making business sense

The economic value of the woodfuel industry to the UK economy by 2020

Report for the Forestry Commission

June 2010

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Authorship and acknowledgements

This report has been produced by the centre for economics and business research ltd (cebr), an independent economics and business research consultancy established in 1993 providing forecasts and advice to City institutions, government departments, local authorities and numerous blue chip companies throughout Europe. The contributors to this report and the wider study were Oliver Hogan and Jörg Radeke.

This study has been commissioned by the Forestry Commission England and has utilised some data provided by the Commission. However, the report does not necessarily reflect the views of the Forestry Commission.

London, June 2010

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Executive summary

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. Our analysis shows that the development and growth of the woodfuel resource 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.
- lead to the creation and support of 15,300 jobs in the UK economy by 2020, also through direct and indirect effects, which equates to:
    - jobs / MW of installed capacity of 2.9 in 2020, which increases from 4.0 in 2010; and
    - jobs / MWh of 0.0014 in 2020, which falls from 0.0021 in 2010.

Table 1: Key outputs from the study – unit GVA and employment contributions

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 FTEs	4.1 FTEs	3.6 FTEs	2.8 FTEs
GVA / MWh of energy demand	£86.50	£266.30	£100.30	£77.30
Jobs / MWh of energy demand (FTEs)	0.0012 FTEs	0.0039 FTEs	0.0015 FTEs	0.0011 FTEs

Other economic impacts for each of the UK nations are summarised in Table 2 below.

Table 2: Other economic effects of the development of woodfuel

2020 (£millions)	England	Scotland	Wales	Northern Ireland
Gross wages / profits demand stimulus in wider economy	459.1	127.8	55.3	26.9

2020 (£millions)	England	Scotland	Wales	Northern Ireland
RHI payments	364.7	34.2	27.8	N / A
RO payments	36.1	3.6	2.9	2.3
Fossil fuel savings				
- 100% heating oil	1,200			
- 50:50 oil : gas	1,071			
Carbon savings				
- 100% heating oil	180.4			
- 50:50 oil : gas	157.8			

1 Introduction and background

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. What follows is a report on the independent analysis conducted by centre for economics and business research ltd (cebr).

1.1 Climate change and the UK's renewable energy commitments

The Climate Change Act 2008 binds the UK to reducing Greenhouse Gas Emissions by 26 per cent by 2020 and by 80 per cent by 2050. To achieve these targets, the overall plan to source 15 per cent of the UK's energy from renewable sources by 2020 incorporates specific sources to:

- generate in excess of 30 per cent of the UK's electricity needs from renewables, including on and offshore wind, biomass (including woodfuel), hydro and wave and tidal;
- generate 12 per cent of the UK's heating needs from a range of renewable sources, including biomass (including woodfuel), biogas, solar and heat pump sources in homes, businesses and communities; and
- source 10 per cent of transport energy requirements from renewables and measures by Government to support electric vehicles and to pursue the case for further electrification of the rail network.

This climate change agenda is the ultimate driver for the projected growth in the scale of the woodfuel industry by 2020 and beyond.

1.2 Woodfuel as an increasingly important renewable resource

The importance of biomass in meeting part of the UK's fuel needs is growing steadily and is expected to play a significant role in meeting the 2020 target. The *Renewable Energy Strategy* predicts that up to 30 per cent of that target could be contributed by biomass heat and power. Biomass consists of materials of recent biological origin derived from plant and animal matter. For heat and power generation, it usually falls into one of three categories:

- biomass from conventional forestry management, including from thinning, felling and coppicing, from tops and branches and from sawmill and other wood-processing residues;
- biomass from agricultural crops and residues, including 'woody' energy crops; and
- biomass from biodegradable waste and other similar materials.

Biomass for transport is more commonly known as biofuel and includes bioethanol and biodiesel. More advanced biofuels can be manufactured from other biomass. Renewable gases include biogas and syngas, also derived from biological sources. This report does not, however, cover biofuels or biogas.

Woodfuel is the fastest-growing contributor to the UK's biomass and wider renewable resource pool. While the Forestry Commission's *Woodfuel Strategy for England* recognises the continued role for sources of woodfuel like existing woodlands, arboriculture, sawmill co-products, woodland creation and recovered wood, the focus of the Strategy is on existing woodland that is currently under-managed. More precisely, the FC estimates that these under-managed woodlands could provide an additional 2 million green tonnes of woodfuel material in England alone, material that is currently not being harvested each year.

This is the basis for our study on the economic value of the woodfuel industry to the UK economy by 2020. For the purposes of this report, we assume that woodfuel incorporates logs, wood chip and wood pellets that are used to generate heat and power and which are derived from virgin biomass fuel, which is sourced from:

- the standing forestry resource, including forest residues (i.e. lop and top including stemwood and branches), small roundwood and stump harvesting direct from the standing forestry resource;
- sawmill and other wood processing residues; and
- arboricultural arisings, the material discarded by those involved in the practice of arboriculture.[1]

Biomass derived from energy crops or from waste / recycled timber (from, for example, the construction industry) is beyond the scope of this study, as is imported woodfuel. However, the methodology we have developed to estimate the economic value of woodfuel by 2020 is easily transferrable to the investigation of the value of these other feedstocks in the future.

1.3 Requirements for a thriving woodfuel market

Currently under-managed woodlands are more likely to be brought back into sustainable management when there is a commercial incentive to do so. This is provided, for our purposes, by the demand for woodfuel from the renewable energy market and the prices that market is willing to pay for woodfuel products.[2]

Woodfuel is already used in the domestic heating sector, to fuel the traditional 'open fire', but increasingly in more efficient stoves and boilers. However, according to the *Renewable Energy Strategy*, it is in local heat generation in the non-domestic sector that woodfuel can make the significant contribution to the UK's renewable energy targets. Woodfuel heat

[1] The practice of arboriculture involves the cultivation and management of individual trees, shrubs, vines, and other perennial woody plants, maintained for permanent landscape and amenity purposes in gardens, parks or other populated settings.

[2] However, other factors such as biodiversity and landscape, as well as shooting, are also important drivers for landowners.

installations are increasingly found at the community level, including swimming pools and schools, and in commercial / industrial settings, such as supermarkets, factories and labs.[3] The predicted strong future growth potential of woodfuel in local non-domestic heating is based on the following emerging trends:

- the scale and capacity of the developing businesses are relatively small;
- the speed of boiler replacement required to generate the scale that is necessary to expedite the development of effective woodfuel supply chains is most achievable in this sector; and
- local non-domestic heat installations can be located so as to provide a close fit with pattern of woodland that will yield the woodfuel harvest, which would minimise transport costs, thus maximising the carbon savings from using woodfuel instead of fossil fuels.[4]

Combined heat and power (CHP) plants are seen as having an increasing role in industry and in towns and cities where there is high heat demand and where they are very efficient. However, successful deployment of biomass CHP in England remains at a relatively low level.

Planned dedicated electricity generation plant will rely primarily on imported wood products but woodfuel is also suitable for co-firing in large coal-fired electricity installations. However, the economics of both technologies is poor with very low conversion efficiencies, typically less than 35 per cent.[5] Moreover, current installations are located such that biomass availability is limited.

These facts lend further support to the use of woodfuel for new local heat installations and the likelihood that this would yield the greatest overall economic and social benefits from existing woodlands.

1.4 Immediate growth potential in local heat generation

The growth of woodfuel at the levels envisaged in the *Woodfuel Strategy for England* and equivalent plans for the other UK nations requires, as seen above, a thriving renewable energy market, in order to secure the demand for the additional woodfuel materials being extracted. The supply chain linking woodlands and other tree-growers to woodfuel energy users is, however, widely accepted as requiring significant development. Moreover, the

[3] Details can be found in the August 2008 report by Northwoods on their study for the Forestry Commission, north east region, and for the NEWHeat programme of One NorthEast. The title of the study was "An economic evaluation of current and prospective value to the north east of England from biomass-related activities". Further details can be found in a number of case studies prepared by TV Energy Ltd in the context of the International Energy Agency's IEA Bioenergy initiative and the associated Task 29.

[4] In other words, transport costs can be (but are by no means the only) limiting factor in the price and financial viability of woodfuel. However, opportunities to reduce costs derive from well-located projects such as, for example, co-location of integrated users of electricity and heat or locating new woodfuel installations for CHP and power generation close to areas of woodfuel availability. We also encountered the idea of developing integrated sites that would attract a wider range of wood-using activities other than just energy.

[5] Conversion efficiency refers to the ratio of final energy outputs (heat and power) to primary energy inputs (woodfuel in this case). See subsection 2.5 below.

investment required will only be forthcoming when there develops a certain and growing demand for the woodfuel resource.

Between now and 2020, the most cost-effective potential lies in local heat generation at both the medium and larger non-domestic scale, according to the *Renewable Energy Strategy*. This will be supported, from April 2011 (with retrospective application to 2009), by the *Renewable Heat Incentive*, which will provide incentives for investment in renewable heat plant, including woodfuel boilers.

Investment in dedicated renewable electricity is being supported under the *Renewables Obligation*, regardless of scale.[6] Combined Heat and Power (CHP) installations will be eligible for the same *Renewable Heat Incentive* tariffs for their useful renewable heat output as dedicated renewable heat installations. Support under the *Renewables Obligation* is also available for the renewable electricity output of woodfuel CHP installations, but this is less than in the case of dedicated electricity.

1.5 Structure of this report

This report is structured as follows:

- Section 2 considers our methodological approach and the key assumptions that drove our approach to estimating the economic value of woodfuel to the UK economy by 2020.
- Section 3 examines the direct and indirect GVA and employment contributions from that part of the supply chain concerned with woodfuel production;
- Section 4 considers the direct and indirect GVA and employment contributions from those parts of the supply chain concerned with woodfuel energy production and boiler manufacturing;
- Section 5 considers other economic effects that are likely to result from the development of woodfuel.

Annex I examines in greater detail the indirect contributions that should be captured by our calculations, while Annex II provides some more on the calculation of employment effects (which we thought was a little turgid for the main body of the report).

[6] Note that, while the new system of *Feed-In Tariffs* is designed for small-scale dedicated electricity generation, current Government thinking is that it will not apply to small-scale biomass plant. Rather, Government plans to extend the *Renewables Obligation* to apply to all scales of biomass electricity plant.

2 Methodology and assumptions

2.1 Introduction

This section explains the methodological approach that has been adopted for the purposes of determining the economic value of the woodfuel industry to the UK economy by 2020. First, the underlying concepts for determining economic value and impacts are explored at a high level. That approach is further elaborated further sections 3 and 4 below in the context of the specific part of the value chain being examined, respectively woodfuel production and woodfuel energy production (along with the manufacture of woodfuel energy installations, the most common being boilers and CHP installations for our purposes.)

We then examine the current state of the woodfuel industry and how we have understood the manner in which it is likely to develop, based on the *Renewable Energy Strategy* scenarios and what we have learned from our desk research. This will also serve to elaborate the manner in which we have modelled the industry and broken down the analysis to arrive at the robust aggregate effects presented in this report.

The following assumptions are examined:

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

2.2 Underlying concept of economic 'value' (GVA)

The underlying concept of economic value used in the study (and this report) is 'Gross Value Added' (GVA). That is, the difference between the value of output and the intermediate consumption required to produce that output or, in other words, the cost of inputs (other than employees) from the fuel for the machinery and equipment involved in the harvesting and processing of woodfuel and the energy required to power and heat the factories where boilers are manufactured to the business services used in the preparation of company accounts and the stationery stacked in the cupboard.

The overall GVA calculation for the UK woodfuel industry involves, therefore, tracking the flow of expenditures on inputs and revenues from outputs through the industry's value chains.[7] Bespoke input-output tables for the woodfuel sector were beyond the scope of the

[7] The complexity of the overall GVA calculation will often depend on the vertical structure of the industry in practice. Specifically, two or more levels in the relevant value chains will often be supplied by vertically integrated companies.

study. Rather, our intermediate demand assumptions are based on cebr's analysis of ONS' 2007 Input-Output tables.

We also consider the contribution of the sector to employment in the UK. The calculation of these impacts likewise involved assumptions derived from ONS Input-Output tables, specifically assumptions about the share of the value of total output that is consumed by employment costs for different sectors. This was combined with assumptions about average wage levels (also by sector) from the Annual Survey of Hours and Earnings (ASHE) and about future levels of earnings growth.

We have calculated direct and indirect GVA and employment effects. Indirect contributions arise from the value and employment that are generated and supported in the sectors that supply intermediate inputs to the woodfuel industry. Direct and indirect calculations are made for each of the two levels of the supply chain (as we have defined it):

- the production and supply of woodfuel, which incorporates growing and harvesting of woodland, processing, storage / conditioning and transportation of the woodfuel outputs;

- the production and supply of woodfuel energy, incorporating the transformation (through combustion), conversion and application of the energy produced from woodfuel inputs, including investment in woodfuel energy installations (boilers etc.).

We consider separately multiplier effects, subsidies and taxes and financial savings from fossil fuel replacement. The methodology is outlined in greater detail in the corresponding later sections of this report.

We did not attempt to estimate the potential loss of economic value and employment in other fuel sectors as energy users and suppliers switch towards woodfuel. The UK imports the majority of its fossil fuel requirements, so it is safe to say that any domestic production of other fuels will always find a market in the UK, certainly in the period to 2020 and very probably to 2050 also. To the extent, therefore, that domestically produced woodfuel is substituted for other imported fuels, the direct and indirect economic and employment contributions presented in this report can be truly considered as net contributions to the UK economy.[8]

The approach to modelling economic effects (direct and indirect) is, as mentioned above, further elaborated below in sections 3 and 4.

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[8] This is most likely applicable to the production of woodfuel itself but may also apply to woodfuel energy production and boiler development and manufacturing under certain specific circumstances. For example, some fossil fuel boilers might have been imported from abroad and if this is substituted by woodfuel boilers manufactured in the UK, then the GVA and employment contributions generated by the production of that boiler could be considered a net impact, as opposed to having to subtract the GVA and employment contributions that would have been made had functionally equivalent fossil fuel boilers continued to be developed, installed, operated and maintained.

2.3 Woodfuel production

The Forestry Commission recorded 2.84 million hectares of woodland in the UK on 31st March 2009, with individual country shares shown below.[9]

Table 3: Share of total UK woodland by nation

Country	Share of total UK woodland
Scotland	47.2%
England	39.7%
Wales	10.0%
Northern Ireland	3.1%

Source: Forestry Statistics 2009 and cebr analysis

The bulk of UK woodlands are in private sector hands, 71.3 per cent to be precise. The Forestry Commission and Forest Service own the remaining 28.7 per cent. [10]

In 2009, the total size of the harvest was 9.3 million green tonnes, of which 95 per cent was softwood and the remaining 5 per cent hardwood. A further 0.1 million green tonnes of softwood brash and stumps were removed in 2009. A total of 8.6 million green tonnes were delivered to industry, including 5.2 million tonnes delivered to sawmills, 1.0 million tonnes to the woodbased panel industry and 0.5 million tonnes to integrated pulp and paper mills. Another 1.9 million green tonnes went into fencing, woodfuel, shavings and exports.

A total of 1 million green tonnes of stemwood was reported by the Forestry Commission to have been delivered as woodfuel in 2009 (600,000 tonnes of softwood and 400,000 tonnes of hardwood). Woodfuel from sawmill and other wood processors (namely pulpmills, woodbased panels and fencing manufactures), from recycled wood, from arboricultural arisings and from brash and stump removals are excluded from these figures.

In order to project the economic contribution of woodfuel production to the UK economy, it was necessary to extrapolate a growth path for the woodfuel harvest to 2020. This involved a number of steps, as follows:

1. The starting point was the 13 TWh of primary woodfuel energy projected for the whole of the UK by 2020 (as outlined in the June 2008 *RES* consultation paper), which we divided between England, Scotland, Wales and Northern Ireland according to their shares of total UK woodland. The resulting 2020 allocation of primary woodfuel energy production is shown in Table 4.

Table 4: Primary woodfuel energy production targets for 2020

Country	Primary woodfuel energy

[9] See Forestry Statistics 2009.

[10] The private sector total includes woodland owned by local authorities and other public bodies.

	production, 2020
Scotland	6.1 TWh
England	5.2 TWh[11]
Wales	1.3 TWh
Northern Ireland	0.4 TWh

Source: Renewable Energy Strategy Consultation, June 2008 (BERR)

2. We allocated the 2009 woodfuel harvest in the same manner which, using the appropriate conversion factors, we converted to primary woodfuel energy. The resulting primary energy allocation in 2009 was, therefore:

Table 5: Primary woodfuel energy production in 2009

Country	Primary woodfuel energy production, 2009
Scotland	1.12 TWh
England	0.95 TWh
Wales	0.24 TWh
Northern Ireland	0.07 TWh

Source: Forestry Statistics 2009 and cebr analysis

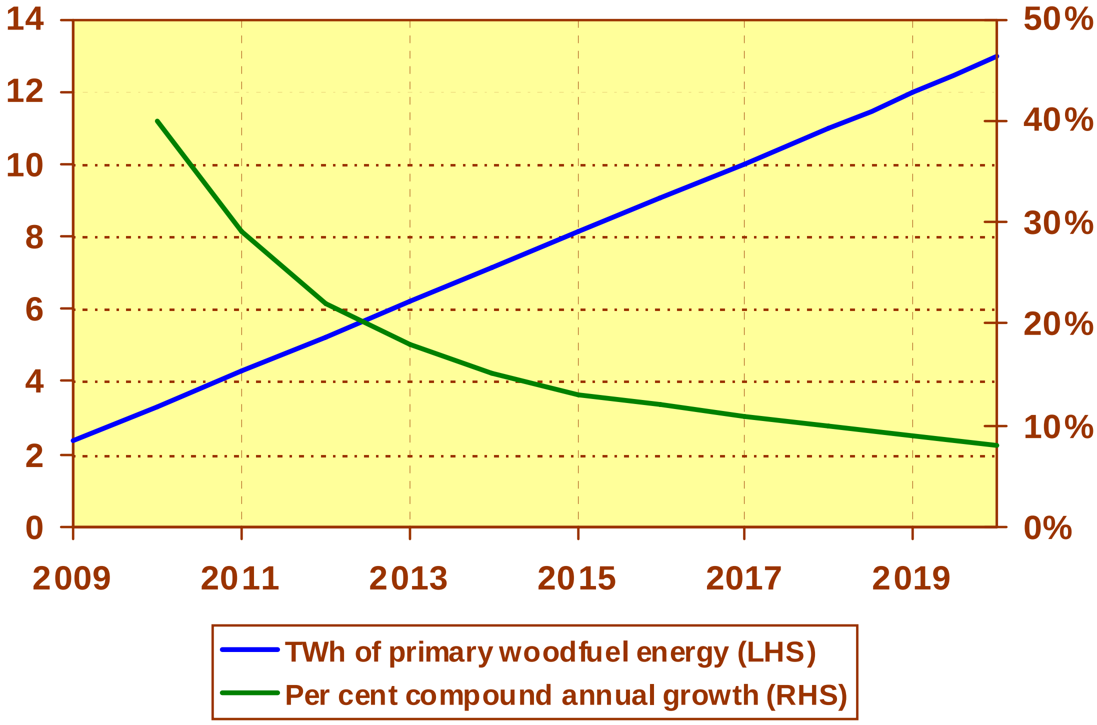
3. We used the information from 1 and 2 to construct an inverse log function of compound annual growth for the period 2010-2020 which, in turn, permits the calculation of a primary energy output for each year of the period. The inverse log compound annual growth path implies a linear time series for primary woodfuel energy production. This is illustrated in Figure 1 below.

4. We applied this growth path to the woodfuel harvest, using the 2009 harvest of 1 million green tonnes as the starting point. The resulting woodfuel harvest projections for 2020 are shown in Table 6 below. The table also shows the harvest on a 'seasoned' tonne basis. The conversion factor of 1.46 green tonnes to 1 'seasoned' tonne is based on 30 per cent moisture content for 'seasoned' wood.[12]

[11] The *Woodfuel Strategy for England* set out the expectation that the envisaged additional 2 million tonnes of woodfuel to be derived from currently under-managed woodlands in England by 2020 would deliver a total of 4 TWh of electricity, which was based on use in Combined Heat and Power (CHP) facilities. Using a CHP conversion efficiency factor, the 5.2 TWh for England (from step 1 above) translated to 4 TWh of CHP (thermal) energy output. We undertook this calculation to ensure consistency.

[12] Freshly harvested wood typically has a moisture content of between 45 and 60 per cent. For our purposes, we have assumed moisture content in the middle of this range, that is, 52 per cent. Following a period of drying to reduce moisture content to somewhere between 20 and 40 per cent, the wood is referred to as 'seasoned' or 'delivered'. For our purposes again, we have assumed moisture content for seasoned wood in the middle of this range, that is, 30 per cent.

Figure 1: Inverse log compound annual growth function and linear time series of primary woodfuel energy production



Source: cebr analysis

Table 6: Size of the woodfuel harvest in 2009 and 2020 on a green tonne and delivered tonne basis

	2009 woodfuel harvest			2020 woodfuel harvest		
Country	TWh	Green tonnes	Seasoned tonnes (30% MC)	TWh	Green tonnes	Seasoned tonnes (30% MC)
Scotland	1.12	472,000	324,000	6.1	2,560,000	1,755,000
England	0.95	397,000	272,000	5.2	2,182,000	1,496,000
Wales	0.24	100,000	69,000	1.3	546,000	374,000
NI	0.07	31,000	21,000	0.4	168,000	115,000
UK total	2.38	1,000,000	686,000	13	5,456,000	3,741,000

Source: Forestry Statistics 2009 and cebr analysis

2.4 Woodfuel energy production

The 2009 Renewable Energy Association biomass boiler survey reported 697 MW of installed thermal heating capacity in the UK, with the following breakdown:

Table 7: Megawatts of installed thermal capacity by nation, 2009

Country	MW of installed thermal capacity (reported in 2009)
England	560 MW
Scotland	55 MW
Wales	45 MW
Northern Ireland	37 MW

Source: Renewable Energy Association biomass boiler survey, 2009

These data are underestimates given their derivation from the results of a survey. Not only is the true total installed capacity unknown, however, so also is the breakdown between the different types of boiler project that make up these totals. Details about whether the boilers were actually designed for woodfuel as defined for the purposes of this report were also unavailable.

Nevertheless, we assume that the production of woodfuel energy will develop across the nations of the UK in these proportions. This translates as an 80 per cent share in England, which is consistent with the bulk of the population living there.[13] However, this assumption also means that 80 per cent of the aggregate primary energy input from the UK woodfuel harvest outlined above is consumed in England. Scotland consumes 8 per cent, Wales 6 per cent and Northern Ireland 5 per cent. [14]

Related studies by the Forestry Commission, other public bodies and consultancies suggest that there are already a number of larger biomass plant of >10 MW installed capacity for dedicated electricity or for CHP at industrial sites.[15] However, these are reliant mainly on imported woodfuel products. Otherwise, the deployment of woodfuel plant has been concentrated in domestic and smaller non-domestic boiler installations, like in homes, country estates, swimming pools, supermarkets and schools.

We noted in subsection 1.4 above the immediate growth potential for woodfuel in local heat generation. The *Renewable Energy Strategy* noted, specifically, that between now and 2020 the most cost-effective potential lies in local heat generation at both the medium and larger non-domestic scale.

These considerations are captured in our analysis by assuming that the deployment of new woodfuel energy installations will be heavily focused on dedicated local heat generation, but also on Combined Heat and Power (CHP). Table 8 below shows the mix of projects that we have assumed will have been deployed in the UK in each of the years 2010 and 2020, along

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[13] We note that this involves an implicit assumption of a large amount of woodfuel being transported from Scotland to England.

[14] This implicitly assumes that all growth is demand driven. However, if resource availability plays a role then Scotland could have a competitive advantage in woodfuel energy production, which could, as a result, grow faster there. Were this to be the case, our assumed proportions would not hold.

[15] See, in particular, Northwoods (2008), "An economic evaluation of current and prospective value to the north east of England from biomass-related activities: A study for the Forestry Commission, north east region, and for the NEWHeat programme of One NorthEast.

with the individual capacities and annual energy demands typically associated with those projects.[16]

Table 8: Breakdown of different woodfuel energy-generating projects for entire UK in 2010 and 2020, including the installed capacity and average annual energy demand associated with different types

UK project breakdowns	Installed capacity (MW)	Average annual demand (MWh)	2010 (number of projects)	2020 (number of projects)
Domestic boilers	0.02	20	3,863	15,000
Business boilers	0.05	70	1,975	7,668
Small industrial units	0.10	140	1,898	7,368
School boiler	0.15	400	165	639
Hotel boiler	0.20	280	322	1,249
Municipal complex	0.25	660	321	1,245
District heating	0.30	360	321	1,245
Municipal buildings	0.50	600	96	374
Hospital	0.70	1,000	65	253
Greenhouse installation	1.00	3,500	48	187
CHP (ORC) (th)	1.85	14,800	35	138
CHP (ORC) (e)	0.40	876		
CHP (Power station) (th)	7.00	16,000	26	101
CHP / Power station (e)	2.00	30,660		

Source: Biomass Energy Centre (BEC) website for Installed Capacity and Average Annual Demand. Number of projects derived by cebr based on projected total woodfuel energy output and the information from BEC.

By 2020, our 'energy model' predicts that 5,223 MW of woodfuel energy capacity will have been installed in the UK. The breakdowns across the nations for 2010 and 2020, including for thermal and electrical capacity, are shown below in Table 9.

Table 9: Megawatts of installed thermal and electrical capacity by nation, 2010 and 2020

Country	2010 installed capacity (MW)	2020 installed capacity (MW)
England	952 (th) 53 (e)	3,698 (th) 204 (e)
Scotland	201 (th)	781 (th)

16 The development of this scheme involved an iterative process of finding the mix of projects that achieved equality between 2020 energy demand (as a result of these projects) and primary woodfuel energy production (as outlined above in subsection 2.3).

Country	2010 installed capacity (MW)	2020 installed capacity (MW)
	5 (e)	20 (e)
Wales	71 (th) 5 (e)	277 (th) 18 (e)
Northern Ireland	54 (th) 4 (e)	210 (th) 15 (e)

Source: cebr analysis

2.5 Converting woodfuel to energy input and output

The conversion of woodfuel to primary energy input

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.

The conversion of primary energy input into final energy output

Primary energy inputs are converted into final energy outputs by applying the relevant conversion efficiency factors to the different types of installation shown in Table 8 above. The conversion factors used are shown below in Table 10.

Table 10: Conversion efficiency factors for different types of energy project

Type of project	Conversion factor
Boilers for heat (all types)	90 %
CHP (ORC) (th)	75 %
CHP (ORC) (e)	18 %
CHP (Power station) (th)	80 %
CHP (Power station) (e)	75 %

Source: cebr assumptions based on discussions with Forestry Commission experts

3 Economic value of woodfuel production to the UK economy by 2020

3.1 Introduction and summary results

This section considers the direct and indirect contributions to the UK economy that we expect to result from the development and growth of woodfuel production. We begin by reviewing the value chain involved in connecting tree-growers to the producers, suppliers and users of the energy generated from woodfuel, including the potential challenges associated with the development of commercially viable supply chains.

We also provide a closer examination of the methodology used to calculate direct and indirect economic contributions from this part of the woodfuel supply chain, before proceeding to the report on our assessment of those economic contributions.

These economic contributions are summarised in the following table.

Table 11: Summary of direct and indirect economic contributions of woodfuel production to the UK economy

UK totals	2010	2020
Direct GVA (£ millions)	25.7	100.1
Direct employment (FTEs)	644	1,956
Indirect GVA (£ millions)	25.4	98.8
Indirect employment (FTEs)	679	2,064

Source: cebr analysis

3.2 The value chain for woodfuel production

The value chain for woodfuel production is illustrated in Figure 2 below. The first link is the growth and harvesting of wood. This can be followed either by processing or storage / conditioning. Significant amounts of timber for heat are stored at yards, where they are allowed to dry (conditioning) before processing. Crucially, however, large plant (such as power stations) can handle wet wood which can, therefore, go straight to the customer. Woodfuel can also undergo in-forest processing.

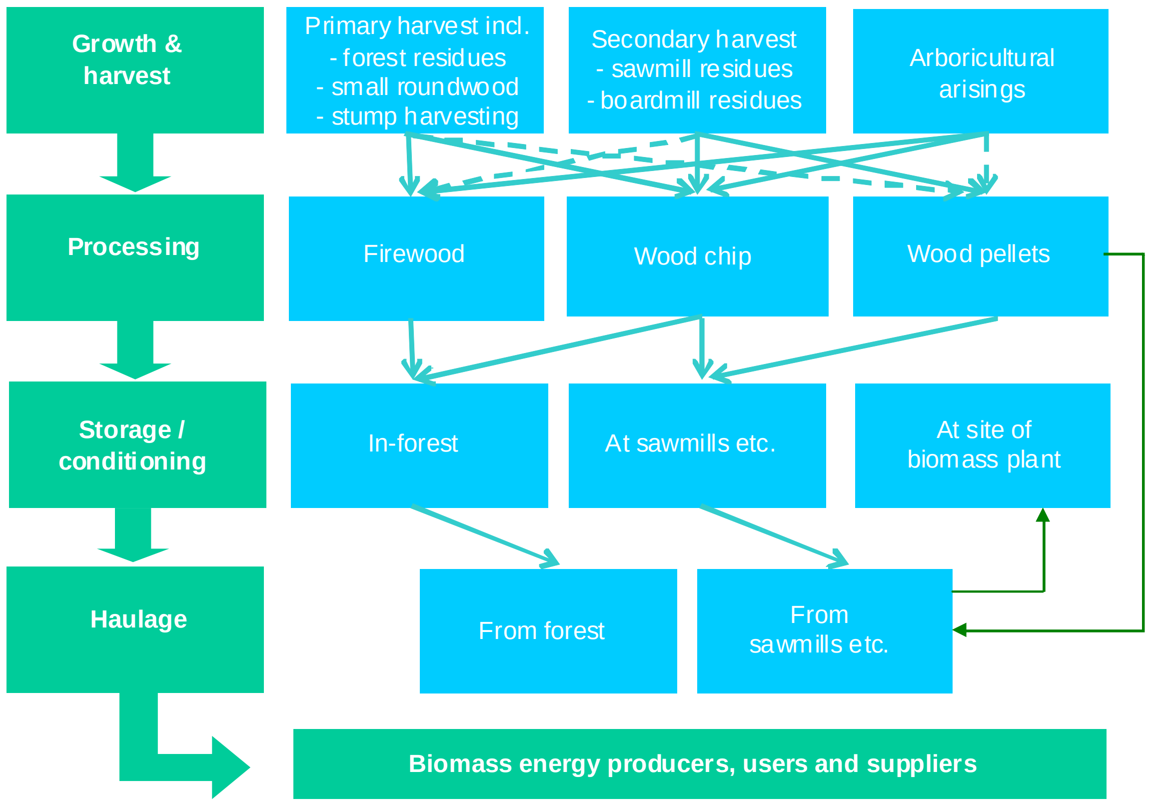
The processing, storage and conditioning of woodfuel is the most important part of the underdeveloped woodfuel supply chain. The supply chain infrastructure of the future will, from what we have gathered, be required to recover all products as cost-efficiently as possible and will involve:

- integrated harvesting systems with product separation in the forest or, alternatively, tops and branches could be recovered in a second pass operation;

- short term storage (typically for a year) to reduce moisture content when required (note the trade-off, however, between reduced transport costs and increased woodfuel costs as working capital is tied up in stockpiles during air-drying);

- chipping on site or at a processing yard, with efficient loading directly from the chipper onto trailers or bailing of coniferous brash in the forest (using currently available Scandinavian brash bailing technology) and transport on conventional round timber lorries.

Figure 2: The value chain for woodfuel supply[17]



Source: cebr analysis

The development of the woodfuel supply chain requires investment in the machinery required to harvest, process and store / condition woodfuel, as well as in the vehicles required for transportation. This, however, requires continued public sector support and private sector investment in the likes of harvesters, chippers, dryers etc.

Eligible organisations can apply for grants under the Rural Development Programmes for woodfuel supply chain equipment and woodland management. The Rural Development Programme for England (RDPE) provides grants for economic and social projects, and aims to increase the competitiveness of farmers, improve the quality of rural life and diversify the

[17] The dashed lines reflect the potential for all primary, secondary and arboriculture harvest products to be processed into firewood, wood chip or wood pellets.

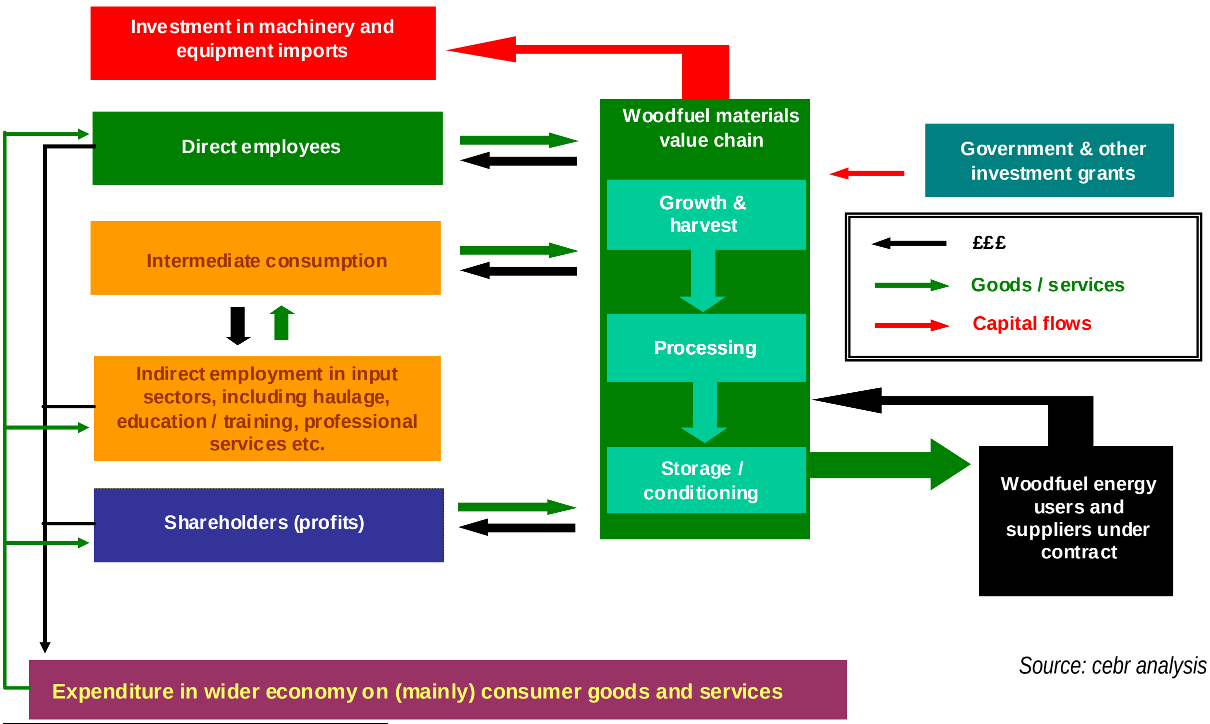
rural economy. The Forestry Commission administers the RDPE-funded English Woodland Grant Scheme.

3.3 Methodology and assumptions for calculating the economic contributions of woodfuel production

To track the monetary flows that will facilitate the calculation of the GVA and employment contributions from woodfuel production, we assume a vertically integrated market structure, such that growing, harvesting, processing, storage and conditioning (air-drying) are all provided by single vertically integrated firms.[18] This is represented in Figure 3 below by the central block representing woodfuel producers, which incorporates all of these processes.[19] They, in turn, supply woodfuel to energy users and suppliers under contract, represented by the black box on the right-hand side.

The flow of woodfuel to woodfuel energy users and suppliers is represented by the green arrow from the central block to the black box. Woodfuel producers, in return, receive revenues (turnover) represented by the (direction-changing) black arrow showing the flow of money (£££) from the energy users / suppliers to the woodfuel producers. This black arrow represents the total value of woodfuel output.

Figure 3: Good / service and monetary / capital flows used as the basis for calculating the economic contribution of woodfuel production.



Source: cebr analysis

[18] GVA can thus be measured as the difference between the final delivered price of output and the cost of intermediate consumption of the inputs required in all of the processes involved in producing that output. The task would be more rigorous, but far more complicated, if one assumed vertical separation, in which case individual GVA values for each of the individual processes would be required. The most significant challenge to such an approach would be data availability and this is the main motivation for the vertically integrated approach.
[19] Developing a scheme of woodfuel-specific transport costs was beyond the scope of this study, so haulage has been removed from the central block that represents the woodfuel production value chain. Transport costs are, rather, incorporated in intermediate consumption.

The right-hand side also shows a flow of capital from grants from government and other sources, which will usually be earmarked for investment purposes.

The left-hand side of Figure 3 shows the flows of products, services and money between the woodfuel industry and the rest of the economy. These are explained as follows:

- *Investment:* the red rectangle represents harvesters, chippers, dryers and the other equipment and machinery required to develop woodfuel production supply chains. The red arrow represents the capital investment by woodfuel producers in this equipment and machinery. The investment will be funded by the aforementioned capital grants, but also by profits retained within the industry for these purposes. The harvesters, chippers, dryers etc. are represented as imports, the value of which flows to other countries and, consequently, do not feature in our analysis.[20]

- *Employment:* the green rectangle represents the direct employees of woodfuel producers, who supply their services to the woodfuel industry (the green arrow) in return for wages (the black arrow). The economic contribution of woodfuel production to the UK economy in terms of direct employment was calculated by assuming that the proportion of the value of total output that is consumed by employment costs is comparable with that for the forestry sector, which we derived from the ONS Input-Output tables. This was combined with our assumptions about expected average levels of pay per person in the sector, which we derived from the *Annual Survey of Hours and Earnings* (as well as incorporating annual earnings growth of 2.5 per cent per annum[21]), to give direct employment impacts in terms of jobs created.

  Indirect employment impacts (that is, jobs supported in the input industries that supply goods and services to woodfuel producers) were determined by following similar procedures to those outlined for the calculation of direct employment impacts. In other words, we derived assumptions about the proportions in which total revenue gets distributed between employment costs and other types of costs and profits, but this time for the whole economy. We combined this with assumptions about average levels of pay derived from *ASHE*, also for the whole economy.

  The incomes of direct and indirect employees will stimulate final demand in the wider economy, generating spillover employment effects. This is represented by the purple rectangle in Figure 3. We have not sought to measure these spillover effects, but we do present the gross wages and profits which, after taxation and saving, will be available to generate these spillover effects.

- *Intermediate consumption and GVA impacts:* the top orange rectangle represents the other sectors of the economy that supply goods and services to woodfuel producers as

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[20] This is because much of the required assets are produced by much larger well-established industries that, we suspect, manufacture products with the required functionalities but for a much broader range of circumstances than just the production of woodfuel such as, for example, loading machinery and haulage trucks. Where these machines and vehicles are manufactured in the UK, the value added and employment will be retained within the UK, while other countries will benefit if they are imported, mainly from Scandanavia, where most forestry equipment is currently produced.

[21] This is in line with cebr's general forecast of modest earnings growth over the life of the next two parliaments in the UK.

intermediate inputs. GVA is simply the value of total output (turnover) less the value of intermediate consumption (the horizontal black arrow pointing from the central block to the orange rectangle. The bottom orange rectangle represents the employment in these other sectors, jobs that are at least supported, if not created, by the demand for their goods and services from woodfuel producers. Assumptions about the amount of woodfuel producers' turnover that is used to purchase intermediate goods and services were also derived from the input-output tables and made comparable with those for the 'forestry' sector, as in the case of employment costs.

The indirect GVA contribution of woodfuel production was calculated by, in a similar manner as in the direct case, making assumptions about the proportion of the value of the input sectors' output (supplied to woodfuel producers) that is spent by those sectors on their intermediate consumption. We assumed that this proportion is consistent with the proportions suggested by the ONS Input-Output tables for the whole economy.[22]

The demand stimulus from the incomes of direct and indirect employees will also generate spillover GVA effects. This is again represented by the purple rectangle in Figure 3.

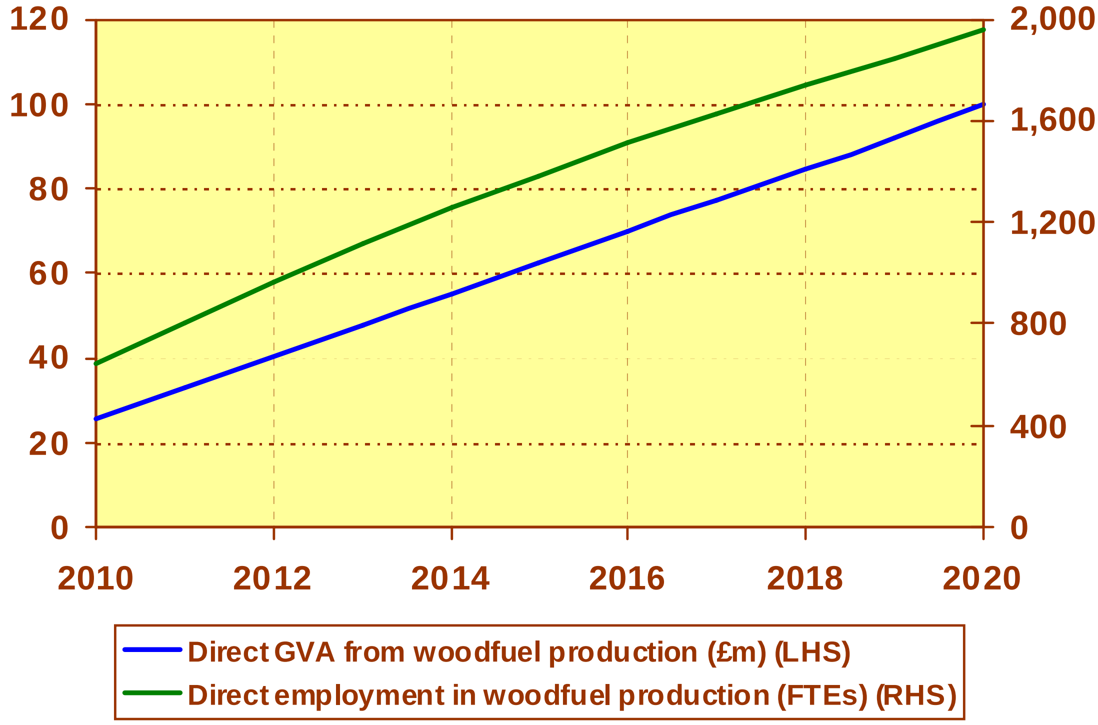
- *Shareholders (profits):* woodfuel producers will generate profits that they will pay themselves as the effective owners of their woodfuel production businesses. However, profits may also be retained in the business for investment purposes, in which case a certain proportion of the flows of capital investment (represented by the larger red arrow in Figure 3 above) will come from retained profits.

3.4 Direct economic contributions of woodfuel production

This subsection considers the direct GVA and employment contributions of woodfuel production to the UK economy and to each of the economies of its constituent nations. Figure 4 below shows our projection for the direct GVA and employment contributions to the wider UK economy.

[22] Greater accuracy might have been achieved by assuming an average across only the sectors that 'forestry' relies on for inputs.

Figure 4: Direct GVA contribution from the production of woodfuel in the UK



Source: cebr analysis

Direct GVA contributions

Figure 4 shows the direct GVA contribution from woodfuel production rising from almost £26 million in 2010 to £100 million by 2020. This is based on a final price per tonne of seasoned woodfuel of £80 per tonne, which is assumed to remain constant over the period.

Our projections for each of England, Scotland, Wales and Northern Ireland in 2010 and 2020 are presented in Table 12 below. The largest share of the total UK contribution comes from Scotland, which is consistent with it producing the largest woodfuel harvest.

Table 12: Direct GVA from woodfuel production by UK nation

Country (£ millions)	2010	2020
England	10.2	40.0
Scotland	12.1	47.0
Wales	2.6	10.0
Northern Ireland	0.8	3.1

Source: cebr analysis

Direct employment contributions

Figure 4 also shows the number of direct employees in woodfuel production increasing from 644 full-time equivalents (FTEs) to almost 2,000 FTEs in 2020. The projections for each of England, Scotland, Wales and Northern Ireland in 2010 and 2020 are presented in Table 12 below.

Table 13: Direct employment in woodfuel production by UK nation

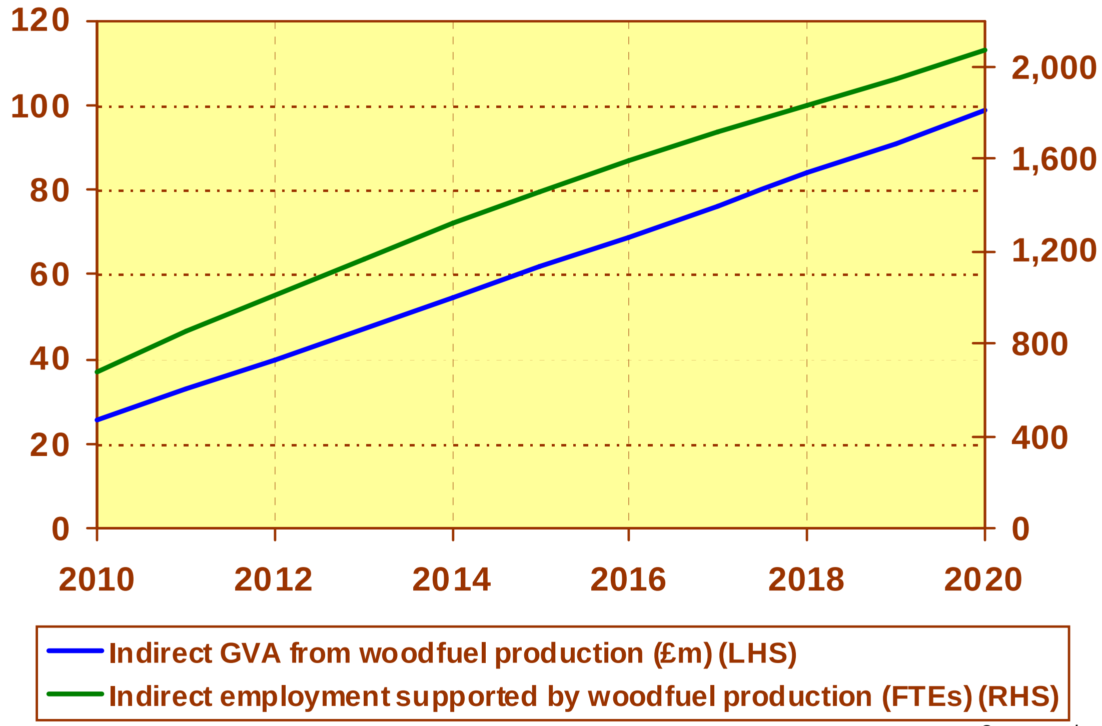
Country (no. of FTEs)	2010	2020
England	256	782
Scotland	304	918
Wales	64	196
Northern Ireland	20	60

Source: cebr analysis

3.5 Indirect economic contributions of woodfuel production

This subsection considers the indirect GVA and employment contributions of woodfuel production. Indirect contributions arise, as outlined in subsection 3.3 above, from the GVA and employment that are generated in the sectors that supply intermediate inputs to woodfuel producers. Figure 5 below shows our projection for the indirect GVA and employment contributions made by woodfuel production.

Figure 5: Indirect GVA contribution from the production of woodfuel in the UK



Source: cebr analysis

Indirect GVA contributions

Figure 5 shows the indirect GVA contribution arising from the growth of woodfuel production rising from almost £26 million in 2010 to £100 million by 2020. Our projections for each of England, Scotland, Wales and Northern Ireland in 2010 and 2020 are presented in Table 14 below.

Table 14: Indirect GVA from woodfuel production by UK nation

Country (£ millions)	2010	2020
England	10.1	39.5
Scotland	12.0	46.4
Wales	2.5	9.9
Northern Ireland	0.8	3.0

Source: cebr analysis

Indirect employment contributions

Figure 5 also shows the number of jobs indirectly supported in other sectors, also resulting from the growth of woodfuel production, rising from 679 FTEs in 2010 to 2,064 FTEs in 2020. This is based upon broader-based assumptions about total employment expenditure, and average levels of pay, using the same sources used in the estimation of direct employment impacts above. The projections for each of England, Scotland, Wales and Northern Ireland in 2010 and 2020 are presented in Table 15 below.

Table 15: Indirect jobs supported in other sectors by demand from growing woodfuel production, by nation

Country (no. of FTEs)	2010	2020
England	270	826
Scotland	320	968
Wales	68	206
Northern Ireland	21	64

Source: cebr analysis

4 Economic value of woodfuel energy production to the UK economy by 2020

4.1 Introduction and summary results

This section considers the direct and indirect contributions to the UK economy that we expect to result from the development and growth of woodfuel energy production, including all the stages involved in the deployment of woodfuel energy installations. We begin by reviewing the value chain that characterises this part of the industry and, as with woodfuel production, consider potential challenges associated with the development of commercially viable supply chains. We examine the methodology used to calculate direct and indirect economic contributions from this part of the supply chain, before proceeding to the report on our assessment of those contributions.

These economic contributions are summarised below in Table 16.

Table 16: Summary of direct and indirect economic contributions of woodfuel energy production to the UK economy

UK totals	2010	2020
Direct GVA (£ millions)	143.9	568.2
Direct employment (FTEs)	1,609	3,366
Indirect GVA (£ millions)	65.9	275.9
Indirect employment (FTEs)	2,514	7,916

Source: cebr analysis

4.2 The value chain for woodfuel energy production

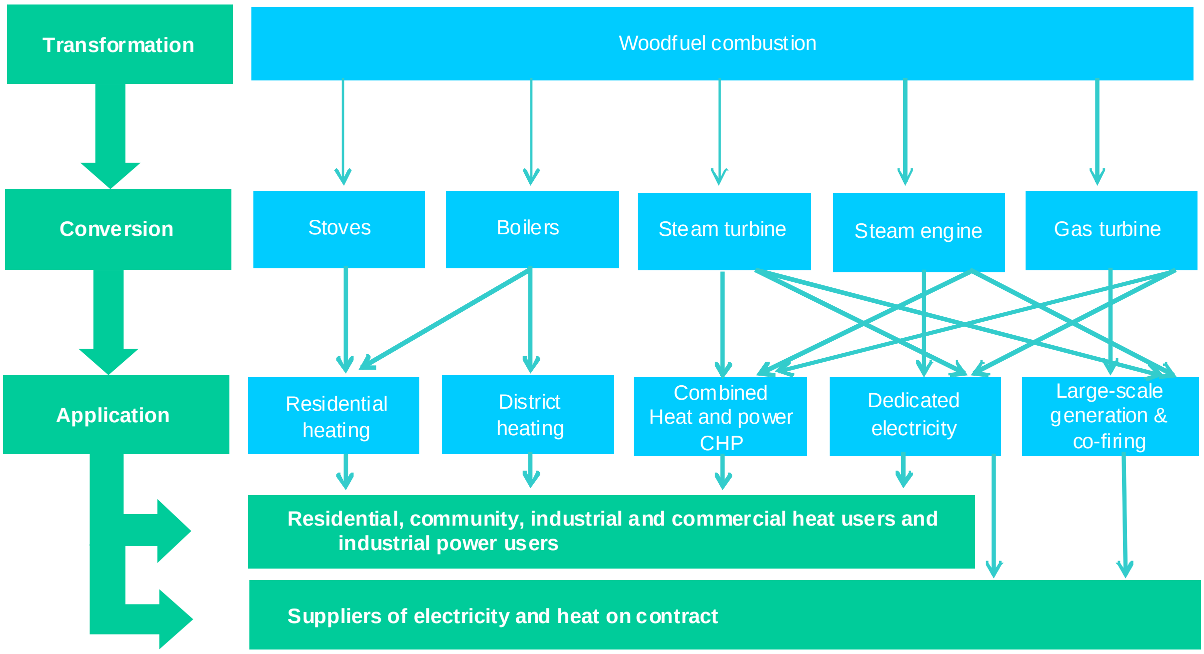
This part of the industry incorporates a number of processes. These are:

- transformation involving, in this case, the combustion of woodfuel;
- conversion involving the generation of heat through boilers and power through turbines and engines; and
- application which is the final use of the energy output involving, in the case of heat, direct heating, hot water or steam (in commercial applications) and, in the case of power, for example, the use of our lights and electrical goods at home and the running of entire industrial-level manufacturing plant.

An indicative value chain for woodfuel energy production is shown in Figure 6 below.

The size of woodfuel heating installations will depend on the scale of demand for heat and, albeit to a lesser extent, on the catchment area necessary to source the woodfuel and transport distances, all of which make up the final delivered cost of the fuel. The viability of projects requires a balance between being large enough to take advantage of economies of scale whilst limiting fuel demand to match fuel supplies. Transport costs are just one consideration.[23]

Figure 6: The value chain for woodfuel energy supply



Source: cebr analysis

Woodfuel heat installations should be scaled to meet both local needs and local fuel supplies, which will, in turn, ensure the development of sustainable local woodfuel supply chains. The requirements of different conversion plant can, moreover, demand mixed woodfuel of different moisture contents. The supply chain infrastructure for woodfuel production outlined above in section 3 will also need to support these requirements.

The demand for woodfuel per unit of energy generated for any given installation will vary according to the energy conversion / application technology being used, with requirements varying according to the size of the plant and the type and / or moisture content of the woodfuel product. These issues are discussed below for each of the woodfuel energy producing technologies under consideration for this study.

Woodfuel boilers for heat

The energy generated by combusting wood is used directly for heating and to produce hot water (and steam in commercial / industrial applications). The technologies used to generate heat in this manner vary from basic residential handfed log boilers to fully automated industrial chip boilers. District-level heating might take the form of a central boiler for an apartment building or a network of pipes delivering heat from a central installation to a

[23] This is not the case for the bigger power stations that plan to rely entirely on imports from North America.

number of local households and businesses.[24] Community-level installations, such as universities and shopping centres, are also conducive to this source of heating.

Table 8 above presents the breakdown of different woodfuel energy-generating projects that we assume will have been deployed in the UK in the years 2010 and 2020, along with the individual capacities and annual energy demands typically associated with these installations. These sizes range from the 20 kW domestic boiler to a 1 MW greenhouse installation. Our examination of the rates of capacity utilisation revealed that larger installations tend to use capacity much more intensively, resulting in greater demands for woodfuel per kW of installed capacity.[25] Rates of capacity utilisation are presented in Table 17 below (which also includes capacity utilisation rates for CHP installations).

The exceptions to the rule appear to be the municipal complex, the district heating scheme and municipal buildings. This is not surprising when one considers that such buildings are more likely to be closed / out of operation for larger parts of the day than, for example, a large farm, a hotel or a greenhouse.

Table 17: Rates of capacity utilisation for a range of typically-sized woodfuel boiler projects

Installation	Installed capacity (kW_{th})	Energy demand (kWh_{th})	Rate of capacity utilisation
Domestic boiler	20	20,000	11.4%
Small industrial unit	100	140,000	16.0%
Large farm with outbuildings	150	400,000	30.4%
Hotel	250	660,000	30.1%
Municipal complex	300	360,000	13.7%
District heating scheme	500	600,000	13.7%
Municipal buildings	700	1,000,000	16.3%
Greenhouse	1,200	4,200,000	40.0%
CHP (ORC)	1,850 (400 kW_e)	14,800,000	91.3%
CHP / Power Station	2,000 (kW_e)	16,000,000 (kWh_e)	91.3%

Source: Biomass Energy Centre website and cebr analysis

Combined heat and power (CHP)

Combined Heat and Power (CHP) involves the simultaneous production of electricity and heat. By making use of the heat produced when generating electricity, CHP guarantees more efficient use of the fuel being consumed that installations used to generate electricity only. This will also guarantee greater carbon savings than any conventional form of electricity-only generation involving renewables like woodfuel.

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[24] DECC's February 2010 RHI Consultation paper notes that district-level heating of this kind can be a cost-effective alternative to installing individual heating systems in individual properties.

[25] Capacity was derived as the ratio of annual energy demand to the capacity of the system, both measured in kWh.

While relatively small-scale CHP projects are presented in Table 17, we note that CHP installations can be as large as 60,000 kW (60 MW). Table 17 also shows that CHP installation achieve much higher rates of capacity utilisation, greater than 90 per cent in the examples presented. Moreover, CHP provides a similar level of efficiency as local heat generation, up to 85 per cent conversion efficiencies compared to 30-35 per cent for primary energy (woodfuel) to electricity only (see Table 10 above). That is why significant public support exists for CHP projects.[26]

Dedicated electricity (incl. large scale) generation and co-firing

The FREDS report noted that co-firing, especially in existing coal-fired power stations, has the potential to act as a catalyst for the development of a biomass electricity industry. However, the economic case for this technology is, as noted above, poor because of the very low conversion efficiencies involved, typically less than 35 per cent. FREDS also reports that there are problems with the location of existing plant in terms of the local availability of a steady supply of woodfuel materials, which it asserts means that transport costs would likely be prohibitive in the short- to medium-term at least.

4.3 Methodology and assumptions for calculating the economic contributions of woodfuel energy production

To track the monetary flows that will facilitate the calculation of the GVA and employment contributions from woodfuel energy production, we also assume a vertically integrated market structure, such that transformation, conversion and application are all provided by vertically integrated firms. The central block in Figure 7 below represents the vertically integrated woodfuel energy producers, which captures all of these processes. These producers supply to domestic and non-domestic users of woodfuel-generated heat or large-scale heat suppliers on contract, represented by the black box on the right-hand side.

The flow of woodfuel energy to these users and suppliers is represented by the green arrows from the central block to the black box. Woodfuel energy producers, in return, receive revenues (turnover) represented by the (direction-changing) black arrow showing the flow of money (£££) from the energy users and suppliers to the woodfuel energy producers. This black arrow represents the total value of woodfuel energy output.

The right-hand side of Figure 7 also shows a flow of capital from payments under the *Renewable Heat Incentive (RHI)*, which are designed to provide incentives for investment in renewable heat installations, including woodfuel boilers.

The left-hand side of Figure 7 shows the flows of products, services and money between the woodfuel industry and the rest of the economy. These are explained as follows:

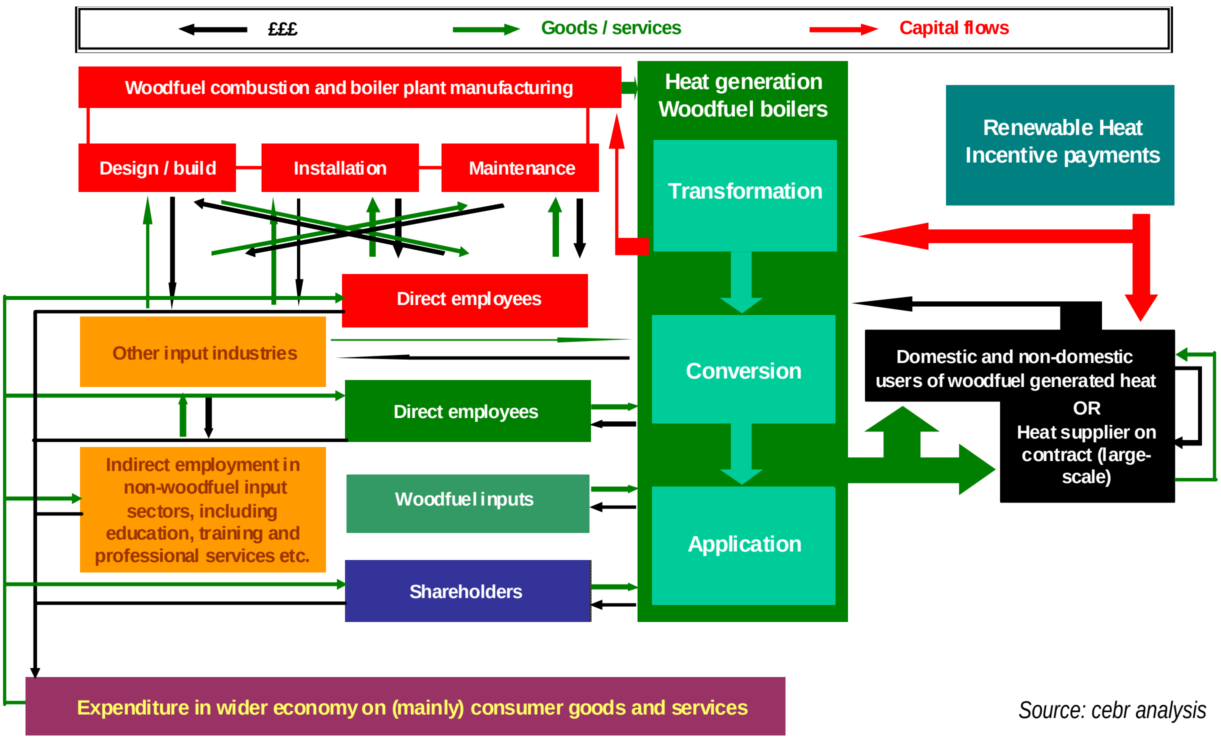
- *Investment:* the series of red rectangles represents the investments required in woodfuel combustion and boiler installations. The red arrow represents the capital investment by

[26] See Forum for Renewable Energy Development in Scotland (FREDS) (2005), "Promoting and Accelerating the Market Penetration of Biomass Technology in Scotland", Scottish Executive, Edinburgh, January.

woodfuel energy producers in these installations. The investment will be funded by the aforementioned *RHI* payments, but also by profits retained within the industry for these purposes. At each of the design / build, installation and operation / maintenance phases of these installation projects, the boiler (and other installation) manufacturing industry will employ the services of direct employees and the goods and services of other input industries. These flows are represented by the green arrows between each phase of the investment and the direct employees of boiler manufacturing (red rectangles) and other input industries (the top orange rectangle). The GVA contributions from these investments will be the difference between the flows of capital investment by woodfuel energy users / suppliers in boilers and other installations and the expenditures manufacturing sector and the expenditure on intermediate consumption by the boiler manufacturing industry.

We note that, as in the case of woodfuel, the additional revenues for the combustion and boiler plant industry generate additional value and employment for the UK only to the extent that the goods and services involved are not imported. There is currently a shortage of woodfuel combustion and boiler plant manufacturing in the UK, so this is, at least in the early years, likely to be dominated by imports. Installation and O&M is more likely to be sourced domestically unless the required skills need to be imported, at least in the early days, from countries with greater experience in the installation, operation and maintenance of woodfuel combustion and boiler installations. For our modelling, however, we present the results under each of the assumptions that all of the investment GVA and employment contributions either stay in the UK (because boilers are manufactured here) or go abroad (because boilers are imported instead).

Figure 7: Good / service and monetary / capital flows used as the basis for calculating the economic contribution from woodfuel energy production for heat



Source: cebr analysis

- *Employment:* the green rectangle showing direct employees represent those of the woodfuel energy producers, who supply their services to the woodfuel energy industry (the green arrow from that rectangle to the central block) in return for wages (the black arrow). The economic contribution of woodfuel production to the UK economy in terms of direct employment was calculated by assuming that the proportion of the value of total woodfuel energy output that is consumed by employment costs is comparable to that for electricity and gas distribution, for which we derived assumptions from the ONS Input-Output tables. For boiler manufacturing, that proportion was assumed to be comparable to that for metal boilers and radiators, which we also derived from the Input-Output tables. These proportions were combined with information on total revenues from woodfuel energy production and on expected average levels of pay per person (from *ASHE*) to calculate employment impacts in terms of jobs created.

  Indirect employment impacts (that is, jobs supported in the input industries that supply goods and services to woodfuel boiler manufacturers and woodfuel energy producers) were again determined by following similar procedures to those for the calculation of direct employment effects. In other words, we derive assumptions about the proportions in which total revenues get distributed between employment costs and other types of costs, this time for the wider economy. Indirect employment is represented by the bottom orange rectangle in Figure 7 above.

  The incomes of direct and indirect employees will stimulate final demand in the wider economy, generating spillover employment effects, represented by the purple rectangle in Figure 7 above. We have not sought to measure these spillover effects, but we do present the gross wages and profits which, after taxation and savings, will be available to generate these spillover effects.

- *Intermediate consumption and GVA impacts:* the top orange rectangle represents the other sectors of the economy that supply goods and services to woodfuel boiler manufacturers and woodfuel energy producers as intermediate inputs. GVA is simply the value of total output (turnover[27]) less the cost of intermediate inputs from these other industries (the horizontal black arrow pointing from the central block and each of the red blocks - representing the phases of the investment project – to the top orange rectangle) and from woodfuel producers (the woodfuel outputs analysed in the previous section of this report and represented in Figure 7 above by a lighter green rectangle. In our modelling, the proportional amounts of intermediate consumption by boiler manufacturers is assumed to be comparable with those for the metal boiler and radiator industry, also derived from the 2007 ONS Input-Output tables. The corresponding proportion for woodfuel energy output was taken as that for electricity and gas distribution.

[27] Woodfuel energy revenues will equal the product of the quantity of heat energy generated (in kWh) and the per kWh retail price. This can be thought of in terms of the case where contracts are held by gas suppliers with customers (domestic and non-domestic) connected to the gas distribution network. Where there are independent owners and operators of heat-generating plant, they will undertake the required investment in the woodfuel boiler installation and charge monthly rents on top of the retail heat prices to the final user. Large domestic households are more likely to undertake the woodfuel to heat conversion process themselves. This heat has, in turn, an implicit value to that user, for which the retail price charged by heat suppliers should be the starting point in terms of finding a proxy for that value. (Another useful proxy for this implicit value is the retail supply price paid by customers connected to the gas mains network to heat their homes and provide hot water.) The household customer usually invests directly in the boiler equipment required.

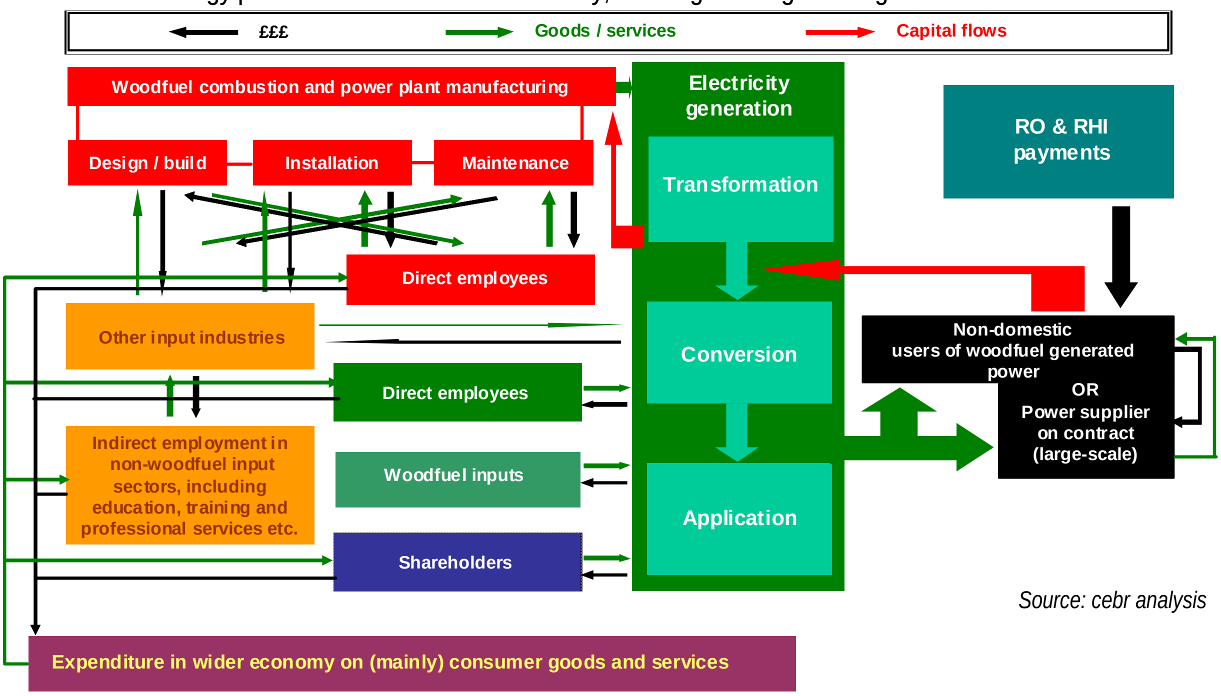
The contribution of woodfuel production to indirect GVA was calculated by, in a similar manner as in the direct case, making assumptions about the proportion of the value of the input sectors' output (supplied to woodfuel boiler manufacturers and energy producers) that is spent by those sectors on their intermediate consumption. We assumed that this proportion is consistent with the proportions suggested by the ONS Input-Output tables for the whole economy.

The demand stimulus from the incomes of direct and indirect employees will also generate spillover GVA effects. This is again represented by the purple rectangle in Figure 7 above.

- *Shareholders (profits):* woodfuel boiler and other installation manufacturers and energy producers will generate profits that they will pay themselves as the effective owners of their businesses. However, profits may also be retained in these businesses for investment purposes, in which case a certain proportion of the flows of capital investment (represented by the larger red arrow) will come from retained profits.

We note, however, that the physical and monetary flows involved in the use and supply of woodfuel installation manufacturing and woodfuel energy production are less conducive to representation by a single scheme, as Figure 3 does for woodfuel production. They will vary according to a number of factors, including the type of energy outputs (that is, heat and/or power), the technology (for example, heat generation, CHP or dedicated power generation) and the nature of the application and the size and nature of the user. We have, therefore, developed a comparable scheme for CHP, dedicated electricity and large-scale generation & co-firing, which is provided in **Error! Reference source not found.** below. This can be explained in broadly similar terms as those for Figure 7 above. The differences include the fact that this scheme is unlikely to apply at the domestic household level, but also the applicability of payments under the *Renewables Obligation*, rather than just the *RHI*.

Figure 8: Good / service and monetary / capital flows used as the basis for calculating the economic contribution from woodfuel energy production for dedicated electricity, co-firing and large-scale generation

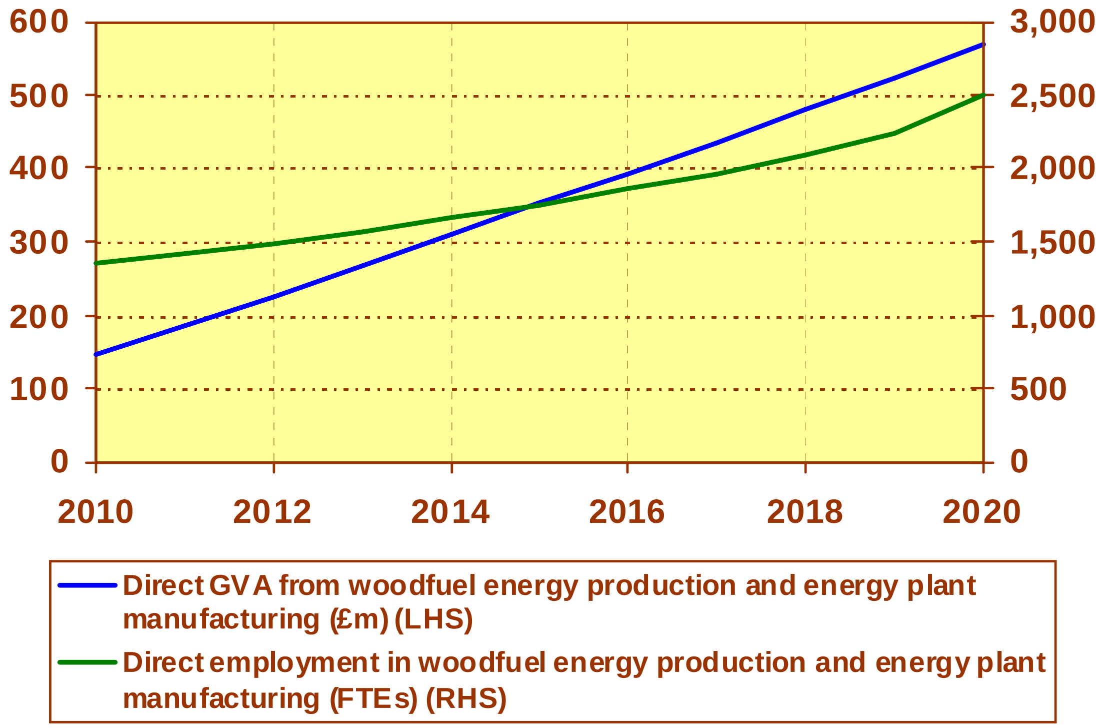


Source: cebr analysis

4.4 Direct economic contributions of woodfuel energy production and energy plant manufacturing

This subsection considers the direct GVA and employment contributions of woodfuel energy production and energy plant manufacturing to the UK economy and to each of the economies of its constituent nations. Figure 9 below shows our projection for the direct GVA and employment contributions to the wider UK economy.

Figure 9: Direct GVA contribution from woodfuel energy production and energy plant manufacturing in the UK



Direct GVA contributions

Figure 9 shows the direct GVA contribution from woodfuel energy production and energy plant manufacturing to the UK economy rising from almost £144 million in 2010 to £568 million by 2020. The contributions from the economies of the individual nations reflect the fact that 80 per cent of the total UK final energy output is produced in England, as opposed to less than 40 per cent of woodfuel. [28]

Our projections for each of England, Scotland, Wales and Northern Ireland in 2010 and 2020 are presented in Table 12 below for three scenarios, all of which are based on a 2009 unit price for final energy output of £45.50 per MWh.[29] The scenarios allow us to examine the

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[28] There is of course the implicit assumption that Scotland exports the majority of its woodfuel output to England and, conversely, England imports half of its woodfuel requirement from Scotland.

[29] Calculated by converting total UK energy spend per unit of energy consumption measured as tonnes of oil equivalents (TOE). Total UK energy spend was based on the expenditure on energy by all final users from DECC's Digest of United Kingdom Energy Statistics (Dukes). This exceeded £121 billion in 2008. Total energy consumption was taken from the 'Online Energy Account 2007', produced by

changes in the direct GVA contributions in response to changes in the assumed growth rate for final unit energy prices. The base assumption is annual 2.5 per cent growth (on which Figure 9 is also based) and Table 12 shows the changes when the growth assumption is raised to each of 5 and 10 per cent.

Table 18: Direct GVA from woodfuel energy production and energy plant manufacturing by UK nation under alternative final energy price growth scenarios

£ millions	2.5% final energy price growth		5% final energy price growth		10% final energy price growth	
Country	2010	2020	2010	2020	2010	2020
England	110.2	428.2	110.8	430.6	112.1	435.3
Scotland	20.6	83.7	20.6	83.9	20.7	84.4
Wales	7.4	31.9	7.5	32.1	7.5	32.5
Northern Ireland	5.6	24.4	5.7	24.5	5.7	24.8

Source: cebr analysis

As should be apparent from Table 18, fairly substantial changes in the final energy price growth assumptions show little impact on these totals when, as they are, swamped by investment in woodfuel energy installations (boilers etc.). The scale and cost of these investments will not vary significantly with final unit energy prices. We have, therefore, isolated the direct GVA contributions from woodfuel energy production. These are presented for each UK nation in Table 19 below.

Table 19: Direct GVA from woodfuel energy production only

£ millions	2.5% final energy price growth		5% final energy price growth		10% final energy price growth	
Country	2010	2020	2010	2020	2010	2020
England	25.0	97.2	25.6	99.6	26.8	104.3
Scotland	1.5	9.6	1.6	9.8	1.6	10.3
Wales	1.2	7.8	1.3	8.0	1.3	8.4
Northern Ireland	1.0	6.4	1.0	6.5	1.1	6.8

Source: cebr analysis

We note that Table 18 and Table 19 show the polar cases of, respectively, all boiler plant manufacturing taking place at home and all boiler plant being imported from abroad. The extent to which UK continues to import the design / manufacture / installation of this plant will determine the extent to which we delay the retention within the UK of this most significant of the potential GVA impacts. Where installation, operation and maintenance is

AEA Energy & Environment, DECC and ONS. The calculation included the use assumptions about the conversion factors for: (i) TOE of final energy consumption to GJ; and (ii) GJ of energy consumption to MWh.

supplied from within the UK, the direct GVA contributions will lie somewhere between those presented in Table 18 and Table 19 but will be closer to those in Table 19.

Direct employment contributions

Figure 9 above also shows the direct employment contribution from woodfuel energy production and energy plant manufacturing to the UK economy rising from almost 1,609 FTEs in 2010 to 3,366 by 2020. Our projections for each of England, Scotland, Wales and Northern Ireland in 2010 and 2020 are presented in Table 20 below for the three growth scenarios for final energy output prices.

Table 20: Direct employment in woodfuel energy production and energy plant manufacturing by UK nation under alternative final energy price growth scenarios

FTEs	2.5% final energy price growth		5% final energy price growth		10% final energy price growth	
Country	2010	2020	2010	2020	2010	2020
England	1,457	2,461	1,463	2,478	1,474	2,512
Scotland	62	370	63	372	63	375
Wales	50	296	50	297	51	300
Northern Ireland	40	239	40	240	41	242

Source: cebr analysis

These projections include the impact of investments in boilers that are assumed to be manufactured in the UK. However, at least in the early years and perhaps over the entire period of our study, the 'design / build' phase of these types of boiler investment projects is likely to be imported from abroad, while installation and maintenance is sourced at home. For that reason, we present in Table 21 below our direct employment estimates for woodfuel energy production combined with domestically sourced installation and operation / maintenance.

Table 21: Direct employment in woodfuel energy production and energy plant installation and O&M

FTEs	2.5% final energy price growth		5% final energy price growth		10% final energy price growth	
Country	2010	2020	2010	2020	2010	2020
England	404	1,358	410	1,375	421	1,409
Scotland	25	134	25	135	26	139
Wales	20	111	21	112	21	115
Northern Ireland	17	92	17	93	18	95

Source: cebr analysis

Finally, in Table 22 below, we show our projections for woodfuel energy production only, that is, if all of the manufacturing, installation and maintenance of boiler and other energy-generating installations was sourced through imports from abroad. This would be the most conservative of assumptions. Closer examination of Table 22 also shows that the entire differences between the employment levels under the different scenarios is entirely explained by the effect on energy production of rising final energy output prices.

Table 22: Direct employment in woodfuel energy production only

FTEs	2.5% final energy price growth		5% final energy price growth		10% final energy price growth	
Country	2010	2020	2010	2020	2010	2020
England	228	692	233	709	244	743
Scotland	14	68	14	70	15	73
Wales	11	55	12	57	12	60
Northern Ireland	9	45	9	47	10	49

Source: cebr analysis

We note that the projections in Table 22 (and this element of the wider projections in Table 20 and Table 21) are based on overall employment cost shares (of the value of final output) that are comparable with those from the utility (electricity and gas distribution) industries, which we derived from 2007 ONS Input-Output tables. Total employment costs of woodfuel energy producers were combined with average levels of pay for employees in these energy distribution sectors from *ASHE* to give the number of jobs supported by woodfuel.[30]

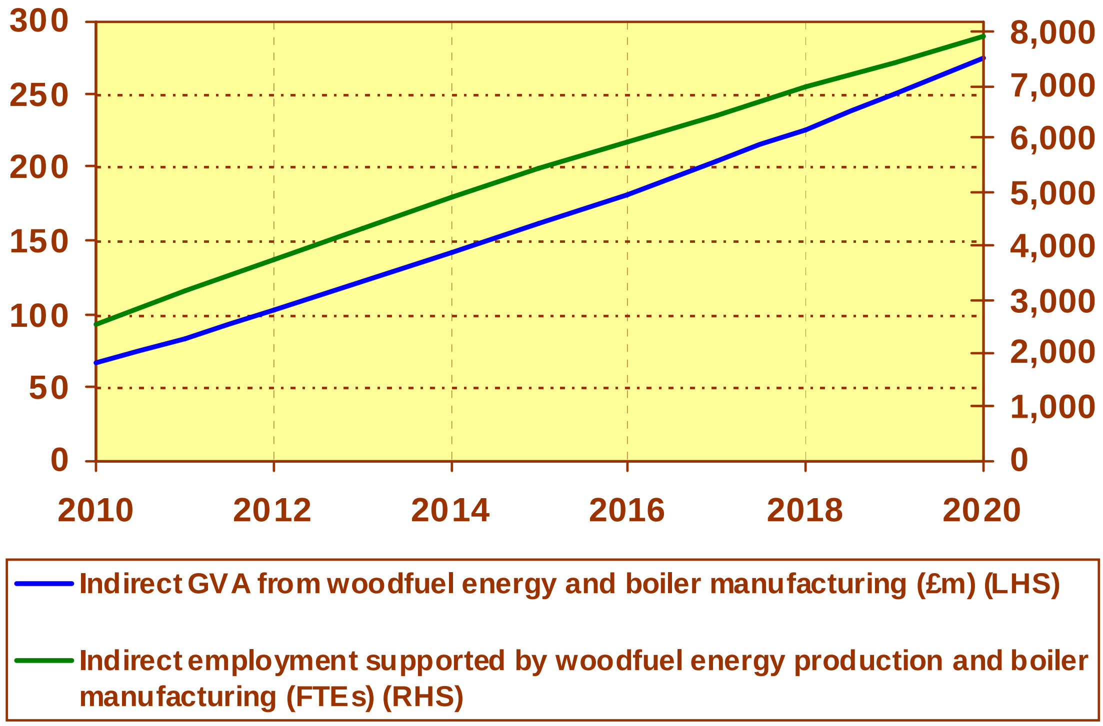
4.5 Indirect economic contributions of woodfuel energy production and energy plant manufacturing

This subsection considers the indirect GVA and employment contributions from woodfuel energy production and boiler and other energy installation manufacturing. Indirect contributions arise, as outlined in subsection 3.3 above, from the GVA and employment that are generated in the sectors that supply intermediate inputs to woodfuel energy producers and to boiler plant manufacturers. These impacts arise from intermediate spend other than that on woodfuel inputs, which was already taken into account in Section 3 above.

Figure 10 below shows our projection for the indirect GVA and employment contributions to the wider UK economy, assuming that all boilers and other energy installation manufacturing takes place within the UK.

[30] The explanation of our methods used to calculate the direct employment contributions from investments in woodfuel boiler and other woodfuel energy-generating plant was a bit more involved and has, therefore, been relegated to Annex II of this report.

Figure 10: Indirect GVA contribution from the production of woodfuel energy and the manufacture of boilers and other energy-generating plant, UK



Indirect GVA contributions

Figure 10 shows the indirect GVA contribution arising from the growth of woodfuel energy production and boiler plant manufacturing rising from almost £66 million in 2010 to nearly £276 million by 2020. Our projections for each of England, Scotland, Wales and Northern Ireland in 2010 and 2020 are presented in Table 23 below.

Table 23: Indirect GVA from woodfuel energy production and boiler plant manufacturing by UK nation

Country (£ millions)	2010	2020
England	61.4	238.6
Scotland	11.3	49.5
Wales	3.3	17.6
Northern Ireland	2.4	13.3

Source: cebr analysis

However, in Table 24 below, we present the polar opposite case in which all phases of boiler and other energy-generating plant investments are imported from abroad, in which case indirect GVA contributions come from woodfuel energy production only.

Table 24: Indirect GVA from woodfuel energy production only

Country (£ millions)	2010	2020

Country (£ millions)	2010	2020
England	8.2	32.1
Scotland	-0.6	3.2
Wales	-0.5	2.5
Northern Ireland	-0.5	2.0

Source: cebr analysis

This suggests that, in the early years, woodfuel energy producers cannot cover the cost of the woodfuel inputs and their other input costs. They would, in these years, need to cut the quantity and / or unit cost of its other inputs or negotiate lower prices with the suppliers of their woodfuel inputs.

Indirect employment contributions

Figure 10 also shows the number of jobs indirectly supported in other sectors, also resulting from the growth of woodfuel energy production and boiler plant manufacturing rising from 2,514 FTEs in 2010 to 7,916 FTEs in 2020. The projections for each of England, Scotland, Wales and Northern Ireland in 2010 and 2020 are presented in Table 25 below.

Table 25: Indirect jobs supported in other sectors by demand from growing woodfuel energy production and boiler plant manufacturing, by nation

Country (no. of FTEs)	2010	2020
England	2,058	6,238
Scotland	302	1,034
Wales	89	368
Northern Ireland	65	277

Source: cebr analysis

However, in Table 24 below, we present the polar opposite case in which all phases of boiler and other energy-generating plant investments are imported from abroad, in which case indirect GVA contributions come from woodfuel energy production only.

Table 26: Indirect jobs supported in other sectors by demand from growing woodfuel energy production only

Country (no. of FTEs)	2010	2020
England	635	1,921
Scotland	-17	67
Wales	-14	53
Northern Ireland	-12	43

Source: cebr analysis

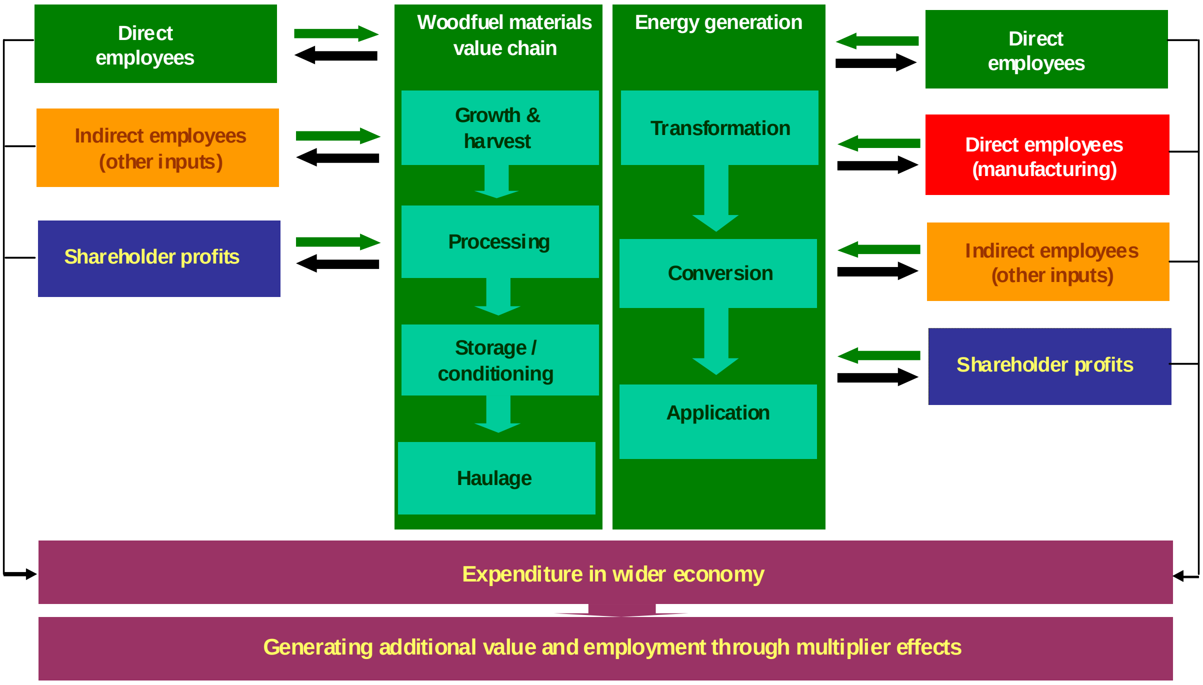
The requirement for woodfuel producers to reduce their other input costs due to the squeeze between final unit energy output prices and woodfuel prices at small scales of operation would involve corresponding job losses in these input industries during the early years.

5 Other economic impacts

5.1 Employee and profit spending impacts

Figure 11 below illustrates the expenditures by direct and indirect employees of the entire woodfuel supply chain and by shareholders (the owners of the businesses involved in the production of woodfuel, woodfuel energy and boiler and other energy-generating plant manufacturing. This stimulates demand for goods and services in the wider economy.

Figure 11: Demand stimulus in wider economy through multiplier effects



Source: cebr analysis

Woodfuel activities affect, therefore, many other economic activities indirectly. Employee and shareholder spend boosts demand for (mainly consumer) goods and services, thereby increasing national income and fuelling growth.

We estimate that, before taxation and savings, the sum of aggregate employee incomes and shareholder profits available for spending on final (mainly consumer) goods and services rises from £169 million in 2010 to £669 million by 2020. Table 27 presents the national breakdowns.

Table 27: Employee incomes and shareholder profits available for spending on final goods and services from the wider economy

Country (£ millions)	Part of supply chain	2010	2020
England	Woodfuel production	10.1	39.5
	Woodfuel energy	23.5	91.34

Country (£ millions)	Part of supply chain	2010	2020
	Boiler manufacturing	84.5	328.2
	Total	118.1	459.1
Scotland	Woodfuel production	12.0	46.4
	Woodfuel energy	1.4	9.0
	Boiler manufacturing	17.8	72.4
	Total	31.3	127.8
Wales	Woodfuel production	6.2	24.0
	Woodfuel energy	1.2	7.3
	Boiler manufacturing	6.2	24.0
	Total	13.5	55.3
Northern Ireland	Woodfuel production	0.8	3.0
	Woodfuel energy	1.0	6.0
	Boiler manufacturing	4.6	17.8
	Total	6.3	26.9

Source: cebr analysis

5.2 Taxes and subsidies

Renewable Heat Incentive (RHI)

From April 2011 (but with retrospective application to 2009), the owners of woodfuel boilers and CHP installations could receive payments under the *Renewable Heat Incentive (RHI)*, subject to the conditions that they guarantee the continued operation and maintenance of the equipment. These payments are designed to bridge the financial gap between the cost of conventional and renewable heat systems at all scales. They are projected to be based on providing for a rate of return of around 12 per cent on the additional capital outlay involved in making the transition. However, it is intended to provide, on an ongoing basis, compensation for the upfront capital cost as well as ongoing fuel and other requirements.

The RHI consultation suggested that the payments will be made annually for installations below 45 kW and quarterly for those above this level and are based on the number of kWh (thermal) generated by the installation and tariffs that vary with the installation's capacity. The details are shown in Table 28 below.

Table 28: Structure of payments to woodfuel boiler and CHP plant owners under RHI

Installed capacity	Tariff	Payment structure
< 45 kW installed capacity:	9.0 pence / kWh	Product of tariff & 'deemed' level plus incremental usage

45 – 500 kW installed capacity:	6.5 pence / kWh	Product of 1st tariff & 'deemed' level *plus*
	2.0 pence / kWh	Product of 2nd tariff & incremental usage
> 500 kW installed capacity:	1.6 – 2.5 pence / kWh	Product of the tariff and metered output

Source: Renewable Heat Incentive

For the smaller capacity boilers, the use of a 'deemed' level of energy output is designed to encourage people to only generate heat that they need. Paying the tariffs on a metered basis could have the undesirable effect of encouraging the generation of surplus heat in order to obtain more RHI support. The *RHI* will apply equally to England, Wales and Scotland. Northern Ireland has the power to introduce its own legislation.

We estimate that the *Renewable Heat Incentive* will involve retrospective subsidies to those in ownership of woodfuel heat generation plant of about £99.8 million in 2010. This is for the Great Britain as a whole (recall Northern Ireland is excluded from *RHI* but has the power to introduce its own) and is projected to rise to about £408.7 million by 2020. The corresponding national breakdown is shown below in Table 29.

Table 29: Payments under the Renewable Heat Incentive

RHI value in £ millions	2010	2020
England	89.9	346.7
Scotland	5.47	34.2
Wales	4.45	27.8

Source: cebr analysis

Renewables Obligation (RO)

This came into effect in 2002 in England & Wales and Scotland (2005 in Northern Ireland) and is designed to incentivise renewable electricity generators. This involves an obligation on UK suppliers of electricity to source an increasing proportion of their electricity from renewable sources. This level started at 3 per cent in the British nations and has risen to 11.1 per cent for 2010-11, while in Northern Ireland it started at 3.5 per cent and is 4.27 per cent for 2010-11.

The system is based on the issuance of *Renewables Obligation Certificates (ROCs)*, certificates issued to accredited generators for eligible renewable electricity generated within the United Kingdom and supplied to customers within the United Kingdom by licensed electricity suppliers. Before 2009, single ROCs were issued for each megawatt hour (MWh) of eligible renewable output generated. However, the system has since been revised so that different technologies get different numbers of ROCs. This is shown in the following table.

Table 30: The new ROCs system

Band	Number of ROCs	Technologies included
Established	0.25 / MWh	Sewage gas, landfill gas, co-firing of non-energy (regular biomass)
Reference	1.00 / MWh	Onshore wind, hydro-electric, co-firing of energy crops, EfW with CHP
Post-demonstration	1.50 / MWh	Dedicated offshore wind, dedicated regular biomass
Emerging	2.00 / MWh	Wave, tidal stream, advanced conversion technologies (anaerobic digestion, gasification, pyrolysis), dedicated biomass burning energy crops (with or without CHP), dedicated regular biomass with CHP, solar photovoltaics, geothermal

Source: Renewables Obligation

Suppliers that do not present sufficient numbers of ROCs to meet their obligations under the scheme must pay the 'buy-out' price for each ROC that is not presented. The resulting payments are made to a fund, the proceeds of which are paid back on a pro-rated basis to those suppliers that have presented the required amount of ROCs. The current buy-out price is £36.99 per ROC, which was updated in February 2010 for 2010-11.

Electricity generated using woodfuel is an eligible renewable output under the *RO*, so each MWh of electricity generated using woodfuel results in a subsidy of £73.98 to electricity suppliers. In other words, we assume that the technology is emerging and that each MWh of electricity generated earns two ROCs. However, under current Government plans (as noted above), the *RO* will also apply to small-scale generation involving biomass, which would imply the accumulation of ROCs by small-scale woodfuel generators.

We estimate that the ROCs value of the electricity generated by the Combined Heat and Power installations in our energy mix to be approximately £21.4 million in 2010. This is for the UK as a whole and is projected to rise to about £90 million by 2020. The corresponding national breakdown is shown below in Table 31.

Table 31: Payments under the Renewables Obligation

ROCs value in £ millions	2010	2020
England	5.7	36.1
Scotland	0.6	3.56
Wales	0.5	2.90
Northern Ireland	0.4	2.31

Source: cebr analysis

5.3 Fossil fuel savings

Value is also retained in the economy through the savings on fossil fuels that have been substituted by woodfuel within the UK, to the extent that those fossil fuels were imported from abroad. To calculate these values, we have used the guide prices provided on the Biomass Energy Centre website. These prices are described there as *"typical prices for bulk purchase of fuels at domestic scale, January 2010"* and *"represent the typical cost per unit of fuel energy for comparison"*. These prices are shown in Table 32 below.

Table 32: Typical prices per kWh for bulk purchase of fuels at domestic scale, January 2010

Fuel	Unit	Price per unit	kWh per unit	Pence per kWh
Wood chips	Tonnes	£80	3,500	2.3
Wood pellets	Tonnes	£185	4,800	3.9
Natural gas	kWh_{th}	4.1 pence	1	4.1
Heating oil	Litres	44 pence	10	4.4
LPG (bulk)	Litres	40 pence	6.6	6.1
Electricity	kWh_{e}	13.3 pence	1	13.3

Source: Biomass Energy Centre website

We assumed growth in fossil fuel prices in line with cebr's forecasts for oil commodity prices. We used the fuel price data from Table 32 above and the primary energy input data to find the difference in cost between using woodfuel to produce that primary energy input and, first, using heating oil to produce it and, second, using a 50:50 mix between heating oil and natural gas. The results are presented below for the UK as a whole.

Table 33: Fossil fuel savings under two substitution scenarios

£ millions	Fossil fuel saving	
Substitution scenario	2010	2020
Woodfuel for heating oil	85.8	1,200.0
Woodfuel for 50:50 heating oil / natural gas	81.0	1,071.0

Source: cebr analysis

Table 33 shows that, by 2020, fossil fuel savings could exceed £1 billion per annum.

5.4 Carbon savings

Large fuel users are required to register their carbon emissions and to pay to offset them if they exceed their allowances. This is the basis of the European Trading Scheme for carbon, which allows for the trading of carbon allowances between participants. While the mix of projects that we have assumed will have been deployed in the UK by 2020 does not include installations above the $20MW_{th}$ capacity threshold, we estimate the value of carbon savings on the basis of, as in the previous section, a 100 per cent substitution away from heating oil towards woodfuel and on the basis of a 50:50 substitution away from heating oil and natural gas to woodfuel.

The results are presented in Table 34 below.

Table 34: Carbon savings under two substitution scenarios

£ millions	Carbon savings	
Substitution scenario	2010	2020
Woodfuel for heating oil	46.6	180.4
Woodfuel for 50:50 heating oil / natural gas	40.7	157.8

Source: cebr analysis

Annex I: More detail on indirect effects

This Annex provides details on some of the effects that the indirect economic impact calculations have been designed to capture.

Education and training

As the biomass sector grows, it will also be necessary to put in place the skills, training and accreditation processes to ensure that companies in the energy and forestry sub-sectors of the economy are familiar with wood fuels (handling / preparation, storage and trading) and with the related biomass equipment.

Northwoods reported that, in the North East of England, education and training is being driven by Northumberland College, whose biomass training programme was (in mid-2008) estimated to occupy approximately one FTE member of staff (at a cost of £30,000 per annum), who will train up to 30 students per year to NVQ levels 2 and 3. Northwoods also reported a number of other initiatives, including:

- Potential interest in the supply of specific biomass-related activities at the proposed Newcastle University CREEL centre at Cockle Park and at Houghall College.
- Biomass training provided by Northwoods on the fuel supply side.
- Training in forestry techniques that go on to be used in the biomass sector.

Northwoods deemed the first and third as unquantifiable at the time, but estimated that its own training helps to support two jobs, with an estimated value to the region of £5,000 per annum.

We can use this information, combined with the corresponding size of the biomass energy sector in the North East region, to extrapolate the indirect employment effects for the whole of the UK as a result of the development of the woodfuel industry.

Professional and administrative services

Value and employment will also derive from the administration of the various investment grants and incentive schemes and from the professional and administrative services required by the industry to generate and administer contracts, maintain accounts etc. The recent woodfuel sector employment survey carried out on behalf of the Forestry Commission reports 198 jobs in 'administration and financial support' in 119 responding woodfuel companies.

Based on its direct dealings with external consultants who carry out feasibility studies into biomass systems in the North East of England, they estimated that there are 5 FTE biomass specialists carrying out work on biomass feasibility and other detailed biomass work in the region. They also refer to additional feasibility work by installation companies which is not directly associated with the installation work itself. Northwoods cites a typical day rate of £400 to £500 per day for such consultants, giving an approximate annual value of £99,000.

Energy networks

Biomass involves different 'patterns' of electricity generation. (FREDS refers to biomass power stations being operational for "> 8,000 hours at rated capacity"). Biomass plant makes more efficient use of the distribution and transmission networks than traditional fuel sources, but these different patterns of generation could require the networks to be upgraded. These upgrades add value to the networks and generate work for network engineers (and others), thereby increasing employment.

For instance, Ofgem has established the Low Carbon Network (LCN) fund for distribution network operators (DNOs). This makes up to £500 million available to DNOs through the distribution price control that will be in place from April 2010 to March 2015 (DCPR5). The LCN fund is financed, therefore, through DNO use of system charges. The fund includes £80 million for relatively small-scale projects, £320 million for a small number of significant flagship projects and a discretionary fund of £100 million to reward successful delivery and projects that help DNOs understand what is expected of them and their networks in the move to a low carbon economy.

Another £530 million of investment in the transmission networks in Scotland and Northern England was agreed under the Transmission Investment for Renewable Energy Generation regime in 2004. This projected investment was incorporated in the prevailing transmission price control (TCPR4) running from April 2007 to March 2012 for the specific purposes of connecting new low-carbon generation. This fund is, however, primarily to accommodate greater amounts of wind capacity.

We have not quantified the extent to which these funds could be considered to be driven by the development of woodfuel and suspect that the share would be negligible.

Annex II: Estimating direct employment contributions from investment in boilers etc. that were manufactured in UK

We derived our direct employment projections for investment in woodfuel-energy generating plant by calculating 'employment coefficients' for different woodfuel energy-generating technologies. These coefficients are expressed in terms of the number of full-time equivalents (FTEs) per MWh of energy output. We calculated in total 6 employment coefficients, one for each of the operations & maintenance and development phases of three types of project, namely domestic boilers, district boilers and CHP installations. The coefficients are presented in

Table 35: Employment coefficients for different phases of the investment project

Installation type	Design, build & installation (FTE / MWh)	O&M (FTE / MWh)
Domestic boiler	0.00075	0.000033
District heating	0.00097	0.000042
CHP	0.00148	0.000091

These coefficients were derived using the cost breakdown information about different woodfuel boiler and other energy-generating plant investments from "Renewable heat initial business case", DEFRA / BERR (2007).

We applied the domestic boiler coefficients to all of the domestic, business and small industrial boiler projects from our project mix in Table 8 above. The CHP coefficients were applied to the CHP projects while the district heating coefficients were applied to all of the other types of project in that same table.