

COMMERCIAL WOODCHIP STORAGE DRYING TRIALS

ETSU B/U1/00674/REP

DTI/Pub URN 01/1175

Contractor

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The work described in this report was carried out under contract as part of the DTI Sustainable Energy Programmes. The views and judgements expressed in this report are those of the contractor and do not necessarily reflect those of the DTI

Commercial Woodchip Storage/Drying Trials

Executive Summary

On the back of the recent positive steps into energy production from Biomass in the North of England, KFP is well aware of the importance of the supply of high quality woodfuel for the Biofuel plants, as well as some smaller emerging installations. The gasification systems in the larger plants is relatively new technology so it is very important to ensure the fuel quality is of the highest order which should help to maximize the efficiency of the plant. It must be remembered the woodfuel is not simply to be burnt, woodchips are to be converted into energy, so a clean dry uniform quality woodfuel will produce more energy than a dirty wet sample having varying sizes.

Once the material is available the efficiency of the chipper as well as the type of raw material being chipped, will have a bearing on the specification of the woodfuel. Generally if the raw material is chipped soon after felling the chips specification will be relatively uniform on the condition the chipper is set up properly. The one disadvantage is that the moisture content will be quite high. This can be rectified by drying the woodfuel prior to sending to the Power Station.

The Power companies will always want the woodfuel as dry as possible and the woodfuel suppliers want to supply the woodfuel at around 52% moisture content which is an average for recently felled brash. There is a figure of 35% to 45%, which seems to be a happy medium on both sides. This means there needs to be approximately a 33% reduction of moisture content after felling prior to entering the plant.

There are two ways of addressing this and they are, allowing the ambient air to dry out the brash naturally or by forcing air through a bed of chips to dry down to the agreed moisture content. This Trial uses the forced air method.

The trial included drying approximately 500 tonnes of forest residues and reducing the moisture content down to 35%. We sourced the raw material from a woodlands in Northumberland which we held on stock as well as a large estate engaged in a project to extend a grouse moor which had a large area of sitka spruce trees to fell and remove. The average age of the trees was about 17 years old the majority of which had no canopying effect so had a high percentage of green needles and healthy branches down to soil level. A tonnage was also set aside for smaller producers to introduce woodchips into the drying system.

The trees were hand felled and brought to the roadside with a forwarder, where they were stacked as roundwood is, up to a height of 3 to 4 meters. When chipping within the constraints of a forest there may be a need, as there was in this case, to build a landing area for both the storage of chips as well as to allow the wagons to manoeuvre more easily. When the stockpile was large enough a wagon was brought in to transport the chips to the drier, this initially caused a few problems before the loading shovel operator and the wagon drivers worked out the best loading methods.

The chips were tipped onto a concrete apron in front of the drying building, which is useful, as it helps to keep the chips clean, away from muck, soil and dirt. With the use of a loading shovel the chips were loaded onto the drier to a depth of 18 inches. Ambient air was then forced through the chips with the use of a Lister fan until the average moisture content was reduced to around 35%. The chips were then removed from the floor and stockpiled undercover.

The method used to dry the woodchips is a very simple method which could be used on many farms as most of the equipment farmers already have. One can visually see the woodchips changing colour as the air is removing the moisture from the bottom of the layer and taking it further up the pile. This drying method would be ideally suited for farmers who grow coppice and want to add value onto the product by reducing the moisture content. On handling larger volumes there is the logistical problem which is having enough space to handle the delivered woodfuel, drying, storage and subsequent loading, which also increases the cost dramatically. If the woodfuel is destined for a small heating unit it is imperative to have a high quality, uniform sample as the combustion systems are very susceptible to fuel variation. This forced air on floor drying system can guarantee the moisture content falls to within a 5% variation, which is acceptable. The smaller units are capable of paying a small premium for drier fuel in comparison to the larger Power Stations.

Conclusions

It must be borne in mind that woodfuel whatever its destination, is a low value product and generally the more you handle it the more expensive it becomes. There must be two categories assumed firstly the NFFO Power Station producing renewable electricity at a very competitive rate. The fuel for this system must be managed and dried within the wood or at the roadside, utilizing the natural air to reduce the moisture content. The raw material needs to be chipped and sent straight to the plant as transferring to a drier and the number of times it would need to be handled, would add on too many costs hence it becoming unprofitable. Secondly the smaller units supplying heat for a school or a large Country House, need to have a very uniform fuel not only for the combustion, but also for the handling systems which are also susceptible to blockages and bridging if the fuel quality deteriorates. Low cost on floor drying systems will ensure the higher standards of fuel quality, which if lacking, will cause major problems with smaller units.

In conclusion

- Keep the number of times the fuel is handled down to a minimum
- Establish specification and moisture content requirements before committing to supply
- Keep moisture content as low as possible priced to drying
- Check you have sufficient inside storage for dry chips
- Keep your transport distances down to a minimum especially after drying.

Recommendations

To concentrate R & D on natural drying, as it will prove to be the norm in the years to come. Keep the method simple, remove brash stockpile and cover - chip when required.

Research is needed into a comparison of:

Method 1) Remove green brash stock pile and cover, leave for 6 months

Method 2) Leave brash on clear felled areas for 2 months, remove, stockpile and Cover.

The moisture content reduction comparison between the two methods will help to guide the industry into utilising the brash for energy production.

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1 Introduction

Information Available

Over the last ten years there has been a huge amount of research into the general comminution of forest residues. We now are able to put the theory into practice as the woodfuel in this project will be used in a gasification system to produce electricity, it is becoming very apparent that the quality of the woodfuel or the way it is handled, is of paramount importance.

There is a misconception within the forestry and renewable industry, that any type of woodchip can be used on a combustion system. If the woodchips are soiled wet and out of specification the converted electricity will be a lot less than clean dry and uniform woodchips. The actual woodfuel needed for these plants is high quality woodfuel, it goes back to what you put in you get out. If the woodfuel is dirty as an example if it has been run over by forestry machines and it is covered in soil then the combustion system produces a higher percentage of ash which reduces the efficiencies. If the woodfuel is wet then the amount of energy needed to dry the woodfuel out prior to the combustion reduces the efficiencies.

The management starts inside the wood in the clear felled areas for high quality woodfuel. Prior to the very slow emergence of the woodfuel industry the forest industry regarded the side branches and tops of the trees as a waste product which generally was used by the forwarders to stay on top of the ground. There is a certain amount of the brash still needed for forwarders to operate, there also is a huge amount of this material wasted in these mats which could be used for woodfuel. This process needs to be addressed in an agreed method of operation prior to any harvesting taking place. The brash must be regarded as a product as is the round wood, and handled accordingly, so the maximum amount of brash can be recovered from each site and converted into woodfuel. This not only fills the criteria of utilizing renewable energy but also gives the forestry industry another useful product.

Issues to Address

Once the forestry industry realizes there is a market for the brash and releases this product into the emerging renewable industry then the most efficient handling methods will emerge, taking into consideration all sites are different. As an example if the brash is left on the clearfelled area for one month to six weeks the moisture content is can reduce down to 35% which is the cheapest way to dry woodfuel. As another example if the forest machines do not run over the brash then the woodfuel will not get contaminated. This will improve the quality of woodfuel which relates back to a simple management plan. These integrated systems will not mature to full efficiency until the woodfuel industry gets into top gear and the renewable industry is demanding large volumes of this material on a regular basis.

The Main Aims and Objectives.

To portray to the renewable industry the importance of consistent production of a uniform high quality woodfuel. To test methods which ensure a high quality woodfuel is achievable with the minimum amount of energy and cost. The minimum handling of large volumes of woodfuel as a bulk product both in the forest and the agricultural environment. The practical benefits of the drying method with the end user always in mind, taking into consideration the woodfuel being a low value product with small margins and what part handling and drying system have to play adding value onto the product.

2 Experimental Works

The raw material used during this trial included prematurely felled Sitka Spruce trees approximately twenty years old and brash from a traditionally mechanically harvested site. The raw material was brought to the roadside by a forwarder and left in rows butts facing into the road, and stacked up three to four meters high. This raw material was then chipped stored in a lay-by then loaded onto articulated tippers and transported to the drier. The trial included 20 similar batches through the drier which totaled approximately 500 tonnes. The lister MK111 fan is used as it is available, and the approx.cost of the dryer was £15,000.

Reduction and Transportation

- 1) Chipper: Fully mounted Eryo 7/65 drum chipper on 1210 Timberjack forwarder self loading and unloading.
- 2) Loading Shovel: Massey Ferguson four wheel drive with extending boom and a two cubic meter bucket.
- 3) Wagon: Articulated tri-axle trailer capacity up to sixty-five cubic meters.

Drying and Storage

Building Description

- 1) Building No 1: 80' x 60' agricultural building including drier.
 - 80ft by 60ft general purpose open span, 18ft to the eaves.
 - Corrugated Asbestos roof
 - 12ft breeze block walling with concrete floor
 - Yorkshire boarding to the North and South side
 - Corrugated west side
 - 12ft entrance on both north and south side
 - 2) Building No 2: 80' x 60' agricultural building 12' feeding passage down center.
 - 80ft by 60ft cattle building
 - Corrugated Asbestos roof
 - 12ft breezeblock walling with concrete floor.
 - Yorkshire boarding round all sides.
 - 12ft raised feed passage running full length of building
 - 12ft entrance to each courting.
 - 3) Drier inside building No 1
- Layout of the storage and drying system is shown in **Fig 1**.

The drier which covers an area of 1600 square feet is positioned in the south west quarter of the building,

Main Air Duct

A wooden main air duct 6ft by 3ft by 20ft is made up of four, five ft. sections clamped end to end by bolts. The rectangular sections are chipboard sheeting held together by 3" by 2" timbers. The side of the air duct exposed to the wet woodchips is sheeted with 25mm marine grade plywood.

Estimated Air Flow Rates

Estimated Air Flow Rate @ 1800 RPM		
Depth of Chips	Air Flow m ³ /s	Pressure N/m ²
0.5 m	15.5	200
1.0 m	15.2	290
1.5 m	14.8	380

Floor Decking

The floor is made up of 25mm marine grade plywood supported by 9" by 3" joists placed at right angles to the existing main duct and spaced so to give 6 to 8" between each joist. The marine ply even when drilled with holes for the passage of air, was sufficiently thick to support a tractor with a front-end loader. To prevent the chips from falling through the air holes a membrane was attached to the underside of the floor. A ramp was attached to the front of the marine ply so to allow the tractor to travel on and off the floor. There are 168 25mm vertical 10mm holes per square meter which equates to approximately 10% of the floor.

Lister Moisture Extractor MK III

The moisture extraction unit comprises of an axial fan driven by a diesel engine and arranged such that the heat of the engine can be picked up by the airflow. The fuel consumption worked out to a gallon of gas oil per hour of drying. The exhaust gases from the diesel engine are channeled from the manifold into the air duct to maximize the efficiency of the engine.

The object was to create a fully active floor ensuring the passage of air was directed equally through the batch of woodchips. This was achieved when the ambient air was circulated the moisture was removed from the woodchips closest to the floor, eventually working its way up the depth of woodchips. If a larger fan had been installed the design of the Air Passage would need to be altered as substantial strengthening operations have been carried out to handle the Mk III.

Moisture Content Testing

There were regular samples taken to test the moisture content of the woodchips in each batch. It became apparent the ambient air was removing the moisture from the woodchips nearest to the floor first. This drying process then worked its way up through the depth of woodchips. A number of samples were taken from varying depths and when the average was 35% this batch was removed from the drying floor.

Introduction of Third Party Woodfuel

Once the method of handling drying and transporting has been established the introduction of smaller producers without the facilities to store and dry woodchips, to deliver woodchips to the drier. Initially there was no reason why introducing woodchips could not be of benefit, but on inspection of the woodchips sample, there was a difference in the particle size to our own woodfuel, we felt this would have an adverse effect on the overall quality so no more samples were accepted.

3 Results and Discussions

General

We are entering a change in the bioenergy fuel markets as more demand for renewable energy slowly moves the market towards woodfuel. It must be borne in mind that our competitors are the oil and gas companies who are some of the largest most efficient companies in the world we must ensure we achieve standards to the highest level. We must set out to achieve this from the beginning, as the highly complex technical power stations being built to compete with the oil and gas need very high quality wood fuel to allow the conversion factors to be competitive. It is a complete fallacy to regard brushings as an unimportant waste product and if somebody has a wagon load of woodchips every now and again the attitude tends to be if its wood it should burn just send it down. This attitude must stop and the brush must be regarded as a product which has to be managed in the same way as any other forestry product with care and attention. There are limits as to how much brush there is available on a site, there may be none on certain sites due to ground conditions, even if there are materials available the site may be too far away to the power station to make it viable. There are however certain sites which will be suitable for the removal of brush and if managed in the correct manner, will provide another source of income for the industry.

On a site where the brush is to be removed for chipping, it is important the material is handled with chipping at the forefront of the harvesting operators mind. In traditional harvesting operations once the chipwood has been removed, the harvester normally cuts the top of the tree into two pieces and then places it in the brush mat to be run over ensuring the loaded forwarders can travel. It is at this time when the harvesting method has to change assuming the ground conditions allow, the harvester must place a percentage of the uncut tops to the side of the mat thus allowing the tops to be clean from soil when the forwarder collects and leads to the roadside. The tops can be stacked as roundwood is, and left to dry or chipped and removed depending on which method is being adopted. There are sometimes limitations on the available roadside space, as some of the sites need to remove the roundwood immediately, to free areas for more roundwood. As the tops can take up quite a large area of the roadside this can compound the problem. The alternative is to build your brush stack in the wood rather than at the roadside, as the chipper has the option of travelling into the wood as they are normally mounted on a forwarder for this reason. One alternative is to leave the tops on the clearfelled area to dry out before forwarding to the roadside, this is the most cost effective, as the ambient air can naturally dry the tops to around 35% moisture content. If this were possible the material would be chipped and the woodfuel would be taken straight to the power station rather than to a drier.

On the condition the roundwood operation has left the harvesting site there should be sufficient room to chip the raw material and load the wagons to remove the chips from site. It would be difficult as far as space is available if the two operations were happening in tandem mainly due to the traffic problems occurring due to volume of wagons. The planning of these sites prior to harvesting is important as you can easily block one product in, if the method is not adhered to. Once the raw material has been chipped and stored on site, large transport wagons are needed to move the chips. These wagons have to travel on forest roads which is not normally what the drivers are used to. It certainly pays if there is any doubt as to the width or loadbearing of the roads, to be advised by the transport company or possibly to have a site meeting to establish the best areas to store the woodfuel. Generally the large arctic grain tippers can now carry over 20 tones, which converts to approximately 65 cubic meters. The trailers have a similar turning circle as the timber trailers, so they are suited for movement over forest roads. It is important the drivers of the wagons, are used with this type of operation and have had experience in travelling on forest roads. Tautliners are even larger than the general tippers there volume increases to 80cubic meters therefore the road conditions need to be better than average to accommodate them, although they all have triaxle trailers which spreads the weight evenly they do need a larger turning area as the trailers are longer. The loading shovels need to have a telescopic arm so they are able to reach the trailers. Most of the shovels are four wheel steer as well as four wheel drive which is essential as the areas given to work in are normally very tight as any assistance with regard to mobility will be helpful. The size of the bucket determines how long it takes to load the wagons, and the number of trips you have to travel from the stockpile to the wagon. Time is money so the quicker the wagon is loaded the better. The bucket size should not be any less than two cubic meters larger if possible, depending on the base unit

The loads entering the drying area are off loaded in the tipping area and sampled then transferred onto the drying floor. **(Fig.2 Photograph of Drying Floor Page 10)** Prior to accepting all the loads it is important there is some form of plan, as well as sufficient room for the wet woodchips and the dry woodchips to be stored in a way they do not mix. They then can be loaded either onto the drier as in the case of the wet woodchips, or onto transport wagons in the case of the dry woodchips. As the drying process will be ongoing throughout the winter months unless there is transport onhand to remove the dry woodchips as they come off the dryer, a covered area will be necessary for storage. The area will have to hold approximately one hundred cubic meters of woodchips which is approximately the size of a large wagon as well as an average batch size. **(Fig.1 Dimensions of Drying Area Page 10)**

The fan is engaged and the ambient air is forced down the air passage under the floor and then pushed through the bed of woodchips. The fan works from 10 hours per day up to 24 hours per day depending on noise and wind levels as local residents cannot be ignored. The depth of the woodchips at approximately 18 inches the woodchips reduced on average one percent per day. The disadvantage of this method is it is quite time consuming and ties up a building for long periods. This bed depth worked well as it equated to one wagon load. which made the logistical aspect easier as, in theory, when one wet load came in one dry load could go out. A decision was taken not to mix the woodchips once on the drier, as this would have taken too long as well as adding more cost to each batch. **(Fig.3 Drying process of wood fuel)** The method is very simple as the dryer is installed in a agricultural building and employs the same principle as old corn dryers to force air through the depth of woodchips. It can therefore be used as a diversification potential for farmers as all the main components are available on most modern farms. As the floor is marine ply, care and attention must be adhered to when off loading the chips to stock. The wheels of the loading shovel must be level at all times so to keep the bucket of the loading shovel level as there is a danger that the corner of the bucket digs into the floor causing damage. It takes approximately twenty minutes to load and twenty minutes to unload the drier, the woodchips then are stockpiled undercover ready to be loaded for the Power Station. The actual cost of drying **(Table 1 Batch Drying Costs)** is £3.96 per wet tonne which is a large percentage of the value of a tonne of woodfuel, as this excludes extra handling and transport costs. If all the woodfuel has to be transported to a drier, dried reloaded and transported to the Power Station the extra costs involved in this operation amounts to £9 per tonne. **(Table 2 Comparison of Force Air Drying/Natural Drying).**

Moisture content of each load varies. **(Table 3 Average Moisture Content).**

The screen properties also vary **(Table 4 Approx.Particle Size)** together with the assortment of wood **(Table 5 Fuel Type).**

4. Conclusions

- As woodfuel is a low value product handle the product as few times as possible to keep costs down.
- To warrant forced air drying a premium price must be achieved and is likely to be channeled to the heating systems rather than for electricity production.
- Transport charges are a large percentage of total costs, so working within a maximum radius of end user is paramount to a viable operation.
- Top quality uniform clean woodfuel must be produced at all times to ensure a competitive non fossil fuel is produced.
- It is possible to reduce the moisture content from 52% down to 35%
- It takes approx.237,600 cub.m.of air to dry 1 tonne of woodchip from 51 - 35%.

5. Recommendations

- To establish best working practice to enhance the natural drying of brash at stump
- Consider drying of woodchips at Power Station.
- Developing methods to channel woodfuel to go direct from the roadside to end-user without the need to use artificial drying.
- Keep transport costs to a minimum by sourcing raw material close to drier. .
- Try using exhaust air gases to maximise efficiency of drier.

6. Acknowledgements

The work carried out in this report and subsequent information within this report would not have been possible without the support of the DTI.

Fig.1
Dimensions of Drying Area

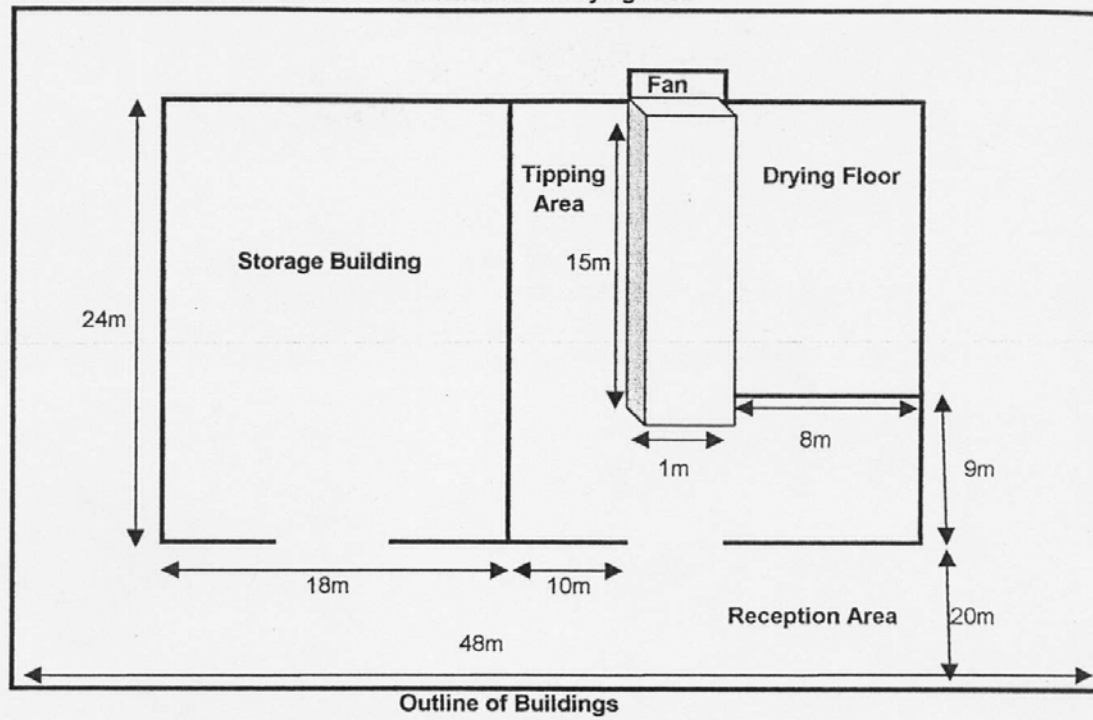


Fig.2
Photograph of Drying Floor

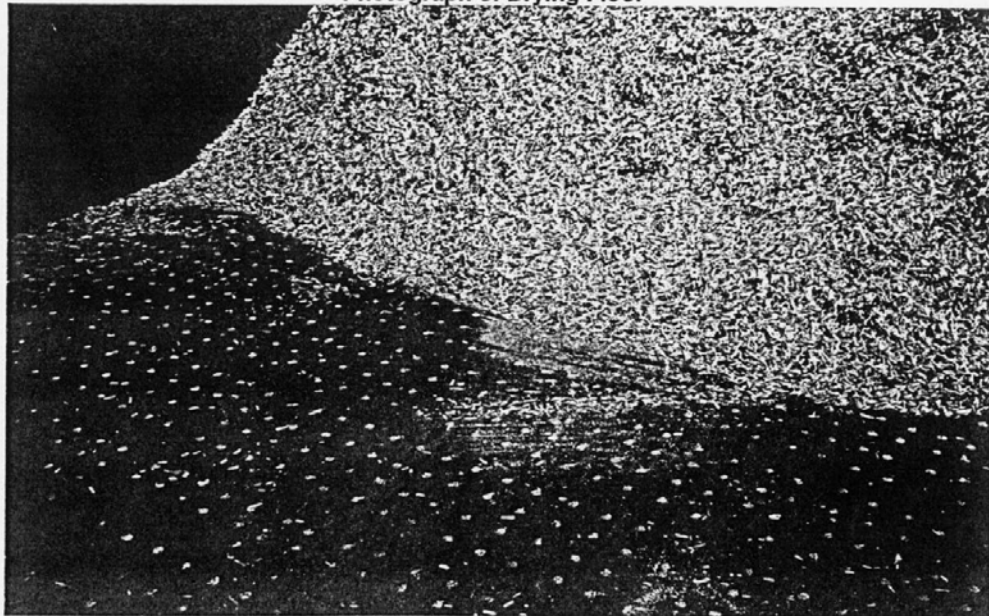
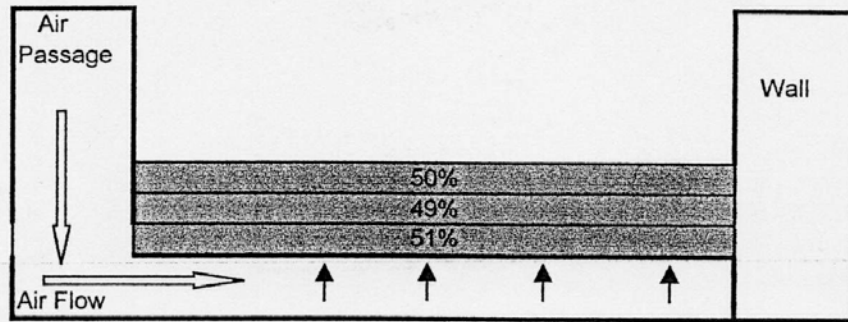
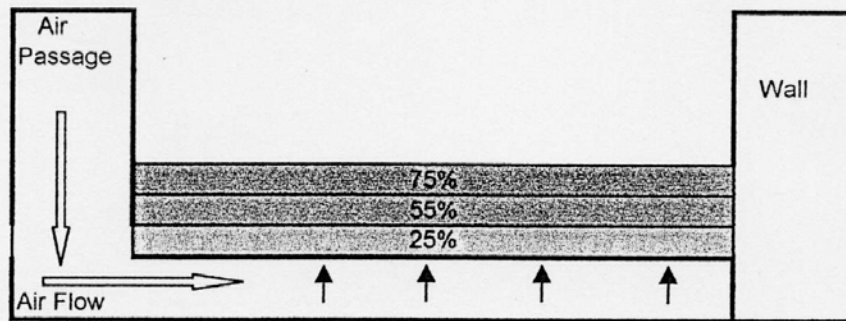


Fig.3

A Moisture content of woodfuel at beginning of drying process



B Woodfuel Half Dried



C Woodfuel Dried

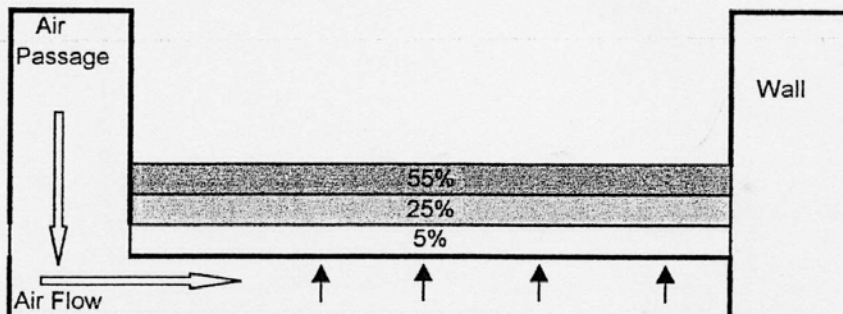


Table 1
Batch drying costs

Cost of Drying/Batch	
Average Weight per Batch	25 Tonnes
Average Moisture Content	51%
Hours to reduce to 35%	110 hrs
Cost of Diesel 1 gall/hr.@.90p/gall	£99
Cub.m of Air/ton	237,600

Table 2
Comparison of Force Air Drying/Natural Drying

Estimated costs of transport of wet woodchips to Drier, Drying and Transport to Power Station		Estimated costs of Natural Drying of wet woodchips, drying and Transport to Power Station	
	£		£
Transport to Drier	5		
Drying	4		
Transport to Power Station	8	Transport to P.Station	10
Handling	4	Handling	2
Total	21	Total	12

Table 3
Average Moisture Content

Random Analysis		
48.7	51.7	50.8
53.1	49.0	51.9
51.8	54.1	52.5
51.4	51.3	53.6
52.3	49.7	53.9
Average Moisture Content		51.72%

Table 4
Approx. Particle Size

Screen Proportions (approx.)	
Size (mm):	
116-180	
51-115	6.67
36-50	3.71
16-35	45.56
4-15	31.40
<3	12.67

Table 5
Fuel Type

Assortment	
Bark	8.67
Fines	0.65
Needles	30.22
Branches	15.78
Wood	44.69

