© COFORD 2010

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.

COFORD - Dept. Agriculture, Fisheries & Food
Kildare Street, Dublin 2, Ireland
Telephone: +353 1 607 2487
Email: info@coford.ie
http://www.coford.ie

FORESTENERGY PROGRAMME

A synthesis and comparison of forest energy harvesting methods in conifer plantations

Pieter D. Kofman[1]

Background

Harvesting wood for energy is at an early stage of development in Ireland. To jumpstart the process, the ForestEnergy programme aimed to show that methods and machines developed on the continent could be used (and perhaps should be adapted) for Irish forestry.

Over a three year period (2006-2008), Waterford Institute of Technology, Danish Forestry Extension, Teagasc, the Forest Service and a host of forest owners, and contractors, from Ireland and abroad cooperated in demonstrating many different harvesting systems for wood for energy in conifer and broadleaf plantations. The focus of ForestEnergy was harvesting wood from first thinnings from private forests, which represents the single largest ownership of young plantations, and the one with the largest knowledge gap.

Most of the trials were aimed at producing a wood fuel in the form of chips for large scale users, like electricity plants, but fuel for smaller installations in the commercial and domestic scale were also demonstrated, albeit on a smaller scale.

Systems demonstrated

The reference method was always the pulpwood system: the stand was opened up by a harvester, taking out every 7th line and a selection thinning was carried out between the lines. The assortments produced were cleanly delimbed 3 m pulpwood, with a top diameter of 7 cm, as well as boxwood from the larger trees, with a minimum top diameter of 14 cm and a length of 2.5 m. In some stands, round stakes were produced from straight stems with low taper. Wood was forwarded to the roadside, logs and stakes were sold and the pulpwood was chipped after one or two summers seasoning. Chips were used as fuel in local installations or co-fired in a peat-fuelled electricity station.

[1] *Danish Forestry Extension, Senior Consultant Wood for Energy. Email: woodenergy@gmail.com.*

A variation on this method was the integrated harvesting system. In this system, where also a line and selection thinning was carried out, the same high value assortments (stake and small sawlog) were produced, but anything that was not suited for these assortments was roughly delimbed and cut into varying lengths, to a maximum of 4.3 m. There was no minimum top diameter for this assortment. The purpose was to reduce harvesting costs and increase the amount of biomass taken from the stand. The assortments were again forwarded to the roadside, the higher valuable products were sold off and the energywood was stored for one or two summers, before being chipped for energy use.

The whole-tree method was also investigated. Here first thinning is a two-stage process: first the lines were felled by chainsaw, the trees were left to season over one or two summers and were then chipped with a terrain going chipper. A year later, the strips in between the lines were thinned by a feller-buncher, a harvester without delimbing knives or feed rollers, but with an extra set of holding arms, to collect more than one tree in each felling cycle. Trees are lifted from the stand and placed in the lines, again for summer drying. This system was demonstrated in two versions, where the trees were either chipped by a special built terrain chipper - the Silvatec - or by a front-fed tractor-mounted chipper, trailing a special high tipping trailer. The chips from the Silvatec chipper were forwarded to the roadside by a chip forwarder; those from the tractor chipper were delivered to the roadside by the machine itself. This method ensures that the maximum amount of biomass reaches the roadside, since all branches and tops are chipped. Due to seasoning, the needles will fall off and remain in the forest.

A minor variation of this method was where small trees were felled in a narrow strip along the forest road by chainsaw. The trees were processed with a small chipper powered by a tractor, and fed into a small high-tipping trailer. This system is suited to supplying a domestic boiler. It is not recommended in general practice, unless the thinned area is gradually extended through the full plantation.

Not only chips were produced, during one season, firewood was also produced. The trees were felled and delimbed and crosscut by chainsaw, skidded to the roadside by a quad with a timber arch and converted to firewood with a small firewood processor, which crosscut and split the logs into firewood in one operation.

All systems and the overall results have been published in a series of COFORD Connects Notes, but without comparing systems. Such a comparison is presented here. More detailed results are presented in the reports on the trials. The results of the harvesting trials will also be combined with the results of the storage trials (see relevant COFORD Connects Notes), so that a good overview is provided about the costs and performance of the systems compared with each other.

Results and costs

In Table 1 the delivered-in costs of the systems are compared. The size of the chip produced, and the obtainable moisture content are given, as well as the extra amount of biomass that can be harvested compared with the standard pulpwood method. For all methods €5 per m^3 solid biomass (€0.70/GJ) has been included as stumpage payment to the forest owner. Another €1.50/GJ has been included for transportation to the end user within 50 km.

It is clear that large scale, whole-tree harvesting methods are always by far the cheapest systems as compared with systems where roundwood is harvested for subsequent chipping. This is due to two factors:

1. With roundwood systems only a limited amount of additional biomass is harvested, which means that the harvesting costs have to be carried by a smaller volume of wood and
2. In roundwood systems, the initial harvesting involves single tree handling, which is a costly way of doing things.

The method that was tested to produce firewood was very expensive indeed as compared with all other methods. This is because of high manual labour content in firewood production from small trees. In the calculations it is assumed that all work is carried out by forest contractors who get paid market rates. However if the forest owner carries out the harvest using a quad and a chainsaw then the labour cost component can be reduced, and a relatively cheap and competitive fuel produced, for home consumption or sale.

The same considerations apply for small-scale chipping: there is a lot of labour involved and low productivity. Still the chips would be suitable for a wood chip automatic

Table 1: Delivered-in costs of wood fuel harvested by different methods, corresponding chip size, obtainable moisture content and additional biomass obtained.

Method	Delivered in cost €/GJ	Size of chip	Obtainable moisture content %	Additional biomass %
Pulpwood	9.60-10.80	Medium-large	25-35	0
Integrated	9.00-10.10	Medium-large	25-35	10-15
Whole tree line, Silvatec	4.20-6.40	Large	40-45	30-60
Whole tree line,TP280, tractor	5.70	Medium	40-45	30-60
Whole tree selection, Silvatec	5.00	Large	40-45	30-60
Whole tree, chemical thin	6.30-8.90	Large	30-45	30-60
Whole tree premature clearfell	4.70-4.90	large	25-30	50-100
Whole tree, small scale	9.10	Small	25-35	40-80
Firewood	20-60	-	20	0

boiler. The chipper could be shared between several forest owners to reduce investment costs.

Apart from the small-scale system, large scale whole-tree harvesting systems yield a wood fuel suitable for large scale energy and CHP installations. However, the fuel is not dry enough for commercial or domestic installations. Felled trees are shaded by the standing trees and have contact with the soil, which prevents them from fully drying out.

Sitka and Norway spruce will easily shed their needles after one summer, provided that they have been completely severed from their stumps. If the trees are not completely off the stump, especially Sitka spruce, will live on and die very slowly and not dry at all.

With chemical thinning, where trees are killed standing up, drying is much better, due to the fact that there is no contact with the ground. An added advantage is that the canopy is not disturbed to the same extent as in other systems, and wind damage risk is reduced.

For all the whole-tree methods it is important from both the fuel quality and site productivity aspects that the needles remain in the forest, more or less evenly spread through the stand. With the integrated method, some of the needles are taken out of the stand and will fall off at the roadside during the chipping operation.

Where assortment methods are used, machines can operate on a brash mat, which improves traction and reduces rutting. However, it has been shown during the trials that if the Silvatec chipper and chip forwarder are equipped with band tracks, that soil damage is much reduced, as the tracks provide much better flotation and traction.

The amount of extra biomass produced (compared with the conventional pulpwood method) depends on the harvesting system. With the integrated system only 10-15% extra biomass is taken from the stand in the form of tops and some branch stubs. With whole-tree systems much more material is taken from the stand, because all branches are taken as well. Also, trees not large enough for pulpwood and which are usually put in the brash mat are now taken for energy. The smaller the tree, the higher the proportionate amount of additional biomass. Thus the small scale chipping system provides a higher amount of extra biomass because it handles smaller trees. On the premature clearfell, the additional biomass was very high because of the poor form and bushy nature of the trees.

The Silvatec terrain chipper produced a large chip, which is best suited for large scale boilers. The tractor chipper produced a medium chip, which could be used for commercial boilers. The small scale chipper produced fuel suitable for a domestic boiler. Truck-mounted chippers can usually be adjusted, either by changing the knife setting or the screen. However, a smaller chip means productivity goes down and chipping costs go up.

The whole-tree systems produce a very large amount of large chip, so a large customer must be found that can accept large volumes of chip year-round, as it is too expensive to have such expensive machines parked-up.

Capital investment

The investment in a Silvatec terrain chipping system, consisting of a terrain chipper, a chip forwarder and the necessary trucking capacity, might well be in excess of €1 million. A truck chipper can be had for €150,000-300,000, depending on the size and required production capacity. A medium-sized chipper on a tractor, with a high-tipping trailer, would cost in the region of €150,000-200,000. A small chipper to produce chips for private use can be had for as little as €6,000-10,000. A chainsaw, quad and firewood processor would cost around €15,000-20,000.

Conclusions

For large scale wood fuel production for large customers, whole-tree harvesting methods are the cheapest solution. The chips will never be dry enough and are too coarse for commercial boilers. Investment in equipment is very high, so these systems have to be in almost daily use, and require customers that can accept large volumes of chips year-round.

Roundwood systems have the advantage that conventional forest harvesting equipment can be used, and roundwood can be moved to a yard for intermediate storage and chipping into a shed before delivery. It is the most expensive way of producing wood chip for fuel. However, this approach can also be used to produce chips for the board industry and for cattle out-wintering pads.

If the work is done by the forest owner, then the production of small chips for local consumption, or firewood, can be a good option. A chipper could be shared with other forest owners to reduce investment cost.

*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***

Note: The use of trade, firm or corporation names in this publication is for the information of the reader. Such use does not constitute an official endorsement, or approval by COFORD of any product or service to the exclusion of others that may be suitable. Every effort is made to provide accurate and useful information. However, COFORD assumes no legal liability for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed herein or for any loss or damage howsoever arising as a result of use, or reliance, on this information.