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 conifer first thinnings

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Introduction

Wood chip and wood pellets are the fuels most commonly associated with the development of the wood energy sector in Ireland. Both fuels rely on specialised boilers and, particularly in the case of pellets, require high levels of upfront capital investment in the production process.

On the other hand, forest owners can produce firewood from their forest to replace or supplement their use of fuel oil or gas, and as a product for sale. Firewood is a flexible wood fuel suitable for use in solid-fuel boilers and stoves and, if hardwood (broadleaf), open fires. Softwood (conifer) firewood is not suitable for open fires due to the potential for sparks.

Firewood production does not necessarily require significant expenditure on equipment. There are many types and scales of processing equipment for efficient firewood production. In addition, firewood can be combusted at very high efficiency in modern gasification boilers. These log burning boilers can replace oil boilers in supplying central heating and hot water. Dry fuel is essential for all applications as well as for gasification boilers, so it is important to reduce the moisture content of the wood from 55% at harvest to less than 25%.

Firewood may be derived from harvested logs of any size, although production rates are low from very small diameter logs. First thinnings are ideal in size, as there is significant volume in each tree, and once they are delimbed and cross-cut into lengths, the logs are suitable for manual handling.

Firewood is produced in a variety of dimensions, depending on the size of the combustion unit. Generally, it is cross-cut into 20-35 cm lengths, although gasification boilers may take lengths up to 50 cm. Similarly, logs are generally split to a thickness suitable for the end use. Cross-cutting and splitting should be carried out prior to seasoning in order to promote rapid drying, as the round shape of the log, as well as the insulating layer of bark, reduce the evaporation of moisture. Water has to be transported from the inside of the log to the outside, which is a slow process. In round logs, water mainly evaporates from the cut

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ends. Splitting the log increases the surface from which the water can evaporate and reduces the distance the water has to travel to evaporate off the surface. In this way the drying time can be reduced from a year to just one summer.

The ForestEnergy firewood trial in conifer first thinning had several objectives. First was to demonstrate firewood production and make comparisons with wood chip production on the same site. Second, the trial compared small-scale harvesting systems with normal commercial mechanised methods. Finally, the firewood produced in the trial was stored under different conditions to compare drying rates.

Skidding firewood logs to the roadside.

Methods and machines

A combined line and light selection thinning was carried out by chainsaw, with extraction by quad and timber arch. Cross racks were cut between the main racks in order to create a one-way circular route for the quad and timber arch. The trees were felled and delimbed, and then cross-cut into random lengths that could be handled manually. The logs were placed in piles of five to six lengths, parallel to the rack. This stacking system facilitated extraction with the timber arch. Branches and other harvesting residues were spread evenly over the ground. Residues and some logs were also used to fill in drains that had to be crossed.

Logs were skidded to the roadside by a quad pulling a small timber arch. The timber arch lifts one end of the logs off the ground, thus reducing friction.

Firewood processing with the Hawk firewood processor during one of the harvesting demonstrations.

At the roadside, the logs are cut and split into firewood by a Hawk firewood processor. The unit is towable and can be transported between sites. It works as follows:

The operator lifts a log onto the in-feed table and pushes the log until it hits a ‘flag’ which was set to the required firewood length. The log is then cut by the hydraulic chainsaw of the machine. Once the firewood block drops down and the chainsaw returns to the rest position, a hydraulic ram pushes the firewood block through the splitting wedge. The wedge can be lowered or raised. In the higher position, the splitting wedge is a cross shape, enabling the log to be split in four; in the lower position the log is split in two. Logs are pushed forward by the next piece until they drop onto a conveyor belt, to be deposited in a bin or a pile.

Cutting firewood to length using a saw horse.

To facilitate drying, split firewood was placed in large net bags. These were designed by erecting a supporting frame on a standard size pallet, with a large containing net hung over the edge of the frame. It was necessary to straighten out the firewood coming off the conveyer and stack by hand in the bags, so that a neat rectangular block of firewood (approximately 1 m^3 stacked volume) was produced. Once the net bag was full, the string at the top was tightened to facilitate handling and transport for storage.

Up to four persons were engaged in producing the firewood: one chainsaw operator felling the trees, the quad driver and two at the firewood processer. This work does not need to be a continuous operation: one could first complete the harvesting, then skid the logs, and afterwards produce the firewood. Alternatively, logs could be transported to a yard for processing into firewood and subsequent storage.

The method was tested in the 2007 harvesting season, in five stands. The firewood produced was stored under a variety of situations to see how the wood dried if left in the open, if stored inside a building, if stored in a shed etc. This is explained further in a separate COFORD Connects note.

Results

Table 1 shows the results for chainsaw felling and snedding, extraction by quad with timber arch and processing by Hawk firewood processor.

The actual harvesting operation by chainsaw shows fairly similar results with a productivity of around 0.75 $m^{3\ sb}$/pmh. There was a large variation in the productivity of quad skidding and of the firewood processor. In some cases it took a long time to change boxes with the net bags on them. These operations were carried out by the same crew.

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 the quad getting stuck. Because of the high labour input in all phases of the production process (chainsaw felling, quad skidding and firewood processing) 50% allowances were added for all operations, to convert net working time to productive machine hours (pmh).

Units

All production figures and costs are expressed in $m^{3\ sb}$/pmh or €/$m^{3\ sb}$. The $m^{3\ sb}$ is cubic metre solid biomass, so if there are branches or stubs on the wood, they are included in the solid volume. This unit has been chosen to make all the results from the ForestEnergy programme comparable. With the measured moisture content of the chips at the time of chipping, the energy content of the firewood is calculated in GJ/$m^{3\ sb}$ and the final cost is expressed in €/GJ.

There is a large spread in firewood production costs.

If a moisture content at the time of sale of 25% is assumed, the total cost per GJ would still be very high at €27.59, due to the low productivity of the felling and extraction system and in some cases the firewood processing as well. The

Table 1: Estimation of production costs for firewood using chainsaw felling, quad skidding and a firewood processor.

Site	Abbeyfeale	Ballybofey	Bweeng	Woodberry	Average
Chainsaw fell and sned ($m^{3\ sb}$/pmh)	0.80	0.65	0.79	0.80	0.76
Quad extraction ($m^{3\ sb}$/pmh)	0.39	0.13	0.61	0.77	0.48
Firewood cut and split ($m^{3\ sb}$/pmh)	1.18	0.588	1.12	1.17	1.00
Chainsaw fell (€25/pmh) (€/$m^{3\ sb}$)	31.42	38.52	31.79	31.42	33.30
Quad extract (€30/pmh) (€/$m^{3\ sb}$)	76.12	231.31	49.38	38.84	98.90
Firewood split (€65/pmh) (€/$m^{3\ sb}$)	55.14	112.48	57.66	55.46	70.20
Total cost (€/$m^{3\ sb}$)	162.68	382.31	138.83	125.72	202.40
GJ/$m^{3\ sb}$ at harvested MC	6.22	6.22	6.22	6.22	6.22
Total cost €/GJ	26.15	61.46	22.32	20.21	32.50

costs associated with these figures assume that all work is carried out by contractors. However, all the harvesting methods used were small-scale, low capital cost methods which could be carried out by a forest owner. If the forest owner would work at a lower hourly cost than the contractor, the production cost becomes lower and the cost of the firewood could be offset by the landowner directly against the cost of purchased fuel for home heating.

Conclusions

This trial was concerned with examining a small-scale supply chain with the purpose of selling net bags of 1 m^3 stacked volume of ready-made firewood on a pallet. The wood was felled and snedded by chainsaw, skidded to the roadside by a quad with a timber arch and processed into firewood with a small firewood processor.

The productivity of the harvesting and extraction operations was low because of the high amount of manual labour involved and the small capacity of the machines used. The harvesting costs per cubic metre solid biomass are therefore very high compared to mechanised harvesting. The suitability of chainsaw thinning and quad extraction may be limited to those sites that are small, inaccessible or too soft for commercial harvesting equipment. On the other hand, with little investment a forest owner can be self-sufficient in wood fuel and possibly develop a small enterprise, supplying locally. A forest owner with a larger area for thinning could employ a mechanised system for thinning to produce the logs for firewood production at a substantially lower cost.

Productivity was also low due to the processor feed speed and the need to stack the firewood into net bags. Firewood processing productivity could be increased substantially by conveying the firewood into a tractor-trailer, rather than stacking in net bags.

Chainsaw thinning and quad extraction combined with firewood production into net bags could not be recommended for general use as a financially viable method of wood fuel production.

There is a wide range of firewood processors available, with a diversity of processing speeds. Other firewood processors, tested in separate trials in broadleaved stands, displayed much higher productivity compared to that used in this trial. In choosing a firewood processor, the two main factors to consider are the quantity of firewood to be produced and the mean log size being processed. The firewood quantity will dictate the capacity of the processor needed. Firewood processors tend to be optimised to handle a particular log diameter range for cross-cutting and splitting.

*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***