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

Storage and seasoning of conifer roundwood in the forest

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Introduction

Energy wood should be seasoned before it is chipped, its as energy content (and price) is directly related to moisture content. Reducing the moisture content of roundwood before chipping, using natural drying in the forest, is the simplest and cheapest method; other systems simply add cost. Transporting freshly felled roundwood will generally increase costs, as the laden weight will exceed the legal limit before the truck is full. Chips produced from freshly felled roundwood decompose very quickly, so it must be dried using heated blown air, in dedicated storage, an expensive option that this low value, bulk product will find difficult to bear.

Seasoning timber at roadside, before transportation or chipping, utilises the ambient climate to remove moisture and does not require investment in dedicated storage. On the other hand, wind and sun exposure differ between sites, and the time required to season timber before chipping will vary.

The purpose of the work reported here was to determine how long roundwood needs to be stored in the forest to get to an acceptable moisture content, and what circumstances are required to achieve this.

Two assortments were stored at the roadside: 3 m cleanly delimbed pulpwood with a top diameter of 7 cm, and 4.3 m long, crudely delimbed energy wood without a specified top diameter. These assortments were stacked separately so that a comparison could be made.

Stacks of each assortment were also covered or uncovered for further comparison. Two covering materials were tested: in 2006 agricultural black plastic, in 2007 paper-based ‘Energywrap’. The latter was applied in 3 m wide sheets on the roundwood stacks and in 4 m widths for the energy wood.

Trials were carried out at eight first thinning sites. Three stands were thinned in February-March 2006: at Frenchpark the stacks were left uncovered, while stacks were covered with agricultural black plastic at Foilagohig and Swan. The storage trials were for one summer season only.

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Covering a pile of energy wood with agricultural plastic.

Putting a paper cover on a stack of energy wood.

Disintegrated paper cover after 15 months storage.

Five more sites were harvested in April–June 2007, with further trials carried out on stacking roundwood and energy wood assortments in the forest. At three sites (Abbeyfeale, Ballybofey and Woodberry) half the stacks were chipped in September 2007, with the remainder stored until chipping in August 2008. Stacks at Bweeng were all chipped in September 2007, while those at Toormakeady were chipped in August 2008. All stacks were covered, apart from one pulpwood stack at Woodberry.

Further trials were carried out to investigate the difference between in-forest seasoning and at a dedicated open yard. Again, both roundwood and energy wood, covered and uncovered, were examined. Timber from Woodberry and Toormakeady was used at the open yard site. This work is described in the COFORD Connects note: *Long term storage and seasoning trial of conifer energy wood.*

At each of the eight first thinning sites, harvesting trials were carried out on whole trees felled and left to season at the stump, prior to terrain chipping. The moisture content changes in this assortment are described in the COFORD Connects note: *Forest storage and seasoning of conifer and broadleaf whole trees.*

Results

Results of the storage trials in 2006, 2007 and 2008 are presented by assortment and whether or not the stack was covered (Table 1).

The initial moisture content of the Sitka spruce was high, from 55.4% to 65.4%, with an average of 60.8% (Table 1). The average moisture content in the autumn of 2006 was 57.9% for all stands and assortments, by 2007, after one summer's drying in the stack, had fallen to 50.9%, and by 2008 it had fallen further to 46.9%. Stacks chipped in autumn 2008 had two summers of drying.

There was a large variation in drying rate, probably due to how exposed the stacks were, and how effective covering of stacks was.

These results demonstrate that it is very difficult to dry timber in the forest. Only at Woodberry did the moisture content decrease to below 35% - and that was after two summers of storage; in all other cases the moisture content was 45% or more.

Table 1: Moisture content MC) of covered and uncovered pulwoood and energy wood stacks over one and two summer seasons.

Assortment	Location	Start MC	MC 2006	MC 2007	MC 2008
			%		
Pulpwood uncovered	Frenchpark 2006	61.6	62.6		
	Woodberry 2007	60.0		54.1	47.0
Pulpwood covered	Swan 2006	65.2	54.9		
	Foilagohig 2006	62.3	54.1		
	Abbeyfeale 2007	61.3		47.7	44.1
	Ballybofey 2007	63.5		56.8	46.2
	Bweeng 2007	59.0		46.7	
	Toormakeady 2007	60.4			56.4
	Woodberry 2007	60.0		41.9	34.5
Energy wood uncovered	Frenchpark 2006	61.8	61.5		
Energy wood covered	Swan 2006	66.1	58.9		
	Foilagohig 2006	59.7	55.6		
	Abbeyfeale 2007	60.4		53.6	50.9
	Ballybofey 2007	61.2		58.6	45.6
	Bweeng 2007	55.4		53.5	
	Toormakeady 2007	58.5			56.4
	Woodberry 2007	58.5		45.5	40.8

To reduce moisture content it is necessary to cover stacks. For example, the moisture content of uncovered roundwood and energy wood stacks at Frenchpark remained unchanged over the summer of 2006 (Table 1). At Woodberry, covered stacks dried substantially more than those left uncovered. In fact, after two summers, the uncovered stack was wetter than the covered pile after one summer. In the covered pile, the moisture content fell from 60 to 34%, while in the uncovered pile the numbers were 60% at the start and 47% after two summers.

Energy wood dried slower than pulpwood (Table 1), more than likely caused by branch stubs, small branches and needles attached to the logs restricting airflow through the stack, and absorbing moisture inside the stack. After the first summer's drying, pulpwood had an average moisture content of 48.3%, while the energy wood was at 52.8%. After two summers the levels had fallen to 45.3% and 48.4%, respectively. In other words, after two summers, the energy wood had only dried to the same level as the pulpwood had after just one season.

In 2006, stacks at Swan and Foilagohig were covered with 3 m wide plastic, while the 2007 stacks were covered with paper. In general plastic performed better than paper, which degraded faster.

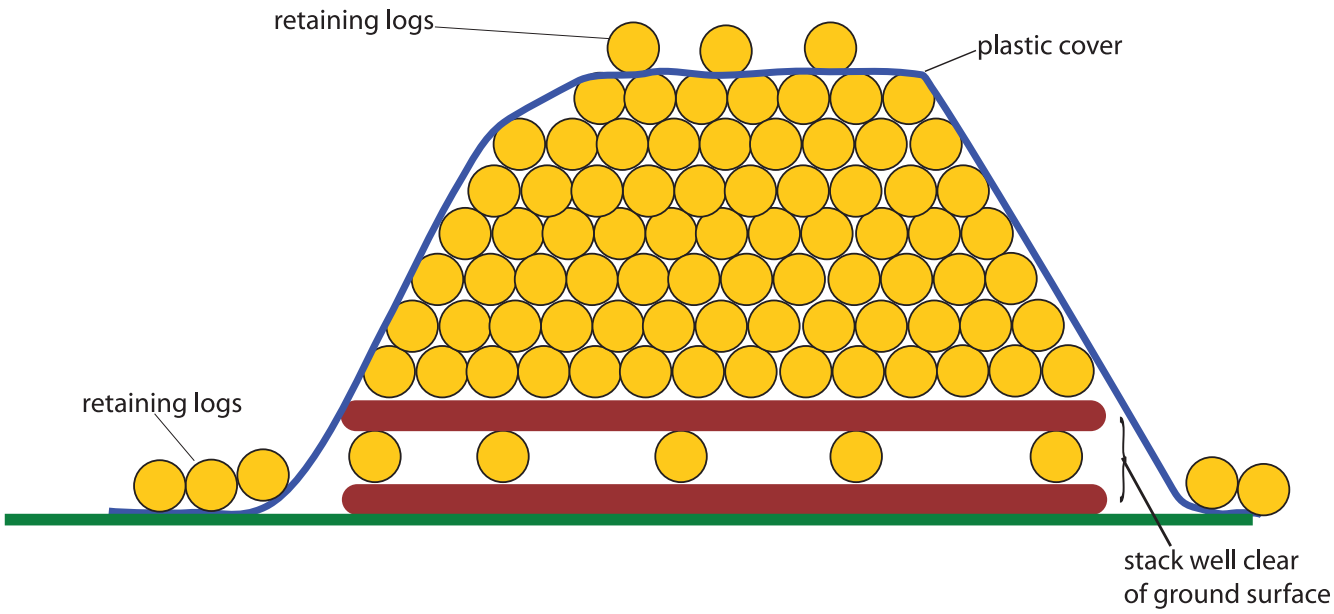
At Toormakeady, which was the last stand to be harvested in June 2007, the paper only lasted for a few months, after which rain had free access to the stacks. At Woodberry, where the first stacks were covered, the paper lasted much longer; nonetheless after two summers there was very little left of the cover. Thus on the basis of these trials 'Energywrap' paper cannot be recommended as a long-term covering material. On the other hand, plastic presents a waste management problem as it must be removed from the stacks and then disposed of, while paper could be put through the chipper and used for combustion. However, the chipping contractors were reluctant to chip the paper because the reinforcing threads of glass fibre were clearly visible, and it was feared that these might wrap around axles and other moving parts. However, after chipping no traces of the paper reinforcing fibers could be found in the machines. If the paper had been more intact, it would have been easier to remove. The glass fibre threads are very thin and only are a very small portion of the paper and would cause a very small increase in the ash content of the chips.

The advantages of storing wood for two summers in the forest are questionable, as compared to one summer only, as the average moisture content of the stacks fell by only 3-4% over the second summer, while the first summer gave reductions in the order of 5-10%. Furthermore, roundwood cannot be left indefinitely in the forest without serious loss of energy value due to decay.

Construction of stacks is of critical importance: they need to be well out of ground contact. During the chipping

Uncovered energy wood stack, showing wet top and bottom layers, with a dry middle layer.

Breakage during chipping due to partial decomposition of the wood following prolonged storage.



Energy wood stack construction and covering to promote drying.

operations in 2008, after two summers' seasoning, stacks that had been in ground contact had deteriorated – logs had turned white with fungi and had become very brittle. Many logs broke during chipping, and time was wasted by the chipping contractor in recovering broken pieces.

In stacks where the rain penetrated the cover, or where they had been left uncovered, the top layer of logs had become soaked and was colonised by fungi. Both effects are clearly seen in a stack at Woodberry: the bottom layer was dark with moisture and heavily colonised by fungi, as was the top layer, while the middle part of the stack was reasonably dry.

Conclusions

All sites included were first thinning areas, with relatively narrow forest roads, limited stacking space and a humid climate, with limited air flow because of the remaining trees. If stacks are placed under these conditions, where air and sun have limited access, drying of roundwood in the forest will only give limited results even after two summers' storage. If wood is stored on clearfell areas, with good exposure, then much better drying can be expected.

After one summer's storage, a reduction in moisture content of 5-10% can be achieved on first thinning sites, but covering is essential. Further drying will take place during a second summer, if the material remains under cover. The moisture content reduction achieved by forest seasoning is sufficient for large scale consumers of wood chips for energy. However it is not possible to achieve sufficient moisture content loss in the forest to produce wood chip for boilers that require a fuel moisture content of less than 35%.

The 'Energywrap' paper did not last for more than a few months. It physically degraded with abrasion by wind and branch stubs and photodegraded with sun exposure over time, and did not remain intact at any site. Paper covering may have more application in a depot where roundwood is stored for shorter time periods. One benefit is that it is more easily disposed of than plastic. By and large, it is recommended to use black agricultural plastic as a covering, kept in place by logs placed on top of the plastic. The plastic should be disposed of after the stacks are chipped.

Cleanly delimbed logs dry better than crudely delimbed energy wood, because there is more airflow through the piles, and rain water is less likely to lodge within the stack. However, energy wood provides a larger wood harvest for a given area (usually some 15% more timber) and may be more economic, particularly for use as fuel for power generation.

Recommendations

Conifer roundwood from first thinning will dry to a limited extent in the forest over one and two summers, provided stacks are covered. It can provide a low cost method of storage. However, in order to produce wood chip with a target moisture content below 35%, a two-stage approach is necessary:

1. Storage under plastic cover for one summer at roadside in the forest, in as open an area as possible, to reduce the moisture content by 10-15%. Stacks should be constructed well off the ground surface. Covering should be across the top of the stack only, leaving the sides fully exposed to air flow. After one summer in the forest, transport the wood to an open yard, preferably with an aggregate or concrete surface, and good exposure to wind and sun.
2. Storage for an additional 2-3 months in the yard, raised off the ground and stacked high, with a good cover. Chipping as and when the wood is needed

By storing the wood for one summer in the forest, the reduction in weight will allow for a greater volume to be placed on the truck, so that transport costs are reduced. There is no need to transport 60% water and a reduced load if one can increase the load volume by reducing the moisture content. Subsequently, drying to the target moisture content can be achieved in an open yard. This method will still have high production costs, relative to a forest-only drying schedule, but will help to guarantee the fuel moisture content and thus the quality of the fuel.

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***