RELB: Job implications of establishing a bioenergy market

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Executive Summary

Bioenergy crops and forestry have a significant role to play in helping the UK meet its 2050 carbon budget. Currently around 10,500 ha of bioenergy crops are grown in the UK, made up of an estimated 7,000 ha of Miscanthus and 3,500 ha of Short Rotation Coppice (SRC). ETI analysis suggests that the UK needs to plant 30 kha/yr of bioenergy crops and Short Rotation Forestry (SRF) until the mid-2050s to deliver the required level of feedstock to meet the UK's 2050 greenhouse gas targets cost-effectively. Of the area of bioenergy crops planted, this study assumes that 50% of the area will be SRF, 25% SRC and 25% Miscanthus. The significant increase in bioenergy crop area planted will require an increase in the number of people employed in the bioenergy crop sector from current levels, as well as an increase in the supply chain (market for end products, machinery available for planting/harvesting etc.) to support this increased area. This work focused on identifying, and quantifying the types of jobs required to support a UK bioenergy sector, understanding what skills are needed, where the current skills gaps are, whether there are any barriers to job development, and identifying the timescales of jobs / skills development needed to meet ETI's targets. The scope of the work covers the UK and considers job creation in relation to the production of SRF, SRC and Miscanthus, with additional implications for achieving the UK Afforestation targets also considered. Job creation up to the point of first processing is included e.g. transport off farm, but any jobs after that initial journey off farm, e.g. processing, are not included. Ancillary jobs (such as administration roles, finance and marketing within companies in the bioenergy feedstock sector) are also excluded.

Currently around 400,000 people are employed in the agricultural and forestry sectors, with our estimates suggesting that the current bioenergy sector supports **62 full time job equivalents (FTE),** with 51 of these in the Miscanthus sector and 11 in the SRC sector although with the pattern of labour requirements for these crops, at peak times up to 156 individual are required at any one time – many of these jobs will be part time with individuals having alternative employment during non-peak periods. By 2055 it is estimated that there will be an estimated **9,100 FTE in total the bioenergy sector**, made up of **5,600 FTE in the SRF sector, 1,300 FTE in the SRC sector and 2,200 FTE in the Miscanthus sector.** However it should be noted that the seasonal nature of bioenergy jobs, up to 17,900 individual job opportunities are created across the year in 2055, with between 4,300 and 16,700 individuals needed at any one time (not full time jobs). Of the 17,900 individual opportunities estimated to be created by the bioenergy sector in 2055, 31% are expected to be specialist contractors, 25% offsite specialists (plant breeders / agronomists), 23% casual labour, 18% farmers and the remainder logistics experts (lorry drivers). There will be jobs created in all of four of the countries in the UK. By 2055 jobs in afforestation are expected to have dropped off to very few (assuming current afforestation targets have been met), having peaked in 2017-2026 at about around 1,300 FTE. There will be some forestry management jobs associated with maintaining the afforested areas however these were outside of the scope of this assessment and have not been included. Some of the skills these individuals have will be relevant to the SRF sector and therefore as the need for jobs decreases in the afforestation sector these individual may move into the growing SRF sector.

The proportion of the different bioenergy crops grown was identified using the ETI BVCM model, this indicates that half the SRF will be in Scotland and Wales, 45% in England and just 5% in Northern Ireland, whilst the majority (90%) of the Miscanthus will be grown in England, with just small areas in Scotland and Wales, with none forecast to be produced in Northern Ireland. For SRC there is expected to be 60% in England, 20% in Scotland, 10% in Wales and 10% in Northern Ireland. Based on these differing distributions of the bioenergy crops it is forecast that there will be 5,300 full time job equivalents created in England (by 2055), although based on seasonality there would be up to 11,200 job opportunities created across the year, with up to 10,400 individuals supported in the peak season, whilst in Scotland and Wales full time job equivalents are forecast at 1,600-1,800 FTEs, with up to 2,700-3,100 individuals

required across the year (seasonal peak of 2,600 – 3,000). Jobs supported in Northern Ireland are estimated to be 400 full time equivalents, with 800 job opportunities created across the year (with 700 required at peak times) (Table 1).

Table 1 Breakdown of forecast full time job equivalents supported by the bioenergy industry in 2055 (total time requirement in hours divided by 1860 hours – annual working hours based on 28 days annual leave- to give total full time job equivalents – note this approach assumes the same level of work each month, which is not the case). In addition, the number of job opportunities created across the year is shown alone with the peak job requirement , based on the number of jobs required at any one time (assuming a 168 hour working month)

Country	Full time job equivalents	Job opportunities created across year	Peak requirement for individuals (February)
UK	9,100	17,900	16,700
England	5,300	11,200	10,400
Scotland	1,800	3,100	3,000
Wales	1,600	2,700	2,600
Northern Ireland	400	800	700

Definitions

Full time job equivalents (FTE) | If total hours of work are combined and then divided by the number of hours that an individual works if they are employed full time this gives the number of FTEs. It indicates the scale of work available but does not account for seasonal peaks and troughs.

Job opportunities created across year | There are five categories of worker assessed in this report. To calculate the total job opportunities the maximum monthly requirement (in hours of labour) for each category is taken and converted into jobs based on the number of people working full time in that month that would be required to deliver those hours. Peak work requirements do not always occur in the same month for each of the worker categories and therefore Job opportunities created is slightly higher than peak requirement for individuals.

Peak requirement for individuals | This approach assesses the number of individual needed (if working full time) based on the total number of hours required in the peak month.

The peak of labour required for bioenergy crop production is focused around January-April for all crops with planting and harvest for all crops carried out in this period. During other times of year the labour requirements are relatively low, focused on maintaining newly established crops and providing agronomy services. This varying labour profile throughout the season means that the bioenergy sector will only be able to provide a limited number of full time jobs, with most workers also working in other areas of the agricultural or forestry industries for the rest of the year to ensure a constant income. The work profile for bioenergy crops, especially Miscanthus and SRC, fits in well with the arable industry, as the main workload largely falls in the quiet period between the establishment of winter crops September to November, and the harvest of winter crops, July to September. The main overlap is with spring drilling and early pesticide and fertiliser applications. This means that for those jobs that are conducted by the farmer they will fit in with the existing workload and enable the farmer to even out the balance of activities on farm, without necessarily creating new jobs.

The demand for the different roles involved in bioenergy crop production varies between crops, although in general the majority of tasks will be carried out by farmers, specialist contractors or casual workers with fewer jobs supported for supporting roles, e.g. breeding and crop agronomy. Most of the skills required to grow bioenergy crops are already needed in the agricultural industry e.g. tractor driving and spray operator licences, so large scale upskilling will not be required in these areas. Skills gaps identified were those involved in bioenergy crop breeding, bioenergy crop agronomy as well as those specific to the forestry sector including chainsaw maintenance and training forestry works managers needed to oversee site health and safety and the harvesting process. A shortage of HGV drivers was also identified as a future issue in the haulage sector where upskilling would be required.

It is assumed in the modelling for this report that there will be an annual increase in bioenergy crop plantings of 30,000 ha per year, plus an additional 27,500 ha per year of afforestation (to a maximum area of 350,000 ha for afforestation only). However, it is recognised that at least in the first few years of establishment the area planted is likely to be lower, so the step change in jobs identified is likely to be more gradual than the modelling in this report indicates. The timescale of job creation varies by crop (due to harvest interval and useful lifespan). In the first year of bioenergy crop planting there will need to be a step change in the number of people employed in the sector in order to meet the requirement to plant 30,000 ha of bioenergy crops and 27,500 ha of afforestation in one year. From then on, the number of jobs involved in crop establishment and annual maintenance will show a steady increase for the first 20-25 years after the initial large increase as a similar area of bioenergy crops is planted each year. In 2032 there is expected to be an increase in jobs in the SRF sector as the first crops of SRF planted in 2017 reach harvest maturity (15 years) at this stage there will be jobs created to in order to start harvesting this crop. In addition, if the planted area is to continue to grow there will also need to be a near doubling of jobs relating to planting in order to maintain the planned increases in crop area through to 2055 (as the harvested area will need to be replanted, as well as continuing to plant in 'new' areas). Some of the skills for this planting will come from those previously employed to plant afforestation projects, although the lag between the target completion for afforestation and the start of SRF harvesting and replacement may result in some of the skills being lost and needing to be redeveloped in the future. A similar step change in job requirements is forecast ten years later as there will need to be a further increase in planting jobs in the SRC and Miscanthus sectors due to early established crops coming to the end of their productive lifespans (25 years) needing to be removed and replanted, as well as continuing to plant in new areas. The steepness of these step changes in employment will in part be dictated by the rate at which initial planting occurs and then by the actual longevity of the planted crop with some crops lasting more or less than the forecast 15 years (for SRF) or 25 years (for SRC and Miscanthus) (Figure 1).

The main skills that are required to grow bioenergy crops and forestry already exist within either the agricultural industry or the forestry industry. However, despite these skills already being available, there are some significant challenges that will need to be overcome, especially in the first few years, in order to meet the challenge of planting 30,000 ha of bioenergy crops per year. The first and most critical of these is the lack of available planting material, with breeding programmes at present only producing sufficient material to plant a few hundred hectares, rather than thousands of hectares of bioenergy crops. Therefore, the first step in increasing the bioenergy crop area will need to be in supporting the development of more commercial planting material production facilities, with the skilled staff available to multiply up the crop. In addition there is a lack of infrastructure available for establishing the crop. The machinery that is used for planting is often specialist equipment and is therefore not already present on farms. This means that although the operator does not necessarily need specialist skills to operate the equipment (beyond their pre-existing tractor driving skills) they are unlikely to have access to the suitable equipment. At present there are insufficient machines available in the UK to plant 30,000 ha of bioenergy crops in any one year. This is particularly the case for SRC, where equipment tends to be highly specialised and expensive. As a result of the expensive nature of the kit there are only five fully functioning planters and ten harvesters in the UK. Most of these are located in areas where there are existing localised markets for SRC fuel (Nottinghamshire, Yorkshire, Cumbria and Northern Ireland). In contrast to SRC, the equipment for SRF planting and harvesting is more widely available as it uses the same technology that is employed in the existing forestry industry. The machinery required for Miscanthus harvesting tends to be cheaper and more widely available than that used for SRC as modified forage harvesters can be used, however, there are a limited number of planting machines in the UK and a limited number of contractors that can carry out this activity.

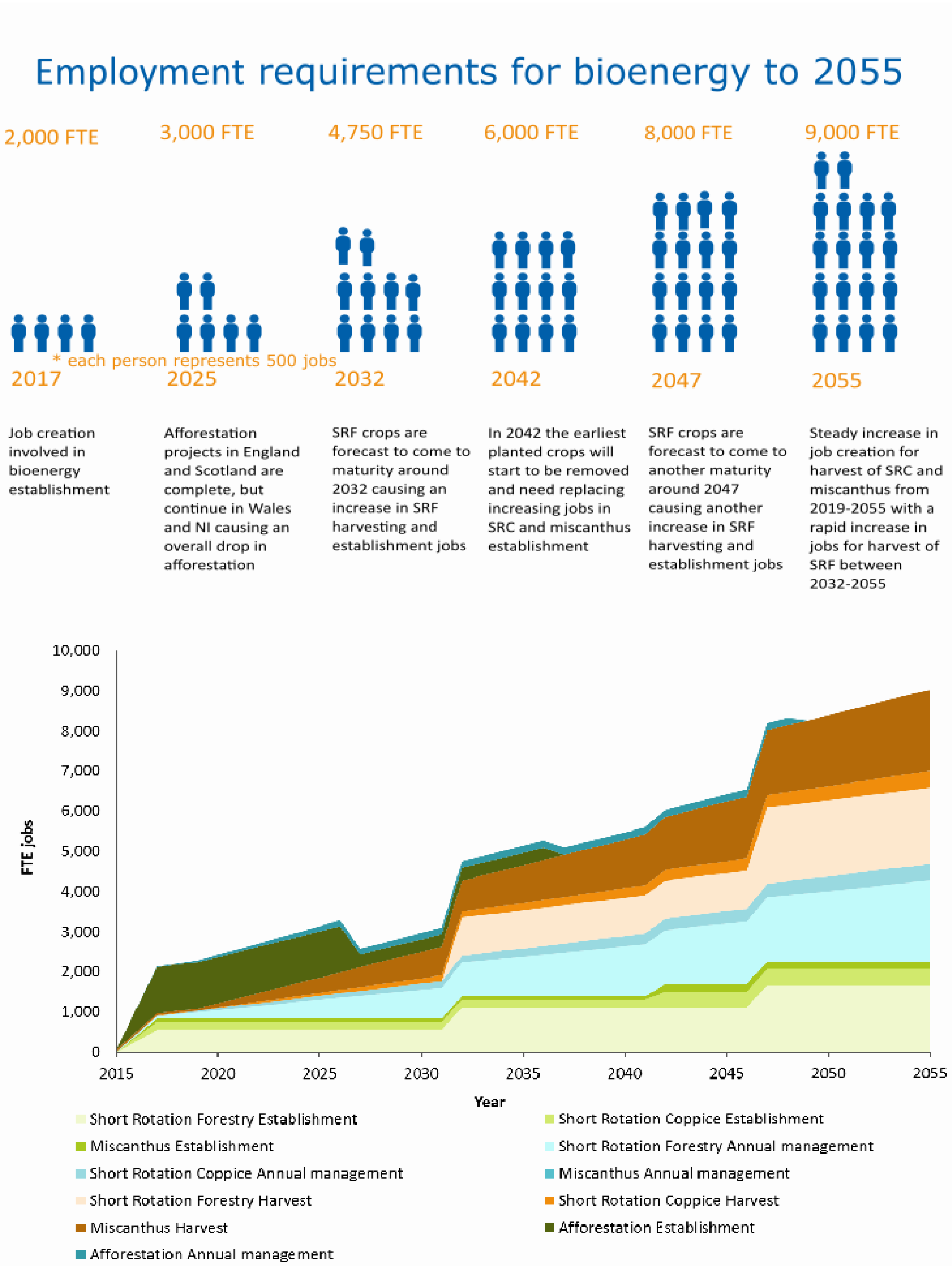

Figure 1 Graphic depicting the change in FTE job requirements over time as the bioenergy crop area increases.

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1 Background

The ETI has identified that 1.3-1.4 M ha of land is required for bioenergy crop production in order to support the achievement of the UK's 2050 carbon target in a cost effective way. However, their current projections are based on a conservative estimate of uptake of 30,000 ha of newly planted bioenergy crops per year from 2016-2050, giving an estimated final area of bioenergy crops in the region of 1.0 M hectares (or 1.2 Mha by the mid-2050s). The ETI has produced a wide range of evidence to support the implementation of a UK bioenergy strategy and are now preparing for the dissemination of project results to key stakeholders including policy makers within the government. In order to support this dissemination exercise, the ETI have requested evidence to demonstrate how many jobs a UK bioenergy sector could create or safe guard.

Aim: To provide the ETI with an estimate of the number of FTE jobs and the types of skills required to support a growing UK bioenergy sector to use in their dissemination strategy.

1.1 Objective(s):

1. To identify, describe and quantify the types of jobs required to support a UK bioenergy sector for the 40 years between 2016 and 2055.
2. Understand what skills will be needed (are they new or will they switch from other areas) and whether there are other barriers to job development – e.g. availability of suitable equipment.
3. Understand the timescales of jobs / skills development needed assuming the bioenergy crop area grows by an average of 30,000 ha per year.

1.2 Scope

This project covers the UK (England, Scotland, Wales and Northern Ireland) and considers job creation in relation to the production of short rotation forestry (SRF), short rotation coppice (SRC) and Miscanthus, with additional implications for achieving the UK Afforestation targets also considered. It considers those jobs associated with five main areas; the production of the planting material, establishment of the crop, annual management of the crop, harvest of the crop and logistics of storage and movement of the crop from point of production to point of initial processing.

The following types of job are specifically excluded from this assessment – machinery manufacture, upstream jobs in ancillary products, and downstream conversion of raw material to energy and imported biomass.

This project was primarily a desk based study, with input from experts where relevant e.g. agronomists, foresters and other stakeholders, who assisted in the identification and description of the jobs required to support UK bioenergy production. The project provides a high level view of the job requirements of the bioenergy sector and where data was not readily available assumptions were made (with justification), rather than carrying out new research.

To calculate the number of jobs required in the bioenergy sector by 2055, a number of assumptions were made, as detailed below:

- **Current area of bioenergy crops grown-** The current area of bioenergy crops planted in the UK in 2015 is estimated to be 10,500 ha, consisting of 3,500 ha of short rotation coppice (SRC) and 7,000 ha of Miscanthus. There is currently no area of short rotation forestry (SRF) assumed to be planted in the UK. These figures are based on Defra statistics[1] which identify that in England **10,000 ha** of short rotation coppice (SRC) and Miscanthus are grown with industry estimates[2] also identifying an additional **500 ha** of SRC currently grown in Scotland, Wales and Northern Ireland.

- **Area of newly planted bioenergy crops-** The model assumes that the area of newly planted bioenergy crops increases by 30,000 ha/year up to 2055– up to a final area of 1.18M ha of bioenergy crops. This is split into 18,000 ha/year in England, 5,625 ha/year in Scotland, 4,875 ha/year in Wales and 1,500 ha/year in Northern Ireland. Of this 30,000 ha/year increase, 50% of this (15,000 ha/year) is expected to come from SRF, 25% (7,500 ha/year) from SRC and 25% (7,500 ha/year) from Miscanthus. The regional split of SRF:SRC:Miscanthus planted each year was based on information from the ETI BVCM modelling[3] (Table 2).

Table 2 Split of forecast energy crop annual area increase across the devolved regions. Source: ETI – BVCM Insights paper[4]

	All UK bioenergy crops annual increase (ha)	Short Rotation Forestry	Short Rotation Coppice	Miscanthus
UK Area – proportion of each bioenergy crop		**50%**	**25%**	**25%**
	30,000	15,000 ha	7,500 ha	7,500 ha
England	18,000	45%	60%	90%
Scotland	5,625	25%	20%	5%
Wales	4,875	25%	10%	5%
Northern Ireland	1,500	5%	10%	0%

- **Afforestation targets-** There were varying levels of data available on afforestation targets for each of the devolved regions. For example in **Scotland** the initial afforestation target aimed to increase woodland cover to 25% of the national area – an increase on 2009 of 650,000 ha, with a proposed planting rate of 10-15K ha a year[5]. However, a review by the Woodland Advisory Group, resulted in this target being revised to an aspiration to create 100,000 ha of new woodland by 2022[6]. In this study we have taken the conservative assumption of 10,000 ha per year up to an area of 100,000 ha for Scotland. For **Wales**, in 2010 the Welsh Government set an afforestation target of 100,000 ha of additional woodland to be planted by 2030, equivalent to 5,000 ha per year[7]. No clear afforestation targets were found for England and Northern Ireland, so for **England** an assumption of 10,000 ha per year was used in line with Scotland and for **Northern Ireland** a figure of 2,500 ha per year was used, half of the target for Wales.
- **Timeframe for planting bioenergy crops**- The timeframe over which new areas of bioenergy crops are planted was calculated for the period 2016-2055 - a period of 39 years. This timeframe aligned with other modelling work carried out by ETI, in support of their efforts to ensure that bioenergy crops are established in time to meet the UK's 2050 carbon target.
- **Useful life of bioenergy crops**- Although bioenergy crops are perennial, after a period of time the crop becomes less productive and therefore it becomes financially unviable to maintain that stand, therefore the crop has to be removed and replanted. The useful life of bioenergy crops was taken to be 15 years for SRF (rotations range in length from 10-30 years) and 25 years for SRC and Miscanthus.

This report is set out into three main sections;

- A review of the existing evidence around employment and jobs in the bioenergy, agriculture and forestry to put the modelling into context
- An assessment of the number of jobs required to meet the bioenergy target and pattern of time input required

- Identification of the skills requirements needed in the bioenergy sector, highlighting any gaps
- Understanding the timescale and pattern of job creation from 2016-2055.

2 Quick review of existing evidence

2.1 Approach

In order to place this piece of work into context, a brief review was conducted to identify papers and reports published on the internet that provide information on job requirements in the bioenergy crop sector. The first part of the review looked at current employment levels in the agriculture sector, focusing on how employment levels changed over time whilst the second part review assessed the evidence on job creation in the bioenergy sector with specific focus on SRF, SRC and Miscanthus.

The aim of the review was to:

- Identify what **existing information was published** about employment opportunities in the agricultural sector and **requirements for a developing UK bioenergy market**.
- Identify **gaps in the existing evidence** that needed to be filled with assumptions and further calculations in order to progress the assessment in the following sections.

2.2 Trends in the agricultural workforce

Each year Defra publishes agricultural workforce data, collected from the June Agricultural Surveys, with the latest data available for 2015[8]. The number of agricultural workers in 2015 was 305,000. Among these, 174,000 were farmers, partners, directors and spouses; 11,000 were salaried managers; and 120,000 were other workers (regular full-time and part-time workers and casual workers). The data for agricultural workforce suggests that there is a long-term trend of decline in agricultural workers, but at slower rate in recent years since 2013.

Figure 2 Farm Workers by Type (2000-2015).Source: Based on data from Defra June Agricultural Survey[9].

This trend of a declining agricultural workforce is shown more clearly in the UK Census data which shows a long term decline in employment in the agriculture and fishing sector[10]. According to the Census data, the share of employment in the agriculture and fishing sector declined from 22% of total jobs in 1841 to 1% in 2011 (Figure 3).

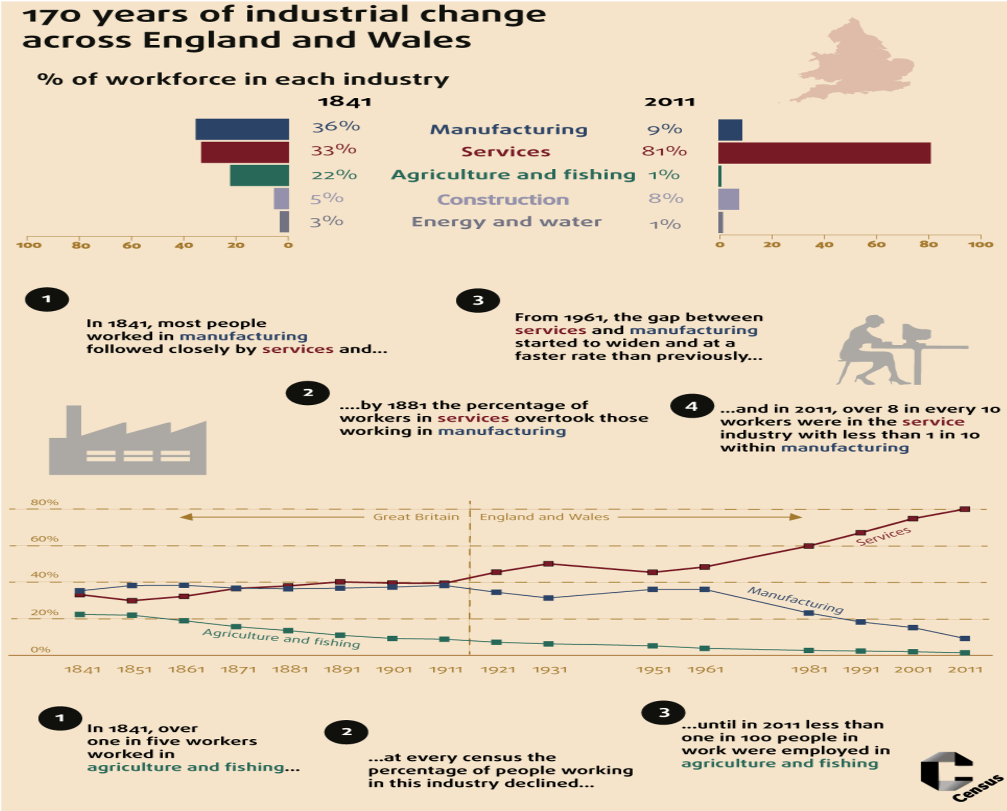

Figure 3 Summary of Census data on the proportion of workers in the different industries contrasting trends from 1841 – 2011.Source: ONS (2013). 2011 Census Analysis, 170 Years of Industry Release.

A study by PwC looked at the past trends in total number of jobs across all sectors in the UK and projected the UK employment level to year 2025[11]. Employment level in the agriculture, forestry and fishing sector was estimated to be 0.4 million in year 2015. This figure for employment represented a 0.9% decline from 1997, and was projected to further decline by 0.9% to year 2025 (Table 3).

Table 3 UK employment growth rates 1997-2015 and 2015-2025. Source: PwC (2016)

Industry	Number of Jobs (millions)			Growth Rates (per annum)	
	1997	2015	2025 (projected)	1997-2015	2015-2025 (projected)
Agriculture, forestry & fishing	**0.5**	**0.4**	**0.4**	**-0.9%**	**-0.9%**
Construction	1.8	2.2	2.4	1.1%	0.6%
Manufacturing	4.3	2.6	2.0	-2.6%	-2.6%
Energy and water	0.3	0.4	0.4	0.8%	0.8%
Distribution, hotels and restaurants	6.6	7.2	7.5	0.5%	0.5%
Transport and communication	2.2	2.9	3.2	1.6%	1.2%
Financial services	1.1	1.1	1.2	0.2%	0.2%
Business services	3.9	6.3	7.9	2.8%	2.3%
Public administration, defence and security	1.6	1.5	1.3	-0.4%	-1.0%
Education and health	5.0	7.1	8.3	2.0%	1.5%
Other services	1.5	1.9	2.2	1.5%	1.5%
Total services	21.8	28.0	31.6	1.4%	1.2%
Total jobs	28.8	33.7	36.9	0.9%	0.9%

2.3 The Trees and Timber Industry

LANTRA carried out a study[12] to identify businesses/employees within the Trees and Timber industry that have been 'hidden' in other sectors of the economy or in businesses not captured within Lantra's traditional industry categories[1]. According to this study, the employment in the Trees and Timber industry in **Great Britain** was estimated at 98,700 in 2011. If included, a separate estimate for Northern Ireland[13], puts the overall workforce in the Trees and Timber industry at around 100,000 (Table 4).

[1] The traditional categories with licensed SIC codes are: 02.10/0 Silviculture and other forestry activities; 02.20/0 Logging; 02.30/0 Gathering of wild growing non-wood products; and 02.40/0 Support services to forestry. These categories were included in the above LANTRA study as 'primary businesses'. The study also looked at 'secondary businesses' that have employed people working in trees and timber-related roles. The top 10 job titles included in the research were: tree officer; arboriculturalist; arboriculture officer; tree assistant; tree surgeon; supervisor arboriculture; collection co-ordinator; tree department head; assistant manager forest centre; and, assistant tree officer.

Table 4 Employment in the Trees and Timber Industry

Country	Businesses	Workforce
England	12,200	84,800
Scotland	1,100	10,300
Wales	900	3,600
GB Total	14,200	98,700
Northern Ireland*	60	400
UK Total	14,300	99,100

Source: LANTRA (2011). The Trees and Timber Industry in Great Britain: Size, Structure and Skills 2011. Numbers were rounded to the nearest 100.

**Data for Northern Ireland was from a separate primary research of LANTRA industries in 2010-2011. See LANTRA Northern Ireland factsheets 2010-2011. Land-based and environmental industries. Available at: https://www.lantra.co.uk/sites/default/files/LMI%20Factsheet%20Northern%20Ireland%20(2010-11).pdf.*

***Calculated from separated estimates for GB and Northern Ireland.*

In this study, the industry was sub-categorised into the following groups:

- *Arboriculture:* cultivation, management and study of individual trees
- *Forestry:* managing forests and woodlands, and primary timber production
- *Greenwood trades:* a traditional sustainable practice of coppicing woodland and producing hand crafted products.

Of these sub-industries, the workforce in the forestry industry was estimated at **11,700** (Table 5).

Table 5 Workforce by Sub-industry in the Trees and Timber Industry

Sub-industry	Businesses	Workforce
Arboriculture	4,500	23,800
Forestry	1,500	11,700
Green wood Trades	*	*

*Source: LANTRA (2011). The Trees and Timber Industry in Great Britain: Size, Structure and Skills 2011. The numbers were rounded to the nearest 100. *Sample size too small to make reasonable estimate.*

The LANTRA report also looked at skills issues and identified training gaps in the trees and timber industry and had the following conclusions and recommendations:

- In terms of recruitment and retention, qualitative evidence within the study suggested that coppicing was seen to have a poorer image than other parts of the trees and timber sector to new entrants. Also, attracting career changers in the coppice industry was particularly difficult as most people working in the industry were self-employed and therefore there are very few job opportunities to gain experience. The evidence also suggested that the lack of a qualification in coppicing was considered a barrier to growth of the industry.
- In terms of the vacancies identified by trees and timber businesses, 42% were considered ‘hard to fill’. Of these, 27% claimed that they had hard to fill vacancies due to a low number of applicants; 18% suggested it was because the applicants lacked the required skills and experience; and another 18% felt that potential applicants found the terms and conditions for the positions they had vacant to be unsuitable. Further evidence suggested one significant barrier to attracting new entrants was felt to be the low wages, as well as the long hours and potentially dangerous conditions, associated with the work.
- In terms of skills gaps in the workforce, the most significant ones were traditional forestry skills, management skills among contractors, as well as non-traditional skills such as negotiation (particularly in coppicing). In addition, skill gaps among new entrants were related to achieving a

balance between legislative training requirements, and the skills and experience to do the job effectively and in a commercially viable way. A number of recommendations to address these skills gaps were suggested in the LANTRA report. These include;

1. The need to develop career progression pathways within the sector, in particular highlighting areas of overlap and transferable skills across land based and environmental sectors.
2. Further promoting skills, training and continuous professional development (CPD) for trees and timber jobs identified with large employers in the forestry and timber sector.
3. Reviewing the availability of training such as chainsaw certification that helps businesses to meet legislative requirements.
4. Reviewing alternative routes to higher level qualifications.
5. Researching the demand for courses specific to different trees and timber sub-sectors in new or growing areas.
6. Undertaking further research into an industry CPD scheme as there is a significant level of support for such a system.
7. LANTRA, alongside the trees and timber industry group, should respond to views on the value of training through promoting standards such as Investors in People (IiP) directly to employers and trade associations.

2.3.1 Job creation in the bioenergy sector

The development of jobs in the bioenergy sector falls into those jobs at the field level, that are likely to be captured in either agricultural or forestry surveys and those that fall beyond the farm gate in either the logistics or energy sectors (where biomass is converted to energy). Most of the studies in this area look at the employment potential for the whole bioenergy sector and include estimates on direct and indirect, as well as induced jobs. However, there is a consensus that bioenergy generated from biomass tends to generate more jobs than other renewable energy sectors. Most of these jobs are in the agricultural sector, in cultivating and harvesting feedstock[14]. This job creation potential could contribute to a certain extent in countering the projected continuing decline in employment in the agricultural and forestry sector where these jobs are additional (for example, bringing in marginal land for feedstock production that is not currently used for food production, i.e. not displacing land for food production).

Only a few studies provide specific figures on direct jobs created in relation to short rotation forestry (SRF), short rotation coppice (SRC) or Miscanthus. These studies are summarised in turn.

A study by Thornley, P *et.al.* (2008)[15] quantified the expected employment impacts of individual bioenergy developments, which included agricultural labour growing energy crops for SRC and Miscanthus options, transport and processing of the feedstock, staffing at the thermal conversion plant, employment within the equipment supply chain and the induced employment impact. This study looked at 22 case studies with different plant/technology types and estimated the labour requirements through consultation with industries and academia with experience of operating bioenergy plants. In particular, full time agricultural jobs for feedstock supply were calculated. The labour requirements for growing crops were calculated based on a detailed assessment of the hours and men required to complete every stage in the agricultural process of preparing the land, growing and harvesting the energy crops (although jobs associated with the production of planting material and provision of advice were excluded). For transport jobs during operation, the calculations were based on the required number and length of delivery journeys to keep the plant supplied, taking into account the limited delivery hours on site, the distance to the plant, likely planting densities, tortuosity factors for different grades of roads, etc. The labour requirements for feedstock supply were estimated on a per hectare basis in this study, which indicated that **0.001 FTE (Full-Time Equivalent) per hectare** would be required for SRC and **0.0014 FTE per hectare** for Miscanthus.

A report conducted by the Centre for Economic and Business Research (CEBR) in 2010 for the Forestry Commission looked at the economic value of the woodfuel industry to the UK economy by 2020[16]. In this report, the employment generated in the production and supply of woodfuel was estimated, including growing and harvesting of woodland, processing, storage/conditioning and transportation of the woodfuel. The supply chain that was examined in this study is illustrated in Figure 4, which also included secondary sources from sawmills and boardmills. Whilst Figure 4 includes stump harvesting, normally once SRF reaches the end of its useful life, the tree stumps remain in the ground and the new plantation is planted around the already existing stumps.

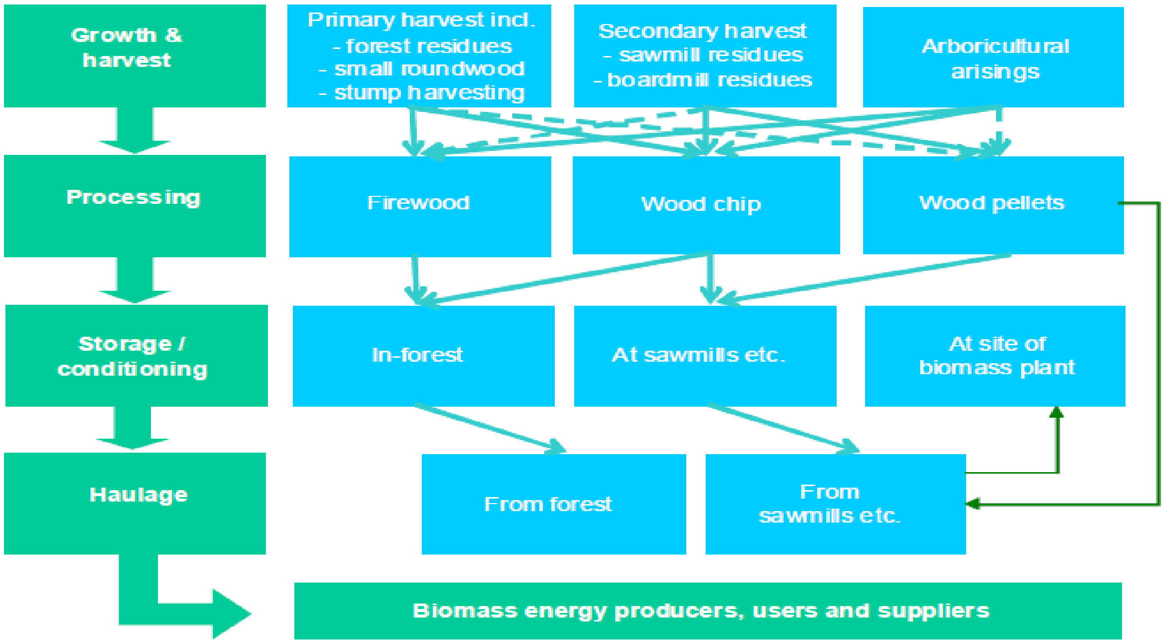

Figure 4 The supply chain of woodfuel production.

Source: CEBR (2010). The economic value of the woodfuel industry to the UK economy by 2020.

The CEBR report made projections of direct jobs (FTE) created in woodfuel production for England, Scotland, Wales and Northern Ireland in 2010 and 2020. The CEBR research projected that 13 TWh[2] of primary woodfuel energy would be produced for the whole of the UK by 2020, which were based on woodfuel harvest of 1 million green tonnes in 2009 as the starting point and an inverse log compound annual growth from that point. The projections were then divided between England, Scotland, Wales and Northern Ireland according to their shares of total UK woodland. The study also made assumptions on the following aspects in order to predict the scale of woodfuel production:

- the conditioning of harvested wood to produce woodfuel;
- the conversion of woodfuel to energy;
- the conversion efficiencies of alternative woodfuel energy-generating technologies;
- the typical load factors (rates of capacity utilisation) of alternative installations;

[2] The woodfuel production was converted to primary energy input following these steps: the moisture content of the delivered or seasoned woodfuel results in a corresponding net calorific value, which measures the energy output in mega joules (MJ) per kilogram (kg) of combusted woodfuel; The net calorific value for woodfuel with 30 per cent moisture content is about 12.5. To perform the conversion from woodfuel to primary energy, the total number of tonnes of woodfuel is multiplied by 1,000 to convert to kilograms and, again, multiplied by the net calorific value to give a total MJ-denominated woodfuel energy input. This is converted to kilowatt hours (kWh) by multiplying the MJ-denominated energy output by the MJ to kWh conversion factor of 0.278. This gives an equivalent kWh- denominated primary energy input from seasoned wood harvest, which can then be translated into equivalent outputs denominated in MWh, GWh or TWh. Primary energy inputs are then converted into final energy outputs by applying the relevant conversion efficiency factors to the different types of installation (Boilers, CPHs etc.).

- the energy mix for a given supply of woodfuel; and
- the underlying costs of different types of energy generating technology.

For the projections on Gross Value Added (GVA) and employment, the study used 2007 Office of National Statistics input-output tables and assumptions made about average wage levels by sector from the Annual Survey of Hours and Earnings (ASHE) and about future levels of earnings growth.

The projections on direct employment in woodfuel production from the study are presented in Table 6, which indicates an increase from **644 in 2010 to nearly 2,000 FTEs in 2020**. It should be noted however, this study only covers logs, wood chip and wood pellets sourced from the standing forestry resource, sawmill and other wood processing residues, and arboricultural arisings, but excludes biomass derived from energy crops or from waste / recycled timber.

Table 6: Direct employment in woodfuel production by UK nation (no. of FTEs)

Country	2010	2020
England	256	782
Scotland	304	918
Wales	64	196
Northern Ireland	20	60
UK	**644**	**1,956**

Source: CEBR report (2010)

Based on energy conversions, the CEBR study also gave estimates on unit employment contribution of energy demand on FTEs per MW basis. The results are presented in Table 7.

Table 7: Unit employment contributions in woodfuel production by UK nation (no. of FTEs)

Country	2020 (FTEs/MWh of energy demand)
England	0.0012
Scotland	0.0039
Wales	0.0015
Northern Ireland	0.0011

Source: CEBR report (2010)

An NNFCC report[17] reviewed a range of studies and synthesised the evidence available on the employment requirements for the feestock production in the bioenergy sector. It looked at the feedstock supply chain which included the following key stages: feedstock planting and management, feedstock harvesting, feedstock processing and feedstock haulage.The number of jobs were converted to the FTE per oven dry tonne of biomass feedstock for SRC, Miscanthus, Straw and Forestry (see Table 8). When these figures for SRC and Miscanthus were conveted into actual number of jobs using the current area of SRC and Micanthus grown and average yields this is equivelent to around 25 jobs in the SRC sector and 55 jobs in the Miscanthus sector.

Table 8: Employment associated with biomass feedstock production & processing feedstock – including conversion to total jobs, based on current and forecast areas.

Feedstock	FTE/odt (oven dry tonne)	Converted to FTE in 2015 (based on current area)	Converted to FTE in 2055
Forestry	0.001341	-	6,300
SRC	0.000945	25	2,100
Miscanthus	0.000852	55	2,400
Average	**0.001046**		

*Miscanthus calculations based 9.3 odt/ha/yr at 20% moisture, current area of 7,000 ha and our predicted area in 2055 of 299,500 ha.

*SRC yields based on yields of 7.5 odt/ha/yr at 30% moisture based on a current area of 3,500 ha and our predicted area of 296,000 ha by 2055.

*SRF yields based on yields of 8 t/ha/yr[18] and our predicted area of 585,000 ha by 2055.

2.4 Summary of bioenergy jobs in the context of the existing agricultural and forestry work force

- **Current combined estimate of jobs in agriculture & forestry-** The agricultural statistics show that the current employment level in agricultural sector was around 300,000 in 2015[19]. According to a LANTRA study, the size of the workforce was estimated at nearly 100,000 individuals in the Trees and Timber industry when considering the 'hidden' employment in the sector. Combining the estimates gives total employment in agricultural, arboriculture and forestry sector as around **400,000.** This is consistent with the estimates in the PwC report[20].

- **Current estimate of jobs in bioenergy to field gate** - The NNFCC report[21] is fairly comprehensive and has reviewed a range of studies and synthesised the evidence available on the employment requirements for the feedstock production in the bioenergy sector. Their estimates included the following key stages in the feedstock supply chain: feedstock planting and management, feedstock harvesting, feedstock processing and feedstock haulage. On average, the direct jobs created in the feedstock production supply chain was estimated at **0.001046 FTE/odt**, although the yield assumptions used in this report are not clear. Using the current area of bioenergy crops grown and average yield estimates, this is equivelent to around 25 jobs in SRC production and 55 jobs in Miscanthus production. Based on our forecast areas of production in 2055 this would rise to 6,300 jobs in SRF, 2,100 in SRC and 2,400 in Miscanthus.

- **Skills needed and how these compare to conventional crop or forestry production**-The LANTRA study suggests that the most significant skill gaps were traditional forestry skills, management skills among contractors, as well as non-traditional skills such as negotiation (particularly in coppicing). In addition, skill gaps among new entrants were related to achieving a balance between legislative training requirements, and the skills and experience to do the job effectively and in a commercially viable way.

3 Identification of labour requirements for a growing bioenergy sector

3.1 Approach

Using the evidence review as a starting point, the number of jobs and job types required to support a growing UK bioenergy sector for short rotation forestry (SRF), short rotation coppice (SRC) and Miscanthus were identified. This process was supported by expert knowledge of bioenergy crop production supported by stakeholder review of the details. The job requirements for meeting the UK's afforestation targets were also assessed including identifying whether these jobs were complementary in skills to those required for increasing the size of the bioenergy sector. This assessment returned to first principles (e.g. hours required per activity, at a hectare level) and considered the labour requirements for the following aspects of bioenergy crop production;

- Planting material production; e.g. seedling trees for forestry, cuttings (from freshly harvested rods) for SRC and rhizomes or micro propagation modules for Miscanthus.
- Advice and technical support on crop establishment and management
- Ground preparation and the establishment of the crop, including any early maintenance, spraying etc. and one off inputs (thinning/cutback).
- Fencing and physical protection of establishing crops, and other jobs associated with the supply chain
- Annual management of the crop
- Harvesting and any on site processing / storage
- Crop removal and land clearance at the end of its viable lifespan.
- Transportation & logistics (single journeys of raw materials from point of purchase to farm, farm to first processing location)

The timing of operations and constraints to timing were also considered; e.g. is planting time constrained by climate, when can crops be harvested and therefore the knock on implications on labour requirements. Simplistically is it 60 days' work over three months – one job, or 60 days' work over one month – three jobs.

A particular element of interest was the profile of the labour input to perennial bioenergy crops over the lifetime of the crop. For example, after establishment of SRC, there is limited management input – harvest is every 3 years – and this uneven labour demand was taken into account when estimating the annual average number of jobs associated with the sector.

A combination of internet based research and ADAS expert knowledge was used to identify the main jobs and tasks required to establish and manage the bioenergy crops. These assumptions were then validated through stakeholder consultation. Stakeholders contacted include:

- Planting material producers - Cheviot trees, IBERS and Elsoms Seeds (for background information on plant breeding)
- Growers and contractors- Crops for Energy Ltd, RIDA Associates.

In order to make this aspect of the work scalable over time, employment requirements were calculated per unit of crop – e.g. per hectare. An excel workbook was produced that shows the types of jobs involved and the time requirement per unit of crop, and then the area of crop forecast for each year between 2015 and 2055. An example of the basic content of the workbook is shown in Table 9. The job types were separated out into production of planting materials, establishment of crops, annual maintenance, harvest and crop removal. For a single hectare some of these jobs would only happen at set intervals, e.g. planting only happens at the start of the crop, with harvest happening at different intervals depending on the crop (annually for Miscanthus, every 3-5 years for SRC and every 10-30 years for SRF), therefore these time intervals were taken into account when collating the final job numbers.

Table 9 Example workbook for capturing job requirements

Short Rotation Forestry	Area	Time requirement (hrs/ha)	Frequency of requirement	Timing of activity			
Job Type				Jan	Feb	Mar	April
Production of planting material		X	Once per ha planted				
Thinning		Y	Annual				
Harvest (felling of trees)		Z	Once every 10 years				

The total job types were categorised into five broad types;

- Off farm specialists including plant breeders, agronomists, technical advisers
- Farmers or farm workers (usually the landowner or one of their staff)
- Specialist contractors – usually anticipated to have the required equipment to either plant or harvest the raw materials
- Casual labour – potentially seasonal labour e.g. to assist with planting or harvesting, with no particular skills required
- Logistics – typically HGV drivers and other parts of the logistics operations.

In addition the timing of the job (to the nearest month) was identified, i.e. planting and harvest are constrained to the late winter and early spring. The total hours required per hectare for each task were multiplied by the forecast area for the relevant crop in each year to calculate a total hours per year. This was then converted into jobs in two ways;

- Converted to full time job equivalents (FTEs) – assuming a 40 hour working week and a 46.5 week working year (28 days annual leave/holidays). This method gives an estimate of the number of jobs that can be supported by the industry, but does not take into account the seasonality of the employment opportunities.
- Converted the total hours per month into FTEs – or individuals required – based on an 8 hour working day and a 21 day working month (no annual leave taken into account – it is assumed leave is not taken during peak periods). The maximum number of jobs from each job type across all the months was taken to be the maximum employment opportunity. This method takes into account the seasonality of the work in that it identifies just how many people will need to have developed those skills, but over estimates how much work is available for them in the other months.

Both these figures are presented in order to capture the scale of the jobs, but also the size of the skilled work force required.

3.2 Findings

3.2.1 Breakdown of estimated number of jobs/time input for SRF, SRC and Miscanthus in 2015 and 2055

The job projections for SRF, SRC and Miscanthus in 2015 and 2055 are set out below. For each crop, the type of tasks and the number of hours/ha required for each task are detailed, followed by the number of estimated jobs in 2015 and 2055. A summary of all the jobs required by the bioenergy sector in 2055 is then given.

Short Rotation Forestry

Tasks and associated time input

Short rotation forestry (SRF) is the practice of cultivating fast-growing trees that reach their economically optimum size between 10 and 30 years from planting, depending on SRF species used (for the purposes of this report it is assume harvest maturity occurs at 15 years). The crop tends to be grown on lower-grade agricultural land, previously forested land or reclaimed land and therefore rarely directly competes with food crops for the most productive agricultural land. This means that any jobs that are created through the establishment of SRF are likely to be new jobs, not displacing existing jobs. It has been suggested that SRF, particularly using Eucalyptus, has the potential to deliver greater volumes of biomass from the same land area than alternative biomass crops, although experience of growing SRF in the UK is currently very limited[22].

There are a number of tasks involved in SRF production. These are split into five main areas; production of planting material, site selection and preparation, annual maintenance, harvest of crop and initial processing, transport and site clearance. In terms of **production of the planting material** this involves sapling production, transport to farm and unloading on farm, taking an estimated **12.4 hours/ha** in the establishment year, with peak activity carried out between November-February – although sapling production actually occurs prior to the planting year. **Site selection and preparation** involves choosing a suitable area, cultivation of land in advance of planting, planting and tubing and staking trees, and spot spraying weeds that could outcompete the trees during early growth. This is estimated to take **56.6 hours/ha** in the establishment year, with cultivations in advance of planting carried out in the autumn, planting carried out between November-February and spot spraying carried out between April-June. **Annual maintenance** can be carried out at any point during the season and takes approximately **8 hours/ha/year** for the first 12 years of production (average 6.4 hours/ha/year across lifespan of crop). **Harvesting** can also be carried out year round (as assumed in the calculations for the purposes of this report), but tends to be carried out during the winter months as this is when the wood quality from SRF is highest and harvesting at this time also avoid impacts on breeding birds or disturbance to other wildlife. Harvesting is estimated to take up to **111.4 hours/ha** in the final year. The final stage of SRF production is **transport to processing plant**, this can take place throughout the year and is estimated to take **6.0 hours/ha** in the final year. The clearance of the site in preparation for replanting is estimated to take **0.7 hours/ha** in the final year.

In total this gives an average annual labour requirement of **18.9 hours/ha** assuming a 15 year cropping cycle as shown in Table 10.

Table 10 Breakdown of labour requirement for growing SRF in terms of hours/ha (at time of occurrence) and hrs/ha/year (with harvest and establishment requirements averaged across the life of the crop assuming a 15 year harvest interval)

Task	Lifetime labour requirement (hours/ha)	Labour requirement annualised across life of crop (hrs/ha/year)
Establishment	69	4.6
Annual maintenance	96	6.4
Harvest (inc transport)	117	7.8
Clearance	0.7	0.043
Total	283	18.9

Current number of jobs

There are currently no large areas of short rotation forestry (SRF) grown in the UK and as such it is assumed that this sector does not currently support any jobs.

Projected number of jobs in 2055

It is forecast that the SRF area will reach 585,000 ha in 2055, assuming an annual increase in area of 15,000 ha/year. In 2055 the number jobs forecast to be sustained by the SRF industry in the UK is 5,600 FTEs, in peak periods this rises to 8,200 individuals required, consisting of 3,700 individuals in England, 2,000 individuals in Scotland and Wales and 400 individuals in Northern Ireland.

The 5,600 FTEs created by 2055 consist of 1,700 FTE in planting/establishment, 2,000 in annual management and 1,900 in harvesting. The profile of job creation is as follows:

- Planting/Establishment: In order to plant 15,000 ha per year there is a need to develop an initial workforce equivalent to 550 FTE to produce the planting material, provide advice on locating and establishing the crop, to prepare the land and actually plant the crop. Once established, this work force remains relatively consistent in size, with the planting material requirement holding steady at 15,000 ha every year through until about 2032. At this point the older crops i.e. those reaching 15 years old will be starting to be harvested and therefore to maintain the increase in in SRF area additional planting material will be required to replant the harvested area. This means that in order to maintain the 15,000 ha year on year increase in area approximately 30,000 ha of SRF will need to be planted annually. This doubles the size of the workforce needed to 1,100 FTEs, increasing again in 2047 (when the second rotation reaches maturity) to 1,700 FTE.
- Annual Management: For every 15,000 ha planted there will be an annual labour requirement (for management of the crop) equivalent to 52 FTEs, therefore these jobs will gradually increase in number as the area of the crop grows (from 52 FTEs in 2016 to just over 2,000 FTEs in 2055). These jobs would typically be carried out by the land owner or casual labour employed to check rabbit fencing and tree tubes during the establishment of the crop.
- Harvesting: In 2032 it is assumed that the first 15,000 ha of SRF will be harvested. This will create around 950 FTEs. In 2047, this figure doubles to 1,900 FTE as the annual harvest area increases to 30,000 ha

The labour profile of the timing of SRF jobs is shown in Figure 5, which shows that the baseline number of jobs needed in the SRF industry (in 2055) is around 3,700 individual jobs increasing to around 8,200 individuals during January and February where site preparation and planting alongside harvesting of mature trees takes place, hence the higher labour demands during these months. The ability to fell crops at any time of year makes the job profile of SRF (once you get to the point of harvest) relatively even, especially for the specialist contractors and off farm specialists, however peak periods of activity coincide with slightly quieter periods in the year for other crops such as spring cereal crops.

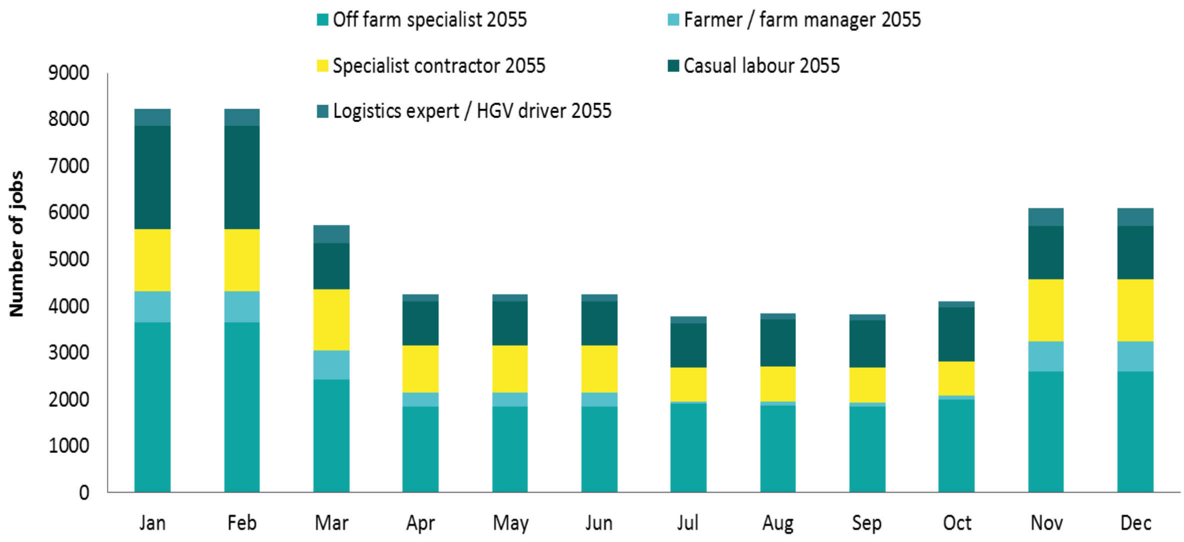

Figure 5 Number of UK jobs projected to be engaged in SRF production broken down by month by 2055

Short Rotation Coppice (SRC)

Tasks and associated time input

The tasks involved in SRC production have been split into six main areas; production of planting materials, site selection and preparation, annual maintenance, harvest of crop, transport and initial processing, and removal of the crop. **Production of raw material** in the UK is carried out by dedicated breeding companies such as Murray Carter or by research institutions such as Rothamsted Research. Breeding material can either be produced by growing rods which are up to 2m in length or via the production of cuttings (up to 20 cm). Once produced, these are then transported and unloaded on farm. The time taken to produce and transport breeding material to farm is estimated to take **36.3 hours/ha** and tends to be carried out between February-March.

Site selection and preparation involves selection of suitable field to grow SRC on, cultivations and applications of pre-planting herbicides, planting and post emergence applications of herbicides and fertilisers to encourage early growth. A stale seedbed is often left over winter with cultivation in advance of planting usually taking place around six weeks prior to planting. The SRC planting season extends from early spring – February/March – when weather conditions allow soil preparation, to late May and even June using cold stored cuttings. Early planting will give early establishment and a longer growing season for the establishing crop with a lower risk of water stress from a late spring dry period. Once planted the land is rolled for consolidation and pre-emergence herbicide applications are applied.

Following establishment and after the first cutback a further herbicide application will be necessary to keep the crop weed free until it achieves canopy closure and a fertiliser application can be made during this period if required. This generally occurs in year 2 of the three year growing cycle around mid-March-mid April. Site selection and preparation is estimated to take around **12.1 hours/ha** with this time commitment spread over the first 2-3 years of the crop**.**

Once the crop has been planted there is a requirement for **ongoing maintenance**. This involves tasks such as cutting back of SRC to <10cm and gapping up (in second year only) and ongoing agronomy support. Cutting back the SRC is carried out between January-February to encourage it to grow from multiple stems[23]. Gapping up is needed where poor planting and weed competition leads to gaps in the plantation, which need to be filled in order to maximise yields. To do this, 60 cm cuttings are purchased from a cutting producer and planted. Averaged across the lifespan of the SRC crop these tasks are estimated to take **2.6 hours/ha/yr.**

Harvesting is estimated to take **8.0 hours/ha** (once every 3 years) and is carried out between December-April depending on soil conditions. There are three main methods of harvesting: *direct harvesting* which is the most popular, along with *stick harvesting* and *billet harvesting*. Direct harvesting is where SRC is harvested at three years old using a modified forage harvester with a specialised header. The SRC is chipped directly in the field and the chipped SRC transported to farm/storage pad for drying. Stick harvesting is where SRC is harvested using a 'Stemster' which is a whole rod harvester. The harvested sticks are then laid to dry out naturally on the field headland or dried at the main yard, before it is chipped after 3-9 months when it reaches 25-30% moisture content. Billet harvesting cuts the rods into 5-20cm lengths before it is transported to the farm and stacked to dry before chipping at around 30% moisture content[24]. Once SRC reaches the end of its useful life (25 years) it needs to be sprayed off with glyphosate and mown using a bush-hogger, this is estimated to take **0.65 hours/ha** (every 25 years).

The final process of production of SRC is the **loading and transport** of chipped SRC off farm for use in a power station. This is estimated to take **1.0 hours/ha (once every 3 years)** and can take place all year round depending on demand from the end user.

In total this gives an average labour requirement of **7.5 hours/ha/yr** for the lifetime of the crop as shown in Table 11.

Table 11 Breakdown of labour requirement for growing SRC in terms of hours/ha (at time of occurrence) and hrs/ha/year (with harvest and establishment requirements averaged across the life of the crop assuming a 3 year harvest interval and 25 year lifespan)

Task	Lifetime Labour requirement (hours/ha)	Labour requirement annualised across life of crop (hrs/ha/year)
Establishment	48	1.9
Annual maintenance	66	2.6
Harvest (inc transport)	72	2.9
Clearance	0.7	0.03
Total	**187**	**7.5**

Current number of jobs

There are currently 3,500 ha of SRC grown in the UK which, by our calculations, is estimated to support 11 FTE jobs, although at peak periods this rises to 27 individuals required (assuming that the areas were close enough together for one person to manage). The number of individuals currently predicted to be employed in the SRC sector is around 22% less than the number of jobs predicted by the NNFCC report (33 jobs), although the NNFCC report includes jobs involved in processing, whilst this report does not include this, possibly explaining the differences between the two figures.

Projected number of jobs in the SRC sector in 2055

By 2055 the area of SRC is forecast to rise to 296,000 ha, and by our estimates is forecast to support 1,200 FTE jobs, with 4,000 job opportunities created throughout the year (in peak periods up to 3,500 individuals are needed). The NNFCC estimates based on 0.000945 FTE per oven dried tonne would be equivalent to 2,100 FTE jobs required by 2055 (if figures are scaled up using predicted future area of SRC planted and average yields of 7.5 odt/ha/yr at 30% moisture based on BVCM model estimates), with jobs involved in processing thought to be the reason for the higher NNFCC figures. The review by Thornley et al (2008) predicts that the labour requirement for SRC feedstock supply is **0.001 FTE (Full-Time Equivalent) per hectare**, equivalent to 296 FTE jobs in 2055. It is unclear just what was included in this assessment as it claims to include land preparation, growing the crop and harvest, but does not detail just what was included in those assessments (e.g. it is assumed that the production of planting material was excluding, the finding of sites and the advice to support establishment and management were excluded).

The 1,200 FTEs created by 2055 consist of 400-450 FTE in each of planting/establishment, annual management and harvesting. The profile of job creation is as follows:

- Planting/establishment: In order to achieve a 7,500 ha a year increase in the SRC area it is forecast that there will need to be an increase in the number of people with the skills required for producing planting materials, identifying sites, providing advice and then also the preparation and planting of the site. The forecast indicates that on an annual basis an initial workforce of around 200 FTE will be required for the planting and establishment of new crops, as crops start to reach the end of their productive life span (assumed to be 25 years) this workforce will need to double to 400 FTE as existing areas are grubbed out and have to be replaced alongside maintaining the increase in area. Some of these jobs e.g. the breeding, advice and specialist planters will be carried out by the same individuals, just applied to different locations, whereas the more casual labour or site specific jobs are likely to be carried out by different individuals depending on the location of the new crops.
- Annual management: For each additional 7,500 ha planted it is expected that the number of jobs associated with annual management of the crop will increase by 11 FTE per year rising to around 400 FTE in 2055.
- Harvesting: Current harvesting jobs are estimated to be equivalent to 5 FTEs. From 2021, when the first of the newly planted SRC reaches harvest, harvesting jobs will also gradually increase as the total area increases by approximately 11 FTE per year up to a total of around 450 FTE in 2055.

Figure 5 shows the timing of job demand in SRC production in 2055. Harvest takes place from December to April, showing as demand for specialist contractors in these months. However, the peak in demand for jobs occurs during the spring, peaking in March as this is when both planting and harvesting take place. There is also a demand for jobs in September and October as this is the period when sites tend to be selected for SRC production and farmers undertake the primary cultivations needed to prepare the land for SRC planting in the spring. The increase in activity in July represents off-site specialists (agronomists) providing advice on ongoing management of the plantation.

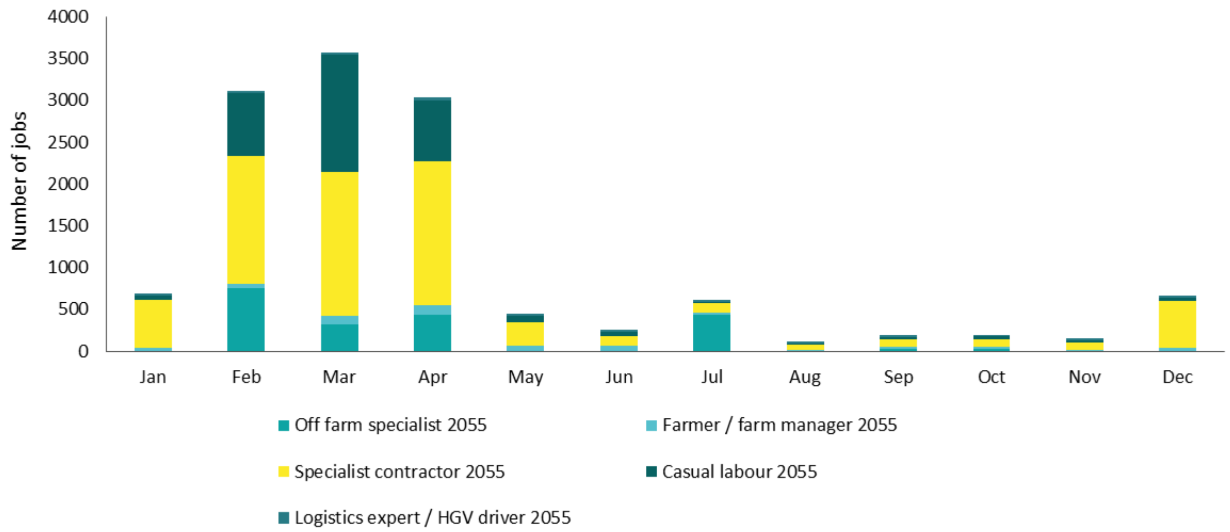

Figure 6 Number of UK jobs projected to be engaged in SRC production broken down by month in 2055

Miscanthus

Tasks and associated time input

Miscanthus species are woody, perennial, rhizomatous grasses, originating from Asia which have the potential for very high rates of growth. Once established (2-3 years) they are harvested annually, with a typical crop lifespan of 25 years. There are currently an estimated 7,000 ha of Miscanthus grown in the UK, with the majority of crops grown in England. The forecast is for the Miscanthus area to rise by 7,500 ha per year through to 2055, giving a total estimated area of 299,500 ha by 2055. There are number of different tasks involved in growing Miscanthus, which are split into four main areas for the purposes of this study; **establishment** (production of planting materials, site selection and preparation), **harvesting**, **transport and processing** and **clearance**. Currently, Miscanthus is produced using self-propagating rhizomes which can be split and small sections planted to produce new plants, however the long term aim, and the focus of current research projects such as the GIANT Link project with the University of Aberystwyth, Terrevesta, Lifecycle Carbon, University of Aberdeen, Ceres Inc, E-on, Blankney Estates and Biocatalysts Ltd, is to breed Miscanthus from seed. This will have the benefit of producing a large number of plants at a fraction of the cost of rhizomes, potentially allowing Miscanthus to be planted on a larger area than currently possible in the UK and overcome some of the existing barriers associated with high cost of establishment using rhizomes.

Seed production is still in the pre-commercial stage. Personal communication with experts from the University of Aberdeen and the University of Aberystwyth suggested that by 2019 plug plants will be available for commercial planting of small areas of crops. It is anticipated that given the challenges of getting Miscanthus to set seed and then for that seed to emerge and establish that plug plants will be a more effective planting material than seed alone, at least in the short to medium term. Plug plants are young plants with well-established, complete and independent root systems. The calculations in the model are currently based on 10% of the forecast area being planted with plugs from seed. Plug plants offer significant time savings as opposed to planting rhizomes as rhizomes take around 7.5x longer to plant than plug plants.

It is currently assumed that a team of 14 people working full time can produce enough seed / plug plants to plant 750 ha of Miscanthus. When applied to a hectare this is equivalent to **3.5 hours/ha** in the year of establishment in the year of establishment. Please note that there is a significant amount of R&D time included in the plug plant figure which might also reduce over time and as such this figure should be treated with caution as seeds/plug plants are not yet in commercial production, and so this figure is based on expert opinion and extrapolation from current vegetable production. As commercialisation continues it is anticipated that this figure will drop as the team is able to deliver more hectares of planting material per year.

For rhizome production, tasks include mowing and baling the existing crop, chopping, lifting and storing the rhizomes before transport off farm. This typically takes **2.7 hours/ha** in the establishment year and takes place between January-March.

Site selection and preparation involves a number of tasks including identification of suitable fields for Miscanthus production, cultivation of the site for planting, pre-planting herbicide applications, planting and post emergence herbicide and fertiliser applications. Cultivation of the site for planting is usually carried out in the autumn, with pre-planting herbicides being applied between February-March i.e. just prior to planting. Rhizomes/seeds are then planted between March-May and fertilisers and herbicides applied between April-May. These tasks are estimated to take around **15.7 hours/ha** in the establishment year**.**

Annual crop management (including harvest) involves mowing/conditioning the crop, baling the crop and stacking the bales on farm and takes place between January-April. Advice from an agronomist is also part of annual crop management and can occur at any point during the year depending on the farmer requirement but typically occurs during the summer months. Annual crop management is estimated to take around **12.7 hours/ha/yr** in a harvest year**.** Clearance of the crop once it reaches the end of its useful life (25 years) involves spraying off with glyphosate and ploughing the crop in. This is estimated to take **1.40 hours/ha** (once every 25 years).

Transport and initial processing can occur at any point during the year depending on demand from bioenergy crop processors, this takes around **1 hours/ha/yr** in a harvest year**.**

In total this gives an average annual labour requirement of **14.6 hours/ha,** when establishment costs are allocated out pro rata as shown in Table 12.

Table 12 Breakdown of labour requirement for growing Miscanthus in terms of hours/ha (at time of occurrence) and hrs/ha/year (with harvest and establishment requirements averaged across the life of the crop assuming an annual harvest and 25 year lifespan)

Task	Lifetime labour requirement (hours/ha)	Labour requirement annualised across life of crop (hrs/ha/year)
Establishment	22	0.9
Annual maintenance	With harvest	With harvest
Harvest (inc transport)*	314	12.6
Clearance	1.4	0.056
Total	**337**	**13.5**

*Assumes 23 harvests (2 years for crop to reach harvestable size and 25 year lifespan)

Current number of jobs

Currently Miscanthus is grown on approximately around 7,000 ha supporting an estimated 51 FTE jobs in the UK, rising to a peak of 130 individuals required during busy periods. The demand for labour is concentrated between January-April where cultivations pre-planting and planting is carried out. From May- December there is very little labour input, mainly focused around loading and transporting Miscanthus bales to a processing plant and ongoing agronomy support throughout the season.

Projected number of jobs in 2055

If the area of Miscanthus grown increases by 7,500 ha/year between 2015-2055 this would result in an area of 299,500 ha by 2055. The increase in the area of Miscanthus planted is forecast to sustain 2,200 FTE jobs by 2055, although there is a strong skew towards work in January – April which means that there are up to 5,600 individuals supported for those months, with only 300-400 individuals supported during the remainder of the year. The maximum number of individuals supported (5,600 individuals) is broken down into 5,000 individuals in England and about 300 individuals in both Scotland and Wales during those peak periods. It is forecast that 46% of these jobs will be carried out by farmers using their existing skills, with 43% of jobs carried out by specialist contractors, 8% by casual labour, 2% by off farm specialists (plant breeders and agronomists) and the remainder by those with skills in logistics. The NNFCC report forecasts 3,300 FTE, which falls between our annual estimate of 2,200 FTEs, and our actual peak demand estimate of 5,600 individuals. However, it is thought that the NNFCC figure includes processing, whilst our calculations exclude this. The review by Thornley et al (2008) suggests a FTE per hectare for Miscanthus of 0.0014 which is equivalent to just 419 FTEs. It is unclear how this report has dealt with the establishment of crops (and the fact it only occurs once in 25 years), and it excludes the production of the planting material. However, that still does not explain why this figure is so far short of what was calculated by returning to first principals in this assessment.

The 2,200 FTEs created by 2055 consist of around 200 FTE in planting/establishment and 2,000 FTE harvesting. The profile of job creation is as follows:

- Planting/Establishment: For each 7,500 hectares planted it is estimated that there are 88 FTE jobs required to support the production of planting material, site selection and preparation and then complete the planting operation. These jobs will remain relatively stable, with the same specialists able to produce planting materials, advice and contracting services each year, however the least specialist skills such as the land preparation will most likely be carried out by the landowners and therefore these jobs will be transient, depending on the location of the new crops for each year. There will need to be a step change in the number of jobs associated with establishment in about 2042, associated with the older crops coming to the end of their useful life and needing to be grubbed out and replaced. This will increase establishment jobs to 174 FTE per year, in addition there will be about 12 FTE per year associated with the clearance of the old crop.

- Harvesting: The jobs associated with harvest will increase gradually as the area to harvest increases, it is forecast that for each additional 7,500 ha harvested an additional 55 FTE jobs would be supported, up to just over 2,000 FTE jobs in 2055. However, given the need to harvest in the winter, the number of skilled operators will need to be closer to 5,600 individuals, although they will not have employment working with Miscanthus all year round.

The profile for demand for labour in 2055 shows that peak labour demand occurs between January-April where planting of the additional area of Miscanthus and annual harvesting is carried out (Figure 7).

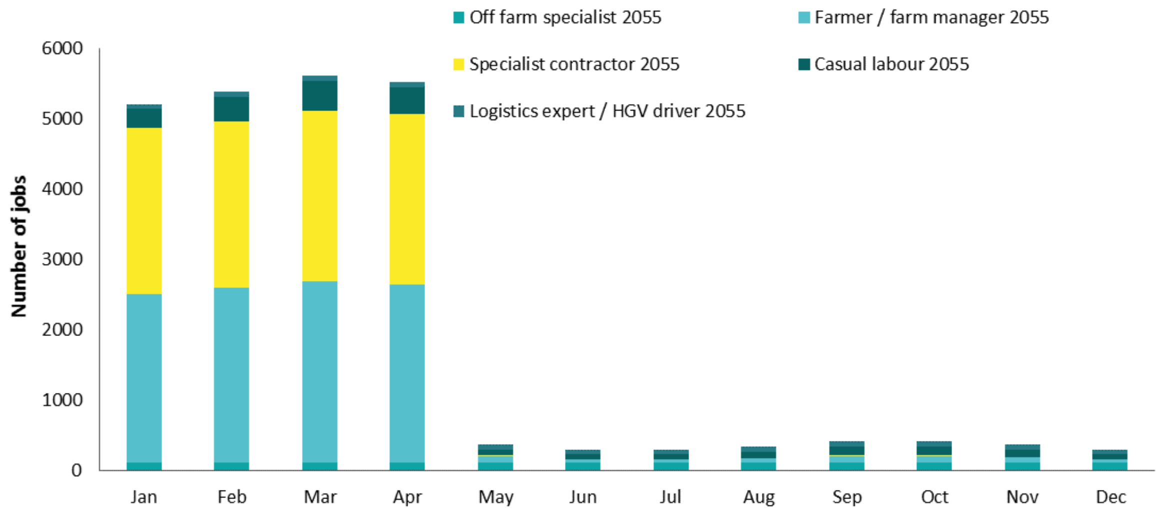

Figure 7 Number of UK jobs projected to be engaged in Miscanthus production broken down by month by 2055.

Afforestation

Tasks and time input required

There are number of different tasks involved in afforestation, which are similar to the tasks carried out when planting short rotation forestry (SRF), but the main difference is that these trees are not harvested, they are left to grow into a mature stand. These are split into three main areas; production of planting materials, site selection and preparation and annual maintenance.

Production of planting materials relates to when saplings are grown in a nursery and involves tasks such as nursery seed bed production, seed establishment, undercutting seedlings, lifting and grading of plants and bagging up plants ready for distribution. These tasks tend to be carried out between November- March, involving a total of around **12.4 hours of time/ha** in the year of establishment.

Site selection and preparation involves selection of a suitable site either by the farmer or land agent, cultivation of the site in advance of planting e.g. by subsoiling, planting, tubing and staking of trees for protection and spot spraying around tree bases against weeds that could compete with immature trees. Site selection can be carried out year round, with cultivations in advance of planting usually carried out in early autumn when the land is dry enough to travel on. Planting and tubing and staking is usually carried out between November-March, with spot spraying where necessary carried out in the spring and takes around **65.3 hours/ha** in the year of establishment**.**

Annual maintenance involves checking for rabbit damage, checking tubes and stakes in place etc. and can be carried out throughout the year where needed, this involves around **8 hours/ha** for the first 12 years of establishment.

In total this gives an average annual labour requirement of **1.7 hours/ha,** assuming a 100 year lifespan of the afforested area as shown in Table 13.

Table 13 Breakdown of labour requirement for afforestation in terms of hours/ha

Task	Lifetime labour requirement (hours/ha)	Labour requirement annualised across life of crop (hrs/ha/year)
Establishment	78	0.8
Annual maintenance (first 12 years only)	96	1.0
Total	174	**1.7**

Current number of jobs created by afforestation

For the purposes of this report it is assumed that there are currently no jobs supported by afforestation projects, however it is recognised that there is tree planting taking place in some areas and there are already 11,700 jobs present in the forestry sector – as identified in the Lantra statistics in Task 1[25].

Projected number of jobs in 2055 created by afforestation

For the purpose of this report it is assumed, based on current policy intent, that each of the nations (England, Scotland and Wales) has an aim to afforest 100,000 ha. In England and Scotland it is assumed that afforestation will occur at a rate of 10,000 ha per year, whilst in Wales the rate of afforestation is assumed to be 5,000 ha per year and in Northern Ireland the rate of afforestation is assumed to be 2,500 per year (capped at 50,000 ha). Once the afforestation targets are reached in 2026 (England & Scotland) and 2036 (Wales and Northern Ireland) no further plantings of afforested areas are made. At its peak in 2026, the number of UK jobs created by afforestation is forecast to be 1,290 FTE. At peak planting times, a labour force of up to 2,400 individuals would be required. However, once targets are met in England and Scotland in 2026, the number of jobs would reduce and focus on those in Wales and Northern Ireland, with those jobs reducing once targets are met in these nations (2036). Some of these planting skills jobs will be transferable into the SRF sector as the planted area of SRF reaches harvest maturity and needs a doubling in the area of crop planted to maintain growth, but those jobs that are no longer required in England and Scotland, will occur earlier than the expected upsurge in demand from SRF.

The labour demand for afforestation in the UK in shown below (Figure 8). The peak months for labour demand are November-February where a total of around 2,400 individuals/month are needed for site selection and preparation, tree planting, tubing and staking trees as well as maintenance of existing trees. Labour demand is lower between April- October at around 350-700 individuals/month as this is where cultivation of the site in advance of planting and spot spraying of weeds around existing trees takes place.

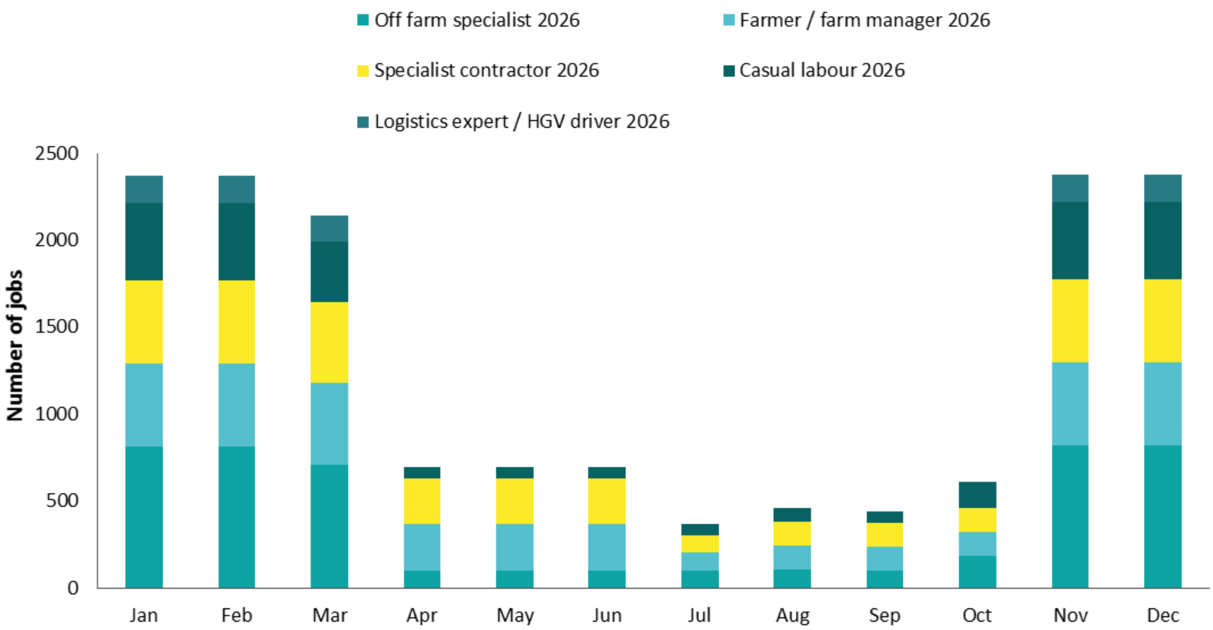

Figure 8 Number of UK jobs projected to be engaged in afforestation production broken down by month at its peak in 2026.

Summary of job creation for all bioenergy crops (and afforestation)

In 2015, an estimated 62 FTE jobs were involved in bioenergy crop production, although around 157 individuals were required at peak times. The uneven nature of tasks in the bioenergy sector means that many of the roles identified are part time, with peaks in activity tending to coincide with lulls in the farming calendar. In a typical arable system peak workloads in July-October when harvest, cultivation and establishment of winter crops occur. Based on an average 30,000 ha per year increase in bioenergy crop plantings, to reach a target of 1.18M ha of bioenergy crops by 2055, this industry could sustain 9,100 FTE jobs by 2055, the majority (5,600 FTEs) of these jobs would be in the SRF sector due to the large area, with 1,300 FTEs in the SRC section and 2,200 FTEs in the Miscanthus sector (Figure 9), although 17,900 job opportunities could be created across the year with up to 16,700 individuals required at peak times to complete the tasks within the required timeframe. Afforestation would create jobs in the early stages of establishment, but once the target area is achieved there are limited further opportunities in this sector, and therefore by 2055 it is assumed that those individuals who developed skills for establishment of afforestation schemes, will have transferred to the growing SRF sector, although the slight time lag between availability and demand may mean that skilled individuals are lost and new individuals have to be trained.

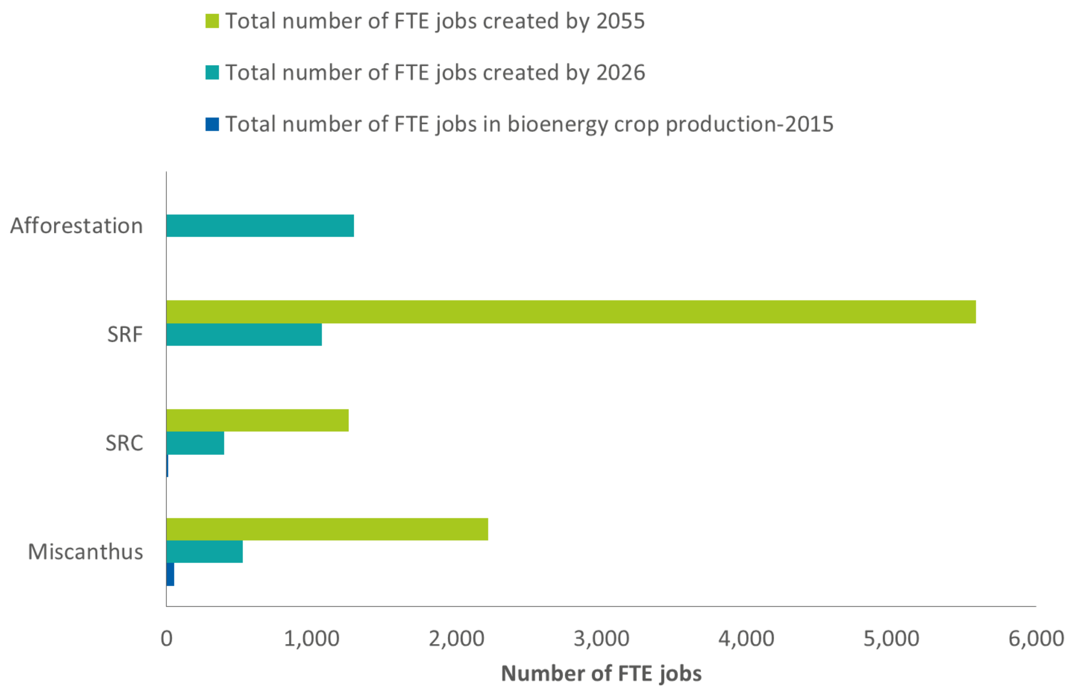

Figure 9 Summary of current levels of employment in the bioenergy sector compared to the projected increase in jobs by 2026 and 2055 due to increased bioenergy crop planting.

Labour profile in the bionenegy sector

The labour profile of individuals required by the bioenergy sector varies by month, with labour demand peaking at between 12,800-16,700 individuals between January and April where planting and harvesting of bioenergy crops takes place and pesticide applications are made. Between May and December the demand for labour is lower, ranging between 4,300-7,000 individuals. This is shown in Figure 10, which is a combined figure bringing together data from all bioenergy crops covered in this report in Figures 6, 7 and 8.

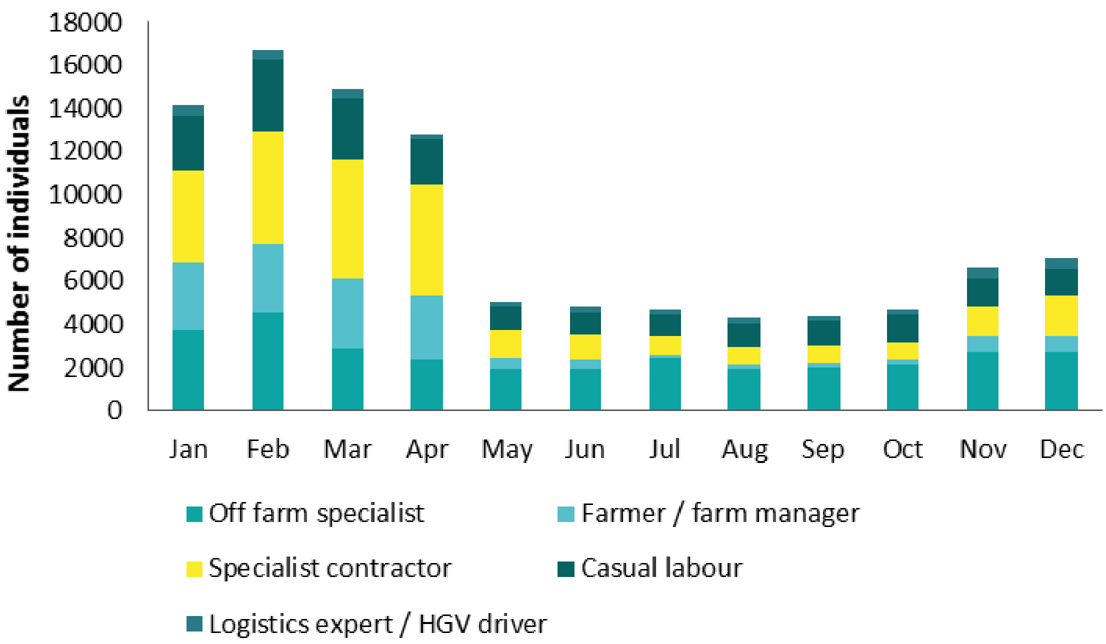

Figure 10 Labour profile of all types of jobs involved in bioenergy crop production and the number of individuals required to deliver them each month in 2055. This does not include afforestation.

This varying labour profile throughout the season fits in well with the arable industry, as the main workload largely falls outside of the main workload associated with harvest and the autumn sowing of arable crops from July to October (see Appendix 1 – Comparison of labour requirements (per hectare per month) of bioenergy crops against arable and livestock production). This period however, does fall during the time when spring crops are drilled, although these make up a small proportion of the crop area, at least in England and Wales and the spring offers a wider window of opportunity to complete land work compared to the autumn meaning that farmers could grow both arable and bioenergy crops on the same farm and it wouldn't impact too much on workload. The nature of the workload also means that there are alternative opportunities for specialist contractors/casual farm workers to be employed across the season as during busy periods in the arable sector (autumn and June-September) they could be employed by the arable industry, moving over to work in the bioenergy industry over winter.

Type of role needed to carry out tasks involved in bioenergy crop production

Of the 17,900 individual job opportunities estimated to be supported by the bioenergy sector in 2055 (during peak times) it is anticipated that 31% will be specialist contractors, 25% offsite specialists (agronomists, advisers, plant breeders), 23% casual labour, 18% farmers and the remainder will be logistics experts (lorry drivers). (Figure 11).

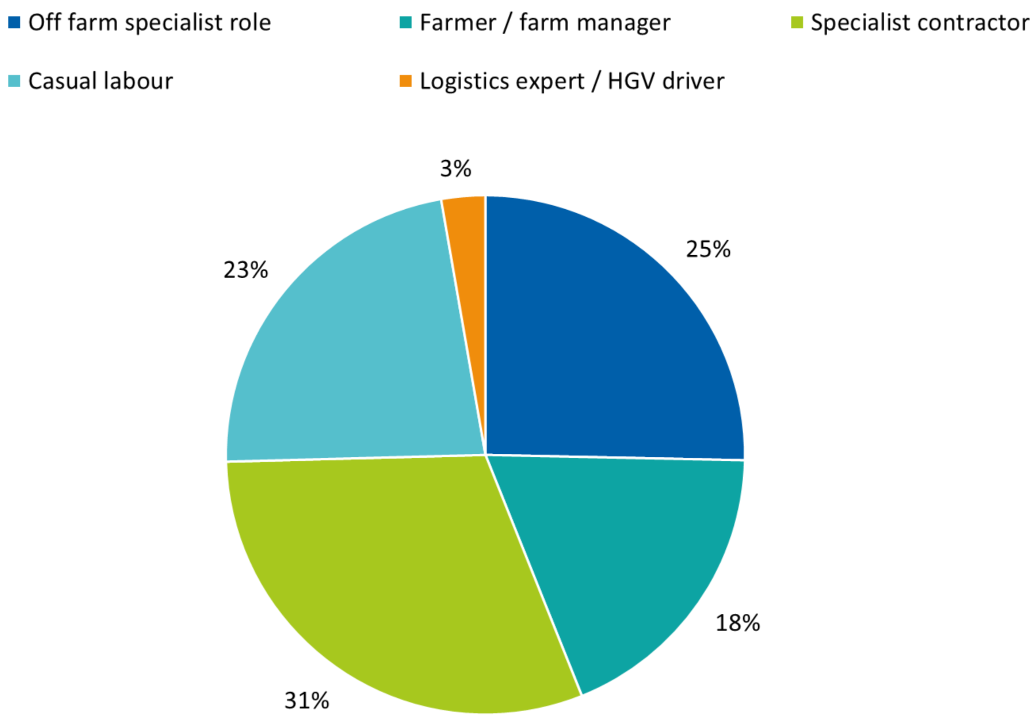

Figure 11 Breakdown of the proportion of labour categories that will be needed to work in the bioenergy sector in 2055.

Table 14 Summary of the different types of roles involved in bioenergy production and examples of the types of jobs carried out by each role type.

Role	Example of types of jobs covered by this role
Off farm specialist	Plant breeding, agronomy
Farmer/farm manager	Cultivating the land in advance of the crop, fertiliser spreading, pesticide application
Specialist contractor	Pesticide application, planting and harvesting the crop
Casual labour	Manual labour tasks such as those involved in tractor driving, annual maintenance e.g. checking fences etc., repetitive tasks involved in the plant breeding process
Logistics expert/HGV driver	Delivery of planting material to farm, transport of crop off farm to first point of processing.

The demand for the different roles involved in bioenergy crop production varies between crops, for example in growing Miscanthus the majority of tasks are either carried out by farmers (46%) or specialist contractors (43% of total jobs), with 8% carried out by casual workers and 1-2% by HGV drivers and off site specialists. In contrast for SRF production, the job profile is split more evenly with 44% of jobs created carried out by offsite specialists, 27% by casual workers, 8% by farmers, 16% by specialist contractors and the remainder by HGV licence holders (Figure 12).

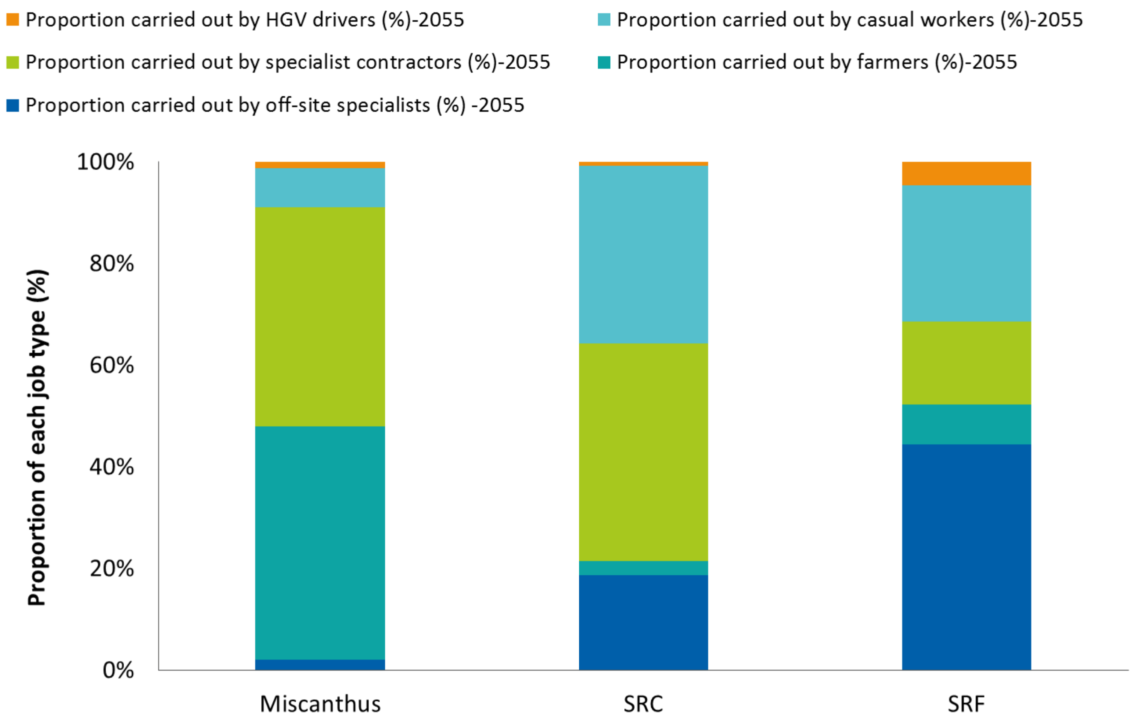

Figure 12 Proportion of jobs that are done by offsite specialists, farmers, specialist contractors, causal workers and HGV drivers for each crop in 2055

4 Understanding the skills requirements needed in the bioenergy sector

4.1.1 Approach

Alongside identifying the number of FTE jobs needed to produce each of the bioenergy crops, the skills required for those jobs were also assessed. In order to put the skills into context, the skills requirements for the jobs identified for each task were mapped against the qualifications (e.g. chain saw training, chartered forester etc.) and quality standards that have to be achieved in order to complete the tasks. This assessment also looked at where skills overlap with the existing work force and where new skills will need to be developed to allow for the market to grow. Information from the Agriculture, Forestry and Fishing: Sector Skills Assessment[26] was used to help compare which jobs are currently present in the Agriculture and Forestry Sector with those that are needed to support a growing bioenergy sector. Skills were identified in a matrix with the type of job, formal qualifications required if any, pre-existing skills that overlap with the current work force and new skills that will need to be developed (example shown in Table 15).

Table 15. Example of how skills matrix is set out

Type of job	Types of skills required	Qualifications required	Skills needed that overlap with current workforce	Skills needed that will need to be developed
Production of planting material				
Thinning				
Harvest (felling of trees)				

4.1.2 Findings

4.1.3 Job types and skills needed

Type of skills required – new or existing skills?

The majority of jobs created in the bioenergy sector overlap with the current skills needed in the wider agricultural industry. For example, for planting and maintenance of bioenergy crops, skills such as tractor driving, pesticide applications and telehandler driving are required; all skills which are currently used in the agricultural industry. If the land used for bioenergy crops is switched from that currently used to grow arable crops there is unlikely to be an increased demand for upskilling in these areas, however where bioenergy crops are grown on areas not under existing management, e.g. bare fallow, marginal land, or brownfield sites, there may be a need for some upskilling in these areas.

There are a number of tasks where **bioenergy sector specific skills are needed** and **upskilling will be required**. In each sector there is the need for sufficient expertise to be developed in basic crop agronomy, these agronomy skills will be similar to those used for other crops (e.g. understanding of how to establish the crop, pest and weed management), but these skills will have to be specially focused for each of the individual bioenergy crops as they are very different crops from the traditional annual arable crop. In addition there will need to be a development of a specialist contractor base with access to suitable machinery for the planting and harvest of each of these crops. The actual technical skills associated with operating the machinery are similar to those used for operating a range of farm machinery. However, the limiting factor in developing this group of skilled individuals will be access to suitable machinery as at present there is insufficient specialist machinery available in the UK to meet the needs of a growing bioenergy sector.

For example the machinery required for Miscanthus tends to be cheaper and more widely available than that used for SRC. There are around 10 planting machines in the UK located in the South West, Shropshire and Lincolnshire. These are relatively cheap to produce at approximately £15,000 (November 2015). Miscanthus is harvested generally with forage harvesters with some of the blades removed. There are thousands of machines that could potentially do this job across the UK, but at the time of writing there are less than 30 contractors who regularly engage in this activity[27].

In contrast to Miscanthus, the machinery required for SRC cultivation is highly specialised and expensive. A new 4-row Step planter costs in the region of £55,000 whilst a new Henriksson Salix AB (HSAB) harvesting head costs around £90,000. Modifications are also required to the self-propelled forage harvester onto which the harvesting head is mounted. The total cost for a header, a forage harvester, making the necessary modifications and spare parts is around £250,000[28]. As a result of the expensive nature of the kit there are only five fully functioning planters and ten harvesters in the UK. Most of these are located in areas where there are localised markets for SRC fuel (Nottinghamshire, Yorkshire, Cumbria and Northern Ireland). The lack of machinery outside these areas is a major barrier for existing growers or anyone interested in planting. This is because the machinery is expensive to transport and contractors prefer to travel with their own trained operatives increasing the cost considerably. Contractors are usually only willing to travel if there is an ample amount of work to do, spread over several growers. Hence, a grower in for instance the South West of England wishing to set up their own self-supply project growing five hectares of SRC would have to seriously consider how they will harvest the crop. Another piece of equipment that is essential for SRC management is a finger bar mower. This is used to cut the SRC down after the establishment year. These are not particularly expensive, but they are not widely available. This is unlikely to change unless the market has a significant upturn as they are only are useful for a single operation for each plantation planted. It is not possible to use a flail on a tractor (used to cut hedges) as this produces very poor results.

SRF can be harvested with conventional forestry harvesting and forwarding machinery. There is a well-established contracting base throughout the UK with a range of machinery capable of harvesting and extracting timber from plantations on a range of sites with different constraints. Large scale mechanised harvester and forwarder combinations are capable of harvesting in excess of 150 tonnes of timber a day in large plantations, whereas for smaller or more constrained sites small scale mechanised harvesters, feller bundlers and forwarders can be used. One critical area for upskilling in and building capacity is the production of planting material for each of the individual bioenergy crops. At present there is insufficient capacity in the UK to produce the volume of planting material needed to achieve plantings of 30,000 ha of bioenergy crops per year. As the SRF reach harvest maturity there will need to be an increase in the specialist skills associated with the harvesting process – e.g. chainsaw operating skills, skills needed to be a forestry site manager as well as a specialist/agent who has the skills necessary to complete a felling licence prior to start of harvest (Table 16).

The gaps in skills identified in Table 16 are similar to those identified by the Agriculture, Forestry and Fishing: Sector Skills Assessment[29] which highlights that skills in crop agronomy and forestry are needed to meet future demands. For example in the forestry sector, technical skills such as chainsaw operation, aerial rescue and regulatory health and safety training requirements are required. In addition, the report suggests that there will need to be upskilling in intermediate skills in woodland management, identification, storage of wood, negotiation and marketing.

Table 16 Summary of areas where there are existing skills in the agricultural industry and areas where upskilling is required

Existing skills	Upskilling required
• Tractor driving • Pesticide spraying and handling • Casual labour skills • HGV licence holders	• Production of breeding material • Bioenergy crop agronomy • Woodland management skills- use of chainsaws, forestry site manager and skills needed to complete felling licence • Specialist contractors to carry out planting and harvesting

More detail about the type of jobs and skills required across all bioenergy crops is shown below.

Off farm specialist

Off farm specialists are defined as those roles that are performed by individuals that are not on the farm. The types of skills included in this category are specific to the bioenergy sector and focus around three key areas- bioenergy crop breeding, bioenergy crop agronomy and specific advice e.g. completion of a felling licence/overseer of forestry harvesting operations. Key skills needed for these areas are shown below.

Skills required for bioenergy crop breeding and sale of breeding material:

- science related degree
- experience of the bioenergy crop breeding sector
- knowledge of genetics
- ability to network with university organisations, crop suppliers etc. to get breeding material to market
- knowledge of marketing/ branding of genetic material

Specialist skills needed for bioenergy crop agronomy:

- BASIS and FACTS qualified
- Knowledge of growing bioenergy crops- Lantra offer a course titled: *'Technical award in energy crops'*

Specialist off farm skills required in the SRF sector:

- Site manager skills to oversee forestry harvesting operations, knowledge of health and safety involved in forestry harvesting and previous experience of forestry harvesting
- Knowledge of how to complete a felling licence prior to felling
- Being trained and competent in using a chainsaw.

Plant breeding

It is estimated that by 2055 there will be approximately **533 FTE** jobs associated with the production of planting materials for bioenergy crop production. Skills involved in bioenergy crop breeding are similar to those involved in other types of crop breeding and follows four main steps: (1) Creation of genetic variation by various means (2) Selection (3) Evaluation and Release as a variety and finally (4) Seed multiplication and distribution among farmers. There are already a number of plant breeding companies that operate in the UK (and worldwide) so there will be some skills overlap, however it is widely recognised that it is very difficult to produce Miscanthus from seed, so there is likely to be some specialist skills development required to oversee a Miscanthus breeding programme. For SRC and SRF breeding lines are already well developed.

Agronomy - BASIS and FACTS qualifications

As stated above, the EU Legislation (Directive (EC) No. 2009/128) sets the legal requirements surrounding the use of plant protection products in the European Union. Under Chapter II, Article 5 of this Directive this states that: '...*Member States shall establish certification systems and designate the competent authorities responsible for their implementation. These certificates shall, as a minimum, provide evidence of sufficient knowledge of the subjects listed in Annex I acquired by professional users, distributors and advisors either by undergoing training or by other means'*. In the UK this requirement is met through individuals attaining a BASIS (Registration) Ltd specific to a particular crop type (e.g. arable, horticultural crops etc.) and attainment of this qualification is a legal requirement for those engaged in selling pesticides, or advising on their use. Individuals who have attained their BASIS qualification can also be part of the BASIS Professional Register where users have to acquire CPD points by attending relevant training events or reading certain technical publications. There is not currently a specific BASIS course focused on bioenergy crops, although it is expected that the BASIS Certificate in Crop Protection (Agriculture) covers this scope adequately. As the area of bioenergy crops increased it should be considered whether a bioenergy crop specific qualification is required.

Bioenergy crops tend to be low input with fertiliser use tending to be restricted to the establishment phase, however it is important that the right amount of fertiliser is applied at the right time to ensure that the crop gets maximum benefit, with minimum impact on the environment. The FACTS Certificate of Competence in Fertiliser Advice is an independent non-statutory certification scheme for advisers in plant nutrient management. Although technically a non-statuary requirement, seeking advice from a FACTS qualified advisor is often a requirement of farm assurance schemes such as Red Tractor Combinable Crop Assurance[30]. This type of scheme is not directly relevant to the bioenergy sector as it stands, but it may be expected that as the area of bioenergy crops grows, there will need to be a formalised approach to ensure that all quality standards are met, not just in the production of the crop, but also in the harvest and processing of the crop. Therefore the development of assurance schemes and the associated formalised skills requirements is a consideration for the future development of the bioenergy sector.

Knowledge of bioenergy crops

Lantra offer a course titled: *'Technical award in energy crops'*

By 2055 it is estimated that there will be the equivalent of just **23 FTE jobs** associated with site selection that require an understanding of bioenergy crops for Miscanthus, SRC and SRF. The Lanta course in bioenergy crops is aimed at farmers and landowners with the idea to help them to make informed decisions about the best energy crop to grow on which type of land and provide knowledge of planting, harvesting and processing methods as well as end markets. The course is run over two days and involves both theoretical session and a practical site visit to growing fields and a biomass boiler. The course is designed to equip individuals to be able to:

- Evaluate the benefits and challenges of farming for energy.
- Establish, manage and harvest short rotation coppice (SRC) and Miscanthus
- Evaluate the potential financial returns from SRC and Miscanthus cultivation.
- Understand the environmental aspects of SRC and Miscanthus cultivation.
- Understand the end-user requirements from SRC and Miscanthus cultivation.

Completion of a felling licence

Before SRF can be harvested, a felling licence from the Forestry Commission is required. In the UK it is an offence to fell trees without a licence if an exemption does not apply. Felling licences usually last for five years, but where there is an approved management plan this can be extended for up to 10 years[31]. The felling licence can be completed by the landowner or a suitable agent who has experience in the forestry sector. To ensure cost effective and efficient approval of these felling licences as part of a growing SRF sector it is expected that there will need to be an increase in the number of trained agents who are able to complete these licenses, in order to ensure that from 2035 there are sufficient licences in place to allow 15,000 ha a year of SRF to be harvested, further upskilling will be required by 2055 as the area felled per year will increase to closer to 30,000 ha. Although these skills are present in the commercial forestry sector, there are insufficient skilled individuals to meet the needs of the growing SRF sector. However, given that the harvest of SRF is varied depending on SRF variety used, with some SRF varieties able to be harvested after 8 years, but a harvest interval of 15-20 years is most usual, there is plenty of time to develop these skills once the crops have been established. By 2055 it is estimated that there will be the equivalent of **84 FTE for completing felling licences**.

Forestry site manager

Skills needed to be a forestry site manager include practical experience of forestry, knowledge of health and safety on site, ability to prepare a risk assessment for the work to be carried out and communicate this to the harvesting team e.g. suitable working practices surrounding safe harvesting around power lines etc. There is currently no compulsory training that a Forestry Site Manager needs to complete, however there is an aim is for this type of training to be made compulsory within the industry in the future[32]. As with the felling licence the increase in the number of skilled forestry site managers will not be required until 10-20 years after the first SRF crops are planted. There are some Forestry site managers that currently work within the commercial forestry sector, and their skills would be transferable to the SRF sector, however the number of skilled individuals will need to be increased by 2035 if 15,000 ha of SRF are to be harvested each year in a safe and efficient manner. A number of companies including Forestry Training and Consultancy Services Ltd run training courses to give attendees the knowledge and understanding of site safety management based around the industry guidance document '*Guidance on Managing Health and Safety in Forestry*'[33]. Lantra also offer numerous courses in health and safety in forestry[34]. As the SRF sector approaches the point where crops are reaching harvest maturity consideration needs to be given as to whether more of these courses should be made available, or a more formalised qualification scheme put in place (if it has not already done so as a result of moves within the commercial forestry sector). By 2055 it is estimated that there will be **155 FTE jobs** for forestry works managers.

Chainsaw operating skills

To carry out annual tree maintenance, skills involved in safe and competent chainsaw use are needed. The Approved Code of Practice supporting regulation 9 of the Provision and Use of Work Equipment Regulations 1998 (PUWER 98)[35] sets a minimum standard for competence of people using chainsaws in tree work with individuals needing to show that they meet licence to practice requirements and are trained and competent in operating a chainsaw. Lantra offer a number of courses relating to use of chainsaws in various settings such as the '*Lantra Level 2 Award in Chainsaw Maintenance and Cross-Cutting'* which if completed, allows users to demonstrate that they meet licence to practice standards[36]. NPTC also offer similar courses[37]. The HSE also recommends that refresher/update training for chainsaw operators is undertaken every two to three years for occasional users and every five years for full time users. There is likely to be a need to upskill in this area, and this is supported by the UK Commission For Employment and Skills (UKCES) report titled: '*Agriculture, Forestry and Fishing: Sector Skills Assessment 2012*' which identified that skills involved in woodland maintenance, including chainsaw use are a 'high priority' area for upskilling.

Specialist contractors

Specialist contractors are required for skills that are specific to the bioenergy crop industry such planting and harvesting of bioenergy crops. In some cases it is not so much that they have specialist skills, but that they have access to and are familiar with the specialist planting or harvesting equipment required for bioenergy crop production.

It is not just skills that make specialist contractors important in the future of bioenergy cropping, it is also the fact that they own/rent the machinery for planting and harvesting of bioenergy crops. There are a number of different contractors in the UK who specialise in bioenergy crop planting/harvesting, for example the company IEC Contractors has been working in the UK for the last ten years and has Europe's largest fleet of forage harvesters (currently 30) for Miscanthus planting and harvesting [38], but the number of machines operated by contractors will need to increase substantially if the area of bioenergy crops is set to increase to 1.18 Mha by 2055- this is discussed in more detail in Section 4.2.

Farmer

The key skills required by farmers growing bioenergy crops are shown below, with more detail about each skill in the subsequent paragraphs.

Key skills required by farmers include:

- *Tractor driving skills*—must hold a DSA Tractor Driving Test Certificate if under age of 16 or full car (category B) driving licence.
- *Pesticide spraying qualifications*- legal requirement to hold PA1, PA2 spray operator qualifications. These skills and qualifications will exist on most arable farms, but may be lacking on smaller farmers, or livestock farms. Contractors can be used to provide this skill in situations where the individual land owners or their staff do not have the qualification.
- *Telehandler operation licence*- not compulsory, but allows operator to meet UK Government Health and Safety guidelines stating that the operator of the machine has been suitably trained and compete to use the machine.
- Knowledge of how to grow bioenergy crops (in conjunction with help from agronomist).

Tractor driving

Tractor driving is an important skill that is needed for land preparation and for spraying pesticides (if using a trailed sprayer). To be able to drive a tractor on the road an individual must hold a full car (category B) driving licence or, if they are between the ages of 16-17 hold their DSA Tractor Driving Test Certificate. In addition to these formal certifications, there are also voluntary training courses individuals can attend to improve their skills, for example Lantra offer tractor driving courses[39] for both novices and experienced tractor drivers which are held over two days with the certificate of training for tractor driving being granted at the end of the course.

Pesticide spraying qualifications

In the EU, according to EU Legislation (Directive (EC) No. 2009/128) those who use, or cause or permit others to apply, plant protection products or who store and/or dispose of products are subject to a number of legal requirements. These Regulations state that to apply pesticides, an individual needs to hold the necessary certificate of competence relevant to the type of pesticides they are applying. In the bioenergy crop sector, sprayer operators will need to hold their *PA1 certificate in Pesticide handling* and *PA2 certificate - Application with a boom sprayer*. These qualifications are relevant where individuals are applying pesticides to any type of crop, not just bioenergy crops, and are widely held by individuals already employed in the agricultural industry. Furthermore, the National Register of Sprayer Operators (NRoSO)[40] operates an ongoing Continuing Professional Development (CPD) accreditation scheme to maintain professional standards in pesticide application, where NRoSO members are required to collect a minimum of 30 CPD points from 'registered activities' (technical events, technical publications etc.) over a three year period starting from their registration date.

Telehandler operation

A telehandler is needed for certain tasks in bioenergy crop production such as stacking SRC/SRF to dry out, unloading breeding material from lorries or loading bioenergy crops onto lorries to go on to be processed off farm. At present, there is no legal requirement to hold a telehandler licence, but UK Health and Safety Executive (HSE) guidelines[41] state that: '*telehandlers and teleloaders should only be driven by authorised, trained and competent people who have completed appropriate training and testing'*. Examples of suitable courses include: ACOP Compliant training courses - e.g. City & Guilds Level 2 Award in Land-based Forklift Truck Operations (Rough Terrain, Masted and Telescopic Types) QCF or Lantra Awards Technical Award in Lift Truck Operations: Rough Terrain Telescopic Material Handler[42].

Background knowledge of bioenergy crops and agronomic challenges

Farmers will need to be informed if they are to make the move towards growing bioenergy crops on their land. Lantra offer a course titled: *'Technical award in energy crops'*[43] which focuses on all aspects of bioenergy crop production with the aim to allow farmers to make informed decisions about site selection, planting, harvesting and processing methods, markets and potential financial returns from energy crops. If 30,000 ha of bioenergy crops are to be established each year there will be an increase in demand for this type of course as an increasing number of land owners have to become familiar with these crops.

Casual labour

Much of the work involved in growing bioenergy crops such as production of breeding material, cultivation of land, erecting fencing and general maintenance can be done by casual labour with no formal skill required and so no formal upskilling will be required in this area – any tasks are expected to be taught 'on the job'.

Key skills needed for casual labour jobs include:

- Being relatively fit and healthy
- Flexible approach to working hours
- Willingness to travel
- Ability to work in the UK.

Logistics specialist

There are multiple points in the production of bioenergy crops where logistics, and the use of a qualified HGV driver are required. For delivering breeding material to farm and for transporting crop material to be processed off farm, a HGV licence is needed. To attain a HGV licence an individual needs to hold a full car driving licence, be over 18 and attain a professional driving qualification called the Driver Certificate of Professional Competence (CPC)[44]. The CPC involves: a) applying for a provisional lorry or bus licence, b) passing the required four tests (theory, case studies, driving ability and practical demonstration) that make up Driver CPC to qualify, c) taking 35 hours of periodic training every five years to stay qualified, d) signing a declaration every 5 years until the age of 45 to show that the medical standards of the CPC are still being met and e) providing a medical report every 5 years after the age of 45 to renew the driving licence.

There are currently around 285,000 HGV licence holders in the UK with almost half of these being over 50. As such there is expected to be an increased demand for HGV licence holders in the future as those that are currently in the industry reach retirement age. Currently the cost (~£3,000) of completing the training necessary to attain a HGV licence is a barrier for younger entrants to the industry. To address this problem, the UK Government has committed to an apprenticeship scheme[45] to encourage young entrants into haulage, but this funding will need to be maintained to meet the increased haulage demand from the bioenergy sector if the area planted increases to 1.18 M ha by 2055. It is estimated that by 2055 the bioenergy sector will need **275 FTE HGV drivers**.

4.2 Barriers to meeting bioenergy crop area and job targets

Currently, the main barriers to increasing bioenergy crop production are the **availability of breeding material** and the **infrastructure needed** (specialist contractors and specialist machinery) to carry out the planting and harvesting of bioenergy crops at the scale required. As part of the main RELB report barriers to uptake of bioenergy crops were discussed in detail. Below a few key points in relation to developing skills and jobs are outlined.

Availability of breeding material

The availability of breeding material is one of the main limiting factors on expanding bioenergy crop production to 1.18 M ha by 2055. For example, Murray Carter, a large SRC breeding nursey based in the UK, currently sells around 40 ha worth of SRC saplings each year. It is estimated that even if every sapling that Murray Carter currently produces is bought that would only be enough to plant 2,000 ha of SRC and would require significant investment in terms of time and labour to meet this demand. Rothamsted Research also have an SRC breeding programme, but taken together these are unlikely to be able to meet the demand for breeding material to plant an additional 7,500 ha per year at current levels of investment. Therefore, one of the key areas to focus on early in order to facilitate the increased the area of bioenergy crops is upskilling and capacity building within the plant breeding operations.

Although the model used in this assessment assumes an immediate shift to 30,000 ha of bioenergy crops planted in 2017, this is not currently physically possible given the level of planting material available in the UK[3], or even from imported sources such as from the wider EU, Eurasia and other non-EU countries such as North and South America[46]. It is considered more feasible to build up the area of bioenergy crops planted more gradually in the first years of production to enable time for the necessary infrastructure to be put into place. This is supported by work done by the NFU between 2008-2009[47] on developing a '*Roadmap for perennial energy crops in the UK'* which suggested that it would be possible to plant 350,000 ha of SRC and Miscanthus by 2020 if the area planted was gradually built up by 500-2,500 ha/year in the first five years, scaling up to 35,000 ha planted/year by 2020. More recent work by Crops For Energy Ltd[48] in 2013 also supports the gradual building up of the area of bioenergy crops planted, stating that a feasible target would be to have 95,000 ha of bioenergy crops planted in the UK by 2020 – 37% lower than the 130,500 ha suggested using ETI estimates (assuming 30,000 ha/year of bioenergy crops are planted from 2017 onwards). The Crops for Energy figure of 95,000 ha consists of 20,000 ha of newly planted bioenergy crops and bringing back under management 75,000 ha of existing forestry crops. The work also suggests that a target to plant 10,000

[3] Based on personal communication with experts from RIDA Ltd and C4E Ltd.

ha/year of bioenergy crops is a realistic objective for the next 44 years (up to 2060) as opposed to the 30,000 ha/year currently aspired to in the BVCM modelling that drove the assumptions in this work.

This barrier can be overcome by:

- Working with bioenergy crop breeding companies to identify constraints to current production of breeding material and working on solutions to overcome these in both the short and long term
- Accelerating the amount of breeding stocks imported from other counties
- Lobbying the government for more funding to be put into bioenergy crop breeding
- Focusing on getting a market in place for bioenergy crops, as if there is end user demand then the development of new breeding material will be accelerated naturally as a result of this.

Infrastructure availability (specialist contractors and specialist machinery) to meet increased bioenergy crop demand

Planting and harvesting bioenergy crops requires both specialist skills and specialist equipment e.g. for Miscanthus a modified potato planter is often used to plant rhizomes and a modified forage harvester is often used. There are number of contracting firms which operate in the UK that provide specialised machinery and trained operators to carry out planting and harvesting operations, but the number of machines available for hire/use by contractors during peak planting and harvesting times is limited. There are also limited numbers of second hand machines used for bioenergy crop planting/harvesting available in the UK (and these are often expensive) meaning that farmers would most likely have to rely on contractors being available to carry out planting and harvesting operations.

A review titled: '*Why we need bioenergy crops in the South West*[49]' by Crops For Energy Ltd sets out the machinery requirements to plant and harvest SRC and Miscanthus, giving a figure of the potential area/year (ha) that could be planted or harvested per machine. If these figures were applied to ETI's estimates of planting 7,500 ha of Miscanthus and SRC per year this would mean for SRC planting/harvesting, 21 planters would be needed, costing £1.26M and 42-self-propelled forage harvesters (with modified headers) at a cost of £5.04 M. For Miscanthus planting/harvesting 21 4-row harvesters would be required at a cost of £1.26 M with 16 forage harvesters required at a cost of £1.92 M (Table 17). These figures only relate to the number required to plant and harvest 15,000 ha of SRC and Miscanthus i.e. the machinery requirement for one year. If these figures were scaled up to the area of SRC and Miscanthus expected to be planted and harvested in 2055 (plant 15,000 ha/ year of each crop (increasing area and replacing crops that had come to end of lifespan), harvesting 277,000 ha of Miscanthus and 91,000 ha of SRC) this would increase the total number of SRC planting and harvesting machines required to **533** and the number of Miscanthus planting and harvesting machines to **633**- a significant level of investment in machinery over current levels.

This barrier can be overcome by:

- Significant upskilling by existing arable contractors in planting and harvesting bioenergy crops so that contactors are available at seasonal peaks as needed
- Encouraging new contractors into the industry e.g. highlighting benefits of flexibility in workload and good rates of pay.
- Growth of existing contracting companies in the UK
- Increasing the amount of harvesting equipment imported from overseas
- A company that sells and markets bioenergy planting/harvesting equipment establishing a base in the UK increasing access to the required machinery.

*Table 17 The number of planting and harvesting machines used for SRC and Miscanthus and the investment required to plant and harvest 7,500 ha of SRC and 7,500 ha of Miscanthus. * The number of days per year indicates the number of days available/year for planting/harvesting of SRC and Miscanthus based on the assumptions below. The potential area/year indicates the estimated area that could be planted/harvested each year based on current work rates (area/hour). From these figures the number of machines required to plant and harvest 7,500 ha of SRC and Miscanthus have been calculated and the total investment required to purchase these machines. Source: 'Why we need bioenergy crops in the South West[48].*

Crop	Activity	Machine	No. of days per year*	No. of hours/year	Area/hour (ha)	Potential area/year (ha)	No. of machine required to plant and harvest 7,500 ha of Miscanthus and SRC	Cost per unit	Total investment required/ £
SRC	Planting	4 row step planter	60	360	1	360	21	£60,000	£1.26 M
	Harvesting	Header for modified self-propelled forage harvester	60	360	0.5	180	42	£120,000	£5.04 M
Miscanthus	Planting	4 row precision planted	60	360	1.0	360	21	£60,000	£1.26 M
	Harvesting	Self-propelled forage harvester	40	320	1.5	480	16	£120,000	£1.92 M

Assumptions:

- Planting and harvesting windows are limited by climatic conditions and subsequent soil conditions
  - SRC planting takes place from Mid March-mid May = 60 days
  - SRC harvesting takes place from Mid November-mid March (SRC harvesting is assumed to be possible for only 50% of the time available (360 hours per year available, but harvesting only possible on half of these available hours due to heavy working conditions and wet weather) = 60 days
  - Miscanthus planting takes place Mid-March- Mid May = 60 days
  - Miscanthus harvest takes place from March-late April = 40 days
- Number of hours per day allows for breakdowns and repairs
- Miscanthus harvesting assumes a higher work rate than SRC due to drier conditions at harvest, longer working days and lighter crops
- It is likely that the cost of machinery would be lower if several machines were ordered together.

Barriers to entry to the forestry industry

The Lantra report titled: '*The Trees and Timber Industry in Great Britain: Size, Structure and Skills 2011*' identified a number of barriers to entrants to the forestry industry that will need to be addressed if ETI's bioenergy target is to be met in 2055. These include the fact that it is difficult for new entrants to enter the forestry industry as most existing workers are self-employed, and it is therefore difficult as a new entrant to gain paid, practical experience and therefore entry into the industry. In addition, the report also raised concerns about coppicers and foresters having the inclination and/or skills to access government funding, in terms of wood fuel grants and environmental stewardship. Government funding was generally said to be diverted to commercial forestry over green wood trades due to its scale, and that more support for coppicing would be welcome.

Ways of overcoming these barriers include:

- Encouraging companies to provide apprenticeships to train individuals in the forestry skills required or lobbying the government to provide these type of apprenticeships
- Lobbying the government or training providers such as Lantra to introduce a formal qualification in coppicing so that those that are interested in entering this sector can demonstrate their commitment to entering the sector and therefore be more likely to be taken on by companies/get work in the sector.

Lack of wider skills needed for bioenergy sector

As identified in Section 4 there is also a need to upskill in certain areas such as woodland management (estimated 240 FTE by 2055), bioenergy crop breeding (estimated 960 FTE by 2055), bioenergy crop agronomy (estimated 240 FTE by 2055) and HGV licence holders (estimated 200 FTE jobs by 2055) to be able to meet the requirements of planting 1.18 M ha of bioenergy crops by 2055.

This barrier can be overcome by:

- Gain government support to improve funding and research in key areas such as skills involved in bioenergy crop breeding and HGV licence training
- Improve knowledge dissemination throughout the bioenergy cop supply chain on the future demand for certain roles to improve uptake of these roles.

Other barriers

Other barriers include creating a market demand for harvest material and encouraging the uptake of bioenergy crops by farmers which are covered in good detail in the main RELB report.

5 Understand the timescales of jobs / skills development

5.1 Approach

Using the labour requirements identified in Section 3 and the skills requirements identified in Section 4, the pattern of job creation over time was determined and displayed in Figure 13. . This shows the number of full time jobs created by establishment, annual maintenance and harvesting of each bioenergy crop over time as well as displaying jobs created by meeting afforestation targets.

5.2 Findings

5.2.1 Pattern of job creation between 2015-2055

Overview of the timeline of job creation in the bioenergy sector between 2017-2055

- **2017-2032 – Job creation involved in bioenergy crop and SRF establishment-** In order to achieve bioenergy crop plantings of 30,000 ha per year 840 FTE jobs need to be created. These jobs include the development of plant breeding businesses to provide the planting material, specialist support in identification of suitable planting sites and the development of specialist contracting businesses that are equipped to provide sufficient scale of planting. Many of these jobs will need to be created and the skills promoted or evolved from existing roles. In addition, there are the jobs associated with land preparation where the required skills are already present within the agricultural work force. Once sufficient skilled people have been identified this group of jobs will remain relatively stable through to 2032 as the area of bioenergy crops planted annually remains consistent. It is not anticipated that the industry will be able to develop all the required skills and infrastructure requirements to achieve plantings of 30,000 ha by 2017, therefore it is anticipated that the actual upskilling process will be more gradual than depicted in Figure 13.
- **2032-2047** – **Increase in SRF establishment jobs** – SRF crops are forecast to come to harvest maturity around 2032 (assuming and average 15 year lifespan), as the first crops start to be harvested, in order to maintain the growth in SRF the area planted per year increases from 15,000 ha to 30,000 ha, effectively doubling the requirement for SRF establishment jobs to 1,112 FTEs. Some of this increase in skills will be met by those who have previously worked on afforestation projects, see below.
- **2042-2055** – **Increase in SRC and Miscanthus establishment jobs** – The estimated lifespan of SRC and Miscanthus is 25 years, therefore around 2042 the earliest planted crops will be nearing the end of their useful life span and will start to be removed and need replacing. This effectively doubles the number of jobs required for SRC and Miscanthus establishment to 396 FTEs in the SRC sector and 188 FTE in the Miscanthus sector.
- **2017-2026** – **Planting of afforestation projects**. Alongside the planting of bioenergy crops and SRF there is the intention to increase the area of 'permanent' forest in the UK, this model uses a forecast planting rate of 27,500 ha per year, requiring an additional 1,148 FTE jobs, once skilled individuals have been developed this level of employment will remain available through until 2026, when, in theory, England and Scotland achieve their planting targets.
- **2025- 2035 – Ongoing afforestation projects in Wales and Northern Ireland** will maintain establishment jobs at just over 300 FTE, the decline in the need for these jobs in 2036, coincides with the increased requirement for establishment jobs in SRF.
- **2017-2055—Steady increase in job creation from annual maintenance (all bioenergy)-** Level of job creation increases relatively constantly between 2017-2055 at a rate of 76 FTE per year to carry out annual maintenance tasks on the ever increasing area of bioenergy crops planted.
- **2017-2048 – Steady increase in job creation for annual maintenance of afforestation projects until 2036 after which it remains constant** until it falls to zero 12 years after the last area is planted.
- **2019- 2055 – Steady increase in job creation for harvest of SRC and Miscanthus** equivalent to 55 FTEs/year for Miscanthus and 12 FTE/year for SRC as the area of SRC and Miscanthus area increases in size.
- **2032-2055 – Rapid increase in job creation for harvest of SRF** –The first 15,000 ha forecast to reach harvest maturity (assuming a 15 year lifespan) although some may be harvested as soon as 5 years after planting. Once harvest is in full swing it is anticipated that 951 FTEs will be supported by the industry, increasing to 1,901 FTE in 2047 due to 30,000 ha being available to harvest.

The overall pattern of job creation is shown below (Figure 13).

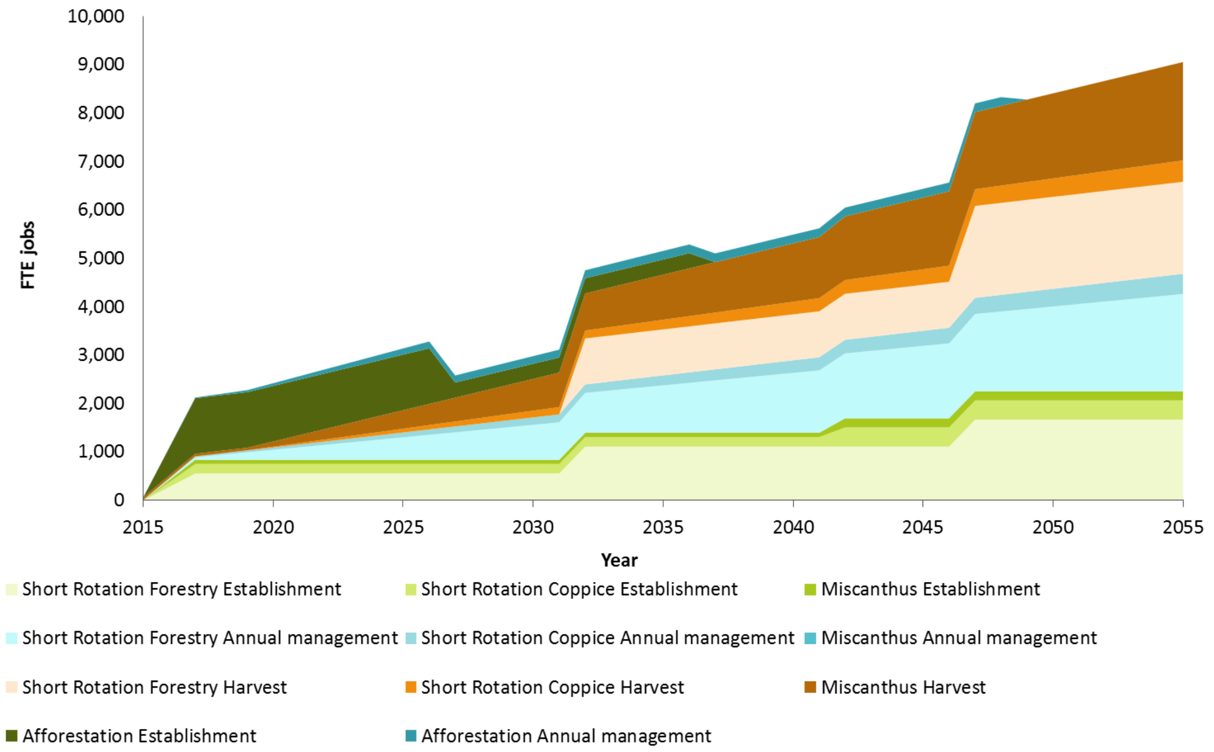

Figure 13 Overall progression of job creation in the bioenergy sector between 2015-2055, broken down by crop type and type of activity (establishment, annual management or harvest).

6 Conclusion

This work shows that in order to grow >1.0 M ha of bioenergy crops by 2055 there needs to be a significant increase in the workforce in the bioenergy industry. Due to the uneven nature of the work involved in the establishment, management and harvest of bioenergy crops the jobs created have been presented in two ways the FTEs which indicate if the jobs were evenly spread though out the year how many Full time Equivalent jobs could be supported. However, due to the fact that the majority of the work is concentrated in January to April, there is a need for a higher number of individuals for this period and fewer individuals for the period from May onwards. Therefore peak work load was also calculated. The roles included in the assessment were those associated with plant breeding, site selection and establishment of the crop, annual maintenance, harvest and clearance of the site at the end of the crop lifespan.

By 2055 the bioenergy sector is predicted to support 9,100 full time equivalent (FTE) jobs, with around 17,900 job opportunities available during peak periods (with up to 16,700 anticipated to be employed at any one time) i.e. during January-April when planting and harvesting is carried out, and dropping off for the rest of the year to a baseline of <5,000 individuals needed. The job requirement in the bioenergy sector falls outside of the peak time requirement in the arable industry, therefore at peak periods 3,300 individual farmer jobs are likely to be carried out by individuals that are currently employed within the agricultural sector, rather than creating new jobs. There is a need at peak times for approximately 5,500 specialist contractors, however, given the unevenness of the work available, these contractors are likely to require alternative income streams in the off peak period e.g. they may also provide arable contracting services. At peak periods, the bioenergy industry of 2055 could support an estimated 3,300 casual labourers, these individuals would require little in the way of upskilling and could be taken from a pool of casual labour already available in the agricultural industry. There is also a need for 4,500 off farm specialists including plant breeders, agronomists and foresters, these individuals will need specialist skill development including provision of sufficient training courses and continuous professional development. At peak periods there is also a requirement for 464 HGV drivers, and although these skills already exist, there is an indication that there may be a shortage in this area due to the aging workforce reaching retirement age.

When calculated at a FTE per hectare basis the methodology used in this report estimates that for SRF the job requirement is 0.01 FTE per hectare, for SRC it is 0.004 FTE per hectare and for Miscanthus it is 0.008 FTE per hectare. These values are calculated by taking the time requirement for establishment and harvest and allocating pro rata across the lifespan of the crop. Previous reports have taken a different approach and come up with different estimates of labour requirements. For example a study by Thornley, P *et.al.* (2008) quantified the expected employment impacts of individual bioenergy developments, which included agricultural labour growing energy crops for SRC and Miscanthus options, transport and processing of the feedstock, staffing at the thermal conversion plant, employment within the equipment supply chain and the induced employment impact. This study looked at 22 case studies with different plant/technology types and estimated the labour requirements through consultation with industries and academia with experience of operating bioenergy plants. In particular, full time agricultural jobs for feedstock supply were calculated. The labour requirements for growing crops were calculated based on a detailed assessment of the hours and men required to complete every stage in the agricultural process of preparing the land, growing and harvesting the energy crops. For transport jobs during operation, the calculations were based on the required number and length of delivery journeys to keep the plant supplied, taking into account the limited delivery hours on site, the distance to the plant, likely planting densities, tortuosity factors for different grades of roads, etc. The labour requirements for feedstock supply were estimated on a per hectare basis in this study, which indicated that **0.001 FTE (Full-Time Equivalent) per hectare** would be required for SRC and **0.0014 FTE per hectare** for Miscanthus. The estimates calculated in the main report for SRC are four times higher than Thornley *et al* and for Miscanthus almost 6 times higher. It is not clear from the Thornley, P *et.al.* (2008) report on the assumptions on which these FTE were calculated (it merely indicated that field preparation, growing and harvest were included – but does not indicate how the seasonality of jobs or the supporting jobs such as plant breeding were dealt with) and so it is not possible here to account for these differences. In contrast an NNFCC report reviewed a range of studies and synthesised the evidence available on the employment requirements for the feestock production in the bioenergy sector. It looked at the feedstock supply chain which included the following key stages: feedstock planting and management, feedstock harvesting, feedstock processing and feedstock haulage.The number of jobs were converted to the FTE per oven dry tonne pf biomass feedstock for forestry, SRC and Miscanthus. When converted to standard oven dry yields (averaged per year of the crop cycle) this gives FTE estimates od **0.011 FTE/hectare** for SRF (similar to this study), **0.001 FTE/hectare** (double this study) and **0.011 FTE/hectare** for Miscanthus (slightly higher than this study)(see Table 18). The NNFCC study results would be expected to be slightly higher than this study as they also include elements of processing that have been excluded from this assessment. However, the fact that the results from this study fall between those of the two existing studies indicate that they are broadly in line with current thinking, but this also highlights the large uncertainty associated with this industry, espeically when it comes to scalling up from a few isolated sites to larger areas of production across the country.

Table 18 Employment associated with biomass feedstock production & processing feedstock – comparison of this study to two others.

Feedstock	This Assessment	Thornley	NNFCC
	FTE/ha	FTE/ha	FTE/ha
Forestry	0.010	-	0.011
SRC	0.004	0.001	0.009
Miscanthus	0.008	0.0014	0.011
Key assumptions	These figures include; Production of planting material, crop establishment, maintenance, harvest and pre-processing on farm through to initial transport off farm.	These figures include; preparing the land, growing and harvesting SRC and Miscanthus but excludes production of planting material, transport and processing of the feedstock off farm.	These figures include feedstock planting and management, feedstock harvesting, feedstock processing and feedstock haulage. Excludes off farm preparation of planting materials and processing at end use conversion plant.

- No FTE given for SRF in the Thornley *et.al.* (2008) report.

Although this report extrapolates assuming a 30,000 ha/year planting area, this is unlikely in the early years due to the limited availability of both planting material and specialised equipment for planting. There are critical barriers that will need to be overcome in order for desired planting targets to be met. Crops for Energy[50] estimates suggest that an increase in bioenergy crop area of 10,000 ha/year up to 2060 is more feasible given current infrastructure. The expectation is that the initial pattern of job creation will be more gradual than is depicted in the modelling for this report, but will need to be higher than that forecast by Crops for Energy in order to achieve the GHG savings required by 2050.

7 Appendix 1 – Comparison of labour requirements (per hectare per month) of bioenergy crops against arable and livestock production

7.1 Labour requirements – Bioenergy crops

The bioenergy crop labour requirements and assumptions are detailed in full in the main body of the report. These figures have been converted into labour requirements per hectare by dividing the total hours anticipated in 2055 by the total area. The charts presented below include all the labour categories included in the main assessment. However, for comparison with the farm enterprise data only the farmer /farm manager, specialist contractor and casual labour categories are relevant. Each chart below (Figure 14 to Figure 16) details the monthly labour estimates per hectare for each of the three bioenergy crops assessed.

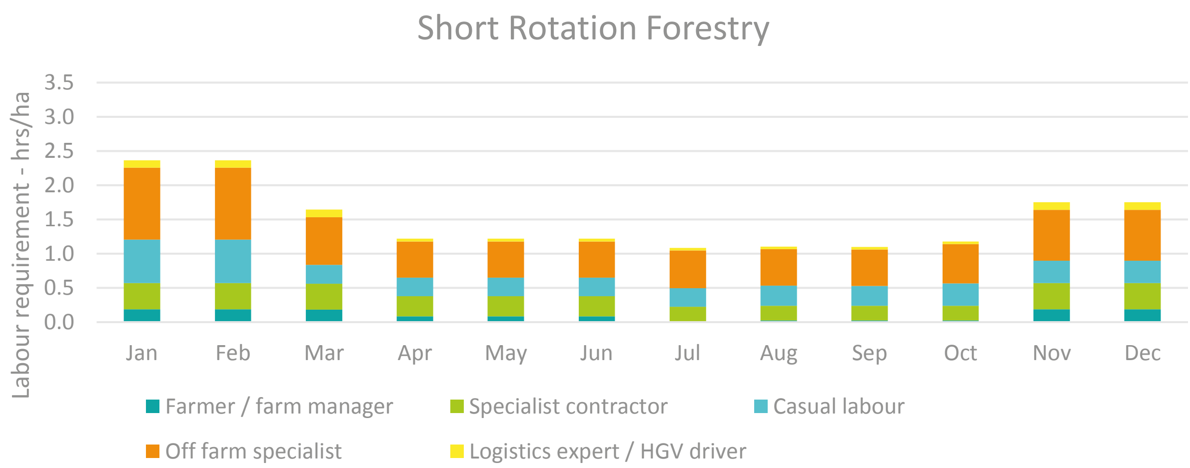

Figure 14 in this report *Short rotation forestry monthly labour requirement per hectare – including all job types assessed*

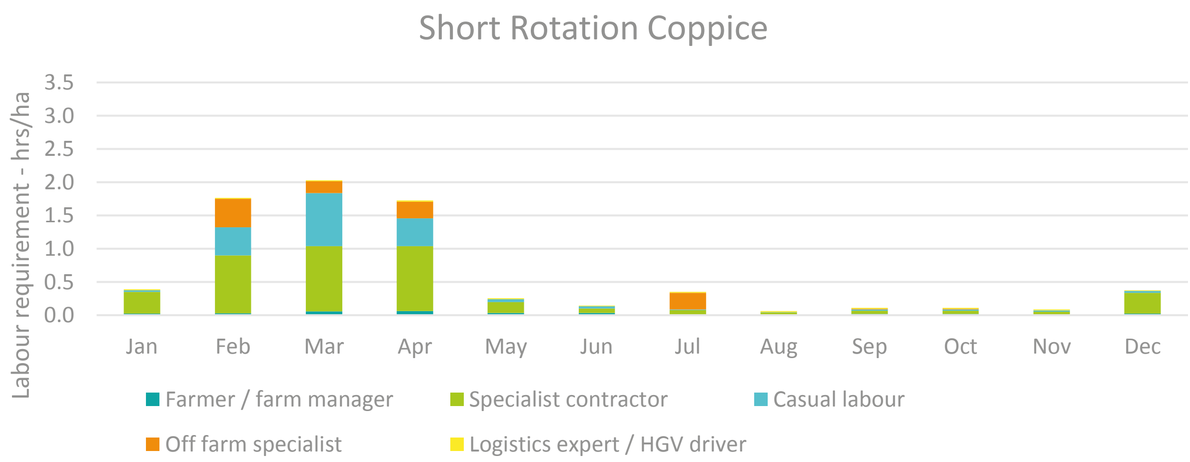

Figure 15 in this report *Short rotation coppice monthly labour requirement per hectare – including all job types assessed*

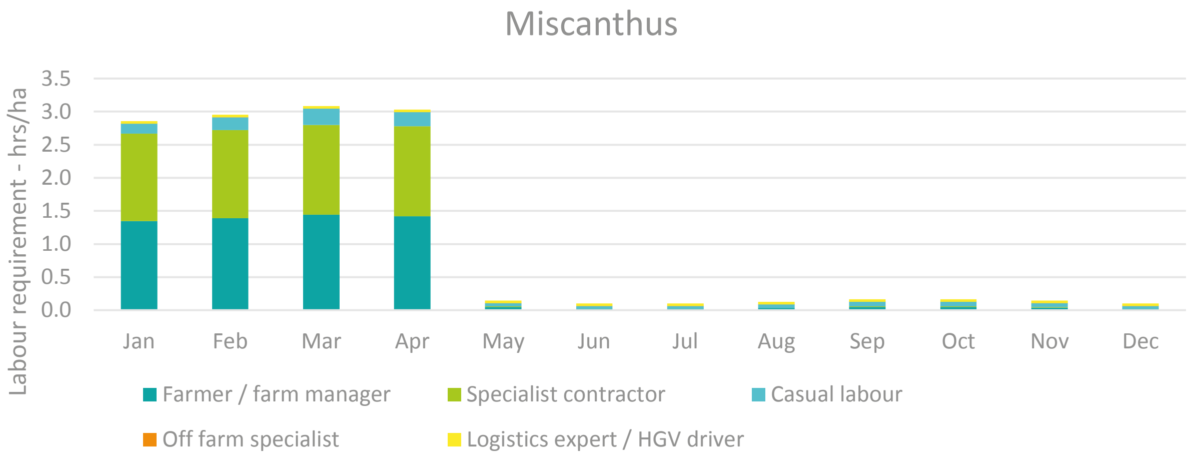

Figure 16 Miscanthus monthly labour requirement per hectare – including all job types assessed in this report

7.2 Labour requirements – Arable crops

There are a wide range of different crop rotations that can be employed by an arable farmer, with soil type and location having an influence on the crops selected. Where farmers have high quality soils that are able to produce high value crops such as potatoes and vegetables it is not anticipated that they will take land out of production to produce bioenergy crops, therefore these crop rotations have been ignored in this assessment. To compare labour requirements to those of an arable system, three typical arable crops have been selected. These are winter cereals (winter wheat), spring cereals (spring barley) and winter oilseed rape (WOSR). In the predominantly arable areas these crops are grown in rotation with wheat:wheat:WOSR or wheat:winter barley:WOSR being common rotations. In Scotland spring barley dominates rotations.

Each different farm will conduct operations at slightly different times depending on how much land they have, what the rotation is and whether they conduct all operations in house or use contractors. For the purpose of this assessment it is assumed that the majority of the operations are carried out by the farmer (although some farms are contract farmed and all or part of the operations are carried out by contractors). Data for assessing the monthly labour requirement has been taken from Nix (2016)[51]. This is the same source that was used to calculate labour requirements for field operations for the bioenergy crops and is a recognised data source within the agriculture sector.

General assumptions across all crops and grass include preparation, travelling to the field, minor breakdowns and other stoppages, and relate broadly to medium or medium heavy land. Timing of operations relate to lowland conditions and will be affected by the season, altitude and latitude of production.

The assumptions for each crop are set our below;

Winter cereals (wheat) | Crops are established using plough based cultivations, typically taking place in September (could range from July – October), followed by power harrowing and then drilling in mid-September – October. Occasional crops may be sprayed with insecticides in the autumn and receive both a pre and post emergence herbicide, but once these applications are complete little is done with the wheat crop until the early spring (March) when spring fertiliser applications and fungicide programmes start. These applications occur through until the crop has completed flowering (June), then the crop is left to mature before harvest commences in August-September. The labour requirement at harvest will depend in part on the distance that the field is from the grain store (and therefore how far the grain has to be carted) and whether or not the straw is baled and removed or chopped and incorporated. In this situation it is assumed that the straw is baled and removed by a contractor. In wheat crops that are established using minimum tillage, labour requirements in September/October would be reduced by 1.2 hours.

Spring cereals (barley) | Crops are assumed to be established using plough based cultivations which take place between July and October. The land is then left bare over winter and spring cultivations (with a power harrow) are assumed to take place in February or March depending on the weather and soil type with lighter land able to be cultivated earlier. Drilling and rolling will take place soon after. Spring fertiliser and pesticide applications are made in May, with harvest typically occurring in August. Time requirement at harvest will be impacted by whether or not the straw is baled, and in this assessment it is assumed that the straw is baled and removed by a contractor.

Winter oilseed rape (WOSR) | Cultivation and drilling of WOSR typically occurs in late August through to early September, with many crops established using sub-soilers or minimum tillage practices. Insecticide and herbicide sprays are usually made in late autumn and then the crop is left until the start of fertiliser applications in March. Harvest takes place in late July through to early August, with desiccation applications made about 14 days prior to harvest.

The pattern of labour requirements for each of these crops throughout the calendar year is set out in Figure 17 to Figure 19.

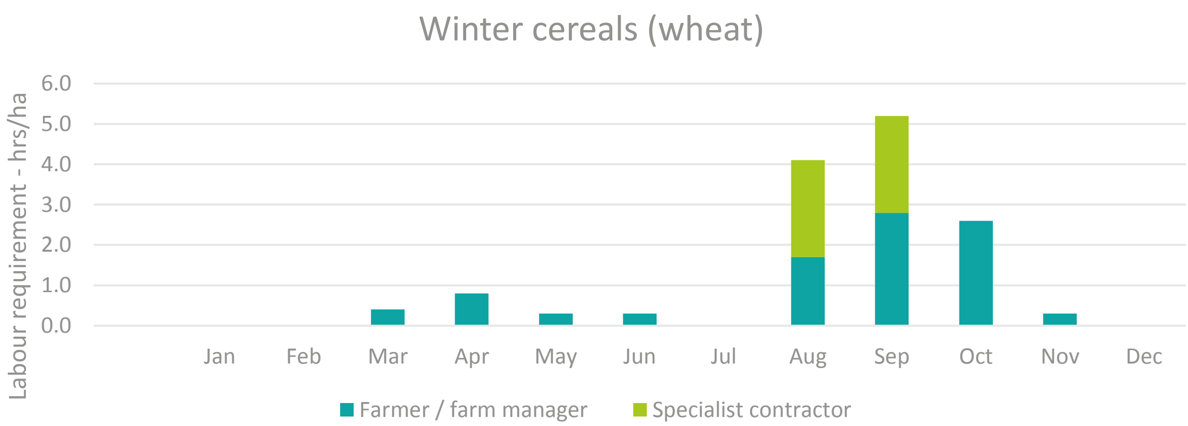

Figure 17 Winter cereals monthly labour requirement per hectare – assessing only the in field labour (farmers and contractors – excluding admin, overheads or agronomy time) – Source Nix Farm Management Pocketbook (2016)

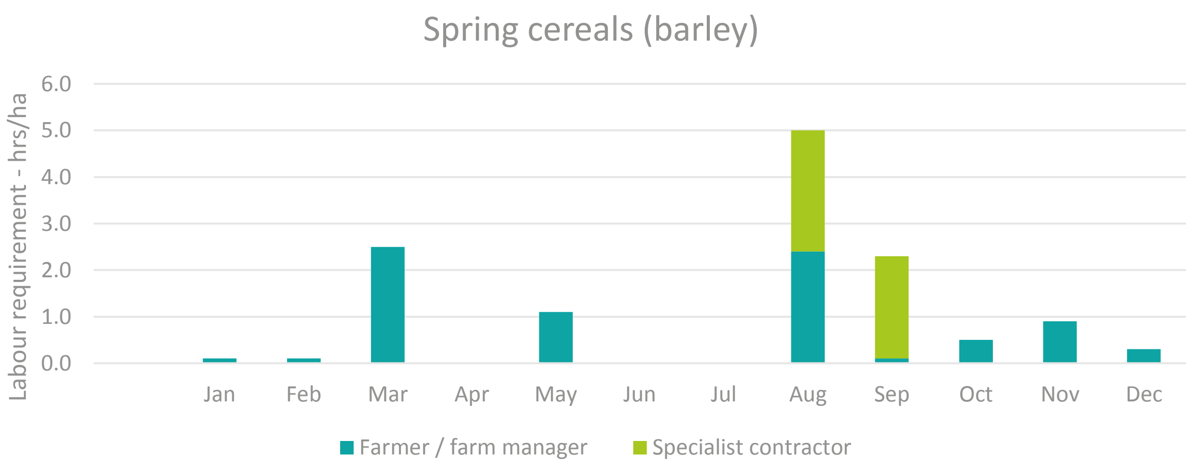

Figure 18 Spring cereals monthly labour requirement per hectare – assessing only the in field labour (farmers and contractors – excluding admin, overheads or agronomy time) – Source Nix Farm Management Pocketbook (2016)

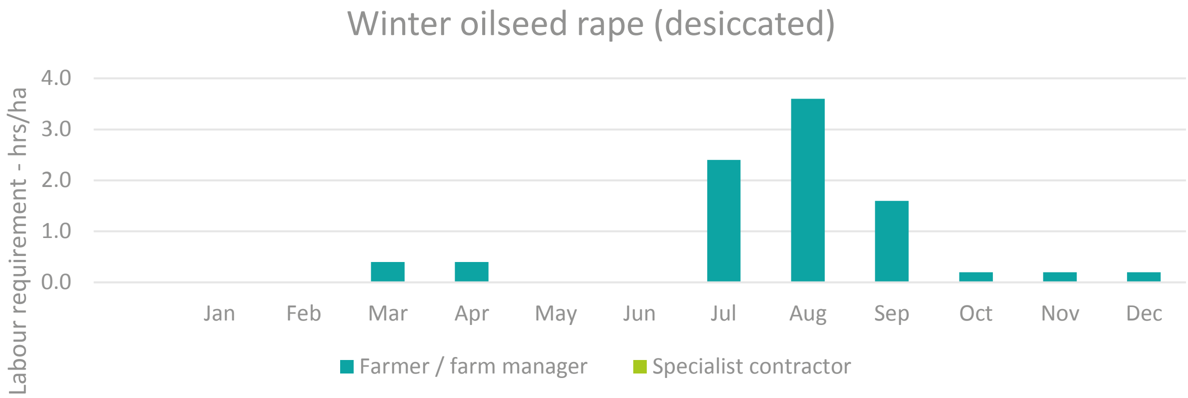

Figure 19 Winter oilseed rape monthly labour requirement per hectare – assessing only the in field labour (farmers and contractors – excluding admin, overheads or agronomy time) – Source Nix Farm Management Pocketbook (2016)

7.3 Labour requirements livestock systems

Choice of livestock enterprise is heavily dependent on factors such as geographic location, altitude and soil type. Additionally there are many different systems operating within each sector based on, for example, grassland type (temporary vs permanent leys), time of calving/lambing, finishing system for beef and lamb and end market requirements and these will impact on the timing of operations. The size of the enterprise, productivity level required and the degree of mechanisation can also have a huge impact on the labour requirements per head. Three illustrative livestock enterprises have been selected; lowland beef suckler cows, lowland sheep and dairy cows. Intensive, predominantly indoor livestock systems have not been included.

Monthly labour requirements have been taken from Nix (2016) as above. Labour requirements are generally reported in hours/head, but have been converted to hours per hectare using typical 'average' stocking rates. It has been assumed that the majority of operations are carried out by the farmer although contract and casual labour may be used for seasonal peaks.

The assumptions for each enterprise are set out below;

Silage (grassland) | A 3-year ley established in late summer/autumn (typically end July – mid- September) with the exact timing dictated by the previous crop. Grass is drilled following plough based cultivations, seedbed cultivations and drilling followed by rolling. The labour for establishment in the autumn is averaged over the life of the ley. Fertiliser is applied throughout the growing season to match production requirements. For permanent pasture the autumn establishment labour requirement could be removed. In this example it is assumed that grass is taken for silage with labour split 2/3rds in May and 1/3 in June and equally between farmer and contractor. The number and timing of conservation cuts will be dependent on the type of livestock system and quality of forage required so additional peaks in workload may be seen later in the season.

Beef suckler cows | Labour requirements are based on a lowland spring calving herd, calving from late February to early May. Single suckling with calves weaned in the autumn. Cows are assumed to be housed over winter, although there is currently increasing interest in extending the grazing period or overwintering outside where ground conditions are suitable to reduce costs. Labour requirements are based on an average 0.9 hrs/month/head and an average stocking rate of 1.6 cows per hectare (Nix, 2016). Stocking rates can be highly variable depending on type of sward, level of grassland utilisation and extent of use of purchased fodder and other feeds. Housing of stock is more labour intensive than grazing stock as forage has to be provided on a daily basis and there is also the additional labour requirement for task such as laying down bedding and then clearing sheds out.

Sheep | Lowland breeding ewes lambing predominantly in March. Additional labour is required at lambing time provided by either farm or casual labour (often vet or agricultural students). The exact timing of lambing can vary greatly between farms from very early flocks lambing indoors in December to outdoor flocks lambing in April/May and some farms may have two or more flocks lambing at different times. A smaller peak is found at shearing (June) where labour may be provided by the farmer or contract shearers. Labour requirements are based on monthly figures per head provided by Nix (2016) and an average stocking rate of 10 ewes per hectare. As above stocking rates are variable depending on the quality and utilisation of grass.

Dairy | Labour requirements for dairy cows vary according to milk yield, management system and herd size. Labour requirements in this example are based on a herd size of 100 cows with milk yield of 8000 litres (Nix, 2016). Labour requirements per cow are increased with higher milk yields, but reduced as herd size increases. A stocking rate of 2.2 cows/hectare is assumed here. Labour requirements do not include any time for managing dairy young stock, but Nix suggest a figure of 2.9 hours/month in the winter and 1.2 hours per month for a 'replacement unit' (equivalent to a calf, yearling and in-calf heifer or 1.25 livestock units) in the summer. Labour requirements are higher over winter when stock are houses as additional forage has to be provided and more time is spent bedding down sheds and clearing them out. Calving occurs in either the spring or the autumn.

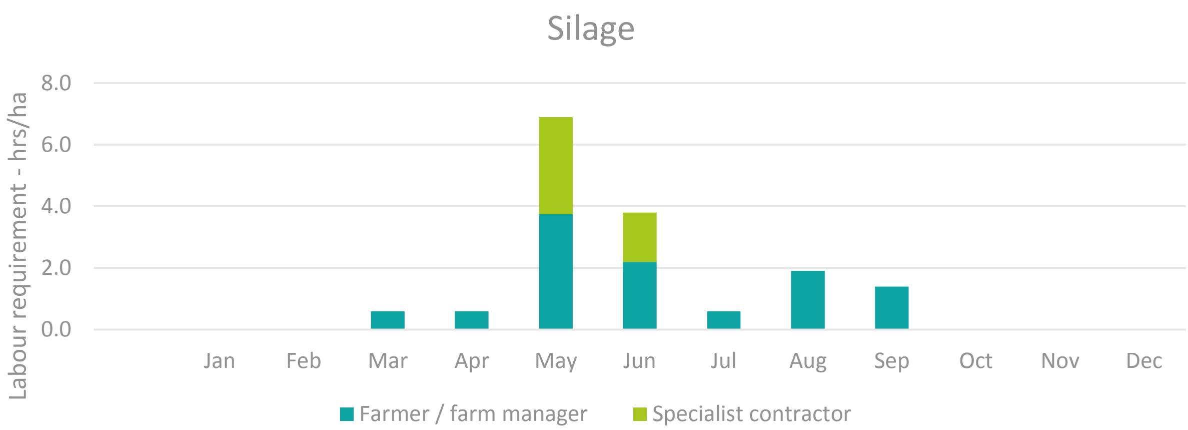

Figure 20 Temporary grassland and silage monthly labour requirement per hectare – assessing only the in field labour (farmers and contractors – excluding admin, overheads or agronomy time) – Source Nix Farm Management Pocketbook (2016)

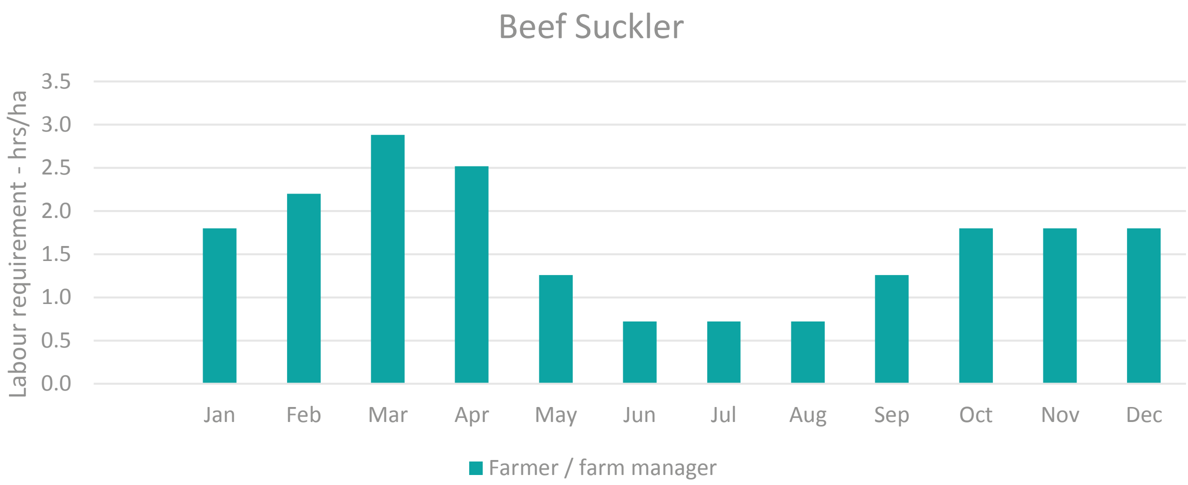

Figure 21 Lowland suckler herd monthly labour requirement per hectare – assessing only the in field labour (farmers and contractors – excluding admin, overheads or agronomy time) – Source Nix Farm Management Pocketbook (2016)

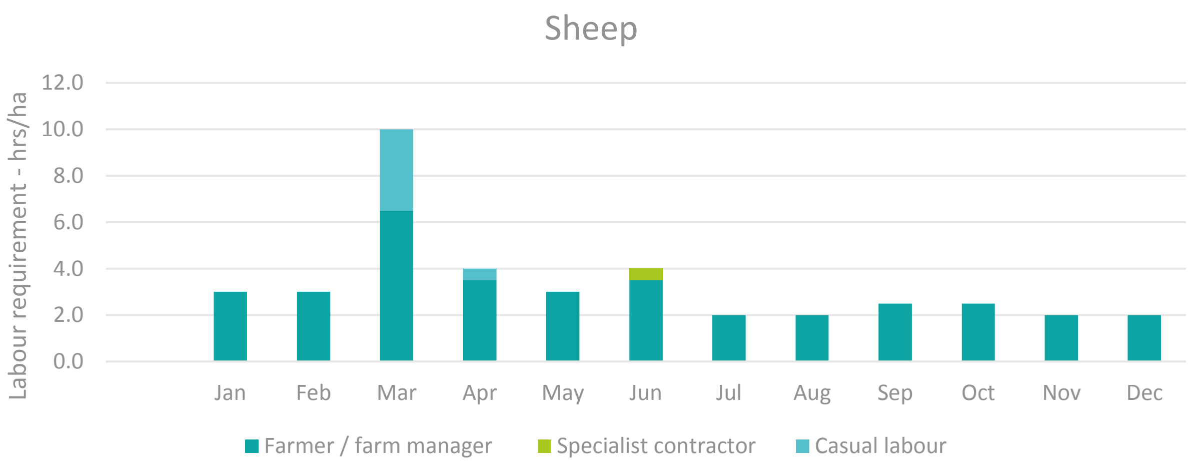

Figure 22 Lowland sheep monthly labour requirement per hectare – assessing only the in field labour (farmers and contractors – excluding admin, overheads or agronomy time) – Source Nix Farm Management Pocketbook (2016)

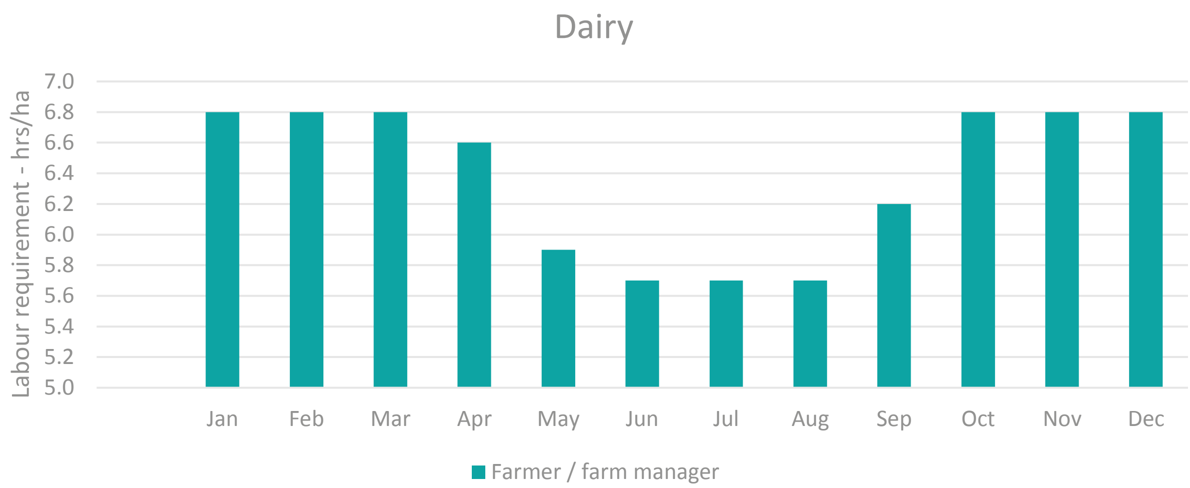

Figure 23 Dairy cow monthly labour requirement per hectare – assessing only the in field labour (farmers and contractors – excluding admin, overheads or agronomy time) – Source Nix Farm Management Pocketbook (2016)

7.4 Final summary

The labour requirements for a range of arable and livestock systems on a per hectare basis are compared to those labour requirements per hectare for bioenergy crops in Figure 24. This shows that on arable farms the peak labour requirement tends to be in the summer and early autumn (July to October) when crops are harvested and winter crops are drilled. In winter cropping rotations there is then a modest labour requirement in the spring for pesticide and fertiliser applications, whilst with spring cropping systems there is a second small peak in activity in March for drilling spring cereals. This aligns nicely with the labour profile of bioenergy crops with peak requirements falling in January through to April, when less work is occurring on the arable farm. On livestock farms there is a more consistent labour profile as the stock need caring for year round. However, over winter when stock are housed (October to April) there is an increase in labour requirement as all forage needs to be provided to the stock rather than them being able to feed themselves at grass. There is also a seasonal peak around March for calving and lambing time. Therefore, the labour profile of bioenergy crops means that their peak activity coincides with times of high labour requirements on typical livestock farms.

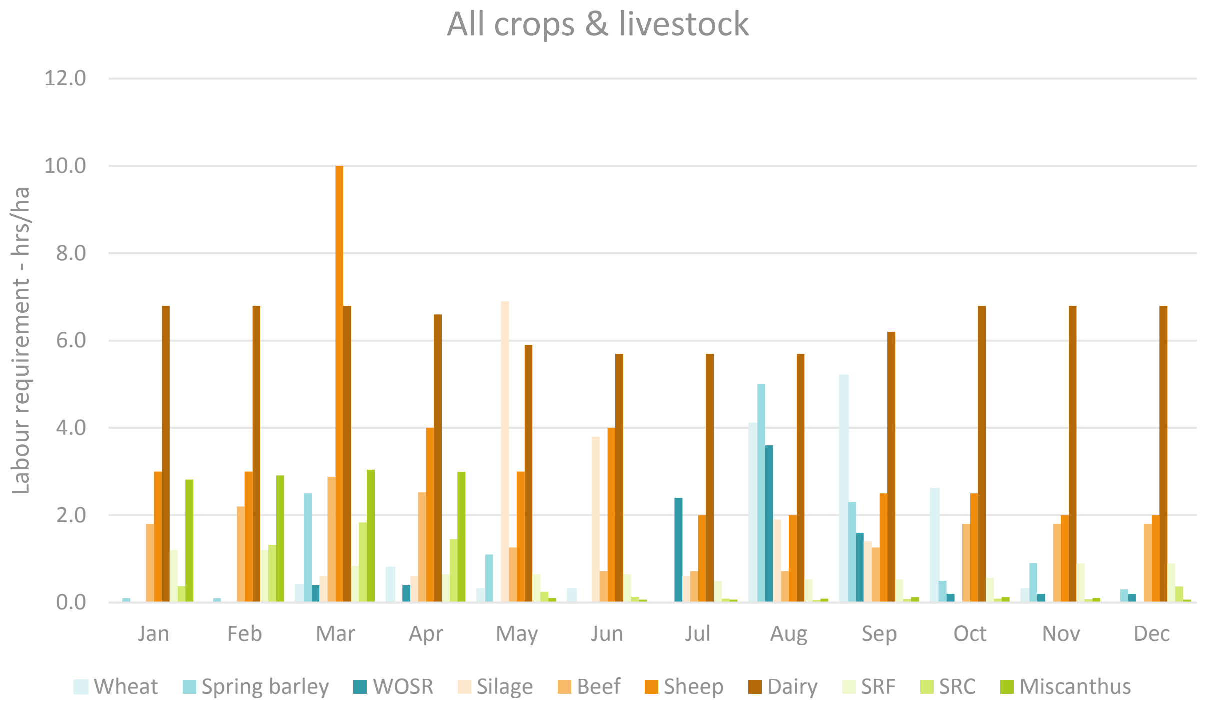

Figure 24 Monthly labour requirement on a per hectare basis for arable crops (blue), livestock systems (brown) and bioenergy crops (green).

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