FORESTENERGY

Harvesting and processing forest biomass for energy production in Ireland

PROJECT TEAM

Tom Kent, Waterford Institute of Technology*
Pieter Kofman, Danish Forestry Extension (DFE)
Dr Eleanor Owens, Waterford Institute of Technology
Enda Coates, Waterford Insitute of Technology
Sarah Cooley, Waterford Institute of Technology

** Email: tkent@wit.ie*

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BACKGROUND

Concerns over climate change, security of energy supplies and sustainable forest management have directed international policy towards supporting the development of renewable energy from wood fuel. The EU plans to produce 20% of energy requirements from renewable sources, with Ireland's overall target 16% by 2020. At a European level, it is expected that almost 65% of the renewable energy target will come from biomass, most in the form of wood. The Irish Energy White Paper and Bioenergy Action Plan for Ireland set out the framework for meeting these targets in Ireland. Sustainable Energy Ireland has mounted a successful campaign to encourage private individuals and commercial firms to install wood fuel boilers, thus creating a demand for wood fuel in the form of wood pellets and dry wood chip.

Three peat-fired power stations are gearing up to fulfill their obligation to co-fire peat with 30% biomass by the year 2015. The Forest Service has had two calls for grants for companies to buy wood chipping equipment.

Wood for energy is a relatively new assortment in Irish forestry and much knowledge remains to be gained. Ireland has a ready-made wood fuel resource in the large areas of farm forests planted over the last 25 years, which now require thinning to achieve production potential. Forest ownership is fragmented and knowledge of harvesting and storing wood for energy limited. The Forest Energy project, commenced in 2006, and renewed annually, aims to develop cost-effective supply chains by adapting commercially used methods from Europe to Irish conditions.

OBJECTIVES

- Demonstration of harvesting, extraction and wood fuel processing equipment in Ireland;
- Production and quality assessment of both wood chip and firewood products;
- Assessment of optimum storage systems to promote maximum seasoning at lowest cost;
- Investigation into moisture content/climate relationships with the view to developing a moisture content reduction model based on simple climatic indicators;
- Chemical composition of wood samples;
- Organisation of dissemination activities including public demonstrations, articles, workshops, presentation of results and display of wood fuel sample materials.

PROGRESS

Harvesting trials in softwood and broadleaf first thinnings

A range of harvesting methods was employed to carry out first thinning in broadleaf plantations, with both wood chip and firewood produced. The generally smaller size of broadleaf stands, the small average tree size, the close spacing and the threat of damage by large machines have led to the opinion that small scale harvesting methods are more appropriate for broadleaves. All broadleaf thinning was carried out in accordance with guidelines on line and selection around potential final crop trees. Felling was generally by chainsaw, though a harvester producing delimbed lengths was trialled at one site. All roundwood was produced to standard 3 m lengths to facilitate transport, and processing into firewood. Extraction by forwarder, grapple, ATV and horse were trialled. Different firewood processors were trialed using the 3 m lengths to produce standard length firewood logs. Woodchip was produced on two sites by felling whole trees into lines and terrain chipping and chip forwarding using the Silvatec chipper and forwarder. All operations were time studied and production was monitored. Production costs to the forest road were calculated for each production system.

Results indicate that the lowest cost method of thinning broadleaves is the whole tree terrain chipping option at between €46/m^3 and €67/m^3. The cost of producing 3 m lengths by chainsaw and extracting to roadside by forwarder was similar, ranging from €44/m^3 to €98/m^3

on the four sites trialled, but this does not include the cost of processing the logs into firewood. The firewood processors trialed ranged in productivity from 0.53 m^3/hr to 3.3 m^3/hr, including addig production costs that ranged from €11/m^3 to €49/m^3. The harvester was more productive compared with chainsaw harvesting but not sufficiently so to offset the higher operating cost. Small-scale extraction methods, such as the tractor with grapple, quad and trailer and horse and arch were all less productive and more expensive than the forwarder. However, these methods are very sensitive to the operating cost assumed. A forest owner could employ these methods directly, with the time valued differently to a contractor. Finally, the productivity of chainsaw harvesting is very sensitive to the operator, as the production rate ranged between 0.38 m^3/hr and 0.8 m^3/hr under broadly similar site and mean tree size conditions.

Energy parameter characterisation of Irish softwoods and broadleaves

All woodfuels produced from Forest Energy first thinning sites were characterized for moisture content, ash content and gross calorific value. Wood chip was also tested for bulk density and particle size distribution. Sampling, sample preparation and test methods were all carried out according to CEN Solid Biofuel technical specifications.

Woodchip bulk density

Bulk density of wood chip, measured in kg/m^3, is an important parameter, as energy content is quantified by weight, whereas the transportation and storage of wood chip is generally limited by volume, as wood chip is a relatively low density fuel compared with fossil fuel. Bulk density is determined by the basic density of wood, moisture content and mean and range of particle sizes produced by the chipper. A total of 1207 bulk density samples were measured on fourteen sites, moisture content was sub-sampled for each bulk density sample. This allowed the relationship of bulk density and moisture content to be investigated. Figure 1 shows the measured bulk density of woodchip from Sitka spruce roundwood against the sample moisture content. There is a strong non-linear relationship, described in the graph by a polynomial function with an R^2 of 0.92.

Variations within species basic density and, to a lesser extent, the variations in particle size distribution have a confounding effect. However, the strength of the relationship between bulk density and moisture content, could allow for the development of a wood fuel quantification method for payment purposes.

The two critical variables for estimating the energy content of wood fuel are weight and moisture content. Where it is neither possible nor practical to measure weight and moisture content directly, the bulk density could be estimated easily by sampling and the total load weight be derived from the load volume and estimated bulk density. The moisture content could be estimated from a fixed relationship with bulk density described for individual species and assortments. Delivered energy content could then be estimated from load weight and moisture content estimates. There are obviously large potential errors associated with this method, but in the absence of a more accurate approach, it could facilitate trade in wood chip for energy purposes.

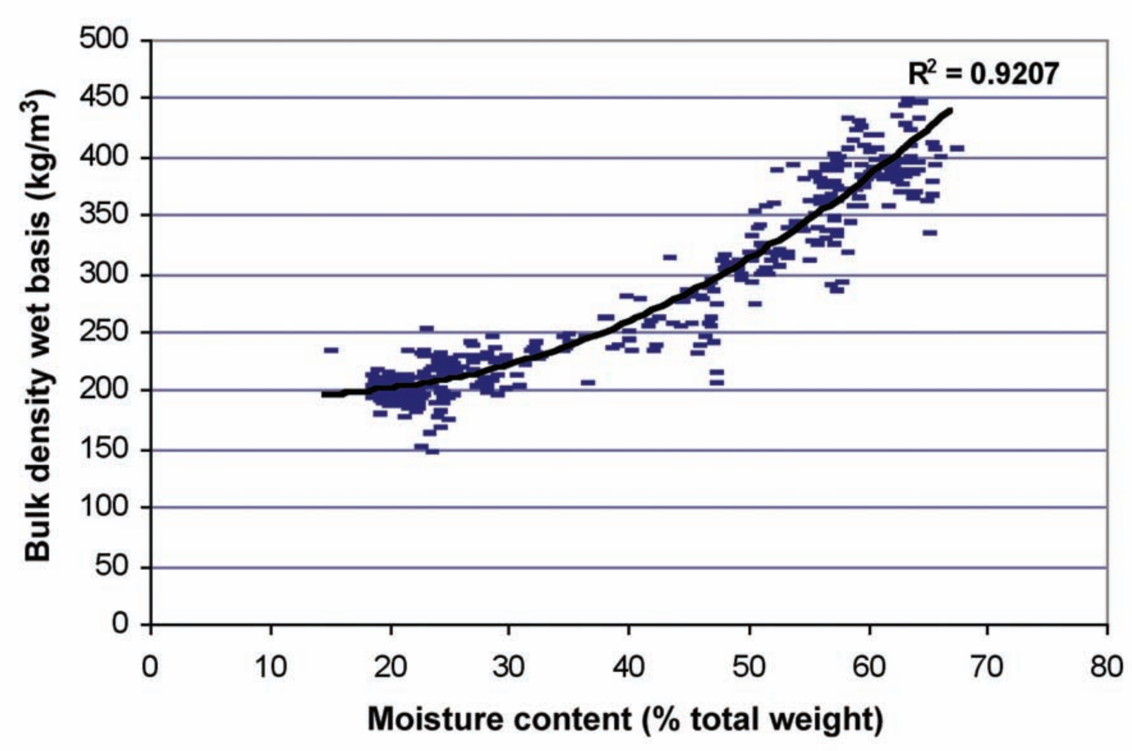

Figure 1: Relationship between bulk density and moisture content for woodchip from roundwood Sitka spruce.

Variation in gross calorific value

Over 1,100 samples from all sites were assessed for calorific value using a Parr 5200 bomb calorimeter. The general trends, which emerge are that wood is relatively homogenous in calorific value, ranging from 19-20 MJ/kg on a dry matter basis. Sufficient samples of different assortments of ash and Sitka spruce were analysed to gain further insight into variation in calorific value. Results are summarised in Figure 2, with the error bars indicating the margin of error associated with the mean at the 95% confidence level. The mean calorific value of ash is significantly lower than that of Sitka spruce. There was no significant difference between the ash roundwood (RW) and whole tree (WT) mean calorific values. Similarly, there was no significant difference between Sitka spruce roundwood and energywood assortments. The spruce whole tree assortment was significantly higher, indicating the higher calorific value associated with bark compared with wood.

Gross calorific value of woodfuels derived from forest sources vary according to species and the relative proportions of bark and wood. Gross calorific value, however, may be used to indicate the purity of the wood fuel tested, as the natural range of variation is narrow. Substantially lower or higher gross calorific values will only be caused by the presence of non-wood material.

Storage trials

In-forest and in-yard storage trial results have been previously reported. Work is on-going in developing a climate-based model estimating seasoning period for in-yard storage. Meanwhile the storage bins and load cells were relocated to Redmondstown, Co Tipperary, and reconstructed on a site provided by Coillte Panel Products. In 2010, it is proposed to undertake a storage trial of compact residue bundles.

Investigation of moisture content variation in Irish softwood and broadleaves

Moisture content of eleven species on eight sites around Ireland was assessed over 2007, 2008 and early 2009. All trees were randomly selected from Forest Energy trial sites. Additional samples were collected from a mixed softwood first thinning stand at Lismore Estate, Co Waterford. A total of 902 trees were felled, extracted, chipped. Five representative moisture content samples were collected from each tree. It should be noted that moisture content is calculated as a percentage of the total weight. Table 1 shows the mean moisture content of the eleven species sampled, at the 95% confidence interval. There was significant variation in mean moisture content between all species with the exception of alder and Douglas fir. Broadleaf moisture contents were all lower than those of softwoods. Ash is the species with lowest moisture content, averaging 40%; while Scots pine had the

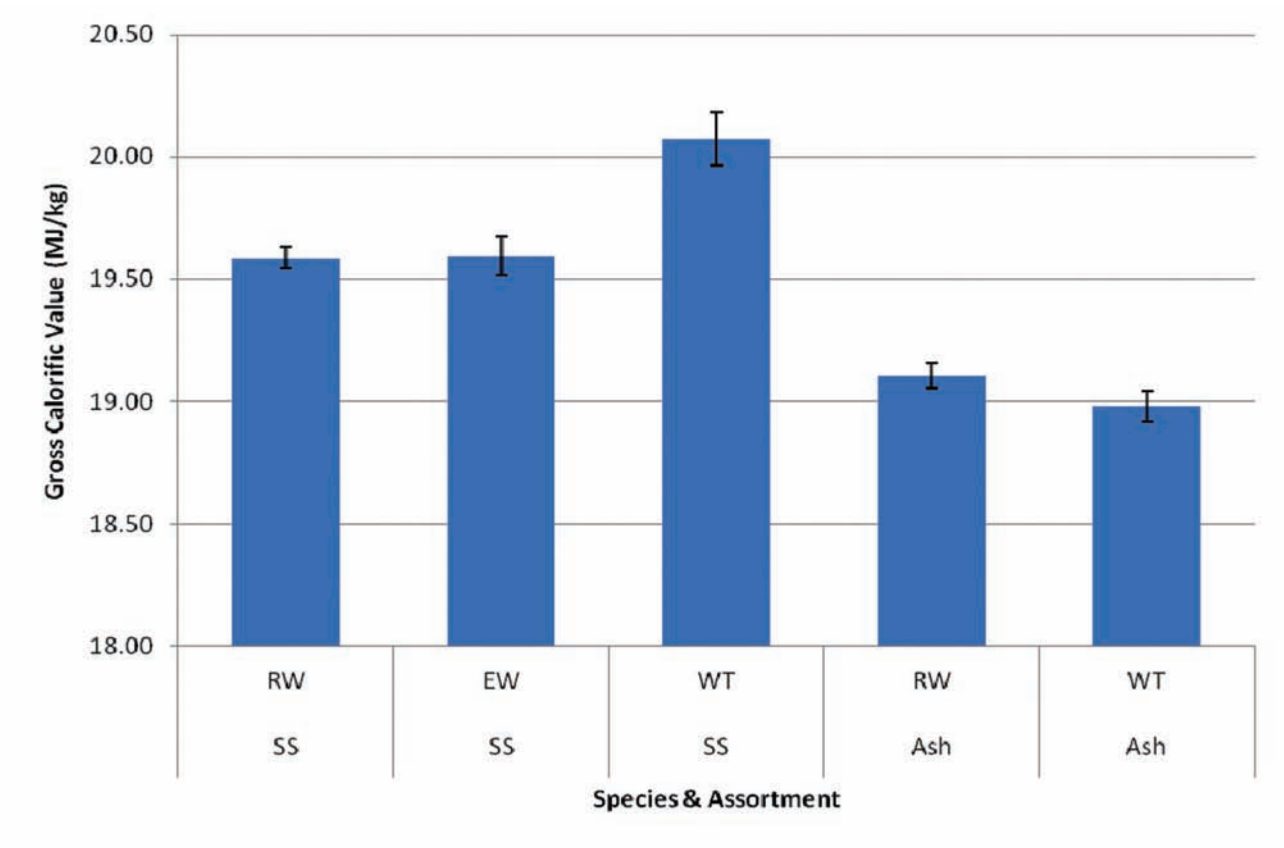

Figure 2: Gross calorific value (dry basis) of Sitka spruce and ash assortments. (For legend, see text.)

Table 1: Green moisture content (% total weight) of eleven species at first thinning in Ireland.

Species	Mean moisture content (%)	Standard deviation	95% confidence interval
Ash	40.0	3.63	0.19
Sycamore	47.6	2.74	0.33
Oak	48.4	2.36	0.22
Beech	49.8	3.28	0.58
Alder	52.6	2.69	0.33
Douglas fir	52.6	3.17	0.31
Larch	55.1	5.70	0.44
Lodgepole pine	57.0	2.93	0.53
Sitka spruce	58.1	3.58	0.28
Norway spruce	60.4	3.22	0.58
Scots pine	64.2	4.98	1.95

highest moisture content at 64.2%, albeit from a relatively small sample.

Sufficient samples of Sitka spruce, lodgepole pine, ash, oak and alder were sampled on a monthly basis to make a preliminary estimae of the variation in moisture content over the year. Results are shown in Figure 3. The bars associated with each data point represent the 95% confidence interval. All five species display a similar trend in seasonal moisture content variation. Moisture content peaks in the summer months of May to August. It falls in September and October and remains low over the winter, rising again in the spring. There is an obvious relationship between rising moisture content and the commencement of annual growth, and a similar relationship between falling moisture content and the cessation of growth in the autumn. The difference between peak month mean moisture content and the lowest mean moisture content was significant for all species. The moisture content of ash was 36.8% in April, rising to 45.6% in July. Sitka spruce moisture content in November was 55.3% and increased to 61.2% in May.

Planning a thinning to coincide with the season when moisture content is naturally low can bring significant advantages in reduced post-harvest drying, where energy is the target market for the thinning.

ACTIVITIES PLANNED

The current Forest Energy Programme is closed and reports and COFORD Connects Notes are in preparation. A further programme of joint research in wood energy, by WIT, UCD and DFE, is proposed for the period of 2010–2014.

OUTPUTS

Kent, T. and Kofman, P. 2009. *Wood Energy Supply Chains for Softwood First Thinning in Irish Forests*. Conference Proceedings: 17th European Biomass Conference and Exhibition: From Research to Industry and Markets, Hamburg.

Kofman, P. 2009. *Evaluation of Moisture Content Changes in Sitka spruce Roundwood and Energywood Assortments in Ireland: The Bin Trial.* Poster Presentation at 17th European Biomass Conference and Exhibition: From Research to Industry and Markets, Hamburg.

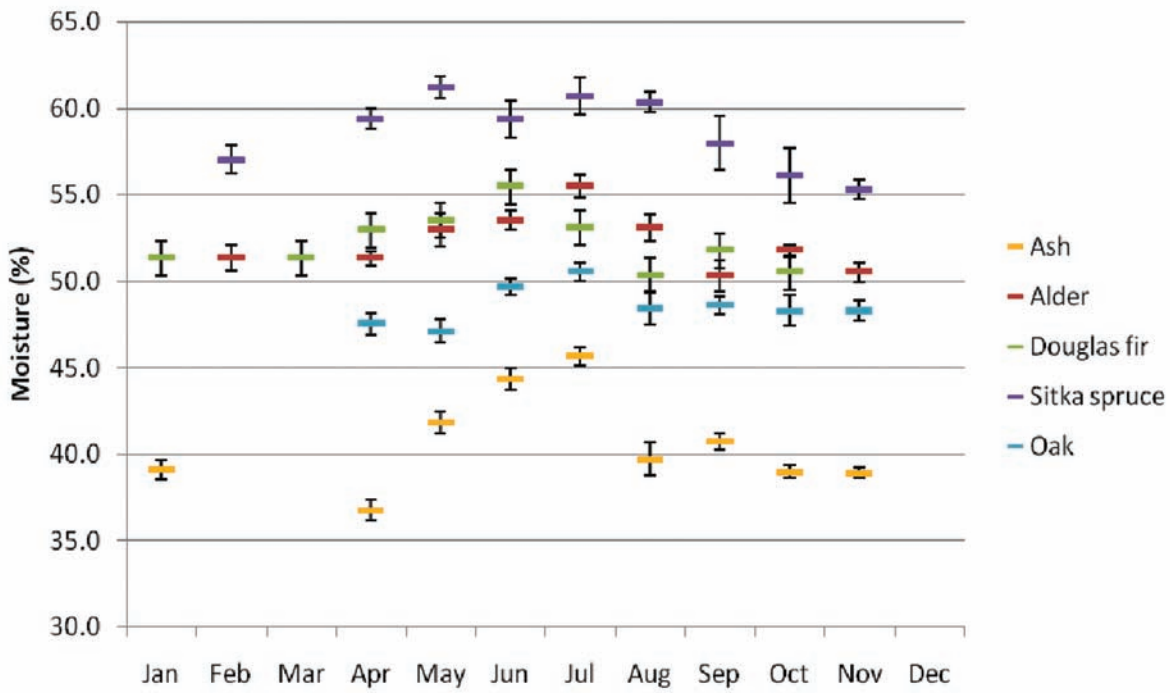

Figure 3: Monthly variation in moisture content of five species in Ireland.