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

Long term storage and seasoning of conifer energy wood

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Introduction

Trees take up moisture from the soil for photosynthesis and to transport nutrients to the growing parts of the tree. Moisture contained in freshly harvested logs adds considerably to their weight and reduces the net energy content of the wood.

Logs lose moisture during storage, as heat, wind, and the differential between the moisture content of the log and atmosphere cause water to evaporate. The main aim of this research was to quantify the rate of moisture loss from stored logs under Irish conditions. The benefit of the work is that seasoning schedules can be optimised and storage areas can be designed and used more efficiently. This research should help wood fuel suppliers improve the quality of wood fuel by better predicting the time required to meet a target moisture content.

It is difficult to continuously measure moisture content loss by direct means from long term storage trials, as only the start and end moisture contents can be easily measured for a pile of timber. Extracting samples to get intermediate readings involves constantly dismantling and rebuilding the stack, which is impractical. For this reason it was decided to measure moisture content loss indirectly, by measuring weight loss of the logs. This involved building a large scale storage trial, where truckloads of wood (20-30 tonne) were placed in large metal bins which had been built on load cells. Bin weight was then logged continuously by computer over the trial period, from April 2007 to August 2008.

Bord na Móna provided the storage site at Rochfordbridge, built the storage bins and supplied a container to house the data logging equipment. The storage site was on cutaway bog, and was fully exposed to wind and sun. A weather station was placed close to the storage site to record air temperature, wind speed and direction, rainfall and relative humidity, at hourly intervals.

The main factors investigated in the bin trial were:

- moisture content loss over time, estimated as change in log weight,
- the influence of assortment on the rate of moisture content loss,

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- the effect of starting storage at different times of the year on the rate of moisture content loss, and
- the comparative rate of moisture content loss of covered and uncovered stacks.

Trial description

Eight large metal bins were constructed in a row. A container was placed between bins 4 and 5 to house data logging equipment. Each bin was levelled and placed on four load cells, which were connected to a computer in the container. Empty bin weights were zeroed, and each bin was then filled with a full lorry-load of logs. The weigh cells were read once every hour and the information was logged on the computer.

Table 1 shows the content of the bins, when they were started, their start and final moisture content, storage duration and how many weeks it took the wood to reach a moisture content of 30%.

The two assortments used in the trial were standard 3 m, 7 cm top diameter cleanly delimbed pulpwood, and crudely delimbed energy wood, of random length, up to 4.3 m, with no minimum top diameter. Bins 3 and 6 were loaded with energy wood, all other bins with pulpwood.

To investigate the rate of drying as a function of the loading date, bins were loaded in April (7 bins), June (1 bin), September (1 bin) and December (1 bin), all in 2007. The wood for the bins loaded in April came from the harvesting trials at Woodberry (Co Galway). Logs for bin 8 came from the trials at Toormakeady (Co Mayo), and for bins loaded in September and December (bin 1 refill and bin 2 refill) material was supplied by Coillte from sites close to the storage site at Rochfordbridge (Co Westmeath). All wood was put into the storage trial within weeks of being harvested.

Figure 2: View of the bin trial in September 2007. Bin 1 is ready to be refilled. Note the load cells under the bins (also see insert).

To determine if covering had an effect on the drying rate of the timber, bin 7 was left uncovered. All other bins were covered on top throughout the trial. Bins 3 and 4 also had two sides covered, so that only the log ends were exposed. Most bins had their cover replaced once during the storage period to ensure continuity of cover, as the original agricultural plastic cover degraded.

In order to compare the moisture content loss achievable for logs stored outside the forest with logs stored in the forest, stacks of pulpwood and energy wood were left at all the conifer harvesting sites of ForestEnergy 2007. Half of each stack was chipped in the autumn of 2007 and the remainder in the autumn of 2008, at four of the sites.

In September 2007 the contents of bin 1 were chipped and the bin was refilled with fresh timber (Figure 2). The contents of bin 2 were chipped and the bin refilled with fresh timber in December 2007.

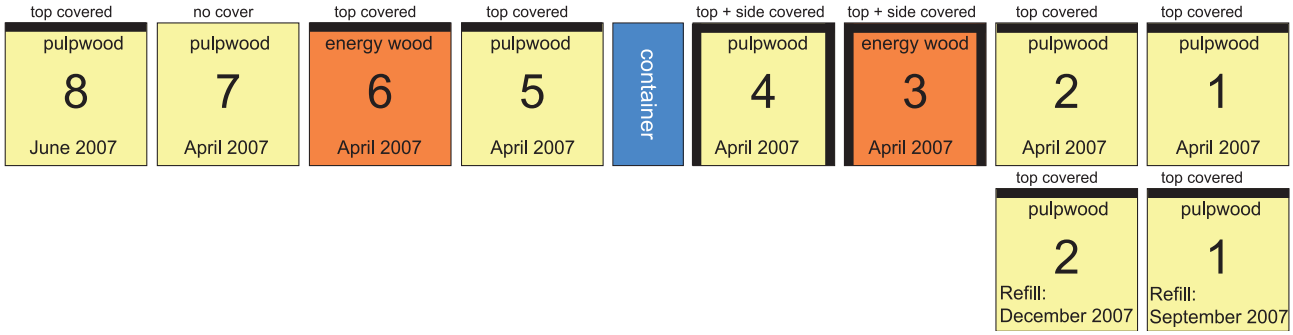
To establish the starting moisture content, 20 random sample logs were taken from each truck load. Logs were measured to establish the degree of delimbing, debarking, diameter (top, mid and butt) as well as weight. Each log was then chipped, the chips were mixed carefully and three replicate moisture content samples were taken.

Results

All wood dried very quickly in the bins, with moisture contents reducing to 18.4- 24.4% by the end of the storage trials which lasted from 5 to 16 months. The lowest moisture content was reached after the longest storage period. The final moisture content depended on what time of year storage began and its duration. Wood put into storage in April dried rapidly, while wood stored in December took much longer to dry. Such a result is more than likely attributable to open, well ventilated storage conditions. Also the stacks were raised 50 cm above ground level, with no contact between the wood and the soil. The

Table 1: Overview of the storage trial with assortments, covering, start and end months, storage duration, start and end moisture content (MC).

Bin no.	Log assortment	Start month	Covering	Finish month	Start MC (%)	End MC (%)	Storage duration (weeks)	Weeks to get below 30%
1	pulp	04-07	Top	09-07	56.4	24.4	20	14
2	pulp	04-07	Top	12-07	57.6	22.6	35	15
3	energy	04-07	Top + side	08-08	52.8	18.4	70	17
4	pulp	04-07	Top + side	08-08	56.8	18.6	70	15
5	pulp	04-07	Top	08-08	59.2	20.4	70	19
6	energy	04-07	Top	08-08	59.4	20.5	70	40
7	pulp	04-07	None	08-08	58	21.8	70	18
8	pulp	06-07	Top	08-08	61.2	20.2	63	23
Refill 1	pulp	09-07	Top	08-08	51.6	20.4	51	24
Refill 2	pulp	12-07	Top	08-08	62.1	23.6	37	26



weather at the beginning of the storage period was ideal, with little rainfall and high temperatures.

Table 1 shows the number of weeks it took for the wood to reach a moisture content of maximum 30%. The duration varied with the month the wood was placed into the bins: wood placed in the bins in April 2007 dried very fast to 30% moisture content, averaging just 16 weeks. Wood placed in bins in June, September and December took longer to reach 30% moisture: 23, 24 and 26 weeks respectively (Figures 3 and 4).

Table 1 shows the start month, the total length of storage and the time required to get to below 30% moisture content. Figure 4 shows the drying rate over time for bin 5 (April 2007) compared to bin 2 refill (December 2007).

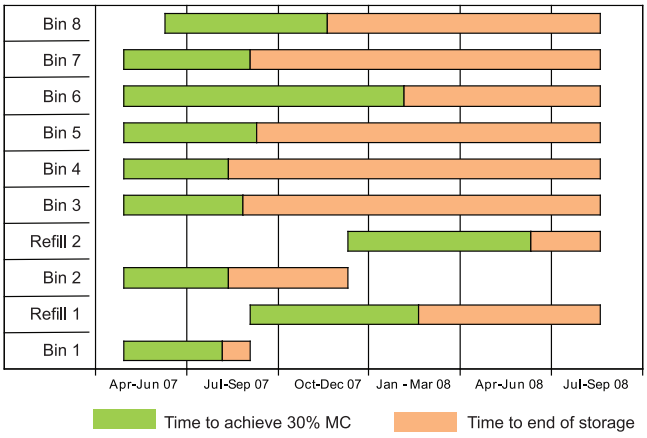


Figure 3: Storage periods in bin trials.

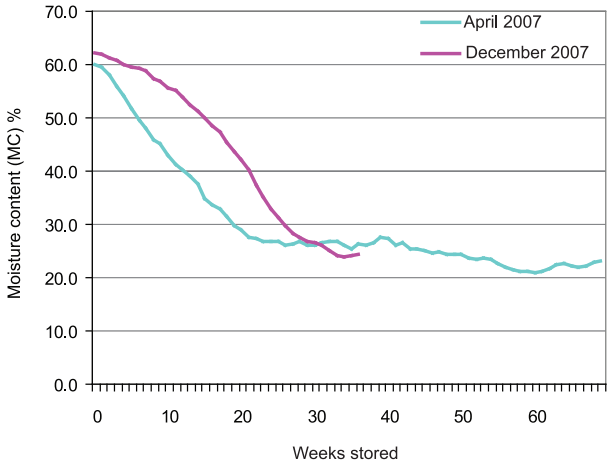


Figure 4: Time required for drying to 30% moisture content, relative to the start month of the storage trial.

Wood in bin 6, loaded in April 2007 took a very long time to dry. Bin 3 was loaded at the same time and with the same assortment as bin 6, but dried far quicker. The only difference between the bins was that bin 3 had both the top and sides covered, while bin 6 was just covered on top. This may partly explain the difference in drying rate (also see Figure 5). This conclusion is supported by the finding that the rate of drying decreased with less covering of the stacks (Figure 5).

The moisture content of wood in bin 7 (uncovered) showed similar average moisture content at the end to the other comparable bins: 4, 5 and 6. However, when the material was chipped in August 2008, samples analysed showed that the moisture content of wood from bin 7 was much higher at the top compared with the bottom (Figure 6).

The bin trial results differ markedly from forest storage, where more sheltered and less open conditions resulted in less drying of stacks. The best result achieved in the forest was 37% moisture content after two seasons. Covering was far more important in the forest than at the open bin trial site. So, for wood to meet a 30% moisture content (for 'dry fuel boilers') it needs to be moved to a wide open, exposed stacking area. This will add cost to the fuel, but is not necessary where wood is destined for power generation or combined heat and power use, or indeed for boilers that can accommodate wood with moisture contents in the 40-45% moisture content range. See COFORD Connects note *Forest storage and seasoning of conifer and broadleaf whole trees* for more information on storage of wood in the forest.

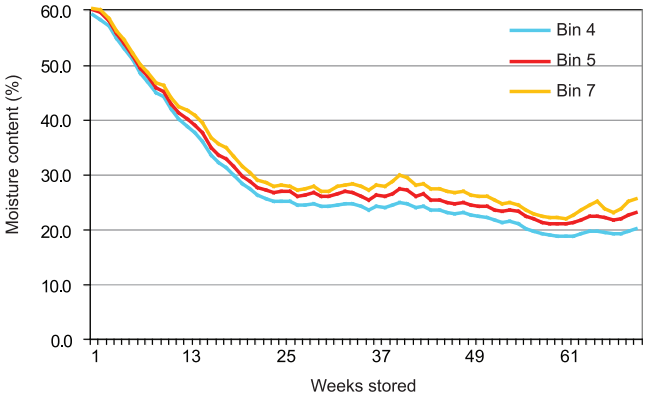


Figure 5: Drying rates of bin 4 (covered sides and top), 5 (covered top) and 7 (uncovered) decreasing with less cover of stacks.

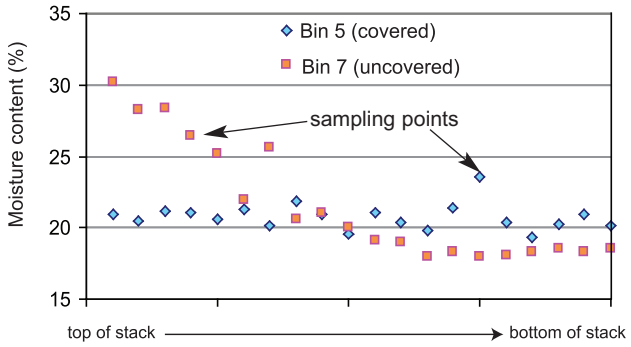


Figure 6: Moisture content of the samples was dependent on position in the stack (covered bin 5 is compared to the uncovered bin 7).

Conclusions

- Location of the storage site for stacking energy wood appears to be the most important factor: wind and sun must have free access to the wood, which will dry quickly when exposed to the elements.
- Storage start date is also important: fresh wood stored in early spring dries much faster than wood stored in autumn or winter. Wood stored in early spring can dry to 30% moisture content in as little as 16 weeks, while wood stored at other times of the year can take 22-24 weeks before reaching a moisture content below 30%.
- Off-ground storage with air movement under the stacks also appears to be beneficial for drying.
- Wood that is crudely delimbed dries slower than cleanly delimbed pulpwood, probably because branch stubs and the needles restrict air flow through the stack, but the final moisture content of both assortments was very similar.
- Covering the top of stacks only slightly improved drying, in contrast to the forest locations where coverage was more important in promoting drying. However, not covering the stacks did lead to uneven drying.

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***