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Scoping Study to identify the potential for Biomass Combinable Crop drying in the North-East

Report for: Aberdeenshire Council and Forestry Commission

Prepared by:
SAOS Ltd
Rural Centre
Ingliston
Edinburgh,

Diack Associates Ltd
Business Management and Marketing Services

New House
Mackstead, Inverurie
AB51 5DU
Tel: 07778 872309
e-mail: diackkay@yahoo.co.uk

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EXECUTIVE SUMMARY

1. There is growing interest within the farming community in biomass as an alternative fuel source for drying combinable crops. Traditionally farmers use gas oil (red diesel) or propane (LPG) to dry their grain crops at harvest, however, due to the rising cost of fossil fuels and concerns over future supplies many are now actively looking for alternatives. Grain drying represents a major cost for arable farmers with fuel costs of the order of £10,000 for a 200ha arable farm.

2. With the introduction of the 'Renewable Heat Incentive' (RHI) in November 2011, eligible schemes can now receive a financial subsidy which makes the commercial case for switching to biomass for drying grain even more attractive. The continuing rise in the price of fuel coupled with the RHI and the drive to reduce carbon emissions is creating a real interest in alternative fuels for drying grain.

3. The study was commissioned by Aberdeenshire Council and the Forestry Commission (Grampian Conservancy) to assess the potential development for biomass grain drying, including the potential demand for biomass and its availability (supply issues), amongst the farming community within the north-east region.

4. Although the north-east is traditionally seen as a livestock region, it actually accounts for over 30% of Scotland cropping area and importantly grows 39% of Scotland's spring barley so this is an important arable region. Annual combinable crop production in the region is circa 911,00 tonnes of which 785,000t is dried, 60% on-farm with the balance (40%) in central stores, using a combined estimated total of 8,227,600 litres of fossil fuel for drying. At an average cost of 67p per litre, this equates to a total fuel bill of in excess of £5.5 million to dry the region's combinable crop production.

5. There are 11 central store operators in the region who dry and store an estimated 441,000 tonnes of combinable crops – nearly half the region's annual production. All 11 operators were contacted and invited to contribute to the study. The study showed that central store operators had only a limited understanding and awareness of the potential of biomass for crop drying. A range of factors was identified as potential barriers for the uptake of biomass drying systems.

6. Predicting the future potential uptake of biomass crop driers will depend on the commercial economic viability and practical considerations. Over the next ten years, three levels of uptake were proposed producing a potential biomass demand of 4,099m^3, 8,200m^3 and 12,304m^3 respectively per annum. The actual uptake would be dependent on many factors but principally economic viability and RHI eligibility. It is known from previous crop storage studies that there is an aging grain drying and handling infrastructure which is in need of updating.

7. The study interviewed two early adopters of biomass grain driers to discover their experiences, better understand the economics and any lessons learned. The report contains two case studies each of different scales and technologies. The first is a central store using a continuous burner (950kW) fuelled by wood chip applied to an existing continuous flow drier. The second is a farm-scale system, using a batch burner (400kW) fuelled by round wood on an existing 100t tray drier.

8. If the use of biomass for crop drying is to be encouraged, it is important there are sufficient supplies of locally sourced biomass to support any future development. At present it is estimated 700-800,000**m^3** is harvested annual from the region, all of which has existing markets. The study has shown that farm woodland in the region, which is largely

unmanaged, has the potential to supply 43,600m^3 per year, providing enough energy to dry over 670,000t of cereals. In addition, farmers also have access to surplus straw which can be used as a biomass fuel source. In particular, there are significant supplies of OSR straw (32,664t) which has little value and the potential to dry 1 million tonnes of cereals – all the region's production.

9. The renewable heat incentive scheme (RHI) was launched by the Government in Nov 2011. It aims to replace fossil fuel with renewable energy sources of heat to reduce emissions and stimulate a new sector. The RHI provides a major incentive for owners to invest in renewable heat technologies. The tariff rates depend on the scale and technology and like feed in tariffs (FITs) for renewable energy will be guaranteed for 20-years and index linked (the rates have been set to provide a return of 12%).

10. The potential uptake of biomass crop drying will largely depend on the commercial viability – the financially case to switch from fossil fuels to biomass. This is a complex issue and will vary with each situation. Factors include: the existing system, the capital cost to change, the scale of operations, operating costs and any practical considerations. Any investment in renewable heat will invariably mean higher capital costs, however, the benefits is usually lower operating costs – lower fuel costs per tonne. The lowest capital cost is associated with existing tray driers which are easily adapted for biomass burners so these are likely to experience the early uptake. The report also shows the relative energy costs of a range of fuels used for crop drying.

11. An important argument for using biomass is that it is carbon lean and therefore contributes to the reduction in greenhouse gases (GHG). The study has shown that the uptake of biomass could make a significant reduction in the GHG emissions associated with grain drying.

12. The key conclusion is that biomass crop drying can be commercially viable and has real benefits for both individual growers and the region as a whole. Although biomass crop drying is at an early stage, drying costs are greatly reduced making the case to switch. The eligibility of biomass crop drying for RHI will only strengthen the case. Biomass driers also provide an opportunity to future proof a farm business against the shock of rising energy costs in the future. Those arable farmers with existing farm woodland or easy access to biomass are likely to show the most interest in biomass crop drying.

1 INTRODUCTION

13. There is growing interest within the farming community in biomass as an alternative fuel source for drying combinable crops. Traditionally farmers use gas oil (red diesel) or propane (LPG) to dry their grain crops at harvest, however, due to the rising cost of fossil fuels and concerns over future supplies many are now actively looking for alternatives.

14. Cereal crops have to be 15% moisture content (mc) or less for safe storage. Normally cereals are harvested in the range of 18-22% mc so crop drying is imperative in Scotland. Often crops are harvested at higher moisture content in late wet seasons e.g. wheat was harvested at over 30% mc last year, which costs over £20 per tonne to dry. Grain drying represents a major cost for arable farmers with fuel costs of the order of £10,000 for a 200ha arable farm.

15. With the introduction of the 'Renewable Heat Incentive' (RHI) in November 2011, eligible schemes can now receive a financial subsidy which makes the commercial case for switching to biomass for drying grain even more attractive.

16. The continuing rise in the price of fuel coupled with the RHI and the drive to reduce carbon emissions is creating a real interest in alternative fuels for drying grain. Renewable energy sources have been identified as a desirable alternative to fossil fuels providing a sustainable low carbon source of energy which also improves the security and diversity of energy supply. This study will set out a clear description of the opportunity to use biomass, the advantages, issues to be dealt with, and how the farming industry in the north-east of Scotland might develop and take advantage of this opportunity.

Study's aim and objectives

17. The overall aim is to carry out a scoping study to assess the potential development for biomass grain drying, including the potential demand for biomass and its availability (supply issues), amongst the farming community within the north-east region.

Specific Objectives include:

- Estimate the number of on-farm driers, tonnages dried and fuel use
- Review of the number of central drying sites, tonnages dried and fuel use
- Describe a typical on-farm and central store biomass drying set up
- Identification of the barriers to the development of biomass drying
- Calculation of the tonnage of biomass required to dry % per tonne of crop
- Calculation of the potential fuel savings, in terms of carbon and £ value
- Estimate of the availability of biomass in the region
- Estimate the added economic value to the area by using local biomass.

Methodology

18. To complete the study, a number of linked stages were undertaken including; desk based research utilising agricultural census data, telephone interviews with central store operators, and case studies for gathering experience and learning. Two previous studies[1] conducted by SAOS looking at on-farm grain handling infrastructure in 2006 and 2011 were also used.

[1] "The Development of Central Co-operative Crop Storage in Aberdeenshire" (2006) SAOS Ltd.
"Aberdeenshire Crop Storage Survey" (2011) SAOS Ltd.

2 COMBINABLE CROP PRODUCTION

19. The study area was defined as the 'North-East' which includes the Local Authority areas of Aberdeen City, Aberdeenshire and Moray. The 'North-East' was selected due to the ready availability of regional agricultural census data[2] from the Scottish Government.

20. The North-East is a mixed farming region accounting for some 11% of Scotland's total agricultural land. Although the North-East is traditionally seen as a livestock region, it actually accounts for over 30% of Scotland cropping area and importantly grows 39% of Scotland's spring barley so this is an important arable region – see table 1 below.

Table 1: Area (ha) of combinable crops in the north-east 2008-11.

	2008	2009	2010	2011	% Scotland
Wheat	18,930	16,184	17,650	18,280	16%
W Barley	24,199	22,320	19,953	18,900	40%
Sp Barley	101,000	101,717	95,217	103,304	39%
Oats	5,334	4,584	4,799	4,132	20%
OSR	11,958	11,938	12,712	12,563	35%
	163,429	158,752	152,341	159,190	

21. Annual production of combinable crops will vary depending on the planted area and average yields – see appendix 1 for average yields 2010-2011. Table 2 shows the estimated annual production for combinable crops in the North-East using the 2011 cropping area and average yields for the region.

Table 2: Estimated Combinable Crop Production (tonnes)

	Area (ha)	Av yield	Tonnes
Wheat	18,280	7.9	144,412
W Barley	18,900	7.2	136,080
Sp Barley	103,304	5.4	557,842
Oats	4,132	6.1	25,205
OSR	12,563	3.8	47,739
			911,278

3 ON-FARM DRYING INFRASTRUCTURE

22. Table 3 shows the estimated number of on-farm driers in the region across the different types. The census data shows there are 3,149 holdings in the North-East who grow combinable crops, however, this over estimates the actual number of farm businesses as some businesses will operate more than one holding. The number of holdings also comprise of part-time and full-time farms – see appendix 1 for breakdown by size. The study estimated there are some 1,271 on-farm driers with mobile driers being the most common drier type (57%).

[2] "Economic Report on Scottish Agriculture" 2012 Edition, RESAS Scottish Government. www.scotland.gov.uk/Topics/Statistics/Browse/Agriculture-Fisheries/PubEconomicReport

Table 3: Estimate of on-farm drier type

Drier Type	%	No.
Mobile	57	724
Tray	24	305
Continuous	16	203
On-floor	1	14
Other	3	25
		1,271

Note, the mix of on-farm driers was established from the earlier (2011) crop storage study.

23. The popularity of mobile driers does limit the potential uptake of biomass for crop drying as they do not lend themselves to integrating with a biomass burner. In contrast, tray driers are relatively easy to adapt with a biomass drier. It is also possible for continuous flow drying systems to utilise a biomass burner.

24. Table 4 shows the estimated tonnage dried each year. Note, this is less than total production as some feed grains are preserved using chemicals (e.g. propcorn). In addition, some grain will be harvested at 16% moisture content or less and simply stored without drying for short-term use. The annual tonnage dried from the region is estimated at 785,094 tonnes of which some 457,094 (60%) is dried on-farm.

Table 4: Estimate of production dried annually

	Tonnes	% dried	dried tonnage	On-farm	Central Store
Wheat	144,412	100	144,412	124,412	20,000
W Barley	136,080	90	122,472	102,472	20,000
Sp Barley	557,842	80	446,273	196,273	250,000
Oats	25,205	96	24,197	16,197	8,000
OSR	47,739	100	47,739	17,739	30,000
	911,278		**785,094**	**457,094**	**328,000**

Annual Fuel Use for Crop Drying

25. The following table shows the estimated fuel use to dry the combinable crops in the North-East. The share of different fuel types was determined from the previous study in 2011. This estimate includes both on-farm and central store fuel use.

Table 5: Estimate of annual consumption of various fuels to dry combinable crops (785,094t)

	%	Use /tonne	Quantity (litres)
Gas Oil	68	10 l	5,338,800
Kerosene	20	10 l	1,570,000
Propane (LPG)	12	14 l	1,318,800
Biomass			
	100		**8,227,600**

4 CENTRAL STORE OPERATORS

26. Central grain stores provide an important service in the grain supply chain. They dry and store combinable crops and provide a procurement service for a range of customers. It is estimated there are some eleven central store operators in the region which also includes three malting plants. Collectively they process over 441,000 tonnes per year – nearly half the annual production in the North-East. It should be noted, however, these central stores and maltsters will draw supplies from a wide area not just from within the North-East. The list of central stores operating in the region is provided in Appendix 2.

27. All eleven central store operators in the region were sent either an e-mail or letter informing them of the study and inviting them to participate in a brief telephone interview. The aim of the interview was to establish current practices, baseline information and to gauge respondents interest in biomass crop drying. In total nine operators participated in the study. The semi-structured interview questions are provided in appendix 3.

28. With respect to grain drying infrastructure, the following table 6 shows the number, range of driers and the fuel type used by respondents. It shows that although there has been some investment over the last 5-years, the majority of the driers in central stores are over 20-years old and in need of upgrading.

Table 6: Grain drying infrastructure on central stores.

Operator	No. Driers	Age	Main Type	Fuel
1	3	4 yrs	Cimbria	Propane
2	2	30 & 33 yrs	Alvan Blanch	Propane
3	2	22 yrs	Law Dennis	Kerosene
4	2	4 & 25 yrs	Master	Gas oil
5	2*	15 & 22 yrs	Alvan Blanch	Kerosene
6	3	15, 25, 30 yrs	Alvan Blanch	Propane
7	5	3 & 15 yrs	Cimbria	Propane
8	1	15yrs	Law Dennis	Gas oil
9	3	3 & 35 yrs	Alvan Blanch	Kerosene

Note, Operator 5 is planning to install a new drier (50t/hour) this summer and opting for another continuous flow drier using kerosene.

29. With respect to the awareness of the potential of biomass burners for grain drying, most of the operators had only a limited understanding and knowledge of biomass systems. Only two of the nine interviewees had a good basic understanding and actually had done some research on biomass burners. The main finding, however, was that operators had only a very limited understanding of the potential of biomass drying. In addition, there was a limited understanding of RHI with no one familiar with the rates or the potential scale of the support.

30. There was some interest amongst operators in biomass drying, however, the majority admitted they didn't know enough to make an informed decision. The impression was that these senior managers were busy people and that biomass drying was still an unproven system in their view.

31. One of the main objectives of the interviews was to determine the barriers for the uptake of biomass crop driers. A range of factors were identified, however, at their root is a lack of information. The main barriers to the uptake of biomass cited were:

- *The high capital cost of biomass systems*
- *Uncertainty of eligibility of gaining RHI support*

- *Happy with current system*
- *Unproven technology. Any new biomass system will need development, adds complexity, risk and hassles.*
- *The economic case is uncertain; costs versus savings, pay-back*
- *Concerns over future biomass supplies and its future cost (an assumption that the cost will simply track energy prices)*
- *Concern over the reliance on RHI subsidy, don't trust Government will not change scheme in future.*
- *Getting the time to research the potential of biomass systems.*

5 POTENTIAL SCALE OF BIOMASS GRAIN DRIERS

32. Although biomass burners are widely used by various sectors their use for grain drying is at an early stage. Unlike gas, biomass has the advantage that it does not give off water on combustion so can dry crops in a shorter period at similar temperatures.

33. The uptake of biomass crop drying will largely depend on the commercial viability and the experience of the few early adopters. If there is an economic case for the switch to biomass burners and the developed systems are practical for crop drying, then uptake will take off. **It is all dependent on these two key factors; the economic case and practical considerations.** With respect to practical considerations, labour and time are limited resources on increasingly busy farms so any developed biomass system needs to take this into account.

34. Until the economic case is proven and biomass crop drying systems are practical then any prediction of uptake and scale is purely speculative. In an attempt to examine the potential demand for biomass a range of potential uptakes was considered. Over the next ten years, three levels of uptake were examined as follows:

Table 7: Potential Biomass demand at three different uptake levels.

	Low	Mod	High
On-farm	10%	20%	30%
Central store	5%	10%	15%
Tonnage dried by biomass	63,355	126,720	190,150
Energy to dry (MW)	6.97	13.94	12.91
Volume wood fuel (M^3)	4,099	8,200	12,304

35. Table 7 shows that with a 'low' uptake the biomass demand could be 4,099m^3, while under a 'moderate' and 'high' uptake the biomass demand would be 8,200m^3 and 12,304m^3 respectively. As previously mentioned, the actual level of uptake would be dependent on the economic case and practical considerations.

36. A point worth noting is that its widely accepted that on-farm grain drying and handling infrastructure is aging and in need of upgrading. In many cases the grain drying and handling systems are over 15-years old. Many growers will be faced with the need to improve and upgrade their drying systems over the next 5-years which presents an opportunity to adopt a biomass burner if the economic case is proven.

6. CASE STUDIES

37. The aim of this section is to provide examples of early adopters of biomass grain driers, to discover their experiences, understand the economics and any lessons learned. There are two case studies, each of different scales and technologies. The first is a central store using a continuous burner (950kw) fuelled by wood chip applied to an existing continuous flow drier. The second is a farm-scale system, using a batch burner (400kw) fuelled by round wood on an existing 100t tray drier.

Whitehills Grain Store, New Deer (courtesy of Gordon & Bill Elrick)

The Whitehills store is owned and operated by brothers Bill & Gordon Elrick. The store was built in 1983 originally as an intervention store, and over the years has expanded to its current capacity of 35,000t with three continuous flow driers.

The brothers had been looking at the potential of biomass for a number of years and eventually, with the support of Ian Cowe (Forestry Commission) were successful in gaining a £100,000 grant under the 'Scottish Biomass Heat Scheme'.

The motivation to invest in a biomass burner was to reduce the cost of grain drying particularly with the rising cost of oil based fuels and increasing concerns over future supplies.

The new biomass burner system was installed in Jan2011 to be in place for the autumn harvest. The new system was installed and project managed by Colin Elrick of Turblown Ltd, Maud (www.kalvisboilers.co.uk).

The new plant involved erecting a shed next to the existing 15-year old Alvan Blanch continuous flow drier (rated at 34t/hr) to house the burner, heat exchanger and wood chip store.

The biomass burner is a Kalvis boiler (K 950M), which is manufactured in Lithuania, capable of 950kWh. Importantly this is a continuous burner so able to maintain the heat output unlike batch systems where the temperature fluctuates.

The burner runs on wood chips, heating water which is pumped through a heat exchanger placed at the air inlet of the drier. The heat exchanger raises the ambient temp by 55^{o}C so normally operates at 65^{o}C. There is also a propane burner (rated 120kw – 1,400kw) on the drier which is used to regulate the temp for crop drying. It can also operate on its own so acts as a back-up and normally used for the first hour when the biomass burner is first light.

The wood chip store holds 80m^3 (approx 30-40t) enough for 4 days and has a moving hydraulic floor to automatically feed the burner. The burner uses approx 1m^3 chips per hour which will dry 20 tonnes depending on the grains moisture content (MC). Wood chips are sourced locally and cost £80/tonne. The moisture content of the wood chips varies from 25-40% although ideally they should be below 30% MC. The business also has 162ha of woodland so will have access to their own supplies in the future.

In total, the capital investment was £250,000, which includes £170,000 for equipment and £75,000 for civil works. The Elrick's believe drying costs have been halved using wood chips – a saving of nearly £4/tonne. They believe pay-back will take 4-years for their new system.

There is also an opportunity to apply for RHI which would involve repaying back the initial grant to support eligibility. If the plant did get RHI accreditation, potentially it could earn £36,337 per annum (or £2.42/t over 15,000t) which would be index linked for 20-years.

Assumptions:

- Dry 15,000t pa using the biomass burner.
- Throughput of continuous drier 20t/hr = operating for 750hrs
- 750hrs @ 950kw = 712,500 kwh
- 712,500 kWh @ 5.1p (tier 1) = £36,337.

Balring Farm, Mintlaw (courtesy of Hamish Watson)

Hamish grows 283ha (700ac) of combinable crops (2,100t) and installed a 100t tray drier with stirrers in 2007 (previously had 2 mobile driers). The tray drier was supplied from Clark & Sutherland and cost approx £60,000 which included the shed.

The tray drier used two burners fuelled by gas oil, normally operating at 55^{o}C with an electric fan blowing the hot air through the grain. A full tray (100t wet grain) would take 12hrs of drying (20% mc grain dried to 14%mc) plus a further 3hrs of cooling. Depending on the grain's moisture content it would normally take 1,000l of gas oil to dry 100t of grain (10,000kWh, 1L diesel = 10kWh). The annual cost to dry the combinable crops was £14,700 and rising annually.

Hamish's interest in biomass was first fuelled when he bought the Pitfour Lake Fishery which included some 80ac of coniferous trees. Originally he didn't put any value on the trees, however, a visit to the Aberdeen All Energy Conference sparked his interest in the potential of biomass burners.

Following some research he invested (Aug 2011) in a Glenfarrow 400kW batch burner (www.glenfarrow.co.uk) at a cost £30,000 which included full installation (burner estimated @£18k). The system took two men 5 days to install. This was used for the 2011 harvest along with one gas oil burner. Experience showed that the original heat exchanger was not big enough so was only able to produce heat to 23℃ instead of the 40℃ required.

To fuel the biomass burner Hamish purchased 7 artic loads (150t) of 2-yr old soft wood from Scottish Woodlands at a delivered cost of £ 44/t. It takes 3hrs to bundle 25 packs (0.5t) together in preparation for drying. The burner is filled by a tractor loader with a bundle of wood every 6-hrs. He estimates it takes 2.5-3t of the round wood to dry 100t grain (2.5t wood = 1,000l of gas oil)

Hamish applied (1st Dec 2011) to OFGEM for RHI approval and following the engineers inspection was informed he would be accepted if he enclosed the burner – the heating must take place in an enclosed space. Once this is completed he hopes to have written confirmation of approval. The accreditation process has been slow but fortunately was all handled by Glenfarrow. Currently there are 1,200 applications with only 50 schemes approved for RHI in the UK.

Glenfarrow have recently added another heat exchanger (@£4,000) which will raise the temp at the air inlet. Tests have showed it can reach a max temp of 46^{o}C although being a batch system falls progressively to 30^{o}C. Being able to re-fill the chamber when half burnt should lift the temp again. This harvest Hamish is planning to dry all the grain solely using biomass, although he accepts it will take longer (18 hours, + 6-hrs longer).
In the future, considering adding a 2nd burner to maintain the temp so can dry quicker and use the surplus heat for alternative uses (heating house, etc.) and earn RHI.

The economics
Previously to dry 100t of grain would take 1,000l gas oil @70p = £700 or £7/t
Using biomass, 100t grain would require 2.5t wood @ £ 50 = £125 or £ 1.25/t
A saving of £ 5.75/t or £ 12,075 per year for the farm (2,100t)

If eligible for RHI, can earn £7,711 for drying the grain which is index linked for 20-years
Effectively the crops are dried for free, plus £ 5,086 surplus.

Balring Farm, Mintlaw (cont)

Assumptions:

- Dry 2,100t pa using the biomass burner.
- Throughput of the tray drier 100t in 18hrs = operating for 378hrs
- 378hrs @ 400kw = 151,200 kWh
- 151,200 kWh @ 5.1p (tier 1) = £7,711

Without RHI, pay-back of the £34,000 capital cost would be 3-years from the savings in fuel cost.
With RHI, pay-back is less than 2-years plus crop drying in the future is free.

Sensitivity to the changing cost of biomass. Even if the price of wood increased to £100/t, the saving would still be £9,450 over gas oil.

Table A: Impact of the price of wood on savings over gas oil.

Price Wood (£/t)	dry 2,100t	Saving over gas oil
£50	£3,150	£12,075
£60	£3,675	£11,550
£70	£4,200	£11,025
£80	£4,725	£10,500
£90	£5,250	£9,975
£100	£5,775	£9,450
£110	£6,300	£8,925

Possible downsides of Balring's biomass' system:

- A bit of labour for filling the burner (15-mits every 6-hrs) and bundling the wood (3hrs to bundle 25 packs @0.5t)
- Have to purchase the biomass in advance of use
- System may need a bit development to optimise drying time.
- Need space to store the biomass – ideally under cover when dry
- Crop drying times may be longer depending on burner output
- Sometimes a bit of smoke, depends what burning – maybe a longer chimney?

There has been considerable interest in the biomass burner from the farming community with approx 120 farmers having seen the plant. Hamish is aware of a number of farmers who are planning to install a biomass system to dry their crops.

7. BIOMASS SUPPLY ISSUES

38. The aim of this section is to research the supply of biomass from farm woodland and other sources in the region. If the use of biomass for crop drying is to be encouraged, we need to ensure there are sufficient supplies of locally sourced biomass to support any future development. At present it is estimated 700-800,000**m³** is harvested annual from the region, all of which has existing markets.

39. Woodfuel is a traditional biomass fuel but has been little used in Scottish agriculture primarily because there is no history of ‘agro-forestry’ within Scotland unlike countries such as Finland and Austria. So although around 25% of the total woodland area within Scotland is on-farm there has been little concerted effort to manage this resource until recently.

40. A Grampian survey report carried out by SAOS working with the Forestry Commission (Grampian Conservancy) (*“Responding to the Woodland Creation Targets in Grampian Conservancy Area – 2010*”) suggested that on average, farms in Grampian had 7.5% woodland cover, nearly 70% of which was unmanaged with most of the farmers surveyed aspiring to achieve a woodland cover of around 10%. The survey also concluded that farm woodlands in Grampian area predominantly consist of small, scattered parcels of mixed and generally unmanaged timber. Much of this timber has been unrecorded, as recorded timber is predominantly within compartments larger than 2 ha – See Fig 1 appendix 4.

41. Given that farmers traditionally have had little interest in managing any farm woodland, there are few farm skills or specialised equipment available on farm. Most skills and equipment are contained within small specialised contracting companies. However, over the past few years timber has increased in price along with petroleum fuels, which has developed Machinery Rings’ interest in assisting their farmer members manage woodland to meet emergent commercial opportunities.

42. Machinery Rings operate by organising logistics between ‘demanders’ - members who require a service (e.g. planting, felling, haulage or wood) and ‘suppliers’ - members who can provide a service or goods (e.g. workers, young plants, felling / forwarding equipment or trucks). Rings also provide training services to their members to build capacity towards delivering services to required standards. Rings can therefore manage demand from farmers to better manage their woodland to provide wood fuel, with coincident management of contracting supply from the many small woodland contracting companies and specialist woodland advisors.

43. Ringlink (Scotland) Ltd is the largest Machinery Ring in the UK and operates throughout the whole Grampian conservancy area with offices in Elgin, Oldmeldrum and Laurencekirk. Ringlink have 2,500 members. Ringlink currently work with the forestry sector, providing services to the Forestry Commission and farmers, and also already actively providing training courses in forestry including chainsaw use, chainsaw from rope/harness, cross cutting & felling, windblown harvesting, etc.

44. Ringlink are ideally placed to provide this intermediary co-ordination and direct farmer engagement role but there are risks and uncertainties from their perspective too. Building the scale of farmer participation and organizing the markets and logistics will require specialist management and currently the overhead cost of that service cannot be met from a relatively small base of existing activity.

45. In order to address some of the challenges raised through the earlier research it was agreed to undergo a pilot “proving” phase to demonstrate whether or not using a Machinery Ring as

the catalyst and co-ordination hub can stimulate significant additional activity in woodland management and expansion on farms in its catchment area.

46. The first year of this project from September 2011 until April 2012 involved capturing data on the woodlands currently under management and owned by Ringlink members. Ringlink have undertaken a survey of their members to get a feel for the likely demand for a full woodland management and expansion initiative.

47. As of April 2012, 60 farms have been surveyed and recorded. The data presented below is based on these 60 farms which provide an excellent overview of the farm woodland resource that will be available for providing biomass.

Estimated Farm Woodland from Pilot project.

Total number of farms as at April 2012	60
Total area of woodland as at April 2012	1688.2 ha
Average woodland size per farm	28.1 ha
Total number of compartments	265
Average size of compartment	6.2 ha
Total m^3 of thinnings over next 5 years	19,033 m^3
Total felling & select fell over next 5 years	33,380 m^3

Analysis of compartments (265)	**Yes**	**No**
Evidence of previous management	116	149
Evidence of deer and squirrel damage	29	236
Foliar discolouration	11	254
Good access to site	194	71
Evidence of windthrow	44	221
Would comply with UKWAS Standard	143	122
Subject to an existing management plan	14	251
Tenant	1	264

Estimate of rough wood fuel from farm woodland in region

48. The following table provides an estimate of what might be called 'rough' wood fuel i.e. wood fuel in various lengths and circumference before any further processing, in the region.

	Pilot (60 farms) m^3	**All Ringlink (478 farms) m^3**
Birch	1,668	16,430
Lodgepole Pine	1,103	10,865
Mixed Conifers	404	3,980
All Thinnings	19,033	187,475
Total Volume	22,205	218,750

Note: The estimate of wood fuel from Ringlink members is based on an earlier survey which identified 478 members with woodland with an average size of 34ha.

Estimate of farm woodland potential

49. With an estimated total supply of 218,750 m^3 largely sourced from thinnings every 5 years the **annual potential farm wood fuel harvest is circa 43,600m^3.** This is largely unrecorded wood fuel so additional to current 700-800,000**m^3** annual supply from the region.

Logwood (stack air dried @20%mc) mixed species, mid range = 1,700 kwh /m^3
Therefore potential annual energy = 74,120 Megawatt hours per annum from biomass

On average a tonne of grain will require 110kwh of energy for drying, so potentially there is biomass to dry 673,818 tonnes of cereals – 74% of the total regional production.

Other sources of biomass

50. In addition to the potential farm woodland identified, farms also have access to a range of biomass' most notably straw. As already mentioned the North-East is a livestock region so straw has an important contribution for livestock feed and bedding. That said, there is OSR straw which currently has little value and is normally chopped and returned to the soil. In addition, there may also be surplus wheat straw available for biomass burning. The table below shows potentially there is 33,469t of straw biomass in the region which will provide approx 133 Megawatt hours per annum, in theory enough energy to dry 1.1MT of grain – more than the combinable crop production in the region (1 tonne straw can dry approx 30t grain).

Table 8: Potential biomass supply from rape straw in region

	Area (ha)	Yield (t/ha)	Straw	Use	Biomass (t)
OSR Straw	12,563	1.5	18,845	100%	18,845
Wheat Straw	18,280	4.0	73,120	20%	14,624
					33,469

51. An important part of the economics of biomass is the material's density and the associated transport costs. The one disadvantage of straw is its low bulk density (100kg/m^3). At best baled straw can be packed at around 250kg/m^3 which makes straw expensive to transport and store. This also links with the biomass' moisture content which should be as low as possible to ensure that one is not simply transporting water. Lower dry matter biomass not only gives a greater heat output but it will also be a cleaner burn.

52. It should be noted, storing OSR straw for long periods may result in the growth of mould and fungi which could lead to health problems.

53. The calorific value (Gigajoules, GJ) is a measure of how much energy is contained in different fuels. The water content of the biomass has a key bearing on the energy output so the aim is to dry and store well to avoid dry matter fluctuations which will affect the energy output when combusted. The typical calorific values for a range of biomass and other fuels is provided in the following table.

Table 9: Typical Calorific Values of a range of fuels

FUEL	Net Calorific Value (GJ/tonne)	Net Calorific Value (KWh/kg)	Bulk Density (Kg /M$^{3)}$	Energy Density KWh /M^3
Log wood (20%MC)	14.7	4.1	350-500	1,400 - 2,000
Wood chips(30% MC)	12.5	3.5	250	870
Wood Pellets	17.0	4.8	650	3,100
Wheat straw	14.4	4.0	150	600
OSR straw (15% MC)	16.8	4.7	150	705
Kerosene	42.5	11.8	845	10,000
LPG	46.3	12.9	510	6,600

Source: Biomass Energy Centre, Phyllis web site (www.ecn.nl/phyllis)

54. As a general rule, the differences between many different biomass fuels when dry are typically pretty small as most of them are simply made up of varying proportions of cellulose, hemicellulose and lignin, each of which has slightly different calorific value. The major differences when used come about because of different moisture and ash contents.

Renewable Heat Incentive

55. The renewable heat incentive scheme (RHI) was launched by the Government in Nov 2011. It aims to replace fossil fuel with renewable energy sources of heat to reduce emissions and stimulate a new sector. Heat accounts for half of the total energy use in the UK (DECC) and 47% of the country's GHG emissions. The first phase of the scheme applies to Industry, business and public sector, while a future 2nd phase will apply to domestic buildings, planned to start in 2013. Eligible technologies include; biomass, ground source heat, solar thermal, and biomethane.

56. The RHI provides a major incentive for owners to invest in renewable heat technologies. The tariff rates depend on the scale and technology and like FITs will be guaranteed for 20-years and index linked (the rates have been set to provide a return of 12%). As of March 2012, the rates are as follows:

Table 10: RHI Tariff rates (March 2012)

Technology	Scale	Rate (p/kWh)
Small Biomass	< 200kw	8.3p*
Med biomass	< 1MW	5.1p*
Large Biomass	> 1MW	1.0p

Note: * Tier 1 rates apply up to 1,314hrs

57. The RHI scheme will be administered by OFGEM who will approve applications and pay the tariffs on a quarterly basis. Applications are on-line with owners having to provide information of their equipment, meter used and description of scheme. Since this is a new scheme the approval process is quite slow and complex at present.

Carbon Savings

58. Energy efficiency and the associated carbon use is a key measure of environmental sustainability. An important argument for using biomass is that it is carbon lean and therefore contributes to the reduction in greenhouse gases (GHG). The carbon emissions associated with a range of fossil fuels used to dry grain is give in the following table. The study previously estimated the fuel use (8,277,600l) to dry the region's combinable crops (Table 5) which will produce GHG emissions of 20,245 tonnes carbon equivalent (Ce). At the 'low' level of biomass uptake this has the potential to reduce emissions by 1,417t Ce.

Table 12: Carbon emissions of various fuels (Ce per 1000 litres)

	CO_2 equivalent (tonnes)
Gas Oil	2.69
LPG	1.50
Kerosene	2.53

Source: CPlan 2012

59. Any actions which reduce GHG emissions is important if Scotland is to meet its ambitious targets of 42% reduction in carbon emissions by 2020 and 80% reduction by 2050. Agriculture will have to play its part and the use of biomass is one way to make a contribution.

8. ECONOMIC ANALYSIS

60. The potential uptake of biomass crop drying will largely depend on the commercial viability – is it financially beneficial to switch from fossil fuels to biomass? This is a complex issue and will vary with each situation; the existing system, the capital cost to change, the scale of operations, operating costs, and any practical considerations. Clearly, the eligibility of earning additional RHI subsidy is also important.

61. Any investment in renewable heat will invariably mean higher capital costs, however, the benefits is usually lower operating costs – lower fuel costs per tonne. The following table shows the relative energy costs of a range of fuels used for crop drying.

Table 13: Relative cost of biomass and other fuels (2012)

FUEL	Price per unit	Kwh /Unit	Pence /kWh
Log wood (20% MC)	£40 /tonne	4,100 kWh/t	0.9p
Cereal straw	£50 /tonne	3,900 kWh/t	1.3p
Wood Chips (30% MC)	£80 /tonne	3,500 kWh/t	2.2p
Wood Pellets	£180 /tonne	4,800 kWh/t	3.8p
Heating Oil	65p per litre	11.8 kWh/litre	5.5p
Natural gas	4.8p /kWh	1	4.8p
LPG (bulk)	42p per litre	6.6 kWh/litre	6.4p
Electricity	12p /kWh	1	12.0p

Note: Biomass prices do not include delivery.

62. Table 13 shows that biomass has a significant advantage over alternative fossil fuels, the most efficient being air dried log wood. The energy required to create wood chip or wood pellets does result in higher costs and a narrowing of the benefit over fossil fuels. The advantage, however, wood chips and pellets have is their ability to flow which allows automated systems.

63. The trade-off between the savings in fuel costs from biomass and the higher capital cost will depend on the scale of operations and actual capital costs. The actual capital costs will depend on the current system and the cost to convert to biomass. Tray driers are probably the easiest to convert to biomass burners and will have the lowest capital costs (e.g Hamish Watson's case study). Table 14 shows that for a grower with an annual tonnage of 2,000t the saving in fuel costs is £8,800 for log wood and £5,720 for wood chips. (It should be noted the performance of log wood will be dependent on its moisture content, it is important the wood has been matured and dried.)

Table 14: Savings in fuel costs at different scales of tonnage dried

	Savings over gas oil	
Tonnage dried	Log Wood	Wood Chips
500	£2,200	£1,430
1,000	£4,400	£2,860
1,500	£6,600	£4,290
2,000	£8,800	£5,720
2,500	£11,000	£7,150
3,000	£13,200	£8,580
3,500	£15,400	£10,010
4,000	£17,600	£11,440
5,000	£22,000	£14,300
6,000	£26,400	£17,160

9. CONCLUSIONS AND RECOMMENDATIONS

64. Grain drying is essential in Scotland for the safe storage of combinable crops. The rising cost of energy used to fuel crop driers is an increasing concern. Drying costs for a typical 200ha arable farm (1,500t) would be circa £10,000.

65. The North-East is an important region for combinable crops, with an annual production of some 911,000t, 30% of Scotland's total production. A feature of the North-East is that is a relatively late region so invariably has higher drying costs. Of the 911,000t annual crop production, it is estimated 785,000t is dried annually, 60% on-farm with the balance dried in central stores (40%).

66. There are a range of drier types used on-farm with mobile driers (57%) being the most common, these have the disadvantage that they do not lend themselves to incorporating biomass burners. That notwithstanding, tray driers are common (24%) in the region and are easily adopted to integrate with biomass burners.

67. Central stores dry a significant proportion of the region's crop production and thus are an important potential market for biomass burner. Of the 11 Central Store operators in the region, one has already successful installed a biomass burner using wood chip. The study showed that central store operators had only a limited understanding and awareness of the potential of biomass for crop drying. A range of factors was identified as potential barriers for the uptake of biomass systems.

68. The economic case for switching to biomass drying systems will vary with the situation. Any investment in renewable energy usually means a higher capital cost but lower annual operating costs so the return will depend on the capital cost and the scale of operations. In terms of fuel costs, biomass has a major advantage over fossil based fuels being significantly lower cost per kWh. There is widespread concern over the future cost of fossil based fuels and one way to future proof a business would be to consider biomass systems. This is particular attractive where the operator has their own or locally available biomass supplies. The RHI provides a real incentive to make renewable heat schemes very attractive. The RHI will compensate for the higher capital costs allowing owners to reduce their payback period.

69. The study has shown that farm woodland in the region, which is largely unmanaged, has the potential to supply 43,600m^3 per year, providing enough energy to dry over 670,000t of cereals. In addition, there are significant supplies of OSR straw (32,664t) which has the potential to dry 1MT – all the region's production. The development of a market for OSR straw would also add to the crop's value and attractiveness.

70. Predicting the future uptake of biomass crop driers will depend on the commercial viability and practical considerations. If biomass crop driers are eligible for RHI, this would significantly increase the attractiveness of biomass systems. Over the next ten years, three levels of uptake were examined producing a potential biomass demand of 4,099m^3, 8,200m^3 and 12,304m^3 respectively per annum. The actual uptake would be dependent on many factors but principally economic viability and RHI eligibility. We know from previous studies that there is an aging grain drying and handling infrastructure which is in need of updating.

71. Biomass burners will not be for everyone. There are some practical obstacles that need to be tackled. Any increase in drying times (due to lower heat output) would be a serious impediment. Currently drying capacities are already struggling to match the output from modern combines (up to 40t/hour) resulting in bottle-necks so any increase would be unwelcome. The extra labour requirement and the need to plan and store biomass supplies

well in advance would also put some farmers off. In general, anything that adds complexities and hassles would be not be popular. That said, economic pressure would force farmers to look at alternatives to fossil fuel and find solutions.

72. The commercial case for the adoption of biomass burners could be further strengthened if alternative use for renewable heat could be found (e.g. domestic heating systems). After all crop drying only takes place in the period between August to October. What other commercial uses could be made for renewable heat?

73. An important argument for using biomass is that it is carbon lean and therefore contributes to the reduction in greenhouse gases (GHG). The study has shown that the uptake of biomass could make a significant reduction in the GHG emissions associated with grain drying.

Recommendation

74. The study has shown that biomass crop drying can be commercially viable and has potential benefits for both individual growers and the region as a whole. The main recommendation is, what can the local authority and other partner organisations do to raise awareness of the potential of biomass crop drying? There is a real need to promote the opportunity for biomass crop drying amongst farmers and central store operators. Promotion could take various forms including; press articles, promotional materials, demonstration visits, production of case studies, amongst others things.

Appendix 1

Scottish Government census data for the North-East.

(Source: "Economic Report on Scottish Agriculture", available on the Scottish Government website on www.scotland.gov.uk/Topics/Statistics/Browse/Agriculture-Fisheries/PubEconomicReport)

Estimated Average Crop Yields (T/ha)

	2010	2011	2-yr Av
Wheat	7.75	8.09	7.92
W Barley	7.12	7.3	7.21
Sp Barley	5.21	5.6	5.41
Oats	6.17	6.1	6.14
OSR	3.49	4.11	3.80

Estimated Production fed on Farm

	Tonnes	Fed on farm	
Wheat	144,412	0.3	43,324
W Barley	136,080	0.5	68,040
Sp Barley	557,842	0.2	111,568
Oats	25,205	0.1	2,521
OSR	47,739	0.01	477
	911,278		**225,930**

Number of Holdings with Combinable Crops in the North-East

Size (ha)	No.	Hectares
< 20ha	1245	11,614
20-50ha	915	30,495
50-100	621	43,217
101-150	217	26,015
>150	151	34,271
	3,149	145,612
OSR	428	11,938
	3,577	**157,550**

Note – The number of holdings over estimate the actual number of farm businesses as some businesses will operate more than one holding.

<u>Estimated number of on-farm grain driers in the North-East</u>

Holding Size (ha)	No.	% with drier	No Driers
< 20ha	1,245	0	0
20-50ha	915	40	366
50-100	621	90	559
101-150	217	90	195
>150	151	100	151
	3,149		**1,271**

Appendix 2

Central store operators: semi-structured interview

1. What tonnage of combinable crops do you normally dry per year?

2. Describe your current drying system?

3. Estimate of the annual quantity of fuel use?

4. Are you happy with your current drying system?
    - If not, what are the issues?

5. Are you aware of biomass burners for crop drying?
    - Yes /No / Unsure (any details)

6. Have you ever considered biomass burner for yourself?
    - Yes /No (any follow up comments)

7. Do you own have access to any woodland /biomass?

8. Are you aware of the renewable heat incentive (RHI)?

9. Are you interested in biomass burners?
    - Yes /No / Unsure (any comments, stage of planning, etc)

10. What are the main barriers preventing you adopting a biomass burner for your system?

National Inventory of
Woodland and Trees
INVENTORY REPORT
Scotland - Grampian Region

DISTRIBUTION OF WOODLAND BY OWNERSHIP WITHIN GRAMPIAN REGION