



# Energy wood harvesting with the farm-tractor based system

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## **Abstract**

Young thinnings are a potential source of biofuel. For such harvesting conditions (small tree size and removal) forestry equipped farm-tractors are feasible harvesting concepts to accomplish the cutting of EW (energy wood) with accumulating felling heads. A demonstration of the farm-tractor equipped with an accumulating felling head and a timber trailer revealed concept's abilities to operate in an efficient way in EW cuttings.

EW harvesting with forestry equipped farm-tractors can be a feasible and profitable business opportunity for farmers having seasonal agriculture works, and for contractors operating year round in energy wood harvesting.

## Preface

This report is a national demo report (WP3) of the 5EURES – Five European RES-Heat Pilots – project (EIE/04/086/S07.38582). In WP3 of 5EURES local feasibility studies, case studies and demonstrations are performed. The main objective of the 5EURES project is to increase of the actual energy produced from bioenergy in the EU. In WP3, the target is to create regional bioenergy producing and/or using pilots. The target is achieved through feasibility studies, case studies and demonstrations.

The Finnish Forest Research Institute's researcher, Mr. Kari Väättäinen made a one-day trip to Sumiainen in Finland in 26<sup>th</sup> of October 2006. The intention of the trip was to observe the EW cutting demonstration conducted by farm-tractor based EW cutting system and to collect some base data of the used equipments. Mr. Jouni Boman from the municipality of Sumiainen was the contractor operating with the farm-tractor in two demo sites.

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# 1. Introduction

## 1.1 Energy wood harvesting from young stands

In Finland, repeated thinnings are a standard and essential silvicultural practice for the efficient production of good quality and well priced industrial wood. Nearly all stands are thinned one to three times during a rotation time. Most of the commercial thinnings are preceded by pre-commercial thinnings, from which felled trees are not collected because of the small tree size.

Young thinnings are a potential source of biofuel. Currently, the highest biofuel yields are found in stands, where silvicultural activities have been neglected. These stands are over-dense, and the trees that have to be removed are too thin or of undesirable tree species for industrial purposes. As such, they are attractive for biofuel harvest (Hakkila 2004). It has been discussed, that management guidelines adapted to biofuel production in young forests could include a so called energy wood thinning. The energy wood thinning is carried out before commercial thinning, and it can delay the first commercial thinning compared to traditional silvicultural regime (Hakkila 2004). In pine stands, an extra benefit can be gained by better quality of the remaining stems, if young trees are growing in more dense position.

## 1.2 Farm-tractors for forestry use

Most of the machines used in mechanized CTL-loggings are designed aiming to high productivity in final fellings. The operating costs of these expensive and heavy-duty logging machines can grow relatively high in first thinnings with small sized trees and low removal. Annual harvesting removal carried out from first thinnings is only about 10% of total harvesting in Finland. Not only first thinnings, but also energy wood harvesting in young stands promotes the use of lighter and cheaper machines, such as thinning harvesters and farm tractors especially equipped for forestry use. A farm-tractor with relatively high productivity and moderate purchase price can be a competitive option, if terrain conditions are favourable and the annual operational hours are adequate (Ryynänen *et al.* 2000).

In general, costly investments of machines enforce a pressure to increase the machine utilization as high as possible. Correspondingly, the hourly costs will be reduced, if the lay-days of machines could be lowered (Pentti *et al.* 2005). The average annual use of farm-tractors in agriculture operations in Finland is comparatively low, and the use is concentrated practically on the growth season. The supplementary use of farm-tractors in biofuel harvesting operations could lower machine hourly costs, and give complementary business activity to farmers. Moreover, forestry use equipped farm-tractors could be even feasible option for year round business in forestry operations in young forests.

Principally, farm tractors used for forestry works needs to be equipped for forest work purposes. In the tractor assembly line a special forest cabin, revising techniques and cut prevented tyres are already installed in the forest farm-tractor. Additionally, the bottom shield and hydraulic pump are also vital to install to the tractor. Depending of the prospective forestry use of the tractor, there are several accessories possible to attach to the tractor, such as crane, forestry trailer, accumulating harvester head for energy wood and chipper.

## 2. EW cutting demonstration in Sumiainen in Central Finland

### 2.1 Background of the contractor and the farm-tractor based EW system

In Central Finland, in the municipality of Sumiainen, the EW harvesting contractor has operated, as a secondary occupation, in EW harvesting operations during latest few years. In the future, the purpose is to concentrate more on the EW harvesting and on the total contracting of supplying forest chips to local bio power plant (2 to 3 MW), which will be launched soon.

The equipments used for EW harvesting are a Farm-tractor (Valmet 805, year model - 86), a timber crane (Kronos3000), a timber trailer (Kronos) and an accumulating felling head (NaarvaGrip1000-23E). Latest investment, co-operated with another small EW-contractor, is a small mobile chipper attached to farm-tractor and powered by it.



*Figure 1. EW harvesting contractor's farm-tractor attached with a crane and accumulating felling head.*

The working radius for EW harvesting has been about 10 kilometres. As a benefit for small scale EW, contracting with farm-tractor has been the possibility to relocate the tractor to new EW stand by driving it. Therefore, there is no need to have a separate relocation truck or need for buying the services of machine relocation companies. Annually, the contractor is operating with the farm-tractor about 1 000 hours.

According to the contractor, the characteristics of the feasibly operable EW stands are as follows: the average stem size being at minimum of 4–5 cm at breast height, dense forest and small amount of drivings in the forest. Especially birch stands, where the amount of removable stems is usually high and the resulting tree density remains quite low (easy to drive), are feasible targets. Other potential EW harvesting sites for farm-tractor based harvesting are the abandoned fields growing energy wood, where all the trees and bushes have to be cut. Additionally, cutting of bushes and small stems right next to the smaller (private and forest) uncared roads are proper working sites, eventhough the share of these sites' EW removal from total remains quite small.

During the cutting with the farm-tractor based EW concept is used mainly one technique. When cutting and bunching the trees, tractor has to be in backwards position to the cutting area. At first, the strip road is opened and both sides are thinned. Usually small offset tracks to the treated stand is made, since the reach and the feasible cutting radius of the boom concept is small (about 6 to 7 metres). The driving during cutting is done reversed.

The contractor is mainly concentrated on the cuttings of EW sites, although he has also made forwarding of EW. Occasionally, when he does the forwarding, he replaces the EW felling head with the normal timber grapple before forwarding. This farm-tractor contractor has made a deal with one local forwarder contractor, which normally forwards the cut EW trees from the stand to the roadside.

## **2.2 Two EW cutting demonstrations**

In the first demo site, the contractor itself was harvesting grey alder stems for EW use (Figure 2). The size of the stems was about 50-60 litres (10 metres height and 12 cm of

dbh as in average). The functionality of NaarvaGrip accumulating felling head for these stems was good. As in average, two stems were taken to the grip of the felling head before bunching. Most of the stems were cut from the middle of the stem at the beginning when stems were still standing (Figure 3). Because the demo area and used demo-time were so limited, there was no sense to collect any time study material.



*Figure 2. EW cutting in grey alder dominated forest site.*



*Figure 3. Cutting the tree in two parts and bunching.*

In the second demo site, the timber trailer was attached to the farm-tractor and overgrown trees and bushes were harvested right next from the small cart way (Figure 4). In this kind of working site the concept is operating well. The tree size was suitable for felling head's capacity and trees were often growing in bushes so, that the boom movements were very small. All the cut EW trees were bunched straight to the trailer's load space. In Finland several forest roads needs for clearing of over growth trees next from the road. Farm-tractor based EW concepts are most suitable for this purpose. Especially transporting full EW loads to main storage area of EW piles is faster compared to the conventional forwarders, when the transportation distance is long (more than 1–2 km). On the road with the load on, the driving speed of the farm-tractor can be 30-40 km/h, whereas the speed of the forwarder can be only 5-6 km/hour.



*Figure 4. Harvesting EW from the cartway side with farm-tractor based EW system.*

### 2.3 Operation costs of the farm-tractor with the EW accessories

A cost calculation for the operation costs of forestry-equipped farm-tractor with the EW felling head, the timber crane and the timber trailer is presented in this chapter. The tractor is second-hand with the year model of 1996 and the engine power of 95 hp. This represents closely the tractor, which the EW contractor in Sumiainen uses. It was not reasonable to calculate the costs for the old tractor presented in the demo, because there was not any information of the second-hand purchase price for that year model or close to it. In addition to that, some forestry adjustments to farm-tractors have been improved a lot in ten years.

In the following tables are presented the main cost factors used in calculating the operating costs of the EW concept (Tables 1 and 2). Values are based on the 5Eures studies (Väättäinen *et al.* 2007, Lamminen 2007). Annual use of the tractor was 1063 operating hours (7 months, 21 days/month, 8 hours/day) and all was based on the EW cutting. The share of operating hours from the total working time was set to 90%. Costs were calculated with the general machine cost calculation method. Machine's and accessories' capital costs were calculated with straight-line depreciation including the share of the interest cost.

*Table 1. Base information for the cost calculations of the forestry equipped tractors.*

	Cost calculation values
Model	Valmet 6400 (1996)
Engine power, hp	95
Purchase price (VAT 0%), €	28,200
Service life, machine hours	10,000
Salvage-% of purchase price	30
Interest rate, %	5
Hourly wage	10.5
Indirect wage cost-%	67.5
repair and maintenance cost, €/h-E <sub>5</sub>	4.0
Consumption, l/h:	
Fuel	8.0
motor oil	0.1
gear oil	0.1
hydraulic oil	0.25
Cost, €/l	
Fuel	0.55
motor oil	1.7
gear oil	2.1
hydraulic oil	1.85
Insurance cost, €	500
Management and maintenance, €	1,500

*Table 2. Base information of the accessories for wood energy harvesting.*

Accessories	
Wood energy harvesting head (accumulating felling head)	Naarva-Grip 1000-23E
Purchase price (VAT 0%), €	6,970
Service life, machine hours	8,000
Salvage-% of purchase price	25
Crane	Kronos 4000
Purchase price (VAT 0%), €	9,410
Service life, machine hours	10,000
Salvage-% of purchase price	20
Trailer	Kronos 100H
Purchase price (VAT 0%), €	5,580
Service life, machine hours	10,000
Salvage-% of purchase price	30

As totally, the annual cost of the farm-tractor system operated in EW cuttings was 39 684 euros. For 1063 operating hours, the cost per hour will be then 37.3 euros. In this calculation case the cutting cost for one cubic metre of energy wood as full tree method would be 12.4 euros, if the average productivity per operating hour was 3m<sup>3</sup>.

*Table 3. Total annual cost and the structure for EW cutting with the farm-tractor.*

	Costs , €
Wage costs	20 902
Running costs	9 829
Fixed costs	7 064
Surplus goal, + 5%	1 890
<b>TOTAL</b>	<b>39 684</b>
<b>OPERATING COST</b>	<b>37.3 €/hour</b>

### 3. Conclusions

The utilization of farm-tractors in energy wood harvesting, especially in young stands, has increased steadily in Finland. Energy wood harvesting with forestry-equipped farm-tractors can be a feasible and profitable business opportunity for farmers having seasonal agriculture works, and for contractors operating year round in energy wood harvesting (Väätäinen *et al.* 2007).

EW cutting with farm-tractor based EW system is cost-competitive concept compared to the conventional harvester with EW felling head, mostly because of farm-tractor's much smaller hourly cost. According to recent study (Heikkilä *et al.* 2005) the cutting cost of full tree energy wood in early thinning stands with the conventional harvester in Finland was 19.7 €/m<sup>3</sup>. The productivity of the harvester was 3.7 m<sup>3</sup>/operating hour and the hourly cost was 70 €/operating hour.

Farm-tractor based harvesting of energy wood is an attractive option in cases, where it is difficult to achieve a full workload for a forest machine based supply chain within a reasonable operational area. This can be the case, for example, in areas with low percentage of forest area, or areas in which the energy wood markets and mechanized harvesting of young stands is emerging. Lower investment and productivity means also lower risk, together with lower demand for work opportunities. These advantages are emphasized, if farm-tractor has complementary work opportunities for example in agriculture (Väätäinen *et al.* 2007).

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