Practical measures to encourage the use of woodfuel

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Introduction

Woodfuel is not new, having been used as a source of heat for thousands of years. It is however going through a renaissance and is seen, in part, as a replacement for fossil fuels, both for use in heating and electricity generation and for its ability to reduce greenhouse gases and other emissions. The use of renewable resources is now stated Government policy and renewables are increasingly being considered as alternative energy sources by both the domestic and industrial markets.

It is Forestry Commission policy to help support the management of neglected or undermanaged woodland but the current low prices obtained for small roundwood, particularly arising from first and second thinning operations, often call into question the economic viability of harvesting. Consequently there is a tendency for some owners to avoid or delay thinning; this in turn can have a detrimental effect on the development of a more diverse woodland structure and a negative affect on the newly developing energy market. Harvesting for the production of woodfuel may make a thinning operation economically viable thus promoting active management of some small woodlands.

The industry in the UK

The United Kingdom (UK) forest industry is currently being swamped with requests for information and support from a new and exciting market about which practising foresters know very little. This lack of knowledge is understandable, as abundant supplies of fossil fuels have been available in the UK over the past two centuries. Although there has been a low level of woodfuel production, particularly logs, there is little established expertise with regard to new products, higher volume production and efficient, reliable supply chains. In order to avoid a barrier to future opportunities, we have to improve our knowledge of woodfuel production particularly in the areas of supply and storage.

The fledgling woodfuel industry in the UK is developing along two very distinct lines: the burning technology and the fuel supply chain. From the technology point of view there are optimum engineering solutions and these often take little account of what may be achievable in a practical sense when it comes to the supply chain (moisture content of wood, particle size and drying and storage). Although information is available on woodfuel harvesting and burner systems, there has been little effort on behalf of the producers/suppliers or the boiler/burner manufacturers to understand each other's requirements and both groups seem to have developed in parallel, with little or no technical integration. This lack of co-ordination between the two industry sectors has been responsible for the failure of installed schemes in some instances.

Identifying industry needs

Against this background Technical Development developed a strategy two years ago to direct and support future operational research into woodfuel production and supply. The strategy identified 13 areas of particular interest:

- Supply chain development
- Small-scale harvesting systems
- Short rotation forestry (SRF)
- Short rotation coppice (SRC)
- Residue harvesting
- Chipper/shredder/chunker technology review
- Transport
- Drying/storage
- Woodfuel standards
- Measurement systems
- Technology transfer (including the provision of advice)
- Calorific values
- Wood ash/waste ash.

The work recently undertaken by Technical Development has covered many of these areas.

Harvesting

Small-scale systems for harvesting woodfuel products from woodlands

The thousands of hectares of small woodlands in Great Britain are a potential source of woodfuel for local heating, but problems arise in identifying suitable and efficient harvesting systems see (Figure 1). The output from this work will be a Technical Note (2005, in press) which provides guidance on the selection of systems appropriate for small-scale harvesting operations. It considers four essential factors that influence the overall selection:

1. Woodland type, tree species and the woodfuel products present.
2. Site and management constraints affecting choice of harvesting system.
3. Options for harvesting system.
4. Specific machinery options.

The guidance is based on a comprehensive series of case studies, and provides outputs, costs and system descriptions for the sites studied, and recommendeds appropriate systems of work. A summary of the woodfuel production costs for the crop types studied and a comparative summary of harvesting options are also provided.

Key findings

The success and financial viability of any harvesting operation depends on the site, access and distance to roadside, methods used and the scale of the operation. Extraction machinery in particular will be a key influencing factor. Some systems may be inappropriate for small woods.

Costs vary widely according to the harvesting system used and are subject to the many factors already discussed. However, in simple terms, costs of extraction in thinning are higher than in clearfelling, with basic costs increasing between £1.00 and £2.00 per cubic metre (m^3) of wood for every additional 100 metres of extraction distance. Current indicative costs for extraction is shown in Box 1.

Large scale mechanised harvesting in a broadleaf crop.

Box 1

Current cost for extraction in thinning on different terrain types. The wide range of costs for each ground type is due to the combined impact of factors including terrain, crop type, and volumes per hectare, machine size and distance travelled.

Steep ground	Cable-crane systems: range £10–£25 per m^3
Moderate ground	Skidder (for example Ford County type): range £5–£12 per m^3 Portable winch (short distance only): range £3–£6 per m^3 Forwarder: range £3–£15 per m^3
Easy/flat ground	Forwarding systems (medium/large): range £3–£12 per m^3 Skidder (for example Ford County type): range £5–£12 per m^3 All terrain cycle equipment: range £13–£17 per m^3 Small scale forwarder (mini): range £4–£15 per m^3

Comments applicable to all crop types

In broad terms the findings from the case studies are as follows:

- Forwarding tends to be more cost effective than skidding, which is considered to be inefficient for longer extraction distances, i.e. greater than 250 m.
- Where difficult sites require maximum man-oeuvrability and flotation, mini-forwarders should be considered for distances up to 250 m.
- Forwarding using the appropriate machine generally causes less ground disturbance on drier sites than skidders and terrain chippers, with small-scale forwarders causing significantly less site disturbance.
- Skyline operations tend to be the most expensive option, their use being dictated by site and set-up time constraints.
- System machine choice must take account of:
  - machine availability
  - machine flexibility
  - differing machine/labour costs within and between areas
  - site conditions.
- Unit costs vary according to the cost factors charged to the primary and or secondary operations, that is, if the primary operation is to fell, extract and convert, irrespective of fuelwood production, then the costs associated with those operational factors will already be incurred. Where this is the case, secondary operations such as fuelwood harvesting should be costed as such.
- In general terms harvesting costs increase when:
  - slopes increase
  - uphill extraction is used
  - lower volume and product densities are harvested
  - smaller product volumes or sizes are harvested
  - poor tree and product forms are worked and produced
  - access is poor or difficult
  - extraction is over longer distances.

Early broadleaved thinnings

- Lower volume returns, coupled with higher unit costs, make them the least profitable option.
- Pole length working is generally the cheapest system.
- On easy terrain a farm tractor-based forwarder is likely to be as cost effective as a larger purpose-built unit, for shorter extraction distance, i.e. up to 250 m.

Mixed broadleaved coppice

- Harvesting costs for machine/system combinations on each site were similar and choice is likely to be influenced by other factors such as availability, capital cost and site / environmental constraints.

Crownwood, scrub and residues

- Precommercial thinnings are often felled and left on site, however, there may be some cost benefit in utilising material as woodfuel.
- Crown wood can be a cost-effective fuel resource although the correct harvesting system needs to be adopted, that is, skidding, forwarding (to stump or roadside) or terrain chipping, subject to the correct machine choice.
- The only case study of terrain chipping showed it to be expensive and not cost effective. However the major factor influencing this was inappropriate machine choice, and the study demonstrated that there was significant room for improving outputs by using a suitable machine. Further research is required in this area.

Technology for burning woodfuel

Investigating methods for achieving woodfuel specifications

The aim of the new Technical Note (2004, in press) is to provide clear advice on the factors affecting quality when producing logwood or woodchip as fuel. It aims to clearly define the required fuel specification for the different generic types of wood burning appliances currently available in the UK.

Currently a wide range of woodfuel burning appliances is available. These vary from small domestic units suitable for installation in homes and other small properties (2–30 kW output range), medium sized units for community and business use (11–500 kW) and large industrial units capable of providing heat and energy for small factories or a cluster of small businesses (Figure 2).

Those interested in using woodfuel for heating and electricity generation need to consider and select the most appropriate wood burning appliances and, equally important, the supply of woodfuel. The need to ensure that it is the correct type and quality for optimum boiler/ burner efficiency cannot be overstressed.

The relationship between burner technology and fuel specification has been identified as one of the major areas requiring further investigation. The essential considerations in terms of burner requirements and achievable fuel specifications will be outlined in a new FC Technical Note due for publication in 2006.

Wood harvested and seasoned to a desired standard can be burnt efficiently. It is a safe, efficient and renewable fuel that can be economically competitive with some fossil fuels. (Currently in the UK mains gas is the most competitive and may be cheaper than woodfuel.) To help development in the industry a European-wide standard has been developed to describe the various types of woodfuel. Tables 1–3 show a synopsis of the Central European Norm draft standard CEN 335 Standardisation of Solid Biofuels.

Figure 2

Various types and scales of burning appliance.
(a) Domestic space heater, fuelled by wood pellets.
(b) Commercial scale wood chip fuelled boiler.
(c) Combined heat and power gasifier unit in Gussing, Austria.

Woodfuel is an internationally traded commodity, particularly within the European Union. In addition to producing a woodfuel that is consistent in quality it is important that the most efficient methods of processing, handling and transportation are used. The energy supply market remains very competitive and failure to produce and supply high quality woodfuel for energy production at an acceptable cost can result in prospective users considering alternative energy sources, thus weakening the development of a woodfuel market in the UK.

A major factor restricting the development of international trade in woodfuel is the absence of a common standard between countries. The European Union (EU) is currently preparing a European Standard (CEN/TC 335) for the various types of biofuels, which includes woodfuel in various forms. It is due to be released in mid 2005 and will be the accepted standard throughout Europe. The current draft can be viewed on the CEN web site, www.cenorm.be

Technical Development have looked at the factors that affect woodfuel quality and link woodfuel specifications to the range of wood burning appliances currently available in the UK. This concentrates on two types of woodfuel: log wood (firewood) and wood chips, both of which can be produced in the forest; however there is growing interest in wood pellet production as fuel for domestic appliances and as a replacement for fossil fuel in some larger sized boilers and burners.It was therefore considered appropriate to include the boiler/burner types suitable for wood pellets.

Wood chips and hog fuel: an example

High quality wood chips recommended for household usage should be sourced from stem wood with the following specification:

- Moisture content < 20 or < 30 %
- Dimensions P16, P45 or P63 (see Table 2)
- Energy density E 0.9 (net calorific value > 900 kWh/bulk m^3).

Table 1

Classification of origin and sources of woody biomass.

Wood origin	Wood source
Forest and plantation wood	Whole trees Stemwood Logging residues Stumps Bark (from forestry operations) Landscape management woody biomass
Wood processing industry by-products and residues	Chemically untreated wood residues Chemically treated wood residues Fibrous waste from the pulp and paper industry
Used wood	Chemically untreated wood Chemically treated wood
Blends and mixtures	Combination of any of the above

Table 2

Particle size for wood chips and hog fuel.

Type of woodfuel	Main fraction (> 80%)	Fine fraction (<5%)	Coarse fraction, max. particle length (< 1%)
P16: Wood chips	3.15 ≤ particle ≥ 16 mm	< 1 mm	> 45 mm, all < 85 mm
P45: Wood chips and hog fuel	3.15 ≤ particle ≥ 45 mm	< 1 mm	> 63 mm
P65: Wood chips and hog fuel	3.15 ≤ particle ≥ 63 mm	< 1 mm	> 100 mm
P100: Hog fuel	3.15 ≤ particle ≥ 100 mm	< 1 mm	> 300 mm
P300: Hog fuel	3.15 ≤ particle ≥ 300 mm	< 1 mm	> 400 mm

P: equates to particle size in the chip and log size categories.

Dimensions for wood logs.

Wood logs	Diameter (D) and length (L)
P200	L < 200 mm and D < 20 mm ignition wood
P200	L = 200 ± 20 mm and 40 ≤ D ≥ 150 mm
P250	L = 250 ± 20 mm and 40 ≤ D ≥ 150 mm
P330	L = 330 ± 20 mm and 40 ≤ D ≥ 160 mm
P500	L = 500 ± 40 mm and 60 ≤ D ≥ 250 mm
P1000	L = 1000 ± 50 mm and 60 ≤ D ≥ 350 mm

P: equates to particle size in the chip and log size categories.

Key findings

The correct choice of raw material, harvesting system, comminution or processing machinery, storage, transport and burner will promote the continued development of a sustainable woodfuel market.

To achieve high quality woodfuel from green timber, moisture content (MC) should be reduced to 20-30 % (wet basis). This improves the calorific and monetary value; in addition the cost of handling and transporting is also reduced. It is important for both the producers and users of woodfuel that a consistent size and quality of woodfuel is achieved.

Transport

The essential features of fossil fuels are that they are readily available commodities and their supply is centralised and mostly in large units. The urban concentration of population in the UK offers scale economies in the supply and marketing of energy derived from fossil fuels, which gives a considerable economic advantage to the users of such forms of energy. This concentration is further encouraged by the transport costs factor, which can provide a marked constraint in the case of alternative energy sources. This contrasts sharply with many areas of widely dispersed woodland, far from developed markets, yielding a low-density, widely dispersed woodfuel resource, the production of which is in its early stages in the UK and almost entirely derived from relatively small-scale production.

In any woodfuel production chain the main cost factors are production (growing, some crops are specifically grown for energy), harvesting, comminution and transport. As production in the UK increases the need to transport material over longer distances is set to increase.

Transport of woodfuel products: development of guidance as a planning aid

This interim phase scoping project looks at the essential aspects influencing woodfuel transport in the UK, namely social influences, resource type, production systems, technology, transport logistics' distribution (physical distribution), woodfuel collection and storage, transport costs, overall energy balance considerations, current research (projects/case studies) and ongoing work.

Research can be marked according to tractability and timeliness as follows:

- Transport costs: fixed and variable costs associated with haulage
- Woodfuel collection and storage: the various methods available in relation to product type
- Distribution: new or existing networks
- Technology: machinery, equipment and computerisation of control systems
- Production system: in terms of standing tree to end use
- Resource type: e.g. virgin fibre, residue
- Infrastructure: the overall system in place to support production, distribution and use
- Social and political influences: political and fiscal considerations
- Transport logistics related to technology
- Overall energy balance considerations, i.e. does more energy go into producing woodfuel than it yields when burnt?

Our scoping studies indicate that joint research between FR, the Timber Transport Forum (TTF) and regional transport groups will be useful.

Drying

Small roundwood drying trials

Moisture content is critical in determining the value and combustion quality of wood. Consequently, there is a need to investigate the potential for in-wood drying, particularly of roundwood material. As part of an initial study into the subject of air-drying, a series of trials will be carried out in north Scotland. One specification of stacking and drying will be tested at two sites. The effects of all variables (e.g. local weather conditions, species, product variables) will be on a case study basis only. Considerably more trails and data would be required to develop accurate forecasts of drying regimes and definitive guidance of methods.

The project objectives include the development of methods to dry short rotation woodland material, and ways of controlling moisture content and the establishment of guidelines for stock management. The trials were laid down in April/May 2004; work is ongoing and there will be a series of data gathering exercises over the next eighteen months.

Technology transfer

Outdoor workshops, feasibility and case studies

As part of Technical Development's outreach commitment we have undertaken three outdoor workshops in the past year. One was specific to woodfuel production and marketing (Lake Vyrnwy, Powys, October 2003) and the other two (Woodland Enterprise centre, Flimwell, East Sussex, October 2003 and Cefn Llwyni Woods, Lanfyllin, Powys, February 2004) related to the management of ancient/small woodlands; both contained components relating to woodfuel. All three events were very well attended and received and we will continue to build on this success.

As part of our ongoing support service we have also undertaken a number of feasibility studies, which aim to help individuals through the initial consideration and selection process of installing a woodfuel burning system. Feasibility studies and case studies have been undertaken at:

- Capernwray Hall, Lancashire for Lancashire Rural Futures (local RDA)
- Forestry Commission Offices, Huntly, Aberdeenshire
- English Nature Area Offices, Wye, near Ashford, Kent
- The West Dean Case Study: an update of the main technical issues.

The West Dean woodfuel heating system has been in operation for the past 23 years and during this time has met all of the requirements placed on it. One of the greatest attributes has been the ability of the whole management team to work together successfully to develop and maintain the system. Additionally, a competently designed and installed woodfuel heating system and a readily available supply of woodfuel has provided an excellent foundation for success, as well as initial good planning by the estate to place the responsibilities for managing system specification and installation into the hands of a well-known UK engineering organisation.

Woodfuel information pack

In an attempt to address the wider information needs of the industry, Forest Research has produced an easy-to-use information pack (Hall *et al.*, 2004). This collection of fact sheets is a good starting point for all those who need to know more about converting wood into energy. It brings together key basic information about the many aspects of using wood for fuel, grouped into four themes: background information, biomass sources, biomass conversion, biomass user. New fact sheets can be added: additional topics are already in preparation.

The future

Technical Development will continue its work on woodfuel, as there is a need for clear, unambiguous information on all aspects of its production and use. The woodfuel industry in the UK is on a cusp. It is ready for considerable expansion, in terms of becoming commonplace alongside other types of energy provision, or it could completely fail to enthuse both industry and the public in general. In order to promote the former more research and support is required into the provision of reliable information, production streams and infrastructure development.

To that end, work for the coming year will include further workshops concentrating on woodfuel production, more feasibility studies and case studies, highlighting in particular good practice, and, as mentioned, additions to the Woodfuel information pack. Also planned is a series of chipper trials aimed at:

- Identifying suitable and readily available chippers
- Defining outputs and costs for the machines/methods/furnish trialled
- Defining optimum equipment settings.

References and further reading

2003 Energy White Paper: Our energy future–creating a low carbon economy http://www.dti.gov.uk/energy/whitepaper/ourenergyfuture.pdf

Aberdeen University (1990). *Wood fuel strategies*, vol. 1. Report B 1176-P1. Aberdeen University, Aberdeen.

Aberdeen University (1990). Wood fuel strategies, vol. 2. *Harvesting trials summaries.* Report B 1176-P2. Aberdeen University, Aberdeen.

Border Biofuels Ltd (1996). *Forest industry wood fuel supply.* B/W1/00420/REP. Border Biofuels Ltd, Tweed Horizons Centre, New Town, St. Boswells, Melrose, TD6 OSG.

Border Biofuels Ltd (1996). *An assessment of the commercial cost of farm-scale wood fuel procurement and processing.* B/W2/00518/REP. Border Biofuels Ltd, Tweed Horizons Centre, New Town, St. Boswells, Melrose, TD6 OSG.

Centre for Biomass Technology (2000). *Danish bioenergy solutions – reliable and efficient.* Centre for Biomass Technology, Denmark

CRE (1995). *Wood as a domestic heating fuel.* BM5/0488/04/REP. CRE Group Limited, Stoke Orchard, Cheltenham, Glos, GL52 4RZ.

Energy Technology Support Unit (1999). *Supply of wood fuel from small-scale woodlands for small scale heating.* Report produced for ETSU by Technical Development Branch, Forest Research. ETSU Report: B/UI/00554/REP.1999. ETSU, AEA Technology Environment, Harwell, Didcot, Oxfordshire, OX11 ORA.

Hall, A. (2005, in press). *Small-scale systems for the harvesting of woodfuel products.* Forestry Commission Technical Note.

Hein, M. and Kaltschmitt, M., eds. (2004). *Standardisation of solid biofuels – status of the ongoing standardisation process and results of the supporting research activities (BioNorm).* Proceedings of the International Conference, 6–7 October 2004, Leipzig, Germany, Institute for Energy and Environment.

Hogan, G. (2004). Advantage West Midlands Biomass Mission to Austria and Denmark, March 2003.

Ireland, D. and Hall, A. (2004). *Woodfuel information pack.* Forest Research, Farnham.

LRZ Ltd (1995). *Fuel wood from undermanaged woodlands.* B/M4/00487/30/REP. LRZ Ltd (Now Econergy Limited), 35 Gwydir Street, Cambridge, CB1 2LG.

Nisbet, T., Dutch, J. and Moffat, A. (1997). *Whole-tree harvesting: a guide to good practice.* Forestry Practice Guide, Forestry Commission, Edinburgh.

Paananen, M. (2000). *Wood fuel basic information pack.* Jyväskylä Science Park, Finland.