GUIDANCE DOCUMENT 5

WOODFUEL DISTRIBUTION AND HANDLING

FOREST FUELS
Forestry Commission England
South West of England Regional Development Agency
regensw sustainable energy agency

HANDLING AND TRANSPORTATION

As bulk materials, the efficient handling and transportation of woodfuels is critical to their relatively low cost per kWh. The logistics of the fuel supply chain need to be carefully considered at all stages from manufacture to delivery.

At the point of use the fuel store must be well matched in size to the heat load; access to the fuel store must be of sufficient scale to accommodate the delivery vehicle which must in turn be matched to heat load and fuel store capacity.

All too often, insufficient consideration is given to these matters resulting in increased vehicle movements, inaccessible fuel stores and compromised solutions which result in an increase in the unit cost per kWh to the end user.

This document highlights key factors relating to the distribution and handling of woodfuel and their potential impact on the economic success of fuel delivery

LOGS

The distribution of logs is well developed across the South West region and, although issues of quality and volume are clearly inconsistent, the model of local distribution networks is largely settled. Small local companies dominate the market working at little more than a parish level, with very few if any large companies operating on a county or regional basis, the best known being CPL a coal, gas and oil merchant.*

This model of local distribution is consistent with a material that is heavy, bulky and relatively expensive to handle, particularly within the context of modern transport systems. Although some companies do bag, palletise and even cage firewood this adds significantly to the cost per kWh and arguably improves service delivery.

Distribution is relatively well matched to the resource, with suppliers either actively engaged in woodland and hedgerow management themselves or alternatively buying direct from landowners, harvesting contractors and timber merchants. Other sources include arboricultural arisings especially in more urban areas, and utilising the by-products of sawmill and small scale wood processing.

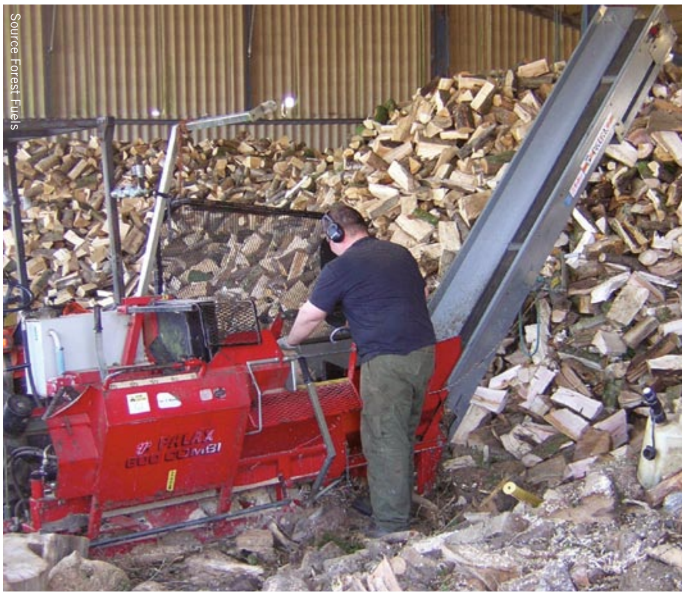
This market is seeing considerable growth at this time driven by the increasing sophistication and efficiency of modern log stoves and boilers coupled with concerns over rising energy costs and climate change. This trend is set to continue particularly in rural and “off-gas” areas and where housing stock permits the use of solid fuel. Improvements to the fuel supply chain that help to resolve quality issues and standardise volumes are inevitable as more innovative and proactive suppliers respond to the rising market and improve their service delivery.

This part of the woodfuel market has the potential to deliver the most direct woodland management activities and biodiversity. Gains sought by the government through its own agency Natural England as they seek to reverse the long term decline in woodland management.

*http://tinyurl.com/4gcjto

PROCESSING AND HANDLING

Relatively well trialed and inexpensive machinery is available to mechanise log production and these machines extend not only from splitting and cross cutting but right through to kindling production and bagging. Processing machinery increases output and economic production of logs significantly, and depending on markets, investment can match the level of sophistication required. As with other machinery, firewood processors can be hired in to provide cost effective log production on site particularly where the end user supplies their own timber or buys roundwood in bulk. Loading is usually a manual process but mechanisation and the use of tipping vehicles for delivery can improve efficiency greatly.



Palax Firewood Processor

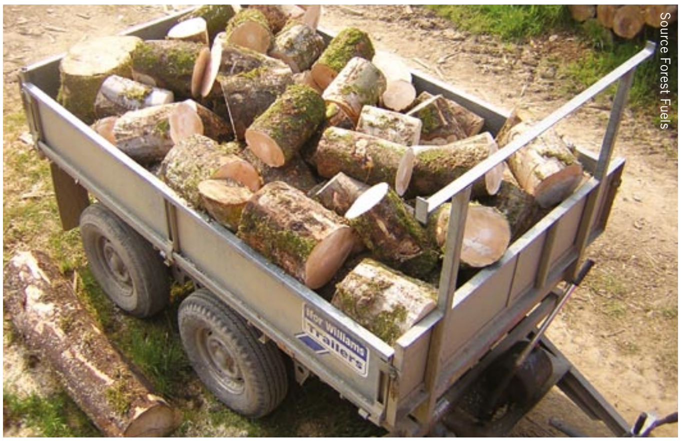
DELIVERY OPTIONS

For bulk use the most cost-effective way of delivering logs for firewood is in 2m to 3m lengths which are then processed on site with a self-loading lorry with a crane. These vehicles are available on a sub-contract basis and haulage can be paid by the cubic metre, which makes it easy to control and monitor costs by volume or by kilowatt hour. This is also the most energy-dense form of delivery, and the speediest method of transport, loading and off-loading.

The disadvantage of delivering this way is that material must be processed into logs on site by chainsaw, axe or purpose-built firewood processing machine. This produces dust and noise, which may be unacceptable. It is more likely to be acceptable if the site is within a working area such as a farm or industrial site.

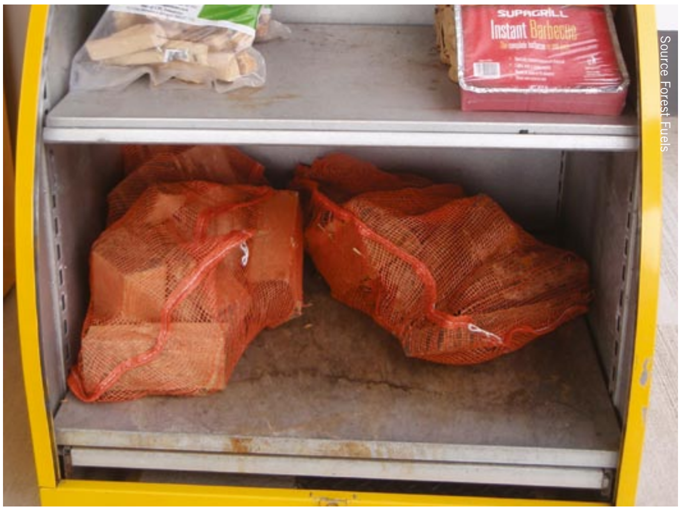
For this reason most firewood customers require material to be delivered in finished form. This will be either in bulk loads or in nets. Delivering in nets – essentially bagging the logs – gives the highest cost per unit. More commonly logs are delivered by tipping trailer or pickup truck.

As with all woodfuels, logs must be of a high standard: they must not only meet the customer's requirements for size and seasoning, but must also be stored correctly and delivered and stacked according to the customer's needs. It is also important to be clear how much will be delivered: merely stating 'half load' or 'full load' is far too imprecise. See Guidance Document 1 for more on standards.



Source Forest Fuels

Tipping Trailer with logs – ease of delivery.



Source Forest Fuels

Log nets for sale at garage outlets, a relatively high value but high cost product.

PELLETS

Unlike both log and woodchip, pellets are better suited to an extensive distribution network because of their relatively high energy density, ease of handling and versatility. This makes them an attractive fuel and consequently creates the widest potential woodfuel market. The UK market for pellets is currently dominated by imports. As a "commodity" its price is influenced by the wider energy market across the UK and Europe rather than by localised issues of raw material supply or demand.

Currently, there is only one pellet manufacturer in the south west although there are a number of potential manufacturers considering entering the market. The key raw material resource (dry sawmill co-product) is severely limited in the south west due to a lack of large scale softwood sawmills producing the co-product in volume.

The largest sawmill in close proximity to the south west is BSW in Newbridge South Wales (http://www.bsw.co.uk/locations/newbridge/). The mill produces around 108,000 cubic metres of sawn timber from around 185,000 cubic metres of roundwood. In comparison, Bolsta Sawmill in Sweden mills around 815,000m^3 of roundwood per annum and is part of group milling around 1.8 million cubic metres each year collectively producing around 180,000 tonnes of pellet per annum. Given these statistics, it is hard to imagine that pellet production in the UK will be significant on a european scale unless there is significant growth in the timber market.

Another potential resource for pellet production in the south west is from green sawmill co-product. This, however, raises a secondary problem from increased embedded energy due to the need for additional drying. Green co-production processing reaches an estimated 20% embedded energy as opposed to only 2.5% when using dry sawmill co-product.*

Another potential source of dry timber could come from the clean recycled wood sector. Welsh Biofuels, one of the UK's largest pellet manufacturers, produce much of their pellets this way and they currently produce around 30,000 tonnes per annum.

As a highly processed fuel, distribution is centralised either by the manufacturers themselves or through regional distribution centres. These centres may also act as bulk importers and can provide packaging for road transport through bagging and palletising.

*(OBERNBERGER, I. and THEK, G. 2005)

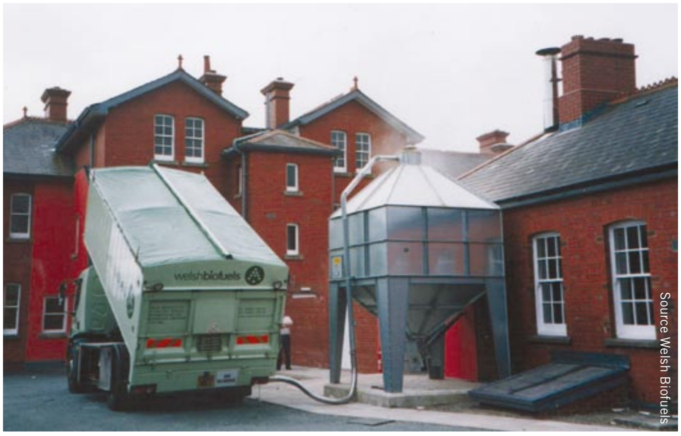
ENERGY CROPS

Both miscanthus and short rotation coppice (SRC) are normally pelletised to increase energy density and improve transportation logistics and the economics of supply. This process is currently being driven by the need for biomass in co-firing at coal fired power stations, and provides a substantial market in areas where existing producer groups have energy supply contracts.

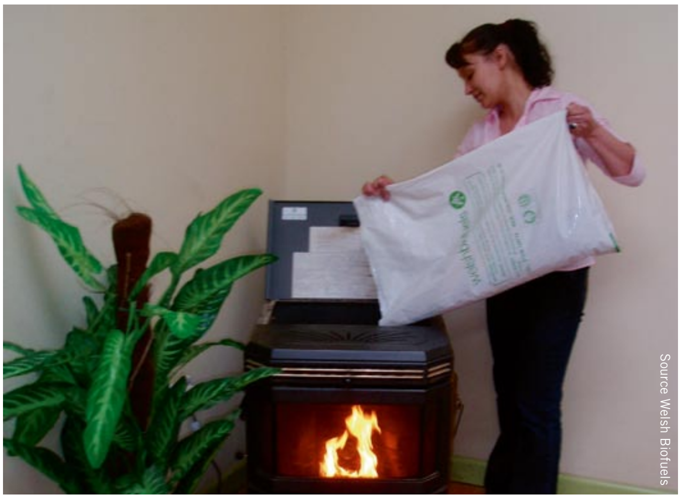
Miscanthus and SRC can be pelletised for the wider pellet market and are potentially well suited because the crops provide a concise homogenous feedstock, which in the case of miscanthus, can be at a low moisture content. There remains, however, some work to be done with the boiler manufacturers to ensure compatibility.

LOADING

Minimal handling during the loading process is critical to avoid unnecessary damage to the pellets and therefore breakdown. To reduce breakages, processors may either bag or load into bulk delivery vehicles directly from the production line. However, more often, bulk loading is undertaken using a large loading bucket from storage. The speed and efficiency of this part of the process is critical to ensuring a competitive sales price.



Blown Pellet Delivery – Note dust emerging from vent at the top of the store helping to depressurise the store during delivery



Pellets being poured direct into the fuel hopper of a room heater

DELIVERY

Pellets can be delivered either in bulk or in bags. Bagged pellets, although convenient to handle on site without specialist machinery, have the highest unit cost by energy. This is because of the additional costs introduced by the bagging process, which involves packing on pallets, shrink-wrappings and delivering by forklift at both ends.

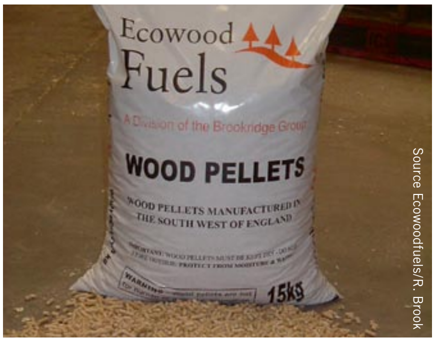
Delivery in bags may be useful for residential customers with low demand as they can store them outside and handle them easily. The bags protect the pellets from excess moisture and the user need only bring each bag in when needed.

Bulk delivery of pellets is more appropriate when customers have large stores, and delivery is by either tipping vehicle or blowing lorry. Most often bulk pellets are delivered by the latter method using a pellet tanker. This is a six-wheeled tanker lorry which delivers material by blowing it directly into the store through a 15cm or 20cm diameter hose.

An advantage of pneumatic, piped delivery of pellets is that the fuel store may be relatively remote from the tanker lorry as the lorry does not need to manoeuvre immediately alongside it. Blowing lorries can also meter the delivery, determining the exact quantity of pellet delivered by volume or weight. They use both a flow and a return hose, partly to prevent pressure building up inside the fuel store, and also to remove dust created during delivery. The design of the store must allow for the free flow of blown pellets into the store. A problem often encountered is pellets colliding with the frame or structure of the fuel store which breaks the pellets up causing excess dust.

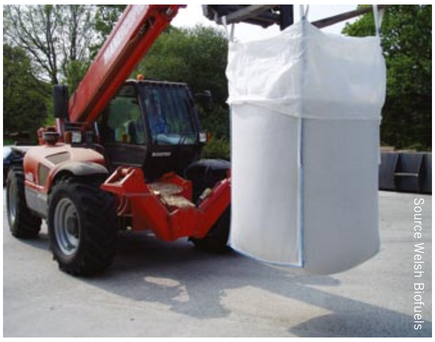
Dust is a critical issue in pellet delivery and will either be created if material breaks down from excessive mechanical abrasion and friction during loading and unloading, or from poor adhesion of the pellet during production. Whilst dust may be removed satisfactorily during the flow and return delivery process, material may still build up inside the fuel store or in the augers. This build up of loose dust can become compacted when subjected to the forces of an auger and may in turn trip the auger motors or shear the auger gear shafts.

Alternatively, pellets may be delivered using bulk tipping lorries. They can be tipped into below-ground fuel stores, or may be handled using a front-end loader such as a teleporter. In both cases handling must be minimised to prevent breakdown of the pellets and creation of dust. Material delivered this way must also be protected from moisture. If pellets do absorb water they very rapidly expand and break down, making them useless for combustion and likely to block the boiler's in-feed system.



15 kg pellet bag for domestic consumers

Bags palletised for bulk delivery



One tonne pellet bags prepared for loading at distribution centre

WOODCHIP

Woodchip is a bulky material, and although relatively convenient for transportation, its low energy density restricts the economics of transporting the fuel over a significant distance. Woodchip arguably has more in common with the distribution of logs rather than pellets.

As processing timber into chip is a relatively flexible and straight forward operation the models for production of the finished fuel are many and varied. Whilst this perhaps presents an advantage over the centralised and retail distribution of pellets, the plethora of options leads to a great deal of misunderstanding as to how best to resolve supply chain logistics, which in turn may lead to mistakes in the processing.

In addition to processing there are many different transport and delivery methods for woodchips. As a high volume fuel with a low energy density it is important to deliver finished fuel in bulk. In volume terms for example, 1 litre of oil would be equivalent to 3 litres of pellet and 9 litres of chip. It is, therefore, only cost effective to deliver chip in substantial quantities.

It is also possible to transport material for processing into chips on site, using standard timber haulage vehicles. However, when processing on site into a barn or direct to a fuel store site, constraints of noise, dust and storage need to be considered. Therefore most chip is delivered in finished form according to the fuel specification and to suit the customer's needs, which in the main is determined by suitability of access for large vehicles and fuel store capacity.

Pellet Tanker for blown delivery
– body compartmentalised to allow for partial delivery.

Woodchip delivery vehicles

Typically, the larger the vehicle, the lower the unit cost of the chip. However, the size of the vehicle must suit the operation and the access to the site.

The smallest bulk delivery vehicle for woodchip is an agricultural trailer with a tractor unit: a grain trailer has a volume of approximately $15m^3$ and a silage trailer between $20m^3$ and $30m^3$. Next in terms of size is a six or eight-wheel bulker lorry with a tarpaulin over the top to prevent material from blowing away or becoming wet; such a vehicle delivers $20m^3$ to $40m^3$ of chip. This size of vehicle can also incorporate containerised systems such as hook bins. The largest vehicle is an articulated bulker, delivering from $65m^3$ to $115m^3$ of material.

Woodchip can also be transported in curtain-sided lorries. The material is packed into the vehicle and only contained during transit by the curtain sides. To unload, the material is pushed out from either side of the lorry with a front-end loader bucket or similar equipment.

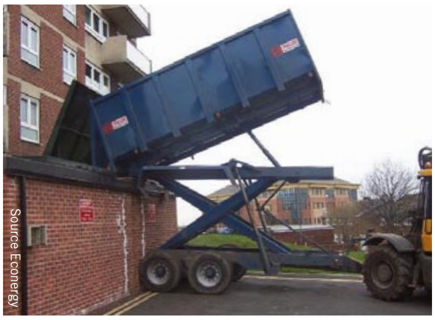
Access requirements for all of these vehicles are very different: a tractor and trailer unit can turn very sharply, reverse easily and requires relatively narrow turning hammer heads or radii on corners; large and articulated lorries need large manoeuvring areas.

It is possible to seek advice in relation to vehicle sizes, such as turning circles and entrance widths, from the Freight Transport Association.* A fee is charged for the information which is available electronically. It is also possible to obtain software suitable for computer aided designs (CAD) which simulate vehicle movements.

Whether a delivery vehicle runs on derv or on red diesel will also affect costs. Currently Customs and Excise in the UK state that provided the contractor delivering the chip is also the owner of the chip at the point of use, the chip is considered a forestry product and may be delivered in a tractor and trailer using red diesel. However if the tractor unit is used only for haulage, and the contractor does not own the chip but is simply engaged to deliver it, the tractor must use derv and full duty must be paid. Lorry deliveries must also run on derv.

*http://www.fta.co.uk/

Eight wheeler being load with finished chip – vehicle volume 28 cubic metres



Scissor lift trailer – specialised trailer for high lift tipping cost circa £15 – 20,000

Hook bin being loaded at distribution depot – loading bucket with a capacity of 5 cubic metres, less than 5 minutes to load a 20 cubic metre bin

Delivery Methods

Chip has an extremely high angle of rest and does not flow like grain or sand. Delivery vehicles, therefore, must be able to manoeuvre and deliver effectively: tippers must be able to rise to their full height and the lorry must be able to position the tipper over the centre of the store. Guidance Document 4 covers design of fuel stores in more detail.

Where material is delivered onto a flat concrete apron the angle of rest of the fuel causes no problems – this issue pertains only to tipping deliveries into below or semi-below ground fuel stores.

A tipping vehicle needs enough clearance to raise the body fully: there must be no overhead obstacles on site. Chip can be extremely obstinate and the vehicle body has to be at least at 45°, and possibly as high as 90°, before the chip will flow out. When it is cold the chip can freeze inside the tipper body, particularly if it is high moisture content fuel. When chip does slide out of a vehicle body it can happen extremely quickly, which represents a potential safety issue if operators are positioned too close.

On some sites tipping is not appropriate as there may be overhead obstacles, or the fuel store may be inside a building without enough clearance. On these sites the chip needs to be shed from the vehicle without its body being raised: suitable lorries are those with a large hydraulic ram at the front which pushes the entire load down the body and out of the rear doors, or lorries with a chain or walking floor system inside the vehicle body which shunts the material to the rear and out of the doors.

Once shed from the lorry the material must be either moved away from the rear doors, or the lorry will need to creep forward as it unloads. Alternatively, the material can drop into a below-ground store, where there is a large enough drop to allow the whole load to pile up below ground.

There is potential when tipping, or indeed blowing directly into a fuel store, for compaction of the chip and resulting bridging as the fuel drops or is forced by air into the fuel store. The weight and compaction of the fuel may also "pin" down the arms of the fuel agitator. To prevent this it is important that the fuel agitator arms are turning during the delivery process and that they are correctly specified for the weight and depth of the chip in the store.

The use of a walking floor or ram unloading lorry will provide improved delivery speed, but may also increase the unit cost slightly because of their higher degree of mechanical engineering, maintenance and capital expenditure.

It should be noted that woodchip can also be blown. To date this has only been tried with dry fuels in the smaller size categories (See Guidance Document 1: Woodfuel Standards). The vehicle body needs to be able to tip to feed material to the chip blower in-feed at the rear of the lorry. An advantage of this method of delivery is that, as for pellets, the fuel store may be remote from the delivery vehicle. Also, material can be metered, and part loads can be delivered at numerous sites.

However, there are very few woodchip blowers available in the UK with only a handful currently in operation. The increased capital expenditure and slower delivery rate add to the delivered fuel price. Chip blowers can currently deliver at a rate of approximately $0.5m^3$ per minute.

Vehicle movements are limited at some sites by planning constraints, or by the end users requirements, for example at a school, deliveries might be unacceptable as children arrive and leave. To keep vehicle movements to a minimum, it is important to determine the optimum combination of fuel store and vehicle size.

Tipping deliveries can produce significant quantities of dust, especially when dealing with smaller grades of fuel, and fuels of lower moisture content. There are ways to contain dust such as skirts, or fans to extract it, but on some sites dust can still cause potential problems, particularly if there are air fan intakes nearby, or machinery that is sensitive to airborne dust.

DETERMINING DELIVERY VOLUME – PELLET AND CHIP

The delivery vehicle's size needs to be appropriate for the volume of the fuel store. Factors that will determine the size of the fuel store will be available space, position of the boiler, the annual heat load and budget. With all woodfuels, understanding the constraints of relatively low energy density fuels with a high volume is important.

A small fuel store for a boiler with a large heat load will necessitate many more vehicle movements resulting in increased cost. Inevitably, on any site, factors conspire to compromise the "ideal" fuel store design. As a biomass boiler is likely to have a life expectancy of at least 25 years, finding the most cost effective solution for storage and delivery is essential.

The volume of fuel in a store cannot be calculated simply by using the volume of the store as there will be dead areas in any store, which contain fuel which is not accessible to the boiler. Only fuel which is accessible should be considered – this is called the **live volume.**

Purpose built pellet stores are carefully designed to allow the pellets to flow downwards to point where they are extracted from the store and therefore, in these circumstances, the live volume should match the fuel store capacity.

However, in most fuel stores fuel is extracted via an auger, and in the case of chip, prevented from bridging by the inclusion of a circular agitator. As most fuel stores are square (for ease of construction), the four corners of chip/pellet remain unextracted during normal operation.

There is also a **dead volume** of chip/pellet which sits below the extract auger where it leaves the fuel store. This can be as much as 15 to 20% of the fuel store capacity in the case of chip, but typically less for pellet which flows more readily.

It is also important to ensure that fuel levels within the store can be checked easily, via an observation window or other alternative means. In addition, a clear understanding of likely usage is necessary in order to predict the timing of and volume for refuelling and the **minimal operational level** that needs to be maintained to prevent the boiler from running out of fuel. To calculate the working volume of a fuel store, take the volume of the whole store and then subtract the dead volume and the minimum operational volume. For example if a store measures 5m by 5m by 3m then its gross capacity is $75m^3$. This may then be reduced by a third by the dead volume and the minimum operational volume leaving a working volume of some $50m^3$, which is the optimal delivery volume.

Scaling deliveries to the working volume of the store will help to minimise the number of deliveries and consequently provide the most cost effective delivery option. Delivering small or part loads will inevitably increase the cost of the fuel.

Building a larger store may not always result in a lower unit cost per kWh because of other factors which need to be considered. Firstly, the store would use valuable space on the site. Secondly, large fuel stores may need different extract and agitator systems such as hydraulic rams or walking floors, which can disproportionately increase costs.

Dead space within the fuel store inaccessible corners beyond the range of the agitator

SUMMARY

The efficient distribution and handing of woodfuels is a critical element to the success of woodfuel projects. Failure to address the logistics and economics issues they present will not only result in a higher unit cost to the end user, but also result in many projects failing to get from the drawing board and into service.

Much of the bad press associated with woodfuels comes from the failure to understand distribution, handling and delivery and the implications that a poorly conceived fuel supply chain can create.

This document is part of a series – other guidance documents available include Woodfuel Standards, Woodfuel Supply Contract Options, Woodfuel Processing and Woodfuel Storage

Further Information

Biomass Energy Centre
www.biomassenergycentre.org.uk

British Standards Institute
www.bsi-global.com

Rural Development Initiative
www.ruraldevelopment.org.uk

The South West Woodfuel Advice Line
08450 74 06 74

The South West Woodshed
www.southwestwoodshed.co.uk

There is a very wide range of accessible web based information and many websites dedicated to woodfuel. However, it must be borne in mind when reviewing this information that woodfuel in the UK is still an emerging market and the information available is limited by the experience upon which it is based.

References

Woodfuels Basic Information Pack 2000

OBERNBERGER, I. and THEK, G. (2005)
Herstellung und Nutzung von Pellets, Volume 5 of the Thermal Biomass Utilization series, Institute of Resource Efficient and Sustainable Systems, Graz University of Technology, Austria.

Credits

Amini, F – Welsh Biofuels Limited
Bent, E – Midlands Wood Fuels
Brook, R – Ecowoodfuels
Farquhar, J – Rural Development Initiative
Hogan, G – Biomass Energy Centre
Halcro-Johnston, A – Regen SW
Rickwood, D – Forest Fuels
Whatmore, S – Forest Fuels
Wilding, J – Clinton Renewables

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