NNFCC

The Bioeconomy Consultants

Report Title: UK jobs in the bioenergy sectors by 2020

Project Number: 11-025

April 2012

A report for DECC

URN: 12D/080

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1 Executive Summary

Biomass is seen as a major contributor to the delivery of the 2020 targets for electricity, heat and transport fuels. However there has been a lack of reliable data on what wider benefits this potentially significant industry could bring to the UK economy.

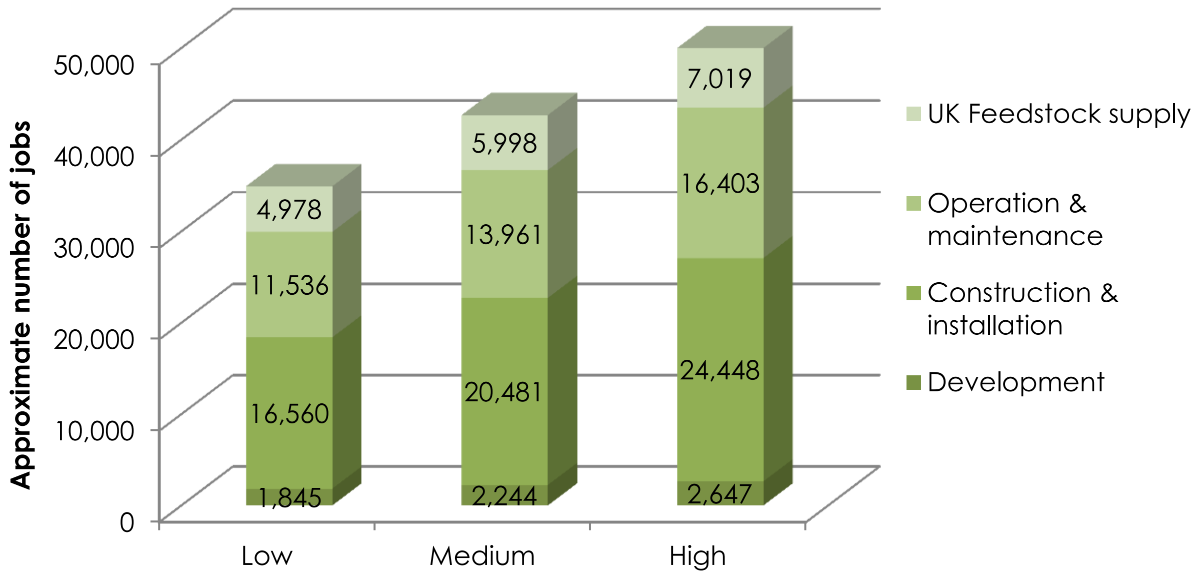
Despite this, employment potential in the bioenergy sector is expected to exceed that in other renewable energy technologies due to the additional element of feedstock production, supply, handling and logistics. This is an added benefit that appears underestimated at present but offers a valuable opportunity for UK economic growth and job creation.

This study estimated the possible number of UK jobs in the biomass combustion (for heat and power) and anaerobic digestion sectors by 2020, based on deployment projections taken from DECC's 'UK Renewable Energy Roadmap' (July 2011).

These estimates of employment were derived using data from previous studies alongside new modelling, and were broken down by jobs in: feedstock supply, plant design and construction, and plant operation. However due to the lack of available data and difficulty in projecting the market for plant components, jobs in the manufacturing sector were not included.

The study found that if bioenergy deployment reached the levels predicted in the Renewables Roadmap (see section 5.3.1), then there may be somewhere in the region of 35-50,000 UK jobs in bioenergy by 2020, see Figure 1.

Figure 1: Approximate UK employment in biomass electricity, heat and AD sectors by 2020



This highlights that there are significant employment opportunities for the UK, and that the economy could benefit considerably from deployment of bioenergy. However the actual number of people employed in the sector will be highly dependent upon the level of uptake of the technologies, whether it is new dedicated biomass plant, conversion of an existing fossil fuel station to dedicated biomass or co-firing of biomass with fossil fuel, and the supply chain structures used. These employment figures should therefore be viewed as maximum levels.

The study also estimated the contributions to overall bioenergy employment from each of the three sectors considered of heat, electricity and anaerobic digestion. Figure 2 below shows the possible job prospects in each of these technologies, with estimations ranging from 1,000 jobs in AD to almost 30,000 at the very upper range for biomass heat.

Figure 2: Approximate number of jobs in each sector

		Jobs, FTE				
Scenario	**Installed capacity MW_{th}**	**Development**	**Construction**	**Operation & maintenance**	**UK feedstock supply**	**TOTAL**
Biomass power	2,740-4,621	513-866	6,753-11,390	2,377-4,008	1,320-2,139	**10,964-18,403**
AD	320-579	68-123	379-868	752-1,360	160-289	**1,358-2,457**
Biomass heat	6,327-8,304	1,263-1,658	9,427-12,373	8,408-11,035	3,498-4,591	**22,596-29,657**

The majority of jobs are likely to be technical roles, primarily in the engineering and construction sectors, required during both the construction and operation phase of new bioenergy plant.

In addition to this there are clear employment opportunities for the UK biomass supply sector; including roles in feedstock production, harvesting, processing and haulage. However the size of this industry is highly dependent upon the origin of feedstocks used, most notably whether the industry uses predominantly UK indigenous resources or imported material. Hence for the purposes of this study it was assumed that in the biomass power and heat sectors, 10% and 50% respectively of the feedstock used was sourced from within the UK. Further to this, there is also significant uncertainty in the labour intensity of this sector as supply chain structures can vary considerably. For example, if a feedstock is used in its raw form within 10 miles of where it is grown then fewer people will be employed than if it was processed intensively and/or transported 200 miles to the end user.

Similar calculation uncertainties are inherent in the estimation of employment in designing, building and operating new plant. Therefore although the figures derived in this study can give a useful indication of the level of employment opportunities in the UK bioenergy sectors, the discrete figures quoted have a considerable degree of uncertainty attached to them and hence should be used cautiously.

Finally, the methodology used in this study was partially dependent upon the outputs of an industry survey, which gathered real employment data from a range of planned and operational biomass plant. It is worth observing that this survey was modest in size and although a relatively good response rate of 28% was achieved, the biomass heat industry was underrepresented in the final dataset. As a result the conclusions for potential employment in this sector will be less robust than those for the other technology groups.

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2 Acknowledgements

The author of this report would like to acknowledge the assistance of the following stakeholders in providing information and comments on the work:

AHS Energy	Forever Fuels
A-Consult Ltd	Fre-Energy
Add Energy	Future Biogas
Anglia Biofuels	Gaia
Aspect Forestry	GWE Biogas Ltd
AW Jenkinson Forest Products	Hadfield Wood Recyclers
Barden Biomass	Helius
Biogas Nord	Job Earnshaw & Bros Ltd
Biogen Greenfinch	KIRK Environmental
Biomass Power	Marches Biogas
Bioplex	MGT
Biowayste	Midlands Bio Energy Ltd
Boomeco	MT-Energie
Bowland Bioenergy	NG Bailey
CLS Civil Engineering Ltd	PBE Fuels Ltd.
Dalkia Bio Energy Ltd	PlanET Biogastechnik
Drax	PREL
Duffield Wood Pellets	RES New Ventures Ltd
Eco2	RWE
EDF Energy	Schmack Biogas
English Wood Fuels Ltd	Sembcorp
Enpure	Silvapower
Entech Biogas Gmbh	Silvigen
EnviTec	South East Woodfuels Ltd
Eon	UPM Tilhill
EPRL	UTS Biogas Ltd
Estover Energy	WELtec
Farmatic	WISE UK Engineering Ltd
FLI-Energy	Xergi

3 Introduction

The Renewable Energy Directive (RED) has set ambitious targets for renewable energy generation by 2020. The UK is starting from a particularly low level of renewable energy generation and will need to deploy all of its resources if these targets are to be achieved. Biomass is seen as a major contributor to the delivery of the 2020 targets for electricity and particularly for heat and transport fuels. However there is a lack of reliable data on what benefits this potentially significant industry could bring to the UK economy, and employment prospects in particular.

Similar studies have been undertaken in other renewables sectors, for example offshore-wind, where numbers of jobs likely in this sector by 2020 have been mapped, broken down by supply chain activity. A comparable analysis is required for the bioenergy sector, to help understand the wider benefits to the economy, over and above the energy generating potential and environmental impact.

3.1 Rationale

Although there are some relevant sources of such information, the data is yet to be compiled and co-ordinated and the relevant data gaps filled. A more detailed review was necessary to understand the employment opportunities the bioenergy industry could offer the UK by 2020. This required a desk based study to research and collate available statistics on the employment opportunities associated with a range of different bioenergy plant. The data from this research could then be used alongside modelling of the potential size of the industry in 2020 to quantify the possible level of employment in bioenergy.

3.2 Objective

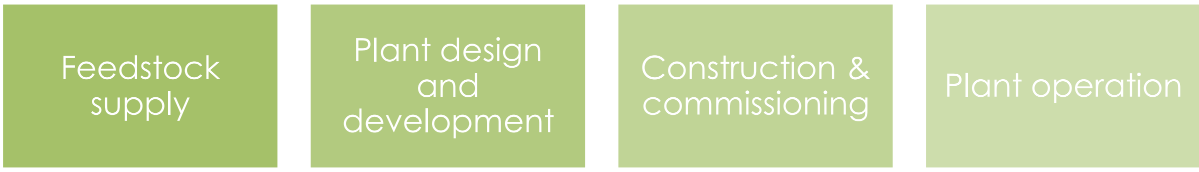
The primary objective of this study was to estimate the total number of jobs in the biomass heat, biomass electricity, and anaerobic digestion sectors by 2020. These technology groups were defined as follows:

- Biomass heat = combustion of biomass feedstock to generate heat either through stand-alone heat plant, combined heat and power, or district heating.
- Biomass electricity = combustion of biomass feedstock to generate electricity either in dedicated biomass plant or in existing coal fired stations (co-firing or conversion).
- Anaerobic digestion = digestion of biomass feedstock with the final aim of generating electricity, heat or producing biomethane to be injected into the gas grid.

NB: Advanced conversion technologies (gasification/pyrolysis) were excluded from this study due to the lack of operational plants and hence unavailability of real world data. (See 6.1)

Furthermore the study sought to disaggregate these total employment figures into types of development activity, using the categories in Figure 3 below.

Figure 3: Project development activity categories to be used



4 Methodology

In order to achieve the objective of the study as set out in section 3.2, a combination of the following three approaches was used:

1. Review existing research
2. Direct stakeholder engagement
3. Data analysis and modelling

1. Review existing research

- Identify all previous studies and understand the methodology used and scope
- Highlight any gaps in the data collected
- Obtain Excel versions of datasets where possible so that figures can be extracted

2. Direct stakeholder engagement

- Identify a list of biomass plant developers which could be consulted to gain data on real-world projects, ideally covering plants of :
    - range of scales,
    - variety of feedstocks,
    - both operating and in development.
- Identify any consultants/trade bodies which could be consulted (these may be involved in a number of projects with different developers and hence could have more balanced and representative views)
- Identify key questions to be answered by the developers and any relevant contractors or consultants. These questions may include:
    - Number of jobs in plant design/development
    - Number of jobs in feedstock procurement and sourcing
    - Number of jobs in plant manufacture and construction

    - Number of permanent and/or contract jobs in operation
- Contact the identified developers and trade bodies to obtain data on their projects.
- Clarify any unusual data through further contact and additional investigations with the relevant project developer.

3. Data analysis and modelling

- Analyse the data collected from previous studies and translate to a form which can be compared with other data sources.
- Collate all data from each developer and analyse to identify key trends, and/or any anomalies in the results.
- Derive employment coefficients for each project development activity.
- Calculate total levels of employment for each technology.

5 Biomass employment research

This section details the findings from the research methodology outlined in section 4.

5.1 Review of existing resources

Web-based research was conducted in order to identify previous research into the employment associated with bioenergy plant development and operation. Six key studies were identified on this topic:

- The Directory of UK Biomass Generation Plants 2010 – Enagri, September 2010
- Quantification of employment from biomass power plants - Patricia Thornley *et a.l*, November 2007
- Biosynergy Integrated project, led by ECN in the Netherlands 2010
- The economic value of the woodfuel industry to the UK economy by 2020, Centre for Economics and Business Research, June 2010
- An economic evaluation of current and prospective value to the north east of England from biomass-related activities, Northwoods August 2008
- Scoping study on the review of the manufacturing and engineering capabilities for manufacture and supply of key plant components and services for the biomass industry, Energy Institute, April 2009
- The scope of each of these studies and their relevance to the objective of this research are now outlined in turn.

5.1.1 Employment Statistics from The Directory of UK Biomass Generation Plants 2010 – Enagri, September 2010 (1)

- This database includes details of all the planned and operational biomass plant in the UK, along with statistics on size, feedstock and estimates of the

number of construction/operation/indirect jobs associated with each of the plants.
- The data relevant to this study (i.e. on jobs) has been extracted into a spreadsheet and categorised by phase of development and UK region.
- Figures are presented as total number of jobs and disaggregated into construction, operation and indirect opportunities.

Limitations:

The data is incomplete and offers varying levels of detail for each installation. It is difficult to break down by supply chain stage, so does not allow for data on number of jobs involved in feedstock supply, for example, to be determined. It is also difficult to extrapolate figures for 'typical' biomass installations.

5.1.2 Quantification of employment from biomass power plants - Patricia Thornley *et al*., November 2007 (2)

- This paper sought to quantify the expected employment impacts of individual bioenergy developments.
- The assessment includes agricultural labour growing energy crops (SRC and *Miscanthus*), transport and processing of the feedstock, staffing at the thermal conversion plant, employment within the equipment supply chain and the induced employment impact.
- Power only bioenergy systems were shown to typically create 1.27 man years of employment per GWh electricity produced, regardless of technology or scale of implementation.
- CHP systems can create more than 2 man years of employment per GWh electricity produced, although most of this enhanced economic impact can be attributed to the fact that a comparative analysis per unit of electricity produced ignores the heat output of the system.

Limitations:

The report highlights the fact that job displacement is not accounted for, in the example of supplying feedstock, growing wheat involves more labour than growing energy crops, therefore a number of jobs will be displaced if arable land is utilised. The displacement factor is not included.

5.1.3 Biosynergy Integrated project, led by ECN in the Netherlands 2010 (3).

- A set of spreadsheets based on statistical data from UN FAO and Eurostats that dealt with wheat straw and forestry production.
- Considered different biorefinery configurations fuelled by varying quantities of either wheat straw and wood chips.

- Developed these for five contrasting European countries (UK, Spain, Poland, Netherlands, Germany) and for each country the spreadsheets give figures for total employment based on supply of a quantity of either of the feedstocks specified by the user.
- This includes figures for direct agricultural labour, feedstock processing, transport (taking into account distances for increasing quantities of feedstock demand and likely geographical location of feedstock production based on existing agricultural patterns and previous work completed by JRC), staffing patterns at a typical biorefinery facility (including unloading and dispatch logistics for feedstocks and products), supply chain employment and induced economic activity due to facility development.

Limitations:

This study is dealing with two specific feedstocks and supply chain routes, with varying data from 5 EU countries; although the methodology is likely to be transferable.

5.1.4 The economic value of the woodfuel industry to the UK economy by 2020, Centre for Economics and Business Research commissioned by Forestry Commission June 2010 (4).

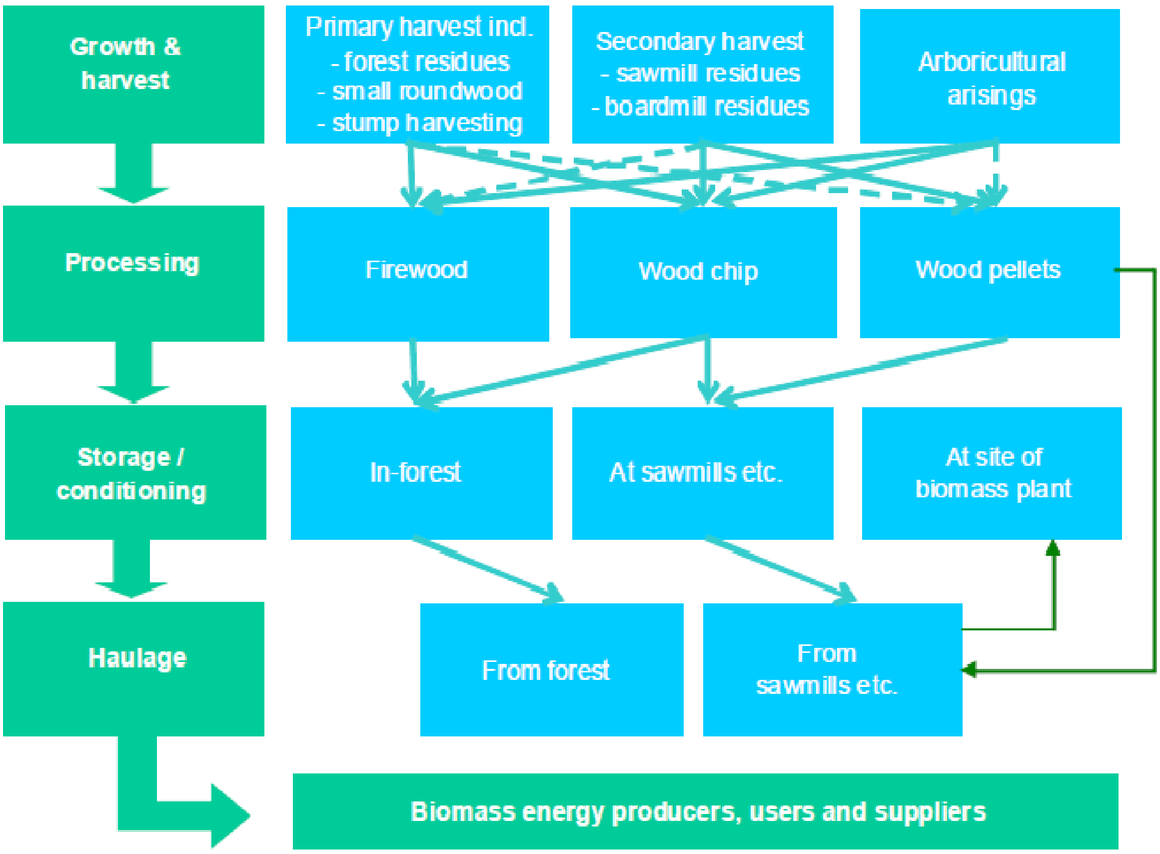
- CEBR was appointed by the Forestry Commission to undertake a study to determine the economic value of the woodfuel industry to the UK economy by 2020 and how this will be divided between England, Wales, Scotland and Northern Ireland.
- Direct and indirect employment opportunities and GVA were established, split by two levels of the supply chain; production and supply of wood fuels, and the production and supply of woodfuel energy.
- Study estimated that the woodfuel industry could generate over £1 billion of gross value added (GVA) to the UK economy by 2020 through both direct and indirect effects, which equates to: GVA / MW of installed capacity of £200,000, which increases from £194,000 in 2010; and GVA / MWh of demand for energy output of £97.20, which falls from £102.30 in 2010.
- It also concluded that the industry could create or support 15,300 jobs in the UK economy by 2020 also through direct and indirect effects, which equates to: 2.9 jobs / MW of installed capacity in 2020, which increases from 4.0 in 2010; and 0.0014 jobs / MWh in 2020, which falls from 0.0021 in 2010.

Figure 4: Outputs from CEBR research on woodfuel industry jobs in the UK (4)

2020	England	Scotland	Wales	Northern Ireland
GVA / MW of installed capacity	£191,293	£282,841	£235,312	£193,862
Jobs / MW of installed capacity (FTEs)	2.6	4.1	3.6	2.8
GVA / MWh of energy demand	£86.50	£266.30	£100.30	£77.30
Jobs / MWh of energy demand (FTEs)	0.0012	0.0039	0.0015	0.0011

- A useful output from the study was the example woodfuel supply chain, which can be found in Figure 5.

Figure 5: CEBR Woodfuel supply chain model (4)



Limitations:

The report excludes biofuels and biogas opportunities. The report only covers biomass from standing forest sources, sawmill and other processing residues, and arboricultural arisings. Energy crops, waste wood and imported biomass are excluded from the calculations, although the methodology is thought to be transferable between feedstocks.

The potential loss of employment opportunities from other fuel supply sectors has not been included; however the majority of fossil fuel is imported into the UK so this loss is not expected to impact significantly on the UK domestic market.

5.1.5 An economic evaluation of current and prospective value to the north east of England from biomass-related activities, Northwoods August 2008 (5).

- Northwoods were commissioned to undertake a study of the value to the north east economy from biomass related activities, and to attempt to quantify predicted levels of activity and value at a future date, set as 2015. This research was partly a contribution to the marketing activities of the NEWHeat project.
- This report aimed to highlight that current activity contributes a significant amount to regional economic activity, and to demonstrate the potential levels of economic activity which could be achieved – given the necessary support – by 2015.
- Showed that there are significant gaps in knowledge about how much biomass from the region is supplied to the three largest users – Egger, Alcan and Sembcorp – and this means that the value ascribed to the biomass material itself may be an order of magnitude less than the true figure. Therefore the figures in the report should be viewed as a conservative estimate.

Limitations:

Have not attempted to quantify the employment benefits which arise as a result of a thriving biomass sector, but existing studies indicate that in the region of 2,000 full time jobs could be created in the region by 2015 if a strong level of support is maintained.

Data only extrapolated to 2015, although methodology could be extended to derive data to 2020.

5.1.6 Scoping study on the review of the manufacturing and engineering capabilities for manufacture and supply of key plant components and services for the biomass industry, Energy Institute, April 2009 (6).

- The Energy Institute was asked by the Renewables Advisory Board to provide a scoping study on the review of manufacturing and engineering capabilities for manufacture and supply of key components and services for the biomass industry.

- The report was written in the context of the UK plans for renewable deployment by 2020 and in particular the substantial growth in biomass heat and electricity production required to meet those targets.
- This report was primarily a desk based review and covered the following elements relevant to this jobs research:
- Supply chain mapping and analysis of the main end uses of biomass identified areas where there are currently UK based manufacturing and engineering capabilities.
- Drew conclusions on where there are gaps in current UK provision; including manufacturing capability, skills shortages and management expertise.

Limitations:

The report only covers issues associated with solid biomass fuels; it does not cover the production of liquid biomass for transportation (or power) or gaseous bioenergy for input into the National Grid.

5.2 Survey of bioenergy industry stakeholders

In order to validate the data collected and conclusions drawn in the previous studies outlined in section 5.1, a survey of relevant industry stakeholders was conducted. The aim of this survey was to gather real-world data on the number of full time positions required to develop and operate AD and solid biomass combustion (for heat and/or power) plant.

Of the 87 stakeholders emailed, 24 responses were received; constituting a 28% response rate. These stakeholder respondents comprised:

- 7 anaerobic digestion plant developers
- 8 biomass power developers
- 6 biomass fuel suppliers
- 3 biomass boiler installers

Details of the questions asked can be found in Annexes 1-3 and the outputs of the survey are summarised in Section 6.

5.3 Data analysis and modelling

Once all survey responses had been received, the results were amalgamated and averages calculated for the number of jobs associated with each of the development activities i.e. plant development, construction, operation etc.

These average employment levels were then divided by the installed capacity of the plant in question, in order to derive an 'employment coefficient' of full time equivalent positions (FTE) per MWe. These employment coefficients could then be used alongside a theoretical total installed capacity to calculate total employment in each of the technology sectors in 2020.

5.3.1 Technology deployment by 2020

As described above, one of the key assumptions used in the study was the level of technology deployment by 2020. In order to prevent duplication NNFCC did not attempt to model this level of deployment, but instead utilised projections provided by DECC. These figures were extracted from analysis conducted for the UK Renewable Energy Roadmap and are summarised in figures below.

Please note that only the 'low' and 'high' figures were provided by DECC; the medium figures stated are simply the median of these two scenarios and were extrapolated by NNFCC for the purpose of this report.

Figure 6: Possible biomass electricity deployment by 2020 (7)

Technology *(incl. CHP where appropriate)*	Installed capacity MWe			Estimated generation TWh		
	LOW	**MED**	**HIGH**	**LOW**	**MED**	**HIGH**
ACT	19	21	22	0.13	0.14	0.15
Bioliquids	-	-	-	-	-	-
Biomass conversion	1,146	1,587	2,028	8.03	12.01	15.99
Biomass dedicated	1,048	1,551	2,054	7.70	11.47	15.25
Co-firing	44	44	44	6.29	6.29	6.29
EfW	483	489	495	3.08	3.12	3.16
Landfill gas	708	708	708	4.09	4.09	4.09
Sewage gas	162	171	180	0.53	0.58	0.64
AD	320	450	579	2.09	3.04	3.99

Figure 6 shows the DECC projections for biomass electricity technology uptake by 2020. Clearly the most significant contribution, to both installed capacity and generation, is predicted to come from solid biomass combustion either in new dedicated plant, or in existing coal fired power stations.

Figure 7: Possible biomass heat deployment by 2020 (7)

Technology *(incl. CHP where appropriate)*	Estimated generation TWh		
	LOW	**MED**	**HIGH**
Liquid biofuels	-	-	-
Biogas injection	3.00	4.64	6.28
Biomass boilers	23.30	28.06	32.82
Biomass DH	3.89	4.33	4.76
CHP	6.07	6.07	6.07

Figure 7 above shows the DECC projections for generation from biomass heat technologies by 2020. Biomass boilers are seen to be the most significant contributor to total heat generation, with much less generation expected from CHP, biomass district heating and biogas injection.

It can be seen in the figures above that the data provided by DECC was split between bioenergy heat and electricity technologies, using the categories outlined in Figure 8 below.

Figure 8: DECC technology categories

Heat technologies	**Electricity technologies**
Liquid biofuels	ACT
Biogas injection	Bioliquids
Biomass boilers	Biomass conversion
Biomass DH	Biomass dedicated
CHP	Co-firing
	EfW
	Landfill gas
	Sewage gas
	AD

For the purpose of this study it was deemed preferable to evaluate anaerobic digestion separately from the other bioenergy technologies, to enable the employment contributions from this sector to be calculated discretely.

The DECC deployment data relating to anaerobic digestion was disaggregated into plant generating electricity and those injecting biogas to the grid for heat generation. However in the timeframe for this study it was not possible to calculate employment figures for biomethane injection separately. So the AD jobs were calculated assuming that all AD plant generate electricity, whereas in reality some will inject biomethane into the grid. Hence any additional jobs in this type of plant which exceed the number associated with electricity generation will not be accounted for.

6 Bioenergy jobs by technology type

This section of the report outlines the number of jobs estimated to exist in each bioenergy sector by 2020. It gives overall figures for each technology, a breakdown for those in the heat and power sectors, and an indication of whereabouts in the project development timeline they occur i.e.:

1. Feedstock production and supply
2. Project design, planning and development
3. Plant construction and commissioning
4. Plant operation

6.1 Biomass electricity

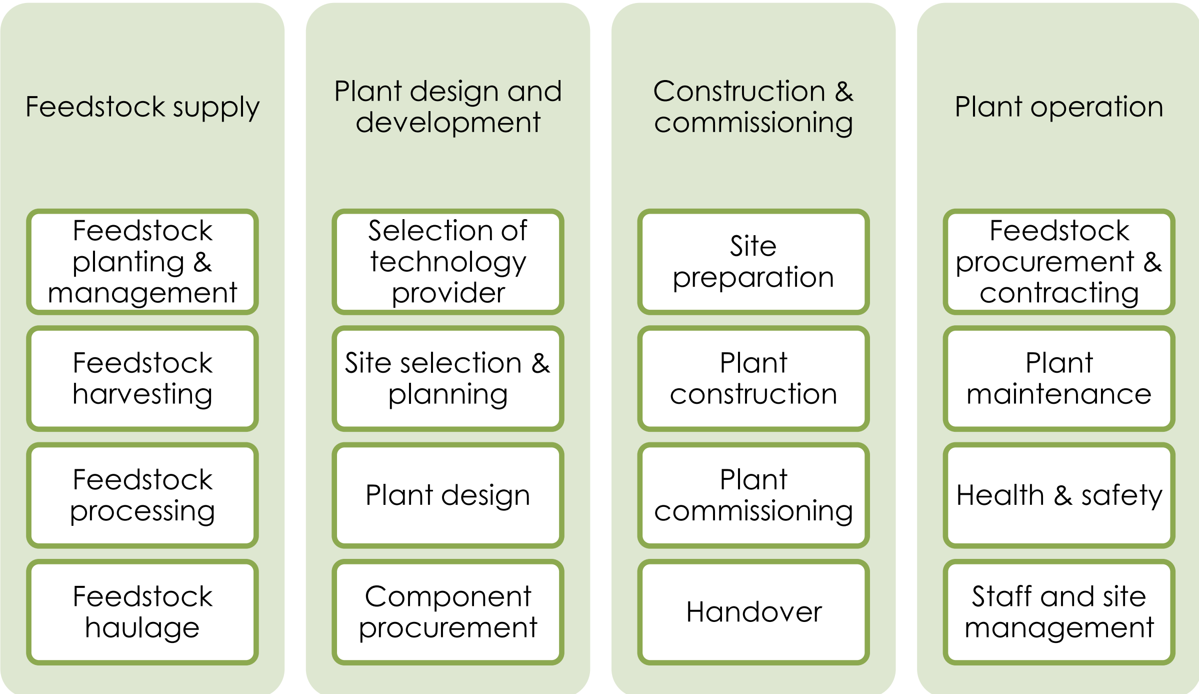
This section outlines the estimates for number of full time jobs that could exist in the biomass electricity sector by 2020. For the purpose of this study this is defined as only plant combusting solid biomass e.g. dedicated biomass plant, co-firing or conversion (see section 3.2). Therefore the estimation of jobs derived here excludes potential employment associated with liquid biomass combustion plant and advanced conversion technologies[1].

A key aim of the study was to separate the jobs into the project development activity which they relate to. An indication of what these activity categories may include for a biomass power project can be found in

Figure 9 below.

[1]NB: Although it was out of the scope of this study to estimate the number of jobs associated with these technologies, the methodology and employment coefficients derived could equally be applied to an estimated installed capacity from these technologies to calculate a comparable number of jobs.

Figure 9: Employment sectors in biomass electricity plant development



6.1.1 Employment coefficients

In order to estimate the labour requirement for each category of activity associated with biomass plant deployment, a survey of biomass project developers was conducted, as outlined in section section 5.2. Each developer was asked to provide employment information based on one particular plant which they had recently developed. A copy of the questions asked can be found in Annex 1.

The results from this survey were then amalgamated and averaged, in order to derive approximate employment requirements per MWe of plant installed capacity. A summary of these findings can be found in Figure 10.

These findings show that on average a biomass plant will require in the order of 290 full-time equivalent (FTE) employees, or an average of 14 FTE/MWe, with a large proportion of this employment occurring during the construction and commissioning phase of plant development. It is worth noting however that the scale of the plant will have an impact on the FTE per MWe. For example, doubling the scale of a plant will not necessarily double the number of people employed, as efficiencies of operation may reduce the number of FTE/MWe.

Figure 10: Survey results from biomass electricity plant developers

Sector	TOTAL FTE during relevant phase, per project[2]	Average FTE during relevant phase, per MWe
Number of jobs in plant design/development	11.00	0.94
Number of jobs in plant construction and commissioning	224.50	12.32
Number of permanent jobs whilst in operation	31.13	0.59
Number of contract jobs in operation (e.g. periodic maintenance)	18.25	0.42
Number of jobs in feedstock procurement and sourcing	2.08	0.20
TOTAL jobs	**286.96**	**14.46**

In order to check that the figures obtained were consistent with findings from previous research, the FTE needed to operate the plant were compared to that calculated by Patricia Thornley *et al.* in the research described in section 5.1.2. This study concluded that 0.8FTE/MWe would be needed, compared to 0.59FTE/MWe resulting from the industry survey. Clearly there is some difference in these two figures, but due to the variables that have to be taken account of (combustion technology used, scale of operation etc) the two figures can be said to be in broad agreement and at the very least are the same order of magnitude.

[2] i.e. how many full-time equivalent employees the plant will require during each phase of development. These full time employees may not be required for the lifetime of the plant. For example, 224.5 FTE employees may be needed during the construction phase, but this will only cover approx 1-5 years.

One important finding to note is that an average biomass electricity plant may require approximately 200 FTE employees to construct and commission the plant. However this level of employment will not be necessary throughout the lifetime of the plant, rather it will peak during the initial construction phase and last up to a maximum of 5 years (for large scale generation). As well as those in the construction phase, employees associated with plant design and development are also unlikely to be involved during the lifetime of the project, but instead for a shorter period leading up to the commissioning of the plant.

Hence the contribution from these sectors to the figure for total jobs has been reduced by a factor of 5, to account for the fact that these employees are likely to move on to work on new projects roughly every 5 years (less for smaller scale plant) assuming the lifetime of the plant to be approximately 25 years.

By reducing the average levels of employment to account for short development and construction periods, the employment coefficients to be used in the total employment in biomass electricity by 2020 analysis were calculated, see Figure 11.

Figure 11: Employment coefficients allowing for reduced contract terms

Sector	Average FTE per MWe
Number of jobs in plant design/development	0.19
Number of jobs in plant construction and commissioning	2.46
Number of permanent jobs whilst in operation	0.59
Number of contract jobs in operation (e.g. periodic maintenance)	0.08
Number of jobs in feedstock procurement and sourcing	0.20
TOTAL jobs	**3.52**

In addition to the findings sourced from the industry survey regarding biomass electricity plant, further data was needed to estimate the employment associated with feedstock production. This was sourced from previous research carried out as part of the Biosynergy Integrated project and CEBR's study 'The economic value of the woodfuel industry to the UK economy by 2020', as described in sections 5.1.3 and 5.1.4.

Data extracted from both of these studies was used to derive figures for the average levels of employment needed to produce 1 oven dry tonne of biomass feedstock. The findings from these calculations are summarised in Figure 12 below.

Figure 12: Employment associated with biomass feedstock production & processing

Feedstock	FTE/odt

SRC	0.000945
Miscanthus	0.000852
Straw	0.000438
Forestry	0.001341
Average	**0.000894**

By combining the coefficients derived in Figures 11 and 12, the final employment coefficients to be used for calculating employment in 2020 were derived. These are summarized in Figure 13.

Figure 13: Summary of employment coefficients used in final calculations

Development activity	Employment coefficient	Unit
Plant design/development	0.19	FTE/MWe
Construction and commissioning	2.46	FTE/MWe
Operation & maintenance	0.87	FTE/MWe
Feedstock supply	0.000894	FTE/odt

6.1.2 Level of deployment in 2020

Once the employment coefficients for each activity had been calculated, these could then be applied to the predicted installed capacity of biomass electricity generation in 2020. These predictions of deployment of biomass electricity by 2020 were taken from DECC analysis as described in section 5.3.1 and are summarised in Figure 14.

Figure 14: Biomass electricity - range of projected operational capacity (including CHP)[3]

Low estimate	**MW**	2,721
	TWh	25.11
Central estimate	**MW**	3,671
	TWh	32.90
Upper estimate	**MW**	4,621
	TWh	40.68

[3] Extracted from analysis for DECC's 'UK Renewable Energy Roadmap', July 2011

6.1.3 Jobs in biomass electricity

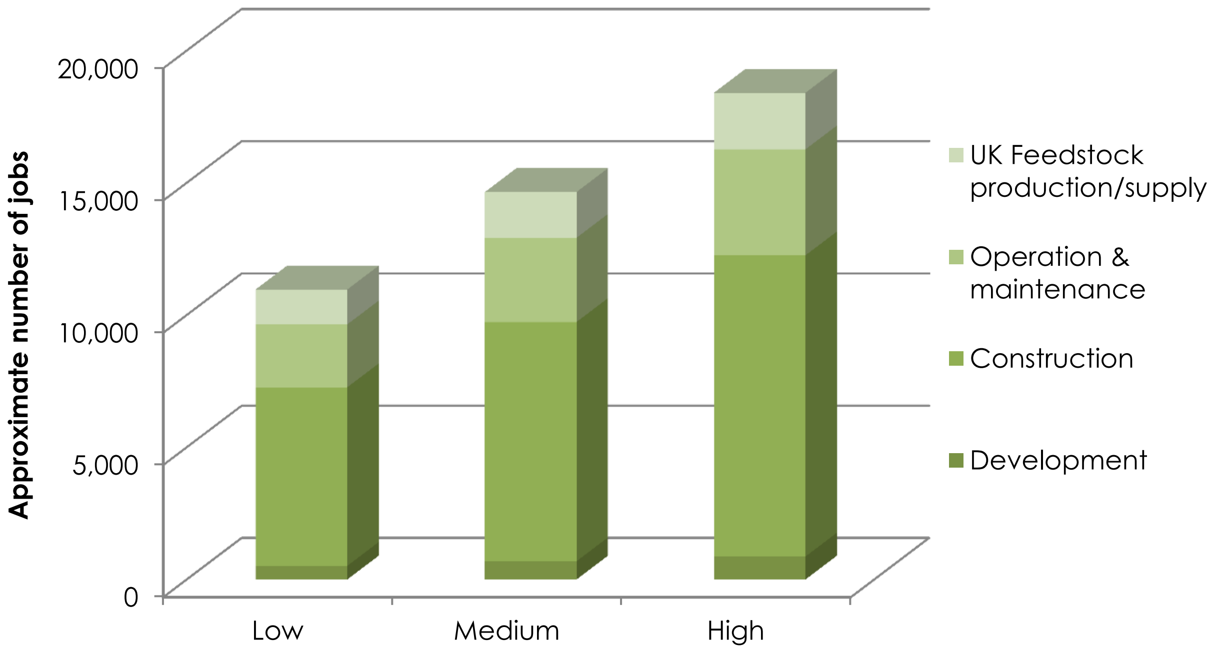
Finally, by using the employment coefficients and level of deployment, the total number of UK jobs that may exist in the biomass electricity sector by 2020 were calculated.

Figure 15: Findings for UK jobs in biomass electricity by 2020

		Jobs, FTE				
Scenario	**Installed capacity MWe**	**Development**	**Construction**	**Operation & maintenance**	**UK feedstock supply**[4]	**TOTAL**
Low	2,740	513	6,753	2,377	1,320	**10,964**
Medium	3,671	688	9,048	3,184	1,730	**14,650**
High	4,621	866	11,390	4,008	2,139	**18,403**

The results in Figure 15 and Figure 16 show that in the high uptake scenario the biomass electricity sector has the potential to employ over 18,000 people by 2020, with over half of these in the construction and engineering industry alone.

Figure 16: Approximate UK employment in biomass electricity by 2020



6.2 Anaerobic digestion

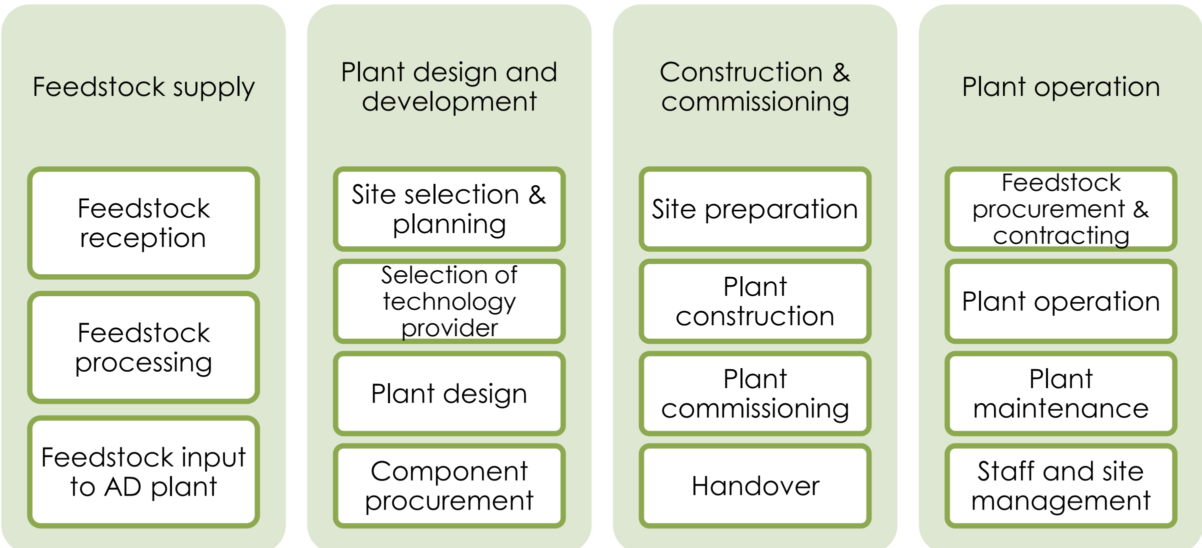
This section estimates the number of full time UK jobs that could exist in the anaerobic digestion sector by 2020. A key aim of the study was to separate these jobs into the project development activity which they relate to. An indication of

[4] Note that these jobs are based on the biomass electricity sector using 90% imported fuel, 10% UK sourced.

what these categories may include for an anaerobic digestion project can be found in

Figure 17 below.

Figure 17: Employment sectors in anaerobic digestion plant development



6.2.1 Employment coefficients

In order to estimate the labour requirement in each section of AD plant deployment, a survey of project developers was conducted. Each developer was asked to provide employment information based on one particular plant which they had recently developed. A copy of the questions asked can be found in Annex 1.

The results of these surveys were then amalgamated and averaged, in order to derive approximate employment requirements per MWe of plant installed capacity. A summary of these findings can be found in Figure 18.

Figure 18: Survey results from anaerobic digestion plant developers

Sector	TOTAL FTE during relevant phase, per project[5]	Average FTE during relevant phase, per MWe
Number of jobs in plant design/development	3.00	2.12
Number of jobs in plant construction and commissioning	12.83	11.84
Number of permanent jobs whilst in	1.61	2.21

[5] i.e. how many full-time equivalent employees will the plant require during each phase of development. These full time employees may not be required for the lifetime of the plant. For example, 224.5 FTE employees may be needed during the construction phase, but this will only cover approx 1-5 years.

operation		
Number of contract jobs in operation (e.g. periodic maintenance)	3.49	1.43
Number of jobs in feedstock procurement and sourcing	1.14	0.50
TOTAL jobs	**22.07**	**18.10**

These findings show that on average an AD plant will require in the order of 22 full-time equivalent (FTE) employees, or an average of 18 FTE/MWe. This ratio is clearly quite high, and demonstrates the relatively small scale (<1 MWe) of an average AD plant.

As explained for the calculations for biomass electricity plant, it is important to note that the level of employment necessary for the construction and commissioning of the plant will not be sustained throughout the lifetime of the plant. Rather it will peak during the initial construction phase, which for AD has been assumed to be up to a maximum of 2 years. Similarly, employees associated with plant design and development are also unlikely to be involved during the lifetime of the project, but instead for a shorter period leading up to the commissioning of the plant.

Hence the contribution from these sectors to the figure for total jobs has been reduced to account for the fact that these employees are likely to move on to work on new projects roughly every 2 years (less for smaller scale plant).

By reducing the average levels of employment to account for short development and construction periods, the employment coefficients to be used in the total employment in biomass electricity by 2020 analysis were calculated, see Figure 19.

NB: The survey requested developers to estimate the number of contract jobs associated with periodic maintenance of the plant as 'full time equivalent' posts. However most respondents did not use these units and so the figures have been reduced using the assumption that each full time contract worker can be responsible for maintaining the equivalent of 10 AD plants.

Figure 19: Employment coefficients allowing for reduced contract terms

Sector	**Average FTE per MW_e**
Number of jobs in plant design/development	0.21
Number of jobs in plant construction and commissioning	1.18
Number of permanent jobs whilst in operation	2.21
Number of contract jobs in operation (e.g. periodic maintenance)	0.14
Number of jobs in feedstock procurement and sourcing	0.50

TOTAL jobs	**4.24**

The final employment coefficients to be used for calculating employment in 2020 were then derived, these are summarised in Figure 20.

Figure 20: Summary of employment coefficients used in final calculations

Development activity	Employment coefficient	Unit
Plant design/development	0.21	FTE/MW_e
Construction and commissioning	1.18	FTE/MW_e
Operation & maintenance	2.35	FTE/MW_e
Feedstock supply	0.50	FTE/MW_e

6.2.2 Level of deployment in 2020

In order to estimate the number of jobs, the likely level of installed capacity first had to be estimated. As before this was taken from DECC analysis as described in section 5.3.1. However the raw figures from the DECC work had to be adjusted to be comparable with the technology categories used in this study. The adjusted figures used for AD deployment in 2020 are shown below.

Figure 21: Anaerobic digestion - range of projected operational capacity

Low estimate	320	MW_e
Central estimate	450	MW_e
Upper estimate	579	MW_e

6.2.3 Jobs in anaerobic digestion

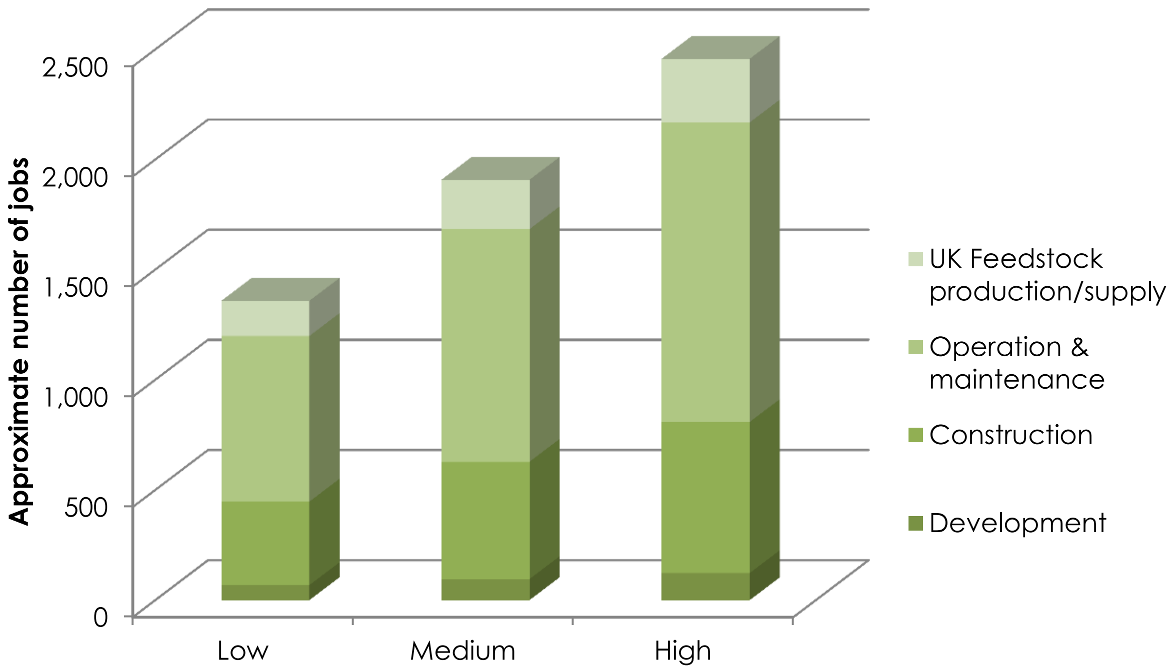
Finally, by using the employment coefficients and level of deployment, the total number of jobs that may exist in the sector by 2020 were calculated.

Figure 22: Findings for UK jobs in anaerobic digestion by 2020

				Jobs, FTE		
Scenario	**Installed capacity MW_e**	**Development**	**Construction**	**Operation & maintenance**	**UK feedstock supply**	**TOTAL**
Low	320	68	379	752	160	**1,358**
Medium	450	95	532	1,056	224	**1,908**
High	579	123	686	1,360	289	**2,457**

The results in Figure 22 and Figure 23 show that the anaerobic digestion sector has the potential to employ up to 2,500 people by 2020, with over half of these in regard to operation and maintenance of the plant.

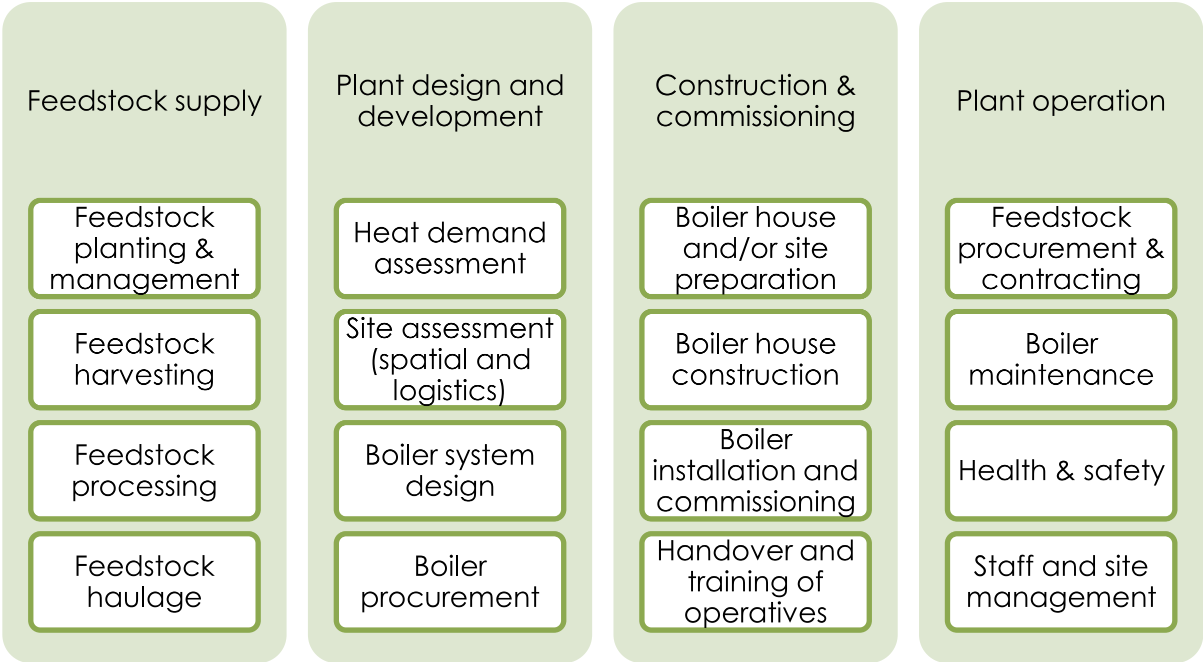
Figure 23: Approximate UK employment in anaerobic digestion by 2020



6.3 Biomass heat

This section estimates the number of full time UK jobs that could exist in the biomass heat sector by 2020; including stand alone biomass boilers, biomass district heating and CHP. A key aim of the study was to separate these jobs into the project development activity which they relate to. An indication of what these categories may include for a biomass heat project can be found in Figure 24 below.

Figure 24: Employment sectors in biomass heat plant development



6.3.1 Employment coefficients

In order to estimate the labour requirement in each section of biomass heat plant deployment, a survey of project developers was conducted, as outlined in section 5.2. Each boiler installer was asked to provide employment information based on one particular plant which they had recently developed. A copy of the questions asked can be found in Annex 1.

The results of these surveys were then amalgamated and averaged, in order to derive approximate employment requirements per MWth of plant installed capacity. A summary of these findings can be found in Figure 25.

Figure 25: Survey results from biomass heat plant developers

Sector	TOTAL FTE during relevant phase, per project
Number of jobs in plant design/development	2.00
Number of jobs in feedstock procurement and sourcing	1.49
Number of jobs in plant construction and commissioning	1.28
Number of contract jobs in operation (e.g. periodic maintenance)	0.50
Number of jobs in feedstock procurement and sourcing	0.10
TOTAL jobs	**5.36**

These findings show that on average a biomass heat plant will require 5 FTE/MW_{th}, with a high proportion of these jobs being in plant design and development. However, it should be noted that the survey was relatively modest in size (87 stakeholders were contacted; with 24 responses received) and although a relatively good response rate of 28% was achieved, the biomass heat industry was underrepresented in the final dataset obtained. As a result the conclusions for potential employment in this sector will be less robust than those for the other technology groups.

As explained for the calculations for the previous technologies, it is important to note that the level of employment necessary for the construction and commissioning of the plant will not be sustained throughout the lifetime of the plant. Rather it will peak during the initial construction phase, which for biomass heat has been assumed to be up to a maximum of 2 years but in most cases will be much less. Similarly, employees associated with plant design and development are also unlikely to be involved during the lifetime of the project, but instead for a shorter period leading up to the commissioning of the plant.

Hence the contribution from these sectors to the figure for total jobs has been reduced to account for the fact that these employees are likely to move on to work on new projects roughly every 2 years (less often for larger scale plant).

By reducing the average levels of employment to account for short development and construction periods, the employment coefficients to be used for estimating total employment in biomass heat by 2020 analysis were calculated, see Figure 26.

Figure 26: Employment coefficients allowing for reduced contract terms

Sector	Average FTE per MW_{th}
Number of jobs in plant design/development	0.20
Number of jobs in plant construction and commissioning	1.49
Number of permanent jobs whilst in operation	1.28
Number of contract jobs in operation (e.g. periodic maintenance)	0.05
Number of jobs in feedstock procurement and sourcing	0.10
TOTAL jobs	**1.78**

The final employment coefficients to be used for calculating employment in 2020 were then derived, these are summarised in Figure 27.

Figure 27: Summary of employment coefficients used in final calculations

Development activity	Employment coefficient	Unit
Plant design/development	0.20	FTE/MW_{th}
Construction and commissioning	1.49	FTE/MW_{th}
Operation & maintenance	1.33	FTE/MW_{th}
Feedstock supply	0.000984	FTE/odt

6.3.2 Level of deployment in 2020

In order to estimate the number of jobs, the likely level of installed capacity first had to be estimated. As before this was taken from DECC analysis. However the raw figures from this work had to be adjusted to be comparable with the technology categories used in this study. The adjusted figures used for biomass heat deployment in 2020 are shown below.

Figure 28: Biomass heat - range of projected operational capacity (including CHP heat)

Low estimate	6,327	**MW**
	33.26	**TWh**
Central estimate	7,316	**MW**
	38.45	**TWh**
Upper estimate	8,304	**MW**
	43.65	**TWh**

6.3.3 Jobs in biomass heat

Finally, by using the employment coefficients and level of deployment, the total number of jobs that may exist in the sector by 2020 were calculated.

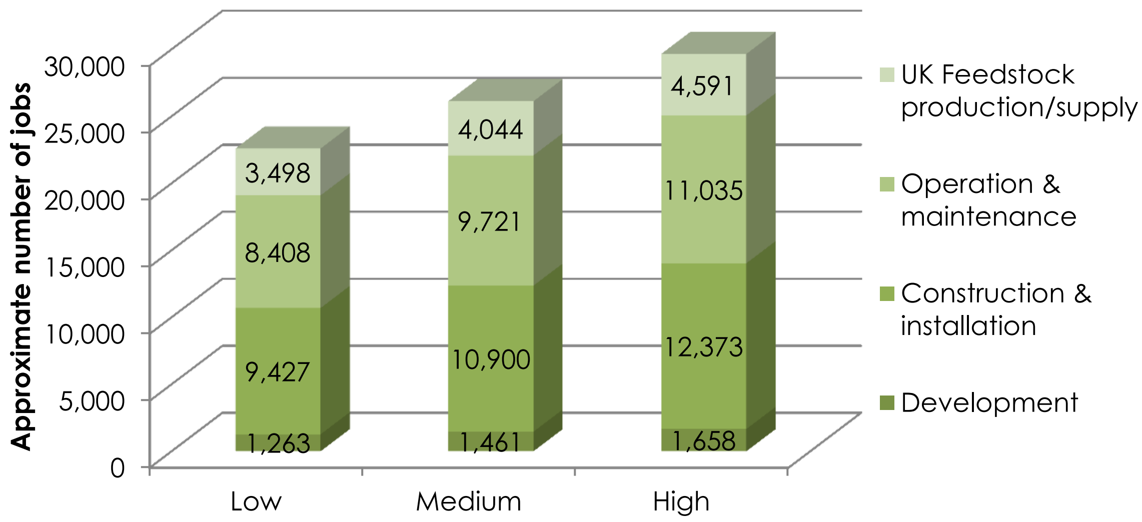
Figure 29: Findings for UK jobs in biomass heat by 2020

				Jobs, FTE		
Scenario	**Installed capacity MW_{th}**	**Development**	**Construction**	**Operation & maintenance**	**UK feedstock supply[6]**	**TOTAL**
Low	6,327	1,263	9,427	8,408	3,498	**22,596**
Medium	7,316	1,461	10,900	9,721	4,044	**26,126**
High	8,304	1,658	12,373	11,035	4,591	**29,657**

The results in Figures 29 and 30 show that the biomass heat sector has the potential to employ up to 30,000 people by 2020, with the largest proportion of these roles relating to construction (installation) and commissioning of the plant.

Figure 30: Approximate UK employment in biomass heat by 2020

[6] Note that these jobs are based on the biomass heat sector using 50% imported fuel, 50% UK sourced.



7 Summary of findings

7.1 Total UK jobs in bioenergy

Figure 31: Estimation of total UK jobs in the bioenergy sectors by 2020

	Installed capacity MW		Jobs, FTE				
Scenario	**Electricity**	**Heat**	**Development**	**Construction**	**Operation & maintenance**	**UK feedstock supply**	**TOTAL**
Low	3,060	6,413	1,845	16,560	11,536	4,978	**34,918**
Medium	4,121	8,198	2,244	20,481	13,961	5,998	**42,684**
High	5,200	9,498	2,647	24,448	16,403	7,019	**50,517**

7.2 UK jobs in biomass electricity

Figure 32: Estimation of total UK jobs in the biomass electricity sector by 2020

		Jobs, FTE				
Scenario	**Installed capacity MW$_e$**	**Development**	**Construction**	**Operation & maintenance**	**UK feedstock supply**	**TOTAL**
Low	2,740	513	6,753	2,377	1,320	**10,964**
Medium	3,671	688	9,048	3,184	1,730	**14,650**
High	4,621	866	11,390	4,008	2,139	**18,403**

7.3 UK jobs in anaerobic digestion

Figure 33: Estimation of total UK jobs in the anaerobic digestion sector by 2020

		Jobs, FTE				
Scenario	**Installed capacity MWe**	**Development**	**Construction**	**Operation & maintenance**	**UK feedstock supply**	**TOTAL**
Low	320	68	379	752	160	**1,358**
Medium	450	95	532	1,056	224	**1,908**
High	579	123	686	1,360	289	**2,457**

7.4 UK jobs in biomass heat

Figure 34: Estimation of total UK jobs in the biomass heat sector by 2020

		Jobs, FTE				
Scenario	**Installed capacity MW_{th}**	**Development**	**Construction**	**Operation & maintenance**	**UK feedstock supply**	**TOTAL**
Low	6,327	1,263	9,427	8,408	3,498	**22,596**
Medium	7,316	1,461	10,900	9,721	4,044	**26,126**
High	8,304	1,658	12,373	11,035	4,591	**29,657**

8 Conclusions

The evaluation of potential levels of UK employment in the bioenergy sectors in this report highlights that there are significant opportunities for the UK, and that the economy is likely to benefit considerably from deployment of bioenergy. However the finite number of people employed in the sector will be highly dependent upon the level of uptake of the technologies and the supply chain structures used.

The methodology used in this study was partially dependent upon the outputs of an industry survey, which gathered real employment data from a range of planned and operational biomass plant. It is worth observing that this survey was relatively modest in size (87 stakeholders were contacted; with 24 responses received) and although a relatively good response rate of 28% was achieved, the biomass heat industry was underrepresented in the final dataset obtained. As a result the conclusions for potential employment in this sector will be less robust than those for the other technology groups.

Figure 35: Approximate UK employment in biomass electricity, heat and AD sectors by 2020

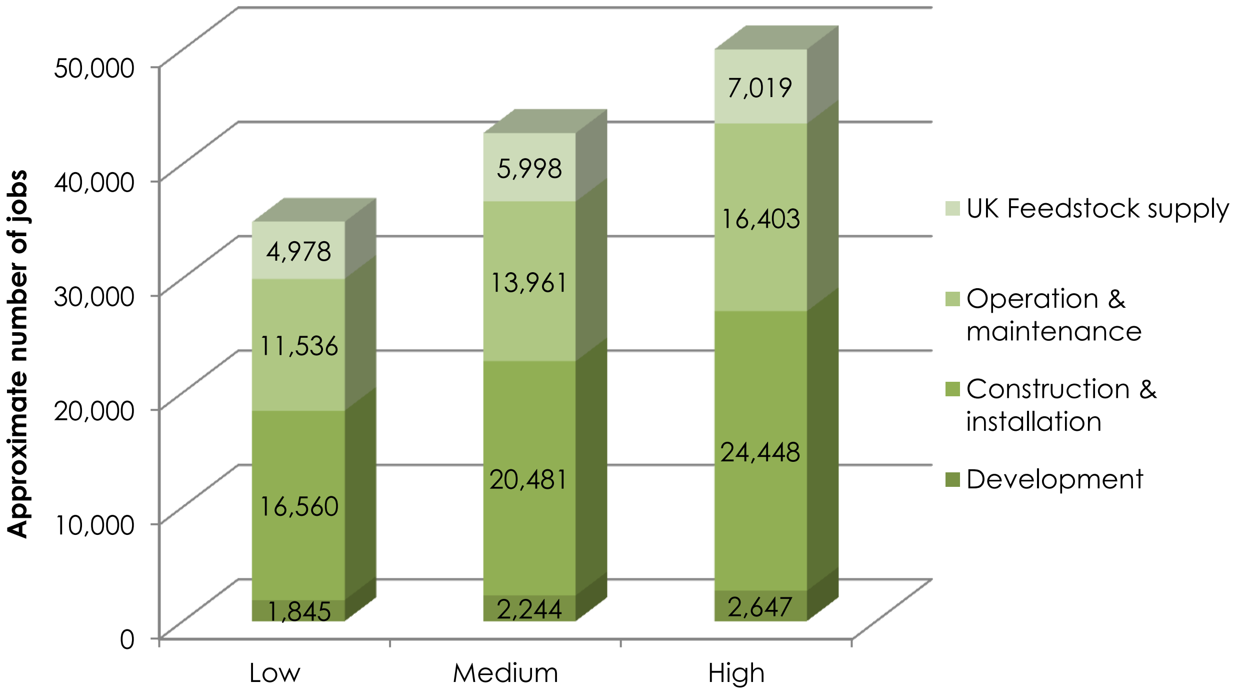


Figure 35 above shows that the majority of jobs in bioenergy are likely to be technical roles, primarily in the engineering and construction sectors, required during both the construction and operation phase of new bioenergy plant.

In addition to this there are clear employment opportunities for the UK biomass supply sector; including roles in feedstock production, harvesting, processing and haulage. However the size of this industry is highly dependent upon the origin of feedstocks used, most notably whether the industry uses predominantly UK indigenous resources or imported material. Coupled with this, there is also significant uncertainty in the labour intensity of this sector as supply chain structures can vary considerably. For example, if a feedstock is used in its raw form within 20 miles of where it is grown then far fewer people will be employed than if it was processed intensively and/or transported 200 miles to the end user.

Therefore although the figures derived in this study can give a useful indication of the level of employment opportunities in the UK bioenergy sectors, the discrete figures quoted have a considerable degree of uncertainty attached to them and hence should be used cautiously.

To further improve the accuracy of the employment projections, NNFCC would recommend the following additional work:

- Conduct a wider industry survey covering a range of technologies, feedstocks and scales in order to test and hopefully validate the employment coefficients used in the model.
- Perform more detailed analysis of likely supply chain structures, projections of feedstock types used and actual efficiencies of operational plant in order to refine the deployment scenarios in the model and increase the sophistication of the calculations.

Figure 36: Summary of UK employment in biomass electricity, heat and AD sectors by 2020

	Installed capacity MW		Jobs, FTE				
Scenario	**Electricity**	**Heat**	**Development**	**Construction**	**Operation & maintenance**	**UK feedstock supply**	**TOTAL**
Low	3,060	6,413	1,845	16,560	11,536	4,978	**34,918**
Medium	4,121	8,198	2,244	20,481	13,961	5,998	**42,684**
High	5,200	9,498	2,647	24,448	16,403	7,019	**50,517**

9 Annex 1 - Questionnaire for biomass plant developers

For one specific project you are developing, please answer the following

1. **Plant information**

i What is the name and/or location of the plant?

ii What technology option(s) will be used (e.g. boiler, steam turbine, engine, gasifier, gas turbine, AD)

iii What size is the plant (MWe and/or MWth)

iv What is its predicted output (MWh/GWh)

v Typical overall efficiency % (either to elec only or CHP, depending upon technology)

vi What feedstock does it use and where do you source it from (UK region/import)?

vii How much feedstock will be used per annum (odt)?

For the same project specified above, estimate the employees as follows

2. **Plant specific employment information, quote in FTE (full time equivalent) or in full 'man-days'**

i Number of jobs in plant design/development

ii Number of jobs in feedstock procurement and sourcing

iii Number of jobs in plant construction and commissioning

iv Number of permanent jobs whilst in operation

v Number of contract jobs in operation (e.g. periodic maintenance)

vi Other

Please estimate the number of employees required on an average plant per MWe

3. **General employment requirements**

i Number of jobs in plant design/development per MWe

ii Number of jobs in feedstock procurement and sourcing per MWe

iii Number of jobs in plant construction and commissioning per MWe

iv Number of permanent jobs whilst in operation per MWe

v Number of contract jobs in operation (e.g. periodic maintenance) per MWe

vi Other per MWe

10 Annex 2 - Questionnaire for biomass fuel suppliers

For your business please answer the following

1. **Company information**

i What is the name and location of your company?

ii What feedstock(s) do you take in? e.g. small roundwood, SRC, waste wood

Feedstock 1:
Feedstock 2:
Feedstock 3:

iii What quantity of each fuel do you produce per year? e.g. woodchip, pellet, SRC (specify moisture content)

Feedstock 1:
Feedstock 2:
Feedstock 3:

iv What sector do you sell this fuel into? e.g. local heat market, power station, other (please specify)

v How long have you been involved in the sector?

vi What is the labour required (in man-days) within your operations to process 1 tonne (state MC) of fuel?

For your business, please estimate the number of people you employ

2. Employment information, please quote in FTE (full time equivalent) or in full 'man-days'

i Total number of people employed

ii Number of jobs in equipment operation

iii Number of jobs in feedstock procurement and sourcing

iv Number of jobs in office management/administration

v Number of contract jobs in operation (e.g. periodic maintenance)

vi Other

11 Annex 3 - Questionnaire for biomass boiler installers

For one specific project you are developing, please answer the following

1. **Plant information**

i What is the name and/or location of the boiler?

ii. What size is the boiler (MWth)

iii. What is its predicted output (MWh) or load factor (XX%)

iv. Typical overall efficiency %

v. What feedstock does it use and where do you source it from (UK region/import)?

vi. How much feedstock will be used per annum (odt)?

For the same project specified above, please estimate the employees required in its design and operation as follows

2. **Plant specific employment information, please quote in FTE (full time equivalent) or in full 'man-days'**

i Number of jobs in project development and design

ii Number of jobs in boiler installation and commissioning

iii Number of permanent jobs whilst in operation (e.g. any full-time boiler operatives)

iv Number of contract jobs in operation (e.g. periodic maintenance)

v Other

For your business, please estimate the number of people you employ

3. **Employment information, please quote in FTE (full time equivalent) or in full 'man-days'**

i Total number of people employed

ii Number of jobs in project development and design

iii Number of jobs in boiler installation and commissioning

iv Number of jobs in boiler operation and maintenance

v Total capacity of all boilers installed by company in the last year (MWth)

v Other

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