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.

COFORD
Arena House, Arena Road,
Sandyford, Dublin 18, Ireland
Telephone: +353 1 2130725
Email: info@coford.ie
http://www.coford.ie

FORESTENERGY PROGRAMME

An outline of the ForestEnergy series of COFORD Connects notes

Pieter D. Kofman [1] ***and Tom Kent*** [2]

The ForestEnergy programme was started in 2006 to stimulate the development of the wood for energy market in Ireland through a combination of demonstration projects and research. The programme principally focused on first thinnings from young farm-forestry plantations. Trials were also carried out on plantations and areas of natural regeneration on industrial cutaway peat. Nine conifer and six broadleaf crops were included in the trials, which also included the clearfelling of lodgepole pine on cutaway peat. Figure 1 shows the location of the trials.

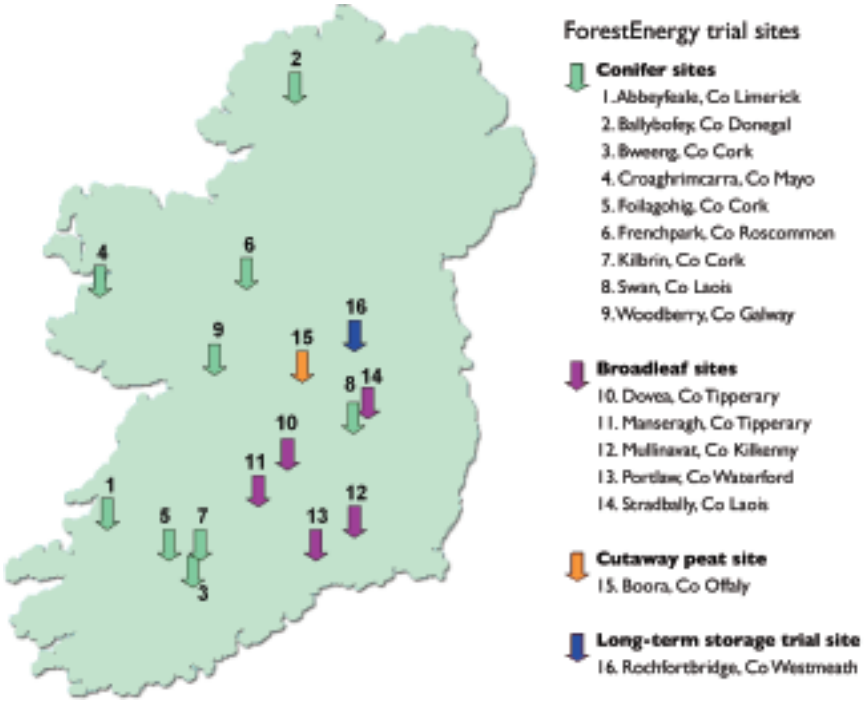

Figure 1: Location of the ForestEnergy programme trial sites.

[1] *Danish Forestry Extension, Senior Consultant Wood for Energy. Email: woodenergy@gmail.com.*
[2] *Waterford Institute of Technology. Email: tkent@wit.ie.*

The programme has run for three years, to the end of 2008. The results are presented as a series of COFORD Connects notes. Further detailed information will be made available in the final reports on the programme, which will also be published. The report on the ForestEnergy 2006 programme is already available from COFORD.

Objectives

The ForestEnergy programme set out to:

- Introduce new wood energy harvesting methods in Irish forests, demonstrate methods and adapt them to Irish conditions;
- Investigate the seasoning (drying) of different assortments over one and two years;
- Carry out dedicated storage trials both inside and outside the forest;
- Investigate the seasonal variation in moisture content of standing trees;
- Assess the heating value, ash and chemical content of the harvested fuels;
- Describe the physical characteristics of the harvested fuels (size distribution and bulk density).

Units

The following units are used in the notes:

- Volume of the harvested material is expressed in two units:
  - Cubic metre solid biomass ($m^{3\ sb}$): the solid volume of the biomass harvested, including branches and tops if they are part of the harvested assortment;
  - Cubic metre loose volume ($m^{3\ lv}$): a unit volume of chips produced by a chipper in bulk volume. In the notes, loose volume in cubic metres is converted to solid biomass using a factor of 0.33, meaning that 1 $m^{3\ lv}$ is equivalent to 0.33 $m^{3\ sb}$.
- Time consumption is in units per productive machine hour. A productive machine hour is the net production time of a unit without any disturbance, but includes an allowance of 30% for maintenance and operator rest. For chainsaw harvesting the allowance is 50%; for chainsaw felling alone it is 70%. For chainsaw work the allowance also includes the time consumption for refueling and sharpening the chain. Chainsaw felling of trees is strenuous work and thus an increased amount of rest is included. These allowances are based on international norms.
- The energy content of the wood is calculated on the basis of the actual moisture content, using the empirical formula *Q = 19.2 – (0.2164 x moisture content) = GJ/tonne*. The formula is derived from international literature and from experience gained in the ForestEnergy programme. Based on the assumption that 1 m^3 of Sitka spruce contains 400 kg dry matter, the answer from the formula is recalculated as the energy content per $m^{3\ sb}$.
- The moisture content is always expressed on the basis of fresh weight at the time of harvesting.

Roadmap of Forest Energy notes

Introduction of harvesting methods

A comprehensive range of wood energy harvesting methods developed on the continent were investigated under Irish forest conditions. Overall the objective was to examine the efficiency and cost effectiveness of the different methods. In order to demonstrate and study these systems, several machines were tested. Machines trialled that were not available at the time in Ireland included a Silvatec feller-buncher, the Silvatec terrain chipper, a TP280 tractor-mounted terrain chipper, and a truck-mounted Jenz chipper, as well as container trucks.

Methods were tested in both conifer and broadleaved stands, using different levels of mechanisation. The notes differentiate between an industrial approach, resulting in large sized woodchip, and a small-scale approach, resulting in firewood and small sized woodchip.

The following industrial approach methods were investigated in conifers:

Whole-tree method

- Line thinning, felling by chainsaw, in-stand seasoning and chipping by terrain chippers (self propelled and tractor-mounted);

Figure 2: Silvatec feller-buncher carrying out a selection thinning.
Figure 3: Silvatec harvester in pulpwood harvesting.
Figure 4: Valmet forwarder.

- Selection thinning with feller-buncher, seasoning in the stand and chipping with terrain chipper.

Integrated harvesting method

- Combined line and selection thinning, felling by harvester of boxwood and energy assortments, forwarding to roadside, stacking and seasoning on the forest road, and chipping at roadside by truck chipper.

Standard method

- Combined row and selection thinning, felling by harvester of boxwood and 3 m pulpwood forwarding to roadside, stacking, seasoning and chipping at roadside by truck chipper.

For the small-scale approach in conifers the following methods were tried:

- Combined line and limited selection thinning, felling by chainsaw, skidding by quad bike, production of firewood. Several different storage options were trialled to investigate firewood drying.

In broadleaves the emphasis was mainly on the production of firewood, but a chipping method was also tried as a comparison. The following methods were tested:

- Whole-tree method, combined line and selection thinning, felling by chainsaw and chipping by terrain chipper after the seasoning period;
- Whole-tree method, combined line and selection thinning, felling by feller-buncher, in-stand seasoning and chipping by terrain chipper;

Figure 5: Jenz 700 truck chipper feeding into a tractor-trailer combination.

Figure 6: Container truck leaving the forest with a load of chips.

Figure 7: MusMax tractor-powered chipper blowing chips into a walking floor truck.

Figure 8: TP230 winching a tree into the chipper.

Figure 9: Silvatec terrain chipper on band tracks in a line thinning.

Figure 10: Silvatec chip forwarder leaving the extraction rack with a load of chips.

Figure 11: Starchl chipper blowing chips into truck.

- Whole-tree method, combined row and selection thinning, felling by feller-buncher, forwarding to roadside, stacking and covering whole trees and chipping at stack by truck chipper after seasoning;
- Pulpwood method, felling by chainsaw, skidding by quad bike or horse, production of firewood and seasoning;
- Pulpwood method, felling by harvester, forwarding to roadside, production of firewood and seasoning.

Harvesting and chipping methods were also trialled in a crop on industrial cutaway peatland. The objective was to produce woodchip for delivery to the electricity generating station at Edenderry, to be co-fired with peat. The following methods were tested:

- Whole-tree clearfelling of lodgepole pine with the feller-buncher, seasoning *in situ*, and terrain chipping with the Silvatec;
- Whole-tree clearfelling of a young birch plantation with the feller-buncher and terrain chipping with a tractor-mounted chipper after seasoning;

Figure 12: Horse and forwarding trailer.

Figure 13: Stump treatment with urea solution after chainsaw felling.

- Whole-tree clearfelling of an area of birch natural regeneration by feller-buncher, seasoning *in situ* and terrain chipping with Silvatec chipper.

Seasoning of assortments

In all cases, chipping was carried out after a seasoning period to allow the moisture content in the wood to fall. In all the conifer trials, whole trees and the two assortments (energy wood and pulpwood) were left in the forest for one or two summers and then chipped. The assortments were either left uncovered or covered by plastic or paper. The initial moisture and final moisture content were measured and conclusions on how to store roundwood in the forest were drawn. In the broadleaf trials, the effect of seasoning was investigated on whole trees, logs and on split firewood.

Figure 14: Sampling wood fuel for moisture content.

Figure 15: Stack of ash left uncovered in the forest.

Figure 16: Stack of Sitka spruce pulpwood covered with plastic for seasoning.

Figure 17: Splitting ash with a Hawk firewood processor.

Figure 18: Ash split for firewood.

Figure 19: Firewood stored indoors.

At each of the conifer plantations investigated in 2007 large net bags of firewood were produced and stored under different circumstances to see how they dried. In the hardwood stands, small net bags of firewood were produced and stored under different conditions.

Dedicated bin storage trial

A dedicated storage trial was established, where the weight loss of stacks of wood could be monitored over time. The purpose was to establish the rate of weight loss, depending on storage duration, and on the commencement of storage. Both pulpwood and energy wood were investigated. Of the eight stacks, one was left uncovered, while the others were covered over the top. Stacks at the storage trial site were compared to similar stacks in the seasoning trials.

Investigation of the seasonal variation in moisture content of standing trees

The moisture content of standing trees varies according to season. This may afford the opportunity to fell trees when the moisture content is at its lowest, in order to shorten the seasoning period. Moisture content of standing trees of a range of species was monitored at a range of sites.

Investigation of the chemical content of the trees and assortments

Shortly after felling, macro and micro nutrient concentrations, as well as those of heavy metals and chlorine were established, based on samples taken from conifer and broadleaf assortments. Samples were taken after seasoning over one or two summers, to evaluate the impact of seasoning on element concentrations in trees and assortments.

Figure 20: Dedicated bin storage trial.

Figure 21: Samples in the drying cabinet for moisture content determination.

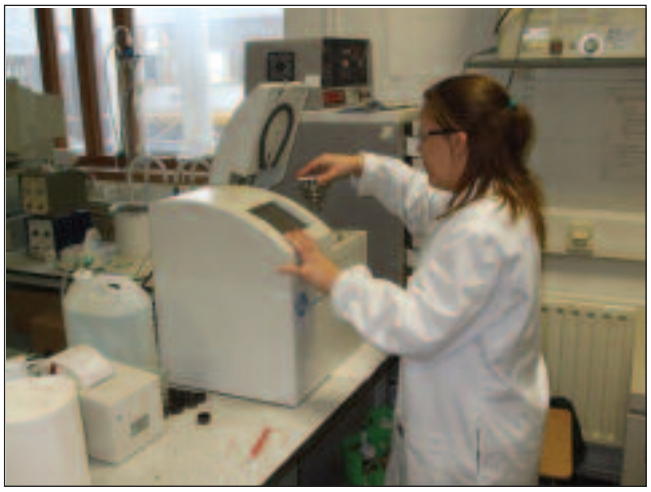

Figure 22: Use of a bomb calorimeter to determine the energy contents of fuels.

Chlorine concentration is an important issue in boiler life span, while heavy metal content may influence disposal costs of ash.

Investigation of the heating value of Irish wood

The initial heating value and the heating value after seasoning for one or two summers was established for a range of assortments in both conifers and broadleaves.

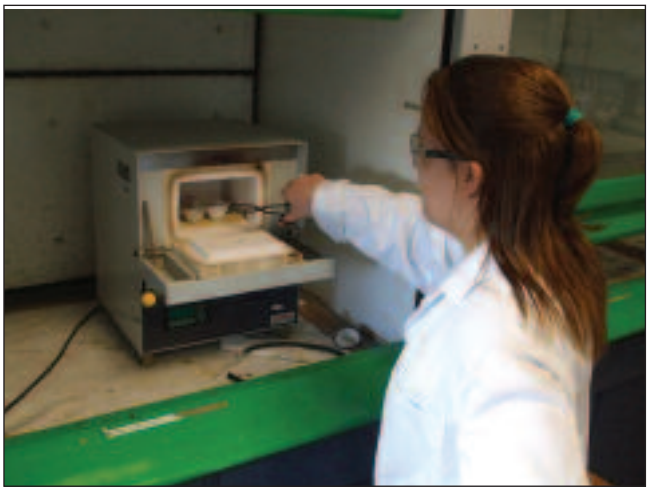

Figure 23: Muffle furnace to determine the ash content of fuels.

Figure 24: Wood samples for analysis.

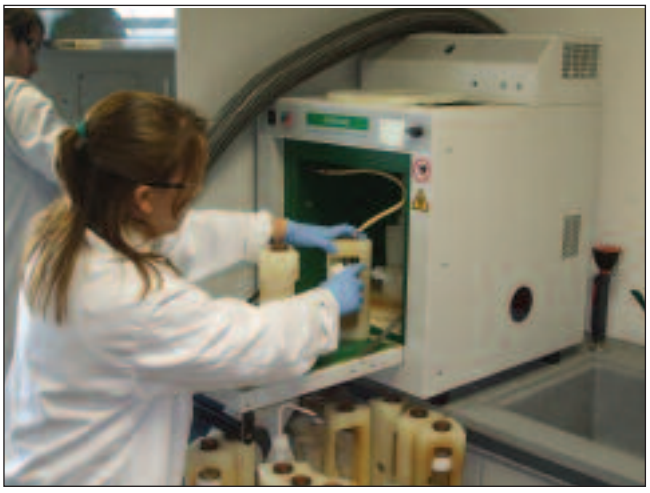

Figure 25: Sample preparation in the digester.

Figure 26:Element analyser.

Investigation of the ash content of Irish wood

Initial and post seasoning (after one and two summers) ash content was assessed for conifers and broadleaves.

Physical characterisation of wood fuels

The size distribution of chip particles was determined for every chipper used. Machines tested were both imported machines from the continent, and those owned and operated by Irish contractors. Size distribution is an important factor in deciding the size of boiler in which chips can be used.

Bulk density of chips was also measured. It is an important quality factor, because it determines the volume of chips that has to pass through the boiler to generate a given amount of energy output.

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***