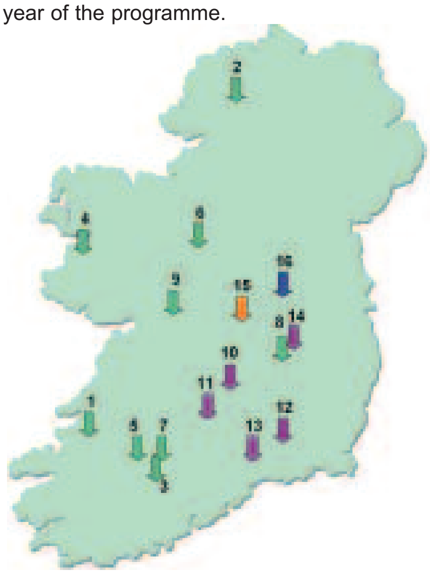
ForestEnergy Programme 2006-08

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

Integrated harvesting of conifer first thinnings for 4.3 m energy wood and industrial roundwood

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Introduction

Integrated harvesting is a method adapted from standard shortwood based thinning. The harvester produces cleanly delimbed sawlog and/or stakewood. The pulpwood part of the stem is crudely delimbed and cut into random lengths of about 4.3 m, without a specified top diameter.

Most of the trees harvested were between 8 and 9 m in length. They were crosscut once, resulting in the 4.3 m average assortment length. Cutting just once is cost-effective compared with the pulpwood 3 m assortment, where stems are cut twice. Longer lengths are also more efficient, in that more wood is handled in each crane grab, thus reducing the number of movements needed.

'Delimbing' is more to remove green material than to produce a cleanly delimbed stick. In this way, the production of wood fuel is integrated with the harvesting operation. As in the shortwood system, branches are placed on the rack to form a brash mat, which protects the soil and prevents machines from bogging.

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 the higher priced small sawlogs or boxwood can be harvested. While this leads to a short term benefit, over the lifetime of a typical crop early intervention has been to shown to be the most profitable option. Early thinning accelerates diameter growth on the remaining stems and brings forward larger more profitable tree sizes for earlier harvest.

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This method can also be used to harvest wood for energy using a pulpwood approach, but using crude delimbing, more random lengths, and no minimum top diameter.

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

Energy wood was stacked alongside the forest road. The rate of drying was determined for covered and uncovered stacks. Outcomes from the storage trials are reported in another COFORD Connects note.

Method

Thinning was row-and-selection in all cases. One row in seven was removed, with selection thinning carried out between the rows. On average, thinning removed 40% of stems, 14% from the rack and the remaining 26% removed selectively between racks.

Trees were felled and pulled down and delimbed at roughly right angles to the rack. Logs were placed in stacks alongside the rack. Energy wood and other assortments were put in separate stacks. Logs were forwarded to the roadside shortly afterwards and placed there in larger stacks. Stacks were raised off the ground by placing bundles of logs under them, parallel to the road.

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

Gremo harvester in the energy assortment.

Machines

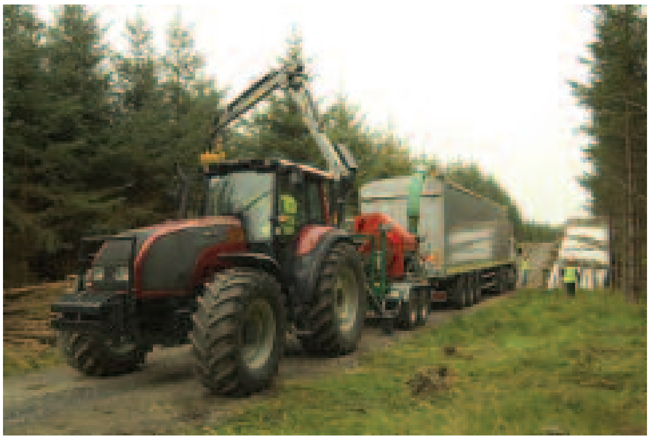
Harvesting of energy wood in 2006 and 2007 was carried using a Gremo harvester. All wood was forwarded to the roadside by Valmet thinning forwarders.

The wood from the 2006 trials was chipped by a Jenz 700 truck-mounted chipper from Denmark. 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 Irish contractors: a Starchl truck-mounted chipper, a Jenz 700 truck-mounted chipper and a Jenz 420 crawler-based machine, fed by a small excavator. The Jenz 700 and Starchl machines were fed by the crane on the machines or the truck pulling the chipper.

In all three years the wood was chipped directly into road transport 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-

Valmet forwarder.

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



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

trailers that were hired in for the purpose. Wood that was chipped into the tractor-trailers was transported for a short distance only, and then tipped off into a pile for reloading onto walking-floor trucks for the long haul.

Results

In this COFORD Connects note, averages for each of the three years of the programme are presented. Full data for each year will be presented in the final report.

Starchl chipper blowing chips into truck.

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 were 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) was 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.

Table 1: Overview of productivity and costs of the integrated method with roadside chipping in softwood.

Year	**2006**	**2007**	**2008**
Number of sites	3	4	4
Thinning type	Row and selectiion	Row and selection	Row and selectiion
Thinning method	Harvester and forwarder	Harvester and forwarder	Harvester and forwarder
Harvesting productivity ($m^{3\ sb}$/pmh)	3.74	5.3	4.88
Forwarding productivity ($m^{3\ sb}$/pmh)	9.35	12.7	11.84
Chipping machine	Jenz 700	Musmax	Jenz 420/700/Starchl
Roadside chipping productivity ($m^{3\ sb}$/pmh)	36.0	10.1	30.7
Harvesting cost (€110/pmh)	34.7	22.6	22.5
Forwarder cost (€100/pmh)	9.9	7.7	8.5
Roadside chipper cost*	7.87	10.0o	8.62
Total cost (€/$m^{3\ sb}$)	52.43	40.20	39.61
Average energy content (GJ/$m^{3\ sb}$) at harvested MC	7.7	6.4	6.8
Average energy cost on road transportation vehicle (€/GJ)**	6.81	6.27	5.82

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

** The moisture content of the chips from the stacks varied from 40-56% after two years of storage.

Table 1 shows the average results of the operations in 2006, 2007 and 2008 for harvesting, forwarding and chipping 4.3 m energy wood from large stacks along the roadside.

Harvesting costs were more or less the same in 2006 and 2007 (the wood chipped in 2008 was harvested in 2007). The productivity of the forwarder increased in 2007 and declined slightly in 2008. Productivity and costs for 2007 and 2008 are not comparable, as different stands were investigated in each year.

The total average production cost of wood chip from 4.3 m length energy wood ranged from €39.61 to €52.43 per $m^{3\ sb}$. Factoring in the moisture content, the production cost per unit of wood energy ranged from €5.28 to €6.27 per GJ. Differences between years are rather small, even though there is a considerable difference in the productivity of the different machines used. However, the low productivity of some of the machines is compensated for by lower hourly costs.

The total harvesting cost at the roadside delivered in transport vehicles would be in the order of €6 to €7 per GJ. If the forest owner was paid €5 per m^3 solid biomass (stumpage), then that would add €0.70 to the cost. The cost of road transport needs to be added to obtain the delivered-in cost at the combustion facility. Road transport of 50 km would add another €1.50, giving a total delivered-in cost at the plant of €9.02 to €10.12 per GJ. In this calculation an allowance for a management fee for the woodfuel trader of 10% is included.

Stumpage (€5/$m^{3\ sb}$) €/GJ..................€0.70

Chipping operation €/GJ....................€6 - €7

Road transportation 50 km €/GJ........€1.50

Traders allowance 10% €/GJ.............€0.82 - € 0.92

Total delivered cost €/GJ ....€9.02 - €10.12

Harvesting energy wood, note crude delimbing and small top diameter.

Stack of fresh energy wood.

Energy wood after harvest and before stacking.

Conclusions

The energy wood method, combined with small sawlog production, is a variation of traditional first thinning of conifers. It assumes thinning has been delayed by a few years to obtain more small sawlog, which fetches a better price than pulpwood. The energy wood logs are crudely delimbed in more or less random lengths, with no minimum top diameter.

The energy wood assortment was stacked at the roadside and covered by either paper or plastic.Wood remained along the road for one or two summers, and was then chipped into road transport. The energy assortment is not suitable for road transport due to protruding branches. The moisture content achieved in the stacks was not low enough to allow use in dry fuel boilers, which require less than 35% moisture content.

The energy wood method is an expensive way of producing energy chips, but cheaper than the standard 3 m pulpwood method. Branches were left in the forest as a brash mat, and as result the havesting cost has to be carried by a smaller volume of wood than in the whole-tree method. (Even so, a 10-15% increase of harvested volume can be expected.)

Wood chip delivered-in price from the forest was in the order of €9.02 to €10.12 per GJ, or roughly €90 to €100 per tonne at 45% moisture content, which is 50 to 100% more expensive than for whole-tree chips.

The presence of a brash mat is an advantage when this method is used, especially on very soft ground.

*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***