ForestEnergy Programme 2006-08

The COFORD ForestEnergy programme has the objective of securing marketable wood fuel of acceptable moisture content for sale as wood chip, firewood and other wood fuels, to support the development of the renewable wood energy sector in Ireland. The programme achieved this through commercial scale demonstrations of forest harvesting supply chains for wood energy on 15 forest sites (Figure 1). At each site the supply chain productivity, fuel quality and delivered energy cost of each system was assessed. Different storage options and seasoning schedules over one and two summer seasons were investigated. Public demonstrations of machinery and methods were held each year of the programme.

Conifer sites
1. Abbeyfeale, Co Limerick
2. Ballybofey, Co Donegal
3. Bweeng, Co Cork
4. Croaghrimcarra, Co Mayo
5. Foilagohig, Co Cork
6. Frenchpark, Co Roscommon
7. Kilbrin, Co Cork
8. Swan, Co Laois
9. Woodberry, Co Galway

Broadleaf sites
10. Dovea, Co Tipperary
11. Manseragh, Co Tipperary
12. Mullinavat, Co Kilkenny
13. Portlaw, Co Waterford
14. Stradbally, Co Laois

Cutaway peat site
15. Boora, Co Offaly

Long-term storage trial site
16. Rochfortbridge, Co Westmeath

Figure 1: Location of the ForestEnergy programme trial sites.

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FORESTENERGY PROGRAMME

Standard shortwood harvesting of conifer first thinnings for 3 m pulpwood and industrial roundwood

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Introduction

Harvesting 3 m pulpwood in combination with industrial assortments, such as small sawlogs or stakes, is the standard method of first thinning in conifer plantations. Branches and tops are placed on the rack to make a brash mat, which protects the soil and prevents machines from bogging. Pulpwood has a length of 3 m (± a few centimetres), with a minimum top diameter of 7 cm. Small sawlog, or boxwood, is cut to 2.5 m lengths, with a minimum top diameter of 14 cm. Stakewood is not produced on every site, as suitable logs must be straight with a low taper, in addition to meeting the required size specifications.

From a silvicultural perspective, thinning should commence when the canopy closes and tree competition begins to reduce diameter increment, generally at a height of 8.5-10 m. First thinning should promote steady, even growth of good quality stems, remove poor quality trees and create extraction racks for machine access through the stand. Trees on exposed sites in particular benefit from early intervention to reduce the risk of windthrow. However, the cost of first thinning needs to be offset, as far as possible, by the sale of products. As a result, first thinning is often delayed until a reasonable amount of higher priced small sawlog or boxwood can be harvested. While this leads to a short term benefit, over the lifetime of a crop early intervention has been to shown to be the most profitable option. It accelerates diameter growth on the remaining stems and brings forward larger, more profitable trees for earlier harvest.

Shortwood harvesting can also be used to produce wood for energy by utilising the pulpwood assortment. In this instance it may not be as important to be as accurate with top diameter, or delimbing, if it is known that the wood will be used for energy.

All the machines used in the study were owned and operated by experienced Irish forest contractors.

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This method was used as a reference for all the others tested in the three years of the ForestEnergy programme.

Pulpwood was stacked along the forest road and used for storage trials to investigate the rate of seasoning. Some stacks were covered (with plastic or paper), others were left uncovered. The results of these trials are reported in other COFORD Connects notes.

Method

In all cases a combined line and selection thinning was carried out. In principle, the aim was to remove one line in seven, with the remainder of the stand receiving a light thinning. On average, thinning removed 40% of the stems: 14% being from the extraction rack, the remaining 26% from the selection thinning.

Trees were felled, pulled down and delimbed at roughly right angles to the rack. Pulpwood and other assortments were placed in separate piles, which were placed alongside the rack. Shortly afterwards the assortments were forwarded to the roadside and placed in large stacks. The stacks were raised off the ground by placing bundles of logs under the stacks, parallel to the road.

Most of the stacks were covered with either plastic or paper for long term storage. The logs from the 2006 trials were chipped after one summer. The stacks that were harvested during 2007 were chipped partly in 2007, partly in 2008, so that drying over two summers could be investigated.

Machines

Two harvesters equipped for first thinnings were used in the trials: a Gremo and a Silvatec. All wood was forwarded to the roadside by Valmet thinning forwarders.

The wood from the 2006 trials was chipped using a Jenz 700 truck-mounted chipper, which had been brought over from Denmark with an experienced operator. In 2007 all wood was chipped by an Irish-owned and operated Musmax T8, powered by a large Valmet tractor. In 2008 three different machines were used from local Irish contractors: a Starchl truck mounted chipper, a Jenz 700 truck-mounted chipper and a Jenz 420 crawler-based machine that was fed by a small excavator. The Starchl and Jenz 700 machines were fed by the crane on the machine or the truck pulling the chipper.

During all three years wood was chipped straight into road transportation vehicles. In 2006 and 2007, these were Bord na Móna walking-floor trucks; in 2008 they were either walking-floor trucks from a private company or tractor/trailers that were hired in for the purpose. The wood that was chipped into the tractor trailers was transported for a short distance only and then tipped out into a pile for reloading onto walking-floor trucks for the long haul.

Gremo harvester in the energy assortment.

Silvatec feller-buncher carrying out a selection thinning.

Valmet forwarder.

Jenz 700 truck chipper feeding into a tractor-trailer combination.

MusMax tractor-powered chipper blowing chips into a walking floor truck.

Starchl chipper blowing chips into truck.

Results

Averages for each of the three years of the programme are presented. Full data for each year will be presented in the final report to be published by COFORD.

Table 1 shows the average results of the operations in 2006, 2007 and 2008 for harvesting, forwarding and chipping 3 m pulpwood from large stacks at roadside.

The harvesting costs were more or less the same in 2006 and 2007 (the wood chipped in 2008 was harvested in 2007). The forwarding in 2007 was more expensive because of the lower ground bearing capacity and/or steeper ground at the sites investigated.

The total average production cost of wood chip from 3 m pulpwood ranged from €46.0 to €48.5 per $m^{3\ sb}$. When the moisture content is factored in, the production cost per unit of wood energy ranged from €6.49 to €7.59 per GJ. Production costs in 2007 and 2008 were similar, although the energy production cost was lower, as the wood was drier in 2008 and therefore had a higher energy content. The differences between the two years were small, even though there was a large difference in the productivity of the different machines that were used. However, the low productivity of some of the machines was compensated by a lower hourly cost.

The total harvesting cost at the roadside delivered in transport vehicles was €6.50 to €7.60 per GJ. If the forest owner was paid €5 per m^3 solid biomass (stumpage), then

Table 1: Overview of productivity and costs of the standard pulpwood harvesting with roadside chipping in conifers.

Year	2006	2007	2008
Number of sites	3	4	4
Thinning type	Line and selection	Line and selectiion	Line and selectiion
Thinning method	Harvester and forwarder	Harvester and forwarder	Harvester and forwarder
Harvesting productivity ($m^{3\ sb}$/pmh)	3.9	3.9	3.9
Forwarding productivity ($m^{3\ sb}$/pmh)	10.3	8.5	8.5
Chipping machine	Jenz 700	Musmax T8	Jenz 420/700, Starchl
Roadside chipping productivity ($m^{3\ sb}$/pmh)	36.0	12.9	32.9
Harvesting cost @ €110/pmh (€/$m^{3\ sb}$)	29.4	29.6	29.6
Forwarding cost @ €100/pmh (€/$m^{3\ sb}$)	8.79	11.0	11.0
Roadside chipper cost* (€/$m^{3\ sb}$)	7.9	7.9	7.9
Total cost (€/$m^{3\ sb}$)	46.1	48.5	48.5
Average energy content at seasoned MC (GJ/$m^{3\ sb}$)	7.1	6.4	6.9
Average energy cost on transport vehicle (€/GJ)**	6.49	7.59	7.03

* Jenz 700 €300/pmh, Musmax €100/pmh, Jenz 420 €150/pmh, Starchl €170/pmh

** The moisture content after storage varied from 35 to 56% after two years of storage.

that would add €0.70 per GJ to the cost. The cost of road transport needs to be added to obtain the delivered-in cost at the combustion facility. An average transport cost of €1.50 would give a delivered-in cost of €9.57 to €10.78 per GJ, which includes a 10% overhead for the woodfuel trader. Typical component costs to arrive at a delivered-in price are summarised as:

Stumpage (€5/$m^{3\ sb}$) €/GJ	€ 0.70
Chipping €/GJ	€6.50 - 7.60
Road transport 50 km €/GJ	€ 1.50
Trader's allowance 10% €/GJ	€ 0.87 - 0.98
Delivered-in cost €/GJ	€ 9.57 - 10.78

Conclusions

Shortwood harvesting, producing pulpwood and small sawlog assortments is the standard method of first thinning in conifer plantations. Experienced contractors with modern productive harvesting and extraction machinery, and efficient road transport are available. Tree tops and branches are left in the extraction rack as a brash mat to prevent bogging, soil compaction and rutting, and allow nutrients in needles to return to the soil. Typically, first thinning is delayed relative to the silvicultural and long-term financial optimum to obtain more small sawlogs that fetch a better price than pulpwood.

Pulpwood can also be chipped to produce fuel for energy generation. Wood is first stacked at roadside and covered using paper or plastic. Stacks remain at the roadside for one or two summers to dry (and increase in net energy content and value). Wood is then transported to a yard, seasoned further and chipped there, or, as in these trials, directly chipped into road transportation vehicles in the forest.

The moisture content of the trial stacks stored in the forest was not low enough to allow delivery of the chips to 'dry' fuel boilers. Typically, pulpwood stored at a depot will season to below the 35% moisture content required by dry fuel boilers.

System productivity

All operations were time studied, and the net productive time was recorded. Net productive time excludes all interruptions and, in order to reflect a normal working day, allowances are added to obtain work place time. Allowances include rest breaks, small repairs and other normal interruptions, but exclude events such as major breakdowns and bogging. By adding 30% allowances for machine work, productive machine hours (pmh) is obtained.

Units

In all cases the volume of loose chips ($m^{3\ lv}$) from the chippers was converted to m^3 solid biomass ($m^{3\ sb}$) by using a conservative ratio: 1 m^3 lv= 0.33 $m^{3\ sb}$. All production figures and costs are expressed in $m^{3\ sb}$/pmh or €/$m^{3\ sb}$. With the measured moisture content of the chips at the time of chipping, the energy content of the chips is expressed in GJ/$m^{3\ sb}$ and the final cost is expressed in €/GJ.

The shortwood method is an expensive way to produce energy chips. The tops and branches are left in the forest as a brash mat, which means that the cost of harvesting is carried by a smaller volume of wood than in the whole-tree method. Also, the whole-tree method uses multiple tree handling, while in the pulpwood harvesting each tree is handled individually. On the other hand, the quality of wood chip obtained using the shortwood system is generally high, with a smaller proportion of bark and overlong pieces that can block the free flow of wood chip along an auger.

Costs of wood chip delivered to a consumer at a maximum distance of some 50 km from the forest were in the order of €9.57 to €10.78 per GJ or roughly €90 to €102 per tonne at 45% moisture content, which is 50-100% more than for whole-tree chips. If the wood is transported to a yard before chipping, then the costs per energy unit would be even higher, because of the extra handling and transportation. On the other hand, it might be possible to reduce the moisture content further so that the chips can be delivered to dry fuel boilers and command a higher price.

*For information and a free on-line advisory service on the wood energy supply chain, the quality of wood fuels and internal handling visit **www.woodenergy.ie***