Northwoods/RDI Associates Ltd

Feasibility Study for a Woodfuel Supply Business in South Northumberland

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Compiled by:
Will Richardson
Ben Tansey
John Farquhar

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Executive Summary

This report sets out our recommendations for the creation of a woodfuel supply business, producing woodchip and firewood within the South Northumberland Area, based at the Kirkley Hall campus.

This report forms the basis of a business plan for the proposed business containing the necessary market and financial information.

Northumberland College has approximately 16ha of woodland cover around the Kirkley Hall site, which ranges from commercial plantation through to recent amenity plantings. Harvest and yields from this woodland are hard to estimate or predict due to its fragmented nature and non-commercial structure, therefore for the purposes of this study we have included a small amount of timber from these woodland holdings, and assumed the great majority of raw material will be outsourced. That way this business case could be considered worst-case, with any additional material sourced from internal woodlands a bonus.

We could expect the market for this business to peak at about **3,500 seasoned tonnes** in year 5 based on the optimum model.

The creation of a good quality supply depot, utilising existing farm buildings and tractors, would require the following investment:

Item	Unit	£/unit	Total
Modifications to existing buildings	1	£15,000	£15,000
Timber trailer and crane	1	£14,000	£14,000
5m3 loading shovel	1	£1,000	£1,000
Vertical log splitter	1	£3,000	£3,000
Medium capacity firewood processor	1	£12,000	£12,000
Vented 1m3 firewood bags	250	£8.50	£2,125
Total			**£47,125**

Capital investment could be softened (subject to availability) with an RDPE grant which could be worth up to 40% of the total cost.

Growth of any proposed supply business should be planned to keep within extreme cash-flow variations, as rapid growth would need to be matched by significantly higher investments than are probably available to this market.

The business is capable of producing the woodchip fuel at a worst case scenario of **2.99p/kWh** and firewood at **£32/m3.** Achievable sales prices are around **3.4 to 3.6p/kWh** for woodchip and **£75 to £80/m3** for firewood.

Under the optimum model, the business could be reaching **positive net cash flow in year 2**, with **positive cumulative balances by year 3** and a net cash flow of **£30,000** by year 3 and **£92,000** by year 5.

Next Steps

- Carry out a detailed site survey in line with the planned re-development of the college buildings to find a suitable site, preferably with existing buildings and equipment
- Cost up actual capital costs based on the actual located site
- Approach possible large woodland owner / managers, with a view to buying seasoned timber from them

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1. Introduction

This report has been prepared by Northwoods and RDI Associates in response to a request made by the Northumberland College to provide consultancy services to assess the feasibility of a woodfuel supply business in South Northumberland operating from the Kirkley Hall campus.

The report provides information on the following;

- An assessment of the likely availability of raw material in the form of roundwood and tree surgery off-cuts from Kirkley Hall campus and associated businesses
- An assessment of the immediate local market for woodchip and firewood
- An assessment of the future local market for woodfuel based on Renewable Heat Incentive (RHI) induced market acceleration
- Financial appraisal of a proposed woodfuel supply business
- Process for setting up the supply of woodfuel at the required specification for the market

2. Innovative Idea

Northumberland College has been involved with a European bio-energy project, enerCOAST (http://enercoast.net/), which, as part of its objectives, looks at supply chain models in each of the target regions. This report aims to consider a very local supply hub for fuel quality woodchips and firewood based around the Kirkley Hall campus as an example which would be typical for this region.

3. Supply Chain Gap

The most crucial aspect of any business is the market. It is important at the outset to design the business, products and services around the actual and expected market place. In the case of woodfuel supply this is a relatively new sector to the UK, so it is even more important to assess the market to ensure the products suit the current and expected end users needs.

For this business we see the most suitable market being the small-medium scale (50kW – 1,000kW) heat market therefore we have concentrated on this in this report

3.1 Regional Market Potential - Current and known wood chip market

Data on current woodfuel installations and markets is a little sketchy, the Renewable Energy Association (REA) in combination with the Forestry Commission have produced data on installations for the last 2 years. However, the data collection methodology would appear to have flaws, as to our knowledge the REA data is inaccurate by about 100% in the NE. We have good data on biomass installations in the NE, which comes from our own register of installations that we have been involved with or otherwise know of through our involvement with the sector. There may well be installations in the large domestic sector which we are unaware of, however these are likely to be on a small scale (less than 50kW) and therefore will not have a great affect on the overall scale of the market. We have estimates of the heat use based on information from the installers, historical heat use figures and estimates based on building use. As such they may be subject to errors compared to the actual use now the boilers are running.

At present the number of woodchip fuelled installations in the North East is not large. Our internal database shows 29 boilers with a total installed capacity of 6,992kW. From a fuel supply point of view expected fuel use is the crucial figure, and these boilers have an estimated annual fuel demand of 18,505 MWh. This equates to about 6,819 tonnes of 35%mc woodchip per annum in the whole of the NE (assuming 85% efficiency in the boilers). However of these 29 woodchip boilers, 14 are self supplied from the owner of the boilers woodlands and operations, using an estimated 3,228 tonnes of 35%mc chip, therefore the quantity which is left on the commercially bought market is 3,591 tonnes at 35%mc.

However, the above market summary applies to the whole of the North East, realistically a depot based in Kirkley Hall would be unlikely to be able to economically supply the whole of the NE. Therefore we have set an operational radius of 30 miles, in reality the economic and sustainable operational limit will depend on the specific delivery quantity.

When we look at the current market for commercial woodchip it is concentrated around the Newcastle – Sunderland conurbations. Therefore if we apply a 30 mile operational radius to the existing installations, only 3 are excluded, and these only use an estimated 400,000 kWh (147 tonnes @35%mc) between them.

In addition to the currently installed boilers we will look at installations which are being built or planned (with planning permission) for the next year or so, and therefore likely to affect the immediate market for woodchip. Our internal database shows 8 installations which are either being built or have planning permission and the finances to go ahead, these have an estimated 1,583 tonnes a year fuel use. This gives a combined market of existing and near future installations of 5,062 tonnes a year (@35%mc).

Market	Number of boilers	Installed capacity (kW)	Estimated heat production (kWh)	Equivalent tonnes @35%mc	Percentage of market
EXISTING SYSTEMS					
Total Existing	29	6,992	18,505,000	6,819	100%
Self supply	14	2,835	8,760,000	3,228	47%
Commercial supply (all)	15	4,157	9,745,000	3,591	53%
Commercial (within 30miles of Kirkley)	12	3,937	9,345,000	3,443	
KNOWN FUTURE SYSTEMS					
Commercial (within 30 miles of Kirkley)	8	1,940	4,296,000	1,583	
COMBINED MARKET					
Combined Existing and Future commercial (within 30 miles of Kirkley)	**20**	**5,877**	**13,641,000**	**5,062**	

Table 1: Summary of current woodchip market

3.2 Future Woodchip Market with an ineffective Renewable Heat Incentive

The existing biomass installations have come about without any financial incentive on heat produced. However a large proportion have had a capital grant of some kind for the boiler equipment, such as the Bio Energy Capital Grant Scheme, Low Carbon Building Programme, Sustainable Development Fund etc. Or they have come about as a result of stringent targets (such as Local Authority installations in schools).

However we now have the Renewable Heat Incentive which the renewable energy sector sees as a very good incentive, and does expect a serious uptake of renewable heat systems. However it would be prudent for a business to look at the market should the RHI turn out to be ineffective in stimulating the market, then risk analysis can be carried out.

In order to estimate the future market we will work out the rate of installations over the last 7 years and then extrapolate this to give us projections as to future growth.

Of the installations in the north east that are already installed, the majority have been installed over the last 7 years, as follows in Figure 1;

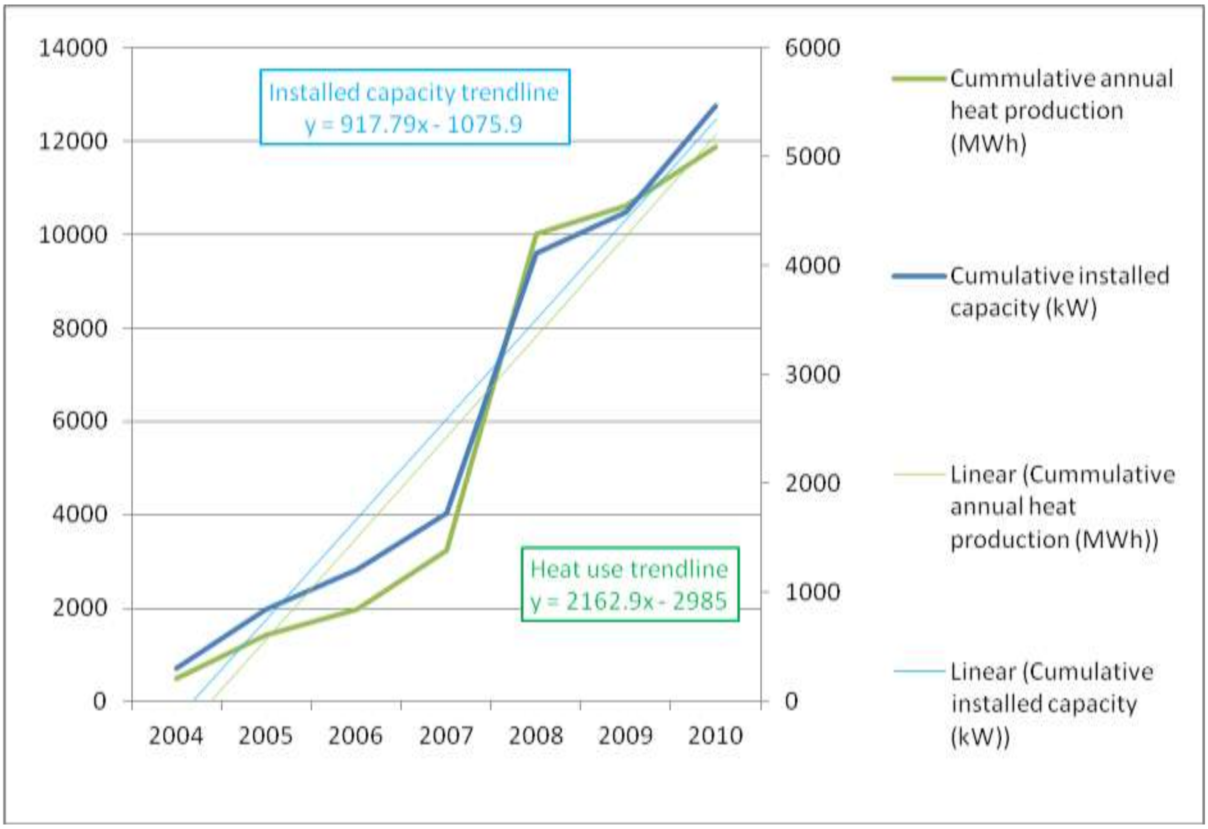

Figure 1: North East cumulative installed capacity and heat-use over the last 7 years

From the above graph we have produced a simple trendline which shows the average rate of installation of wood chip boilers as 917.79 kW a year. We have rounded this down to 900 kW installed a year to reflect the fact that the target market area does not cover the whole of the NE. This is the figure we will use for assumed new installations per year.

More importantly, as far as a fuel supply business is concerned, we have also produced a simple trendline showing an average rate of increase in heat-use of 2,162,900kWh a year. Again this has been rounded down to 2,000,000kWh to reflect that it does not cover the whole of the NE.

Of this 2,000,000kWh only a proportion would be supplied on the commercial market, the rest would be from self-supply. From Table 2 we see that at present 53% of the woodfuel is bought on the commercial market. However we feel that the self-supply market will not grow at the same rate as the commercial market, due to the fact that the self-supply installations are amongst the most economically viable and therefore a large number have already been done, and we would expect the proportion of self-supplied fuel to decrease gradually over time. As a very subjective estimate we would assign the following market shares to the sector.

	2011	2012	2013	2014	2015	2016
Self supply	47%	42%	40%	38%	33%	30%
Commercial	53%	58%	60%	62%	67%	70%

Table 2: Summary of projected market share to 2016 with an ineffective RHI

From these assumptions we can produce a forecast of the likely market in the target area should the RHI turn out to be ineffective in stimulating the market. As such this forecast can be assumed to be a *worst-case* scenario.

	2011 (known)	2012 (known)	2013 (estimated)	2014 (estimated)	2015 (estimated)	2016 (estimated)
kWh	9,345,000	13,641,000	14,841,000	16,081,000	17,421,000	18,821,000
Tonnes at 35%mc	3,443	5,062	5,468	5,925	6,419	6,935

Table 3: Summary of projected wood chip market to 2016 with an ineffective RHI

3.3 Future wood chip market

The wood chip market in the UK is expected to increase over the next 10 years, due in the main to the fact that the UK has committed to a target of 15% of its energy from renewables by 2020. In order to achieve this target the government has already put in place financial incentives for renewable electricity, in the form of the Renewable Obligation (RO) and Feed-in-Tariff (FIT), and also for renewable transport fuel with the Renewable Transport Fuel Obligation (RTFO). However, the government has recognised that it cannot achieve its 15% overall goal without including renewable heat.

To address this, the government has introduced the Renewable Heat Incentive (RHI), a financial incentive which pays renewable heat users for the heat they produce. The amount paid is dependent on the scale and type of woodfuel system, however the scheme is designed to give an average Return On Investment (ROI) of 12% per annum. This level of return would no doubt generate a drastic increase in the uptake of woodfuel heating systems throughout the UK over the next couple of years.

In order to form a business plan we need to quantify any expected increase for the next 5 years, to 2016, and in order to do this we have taken as our baseline for predicting the expansion the target for renewable energy which the UK has committed to through the European Union.

The target for UK primary energy generation from renewable sources by 2020 is set at 15%[1]. This is a ten-fold increase in capacity and activity across the board. The increase between 2010 and 2015 is significantly less than this, though still a large factor of growth.

Heat makes up 49% of UK energy demand; renewable heating will make up 14% of this by 2020 (Figure 3).

[1] UK renewable energy strategy consultation, BERR, June 2008

2006 baseline (UK)

In order to determine the activity at 2015, we will use UK-wide figures of predicted capacity. We therefore have to calculate the current activity levels UK-wide. The most recently published data come from 2006, unfortunately the figures which are more recent than this do not have enough breakdown by the type of technology to be of use in estimations.

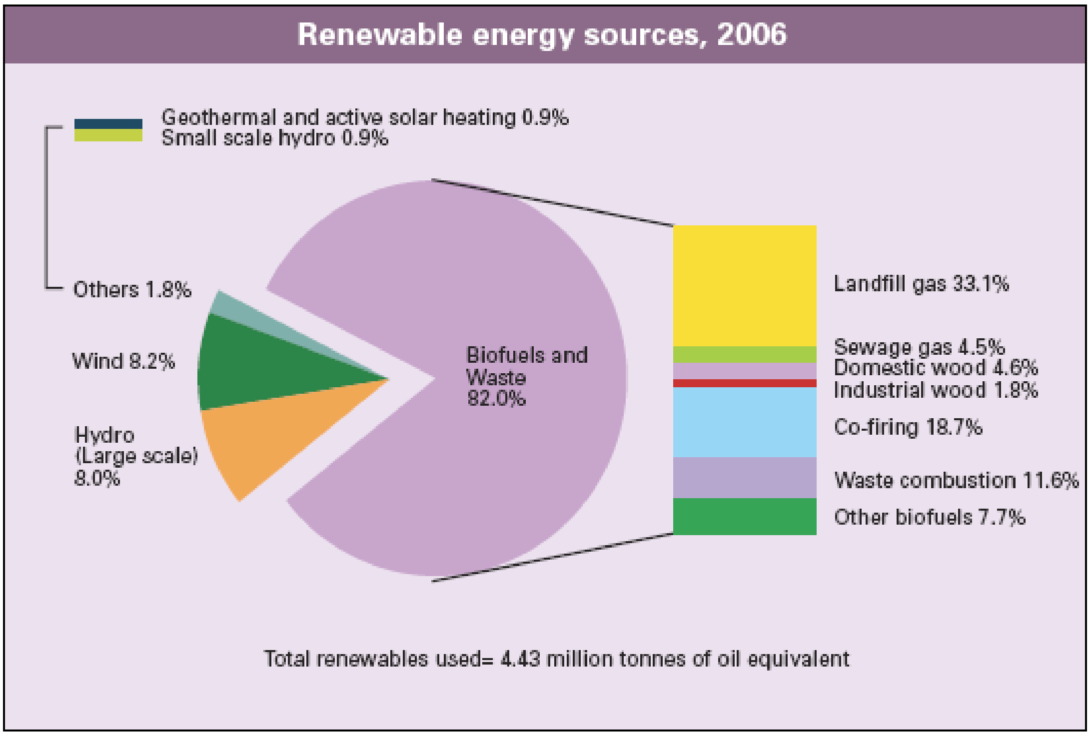

Figure 2: Renewable energy supply to the UK, 2006 (DBERR)

Of the 4.43Mtoe[2] supplied by renewable energy, 4.6% was supplied to domestic wood users, 1.8% to industrial wood users, and 18.7% generated in co-firing (the vast majority from woody biomass). We can therefore calculate the generation figures and Mtoe equivalents as follows:

Renewable source	Energy sector	Proportion of renewable supply generated (%)	Mtoe	Proportion of total energy supply (%)
Biomass	Heat	5.2	0.23	0.10
Biomass co-firing	Electricity	15.3	0.68	0.43

Table 4: Biomass contribution to energy supply, 2006

[2] Million tonnes oil equivalent

2020 prediction (UK)

The illustrative technology breakdown to reach 2020 targets of 15% total energy from renewables is outlined in Figure 3.

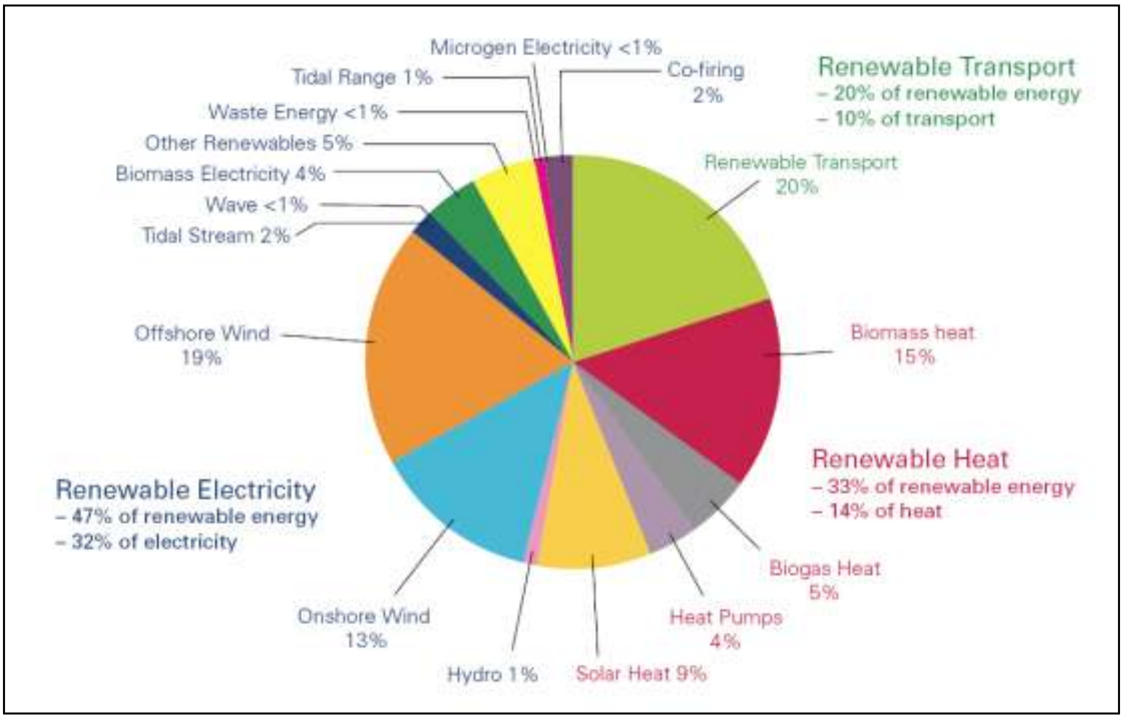

Figure 3: Illustrative breakdown of renewables by 2020 (source: DBERR)

This enables us to calculate the proposed energy output from biomass by 2020 and to compare it with current output. Note that we use the figures of 49% of total energy supplied as heat[1], with the remainder assumed split evenly between electricity and transport (25.5% each).

In TWh	Renewable energy in final energy consumption, 2006	Renewable energy in final energy consumption, 2020	All energy final energy consumption, 2006	All energy final energy consumption, 2020
Heat (excluding electricity for heat)	4	90	735	635
Electricity	19	120	393	375
Transport	2	55	653	730
All sectors	25	265	1781	1740

Table 5: Energy figures for the UK (DBERR)[3]

The latest DBERR assessment (see Table 5) suggests a marginal reduction in total energy use by 2020, from 157.8Mtoe in 2006 to 149.6Mtoe. This assumption is shared by the Renewables Advisory Board[4].

[3] Conversion of TWh to Mtoe is 11.63:1
[4] www.berr.gov.uk/files/file46652.pdf

Energy source	Energy type	Share of renewable heat market (%)		Share of renewable electricity market (%)		Share of total energy market (%)		Mtoe	
		2006	**2020**	**2006**	**2020**	**2006**	**2020**	**2006**	**2020**
Dedicated heat	Heat	88.0	45.5	n/a	n/a	0.1	3.1	0.3	4.7
Dedicated electricity	Electricity	n/a	n/a	0.0	8.5	0.0	0.7	0	1.0
Co-firing	Electricity	n/a	n/a	18.7	4.3	0.4	0.4	0.7	0.5
Totals		**88.0**	**45.5**	**18.7**	**12.8**	**0.5**	**4.2**	**1.11**	**6.2**

Table 6: Energy output from biomass[5]

This means that dedicated biomass heating will supply 45.5% of renewable heat, 6.4% of total heat, and 3.1% of total energy by 2020.

Several interesting points immediately fall out of this analysis:

- BERR figures suggest that the amount of electricity generated from co-firing will reduce from 2006 to 2020
- Heat from biomass (generally the most effective use of the raw material) will take three times more of the market than electricity by 2020 (which is the reverse of the current situation)

2008-2015 activity increase (UK and South Northumberland)

If we assume that there is a linear increase in activity between 2006 and 2020, and extrapolate figures for Mtoe activity at each point, and for each biomass sector. This provides an indication of the factor by which the sector has to increase to meet the 2020 target.

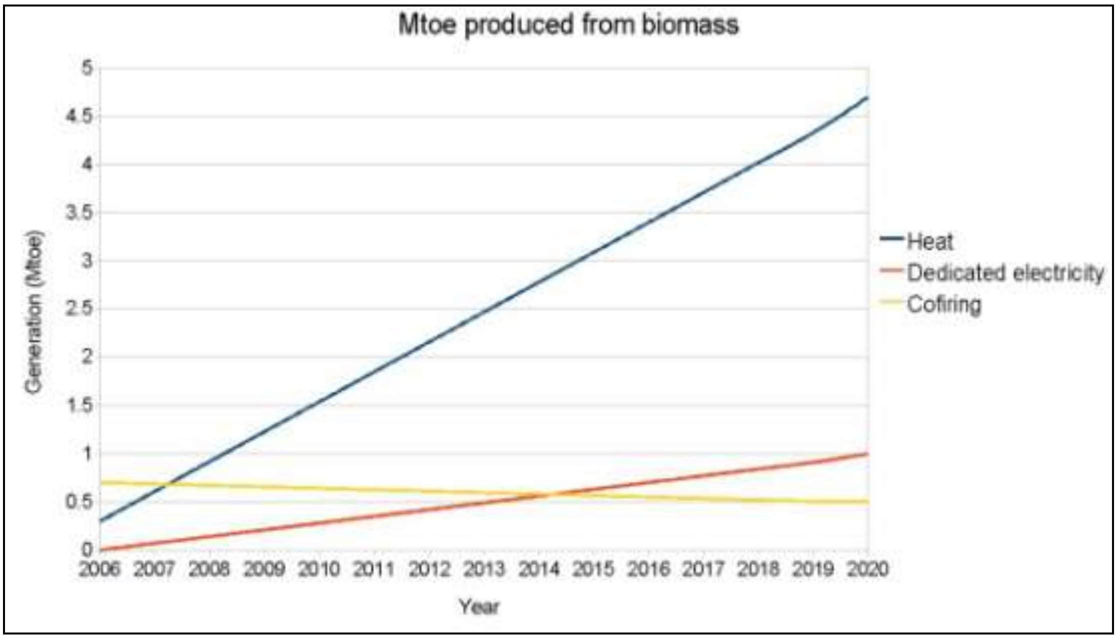

Figure 4: Predicted increase in UK biomass activity, 2006 to 2020

[5] Table summation errors are caused by rounding

So the increase in biomass activity can be calculated using figures extracted from the above graph:

Type of generation	Generation 2008 (Mtoe)	Generation 2015 (Mtoe)
Heat	0.92	3.09
Electricity	0.14	0.63
Co-firing	0.67	0.57
Total	1.73	4.29

Table 7: Predicted increase in activity per biomass sector, 2008 to 2015

The above figures are for the UK as a whole so we need to extrapolate these to Northumberland. We have decided to use the population base as the basis for extrapolation.

Northumberland has a population of 311,000[6], which is 0.50% of the UK population (61,792,000[7]). Therefore we will assume that Northumberland will use 0.50% of the predicted UK biomass heat, this equates to 0.0154Mtoe or 179,102,000kWh predicted biomass use for heating in 2015.

However not all of this would be wood chip, some of it would be pellet, log or straw fuelled in the smaller sites and sites which have storage or access issues. It is difficult to estimate the proportion of this biomass heat which is provided by each fuel type. There are national figures on biomass use for woody biomass; I.I million oven dry tonnes for woodchip and half a million oven dry tonnes for pellets[8] in 2008, but these figures include some biomass going into power generation (the majority of the UK use) and also waste wood derived woodchip.

We have very good data for biomass heating use in the NE of England which has 79 known installations. And of these approximately 39% of the biomass heating is from virgin wood chip, 10% from reclaimed wood chip, 46% from pellets and 5% from other biomass fuel types such as logs and straw. The use of reclaimed wood chip is mainly in the manufacturing industry which generates large volumes of waste timber, however as this is considered good practice for a sustainable waste disposal solution then we would expect this not to increase significantly in the future, as most manufacturers already have this technology installed.

In the absence of any better data we will use these proportions (modified to reflect the lack of expansion in the reclaimed woodchip market) for Northumberland giving an expected proportions of 43% of the biomass heating from virgin wood chip, 3% from reclaimed wood chip, 49% from pellets and 5% from other biomass fuel types such as logs and straw. This means that of the 179,102,000kWh of expected biomass use for heating in 2015, 77,013,860kWh would be provided from virgin wood chip, this equates to 28,314 tonnes at 35% mc in 85% efficient boilers.

3.4 Summary of the wood chip market

From the above information we see that we have a minimum market of 6,935 tonnes a year by 2015, which comprises the current use and the future potential use. However if any sort of financial incentive is introduced to help the UK meet its targets then we would expect a four-fold increase in Northumberland over the next five years. This is unlikely to be a linear increase as the industry does not have the present capacity to achieve this, but will need to increase the installer capacity which will probably take a couple of years.

	Current / very likely by 2016	In 2016 with RHI
Tonnes at 35%mc	6,935	28,314
kWh	18,865,000	77,014,000

Table 8: summary of current and expected wood chip market

[6] http://www.northumberland.gov.uk/idoc.ashx?docid=ee5d1b25-1aa7-4bf1-ab7b-24696d920f9e&version=-1
[7] http://www.statistics.gov.uk/cci/nugget.asp?ID=6
[8] http://www.forestry.gov.uk/pdf/Woodfuel2008.pdf/$FILE/Woodfuel2008.pdf

3.5 Market Share

In order to build a business plan it is important to estimate what market share the proposed business could take. In other parts of the country, which have a more established supply chain, it is commonly the case that a small number of suppliers dominate the market, examples being Southern Scotland is dominated by Buccleuch BioEnergy, the West Midlands dominated by one large supplier – Midlands Wood Fuel and the South West of England dominated by one supplier – Forest Fuels. The reason for market domination by a small number of suppliers is usually customer confidence, i.e. customers often prefer to use a supplier who is already supplying chips rather than taking a risk on a new supplier (even if there are possibly cost savings), therefore those suppliers increase their market share.

The most severe threat to this proposed business is the already established woodfuel businesses, No1 Woodfuels and Park End Estates, both of which have well established depots that can serve most of Northumberland. These companies not only already have the equipment and know-how to produce good quality woodfuel, they have the main advantage of a history of supplying which will give the customers confidence and experience shows that customers are less willing to risk an unproven supplier.

For the purpose of this study we have assumed the capacity by 2015 to be 1,000 tonnes a year or 10%, without major investment in a new / extended depot. In order to achieve this capacity the business would almost certainly need to buy in extra timber from sources outside the Estate.

Therefore if the business can gain 15% of the market it would supply the following quantities over the next 5 years without any RHI;

	2012	**2013**	**2014**	**2015**	**2016**
Tonnes (35%mc)	760	820	890	960	1040
kWh	2,067,200	2,230,400	2,420,800	2,611,200	2,828,800

Table 9: Summary of projected fuel demand over the next 5 years (assuming 15% market share) without RHI

If the business were to gain a 15% market share with a Renewable Heat Incentive rapidly escalating the market, the supplied quantities could be as follows;

	2012	**2013**	**2014**	**2015**	**2016**
Tonnes (35%mc)	3,050	3,300	3,600	3,900	4,250
kWh	8,296,000	8,976,000	9,792,000	10,608,000	11,560,000

Table 10: Summary of projected fuel demand over the next 5 years (assuming 15% market share) with RHI

3.6 Market requirements

3.6.1 Customer requirements for wood chip

For the purpose of this study we have assumed that the market we will look at is for space heating woodfuel. This market is a premium market with the highest returns per tonne. Customer requirements for woodfuel vary greatly depending on boiler equipment, fuel delivery system, fuel storage design and building use. However we would see the following as a common requirement list;

- Below 35% moisture content
- G50 or below equivalent particle size (according to the ONORM specifications)
- Sourced from virgin roundwood (some of the more industrial site may choose to go down the route of using reclaimed wood and the licensing that goes with it but this is not, in our opinion, the market most suited to this proposed business)

- Quality Assured via a recognised scheme such as the HETAS – *Quality Assured Fuel*
- Sustainably sourced, possibly assured through a third party programme such as the *UK Woodland Assurance Standard* (UKWAS) or *Central Point of Expertise on Timber Procurement* (CPET).
- Payment on heat at a heat-meter, not by the tonne or volume

3.7 Raw Material Assessment

Woodfuel can come from a variety of raw material, amongst which are;

- Virgin forestry timber
- Sawmill co-products
- Timber product manufacturers off-cuts
- Reclaimed wood (e.g. pallets and packaging)

For the purpose of this proposed business we are only looking at using forestry timber. Forestry timber is classed as the following;

- “Sawlogs” - the part of the tree which is large enough to make planks and posts out of
- “Pulp wood” or “chip wood” - only useful to chip, made up of the following;
    - “Small roundwood” - parts of the tree which are too small to plank
    - “Oversized” – logs which are too large for sawmills to handle
    - “Low quality” - timber which is too bendy, knotted or twisted for sawmills
    - “Un-marketable” - species which have no market in UK timber production

Sawlogs have a ready market and command a good price in the sawmills at £30 - £40 a tonne. Traditionally pulp wood was mostly used to make chipboard or paper, however almost all our paper manufacturers in the UK have converted to producing recycled paper, and only use a small amount of fresh timber pulp. In the last 3 years several biomass power stations have been built in the UK which take large amounts of pulp wood. The price for pulp wood varies across the country, however on average it is about £26 a tonne.

For woodfuel supply it makes sense to use pulp wood as the raw material as it has a far lower value, and sawlogs will fetch a higher value for timber production. Therefore for this business this is the raw material we will focus on.

3.7.1 Woodland Management at Kirkley Hall

The Estate has approximately 16 ha of woodland. It is divided into broadleaf and coniferous compartments. The estimated planting years are between 1958 and 1962 which gives a fairly narrow age class distribution. About 2/3 or 10.5 ha are broadleaf and 1/3 or 5.5 ha are coniferous. The dominant broadleaf species is sycamore and the dominant coniferous species is Norway Spruce.

The estates woodlands are managed primarily as a training ground for foresters and arborists undertaking courses at the college. The woodlands are not managed as commercial entities and are fragmented in nature. There is no exact information on expected timber production on the estate. However we can make rough estimates of sustainable production based on basic woodland management models.

The maximum sustainable yield of a woodland is equal to the amount of volume the trees grow in one year. However young woodland doesn’t grow as quickly as an older woodland, so the sustainable yield is taken as an average over the expected harvesting cycle of the woodland (about 40-60 years for most softwoods). Based on the average planting year and species we can estimate the average yield class (the amount of timber the woodlands grow each year) to be 8 m^3/ha/yr over the estates woodlands. This means that on average 128 m^3/ha/yr can be harvested from the estate woodlands without reducing the overall amount of woodland.

If we assume that 10 ha of the 16 ha are harvestable, then that gives an overall maximum annual sustainable harvest of 80 m3, which is about 72 green tonnes at 50% moisture content (use 0.9 as conversion factor for m^3 to tonnes) or 50 tonnes at 35% moisture content.

It would be safe to assume that all of this timber is of lower value and would suit woodchip/firewood production. It may be possible, during training courses, to ensure that the sustainable annual yield is removed each year and this is extracted to the woodfuel processing area.

3.7.2 Arboricultural Arisings

In addition to the woodland work, some arboricultural work is carried out. This is carried out in the parkland areas and around the buildings. In many instances it is a response to health and safety issues. It is undertaken in-house by experienced staff and students. Only a small proportion of timber is produced in this way each year and we have estimated this to be no more than $10m^3$ or 9 tonnes.

3.7.3 Woodland Owner Partnership Structure

A large number of wood fuel supply businesses are operated by or have a partnership with woodland owners; often the reason is self-supply or finding a market for small woodlands with low grade timber. Small woodland owners often have difficulty getting economical management options for their woodland holdings due to the small or fragmented structure of the woodlands increasing harvesting and extraction costs. Therefore one strategy these types of woodland owners have is to add value and market the timber from thinning operations and low grade timber themselves via woodfuel.

However in the case of most estates they have enough woodland holdings to have commercial management options available to them, and therefore sell their timber into the commercial market. If these larger woodland owners were to tie themselves into timber contracts with a woodfuel supply business they could end up under-valuing their own timber as the timber market increases (as it is at the present time).

Therefore a suitable structure could be one whereby the woodfuel supply business buys its timber at the market rate, even though some of the timber will come from the woodland owner partner. All this will mean is that the woodland owner gets a better return due to reduced haulage costs.

So in this case the benefit of partnership is to the woodland owner, however from the supply business point of view, in what is essentially a carbon / sustainability market, locally sourced material is a definite positive.

Also woodfuel supply can suit labour availability on estate type businesses as most of the labour is required in the winter months when the work loads are lower on estates (depending on shooting and other sporting events).

3.8 Supply Chain Gap Assessment Summary

Table 11 below shows the estimated availability of raw material from Kirkley Hall woodlands and arboricultural operations.

	Area in ha.	35% mc fuel pa (t)	35% mc fuel 20 yrs (t)
Woodlands	16	50	1000
Arb arisings	NA	7	140
Total	**16**	**57**	**1140**

Table 11: Raw material summary for 20 years

If we consider the market assessment above, then we see that there is a significant shortfall between raw material supply from Kirkley Hall and the projected demand with and without a Renewable Heat Incentive. The shortfall as summarised in Table 12 and Table 13 will have to be bought on the commercial market.

	2012	2013	2014	2015	2016
Demand Tonnes	760	820	890	960	1040
Supply from internal sources	57	57	57	57	57
Shortfall required from external sources	703	763	833	903	983

Table 12: Summary of raw material requirements without RHI

	2012	2013	2014	2015	2016
Demand Tonnes	3050	3300	3600	3900	4250
Supply from internal sources	57	57	57	57	57
Shortfall required from external sources	2993	3243	3543	3843	4193

Table 13: Summary of raw material requirements with RHI

4 Process for Woodchip Production and Supply

4.1 Forced drying of wood chip

Most biomass boilers only take dry wood chip with a moisture content of below 35%, therefore it is crucial to have some means of obtaining dry wood chip in the production process. Wood chip itself will not dry out a great deal passively i.e. if you leave wet wood chip in a pile it will compost before it dries. The only way to dry it is to use a “forced” drying technique similar to those used for drying grain.

Photo 1: Examples of grain driers

However for forced techniques you will always need to put in more energy than you will gain from the drier woodfuel, as some energy is lost in the drier (up to 80% in basic drying bins).

Therefore unless you have very cheap or free heat and electricity, as the fans can be up to 40kW, then this is not normally economically viable. The advantage is that it frees up cash-flows by the fact that you do not need to store timber for a year or more to season it before you sell the woodfuel.

Timber in log form (roundwood) does not compost as quickly; it is able to dry down in a year to below 35% moisture content. Therefore we recommend that the drying is carried out passively by leaving the roundwood in an exposed and windy location. A suitable site could be up near the farm as this has an open aspect with space available to store roundwood.

4.2 Overview of the Woodchip Production Operation

At the very basic level the supply chain consists of harvesting timber, drying your timber, processing timber into chip and finally delivering it to the end user (see Figure 5). However there are several options at each stage which will be discussed further in this chapter.

For the purposes of Quality Control we have identified the chipping operation at the depot as the key stage. This is known as a **Critical Control Point,** i.e. if the timber is not dry enough, or the chipper is not producing chip of the correct size then this is the stage where you need to test for these things.

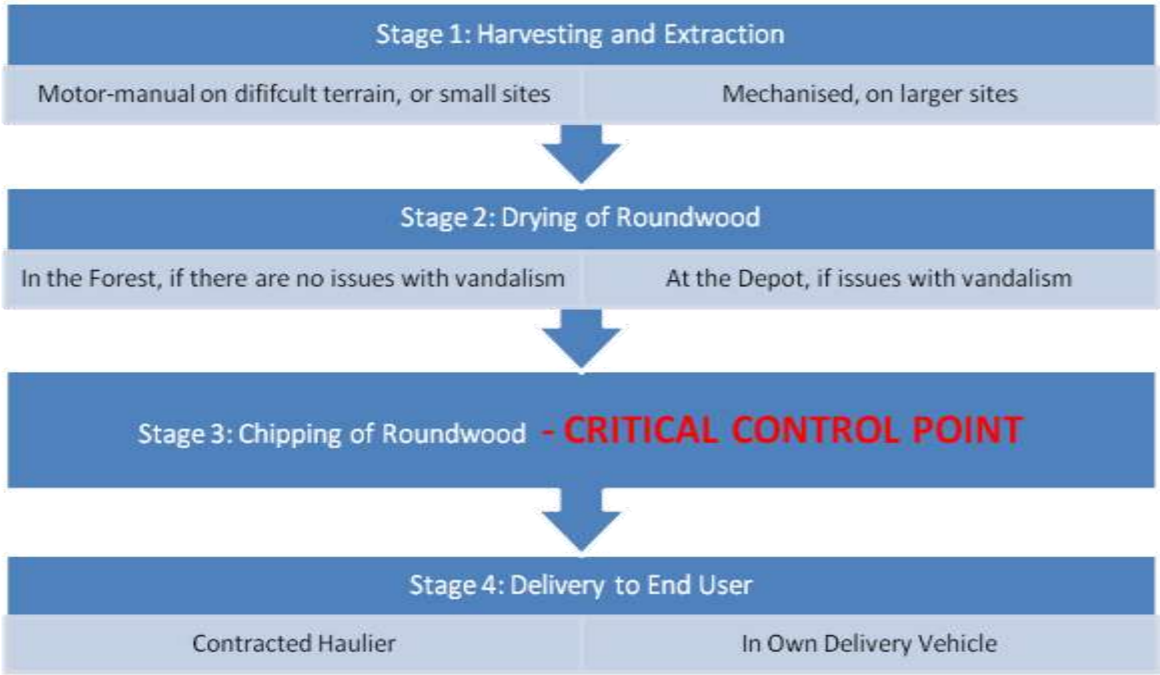

Figure 5: Overview of the woodchip supply operation

4.3 Stage 1: Harvesting and Extraction of Roundwood from the Woodlands

4.3.1 Kirkley Hall Woodlands

During discussions with Nick Johnson during the site visit on the 29th June 2012 it was explained that there was no scheduled rolling programme of felling activities which took place on the estate. The felling programme was more a result of training operations where trees are felled and cross cut by students attending chain saw courses.

From the outline data gathered on species, planting year and compartment size, it is evident that the estate is capable of producing, on a sustainable basis, 57 green tonnes of chip and firewood a year. This can be sourced from both coniferous and hardwood stock although hardwood is less suitable for wood chip production. The reason for this is;

1. Coniferous roundwood dries more quickly, particularly small round wood. See Table 14 for predicted drying times.
2. Hardwood roundwood, including small roundwood, can often fetch a higher added value price from other markets such as domestic firewood.

The use of agri-based forwarding/skidding would be the best way of extracting any timber felled from the woodlands and could be used with any felling being undertaken manually. The farm has tractors that could be used in conjunction with a timber forwarding trailer to extract the felled and dressed round wood.

The estate does not currently own a forwarding trailer and it may be more cost effective to hire in an operator with tractor and trailer to do the timber extraction on a contract basis. However, if the estate were to invest in a trailer of the type shown in photo 2 below it could expect to pay up to £14,000 for a new machine capable of extracting up to 8 tonnes at a time. A machine such as the Botex 8 tonne Euro trailer with 360TL mounted crane would tackle most jobs. The trailer could also be used for moving roundwood around the storage and processing depot. The Defra Farming and Forestry Improvement Scheme can contribute towards the cost of purchasing equipment like this and intervention rates are currently set at 40%. However, at the time of writing, round 2 of the FFIS has closed and it is unknown if and when a third round will be announced.

Photo 2: Timber forwarding trailer and crane

In summary, the estate could fell and dress the timber in the woodlands to 3 meter lengths where it can be collected by the forwarding trailer and extracted to the storage area for seasoning and processing.

4.4 Stage 2: Drying and Storage of Roundwood

There are two options for drying and storage of the roundwood timber;

1. Stacked on a windy site in the woodlands where the timber is felled for at least 1 summer, then transported to the depot to be processed. This option reduces the space required at the depot to store and dry timber.
2. Delivered straight from the woodlands after felling, and stacked in the depot in an exposed, windy location.

We would recommend extracting the timber as felling is done and finding a suitable storage site at the depot for storing the roundwood and allowing it to season. The roundwood may well be stored for up to 18 months at a time in order to season it to below 35% moisture content at which point it becomes safe to chip (risk of composting from wet chip is greatly reduced at this point).

Table 14 sets out approximate seasoning times for both softwoods and hardwoods that will be used by the estate. Larger diameter timber (>50cm diameter) will not dry properly unless the wood is split down by the use of a wood cracker or wood screw, such as the Lasco screw, to speed up drying times.

Type	<30cm diameter small roundwood
Softwood	9-12 months
Hardwood	12-24 months depending on species and diameter e.g. small diameter birch and sycamore will season considerably quicker than oak and beech.

Table 14: Approximate seasoning times to reach 30-35% from 60% moisture content

At this stage an exact site has not been chosen for a depot, however we understand the College has 2 main options with regards locations and will therefore choose a suitable site as this project progresses. In choosing a suitable site we would recommend a windy, exposed and open location (wind is the most important factor in drying timber) is chosen and this is especially important if the depot is to be used as the primary seasoning site for the timber i.e. the timber is not left in the woodlands to dry.

The two options discussed at the site meeting on the 29th June were at the back of the workshops at the Kirkley Hall site and up at the farm. Photo 3 shows the possible location of the depot at the Hall and photo 4 the possible location of the depot at the farm.

Photo 4: Option 1 – Kirkley Hall

Photo 3: Option 2 - The Farm

If possible, enough area is needed to store at least 1 year's worth of <u>dry</u> timber in the round. Working out the amount of area you need to store roundwood depends on the maximum stack height and this is dependent on health and safety considerations. It is considered good practice to limit the height of the stack to the length of the timber in the stack[9], so for the purposes of this site we will assume that the stack height is about 3m high and the ends are supported vertically with fixed posts, thus making it possible to make the stack level and maximising the available space. You will need approximately 0.8m^2 per tonne. Therefore for the expected maximum annual demand of up to 4,000 tonnes (2016 maximum market demand with an effective RHI) you would require 3,200 m^2 of stacking space. However, the stacks require access to them therefore you will have to have access tracks between the stacks (see Figure 11: Roundwood stack layout with access tracks in

[9] www.hse.gov.uk/fod/**stack**log.pdf

Appendix 2 - Depot design recommendations).

These access roads would add about 30% to the overall required area, therefore to accommodate the entire years supply the storage area needs to be 4,100 m^2 (0.4 ha). However this could be unrealistic in terms of the amount of space tied up storing roundwood and prohibitively expensive in business rates. Therefore an alternative to save costs could be to only store 4-6 months' timber.

Good articulated lorry access is also of great importance. If you consider that the depot could be delivering up to 4,000 tonnes of chip a year, this equates to the following number of lorry movements:

- About 100 woodchip delivery lorries (assuming an average of $40m^3$ per delivery).
- Also the timber needs to be delivered to site and to supply 4,000 tonnes of dry chip (35%mc), 5,800 tonnes of green timber is required (assuming it averages 55%mc coming into the yard). This means about 250 deliveries of fresh timber (assuming average load per delivery is 24 tonnes).

With this number of vehicle movements it is important to have a good access layout in order to avoid lorries getting in each other's way. (See Appendix 2 - Depot design recommendations).

We would recommend siting the depot up at the farm as there is more space, existing areas of hard standing that could be utilised for storing roundwood and existing farm buildings which could be used for storing both woodchip and firewood. However, during the site meeting on the 29th June it was pointed out that the college will be going through a re-development of both the Kirkley Hall and farm sites and therefore consideration to the storage and processing of woodfuel should be given at the early stages of this process.

4.4.1 Moisture Content

It is our recommendation that the business tries to achieve a moisture content of below 35%. We believe this is achievable given the conditions of the site and this will help to ensure the efficient running of customers woodfuel boilers. In order to achieve this specification, the business will need to monitor the moisture content of the roundwood and this can be done fairly simply with the use of a roundwood specific pin moisture meter. We recommend that the business invests in a device similar to that shown in Photo 5.

It should be noted that this is only suitable for taking moisture readings of roundwood timber and should not be used to measure the moisture content of woodchip. It also does not work on timber that is frozen. This particular device has calibrated scales for different species and is fitted with a temperature probe for more accurate moisture readings when timber is significantly different to 20 degrees.

The device should be used on a random selection of logs from the stack, the bark should be removed and a notch cut into the timber to expose heartwood, readings taken from the centre of each log and an average cal. When this average shows a moisture content of less than 30% - 35%, the round wood is ready to chip. We recommend that the members of staff responsible for the production of the woodchip fuel test softwood stacks after 9 to 12 months and hard wood stacks after 12 to 24 months depending on species and diameter.

Photo 5: Roundwood moisture meter

4.5 Stage 3: Processing of Timber into Fuel

4.5.1 Chipping

Once the roundwood is below 30% to 35% moisture content, it should then be chipped. Chip at this moisture content does not compost quickly, therefore it is safe to store for 3-6 months. If it is stored for a further 2 to 3 months before delivery to the biomass boiler, it will continue drying a small amount. This should bring it down to about 25% – 30% moisture content.

If any hardwood is used for chip it should be noted that hardwood and softwood dry at very different rates - hardwood can take more than twice as long to dry as softwood. We would recommend that the stacks of softwood and hardwood are kept separate so that the wood in any one stack is of similar moisture content. This helps produce a chip of even moisture content.

The type of chipper selected is critical and one capable of handling both softwood and hardwood of varying diameter and capable of controlling particle size should be used. Typically, there are two types of chipper used for woodfuel production:

1. **Drum chippers** are used for producing woodfuel specification woodchip at the medium to small scale. Woodfuel drum chippers have interchangeable screens set at a particular mesh size – usually 30 or 50mm – through which the chips can pass so setting the particle size. This combined with well maintained, sharp blades and a fast rotation speed can ensure a quality controlled particle size.

Photo 6: Drum chipper suitable for woodfuel.

2. **Multiple blade disc chippers** have been known to be used successfully. Disc chippers vary in terms of features for controlling particle size but well maintained and sharp blades, along with in-feed angle and the addition of a slither breaker in the out-feed chute, are some of the features that can be incorporated to ensure a quality controlled particle size that will conform to boiler specifications.

Photo 7: Disc chipper suitable for woodfuel production

Capital costs of chippers capable of producing fuel quality woodchips are often high, ranging from £15,000 for a basic PTO driven disc chipper to £180,000 for a high capacity drum chipper, as are running costs. It is recommended that chipping services are contracted in, at least in the short to medium term. However, the college already owns a small diameter PTO driven disc chipper that is used for training purposes and has plans to invest in a new machine. The new machine could be specified to produce a woodfuel quality woodchip which could be capable of producing small amounts of fuel grade chip. However, as this business plan has set a target of 4,000 tonnes of dry chip by 2016, a small machine would not be capable of producing this amount of fuel. Basing the plan on a contract chipper would seem the better option and presents a worse case scenario.

Contract chipping costs are quite variable; some contractors charge a flat day rate, some by the cubic metre and some by the tonne. On average we would budget for £10/tonne chipping costs for contract chipping

The production rates of chippers vary a great deal, depending on the chipper, timber size, distance from timber storage to the chipper location and loading equipment. But a small scale chipper will produce approximately 20-50 tonnes a day, medium chippers range from 50-100 tonnes a day, and large chippers can produce anything up to 300 tonnes a day.

Out of the two chippers described above, the hire of a large woodfuel drum chipper would be the recommended option, primarily due to the amount of timber which needs to be processed and the ability to produce a consistent sized product.

4.5.2 Storage

Once the timber is chipped, it needs to be stored out of the rain and normally an agricultural type shed is used. These are ideal as they are usually very well ventilated which is important to allow the chip to continue drying down towards the 25% mark which makes it a premium product. The Farm site has various buildings that would be suitable for storing woodchip as identified in photo 4 above.

For this business to supply up to 4,000 tonnes of chip a year in year 5 (assuming the RHI is accelerating the market) then it would need to store a buffer of at least 1 month's supply of dry chip. As most of this 4,000 tonnes would be supplied in the winter months (most heat users use 70-80% of their heat in the 5 coldest months), this would give about 600 tonnes in the coldest month. If we assume the chip is 35% moisture content then its bulk density is about 270 kg/m^3 which gives 3.7 m^3/tonne. This would mean that to store 600 tonnes you would need 2,200m3 of storage. Most fuel stores are piled to an average of 4m with chip, which requires 550m^2 of floor area. So an approximately 25m x 20m shed is ideal which would allow the business to easily supply 4,000 tonnes a year. It would be most cost effective to utilise one of the existing sheds up at the farm with only slight modifications to allow it to store woodchip e.g. the removal of any internal structures and reinforced side walls which can withstand the weight of the stored chip and loading shovels being pushed up against them.

If a new shed were to be built, its cost is very dependent on what the site is like on which it is to be built. But if you were to start from scratch, we would estimate the cost to be £80,000 for a shed capable of holding

2200m3 of woodchip.

The turning of chips with a loading shovel should be avoided as this will only increase the cost of production, and it is estimated that a further cost of £5 per tonne could be added to the fuel every time it is handled. If the timber is chipped below 30%-35%mc then this should not be necessary.

This stage of the process is a **Critical Control Point** for maintaining the quality of the fuel. Therefore it is at this stage that your regular sampling schedule should take place. A testing sample should be taken from each chipping batch.

For taking a sample of woodchip fuel, *CEN standard 14778-1 Sampling – Part 1 Method* should be followed and for taking total moisture content as a % wet basis, *CEN standard 14774-2 Methods for the determination of moisture content* – oven dry method should be followed. We have included in Appendix 1 - Fuel Quality Assurance, a simplified microwave oven and conventional oven based test that the business can do in-house. Please note, if testing is carried out in-house using this method, it will not provide scientifically accurate results as the devices that will be used are unlikely to have been independently calibrated and tested. If the business wishes to find out accurate moisture content readings of the fuel then samples should be sent away to a suitable laboratory for sampling. Contact details of testing facilities are included in Appendix 1 - Fuel Quality Assurance.

If woodchips need to be bought in from external suppliers, it should be noted that the point of delivery should also be considered as a **Critical Control Point** and the business should undertake random sampling and moisture content tests of the delivered fuel to ensure it is compliant with the boiler specification. *CEN standard 14778-2 Sampling- Part 2 Methods for sampling particulate material transported in lorries* should be followed when taking a sample of fuel from a lorry or trailer if it is considered safe to do so.

4.5.3 Modifications to existing buildings and equipment for a supply depot

Capital costs can be vastly reduced by using existing buildings and storage areas often with only minor modifications and upgrading.

For the purposes of this study we have assumed that one of the sheds at the farm can be modified at relatively low cost for it to be used for storing woodchip and firewood fuel.

Conversion of common agricultural sheds is fairly straightforward;

- If they do not have Yorkshire boarding or open slated sides it is a good idea to either change the side panels or put openings in the side to allow adequate ventilation and let the wind in
- If the floor is not already power-floated concrete suitable for scraping a loader bucket across without breaking up then a power-floated finish would be required
- A power-floated concrete apron should extend in front of the shed for at least 3m so that any chip which spills out does not get contaminated with stones or dirt
- Ideally the height of the eaves should be high enough to allow loading of a delivery vehicle under cover which for large articulated lorries could mean 7m to the eaves. However, if such a building is not available, then the cost of raising the structure would be prohibitive, and we would recommend putting up with loading outside (which, if done fast enough with a large loading bucket, should not cause a problem even in the rain)
- A storage area either behind (if you chip in through an opening in the back of the shed) or in front of the building of a sufficient size to store at least one days chippings worth of roundwood. This storage area should have bearers to raise the round wood off the ground
- A seasoning area close by to stack the timber if it can't be left in the forest then field edges along existing access tracks (which can be upgraded to take lorries) are suitable for this
- We would recommend setting aside a budget of between £10,000 and £15,000 for modifications to an existing shed.
- Most farms have a tele-handler or loader of some description. These can be used well as chip loaders. However most farms have them with small buckets designed for grain (which is 2 or 3 times more dense than wood chip), therefore we would recommend buying a large bucket of around 5 – 8m3 depending on the lift capacity of the loader at full reach (softwood chip at 35% mc is about 270kg/m3)
- What most farms no longer have is a timber trailer to move roundwood around, however these can be bought for tractors with a capacity of up to 12 tonnes, to be used for moving roundwood from the seasoning area to the chipping area. A new 8 tonne capacity forwarding trailer could be bought for around £14,000.

4.6 Stage 4: Delivery to the Boiler

As this proposed business will be delivering to a variety of customers, it should be expected to have to deal with a variety of delivery systems. There could be several options for fuel delivery depending on the fuel store chosen. The common systems are described in this section.

4.6.1 Delivery to above ground high sided fuel stores

If the fuel store is a separate above ground option then a mechanism of loading the fuel to a height will be required. One method of doing this is to use a conventional tele-handler or front-end loader with a large bucket to fill the store from a trailer. However this necessitates tipping the chip onto clean concrete as shovelling directly from the trailer would damage it.

An alternative could be to use a high-lift tipping trailer as pictured below. These cost £8,000-£20,000 new, but can be found second-hand from about £3,000.

Photo 8: Example of a high-lift trailer loading into an above-ground store

A frequently used method for delivery to an above ground fuel store is to blow the chip in using either a specialised blowing vehicle (see Photo 9) or a fixed blower at the customer's site (owned by the customer) see Photo 10. However these blowing systems work best on small very dry chip or they are prone to jamming. They can take up to 45 minutes to deliver 10m^3 and there is considerable noise associated with them which makes them less suitable for urban sites. The specialist blowing trailer costs about £25,000 - £35,000, and the static blowers about £8,000 - £15,000.

Photo 9: Specialist chip blowing lorry (courtesy of Forest Fuels Ltd)

Photo 10: Customer based chip blower (courtesy of Practicality Brown)

Clamshell grab-loaders on a lorry (see Photo 11) can also be used effectively, however the delivery is very slow with $10m^3$ taking up to 30 minutes depending on the size of the bucket.

Photo 11: Clamshell grab lorry (courtesy of KSD)

A relatively new piece of equipment to enter the UK market is the auger-discharge trailer (see Photo 12), which can deliver to a height of 5.3m, and can be fitted as an agricultural trailer or a lorry trailer. These systems will deliver very rapidly, taking about 45 seconds to empty $10m^3$. However they have the drawback that the systems available at the moment have the auger fixed in one position, which does not allow for flexibility when delivering to sites where access is difficult. These trailers cost from £35,000 for the agricultural version and £60,000 for the lorry version.

Photo 12: Auger discharge trailer (courtesy of Fliegl)

4.6.2 Hook-bin fuel store

The Hook-bin system is based on an ISO CHEM 20 container bin, and combines a delivery container and fuel store in one. The idea is that one of the bins will be at the site as fuel store, and a second bin will be at the fuel suppliers site being filled.

Normally the hook-bins are owned by the customer and supplied with the boiler. It is important that the business has insurance to cover these hook-bins whilst at the depot.

Each bin's capacity is approximately 30-35m^3, and weighs 3 tonnes. Therefore, assuming a bulk density of 250kg/m^3 (with 35% moisture content chip) it will give a maximum total loaded weight of about 12 tonnes. Therefore to save trips with partially loaded bins it would be wise to have a vehicle which can carry 15 tonnes.

Assuming that the hook bin holds about 8 tonnes of chip at 35% moisture content then it will hold 21,760 kWh of energy (assuming 85% efficient boiler).

Versatility: the hook-bin can be filled at the supplier's premises by any front end loading vehicle, conveyor or direct chipping into the bin, thus avoiding any messy tipping at the customers site.

Walking floor: the walking floor ensures almost complete extraction of the fuel into a trough which contains the feed auger to transport the wood fuel into the boiler.

Ease of fuel deliveries: simple unobtrusive delivery using any vehicle equipped with a hook-lift loading mechanism, of which there are many easily available in the UK, either trailer based or lorry based, with no fuel handling on site.

Photo 13: Hook-bin delivery system

4.6.3 Delivery to underground fuel stores

Underground fuel stores offer the widest range and greatest flexibility in delivery vehicles. Almost any vehicle can get chip into the store.

Photo 14: Delivery to an underground fuel store using standard tipping trailer

4.6.4 Delivery to open barn-type structure

If the fuel store is located in an existing building with an open front then this would only require a tipped delivery if the building has sufficient height to permit tipping. If not, a horizontal discharge system will need to be used such as a walking-floor trailer or push-off trailers. However once the pile has been tipped, it may need to be moved on to the fuel feed system (auger or walking floor) by a tele-handler or front-end loader.

4.6.5 Recommended delivery option

Considering the wide range of customer delivery requirements, and the high cost of most of these delivery vehicles, we would not recommend investing in a delivery vehicle for woodchip in the short term. Initially the business should contract out the haulage to a commercial haulier.

Cost of chip haulage depends mostly on the size of the load which the vehicle can hold and deliver. There is not much difference in contract price between a full sized articulated lorry which holds over 20 tonnes, and a 6-wheel lorry which holds 6-7 tonnes. Therefore as a rule-of-thumb the larger delivery vehicles cost less per tonne. Assuming a delivery distance of less than 30 miles we would normally budget on the following costs for chip haulage;

- High lift trailer (20m^3) = £30/t
- Standard agricultural tipping trailer (20m^3) = £30/t
- Chip blowing agricultural trailer (28m^3) = £22/t
- Clamshell loader lorry (30m^3) = £22/t
- 6 or 8 Wheel hook-bin delivery lorry (27m^3) = £20/t
- Chip blowing <u>lorry</u> (50m^3) = £19/t
- Bulk tipping lorry (60 - 70m^3) = £12/t
- Maximum sized walking-floor lorry (100 -115m^3) = £7.50/t

4.7 Properties for woodchip fuel

Firstly a quick explanation on the more critical properties of woodchip which affect the quality;

- **Particle Size**: The boilers, or more specifically the augers, will only take chip of a certain size. The size of the chip is mainly determined by the chipper, but moisture content and species can play an important part.

- **Moisture Content**: The boilers will be designed to take maximum moisture content of chip before they stop working efficiently; this can range from 30% up to 50%. The moisture content of the chip is determined by combination of size and age, species, time of year harvested and time allowed to season.

- **Ash Content**: Again, boilers are designed to take a fuel with a maximum ash content. However, wood is normally far below most boilers' maximum threshold, but the ash content does determine how often you have to empty the boiler; therefore ideally ash content should be kept to a minimum. Ash content is mainly determined by bark content of the fuel, as bark produces far more ash than heart wood.

The above are referred to as *Normative* properties of solid biomass fuels, information that must be provided about the fuel. There are many other *Informative* properties such as density and chlorine content that also affect the quality of woodchip fuel that the estate may wish to test for, however this is information that can be included but is not required. See *Appendix 1 - Fuel Quality Assurance* for further information on quality assurance.

5 The Business Case

5.1 Charging for Woodchip

There are various methods of charging for the fuel. The simplest option would be for the business to charge the customers for the heat on a pence per kilowatt hour (p/kWh) basis. This information can be worked out by calculating the actual cost of producing one tonne of woodchip and then divide that by the calorific value at a set moisture content. The business would take regular meter readings (weekly or monthly) from the heat meter and charge the customer for the heat used by the set p/kWh. This puts the onus on the business to produce a better quality dry woodchip, therefore requiring fewer deliveries, and less overall timber. When entering into a contract on a heat purchase basis it is important to bear in mind the following points;

- It is important that an industry standard heat meter, which has been correctly calibrated for the correct pipe size, is fitted as close to the boiler as possible (before any accumulator tanks).
  - The most efficient types are those which incorporate an ultrasonic flow meter which conforms to EN 1434, as these have no moving parts to jam.
  - The heat meter needs to be calibrated and serviced as per manufacturer's recommendations. It is important that records are kept of this to give you, as the supplier, confidence that it is accurate.

Photo 15: Example of a heat meter; source www.dmsltd.com

- Any form of heat sales should be through a contractual agreement, preferably over a set number of years, which should highlight the following areas in order to protect the supplier.

  - **An annual review of the unit price:** this will enable the business to adjust their price to take into account any external factors which may affect the cost of the fuel, for example an increase in the price of timber or an increase in the price of fuel.

  - **Boiler efficiency:** it should highlight that if the efficiency of the boiler drops below a set percentage, due to seasonal demand, maintenance or other reasons, then the supplier should be compensated for the reduction in boiler efficiency. The efficiency can be estimated from flue gas analysis during the routine services. It is important that the supplier has access to these records.

  - **Contract extensions:** if the boiler breaks down for periods of more than 2 weeks, then it is important that there is provision to extend the contract by the same period. This allows the supplier to sell the chip for which they have already bought the roundwood for at least a year in advance.

- **Contract withdrawal penalties**: If the customer should decide to withdraw from the contract through no fault of the supplier, again this could result in the supplier having large quantities of timber already paid for and no means of selling it. Therefore some kind of penalty clause is advisable, which pays out on a *pro rata* basis for the remains of the contract, to cover the costs of the pre-purchased timber.

5.2 Cost Breakdown of Producing Woodfuel Specification Woodchip

In this section we will cover the costs for producing woodchip. To produce the cash-flow model later in this report we will assume that the chip is 35% moisture content as this is usually the maximum it can be for most boilers and has the highest costs. However it is more cost effective, when selling on a heat basis, to produce as dry chip as possible. To demonstrate this we have included the costs for 25% moisture content chip as a comparison.

We have based our costs on buying timber on the commercial market. The commercial market for pulp wood has not increased to the same degree as the sawlog market over the last 18 months, with a very large range in prices fetched for pulp wood from £22/t into the large users such as the power stations and particle-board manufacturers up to £30/t into the small scale market. Therefore it would be easy to get hold of pulp wood if you are prepared to pay more than the large scale users. For the purpose of this study we have assumed an average price of £25/t for green timber.

5.2.1 35% moisture content supply model

Wood at 35%mc contains about 3200 kWh per tonne. In an 85% efficient boiler, 480kWh of this will not go into the heating system, therefore for every tonne of fuel 2720kWh will go into the heating system.

To supply each tonne at 35%mc will require 1.63 tonnes of freshly felled timber. This is due to the fact that wood decreases in weight by 38% when drying from 60%mc down to 35%mc. This inversely relates to a 63% increase in weight from 35%mc up to 60%mc, therefore you need 63% more fresh-felled wood by weight than you do 35%mc fuel. The following model in Table 15 assumes the wood is left at the depot to dry and then chipped. This is the highest cost option, therefore this represents a worst-case scenario. Also assuming that the fresh felled timber is 60% moisture content is erring on the side of caution, as it is frequently below this at between 50-55%.

Item	Cost (£/t)
Delivered timber value, felling and extraction to roadside for both softwood and hardwood SRW and low value timber and delivery	25.00
Total for 1.63 tonnes	**40.75**
After this point the wood has been dried down to 35%, therefore you only require 1 tonne	
Processing (chipping and or cracking over size material)	10.00
Storage (depreciation of the shed and site)	3.00
Business rates	3.00
Insurances	1.50
Handling	5.00
Total production cost for 1 tonne of 35%mc chip	**63.25**
Delivery (average)	18.00
Total cost for delivered woodfuel	**81.25**
Equivalent price in pence per kWh (assuming 85% efficient boiler)	**2.99**

Table 15: Production cost breakdown for 35%mc chip supply (assuming 2,000t/yr)

Please bear in mind that for every percentage of moisture content lower than this, the business will make a saving on its fuel production costs. Therefore this represents a worst-case assessment to demonstrate this, below is a supply model at 25% moisture content.

5.2.2 25% moisture content supply model

Wood at 25%mc fuel has an energy content of 3800kWh per tonne. In an 85% efficient boiler 570kWh of this will not go into the heating system, therefore for every tonne of fuel 3,230kWh will go into the heating system.

To supply each tonne at 25%mc will require 1.88 tonnes of freshly felled timber. This is due to the fact that wood decreases in weight by 47% when drying from 60%mc down to 25%mc. This inversely relates to an 88% increase in weight from 25%mc up to 60%mc, therefore you need 88% more fresh-felled wood by weight than you do 25%mc fuel. The following model in Table 16 assumes the wood is left at the depot to dry and then chipped. This is the highest cost option, therefore this represents a worst-case scenario. Also assuming that the fresh felled timber is 60% moisture content is erring on the side of caution, as it is frequently below this.

Item	Cost (£/t)
Delivered timber value, felling and extraction to roadside for both softwood and hardwood SRW and low value timber and delivery	25.00
Total for 1.88 tonnes	**47.00**
After this point the wood has been dried down to 25%, therefore you only require 1 tonne	
Processing (chipping and or cracking over size material)	10.00
Storage (depreciation of the shed and site)	3.00
Business rates	3.00
Insurances	1.50
Handling	5.00
Total production cost for 1 tonne of 35%mc chip	**69.50**
Delivery (average)	18.00
Total cost for delivered woodfuel	**87.50**
Equivalent price in pence per kWh (assuming 85% efficient boiler)	**2.70**

Table 16: Production cost breakdown for 25%mc chip supply (assuming 2,000t/yr)

Therefore we see that there is a 0.29 p/kWh saving in production costs, **which is a 9.7% saving over the 35%mc fuel**.

From these figures it would seem that delivered costs are nearly 3p/kWh and that is before any profit. In the UK the price of wood chip varies a great deal around the country. However one common trend which has been seen is that in areas where the woodfuel supply chain is relatively new the price is lower. As time goes on the price increases as they often realise that they have incorrectly priced it initially.

Notwithstanding incorrectly priced fuel there are many markets across the country where the supplier is charging very close to 3p/kWh and making a profit. This is due in part to the fact that the pricing structures above are on the cautious side, and hence represent the absolute maximum in production costs, and partly due to the fact that most suppliers are not building the business from scratch. They are often already involved in some part of the supply chain and therefore can bring in some capital equipment, a site etc. which greatly reduces the capital costs.

5.3 Firewood Supply

In this section we will consider a firewood supply business as an add-on to the main chip supply business. Firewood operations usually have a high mark-up but low volume compared to chip operations, however they can complement each other, as the same facilities can be used for both. Also firewood uses spare labour quite effectively in both production and delivery (depending on the delivery method chosen).

Traditionally in the UK predominantly hardwoods have been used for firewood. However in modern stoves there is no reason to not use softwood as it is a readily available resource and seasons far quicker than hardwood (about half the time). The only issue against softwood is frequency of loading the stove and storage space. However, it is cheaper to produce and therefore cheaper for the customer.

5.3.1 Seasoning

If storage space is not too much of an issue, it is best to process the roundwood green and season it as firewood in some kind of open vented container. Those commonly used are vented 1m3 dumpy bags , wooden potato crates or the steel cages which surround International Bulk Containers (IBCs) these are the 1000 litre liquid containers commonly used for bulk liquids. All of these are stackable and can be left stacked outside in a windy location to season, and can then be used to deliver the firewood to customers if you have, or hire, the correct vehicle.

Seasoning the split firewood has the advantage of vastly reducing the seasoning times often to as little as one summer, which in turn will help cash flow.

5.3.2 Delivery

Delivery is the aspect of firewood supply which is the least efficient in most cases in the UK. Commonly deliveries are tipped from the back of a transit van or pickup with only one delivery per journey. Tipped deliveries often do not suit the newer customer base in more urban areas, they are looking for convenience, and would rather not move several cubic metres of logs to the firewood store. Also this often involves multiple handling of the firewood which is inefficient.

There are several options for delivery (which can also be used for seasoning) which save on handling and provide the customer with convenient deliveries;

5.3.3 Vented bags

Photo 16: Vented 1m3 dumpy bag, courtesy of bagsupplies.co.uk

These 1m3 bags can be loaded directly from the processor and are then stacked in wind-rows to season in a windy location. In areas of high rainfall it will help if the top layer is covered with tarpaulin or similar. However the “vented” panels will not allow as much air flow as other systems such as steel mesh or wooden slats, therefore will not be as effective for seasoning. It should be noted these are 1m3 unlike most “1 tonne dumpy bags” found at builders merchants which are commonly 0.7m3 or less. The disadvantage of this system is that you will need some kind of pallet delivery system on your vehicle, either a crane or a mobile forklift. These type of vehicles can be hired (with or without a driver) which would save on capital expenditure. With this type of delivery system it is important to do a delivery round so that each journey maximises the number of deliveries.

Photo 17: Vented "barrow bag", courtesy of bagsupplies.co.uk

These smaller “barrow bags” are about 200 litres (0.2m3), and provide a handy delivery unit for customers with difficult access as each bag can be moved on and off a transit type vehicle with a tail-lift and then moved around on a normal hand cart (or stair-climber cart if stairs are an issue).

5.3.4 Stackable steel / wooden cages

Photo 18: Stackable steel / wooden cages, courtesy of barndriedlogs.co.uk

These are an ideal solution for seasoning and delivering, (the photo above shows an adapted IBC container and potato crates), however they can be made from scratch for a more aesthetically pleasing cage. The firewood is loaded into them straight from the processor and does not need to be handled again, just moved into a windy location and stacked in wind-rows to season, with the top row covered with a tarpaulin or similar.

Often these cages are painted black to make them more acceptable to the customer and are supplied with a lid to shed the water. A good idea is to charge the customer for a deposit, of roughly the cost of the cages, with their first delivery along with a lid which stays with the customer and is transferred to the full cage which is delivered. The deposit system is similar to bottled gas delivery, and has the advantage that it ties the customer to you as a supplier.

5.3.5 Economics

Firewood is recommended to be sold by the volume, either a “load” or by the loose cubic metre. As it does not change volume as it dries, the customer knows how much they are going to get, however this does not mean it should be supplied wet (unless clearly stated as such to the customer) as it will not be ready to be burned until seasoned.

In this business model it is assumed that the costs of storage, rates, insurance etc are absorbed into the costs of the chip operation and therefore are not considered as a cost for firewood supply

5.3.6 SOFTWOOD 25% moisture content supply model

To supply each loose cubic metre of softwood firewood at 25%mc will require 0.48 tonnes of freshly felled timber.

Item	Cost (£/loosem3)
Delivered timber value, felling and extraction to roadside for softwood SRW and low value timber and delivery assuming £25/t	10.12
Processing (Logging and or cracking over size material)	3.00
Handling	2.00
Total production cost for 1 loose m3 of 25%mc firewood	**15.12**
Delivery (average depending on method)	10
Total cost for 1 loose m3 delivered softwood firewood	**25.12**

Table 17: Production cost breakdown for 25%mc softwood firewood supply

5.3.7 HARDWOOD 25% moisture content supply model

To supply each loose cubic metre of hardwood firewood at 25%mc will require 0.52 tonnes of freshly felled timber.

Item	Cost (£/loosem3)
Delivered timber value, felling and extraction to roadside for softwood SRW and low value timber and delivery assuming £45/t	23.44
Processing (Logging and or cracking over size material)	3.00
Handling	2.00
Total production cost for 1 loose m3 of 25%mc firewood	**28.44**
Delivery (average depending on method)	10
Total cost for 1 loose m3 delivered hardwood firewood	**38.44**

Table 18: Production cost breakdown for 25%mc hardwood firewood supply

From the above calculations we see it should be possible to produce seasoned firewood for £25 for softwood and £39 for hardwood.

The current firewood price for loose hardwood loads in “dumpy bags” in the area is averaging £65 (from internet search). However often these are not cubic metre sacks (they are often 0.7m3 or less) and often it is not stated if it is hard or softwood.

We would recommend setting a sale price of £75m3 to £80m3 of softwood/hardwood mix, quality assured firewood at a moisture content of 25%. At this price, it would be possible to achieve profit on firewood sales from relatively small volumes.

As the estate does not currently own any firewood processing equipment it would be necessary to invest in new and or used machinery in order to be able to produce and sell firewood.

Table 19 shows the minimum requirement for equipment and machinery if the estate is to set up a firewood production and supply operation:

Item	No	£/ea	£
Vertical log splitter. Woodline 16 tonne force PTO or tractor hydraulic drive or equivalent machine would cope with all material to be handled.	1	£3,000	£3,000
Medium capacity firewood processor Balfor SSC 700 combination firewood processor with circular saw or equivalent	1	£12,000	£12,000
Vented 1m3 firewood bags www.bagsupplies.com	250	£8.50	£2,125
Total			£17,125

Table 19: Equipment and machinery list for the firewood operation

5.4 Economic case

5.4.1 Cash-flow modelling

For the purposes of the cash-flow modelling we have chosen the following models;

- market demand with an ineffective RHI
- market demand with an effective RHI.

The modelling is based on the estate using/modifying existing storage areas, buildings and machinery but does require investment in some equipment in order to produce quality woodchips and firewood. We have assumed that a grant could be made available to help with the purchase of the equipment via the Rural Development Programme for England Farming and Forestry Improvement Scheme.

We have also done a sensitivity analysis of the cash flows to show the impact of reduced sale prices and increased raw material prices.

5.4.2 With an ineffective RHI

The demand has been taken as per table 9 in the Markets section of this report.

	2012	**2013**	**2014**	**2015**	**2016**
Demand Tonnes 35% mc	760	820	890	960	1040

Table 20: Summary of market demands (assuming 15% market share) with an ineffective RHI

Assumptions to this model:

- £47,125 Capital costs in year 1 made up as follows:
    - Timber forwarding trailer and crane: £14,000
    - 5m3 loading shovel: £1,000
    - 16t vertical log splitter: £3,000
    - Medium capacity firewood processor: £12,000
    - Vented firewood bags: £2,125
    - Modifications to storage shed: £15,000
- £28,275 loan introduced in year 1
- £18,850 grant in year 1
- Supplying 35% moisture content fuel
- Buying timber throughout the year
- Only seasoning the timber for one summer
- Charging 3.40 p/kWh for woodchip
- Charging £75/m3 for firewood
- Includes a firewood supply business of 400 tonnes by year 3

The graph below shows a closing balance of -£19,700 at the end of year one and negative balances remaining through years 2, 3 and 4. By year 5 there is a net cash flow of £31,500 and a closing balance of £17,800.

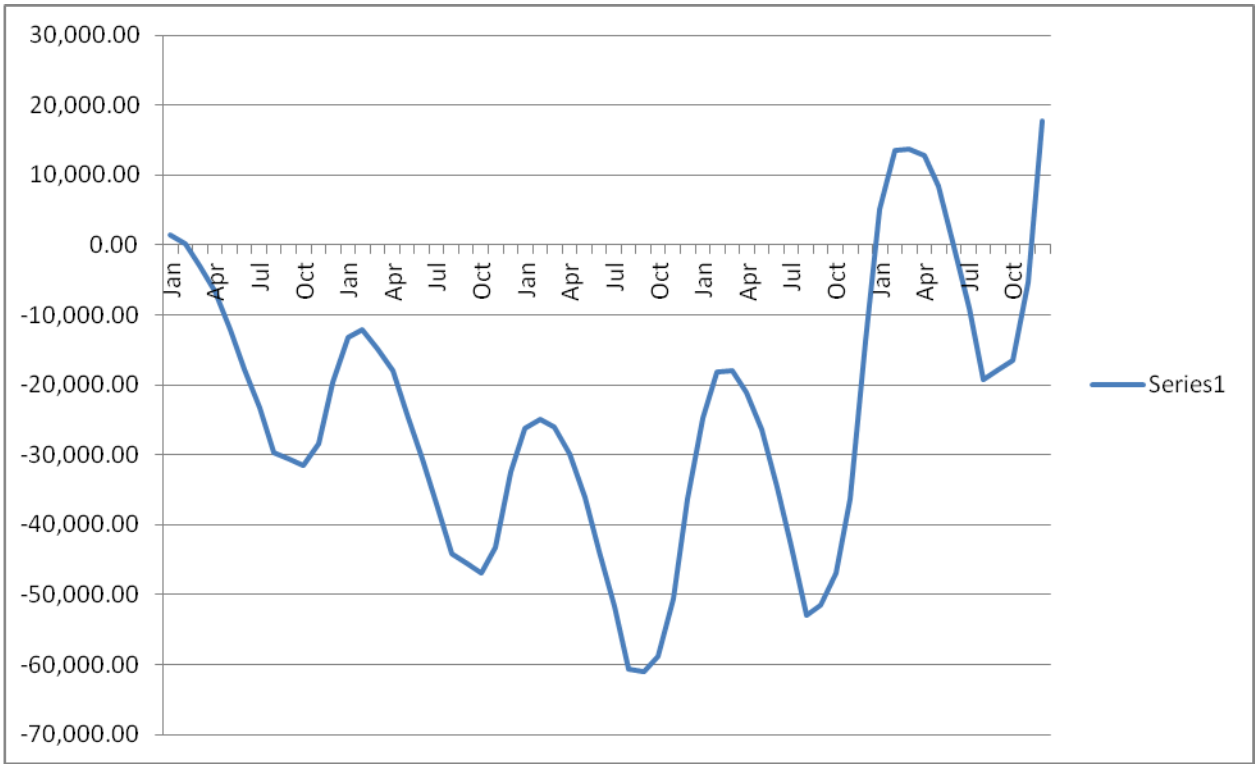

Figure 6: Net cash-flow with an ineffective RHI

5.4.3 With an effective RHI

The demand has been taken as per table 10 in the Markets section of this report.

	2012	2013	2014	2015	2016
Demand Tonnes 35% mc	3,050	3,300	3,600	3,900	4,250

Table 21: Summary of market demands (assuming 15% market share) with and effective RHI

Assumptions to this model:

- £47,125 Capital costs in year 1
- £28,275 loan introduced in year 1
- £18,850 grant in year 1
- Supplying 35% moisture content fuel
- Buying timber throughout the year
- Only seasoning the timber for one summer
- Charging 3.40 p/kWh for woodchip
- Charging £75/m3 for firewood
- Includes a firewood supply business of 400tonnes by year 3

From the graph below we see that the business has a much smoother cash flow than the previous cash flow model and by the end of year 1 has a closing balance of £9,500. This rises to £219,000 by the end of year 5 with a net cash flow of £82,000. The issue of cash flow in the summer months is still present and shows negative balances through to year 3.

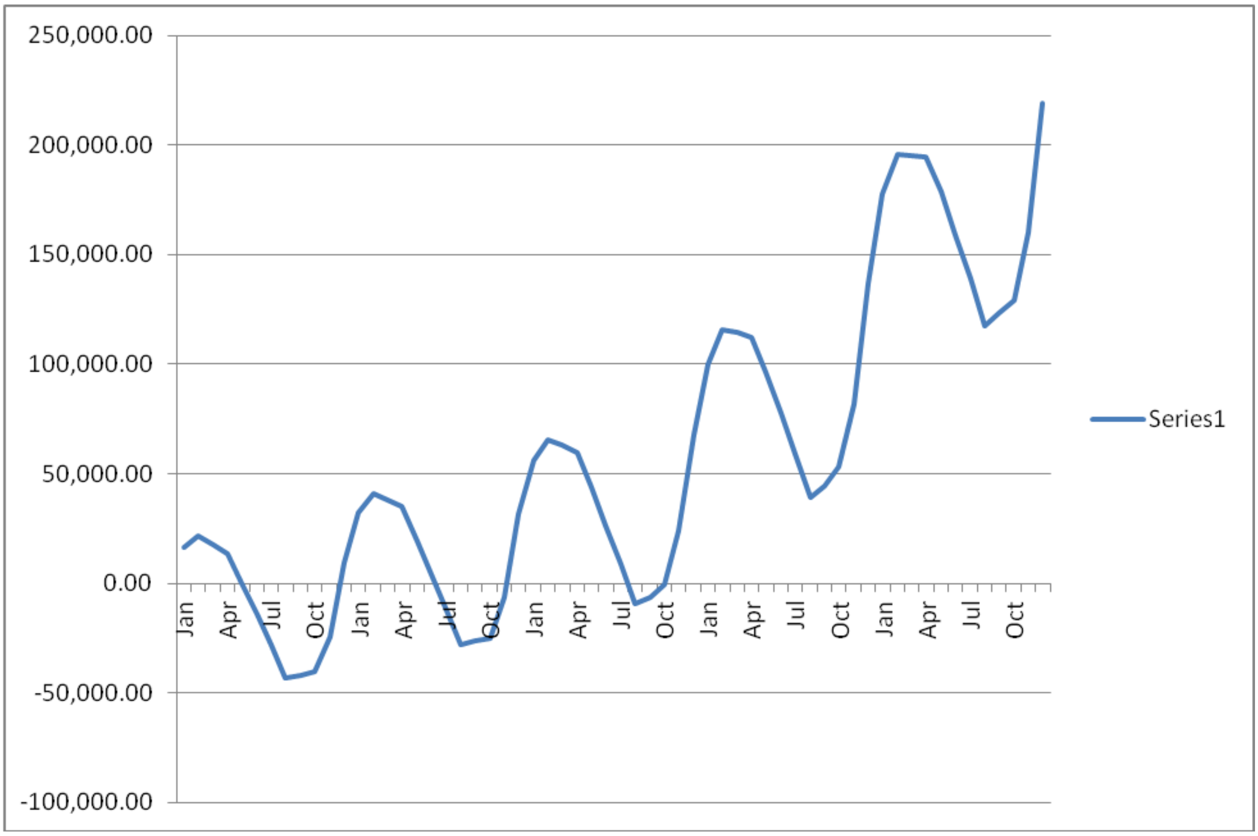

Figure 7: Net cash-flow with an effective RHI

5.4.4 Sensitivity Analysis – effective RHI

The graph below shows the potential impact that reduced sale prices and increased raw material prices may have on the business under the effective RHI scenario.

Assumptions to this model:

- Reduced woodchip sale price to 3.1p/kWh
- Reduced firewood sale price to £65.00/m3
- Increased roundwood price for chip to £30.00
- Increased roundwood price for firewood to £50.00

From the graph we can see that there is a significant impact on cash flow balances with a balance of -£44,000 in year 1 escalating to -£144,000 in year 5.

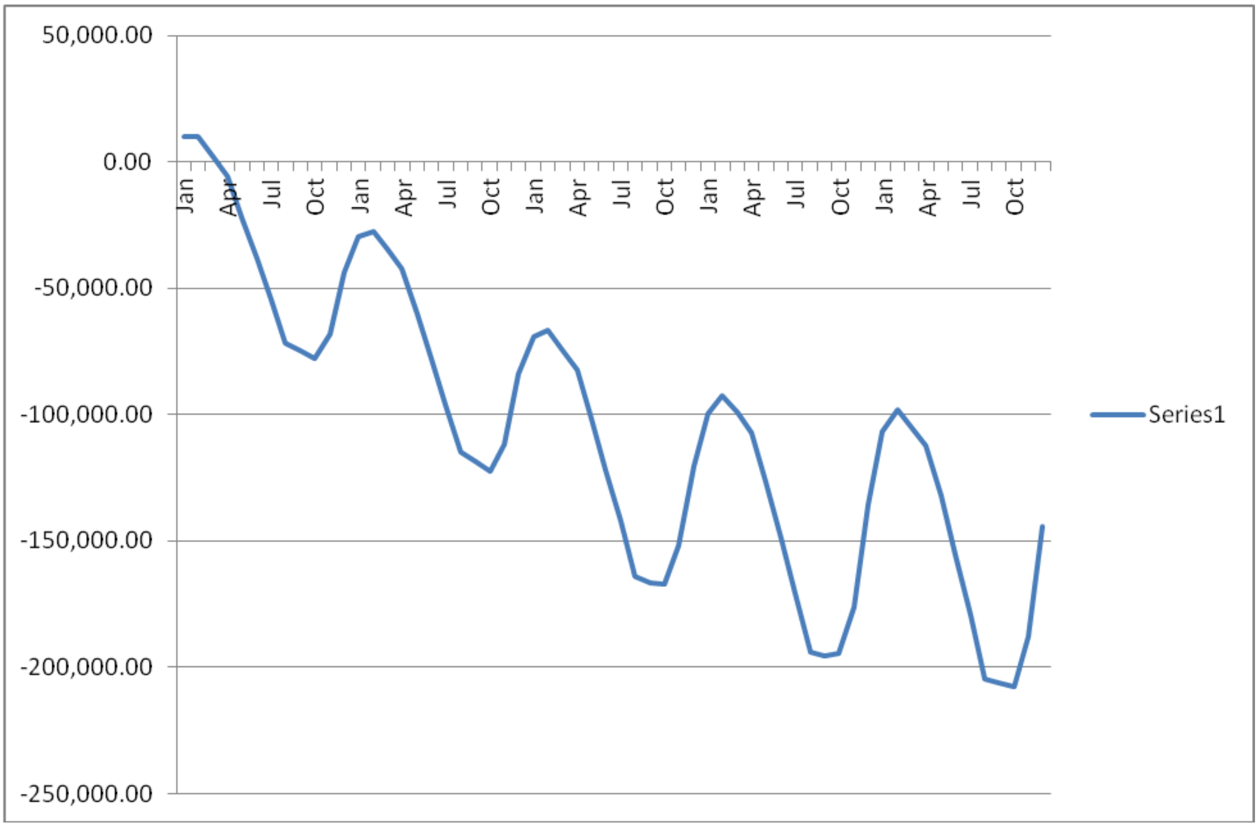

Figure 8: Net cash-flow effective RHI sensitivity analysis

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5.5 Cash-flow Summary

The net cash-flow for the model based on an ineffective RHI shows negative balances for the first 2 years and cumulative losses to the value of -£27k through to year 3. By year 5, net cash-flow is at £32k and the cumulative cash flow balance is at £27k.

The cash-flows for the effective RHI models show positive net cash flows from year 1. Indeed by year 5, the cumulative cash flow balance to the business is £196k. The sensitivity analysis shows how sensitive the model is to changes in sales prices and raw material prices. Over 5 years, the cumulative cash flow losses are £168k. Of course, sales prices could indeed go up and, based on trends over the last 5 years, woodfuel sales prices have indeed risen and in some areas, prices for firewood have increased by as much as 50%.

From the cash-flow prediction it can been seen that one of the largest single expenditure is the contract haulage of the woodfuel - £85k by year 5. At this stage of the business it would be worth investing in a delivery vehicle suited to most situations, such as an 8-wheel hook loader which has the versatility to be used for a number of applications. A delivery lorry could easily be used full time just within the business having over 400 deliveries during the heating season, and it would be available for commercial hire in the summer months. This way the business can recoup a greater proportion of the costs and increase profit, and more importantly gain an income during the cash-lean summer months.

Even by year 5 we would not consider it necessary to invest in a chipper unless it can be used as a contract chipper outside of the business. The business only has need of a chipper about 30-40 times a year (less than once a week) costing less than £45k for contracting, therefore it would need a significant amount of outside contracting to make the investment work. The chipper contracting market is highly competitive, already there are more chippers available than are needed for the emerging woodchip market.

Based on the cash flow results of the two models, we have performed a third model which is based on a more conservatively effective RHI accelerated market but with slightly higher but stable fuel sale and raw material prices. The market grows much more exponentially from an initial 1,500 tonnes in year 1 to over 3,500 tonnes in year 5 as shown in table 22 below.

	2012	2013	2014	2015	2016
Demand Tonnes 35% mc	1,500	2,000	2,500	3,000	3,500

Table 22: Summary Market demands on conservatively effective RHI

We believe this could be a more realistic model on which to base the business. The graph below shows the 5 year cash flow.

Assumptions for the third model:

- £47,125 Capital costs in year 1
- £28,275 loan introduced in year 1
- £18,850 grant in year 1
- Supplying 35% moisture content fuel
- Buying timber throughout the year
- Only seasoning the timber for one summer
- Charging 3.60 p/kWh for woodchip
- Charging £80/m3 for firewood
- Includes a firewood supply business of 400tonnes by year 3

From the figure 9 below we can see that there is a negative net cash flow in year 1 of -£15,000 but by year 5 the net cash flow is £92,000 and a cumulative balance of £184,000 by year 5. There are significant summer negative cash flows through to year 3.

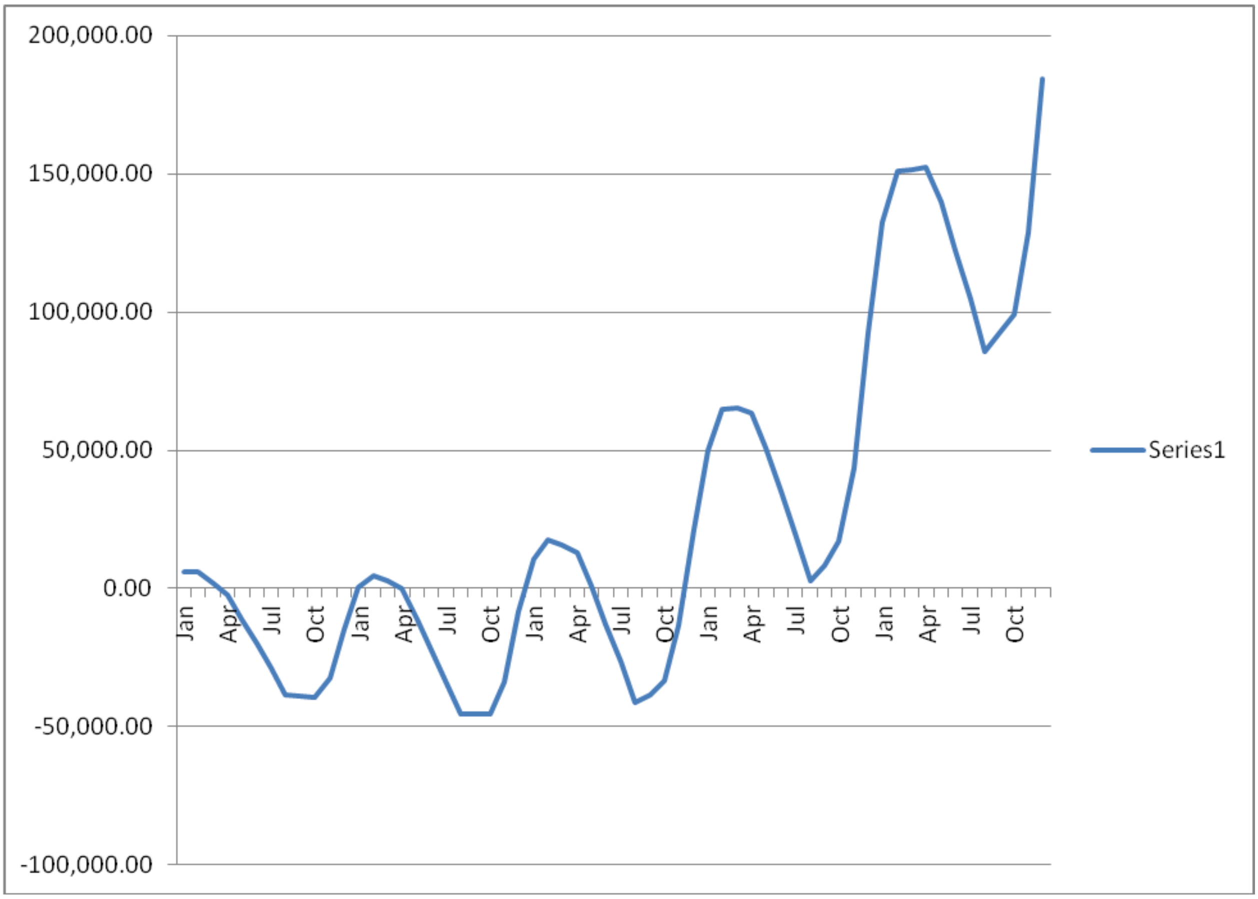

Figure 9 Conservatively effective RHI

6 Risk Assessment

In this section we will review the overall risk involved with the business. Please note that the assessment will be a subjective opinion from ourselves.

From the above cash flows the most stable business model is the Third Option which expands exponentially with an annual increase of about 500 tonnes a year.

For any supply business, the larger the number of supply contracts or boilers, the lower the risk from boiler breakdown or customer bankruptcy causing cash flow problems. Suppliers who have fewer customers will have a greater proportion of their income stopped should a boiler break down or a customer go bankrupt.

It is also advisable to enter into longer term supply contracts, say for at least 5 years, with annual price reviews as this will help to plan cash flow, purchase raw material in advance and indeed secure future investment in the business as it expands.

Competition is likely to be the greatest risk to this business, as there are established business who are operating close to Kirkley Hall such as No 1 Woodfuels and Park End Farms. Both of these companies have a good reputation for delivery of quality fuels. At present these competitors don't have a physical depot in the immediate vicinity of Kirkley Hall, but the way their business model works they could quite quickly move into the area by partnering with a farmer or similar business that has available storage facilities, to act as a satellite depot to the parent company. At the present time the wood fuel market in South Northumberland would not justify these businesses setting up a depot in the area, however the RHI will undoubtedly create the level of market where these competitors will be planning expansion. One means of mitigation against these competitors would be to ensure price competitiveness. However, these competitors are buying large volumes of timber for the whole of their business and therefore should be able to buy timber relatively cheaply, which could make undercutting their price uneconomic. Therefore without a solid partnership with some other large heat user it could be difficult to win tenders against these competitors.

Public Sector Procurement Policy Issues

At present public sector procurement policy does not have provision to assess tenders on a "Local / Sustainable" criteria, with the exception of CPET requirements for wood products (which is designed to avoid international deforestation, rather than address the issues of carbon and social sustainability in the UK market which is well regulated enough to ensure resource sustainability). In our opinion this makes it difficult for smaller, local suppliers to get a foot in the door against the large scale national operators. Also a number of public sector bodies are looking at national and regional framework procurement contracts, these by their very nature are not flexible enough to allow localised supply and only usually involve large national companies. To be as sustainable as possible from both a carbon and social point of view, woodfuel supply chains need to be as local as possible.

Therefore public sector procurement policy in some ways is contrary to government carbon, social and sustainability targets as set out in climate change, energy and sustainability policy.

Raw material availability is unlikely to be a limiting factor in the next 5 years for this business as the timber harvesting programme in Northumberland is very active, and likely to continue to be so with the continued upturn in the timber market. However, the open timber market is subject to price fluctuation and competition like any other market. At the present time the main competition for the wood fuel grade timber is the biomass power producers and the panel board industry. Renewable power production is subsidised under the Renewable Obligation (RO) and the Feed-in-Tariff (FIT) therefore they are able to pay a higher price than the panel board manufacturers. However the heat market is now subsidised in the form of the RHI, and is also normally displacing a costly fuel such as kerosene, which means the heat purchaser can afford to pay more than either of these competitors for the raw material.

7 Appendices

Appendix 1 - Fuel Quality Assurance

Contact Details of Testing Facilities

	CERAM	TES Bretby	SGS
Address	Queens Road Penkhull Stoke-on-Trent Staffordshire ST4 7LQ	Bretby Business Park Ashby Road Burton upon Trent DE15 0YZ	
Tel	01782 764444	01283 554400	0151 350 6652
Web	www.ceram.com	www.esgl.co.uk/tesbretby	www.uk.sgs.com

Woodchip Moisture Content Testing Methods

Conventional Oven

Take a known quantity (i.e. weigh it!), e.g. 1000g, and place on a tray or in a steel receptacle in your oven and leave for 12 hours at 105^{o}C.

Re-weigh your sample and perform the sum:

$$MC\% = \frac{(W_s - W_o)}{W_s} \quad 100$$

W_s is weight of sample
W_o is weight after drying

e.g. a 1kg sample which when dried weighs 500g had a moisture content of 50%.

Microwave Oven

(PLEASE NOTE THIS METHOD DOES HAVE A RISK OF FIRE AND THE MICROWAVE OVEN SHOULD NOT BE LEFT UNATTENDED)

Sample size: The sample was taken from the back of the delivery vehicle, a twin axle which holds approximately 8m3 (~2tonnes).

12 increments where taken (twice the number recommended for this size load) with a size 4 shovel, as per the draught European standard;
CEN/TS 14778-2:2005 Solid biofuels - Sampling - Part 2: Methods for sampling particulate material transported in lorries

This resulted in a combined sample weight of 13.2kg.

The combined sample was coned-and quartered as per the draught European standard;
CEN/TS 14780:2005 Solid biofuels - Methods for sample preparation

This resulted in an analysis sample of 3.3kg

Drying method: Please note that this method is not using a European Standard method but does however give a very good guide to the moisture content.

The 3.3kg analysis sample was split into 4 and loaded into plastic tubs (which were weighed when empty) and then weighed to give the wet weight.

1) Each tub was then microwaved on high for 10 minutes, stirred

2) Microwaved on high for a further 10 minutes, stirred

3) Microwaved on medium for a further 10 minutes, stirred

4) Microwaved on low for 5 minutes then weighed.

5) Repeat step 4 until 3 consistent weights are obtained, this is the dry weight.

Results:

	Sample 1	Sample 2	Sample 3	Sample 4
Wet Weight (g)	825	765	845	865
Dry Weight (g)	610	585	645	645
% Moisture	26	23.5	23.7	25.4

Average Moisture content = 24.65 %

Appendix 2 - Depot design recommendations

The depot is always an important part of any supply chain and depot design is important to help factors such as timber drying, chip drying, vehicle control and to minimise handling.

Please bear in mind the following are general guidelines and are considered best practice, however actual site constraints will often necessitate different designs. Therefore please consider the following as recommendations.

Overall site layout

The site layout will determine the amount of handling of timber and product and also vehicle control. In Figure 10 we have a suggested ideal layout.

It is important to have the timber seasoning area as close to the chip store as possible to reduce timber handling times when moving timber to be chipped.

During a chipping operation it is possible to double the chipping output rates through well thought out layout. If it is possible place a temporary timber stack right next to the chip store where the chipping will take place. This stack should hold at least the amount of timber expected to be chipped in each chipping operation (even if that operation is over several days) which for most large commercial chippers is between 100 and 150 tonnes a day. Chipping lasts at least one day, normally involving a stationary chipper and a loading vehicle, and if this operation were to take place in the front of the chip store it would get in the way of any delivery vehicle that needs to be loaded with chip. A way to avoid this is to move the chipping operation to the rear of the chip store and fire the chip in through holes in the back wall of the store.

On larger depots, which can expect to have several delivery vehicle movements a day, it is important that the vehicles do not get in each other’s way thus increasing vehicle waiting times, which in turn can lead to increased costs. Therefore a good depot will have an apron (normally concrete) in front of the chip store where lorries can wait whilst being loaded, this apron should not get in the way of any access roads.

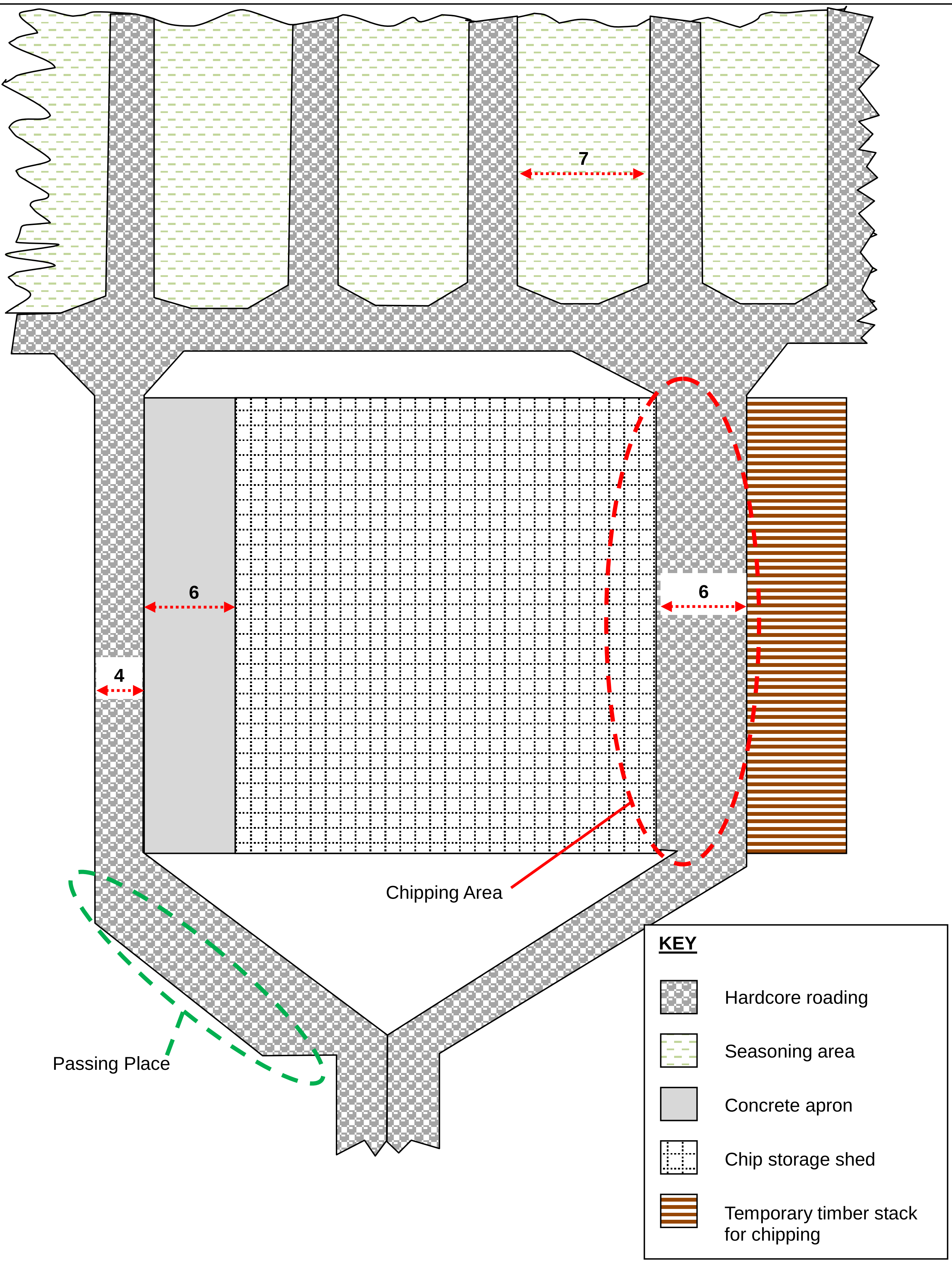

Figure 10: Depot layout with key dimensions in metres (NOT TO SCALE)

Seasoning area

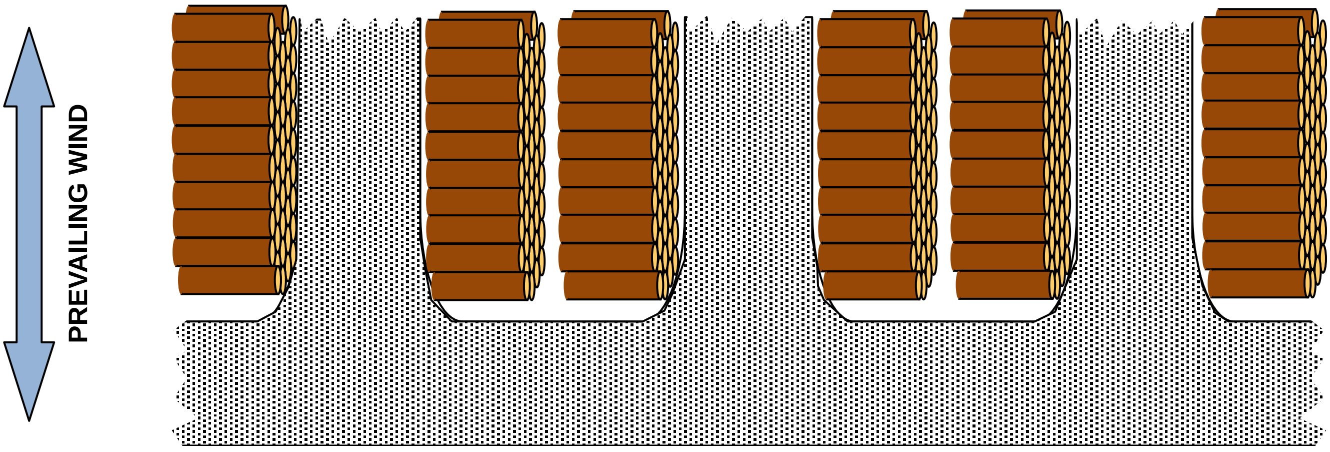

Figure 11: Roundwood stack layout with access track

Chip store

The overall design idea of the chip store is to stop rain wetting the chip, but to allow as much ventilation as possible. A modified agricultural storage shed is ideal, see Photo 19. The general design we would recommend is as follows;

- A strong 2m high wall on the sides and back capable of taking the pressure of a loader pushing chip against it (breeze block is normally sufficient)
- Open wooden slats above the wall to the eaves (Yorkshire boarding or equivalent) enough to keep out the worst of the rain but allow the wind to get in
- At least 7.4m height to the eaves and 9m to the ridge to allow loading of delivery vehicles inside
- The open side away from the prevailing wind if possible
- Smooth finish concrete floor (float finish or similar) capable of taking heavy vehicles without disintegrating
- The concrete should continue onto an apron extending at least 4m in front of the store so that any chip which spills out of the store does not get contaminated with soil and stones.

Photo 19: An example of a well designed woodchip store