An integrated study on the viability of using slash for domestic energy in the form of briquettes

Karl Coggins

Forest Service, Department of Agriculture, Food and Forestry, Leeson Lane, Dublin 2

Summary

Once the particle size and moisture content of slash have been reduced to 3 mm and 10% respectively, it is possible to produce a well-structured briquette with a calorific value of 4,380 Cal/g. County Wicklow would be an ideal location for a briquetting plant, given its proximity to the large Dublin market and the consequent reduction in haulage costs. This assessment is also supported by the potential for realizing a sustained yield of approximately 75,000 m^3 of slash per annum from surrounding forests. The cost of harvesting slash would vary between £6.17 and £11.48 per green tonne (gt), depending on site conditions and the harvesting system employed. However, the harmful impact on the forest site after removal, in terms of soil acidity and nutrient depletion, would mean that only the most fertile sites could be harvested for slash. This limiting factor, coupled with the high cost of manufacturing this type of briquette, probably prevents this new product from becoming a commercially viable enterprise in the short term.

Introduction

The high cost of energy and the need for an environmentally sound and renewable source of fuel have led to the study of alternative sources of energy. One of these sources is slash, i.e. the branches and needles left behind after commercial forest harvesting. Slash can either be chipped and used directly in industry, or densified into briquettes and burned as a domestic fuel.

The utilization of low grade forest material for alternative and more profitable products may increase the profitability of Irish forest crops, not only by creating new markets for traditional assortments, such as pulpwood, but also by creating an opportunity to harvest non-traditional assortments, such as slash, providing there is a market for such products. Slash could be used as a source of energy for industry, as previously described, or as a horticultural mulch. Unlike these products, however, briquettes made from slash represent a significant value added product from what is, in effect, a low value raw material.

The objectives of this study were as follows.

1. To determine the potential supply and the cost of harvesting slash to the roadside.
2. To determine whether marketable briquettes could be produced from slash.
3. To assess the market potential for slash briquettes.

Materials and methods

The supply of slash

Rather than attempting to calculate the volume of slash generated in the country as a whole, the study concentrated on the Co. Wicklow region. Its proximity to a large market, i.e. Dublin, and the availability of a large supply of raw material, indicate that Co. Wicklow would be an ideal location for a briquetting plant. The total volume of slash was calculated over a four year period, 1993 to 1996, to examine whether there would be a sustained yield of slash during this period. Data necessary for calculating the volume of slash was supplied by Coillte in the form of a harvesting forecast for Districts 11 and 12, i.e. the Wicklow region and adjacent Dublin forests. This information was broken down into thinnings and clearfells, with the average stem volume for both supplied for each of the four years. Relationships between stem volume and residue, derived by the Wood Supply Research Group, University of Aberdeen (Figure 1), were then used calculate the volume of slash left behind after harvesting for each forest in Districts 11 and 12. The large volume of data resulting from Coillte and the data calculated using Figure 1 was organised using the Microsoft Works database. A total of 384 records were produced, with a total of 3,456 field entries.

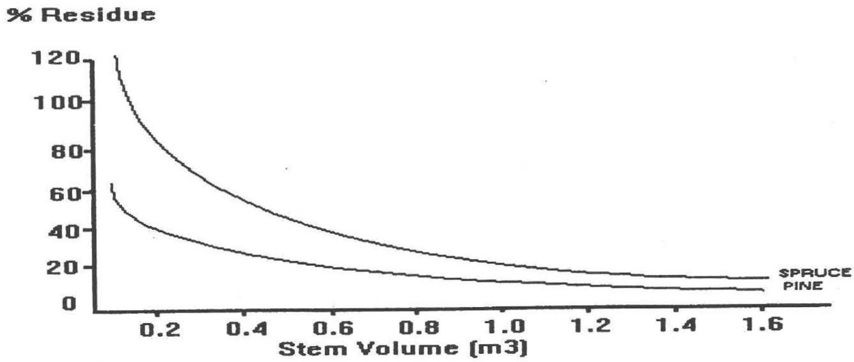

Figure 1. *Estimation of residue per stem*

The Harvesting Decision Support System (HDSS), a computer simulation programme developed by the Faculty of Forestry at the University of Aberdeen, was used to determine the cost of gathering, chipping and hauling slash to the roadside. HDSS requires both site data and a description of the harvesting system to be employed.

Tables 1 and 2 offer examples of two sites used to calculate the cost of harvesting slash in this study. The tables show the details for each site and the hypothetical harvesting systems selected. Both sites are located in Aughrim Forest, Co. Wicklow.

Table 1. *Site information for HDSS.*

Site	*Compartment*	*Spp.*	*YC* $m^3/ha/yr$	*Age*	*Mean dbh cm*	*Av. stem vol.* m^3	*Stems/ha harvested*	*Terrain Class*	*Extraction distance m*
1	82351J01	SS	20	42	35	1.20	263	3:2:4	90
2	82352E02	SS	12	42	22	0.14	600	3:2:4	50

Table 2. *Details of harvesting systems for HDSS*

Site	*Harvest type*	*Operation type*	*Machine used in simulation*			
			Felling	*Extraction*	*Processing*	*Chipping*
1	Clearfelling	Integrated landing	Chainsaw	Forwarder	Chain flail delimber/debarker	Trailer mounted chipper
2	Premature clearfelling	Slash landing	Chainsaw	Forwarder	Chainsaw	Trailer mounted chipper

The first harvesting system listed in Table 2 represents an integrated harvesting system, as two distinct products, round logs and slash, are removed. Whole trees are extracted to the roadside using a forwarder, where they are then processed with a chain flail debarker. The branches, needles and bark are then chipped. The second system involves the post-harvest recovery of slash, with processing taking place in the forest, as opposed to at the roadside. A forwarder is used to gather the slash and extract it to the roadside, where it is then chipped.

Producing a slash briquette

Slash from lodgepole pine (*Pinus contorta* Dougl.) (P 1966, YC 12 $m^3/ha/yr$) was collected at a whole tree chipping trial held at Oughterard, Co. Galway in March, 1992 (Figure 2). The ratio of stem dry matter to crown dry matter for the site would be approximately 1:1 (Anderson, 1983). Branches and bark were removed from the stems using a flail delimber/debarker, before being passed into a Barkbuster machine which broke the material down into pieces ranging in size from 5 mm to 50 mm. The clean stem was then passed into a Morbark chipper capable of producing chips with a bark content of around 1%.

Samples of both slash and white chips, amounting to approximately one tonne

Figure 2. *The whole tree chipping site at Oughterard, Co. Galway. The system involves a Manitowoc delimber/debarker, a Morbark chipper, and a Barkbuster.*

of material, were collected. The samples were then transported to Eolas, now Forbairt, in Glasnevin, Dublin, where they were placed separately into a fan kiln to reduce the moisture content to 10%. Because of the nature of the kiln, a wire cage with a volume of 0.3 m^3 was constructed to contain the samples. This cage was constructed using wooded supports surrounded by three layers of mesh, giving an overall mesh size of 5 mm. A drying schedule of four weeks was applied, involving the passing of ambient air through the chips.

After drying, the material was taken to Irish Carbon Products Ltd., Callan, Co. Kilkenny. This company was involved in the production of Heatlog briquettes from sawdust. The particle size of both the slash and white chips was reduced using a hammermill with a 3 mm sieve. The white chips were then mixed with an equal amount of slash chips, in order to simulate material produced from whole tree chipping, i.e. with branches intact. The two samples, i.e. pure slash chips and slash/white chip mixture, were subsequently fed separately into an extrusion screw. The extrusion screw applied heat (300°C) and pressure (14.1 x 10^6 kg/m^2), in order to plasticize the lignin contained in the slash. This lignin acts as a glue, binding the wood particles together to form the briquette.

Slash briquettes in the marketplace

An overall marketing strategy was formulated to predict how a briquette business would compete in the marketplace. A domestic fuel survey, which involved a total of 150 respondents, was conducted to assess the market for slash briquettes. During the interviews, respondents were shown a sample of a slash briquette before being questioned. Questions included whether or not the respondent considered environmental issues when purchasing fuel, his or her reasons for purchasing a particular type of fuel, whether s/he would be prepared to pay a premium for slash briquettes made in Ireland from a renewable resource, and the type of fuel s/he was using at that time. The results of the survey formed an important part of the overall marketing strategy, identifying the strengths and weaknesses of the product.

Results

The supply of slash

Figure 3 summarizes the database produced to calculate the volume of slash generated in Districts 11 and 12.

It is clear from Figure 3 that there would be a sustained yield of slash if this material was being utilized. Each year, approximately 75,000 m^3 of slash becomes available within this region.

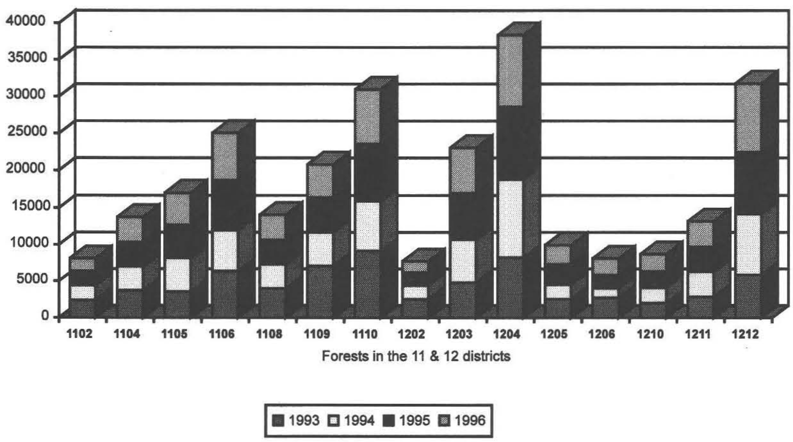

Figure 3. *Estimated volume of slash generated in each forest in Districts 11 and 12 over the four year period, 1993 to 1996.*

The cost of harvesting slash

Table 3 compares the cost of harvesting slash for the two sites described in Tables 1 and 2.

Table 3. *Cost of harvesting slash using two different harvesting systems.*

Site	Felling	Extraction £/gt	Chipping £/gt	gt/ha	Total cost/ha	Cost/gt
1	0.13	1.21	4.83	143.22	883.97	6.17
2		4.46	7.03	53.92	619.54	11.49

When comparing the results of each site, it becomes clear that the harvesting system used on Site 1 is the more efficient of the two. The cost of extracting slash on Site 2 is much higher that that on Site 1, due to the fact that trees are processed motor manually at the stump, which results in the scattering of slash over a large area. The cost of gathering and extracting this material is significantly higher than if the slash was concentrated in piles, as is the case where trees are processed mechanically using a harvester. The cost of chipping is also significantly higher. This can be attributed to the delay in bringing material to the landing, which results in the chipper lying idle for a period of time while it awaits material for processing. This situation could be eliminated by introducing more forwarders or by using a less productive chipper, which would also have the added advantage of being cheaper to run.

Producing a slash briquette

Both types of briquette were well-defined and structured, proving that it is physically possible to produce a briquette from both slash and whole trees. Samples were taken to the Industrial Chemistry Department at Eolas, where the calorific value of each type of briquette was determined, using the methodology set out in British Standard BS 1016:Part 5, 1977: *Methods for Analysis and Testing of Coal and Coke*. The calorific value was measured on a dry basis in order to eliminate any differences in heat value between the two samples arising from variations in moisture content. Table 4 summarizes the results of this study, illustrating the negligible difference in calorific value between the two types of briquettes.

Table 4. *Comparison between heat values of briquettes made from slash and whole trees.*

	Slash briquettes	Whole tree briquettes
Cal/g	4,790	4,680
Cal/25 kg bag	1.197×10^8	1.17×10^8
Density (g/cm^3)	1.04	1.10

Slash briquettes in the marketplace

The results of the domestic fuel survey indicated that people place cleanliness and convenience high on their list of priorities when deciding upon which fuel to buy. The survey also showed that consumers' attitude to price was highly negative, suggesting that people were unable to identify any significant advantage slash briquettes would have over other products, particularly peat briquettes.

If slash briquettes were to succeed in the market, the product would have to distinguish itself from all other fuels. This means focusing on servicing the consumer's needs for convenience and cleanliness. One example of how this could be achieved would be to package the briquettes in smaller, easy-to-carry bags. These bags could be designed with a comfortable handle. Fire lighters could also be included as part of the overall package.

Discussion and conclusion

The findings of this research indicate that a marketable briquette can be produced from slash and that there is a sustainable supply of raw material to manufacture this product. However, the market potential for slash briquettes is limited and the product is currently not economically viable. There are a number of reasons for this evaluation.

1. Slash is an important source of nutrients for future forest crop rotations, containing a higher proportion of easily decomposable material than soil organic matter (Dyck and Beets, 1987). The removal of slash may therefore have the effect of reducing the productive capacity of future rotations, especially on nutrient poor sites such as peats and podzolized soils.
2. The removal of biomass has the effect of increasing the acidity of the soil. It has been shown that the difference in acidity after whole tree harvesting and conventional harvesting can be 2.0 units (Nilsson *et al.*, 1982). One of the most startling effects of this increase in acidity is the increased concentration of inorganic aluminium in nearby watercourses. This increase can reach levels toxic to some fish (Lawrence *et al.*, 1987).
3. The high cost of harvesting slash, together with the tendency towards oil and gas as the chief sources of domestic energy, would leave slash briquettes in the unenviable position of being over-priced in a highly competitive market, with no distinct comparative advantage over its competitors.

Recovering slash by means of a second pass over the site is likely to result in unacceptable levels of soil damage and disturbance, particularly with the absence of a brash carpet. Therefore, the only system of harvesting slash suitable for adoption under Irish conditions is one which involves the extraction of whole trees to the roadside. This system, however, would still have to consider the implications of harvesting without a protective slash cover, and in most situations, this would involve leaving a proportion of stems behind to provide the necessary soil protection.

With smaller diameter crops, it may be more economical to chip the entire tree at the roadside and to produce high quality chips for pulping, and broken-down slash for energy. As illustrated in Figure 4, new technology is now making this type of harvesting possible.

Figure 4. *A Morbark Total Harvester in operation in north-western Ontario, Canada. This machine is capable of producing 100 m^3 of chips per hour, and represents state-of-the-art technology in relation to whole tree chipping.*

Although a renewable source of raw material is used to produce slash briquettes, a significant amount of energy, in the form of fossil fuels, is required during production. The amount of fossil fuel required during the harvesting, transportation, drying and briquetting processes may be greater than the energy output of the resulting product. The actual final energy balance, i.e. the value of energy used to make the briquette versus the final calorific value of the briquette, is questionable.

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