és Faipari Kft., Kiskunsági Erdőgép Kft.).

Figure 11. Grab mounted on an engine.

As the result of our research we have designed the prototype of a forestry superstructure which can be mounted on the undercarriage of a front loader. This equipment is suitable for collecting and loading of the felling site harvesting losses primarily the branch material and the stumps.

4 Conclusion

The major aims of the action plan intending to utilize renewable energy resources better in the future, as well as the vast amount and characteristic composition of the domestic biomass potential reason the significance and actuality of the research and machine developments in this field.

As a result of our research and development we have designed and established prototypes of machines out of which some have already been built while some are still under construction. These new line of equipment are ideal for the domestic circumstances and can well be used on energy tree plantations. The planting of such plantations has been intesively started recently in Hungary, which will hopefully contribute to the improvement of the competitiveness of the national economy in the future.

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