WOODFUEL STORAGE

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

STORAGE OF RAW MATERIALS PRIOR TO PROCESSING

Whether producing logs, chips or pellets, the collection and storage of the raw material is a critical part of the process with consequent impact on both the quality and price of the final product.

ROUNDWOOD – Logs/Chip

Timber should be stacked on bearers to keep it off the ground. This limits the wicking of moisture from the soil, stops grit entering the stack, and helps air to flow round it.

The aim of stacking is to maximise airflow in order to reduce moisture. To this end, stacks should be as high as possible. Although the maximum legal stack height in the UK is two metres there is no legislation for whole tree materials so these stacks can be substantially higher, and safer. Stacks should be made in sunny, open, airy and windy locations, and stacked with the log ends facing the prevailing wind so it can blow through the stack at roughly 90 degrees.

Stacks may be protected from the rain with sheeting over the top and with only a short turn-down that does not cover the sides. In the south west it is normally only necessary to use sheeting in the winter to protect material that is already dry and ready for burning. It may be useful to sheet two or three weeks before conversion to chips to allow rainwater to leave the stack.

Most seasoned timber does not 'unseason': rain falls at one bar of pressure, but several bars are needed to force water back into timber. Some species are hydroscopic, however, and reabsorb moisture – such as poplar, larch and pine's sapwood. Beyond a certain point, once material starts rotting, the breakdown of cell structures permits water to re-enter timber.

Health and safety is paramount. Stacks should be both signed (to keep people away from them) and safely and correctly stacked to ensure maximum stability – as it dries timber shrinks, which can cause stacks to become unstable.

Pallets ready for recycling – the technology is available to convert such material to woodfuel and the volumes of clean recycled wood are potentially huge and this will undoubtedly enter the fuel wood market once it becomes cost effective to sort and remove contaminated material.

RECYCLED MATERIAL – Pellets/Chip

The key advantage of recycled material is its dryness particularly for pellet production, it is therefore critical to ensure this advantage is not lost when transporting and storing the raw material prior to conversion.

Save for immediate conversion of the raw material, covered storage within a building is likely to be preferable. The use of metal storage bins provide another useful means, not only of storage, but of collection also. A number of fuel suppliers collect directly from "waste" producers, such as joiners, using a hook bin system.

SAWMILL RESIDUES

Slabwood, sawdust, and off cuts are all potential fuel sources. Residues from primary processing are more likely to be suited to woodchip production whereas residues from re-working kiln dried material will be dry and therefore a perfect raw material for pellet manufacture. The majority of large scale pellet producers are either part of, or closely associated with, high volume sawmills producing large quantities of sawdust.

Green slabwood being unloaded from an arctic and being stockpiled for drying prior to chip production – G30 specification is hard to achieve consistently with slabwood as it tends to "shatter" during the chipping process

STORAGE OF PROCESSED WOODFUEL AT DISTRIBUTION DEPOTS

The key advantage of all woodfuels is there relatively low cost and it is therefore crucial that handling, storage and transport costs are kept to a minimum. Frequent handling of any bulk material rapidly adds to its price, and this is especially true of relatively low energy density woodfuels. To achieve a smooth production process, depot layout is crucial.

LOGS

Covered barn storage offers the simplest and arguably the most cost effective solution for storing logs.

Processing logs in to a split form aids the drying process and covered storage prevents re-wetting. Sheeting provides a less costly storage solution but equally reduces the quality and arguably the return to the contractor, as it is much harder to control the quality of the finished product.

Agricultural barn provides an ideal log store –direct processing into the barn using a relatively low cost processor accelerates the drying process.

Well designed fuel store built to an Austrian specification–power floated concrete floor, good ventilation, excellent access for haulage vehicles and chipping, reinforced pushing wall, rear of structure orientated towards prevailing weather conditions.

WOODCHIP

Indoor storage of woodchip
The ideal fuel store has its back to the prevailing wind to prevent re-wetting of the woodchip. If exposed to the weather or incorrectly oriented, plastic screening, similar to that used on warehouse entrances, can be used to block moisture from entering.

Dry fuel should ideally be stored undercover to avoid rewetting. Even though rewetting of chip will not reverse the seasoning process, and water will only enter skin-deep, it will increase the woodchips' moisture content because of increased surface area.

Upper areas of the barn need to be well ventilated. Even low moisture content fuel has some water in it, and following chipping some of this water evaporates. As the evaporated water is slightly acidic, if it condenses onto the steel frame of the building, it can cause corrosion. Good airflow vents this moist air.

Barns for storing dry fuel should be rectangular rather than square to allow fuel to be processed directly from depot storage stacks into the fuel store.

The gap between the building and the stacks should enable the chipping machinery to blow well inside the building, timber stacks also need to be positioned to minimise handling when feeding–by crane or by hand– from stack to chipper in-feed.

WOODCHIP continued

Different grades of chip should be kept in separate bunkers and clearly signed; operators need to know which is which so that there is no confusion when making deliveries.

Chipping machinery is best used outside. It should be used inside only in extremely well ventilated or forced ventilated buildings as the engine fumes affect the operators' health and safety.

Wet fuel must not sit too long or it will begin to compost, which has serious health implications: the fungi and fungal spores that rapidly develop on processed chip of over 27% moisture content are toxic to the lung's lining. They cause a disease aspergillosis, which produces a hacking cough and if untreated with antibiotics can be fatal.

Outdoor Storage of Chip
Chip can be stored outside and a permeable fleece material, similar to gortex, is currently being marketed as Toptex. This can be used to sheet chip piles and has been shown to shed a high proportion of rain while allowing moisture to evaporate up and through the fleece. Further information can be obtained from a widely reported study undertaken in Austria.*

Outdoor storage, even without fleeces, is acceptable when producing high moisture content fuel. However, when dry fuel gains moisture after processing, its energy value is reduced.

*www.swwf.info/images/Toptexstudy.pdf

Well stacked timber on bearers, covered to prevent water ingress, timber stacked close to fuel depot, to allow timber to be chipped direct via "windows" into the building without further handling following haulage

Toptex Fleece used to protect chip from rainfall and to promote drying through permeable membrane. The chip is stored on impermeable surface to prevent ground absorption of moisture. Note: ideal machinery for bulk handling

PELLETS

The key factor to consider when bulk storing pellet is dryness, both the atmospheric condition of the store as well as the need for weather tightness. The compressed structure of pellets is critical and relatively small changes in their moisture content will rapidly result in degrade, further exacerbated in the loading and handling process.

Dust is an inevitable consequence of pellet storage and represents both an explosive and respiratory risk. Large quantities of dry dust can result in an illness similar to farmer's lung, and respiratory equipment or face masks should always be worn.

"Over-handling" of pellets causes them to break down, increasing the dust and fines in the finished product. These fines can block augers and cause blockages in fuel stores from dust compaction, with serious consequences for boiler in-feed systems. As a rule of thumb each handling 'event' increases the proportion of dust by 1%.

Features pertinent to both chip and pellet depots

Floors should be clean and of reinforced concrete (preferably with "power floated" finish) so it may be driven on to allow loose material to be cleanly loaded from the floor by a front-end loader bucket. Contamination with stones or soil will cause clinker production and wear and tear in the boiler.

At least one of the walls of the building must be of sufficient strength, ideally reinforced, to permit mechanised shunting with the chosen loading machine.

Well designed subterranean fuel store for woodchip permitting tipped delivery – sliding roof cover

Galvanised pellet store, pneumatic delivery via inlet pipe from building exterior

POINT OF USE FUEL STORES – WOODCHIP AND PELLET

GENERAL

All stores must have adequate safety signage and should be lockable or in a secure zone to ensure that individuals or operators do not enter – these are restricted spaces and have dangerous moving equipment within them.

Fuel stores need to have some method of assessing the level within. Clearly just as an oil tank has a level indicator gauge there needs to be some visual inspection window or way of looking inside the store practically and easily to assess the level and determine when a new delivery is required.

Delivery methods such as tipping, chipping direct into the store or blowing are often extremely dusty and steps need to be taken to control and limit dust. Sealed systems, such as bagged deliveries or hookbins, may present a "clean" solution where dust may not be acceptable.

Where possible the advice of fuel suppliers should be sought during the design phase to determine the size of the fuel store and to balance the acceptable level of vehicle movements on site with the available access for different delivery vehicles.

A tractor and trailer need just a small access but carry only in the region of 15 to 25m^3 of fuel at any one delivery. A six- or eight-wheeler bulk delivery lorry carries 20 to 35m^3, articulated bulkers 60-85m^3 – and an articulated lorry up to 110m^3 of woodfuel. However access for such vehicles needs to be substantial so it is important to assess whether the location of the fuel store is suitable, and whether there is a satisfactory turning space and height to accommodate tipped deliveries.

Pellets can arguably offer more flexibility in terms of delivery from individual 25kg bags to pallet lorries, one tonne dumpy bags and even blown deliveries via specialist tankers. However, access issues remain a critical consideration.

An assessment needs to be made to determine the minimum level of fuel permitted in the store: it is not acceptable to wait until fuel has run out before making a delivery, as there must always be enough material in the store to maintain continuous operation of the boiler. A notice period needs to be calculated (see Guidance Document 2).

When calculating the amount of fuel in a store it is important only to include that fuel which is actually available to burn. Angled extractor augers produce a dead space beneath them – this should be deducted from the gross volume of the store to calculate the live volume. Round agitator systems also leave a residual quantity in the corners and this needs to be deducted. The minimum level maintained, to avoid the boiler running out of fuel, needs to be deducted from the gross volume. After these deductions an estimate can be made of the quantity required in a single delivery.

The fuel layout (as discussed in the below-ground fuel store section below) is also critical as without an adequate drop height in the fuel store, it may not be capable of receiving a full load without the need to shovel chip by hand –this is a time-consuming and therefore costly operation.

The siting of the fuel store is critical to an efficient and cost effective fuel supply, regrettably, the position of the fuel store is often given secondary consideration to the siting of the boiler and fuel suppliers are presented with a "fait au complit". Once installed a boiler may have a life of up to 30 years, and poor judgments made about the location and the design of the fuel store may add as much as 30% to the fuel cost. In the short term this may seem insignificant, but scaled up over the life of the boiler it will represent a significant cost penalty. Regrettably, bulk handling and storage is constantly misunderstood by Boiler specifiers and often unnecessarily increases the ongoing running costs of the system.

Hydraulic lid has insufficient lift to permit easy tipping and no safety bar in place to prevent reversing vehicle contacting the edge of the fuel store

WOODCHIP STORES AT POINT OF USE

There is a great range of woodchip stores. Choosing the correct one for a site is an extremely complex decision based on a thorough understanding of the constraints of the site, scale, fuel type, labour and machinery availability, and capital constraints. The following section describes the various options for fuel store design, always taking into account the need for smooth, easy delivery of the fuel in order to keep costs down.

Below-ground fuel stores

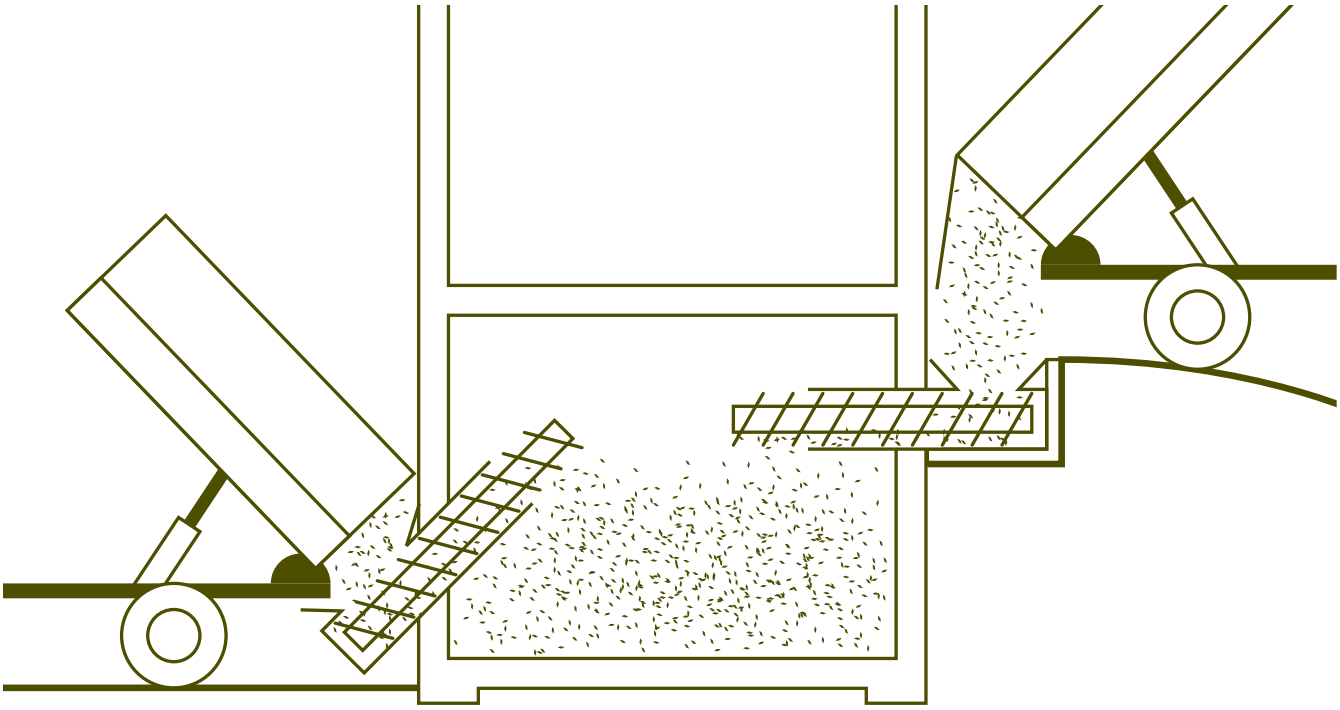
One of the best and most common designs in Europe puts the fuel store below–or semi-below–ground, either in a sunken building with all four walls below ground, or with half the building built into a slope. The uneven topography of south-west England often makes semi-below-ground stores a very suitable option. A significant advantage of semi-below ground stores is that, in contrast to below-ground stores which require careful construction to ensure that they are completely waterproof and that any water reaching the outer surface is drained away, a semi-below-ground store can simply have a blockwork construction wall. There will be a cavity on the faces touching the soil or bedrock to allow the water to drain away down the slope below. The main advantage of both these stores is that material can be tipped in bulk from tractor and trailer, small lorry or even large articulated lorry.

In these stores the wall adjacent to the point of tipping needs reinforcing to withstand, without buckling, the substantial rear axle loading of a tipping vehicle. There should also be a safety stopping bar to prevent vehicles from reversing into the fuel store. The roof must include an opening hatchway of a suitable width for delivery vehicles to tip without spilling material on either side. Clearly the roof must be designed to shed water without allowing water to build up or to enter the store.

The opening hatchway needs a safety grill, with holes large enough to allow chip to be poured rapidly through without bridging during delivery, and small enough to prevent people from falling into the fuel store.

The advantage of tipping delivery is its ease and rapid delivery rate: gravity remains the quickest delivery method, requiring no specialist machinery, as suitable bulker lorries and tipping trailers are widely available. Such fuel stores must have an adequate drop height as woodchip has a very high angle of rest and so does not flow “across” a fuel store.

High quality fuels store, metal safety grid, “book” opening doors prevent tipped fuel spilling



Schematic of fuel transfer pit and transport auger

Below-ground fuel stores continued

The drop height must be enough to take an entire load at one time: delivery of partial loads adds to the finished energy price. One method of improving this is to develop a fuel store with a partially reinforced roof to allow the delivery vehicle to reverse part way over the store, or for the tipping bed of the delivery vehicle to be pivoted so that the rear tipping point reaches far back over the centre of the store. This allows tipped material to form a cone-shaped base centered on the middle of the fuel store so that despite the high angle of rest of woodchip, the store is fully refilled at each delivery without wasting space.

Tipping vehicles must be able to reverse onto a completely level surface as, once a tipping body is raised, any cross slope angle can cause the trailer unit to tip over. The tipping body must have enough clearance to be raised to its full extent, as chip, and especially wet chip, can be extremely stubborn and needs a high angle for it to slide out. The clearance height also needs to avoid overhead wires and obstructions.

To further increase the drop height of the fuel store an alternative is to construct a small ramp, although this needs to be at a suitable angle to allow the tipping vehicle to reverse onto it.

Fuel Transfer Pits – Transport Augers

In many European countries fuel transfer pits with high speed auger mechanisms are used to transfer fuel from a tipped delivery vehicle into fuel stores within a building. The transfer can be horizontal, vertical up or down. The auger mechanism is set into the ground and the delivery vehicle tips the fuel whilst the auger transfers the fuel to the store.

Receipt pit and Auger

Source Forest Fuels/Heizoschneck

Transport Auger

Low cost galvanised woodchip store suitable on agricultural site where machinery is available to permit loading

Above-ground fuel stores

A second store type, useful where the previous store design may be inappropriate, is an above-ground fuel store. A disadvantage of an above-ground store is that material can only be tipped using a scissor-lift or high-lift trailer. Specialist machinery is only justified if used often enough – delivering to one store on an infrequent basis would be unlikely to cover the purchase cost. Alternatively, fuel for such a store can either be chipped directly in, or filled using a front end loader where chip is stored onsite and such machinery is available.

Another option is to blow material using specialist blowing equipment. Again, the cost of blowing equipment can only be justified by high usage, probably where there are several neighboring boilers all requiring this method of delivery or the volumes consumed are large.

Above-ground fuel stores have the advantage of lower capital costs as they require less engineering and specification than below-ground stores. They can be constructed of simple single, or double-skin, block-work or prefabricated hoppers. However this avoidance of capital cost on storage specification can lead to increased operational costs for the fuel supplier such as a slower delivery rate when blowing, delivering by high-lift trailer or chipping directly into the store. In addition, the fuel supplier may have to invest in specialist equipment to supply and all of this will inevitably increase the fuel price for the end user.

An alternative design for an above-ground fuel store consists of three walls only, the store being open on one side. The fuel is tipped onto the store's clean concrete surface and shunted across that surface into the live zone of the fuel store. In the centre is the auger, agitator and/or walking floor used to extract the fuel. Material tipped onto the floor needs to be shunted up and over the extraction equipment from the fuel store using a front-end loader or similar equipment.

Clearly it is important to mark out the start of the live fuel store (containing the floor-mounted transportation equipment of agitator, auger, walking floor, etc.) in order to avoid this being damaged by the front-end loader pushing forward. Alternatively, a small retaining wall can be constructed to protect this equipment. This store type is most appropriate in a location where machinery, such as telehandlers and front loading tractors, are parked up nearby. This ensures material can be shunted forward as and when it is required.

HOOK BIN DELIVERIES

Under certain circumstances, where site constraints do not allow a purpose-built building or below-ground store, a hook bin system may be suitable. This consists either of two hook bins, one being replaced whilst the fuel in the other is being used, or a single hook bin system.

Single hook bins can be used with boilers which have an accumulator tank, and a rapid turnaround from a nearby fuel depot.
Hook bins connect into an auger and fit on a metal support structure which remains on site: they are changed over like cartridges.

The advantage of hook bin systems is that hook bin lorries are relatively easily provided on a contract basis at around £45-55 per hour. However hook bins do require substantial capital investment – a single hook bin with internal walking floor costs in the region of £10,000. The fuel volume of many hook bin systems is limited resulting in relatively high haulage costs and a consequent increase in fuel price.


Source Forest Fuels

Hook delivery onto specially designed receipt cartridge – chip transferred by walking floor mechanism (note hydraulic connections) transferred into the boiler via auger

PELLET STORES AT POINT OF USE

Much of the detail provided on storage for woodchip applies to pellet and as with woodchip, pellet stores can be subterranean or above ground. Again tipped deliveries being the optimal for larger projects such as the Welsh Assembly.*

Both containerised and above ground bin systems can be more flexibly serviced by blown pellet delivery, which is more common than blown delivery for chip. Ideally, the delivery should be free from obstructions to minimise physical degrade of the pellets during the blowing process.

It is important for both fuel supplier and installer to ensure the coupling method is agreed, as currently there are no UK wide standards for connections. Typically, two connections are necessary as the in-feed blows a mix of air and pellets at high pressure into the store, while the out-feed removes dust. In the absence of an out-feed the air pressure builds up inside the fuel store pressurising the structure which may lead to damage.

Pellets' high energy density means that their stores can be smaller than those for woodchip. Manufacturers provide a range of simple clean storage solutions for pellets particularly for the domestic market; however, these stores can often be sited in inaccessible locations and present many delivery issues. In order to overcome the complex delivery issues suppliers such as Ecowoodfuels have designed their own external pellet hopper similar in design to a modern oil tank. External stores ensure that the siting of the fuel store can be adequately and economically serviced in the long term.

*http://tinyurl.com/4qhvs2


Source Ecowoodfuels/R. Brook

External bulk pellet fuel store


Source Ecowoodfuels/R. Brook

Palletised bags of pellets

Walking floor mechanism prior to installation

Fuel agitator and pressure plate Empty

FUEL TRANSFER – STORE TO BOILER

The final phase of fuel storage is the transfer of the fuel to the boiler. Fuel is most commonly fed into the boiler by either an agitator or hydraulic ram.

Smaller fuel stores commonly use a round agitator arm, which prevents the fuel from bridging (where fuel binds together and prevents material from falling into the auger for extraction), combined with an auger. An agitator arm is usually a heavy spring-loaded arm or leaf spring, which rotates from a central motor.

Larger fuel stores may have a walking floor extraction system, consisting of rising and falling metal plates, which move the fuel towards an extractor auger at the side of the store. Some large stores may also have hydraulic rams shunting the bottom layers of material across into the auger.

Although such systems also apply to pellet, pellet fuel stores can be of a relatively low volume, particularly if for domestic use, and may be in the form of a loose material bin with an auger at the bottom. Pellet augers are relatively small and less robust compared to chip augers, but can travel round corners using flexible pipes. On the whole pellets do not bridge like chip, so an agitator system is not necessary.

Fuel agitator and pressure plate in operation

SUMMARY

Fuel store design is a critical element to the success of any woodfuel project, and the solution must provide for the life of the installation. Site factors will compromise the “ideal” design and may dictate fuel type but a workable economic solution is essential. Poorly conceived fuel delivery and receipt methods could result in a fuel penalty that could represent as much as one third of the fuel cost.

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

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

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

This Guidance Document has been produced as part of The South West Bioheat Programme, an initiative managed by Regen SW and funded by the South West RDA and The Forestry Commission. Visit www.regensw.co.uk/bioheat for further information on the bioheat programme.

Published July 2008

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