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

Producing firewood from broadleaf first thinnings

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Introduction

Firewood, especially hardwood, is an increasingly popular fuel in Ireland. Firewood from young broadleaf plantations is small in size and does not always require splitting. In general however, splitting will greatly improve drying rate.

Firewood should have a moisture content of 25% or less when used. If it is too wet, there is a risk of poor combustion, leading to smoke and fine particles, forming soot in the chimney, which in turn can lead to a chimney fire. The energy content of firewood is directly related to the moisture content. Natural drying is the simplest and cheapest method; all the alternatives add cost.

Long lengths of roundwood take a long time to dry. Most water evaporation takes place from the ends of the log, as bark traps moisture underneath. To speed up the drying process, firewood is usually cross-cut into short lengths and split as soon as possible after harvesting. Cross-cutting and splitting increase the surface area for water to evaporate, and shorten the time before firewood can be used.

Young broadleaf stands in Ireland can have a wide variation in stem quality and volume production. The proportion of dominant straight trees, which could be characterised as potential final crop trees (PCTs), differs between sites. PCTs have to be marked before a thinning is carried out, and where possible extraction racks should avoid them. It is a good idea to get a professional forester to mark the PCTs, as well as the trees to be removed during the first thinning. This is especially the case in ash stands; trees with butt sweep can be used for the production of hurleys. Even though only the lower 1.5 m of the tree is used, this is a very valuable assortment. Care should be taken to save a proportion of these trees during first thinning; they can then be removed during subsequent thinning operations and the crop left to grow on to full commercial size.

Typically, first thinning of broadleaves removes upwards of one third of the stems, and involves installing permanent extraction racks, as well as selectively felling trees competing with PCTs. The small diameter and low value of first

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thinnings entails either leaving them in the forest or removing them as a firewood assortment. In firewood production, thinnings are felled, delimbed, crosscut, and then forwarded or skidded to a landing to be converted into fuel logs. Tops and branches are retained in the forest to be used as a brash mat or to temporarily fill in drains during extraction. Drains must be reopened after the work is finished to prevent waterlogging.

Thinning is usually a one stage approach in hardwoods: one line in seven is felled by chainsaw to create an extraction rack, and the intervening rows are thinned selectively. Thinnings are delimbed and crosscut into logs for forwarding or skidding to the roadside. Logs need to be presented in neat stacks in the rack, with butts facing the direction of travel (Figure 1). Where forwarding is used, logs have to be presented in neat stacks at right angles to the rack (Figure 2). A uniform length of at least 3 m is preferred.

Harvesting first thinnings in broadleaves with a harvester can be a difficult operation. Trees tend be more crooked than pine or spruce, with more double stems and forks, all of which make processing more difficult. An experienced driver is needed, to deal with the harvesting and to avoid damage to the remaining trees.

Scale largely determines the type of harvesting: for small blocks (less than 2 ha), it is usually too expensive to hire a contractor, unless a machine is already working close by.

Trials

Three harvesting/extraction/processing systems were trialled in the ForestEnergy programme:

1. Felling by chainsaw, skidding to the roadside by quad, horse or a tractor with a hydraulic grapple, and firewood production,
2. Felling by chainsaw, forwarding to the roadside and firewood production,
3. Harvesting with a one grip harvester, forwarding to the roadside and processing with a firewood processor.

The first method is best suited to situations where the forest owner can carry out the work. The second option is typically where the forest owner does the harvesting and then hires-in a contractor to forward the wood to roadside. In the last option, all the work, until the firewood processing, is carried out by contractor.

Figure 1. First thinning in an ash stand with wood presented for skidding by quad bike.

Figure 2. An ash stand after first thinning with wood presented for forwarding.

Several firewood processing machines were tried; all machines processed a single log at a time. A number of additional skidding methods were also tested; these are covered in the final report of the ForestEnergy programme.

Machines

In all stands trees were felled, delimbed and crosscut by chainsaw. New chainsaw operators were employed at each site. A common set of instructions was therefore given on each occasion. A Gremo harvester was used at one of the sites to fell, delimb and crosscut. Different forwarders were used to transport the logs out of the stand to the roadside.

Several firewood processors were trialled: the Hawk/Pilke was the most widely used. On this machine the log is placed manually on the infeed tray and pushed into the machine

until it rests against a stop block. Firewood lengths are then cut with a hydraulic chainsaw. Once the piece has fallen down, a hydraulic ram pushes it through a splitting wedge. After splitting, lengths fall on to a conveyor belt, and are moved away from the machine. While the hydraulic ram is in operation, the chainsaw cannot be activated, so there is a waiting time before the next piece can be cut off. The splitting wedges can be raised or lowered. In the lowest position the log is split in two, in the higher position it can be split in four. The wedges can be easily adjusted to the diameter of the logs. Overall the machine produces clean-cut firewood.

The Bilke machine operates on another principle: a large knife passes an opening in the side of the machine. The point of the knife passes the middle of the opening. In this way, the log is split in two and cut off from the bolt in one operation. The firewood length can be adjusted using a plate inside the machine.

Results

Time studies

All operations were followed with time studies and the net productive time recorded. This time excludes all disturbances and in order to come to a more normal working day, allowances are added to the productive time to get to work place time. These allowances include rest breaks, small repairs and other normal things, but exclude major events like major breakdowns, getting stuck etc. By adding 30% allowances for machine work and 70% for chainsaw felling work we get to productive machine hours (pmh).

Production units

In all cases the volume of loose firewood ($m^{3\ lv}$) from the firewood machines is converted to m^3 solid biomass ($m^{3\ sb}$) using a factor of 0.75. This is a standard factor for converting loosely piled firewood to solid and means that 1 $m^{3\ lv}$ = 0.75 $m^{3\ sb}$. All production figures and costs are expressed in $m^{3\ sb}$/hr or €/$m^{3\ sb}$. It is assumed that the firewood will be delivered only after seasoning, so a moisture content of 25% has been used to obtain the energy content of the firewood in GJ/$m^{3\ sb}$; the final cost is expressed in €/GJ.

Average figures for the studies are presented here; further details will be provided in the project final report.

Results for the three systems trialled are presented in Table 1. Since firewood processing was independent of the extraction method, the same average cost for processing has been added, while average harvesting and extraction costs are presented for each method. Costs were contractor hourly costs. If the forest owner carries out the work, then the labour charge used, €25/hour, may be considerably lower. The work is typically carried out during the winter when the level of farm work is low. The same labour cost (€25/hour) was used for chainsaw and quad work. For firewood processing (machine and two men) an overall cost of €65/hour was used. Machine costs were: forwarder, €100/hour and harvester €110/hour. The impact of reduced labour costs can be calculated using the productivity figures in Table 1.

The costs of harvesting by chainsaw or harvester were more or less comparable, but forwarding was much cheaper than skidding by quad. Forwarding after the harvester was

Table 1: Productivity and costs for a number of firewood felling and harvesting systems in broadleaf crops.

Number of sites	4	4	1
Felling method	Chainsaw	Chainsaw	Harvester
Extraction method	Quad	Forwarder	Forwarder
Felling productivity (m^3/pmh)	0.57	0.60	3.05
Extraction productivity (m^3/pmh)	0.69	5.20	3.34
Firewood processing productivity (m^3/pmh)	0.44	0.44	0.44
Chainsaw cost @ €25/pmh (€/$m^{3\ sb}$)	43.86	41.67	36.06
Extraction cost (€/$m^{3\ sb}$)	43.47	19.23	29.94
Processing cost @ €65/pmh (€/$m^{3\ sb}$)	155.90	155.90	155.90
Total cost (€/$m^{3\ sb}$)	243.23	216.80	221.90
Average energy content (GJ/m^3) at 45% MC	9.46	9.46	9.46
Average energy cost to roadside (€/GJ)	25.71	22.91	23.45

slower, as the log piles were not as neat as when logs had been piled by hand after chainsaw felling. The total costs per $m^{3\ sb}$ are to a large degree determined by the processing costs. The small diameter of the logs and the slow speed of the machines caused very high cost. Other methods of processing need to be investigated.

Costs

An estimate of the delivered cost of firewood to the end-user may be made by including some assumptions on the whole chain costs. If the forest owner gets €5 per m^3 solid biomass as payment for the right to harvest the wood (stumpage), then the total cost at the roadside delivered in containers would be in the order of €24.37 to €27.28 per GJ. To this amount the cost of road transportation should be added. Depending on the distance to be covered this would add another €1.50/GJ to the cost, giving a total cost delivered at the plant of €28.45 to €31.65 per GJ. In this calculation there is a management fee for the woodfuel trader of 10 % included. This fee also includes interest on the harvesting and processing expenses during the seasoning period.

Conclusions

Harvesting and extracting hardwood for firewood processing can best be done by either chainsaw and forwarder or harvester and forwarder. The costs for these two systems were more or less comparable. Skidding by quad results in far higher cost. The cost of firewood is, to a large extent, influenced by the cost of processing, particularly as in this case where the machines tested were small and could only handle one (small) log at a time.

Skidding might still be used when the forest owner carries out the work during slack periods.

For small plantations (of less than 2 ha), the methods outlined may be too expensive unless machines are close by doing another job.

The total delivered-in costs of firewood from hardwood thinnings to a consumer would be in the order of €27.46-30.64 per GJ or roughly €260-290 per tonne at 45% moisture content, based on the very high cost of firewood processing. Considerable cost reductions can be expected if local labour and better firewood processing systems are used.

Further studies on the processing of firewood are needed with higher capacity machines.

	€/GJ	€/tonne at 45% mc	€$m^{3\ sb}$ at 45% mc
Stumpage (€5/$m^{3\ sb}$)	0.55	5.20	4.26
Firewood production	22.91-25.71	217-243	178-199
Road transport 50 km	1.50	14.19	11.63
Traders allowance 10%	2.50-2.88	23.65-27.24	19.38-22.32
Total delivered-in cost	27.46- 30.64	260-290	213-237