Wood fuel for warmth

A report on the issues surrounding the use of wood fuel for heat in Scotland

Sustainable Development Commission Scotland

Acknowledgements

This report is based on research undertaken by Forest Research and North Energy Associates Ltd. The Commission would like to thank the following for their assistance in the production of this report.

Contributors: Ken Brady (EST), Janet Brindley (Forest Research), Gavin Gulliver-Goodall (3G Energi), Sophie Hale (Forest Research), Andy Hall (Forest Research), Jane Hunter (North Energy Associates), Elspeth Macdonald (Forest Research), Ewan Mackie (Forest Research), Robert Matthews (Forest Research), Nigel Mortimer (North Energy Associates), Nicola Smith (North Energy Associates), Ian Tubby (Forest Research).

Acknowledgements: Jim Birse (Econergy), Les Bryson, (Forestry Commission Scotland), Rebecca Carr (Forestry Commission Scotland), Jenny Claridge (Forest Research), Mr & Mrs Di-Duca, Willie Dobie (Fuelwood Harvesting), Brian Elmer (Scottish Renewables), Amy Fielding (Talbotts), Barry Gardiner (Forest Research), George Gate (Forest Research), Duncan Ireland (Forest Research), Heather Jackson (Foundation Firewood), Steve Luker (Scottish Forest Industries Cluster), Alastair Lyon, Bob McIlwraith (ALIenergy), Alison Melvin (Forest Research), Chris Morris (EST), Bruce Nicoll (Forest Research), Neil Stewart (Scottish Executive), James Thomson (Scottish Executive), Mike Thornton (EST), John Williams (Forest Research), Helge Wonsbek (Vital Energi), Christine Woods (Forest Research), Joe Zigmunt (Foundation Firewood).

The views expressed are those of the Sustainable Development Commission

June 2005

Cover photograph courtesy of Digitalvision

Executive Summary

The Sustainable Development Commission (SDC) in Scotland commissioned this study to examine the potential of renewable heat from wood fuel, particularly in rural Scotland.

Current Scottish Executive policy development includes a public consultation on the Forestry Strategy, development of the Energy Strategy and the Scottish Sustainable Development Strategy, and a review of the Scottish Climate Change Programme. The UK Government is also consulting on its strategy for micro-generation. This report is intended to contribute to each.

The research shows that small- to medium-scale wood-fuel heating could make a significant contribution to sustainable development - by providing locally-sourced, clean and economic heating with significant potential to reduce CO_2 emissions and generate jobs in rural areas.

Forests cover more than 1.2 million hectares or around 17% of the land area in Scotland. As Scotland's forests mature, timber production is set to double by 2015, leading to a plentiful supply of wood. While not usually the automatic choice, wood is an excellent source of fuel. Modern heating systems relying on wood differ from logs burning in a fireplace: today's wood fuels are either pellets or chips, automatically fed into a boiler. Renewable energy from wood is particularly relevant to Scotland, where a significant resource and an established forestry culture coincide with a substantial demand for heat and high fossil fuel prices.

The policy context

Scottish Ministers have frequently stated their commitment to promoting the increased use of renewable energy sources. First Minister Jack McConnell has stated:

> ***"I know that an investment in renewables is an investment in the future of Scotland - our country, our environment and our economy".***

The Executive's commitment recognises the need to diversify Scotland's energy supply, support economic development, and reduce carbon dioxide emissions (the major cause of climate change) – in the context of United Kingdom Government goal of reducing the UK's CO_2 emissions by 60% by 2050.

To date the focus for using wood as a renewable fuel has been on wood fuel-resourced electricity generation. The Scottish Executive has set a target of 18% of electricity generated in Scotland to come from renewable sources by 2010, and an aspirational target of 40% by 2020. While an increase in renewable electricity generation is important, there is also a potentially large market for renewable heat in homes and small businesses. This is particularly true in rural areas off the natural gas network.

In May 2004 the Royal Commission on Environmental Pollution (RCEP) published its report 'Biomass as a Renewable Energy Source' - a UK-wide study on the use of biomass for heat and power production. Among its recommendations was the conclusion that the scope for biomass as a source of renewable heat needed further investigation. This study from SDC Scotland contributes to such an investigation.

Wood fuel resources in Scotland

Large-scale conifer planting in Scotland in the 1960s and 1970s means potentially large volumes of timber will come into production over the next two decades. This supply may exceed demand from traditional markets. We estimate that the immediately-available resource is 723,000 oven dried tonnes (odt) per year in 2005/2006, and that approximately 10% of round wood currently has no market. Wood fuel availability is expected to increase by 11% between 2005 and 2016, reaching over 800,000 odt per year at that point, before reaching a peak around 2020.

Existing wood fuel heat use

There are currently around 50 automated and semi-automated wood fuel heating schemes in Scotland, with an estimated total heat output rating of around 4.6 MW. This represents the installed capacity of six suppliers, three of whom are based in Scotland. They use in total an estimated equivalent of 3,000 to 5,000 odt of wood fuel annually, in the form of all the main wood fuels (forestry wood chip, sawmill co-products, chipped clean recovered wood, wood pellets of compressed sawdust, and logs).

Wood fuel is largely used for heating in areas off the natural gas network. Gas is popular because it is clean and convenient, and has previously been cheap in comparison with other heating fuels. But the gas network in Scotland extends only from Aberdeen down the East Coast and across the Central Belt, leaving large areas of the North and West without access to natural gas. These areas are also predominantly rural and have good wood fuel resources.

Carbon savings from wood fuel

Wood-fuel heating systems can achieve significant reductions in total emissions of greenhouse gases. While CO_2 is emitted when chips, pellets or logs are used in wood fuel heating systems, an equal amount will have been absorbed during the growth of the trees - hence their 'carbon neutrality'.

The largest net savings in total greenhouse gas emissions are achieved when wood-fuel heating systems displace coal-fired heating systems or electric heating supplied by the national grid, and range from 89% to 96%. When displacing LPG and oil-fired heating, wood fuel deliver emissions savings of 80% to 94%. The smallest savings, of between 73% and 90%, are made relative to natural gas-fired heating systems.

On the basis of available evidence, it has been estimated that the wood fuel resource of 700,000 to 1M odt per year would be able to support between 1.5 and 3.4 TWh per year of delivered energy consumption – enough to account for between 5% and 11% of domestic space and water heating requirements in Scotland. As rural areas without natural gas are likely to be the most cost-effective areas for using this resource, the displacement of coal, electricity, LPG and oil heating is more likely. This would result in carbon savings of from 0.16 to 0.4 million tonnes of carbon (MtC), or 0.6 to 1.4 million tonnes of CO_2 ($MtCO_2$). Such savings equate to between 7% and 23% of CO_2 emissions from domestic space and water heating in Scotland.

Job opportunities

Forestry has a major role in Scottish land use. It already employs around 10,000 people, mostly in rural areas, and is worth over £560m to the Scottish economy. Another benefit of increasing the uses of wood-fuel heating schemes is that jobs will be generated, often in rural areas, throughout the supply chain. Megawatt for megawatt, wood fuel heating creates between five and ten times more jobs than other renewable technologies, and also more than nuclear.

Barriers to wood fuel development

In contrast with the policy for renewable electricity generation (the Renewables Obligation), there is a much less coherent and effective approach to the promotion of heating from renewable sources. A range of incentives and support mechanisms is currently used to assist renewable heating schemes, and wood fuel heating in particular. Although welcome, this support is not currently adequate to deliver the desirable level of wood-fuel heating in Scotland.

Our research highlights confusion among householders and the industry supply chain over issues such as Building Regulations and VAT. In Scotland, unlike in England and Wales, the Building Standards do not specify the fuel efficiency level of the boiler.

Regarding VAT, the reduced rate applies to solid substances sold solely as fuel. Since wood is sold not just as a fuel, there is confusion in the supply chain about the VAT rate to be applied. Wood chips for domestic fuel use should be liable for the same VAT rate as other fuels for domestic use - currently 5%.

Capital and running costs

The capital cost of wood-fuel heating is significantly higher than with conventional competition: comparisons show that a 150 KW wood chip-fired boiler, accumulator tank and fuel store costs from £60K to £70k whereas an alternative 170 KW oil boiler and tank would cost from £10K to £14k. Over the lifetime of the wood burner and heating system, however, the running costs can be considerably less than fossil fuels such as oil and LPG (especially when fossil fuel prices are high, as in 2005). Our modelling shows that wood chip at £38 per tonne is already cheaper than heating oil or LPG for heating purposes.

Grants are available to support the capital cost, under the Scottish Community and Householder Renewables Initiative (SCHRI), but these need to be more generous and secure over the long term.

The supply chain

The supply chain for wood fuel heating covers a wide range of separate industries: forestry, transport, farming and land ownership, sawmills, forest and woodland equipment suppliers, heating plant suppliers and installers, central heating firms, energy supply (ESCOs) and operation and maintenance (O&M) companies, consultants, advisory and funding services. Successful exploitation of wood-fuel heating depends on a complete supply chain being in place even for the smallest installation.

Clustering is important for the supply chain. From a commercial perspective, the transport distance of low value, high bulk fuels like wood chip or logs should be minimised. Each fuel supplier needs to be able to supply a group of heating installations. To ensure that such clusters develop fast enough to provide a viable business for the supply chain, pro-active promotion and readily-available technical expertise in targeted areas is essential.

SDC recommendations

The main drawbacks of current support are that it is confusing and difficult for potential applicants to exploit, and insufficiently generous for the ambitious growth warranted by the available wood fuel resource in Scotland.

A simpler, more focused and integrated package of measures is required – preferably set in a clear policy framework, specifically addressing wood-fuel heating, with targets for progress.

The SDC believes that wood-fuel heating in Scotland has great promise in delivering sustainable development on many fronts: reduced CO_2 emissions, sustainable job creation, and a means of reducing heating costs and addressing fuel poverty.

To consolidate growth and stimulate significant expansion, we recommend that:

1 A clear and coherent renewable heat strategy is formulated for the use of wood fuel heating. Clear targets for the volume of renewable heat need to be established and a clear and coherent policy framework developed.

2 A Renewable Heat Obligation or similar measure should be investigated to enable targets to be set for development of renewable heat.

3 The concept of 'wood fuel refineries' should be investigated and promoted, particularly through local government, to introduce economies of scale into wood fuel supply. Existing wood processors should be involved in this initiative, to build on existing expertise.

To realise immediate potential for wood fuel heating in Scotland, we recommend that:

4 Capital grants available under the Scottish Community and Householder Renewables Initiative (SCHRI) should be increased and secured over time, progressively to reduce the capital cost of wood-fuel heating.

5 The definition and application of VAT to wood-fuel heating appliances and fuels should be clarified to avoid confusion and uncertainty among prospective customers.

6 Grant funding should continue to be available through the Community Energy Programme for community-scale biomass schemes. Such relatively large-scale schemes can act as nuclei for creating clusters of wood-fuel heating users. Additional grant funding is necessary, to be used in conjunction with Public Private Partnerships (PPP).

7 Between 25 and 100 directly supported domestic and medium-scale demonstration projects should be established across Scotland, to increase visibility and confidence, and attract an increasing number of users to wood-fuel heating.

Contents

1. Introduction **3**
1.1 Background 3
1.2 Aims and objectives 4

2. Existing wood fuel use for heating in Scotland **5**
2.1 Aspects of modern wood fuel heating systems 5
2.1.1 Wood fuels 5
2.1.2 Wood fuel heating appliances 7
2.2 Extent of modern wood fuel heating in Scotland 7
2.3 Experience of modern wood fuel heating in Scotland 8

3. Wood fuel resource scoping **10**
3.1 Sources of wood fuel in Scotland 10
3.2 Wood fuel resource assessment for Scotland 10

4. Non-renewable energy scoping **17**
4.1 Competing sources of heating 17
4.2 Coverage of non-renewable energy supply 18
4.3 Price data for non-renewable energy sources 18
4.4 Current and future opportunities for wood fuel heating in Scotland 22

5. Cost comparison **23**
5.1 Basis of cost comparison 23
5.2 Costings 23
5.2.1 Capital costs 23
5.2.2 Running costs 24
5.2.3 Sources of cost data 26
5.3 Simulated cost comparisons 26
5.3.1 460 kW Wood chip boiler for district heating 26
5.3.2 150 kW Wood chip boiler for a single building 28
5.3.3 5 kW Wood pellet stove for a holiday log cabin 28
5.3.4 30 kW Long log boiler for a private house 29
5.4 Generic comparisons with fossil fuel prices 29
5.4.1 Wood chip 30
5.4.2 Wood pellets 30
5.5 Cost Implications for wood fuel heating in Scotland 31

6. Wood fuel heating supply chain **32**
6.1 Elements of the wood fuel heating supply chain 32
6.2 Considerations for the wood fuel heating supply chain 35

7. Emission and employment benefits **37**
7.1 Greenhouse gas emissions 37
7.1.1 Basis for evaluating emissions 37
7.1.2 Evaluation of net emission savings 38
7.1.3 Comparison of total greenhouse gas emissions 38
7.2 Employment 41

8. Government policies **42**
8.1 International context 42
8.2 European Union initiatives 42
8.3 Emissions Trading Scheme 43
8.4 UK Government policies 43
8.5 Scotland 43

Contents

9. Major barriers and solutions **46**

9.1 Experience of the wood fuel industry 46

9.2 Analysis of barriers and solutions 46

- 9.2.1 Regulatory barriers 47
- 9.2.2 Potential solutions to regulatory barriers 47
- 9.2.3 Barriers relating to costs and funding 47
- 9.2.4 Potential solutions relating to costs and funding 48
- 9.2.5 Barriers relating to skills 48
- 9.2.6 Potential solutions relating to skills and industry size 48
- 9.2.7 Awareness barriers 48
- 9.2.8 Potential solutions relating to awareness barriers 48
- 9.2.9 Technical barriers 49
- 9.2.10 Potential solutions to technical barriers 49

9.3 Conclusions 49

10. Future strategy and key recommendations **50**

10.1 Future strategy 50

10.2 Key recommendations 50

Appendix A: Whitegates District Heating Scheme, Lochgilphead **54**

Appendix B: Log-burning boiler, Fort Augustus **58**

Appendix C: Pellet stove in log cabin, Aviemore **60**

Appendix D: Estimation of wood fuel resource in Scotland **62**

Appendix E: Estimated wood fuel heating potential in Scotland **71**

Appendix F: Details of heat cost comparisons **74**

Appendix G: The wood fuel heating supply chain **75**

Appendix H: Wood fuel advisory services in Scotland **83**

Appendix I: Initiatives for wood fuel heating **84**

Appendix J: Net greenhouse gas emissions saving fuel heating **86**

References **88**

1 Introduction

1.1 Background

There is a growing consensus that over-reliance on fossil fuels, the main source of energy in developed countries, is leading to a crisis of potentially global proportions. Reserves of fossil fuel are finite and, eventually, they will be exhausted. In some regions of the world, major reserves of fossil fuel are already showing signs of becoming depleted. The burning of fossil fuels liberates heat-trapping or greenhouse gases, such as carbon dioxide, to the atmosphere. This results in an enhanced greenhouse effect and profound changes in global climate. It is difficult to overstate the magnitude of the challenge presented by these issues. For these reasons, the search for sustainable sources of energy has received increasing priority in recent times.

For at least three decades, sustainably-produced biomass has been recognised as a significant renewable energy source (RCEP, 2004; Matthews and Robertson, 2001). Biomass covers an extremely wide range of organic source materials which can be used for energy and other purposes. Amongst these, wood fuel is an important example. There are well-established systems for producing and using wood fuel, by means of both traditional and modern technologies. Heat, electricity and combined heat and power production from wood fuel are known to require only small inputs of fossil fuels and to involve low emissions of greenhouse gases (Elsayed et al., 2003). Increasing the use of wood fuel could, therefore, be one way of reducing dependence on depletable energy resources, diversifying energy production and tackling the challenge of global climate change.

Wood is a renewable energy option which is particularly relevant to Scotland where a significant resource of wood fuel and an established forestry culture coincides with a substantial demand for heat and electricity with high fossil fuel prices. Stimulating growth in the wood energy sector in Scotland would provide many benefits, such as:

- enhancing the use of an indigenous renewable energy resource
- contributing to a series of measures necessary for reducing the impact of global climate change
- sustaining a major rural industry and supporting rural communities and their economies.

The Scottish Executive is committed to increasing renewable energy production in Scotland, with a target of 18% of electricity produced from qualifying renewable sources by 2010, rising to 40% by 2020. However, a significant omission from this important policy, and from similar policies throughout the UK, is specific reference to targets and measures to promote and expand the production of heat from renewable energy sources. This situation undermines current attempts to develop and increase an effective, practical and commercially-viable market for wood fuel in Scotland and the rest of the UK. There are many reasons why policies fail to address expansion of heat production from renewable energy sources. However, the main obstacle is that most heat production in the UK is provided in individual buildings, such as homes, factories, offices, shops, schools, hospitals, etc. Hence, appropriate policy measures must be able to address individual decision-making by a multitude of owners, operators and customers who could benefit from the application of renewable wood fuel energy at this small-scale where it can be used most effectively (Heaton and Matthews, 2005).

1.2 Aims and objectives

Over the last decade, there have been a number of initiatives in different nations and regions of the UK which have been intended to promote the sustainable use of wood fuel. Despite such attempts, many projects have fallen by the wayside while, in general, uptake among potential consumers has been limited. The reasons for this slow progress are many and complex but, according to most analysts (see, for example, Ilex Energy Consulting, 2003; Jaako Poyry Consulting, 2003; RCEP, 2004; Wood fuel Energy Group, 2005), the prime causes are:

- over-emphasis on large-scale projects and electricity generation rather than small-scale heat production
- over-reliance on unproven technologies rather than existing, tried and tested systems
- unduly high capital costs of wood energy systems
- problems with public perception and poor engagement with potential consumers
- barriers arising from policies and regulations that do not account for the potential benefits of wood fuel-derived energy
- lack of engagement between the existing wood-using industries and with growers.

The aim of this report is to address these issues and, in particular, to:

- clarify the potential of sustainably-produced wood fuel as a source of renewable energy for heat production in Scotland
- highlight key actions needed to realise the potential of wood fuel-derived renewable energy to tackle climate change and contribute to sustainable development in Scotland.

The report concentrates on scoping the early phases of development of a Scottish wood fuel industry, through the exploitation of the existing and growing forest resource. Whilst recognising the importance of energy crops, such as short rotation coppice, the potential and significance of these new wood fuel energy sources are not considered here. It should be noted that the anticipated time horizon for the recommendations of this report is the next 10 years and, in this context, the objectives of the report are to focus on:

- the current position, notably the size of the wood fuel resource, the state of development of wood fuel production and the performance of conversion systems
- the potential for increasing capacity in the wood-fired heating sector and associated environmental and socio-economic impacts
- the technical, socio-economic and commercial barriers to capacity building and market penetration
- the key solutions and instruments to address barriers.

2 Existing wood fuel use for heating in Scotland

2.1 Aspects of modern wood fuel heating systems

This summary of existing wood fuel use for heating in Scotland concentrates on modern automated appliances which are the current and future basis of wood-fired heating systems. Whilst recognising the role of manually-loaded conventional log-burning and multi-fuel stoves, attention is focused on automatically-loaded wood heating systems that are beginning to be utilised in the commercial and public sectors and, in the domestic sector, chiefly in large private houses. In particular, this summary considers heating systems fuelled by wood in log, chip or pellet form from the following sources:

- forestry and woodland
- arboricultural arisings
- sawdust and offcuts from sawmills
- clean recovered wood derived from pallets and untreated wood
- imported wood pellets of compressed sawdust.

Commercially-produced wood co-product and offcuts used for on-site heating in the factories in which this material is produced have not been considered here. For such fuel, there is an established commercial market and such systems are in regular use for heating and, effectively, for waste disposal, as, for example at the IKEA store in Glasgow.

2.1.1 Biomass

Biomass is a generic term for organic matter used as fuel. Crops such as miscanthus and sugar cane, and agricultural residues such as straw, poultry manure, olive pits, rice husks and nutshells are classed as potential wood fuel energy sources. Such fuels are sometimes used in electricity generation or combined heat and power schemes. This report, however, concentrates on wood-derived fuel available in several forms, including:

- logs
- wood shavings, sawdust, offcuts, etc.
- wood chip
- wood pellets
- wood briquettes.

In considering specific forms of wood fuel for heating purposes, it is essential to ensure that its characteristics and quality are suitable for chosen appliances. If the wood fuel is too wet, for example, the boiler will not operate efficiently. Automatic systems, fed with an auger and/or conveyor, use chipped or pelletised wood which must be the correct size for the feed system to handle.

Logs up to 50 cm long and 15 cm thick are used in open fires, closed stoves and manually-fed boilers. The size of logs required varies with the appliance. Semi-automated log boilers can normally take “long” 50 cm logs. This reduces the amount of preparation and handling required and keeps costs down. Log boilers are usually fully-loaded and fired in the morning to heat water in an accumulator tank. When the fire goes out, the central heating water is heated by the accumulator tank. In extreme weather during the winter, a second firing in the evening may be needed.

©Forest Research / North Energy Associates

Wood chips range in size from 0.5 cm^2 to 5.0 cm^2, without fines (very small particles or dust) and with no oversized pieces. Properly made wood chips are rectangular, roughly cut and produced by only a small number of types of chipper. The type of chips produced, for example, by landscape firms for composting are not suitable for fuel. Wood chips are used in automatically-fed boilers. These boilers are designed to take chips at set specifications and are sensitive to size and moisture content. The manufacturer of the boiler must be consulted by the prospective user when securing a wood chip fuel supply.

©Forest Research / North Energy Associates

Wood pellets range in size from 5 - 40 mm in length with a diameter of between 5 - 12 mm. They are produced by compressing sawdust and shavings in a pellet mill. No additives are used. Pellets are easy to handle in semi- and fully-automatic systems. They are fed into the storage hopper manually by sack or from a pneumatic delivery vehicle. Wood pellets must contain only pure wood dust. Pellets made from medium density fibreboard (MDF), chipboard or other materials must be burnt in purpose-designed incineration equipment or in power stations. Currently, pellets are not made in Scotland although imported pellets are available in sacks. Pneumatic delivery of domestic grade pellets is not yet available in Scotland. However, commercial grade pellets are made and delivered pneumatically in the North East of England.

©Forest Research / North Energy Associates

Wood briquettes can be used in place of logs in traditional fires and modern log boilers. They are produced from clean waste wood such as joinery offcuts and sawdust. They are made in small quantities at several locations in Scotland and supplied in plastic sacks. As with pellets, the source material must be clean and uncontaminated in order to avoid undesirable emissions. Wood briquettes are always manually-loaded into heating appliances.

2.1.2 Wood fuel heating appliances

Fully-automated wood- and straw-fired heating systems have been commonplace in Scandinavia, Germany and Austria for nearly 30 years since fossil fuel taxes were introduced after the 1973 oil crisis. Until about 5 years ago, however, there were no fully-automated wood-fired heating systems in commercial and public sector buildings in Scotland. This does not mean that wood was an insignificant heat resource, as large numbers of home owners heated their houses with wood or a mixture of wood and solid fuels. As the natural gas network has grown, and oil and liquefied petroleum gas (LPG) have increased in popularity, there is now a general expectation that heating will be effortless, convenient and controllable. At the same time, an interest in the environmental benefits and economic opportunities of wood heating has developed and new ways of burning wood have been explored. The increasing concern about global climate change and need for reductions in greenhouse gas emissions have encouraged the import of high efficiency, fully-automatic heating appliances from Scandinavia and Austria. New interest is emerging in clean, green, convenient wood fuel heating systems. The advent of grant schemes to help with the higher capital costs and some bold risk-taking by individuals and small companies have helped to inch forward the market for wood heating in Scotland.

Instead of attempting to describe the details of all available wood fuel heating appliances, three case studies have been prepared for illustrative purposes (see Appendices A, B and C). These case studies consist of a wood chip-fired district heating scheme, a wood pellet-fired stove and a log-fired boiler. They are all fairly typical of the type of wood fuel heating appliance already installed in Scotland although the Laka/Veto wood chip boiler in the district heating scheme is not necessarily representative of the automatic systems that will be installed in future. The more recent imports of high efficiency, state-of-the-art Austrian boilers are not yet represented in Scotland, even though several have been installed in the North of England. They will be used in projects now in the pipeline.

The basic features of the selected case studies can be summarised as follows:

- Whitegates district heating scheme, Lochgilphead (Appendix A): a fully-automated wood chip-fired district heating for a housing development using a Finnish Laka boiler with Veto stoker supplied by Torren Energy (formerly based in Edinburgh) and now run by Vital Energi for Fyne Homes (housing association)
- Wood pellet-fired stove, Aviemore (Appendix B): an Italian Extraflame Preziosa pellet-burning stove in a log cabin supplied by 3G Energi of Kelso in the Borders
- Log-fired boiler, Fort Augustus (Appendix C): a partially-automated log-burning boiler for a private house using a Danish Baxi Solo Innova boiler supplied by Foundation Firewood from Hertfordshire.

2.2 Extent of modern wood fuel heating in Scotland

Research has revealed that, in March 2005, there were around 50 automated and semi-automated wood fuel heating schemes in Scotland, with an estimated total heat output rating of around 4.6 MW (megawatt = 1 million watts). This represents the installed capacity of wood fuel heating systems from six suppliers (of which three are based in Scotland). These schemes are mainly in areas which lack mains natural gas supplies. They are fuelled by all the main wood fuels (forestry wood chip, sawmill co-products, chipped clean recovered wood, wood pellets of compressed sawdust, and logs) using in total an estimated equivalent of 3,000 to 5,000 oven dried tonnes[1] (odt) of wood fuel annually. Furthermore, it is thought that schemes with a cumulative heat output rating in excess of 5MW are being investigated or planned in Scotland.

In terms of future wood fuel heating projects, the following local authorities are known to be considering wood chip heating schemes: Aberdeen City, Aberdeenshire, Angus, Argyll, Ayrshire, Dundee City, Edinburgh City, Fife, Lanarkshire, Midlothian, Perth and Kinross, and Stirlingshire. These projects total several MW of heat output rating, as some are being considered for large comprehensive schools and other district heating schemes. In order to proceed, all of these proposed projects depend on levels of extra capital funding to cover capital cost over and above the cost of a fossil fuel-fired boiler. Local authority repair and renovation budgets cannot stretch to the high capital costs of wood fuel boilers despite the potential fuel savings and the possibility of carbon credits in future. Whilst funding partnership opportunities are presented by the Public Private Partnership (PPP), local authorities still face the risk of investing in an unfamiliar though proven technology. It is possible that there are other projects which are being investigated and planned which have not been covered here.

2.3 Experience of modern wood fuel heating in Scotland

The bulk of early wood chip heating systems were installed as recently as 2001 to 2003. These were mainly situated on the west coast and Western Isles of Scotland. Here, the cost of competing fossil fuels is relatively high because of transport costs. Torren Energy marketed wood heating actively as a cheaper alternative with security of supply and benefits for the local economy. The company operated an ESCO to remove the labour element from wood fuel users. Torren Energy was one of the companies which acquired funding under the UK-wide Bio-energy Capital Grant Scheme (BECGS) and, hence, were able to subsidise the capital cost of plant. The company was able to set up fuel suppliers and encouraged local wood producers to follow suit.

Whitegates district heating scheme, Lochgilphead; (Appendix A) touches on the demise of Torren Energy which had, until 2003/2004, been delivering wood heating in parts of Scotland. Anecdotal evidence suggests that the company's difficulties were due, at least in part, to very fast growth, to management issues and to cash flow problems (common in small business) caused by late payment of grants. The fact that the company did grow so fast and succeed with so many installations in a short space of time helps to indicate the effectiveness of both the injection of capital funding provided by BECGS and the ESCO concept. It also suggests what could be achieved if better support and a stable framework for growth can be established.

On the strength of the activities of the first wood fuel suppliers and early wood heating schemes,

1 The amount of wood fuel needed by wood fuel heating schemes is determined by its calorific value, or energy which it can provide when burnt, which depends on its moisture content. The relationships between these factors can be found elsewhere (Matthews et al., 1994).

other companies began to take notice of possible opportunities. Consumers were being presented with a completed service: fuel supply, boiler supply, day-to-day maintenance and funding support. It was obviously attractive and the number of installations started to grow. Once this initial phase was underway, it seems that more interest has developed in individual wood-fired installations. A review of existing wood fuel heating schemes also shows the significance of heat users who have access to their own wood supply. Apart from the Torren examples, there are few installations where wood fuel is being bought in from an outside supplier. So far, the development of wood fuel heating is becoming more widespread but seems to be very closely aligned to the availability of capital funding, fuel supply and support agencies.

In order to gauge the importance of grant schemes and promotional activities in initiating wood fuel heating schemes, it would be desirable to locate all of the existing installations on a map and to relate this to boundaries of grant and promotion schemes. Another useful exercise would be to determine the dates of installations of existing wood fuel heating schemes. It is possible that the number of larger schemes dropped sharply following the failure of Torren. Since then, Buccleuch Bio-energy and Highland Wood Energy have recently begun to offer similar services, and Vital Energi are now offering an O&M service. Hence, the number of new large schemes now seems to be increasing. However in number terms, the growth of wood fuel heating appliance sales has continued to expand during the time period between the end of Torren and the start of their successors. Gaps in the market have been filled, at least in part, by the newly-developing demand for wood pellet-burning stoves and wood pellet- and log-fired boilers. Additionally, demand is being created by landowners and saw-millers who are using their own wood sources to heat their own buildings.

As far as the future is concerned, the issues of capital costs and security of wood fuel supply are probably the two main inhibitors to the development of wood fuel heating. There are, however, encouraging signs in that there are now two organisations in Scotland aiming to deliver wood heat to customers and which will take responsibility for boiler installation, wood fuel supply and maintenance. If there continues to be financial assistance toward capital costs and increasing levels of advice, demonstration and support, then indications are positive and many more wood fuel heating installations in areas outside the natural gas network (“off-gas”) can be expected in the years to come. Whether this spreads into areas with access to the natural gas network (“on-gas”) will depend largely upon the relative price of natural gas and the extent of long-term planning by the organisations and individuals installing new heating systems. Currently, there are encouraging signs amongst companies involved in Public Private Partnerships (PPP) building and running schools and other public buildings in both on- and off-gas areas who are showing interest in using wood for heating.

3 Wood fuel resource scoping

3.1 Sources of wood fuel in Scotland

Quantifying the availability of wood fuel in Scotland, both immediately and within the next decade, is fundamental to establishing the potential of wood as fuel for the heating industry. Wood fuel can come from a number of sources. Each has advantages and disadvantages. Many commentators have pointed out that harvesting residues (branchwood, tree tops and tips left on site when stem wood is harvested) could be used as fuel. This resource is already exploited in Sweden and Finland where systems for the collection of residues are operating commercially. In Scotland, residues could make a significant contribution to wood fuel supply but currently the technology for doing this is not readily available and an infrastructure would need to be developed. In many locations, the collection of residues will be impractical due to technical and logistical constraints. On other sites, removing residues could lead to negative impacts on soil fertility. These factors have been considered elsewhere (McKay et al. 2003) and estimates of potential wood fuel production from residues were adjusted accordingly. Aboricultural wood (wood fuel arising from the management of trees along railway embankments, under power lines and in urban/peri-urban locations) has also been identified as a readily available and almost free fuel source. It has been estimated that between 10% and 18% of arboricultural wood currently has no market, with much ending up in landfill sites (McKay et al., 2003). This is also true of between 2% and 10% of secondary wood generated by forest industries (typically chips, sawdust and offcuts generated as co-products of sawn timber). Landfilling of such potentially useful wood fuel incurs costs to industry and the environment.

While these sources of wood fuel could be important, the major sources of wood fuel in Scotland are in the form of conventionally harvested wood: roundwood (small diameter wood feeding mainly the paper, board and pallet markets) and sawlog material (larger diameter suitable for conversion to sawn timber). It has been estimated that approximately 10% of roundwood currently has no market (McKay et al., 2003). Prices for roundwood are suppressed and in some areas, low quality stands are producing low quality sawlog material that does not attract favourable prices. There is an opportunity for a new wood fuel industry to tap into these resources, provided that market conditions remain favourable. In addition, the large-scale planting of conifers in Scotland in the 1960s and 1970s is also resulting in potentially large volumes of timber coming into production which may exceed demand from traditional markets.

3.2 Wood fuel resource assessment for Scotland

Estimates of the total wood fuel resource in different regions of Scotland can be obtained from the forecasts published in a recent report and website prepared for the Department of Trade and Industry (DTI) quantifying the current and future wood fuel resource in Great Britain (McKay et al., 2003). These estimates can be adjusted to represent available wood fuel by drawing on existing data, and experience of timber markets and practical constraints. This approach was adopted to assess the available wood fuel resource for heating in Scotland.

The assumptions used are outlined in Appendix D. In this context, wood fuel from the following sources, considering both public and private forests, was included in the assessment:

- arboricultural wood
- secondary wood generated by the wood processing industries
- harvesting residues (primarily branchwood and stem tips)
- wood from early thinnings and stands of low quality
- roundwood (stem wood in 7 – 14 cm and 14 – 16 cm diameter classes)
- sawlog material (stem wood in the 16 – 18 cm and 18 + cm diameter classes).

A detailed breakdown of the total amount of wood fuel available from all of these sources is presented in Appendix D. Since the quantity of wood present in a forest varies depending on the pattern of growth, the relative maturity of trees and the nature of forestry operations, it is necessary to consider the effect of time on the assessment of wood fuel resources from these particular sources. Hence, the amount of wood fuel available from forestry sources in Scotland was calculated for three time periods: 2005 to 2006, 2007 to 2011, and 2012 to 2016. The extent of available wood fuel and the sensitivity of estimates to assumptions about competing markets were investigated by considering three scenarios:

Scenario 1 (Immediate): This represents the quantity of wood that is readily available to a newly-established wood-based heating industry. This scenario considers wood for which, at present, there is low demand and assumes minimal investment and development of the existing wood supply chain.

Scenario 2 (Growth): This represents the quantity of wood that might become available if growth of the wood fuel heating industry was to be encouraged over 5 to 10 years. It assumes that a proportion of wood currently feeding existing markets might be diverted into a developing wood fuel supply chain in response to favourable market conditions and incentives.

Scenario 3 (Theoretical Total): This represents the total potential for wood production in Scotland. It ignores the existence of other markets for wood.

The estimates in Table 3.1 show the total wood fuel resource available annually from forestry sources across Scotland, for Scenarios 1 and 2 described above (i.e. immediate availability, and availability given suitable market conditions and development to promote growth). These estimates are contrasted with the theoretical totals (Scenario 3). The immediately available resource is 723,000 odt per year in 2005/2006, rising to just over 800,000 odt per year by 2016.

Table 3.1 shows that if growth and development in the wood fuel heating sector was actively encouraged by means of financial incentives or regulatory measures (‘Scenario 2’), the potential wood fuel available to this industry might rise by approximately 200,000 odt per year, to give a total of 900,000 odt per year in 2005/2006, expanding to just over 1,000,000 odt per year by 2012. This latter estimate is comparable but somewhat lower than that published in a recent report prepared by the Forum for Renewable Energy Development in Scotland (FREDS) and published by the Scottish Executive (Scottish Executive, 2005a). Although the timescale studied is slightly longer than that referred to here, a comparison is still useful. The FREDS study estimated that an increase in production will lead to a surplus of 5 million cubic metres of wood throughout the UK, once traditional markets have been saturated. Sixty percent of this surplus will be produced in Scotland (3 million cubic metres). Using a value of 0.4 as a typical factor for converting cubic metres of wood to odt (Lavers and Moore, 1983), this equates to 1.2 million tonnes. However, it is not clear whether the FREDS study took account of potential production from harvesting residues or secondary wood.

The results shown for Scenario 3 take into account all stem wood greater than 7 cm diameter, all sustainably harvestable residues, all co-products and all arboricultural wood (McKay et al., 2003).

Over the next 20 years wood production in Scotland will increase dramatically as forests planted in the 1960s and 1970s reach harvest age. Forecasts suggest that production will reach a peak around 2020 although the first signs of an increase in wood production are apparent in the 11% increase in wood fuel availability between 2005 and 2016, as seen in all three Scenarios (Table 3.1). The increase in production over time and the longer timescale considered in the FREDS study may be one cause of discrepancies between estimates presented by that study and in this report.

Map 3.1 shows the distribution of forest areas throughout Scotland, with public forests in green and private forests in blue. Forestry Commission (FC) districts are marked for reference. Figures 3.1 and 3.2 illustrate the breakdown of the total potential wood fuel resource for areas covered by FC Forest Districts for Scenarios 1 and 2, respectively. Figure 3.3 shows the breakdown of the theoretical total wood fuel (Scenario 3). Districts appear in Figures 3.1, 3.2 and 3.3 in an order which roughly reflects geographical location within Scotland: North and West, North East, Central Belt and Lowlands.

Table 3.1 Potential wood fuel available for heating in Scotland under Scenario 1 (Immediate), Scenario 2 (Growth) and Scenario 3 (Theoretical Total)

Time period	Available wood fuel resource (odt per year)		
	Scenario 1	Scenario 2	Scenario 3
2005-2006	723,036	900,998	2,971,713
2007-2011	758,854	922,548	3,263,591
2012-2016	805,168	1,007,775	3,702,281

Map 3.1 Distribution of forest areas in Scotland

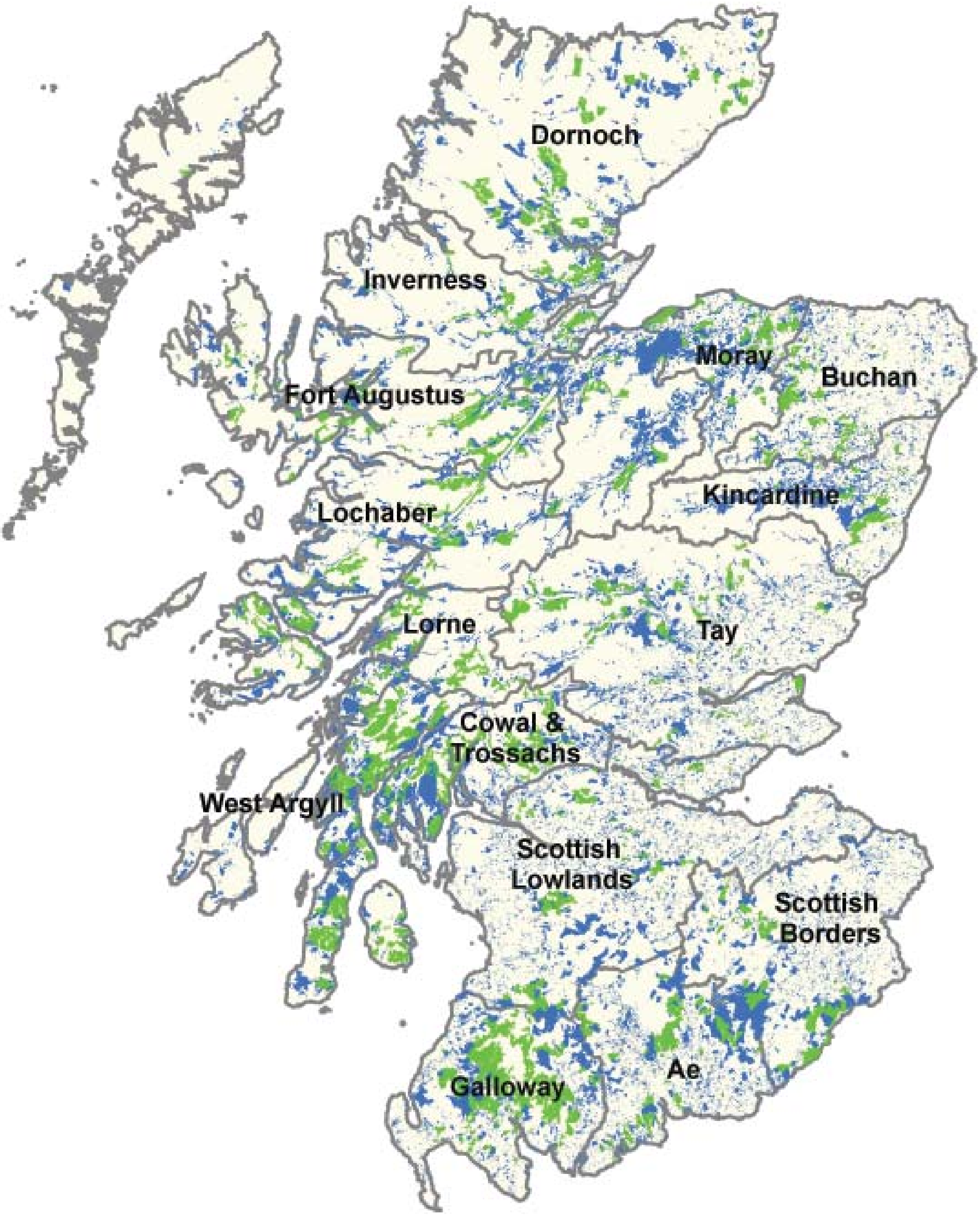


Figure 3.1 Wood fuel resource immediately available for heating purposes in each forest district over the next decade (Scenario 1)

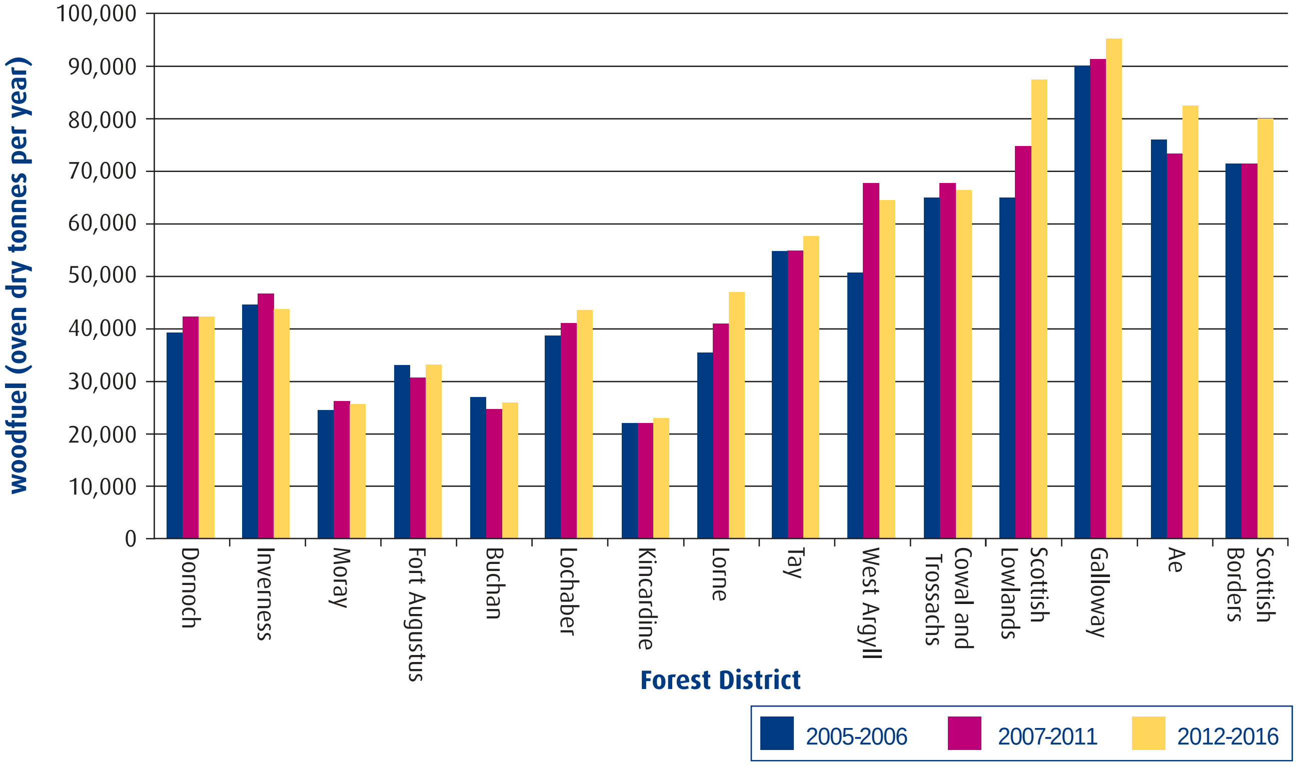


Figure 3.2 Wood fuel resources potentially available for heating purposes with favourable market growth conditions (Scenario 2)

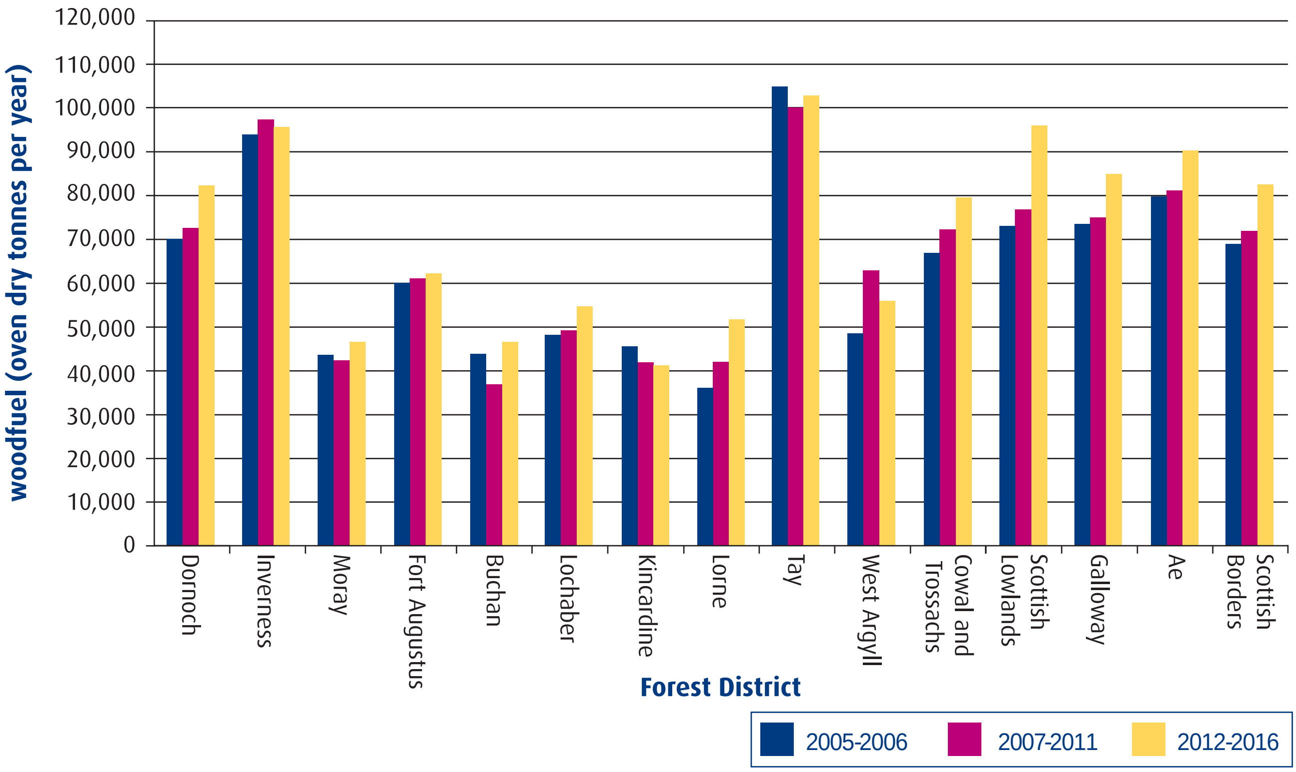
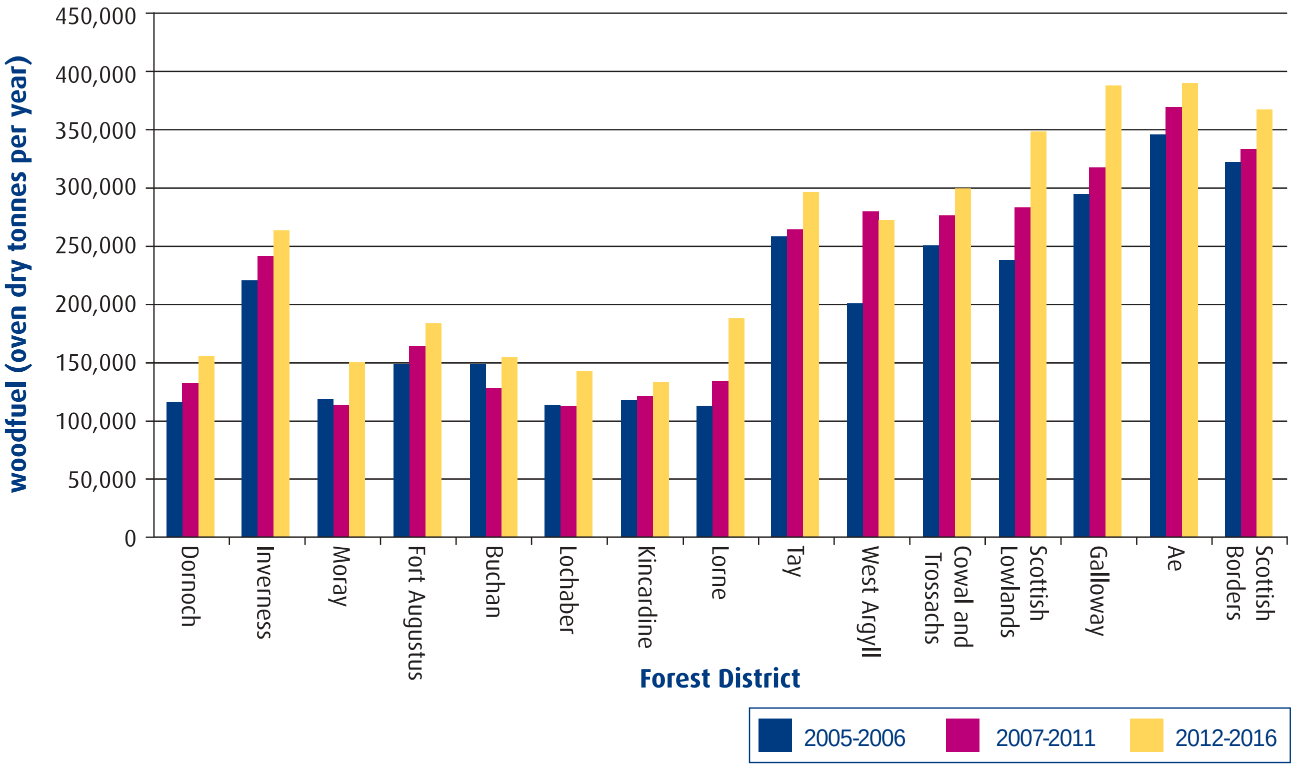


Figure 3.3 Theoretical total wood fuel resource in Scotland ignoring other markets (Scenario 3)



For both Scenarios 1 and 2, wood fuel production is lowest in North East Scotland (the Moray, Buchan and Kincardine regions), at 30,000 to 40,000 odt per year. In North West Scotland, production is approximately 30,000 to 45,000 odt per year for immediate availability (Scenario 1), and this rises considerably to 70,000 or 80,000 odt per year in the Dornoch and Inverness regions under growth assumptions (Scenario 2). Production in the Tay, Central Belt and Lowlands regions of Scotland is high (60,000 to 95,000 odt per year) in terms of immediate availability (Scenario 1), with availability under growth assumptions (Scenario 2) giving values similar in magnitude to the Dornoch and Inverness regions. Many rural areas have potentially high amounts of wood fuel available.

In order to put the wood fuel resource estimate for Scotland into perspective, it is possible to assess its potential for domestic space and water heating in terms of energy supply and net carbon dioxide emissions savings (Appendix E). Based on the broad interpretation of data and by the application of simplifying assumptions, it has been estimated that 700,000 to 1,000,000 odt per year would be able to support between 1.5 to 3.4 x 10^6 MWh per year of delivered energy consumption (1 MWh = mega watt-hour; the amount of heat emitted by 1,000 single bar [1 kW] electric fires in 1 hour). This would account for between 5% and 11% of domestic space and water heating requirements in Scotland. The amount of carbon dioxide emissions savings which this could generate depends on the mix of conventional heating fuels which would be displaced by wood fuel. Since the most economically favourable markets for wood-fired heating are rural areas without natural gas supplies and assuming that an equal mix of coal, electricity, LPG and oil heating is displaced, then it has been calculated that carbon dioxide emissions savings of between 0.6 and 1.4 x 10^6 tonnes of carbon dioxide could be achieved each year in Scotland. This would amount to between 7% and 23% of carbon dioxide emissions from domestic space and water heating in Scotland.

However, for this wood fuel resource to be available to the wood fuel heating industry, and for the industry to develop to make use of the resource, measures must be put in place which promote the use of wood fuel heating and which establish favourable market conditions, allowing the industry to compete successfully for the resource. In particular, conditions would have to be promoted which would enable the heating industry to compete effectively with the electricity generation industry over access to the available wood fuel resource in Scotland. Current and expected future demand for wood fuel co-firing by existing coal-fired power stations in Scotland and elsewhere in the UK may provide stiff competition for the wood fuel heat industry.

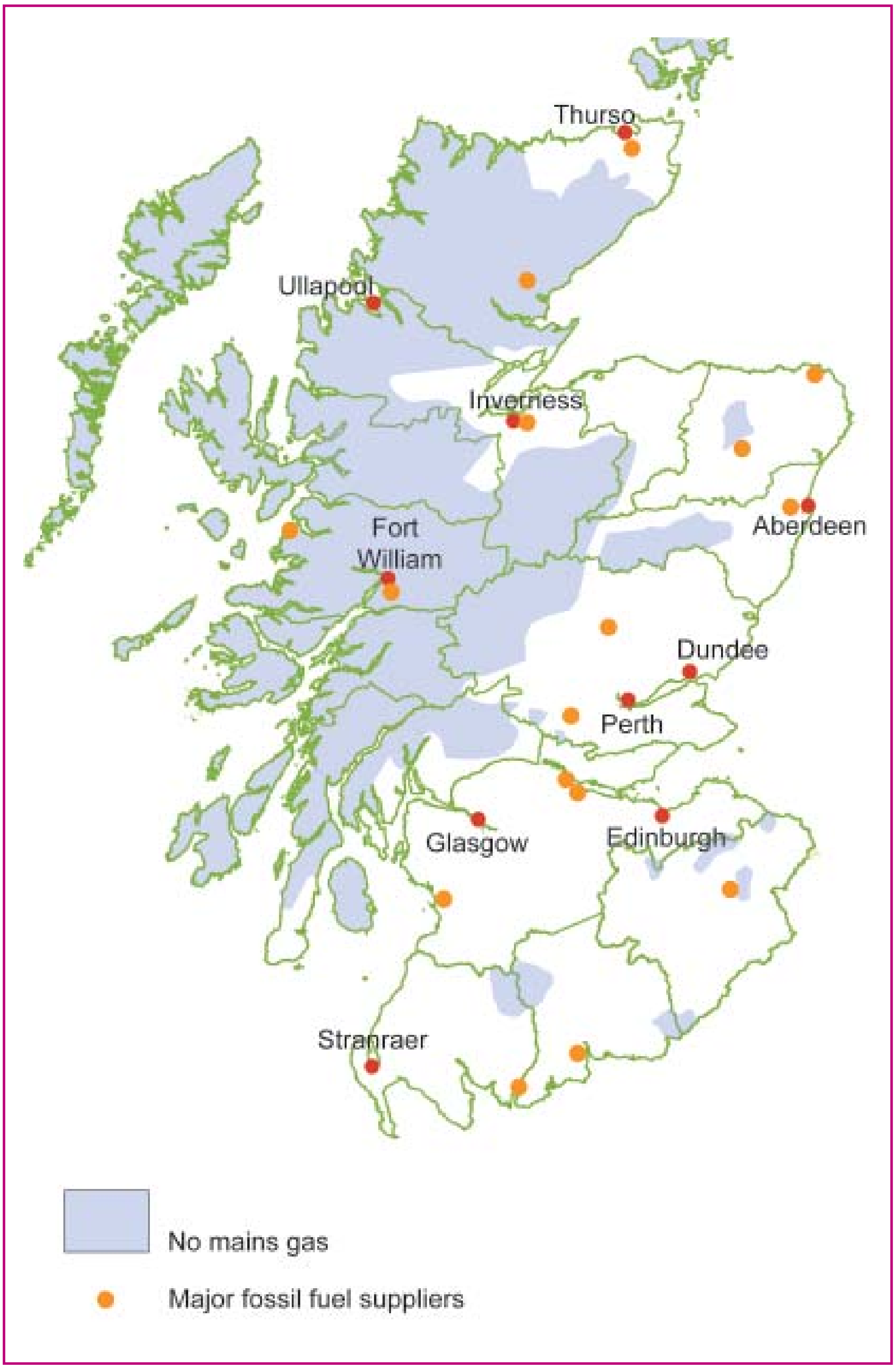
Equally critical is the risk of potential future conflict or competition with the existing wood-using industries. In this context, there is a very important proviso that must be attached to the estimates of available wood fuel that have been presented here for Scenarios 1 and 2. All calculations are based on an understanding of current and evolving market conditions. Specifically, a set of assumptions have been made about levels of demand for Scottish-grown timber from the existing wood processing industries. The extent of any surpluses is inferred from an analysis of wood resource forecasts, involving these assumptions (see Appendix D). However, there are important past examples of very rapid and profound changes in market conditions. Most obviously, there could be major consequences for future wood fuel availability if the existing forest industries were to make major investments and commitments towards new processing facilities, specifically to exploit the surpluses that have been identified. While surplus production may be available under current conditions, the dynamic nature of the market requires a growing wood fuel heat industry to take active steps to secure a long-term stake in access to this resource at sustainable prices. This emphasises the critical importance of close engagement between the wood fuel heating industry, the wider wood-using industry and growers. There are also implications for the targeting of locations for wood fuel heating projects at different scales, and for the approaches taken to developing wood fuel supply chains.

4 Non-renewable energy scoping

4.1 Competing sources of heating

The prices of non-renewable energy sources, in the form of current fossil fuels and electricity, provide the basis for evaluating the economics and future prospects of wood fuel heating systems. In particular, such prices determine the baseline for operating costs which consumers consider and compare so that they can decide which heating systems they will use. Such decisions are also based on the availability of competing fuels which can vary considerably across Scotland, especially in rural and remote areas. In the UK generally, the price of natural gas is an important factor in the choice of a suitable heating system and its fuel. Natural gas is a popular choice because it is a clean and convenient fuel that has been previously cheap in comparison with other heating fuels. However, the option of using natural gas depends on the availability of this fuel in any given location and this, obviously, is governed by the penetration of the natural gas supply

Map 4.1 Coverage of the natural gas network and locations of major suppliers of coal, burning oil and LPG in Scotland



network. The current network in Scotland extends mainly from Aberdeen down the east coast and along the central belt. Essentially, this provides natural gas to the major population centres in Scotland. Other smaller areas of natural gas supply exist. However, most of the remainder of Scotland, which includes most of the rural areas and all the remote locations, do not have access to natural gas. In these areas, the choice of heating fuels depends on the delivery network for fossil fuels, such as coal, heating oil and LPG, and the penetration of the electricity supply network, which covers most of the population. This means that, in general, wood fuel heating must compete primarily with natural gas in the main urban areas of Scotland and with coal, heating oil, LPG and electricity in most of the rural areas.

4.2 Coverage of non-renewable energy supply

Regional energy supply statistics were used to derive an approximate indication of natural gas penetration in Scotland which is shown in Map 4.1. This map also includes the location of major suppliers of coal, burning oil and LPG in those areas of Scotland which do not have natural gas supplies. It should be noted that some areas which have no natural gas supply coincide with those with considerable wood fuel resource potential. It can be seen that with few exceptions, the whole of the north and west of Scotland, down to the central belt does not have mains natural gas supply. There are also isolated pockets with no supply in Aberdeenshire, Dumfries and Galloway, the Lothians and the Borders. This suggests that applications in rural areas with significant local wood fuel resource potential may offer the most favourable opportunities for expanding wood fuel heating in Scotland.

4.3 Price data for non-renewable energy sources

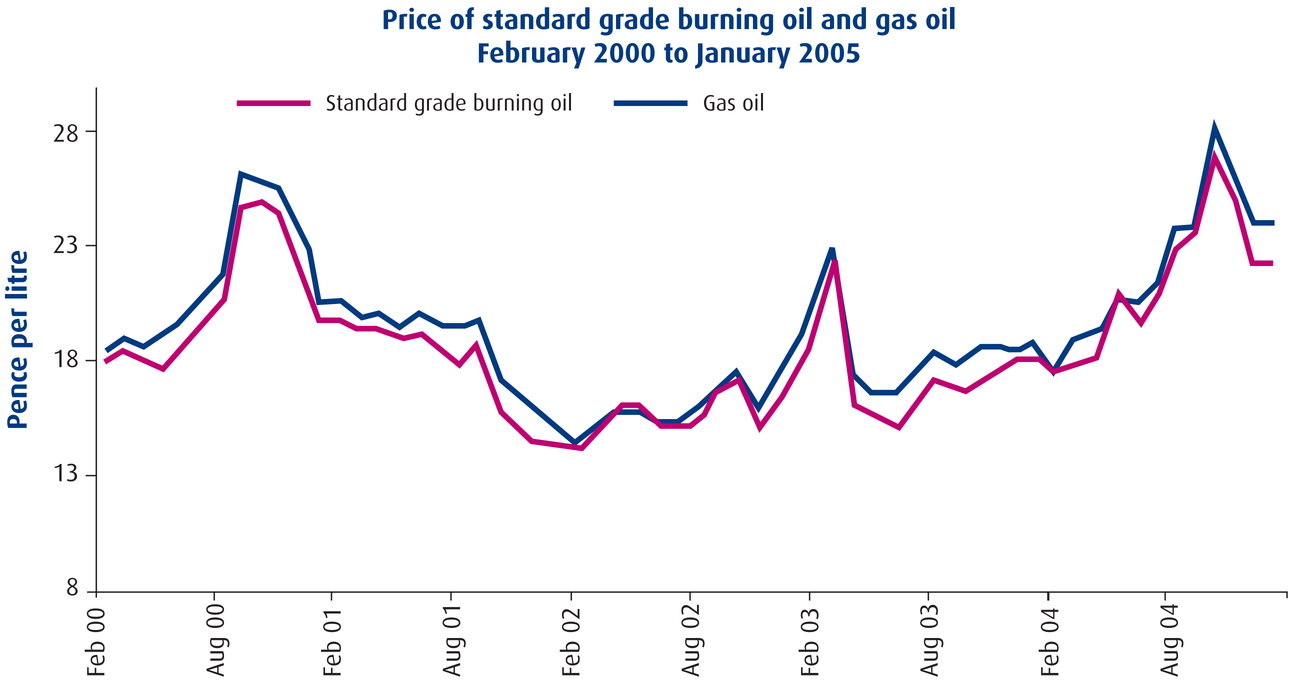
Only limited published statistics on the prices of heating fuels are available for Scotland. In particular, average prices for domestic electricity and natural gas are published for Aberdeen and Edinburgh on a quarterly basis (DTI, 2004b). These statistics include average, smallest and largest bill prices for credit, direct debit and pre-payment customers. The average bill prices are based on average annual consumption of 3,300 kWh of electricity and 18,000 kWh of natural gas. The average bills are divided by the average annual consumption to obtain the average bill price. Value Added Tax (VAT) at 5% is included in these prices. Prices of other conventional heating fuels for use in domestic or other applications are not provided by national statistics. Instead, it was necessary to conduct a limited survey of suppliers in Scotland during the end of March 2005. These suppliers provided quotes for current prices of coal (house coal and anthracite), burning oil and bulk-supplied LPG. Coal prices were given in terms of single 50 kilogram sacks, and burning oil and LPG prices were quoted in litres. LPG prices refer to bulk deliveries to customer tanks rather than delivery by bottle or canister since these are normally used for relatively small quantities of this fuel. The prices for all these heating fuels include delivery charges and VAT at 5%. It should be noted that delivery charges can vary depending on the location of the customer relative to the nearest supply depot. Prices of heating fuels for other customers, such as small industrial, commercial and administrative (schools, local authorities, etc.) are not available in the form of national statistics. Prices for these customers include the Climate Change Levy (CCL) as well as VAT. It should be noted that, due to their bulk demand with larger and / or more frequent deliveries, these customers can sometimes negotiate discount prices for coal, heating oil (burning oil and gas oil), and LPG.

Using a combination of national statistics and survey data, current ranges for the prices of conventional heating fuels were derived for domestic consumers in Scotland and these are compared in Table 4.1. For comparative purposes, the prices shown in Table 4.1 are given in terms of per unit of delivered energy measured in kWh (kWh = kilo watt-hour; the amount of heat emitted by 1 single bar [1 kW] electric fire in 1 hour). Delivered energy is the energy available in the fuel as purchased by the customer. This takes into account the energy content or calorific value of the fuel. The ranges of prices shown in Table 4.1 should be regarded as typical rather than comprehensive and representative since more detailed data collection and analysis would be needed to achieve this. It should also be noted that prices for certain conventional fuels can vary considerably over very short periods of time. In particular, the prices of heating oil (burning oil and gas oil) and LPG are subject to fluctuations in the world price for crude oil. Some impression of the nature of these variations can be seen in Figure 4.1 which summarises the retail price of burning oil and LPG for domestic consumers during 2003 (DTI, 2005).

Table 4.1 Comparison of fuel prices for domestic consumers in Scotland

Type of fuel	Range of prices (pence / kWh)	Notes
Natural Gas	1.56 – 2.01	Average unit prices, including VAT, for all types of domestic consumer in Aberdeen and Edinburgh for 2004 (DTI, 2004b).
Coal - House Coal	1.77 – 1.96	Quoted unit prices, including delivery charge and VAT, in Kilmarnock for March 2005.
Coal - Anthracite	1.99 – 2.39	Quoted unit prices, including delivery charge and VAT, in Dumfries and Kilmarnock for March 2005.
Burning Oil	2.88 – 3.21	Quoted unit prices, including delivery charge and VAT, in Kilmarnock and Perth for March 2005.
LPG	2.56 – 5.07	Quoted unit prices, including delivery charge and VAT, in the UK for December 2004 and in Kilmarnock for March 2005.
Electricity (Economy 7)	7.04 – 9.84	Average unit prices, including VAT, for all types of domestic consumer in Aberdeen and Edinburgh for 2004 (DTI, 2004b).

Figure 4.1 Price for heating oil in the UK (DTI, 2005)



A growing number of commentators and analysts are now predicting that future prices of petroleum products are likely to rise in real terms. This is due to sustained increases in world oil prices which are currently responding to short-term imbalances between supply and demand, and long-term trends in supply growth, especially for developing countries such as China and India, and the underlying effects of oil resource depletion (ASPO, 2005; Deffeyes, 2001; Laherrère, 2001). The actual effect on the prices of heating oil and LPG are difficult to predict although a pattern of increases with rapid fluctuations seems likely. Coal prices are influenced by world market conditions as well as the world oil market.

Similarly, the price of natural gas is affected by world crude oil prices and the UK price of electricity is influenced by the prices of fossil fuels generally due to their importance in the current power generation mix. An official attempt has been made to project future prices for domestic supplies of natural gas and electricity in the UK up to 2010 (DTI, 2004a). These projections, which are shown in Figures 4.2 and 4.3, take into account national considerations including plans to replace declining UK natural gas production with imports and expected changes in electricity generation. However, they do not account for rising crude oil prices which have become a feature of recent world oil markets.

Figure 4.2 UK real price index for domestic natural gas (DTI, 2004a)

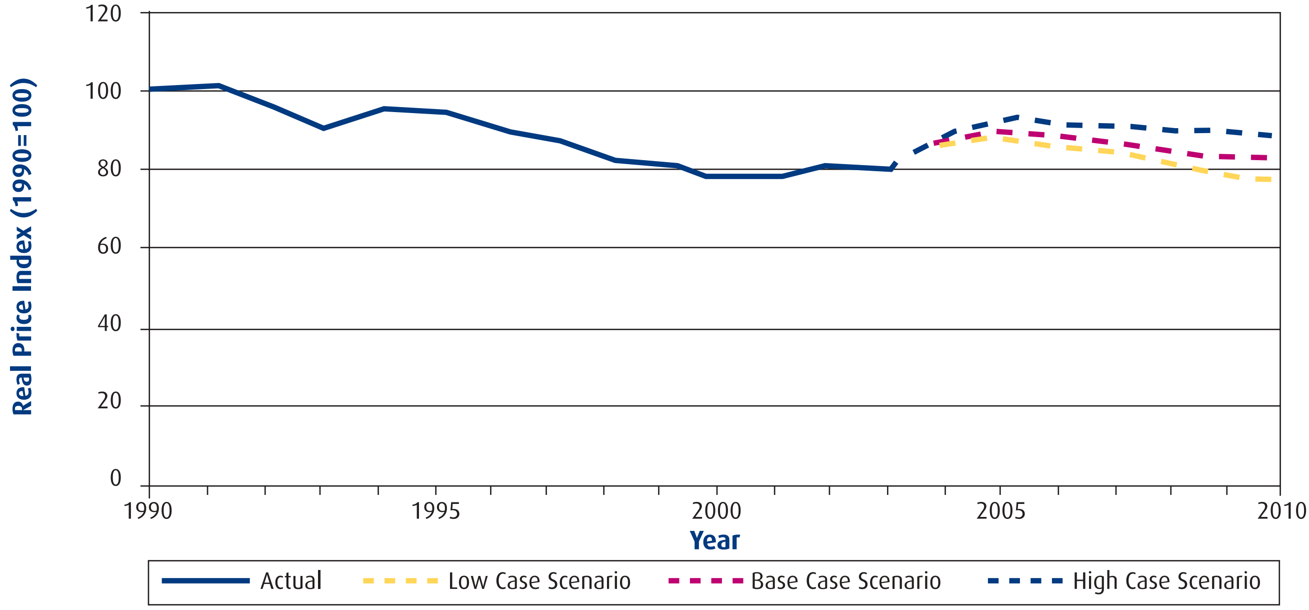
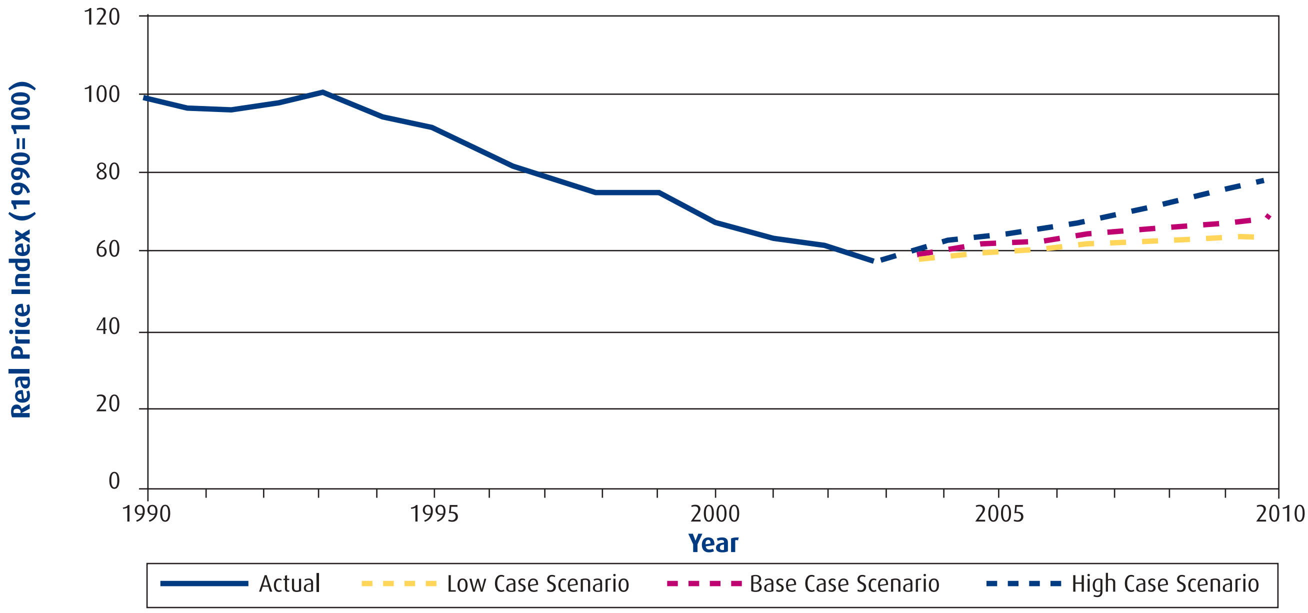


Figure 4.3 UK real price index for domestic electricity (DTI, 2004b)



Instead, it appears these official projections assume that the world price of oil will remain relatively stable in the foreseeable future and, perhaps, that natural gas prices can be de-coupled from world crude oil prices even if these eventually increase permanently. However, the recent trend of increasing world crude oil prices suggest that the effects of approaching peak oil production are now beginning to have a fundamental impact on current and future oil markets. Hence, it is probable that previous conventional thinking on world crude oil prices and UK fuel prices may have to be revised radically.

Although there are no published statistics on prices for non-domestic consumers of conventional heating fuels in Scotland, some limited national data are available for small manufacturing industries across Great Britain (DTI, 2004b). These prices are presented for illustrative purposes in Table 4.2 and they indicate the challenge faced by wood fuel to compete outside domestic, some public sector and niche markets.

Table 4.2 Comparison of fuel prices for small manufacturing industry consumers in Great Britain

Type of Fuel	Price (pence / kWh)
Coal	1.00
Natural Gas	1.45
LPG	1.99
Gas Oil	2.42
Electricity	4.40

Note: Values shown are provisional average unit price, including CCL and VAT, in Great Britain for Q3 2004 (DTI, 2004b).

4.4 Opportunities for wood fuel heating in Scotland

This analysis of the competing prices of conventional heating fuels in Scotland suggests that the immediate opportunity for the current development of wood fuel heating systems occurs in areas where the natural gas network does not penetrate. In the off-gas areas, the economic basis for wood fuel heating systems is set by the prices of coal, electricity, heating oil and LPG. Significant fluctuations on an underlying upward trend in prices for these heating fuels can be expected in the foreseeable future. This should improve the full life economic feasibility of wood fuel heating systems, especially in rural areas of Scotland where other considerations, such as local wood fuel resource potential, are advantageous. Uncertainty over future natural gas supplies and their price will determine whether wood fuel heating systems can operate viably in urban areas of Scotland. Once alternative heating costs rise enough to give reasonable commercial payback times on wood-fired heating systems then the growth in commercial scale and public sector wood fuel installations should expand rapidly.

5 Cost comparison

5.1 Basis of cost comparison

Any evaluation of the potential for wood fuel heating must consider its associated economic costs and how they compare with the cost of heating from conventional sources of energy, such as fossil fuels and electricity. In order to provide a basis for comparison, the essential features of the three Case Studies introduced in Section 2, and presented in Appendices A, B, and C, are used to illustrate both capital and running costs. These simulated costs can then be compared with the costs of installing and operating equivalent natural gas, burning oil and LPG heating systems. Assumptions and brief details of the simulation of costs for wood fuel heating systems are summarised in Appendix F. By approaching the economic evaluation in this way, it is possible to simulate and compare the costs of producing heat from the three typical types of wood fuel: wood chips, wood pellets and logs. It should be noted that, owing to the volatility of prices for fossil fuels, especially those derived from oil, relative to stable price of locally-produced wood fuel, cost comparisons can change quite markedly over time. In particular, if fossil fuel prices continue to increase it will be necessary to re-calculate the costs of conventional heating systems. In order to achieve a more generic comparison, it is possible to demonstrate, graphically, how typical wood chip prices and typical running costs relate to prices of the main competitive fossil fuels.

5.2 Costings

5.2.1 Capital costs

Wood fuel heating has a huge potential in Scotland; a quick glance at its use by our European neighbours is enough to illustrate the extent to which it could be used in future. Wood fuel-fired boilers and heating systems are robust, highly-engineered and sophisticated items of equipment with a longer life than typical mass-produced gas- or oil-fired boilers, but wood fuel storage and delivery systems are large and costly. The size of the combined boiler-room and fuel store often necessitates the use of a separate boilerhouse building whereas a natural gas- or oil-fired boiler will fit in a small room that is usually integrated into the building which is being heated. For these reasons, the capital costs of automated wood fired heating systems can be as much as five times higher than for fossil fuel-fired heating systems.

It is worth pointing out, however, that the capital costs of wood fuel systems fired by pellets are lower than wood chip systems because the pellet fuel is more compact and flows more easily, so less mechanical handling is required. Wood pellet stores are smaller and can be filled relatively easily using sacks or pneumatic delivery. Wood chips, on the other hand, have to be delivered by tipping or push-off trailers which necessitates using an extra high building with large doorway or an underground fuel store; both add significant cost to the project. Loose pellets can be stored in any square or round room suitable for the agitating mechanism, or in a metal silo.

Table 5.1 gives, by way of example, the capital costs of a number of different wood fuel-fired installations including those types illustrated in the Case Studies of Section 2. For comparison, indicative capital costs of alternative heating systems which use oil or electric heating are also presented. Thus far, few wood fuel systems have been installed in areas with a natural gas supply. As natural gas prices rise, the running costs of wood fuel heating will also become increasingly attractive in those areas. The capital costs of natural gas-fired heating systems are somewhat cheaper than those which use oil, mainly due to the fact that an oil storage tank is not required, and an even higher capital incentive may be required to persuade natural gas users to convert to wood fuel.

Table 5.1 Comparison of capital cost of wood fuel and non-renewable heating systems

Description of scheme	Approximate price of installed wood-fired heating system	Approximate price of installed alternative heating system
Wood Chip-fired District Heating 51 homes, 460 kW boiler, 400 kW oil boiler, fuel store, boiler house and installation (Appendix A)	£260,000	£153,000 51 individual oil-fired boilers and tanks
150 kW Wood Chip-fired Boiler with Accumulator Tank and Boilerhouse/Fuel Store	£60,000 - £70,000	£10,000 - £14,000 170 kW oil boiler and tank
32 kW Log-fired Boiler including Boilerhouse/Fuel Store, fully installed and plumbed in (Appendix B)	£9,953	£3,500 - £4,000
5kW wood pellet stove with flue. DIY installation. Supplier and installation inc hearth and VAT (Appendix C)	£2,343 (including 17.5% VAT) + £600	Log stove £1,500 Electric heaters £500 (maximum)

5.2.2 Running costs

Running costs for heating systems depend on a number of different elements: fuel costs; calorific value (or heat value) of the fuel (in the case of wood fuels, this is strongly dependent on the moisture content of the fuel); the efficiency with which the boiler converts energy in the fuel into heat; regular O&M costs; and annual servicing costs. For district heating schemes or plant run by an ESCO or O&M company, the expenses of that company must also be covered by the charge for heating. This charge will, thus, include such items as insurance, O&M costs, consumables, electricity for pumps and feed systems, replacement of parts, repairs and maintenance to the boilerhouse building, boiler and pipework, meter reading, administration and billing. Often, the heat charge also covers the cost of financing the capital cost of the boiler and group heating system. For wood fuel heating systems, this full cost is currently higher than it would be for natural gas- or oil-fired district heating systems because of the higher capital cost of the plant and the labour costs involved in running the boilers and in delivering fuel. However, wood chip-fired heating to single buildings provides heat more cheaply than all fossil fuels at March 2005 fuel prices if the capital cost is excluded from the calculation. Whilst the running costs of wood-fired district heating schemes are less that those for oil or LPG heating systems, they are somewhat higher than those for natural gas heating systems. This is the reason why capital grants are still an essential driver to wood fuel heating, at least until the price of fossil fuels rise enough for running cost savings to finance the extra capital costs. Illustrative comparisons of the running costs of wood fuel and non-renewable heating systems are given in Table 5.2.

Table 5.2 Comparison of running cost of wood fuel and non-renewable heating systems

Description of scheme	Approximate running cost of wood-fired heating system	Approximate running cost of fossil fuelled heating system
Wood Chip-fired District Heating 51 homes (460 kW boiler, 300 kW oil boiler (backup only), fuel store and boiler house) heat load of 930,000 kWh (Appendix A)	£27,544 pa 3.15p / kWh includes O&M costs of £14,000 pa wood chip @ £45 / tonne	£37,980pa 4.31p / kWh includes O&M costs of £11,000 pa oil @ 32p / litre
150 kW Wood Chip-fired Boiler with Accumulator Tank and Boilerhouse / Fuel Store heat load 175,000 kWh (single building)	wood chip @ 35% mc £3,500 pa includes maintenance of £400 pa 1.96 p / kWh	Natural gas @ 2.2p / kWh £3,850 pa LPG @ 31p / litre 5.58p / kWh £9,765 pa oil @ 32p / litre 3.22p / kWh includes £100 boiler service £5,635 pa
32 kW Log-fired Boiler including Boilerhouse / Fuel Store heat load 2600 kWh (Appendix B)	logs @ £50 per tonne £577 pa without maintenance costs 1.92 p / kWh	oil @ 32p / litre 3.5p / kWh includes £100 boiler service £1,049 pa
5kW wood pellet stove heat load 2,065 kWh (Appendix C)	bagged pellets @ 267 / tonne 8.9 p / kWh £180 inc £60 service. (the price of pellets is expected to reduce this year to around £150 / tonne)	electricity 9p / kWh £182 pa LPG heater 6.35 p / kWh £129 pa

5.2.3 Sources of cost data

Information on the capital costs of installations and the cost of wood fuel for the Case Studies has been obtained directly from the users. For the fossils fuels used in the cost comparisons, the cost of electricity and natural gas in the region has been obtained from websites such as "uswitch" and "simplyswitch" that give a range of current fuel prices from different suppliers. The price of oil, coal, anthracite and LPG has been obtained by contacting fuel suppliers in Scotland. An average price based upon this information and, in the case of transported fuels, the delivery distance has been estimated. As the log boiler and pellet stove installations are some distance from a sizeable town, a higher price has been used in the comparisons than would apply for installations nearer to distribution points. The wood chip price was derived from a published source (Luker, 2004) and represents an average price per tonne of chip at 35% moisture content, wet basis. It should be noted that wood chip can be found with prices as low as £25 per tonne, or as high as £55 per tonne depending on moisture content, delivery distance and local market conditions.

5.3 Simulated cost comparisons

The main features of the wood fuel heating systems included in simulated unit cost comparisons can be summarised as follows:

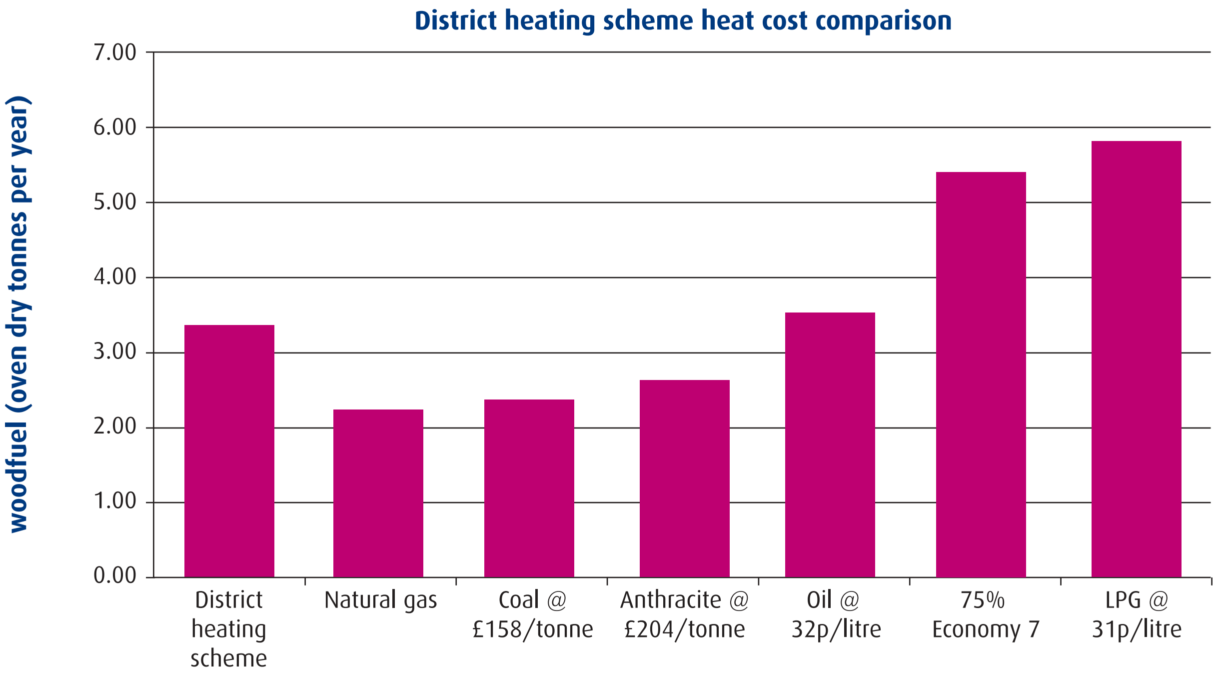
- Medium-scale 460 kW Automatic Wood Chip Boiler; typical district heating scheme for housing
- Small-scale 150 kW Automatic Wood Chip Boiler; heating for workshops
- Manually-loaded 5 kW Wood Pellet Stove; heating for a holiday log cabin in Aviemore
- Manually-loaded 32 kW Long Log Boiler; heating for a private house in Fort Augustus

Simulations represent the type of wood fuel heating system typified by the three Case Studies described in Appendices A, B and C, plus an example involving a wood chip-fired boiler for a single building. Details for these Case Studies are summarised in Appendix F. The unit cost comparisons shown here represent running costs and exclude capital costs. Unit costs for wood fuel heating are compared with those for non-renewable heating including anthracite, coal, electricity, LPG, natural gas and oil. In the case of electricity, it is assumed that 75% of heating is provided by storage heaters charged at the "off peak" Economy 7 tariff whilst the remaining 25% is supplied by supplementary electric heating based on the higher "on peak" Economy 7 tariff.

5.3.1 460 kW Wood chip boiler for district heating

Figure 5.1 shows the running costs that might be expected for a district heating scheme such as Whitegates at Lochgilphead with a heat load of 1,000 MWh per year. Figure 5.1 compares the unit cost per kWh of wood chip-fired district heating with the cost of heat from fossil fuel-fired boilers in individual homes. A boiler efficiency of 75% to allow for down-rating and losses within the pipework has been assumed. The estimated O&M costs of £14,000 for the district heating scheme have been included in the calculation. Maintenance costs, such as boiler servicing and flue cleaning, have also been incorporated for the fossil fuel-fired boilers. This has been assumed at £80 to £100 per boiler per year. The unit cost of 3.36 pence per kWh for district heating would be the minimum that a heat supply company could charge to cover its costs (but without a profit element or any contribution to financing the capital costs) including purchasing the wood fuel at £45 per tonne. If sufficient wood chip could be found from a source close to the boiler installation, or a cheaper contract with a fuel supplier could be negotiated, the wood fuel price may go down, which would result in a more competitive heat charge for wood fuel heating. With a wood fuel price of £45 per tonne, Figure 5.1 suggests that the wood fuel district heating is more expensive to run than conventional individual heating systems using natural gas, house coal and anthracite. However, natural gas is not available for much of Scotland, including the areas in which all of the Case Studies are situated. House coal and anthracite are labour intensive since the householder is involved in ordering and handling the fuel and cleaning the boilers. Additionally, fuel storage facilities are needed. Another less easily quantifiable cost of solid fuel is the amount of pollution and greenhouse gases they produce and the costs of ill health connected to poor air quality. Burning wood fuel would improve the air quality and general health of the neighbouring population.

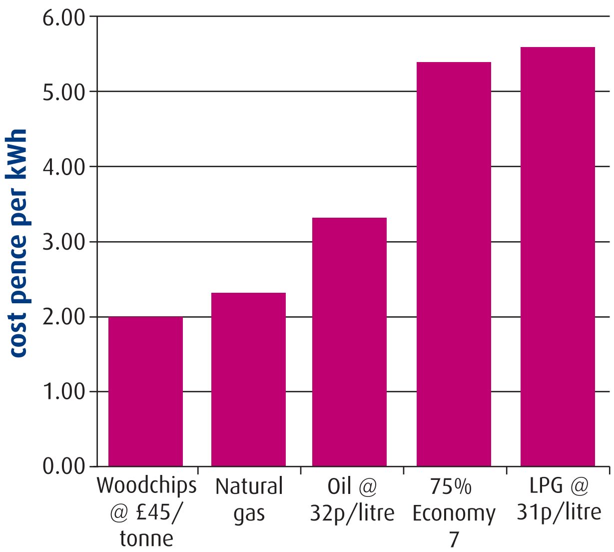
Figure 5.1 Comparison of unit heating costs of a 460 kW wood chip boiler for district heating



5.3.2 150 kW Wood chip boiler for a single building

Figure 5.2 illustrates the difference in running costs between a wood chip-fired boiler in a single building with a heat load of 175,000 kWh per year and a boiler serving a district heating scheme above (see Section 5.3.1). The seasonal boiler efficiency has been assumed at 85% and the delivered cost of wood chip fuel at £45 per tonne. The O&M costs associated with district heating do not apply as there is little pipework and these costs have been replaced by annual servicing and cleaning, and a nominal sum paid to a caretaker for de-ashing and attending deliveries. This has been assumed at £400 per year. It is unlikely that solid fossil fuel, such as house coal or anthracite, would be used in this situation, so the costs of these alternatives have been excluded. A comparable boiler using oil or LPG would entail higher service costs than for the small individual boilers shown above in the district heating but, as the overall heat load is higher, the unit cost of oil and LPG is less per kWh. The fossil fuel costs include a small amount of £80 to £100 per year for servicing where applicable.

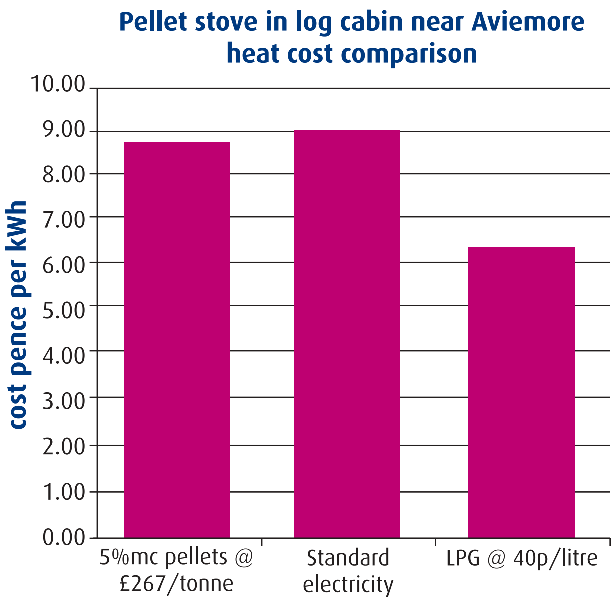
Figure 5.2 Comparison of unit heating costs of a 150 kW wood chip boiler in a single building



5.3.3 5 kW Wood pellet stove for a holiday log cabin

The unit costs for heating the log cabin presented in Figure 5.3 shows only the running costs of the wood pellet stove, electric heating and a space heater burning LPG. Due to safety reasons, wood logs, coal and anthracite have been discounted as suitable heating fuels in this instance. As there is no central heating, an oil boiler is not considered to be appropriate. The cabin is in an "off-gas" area so there is no comparison with the unit costs of natural gas-fired heating

Figure 5.3 Comparison of unit heating costs of a 5 kW wood pellet stove for a holiday log cabin

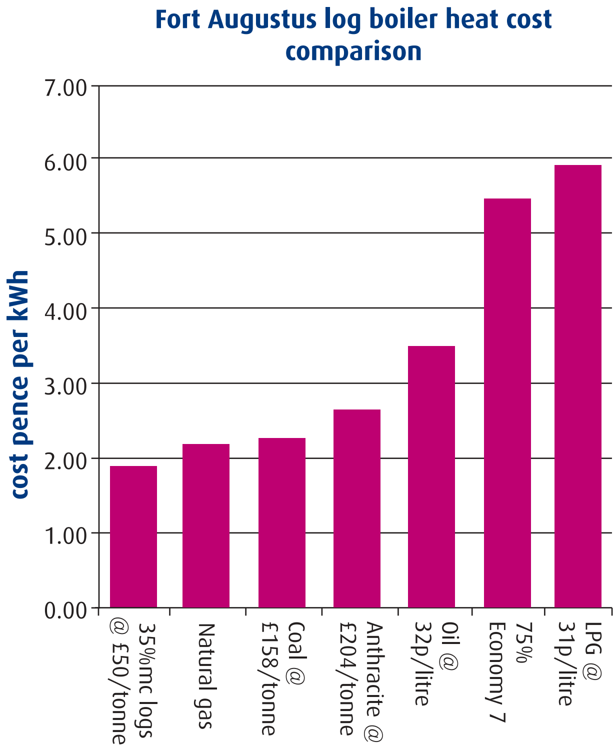


Although heating with wood pellets at 5% moisture content, it is cheaper than standard daytime electricity, but more expensive than using LPG for heating using free standing heaters. It is expected that as more wood pellets are produced locally and more suppliers are established, the price of this wood fuel will drop from the £267 per tonne paid by this user. The current base price for loose pellets in accessible locations is now about £125 per tonne. For bagged pellets, such as those above, the cost will necessarily reflect the cost of bagging. It is also anticipated that LPG will increase in price in line with world crude oil prices.

5.3.4 30 kW Long log boiler for a private house

In Figure 5.4, it can be seen that the logs provide the cheapest form of heating in this particular situation. In the actual Case Study, the wood fuel is collected by the building owner who does not place a value on his own time and the only expenditure involved consists of the fuel used in transportation. An average price for dry, split logs delivered for £50 per tonne (35% moisture content) has been used in the calculation to give an indication of the running costs for users who have to buy fuel. A seasonal boiler efficiency of 85% has been assumed.

Figure 5.4 Comparison of unit heating costs of a 30 kW long log boiler for a private house



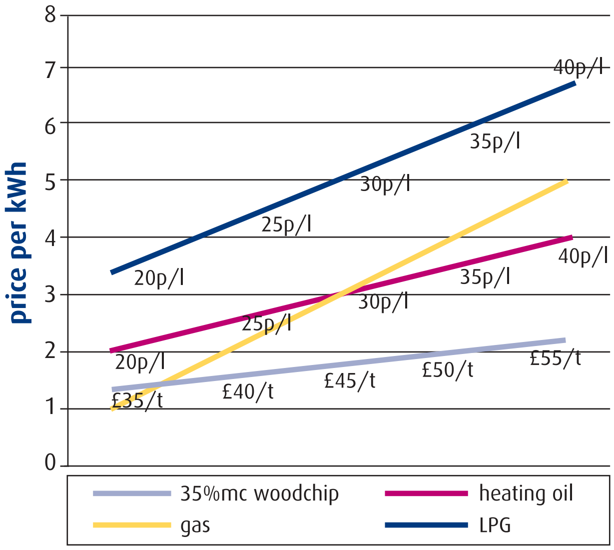
5.4 Generic comparisons with fossil fuel prices

It is possible to make generic comparisons between the unit price of wood fuel and prices for conventional heating fuels by means of nomographs which translate the price of these fuels, in terms of their original purchased units, into comparable costs per unit of useful energy. In such nomographs, prices are shown for each fuel in their original units (specified by the line for each fuel) and these are related to their subsequent unit costs (given on the vertical axis in pence per kWh), These unit costs do not include maintenance charges but they do take into account typical boiler seasonal efficiencies. It should be noted that prices for natural gas are already given in pence per kWh and, hence, this information is excluded from the nomographs to avoid confusion. The purpose of these nomographs is to illustrate the point at which it becomes competitive to use wood fuel instead of conventional fuels.

5.4.1 Wood chip

Figure 5.5 shows a range of prices for conventional heating fuels and for wood chip at 35% moisture content. This indicates that natural gas at prices less than 1.6p per kWh is the cheapest heating fuel. Once the natural gas price rises above 1.6 pence per kWh, wood chips at about £38 per tonne become competitive as a source of heating. Figure 5.5 demonstrates that wood chip is already cheaper than heating oil or LPG for heating purposes. It has been assumed that 20p per litre is the minimum price that would be paid for both heating oil and LPG. Gas prices vary from one supplier to another and depend on the quantity of gas purchased. Large users such as local authorities usually collaborate in order to negotiate lower prices for bulk purchase.

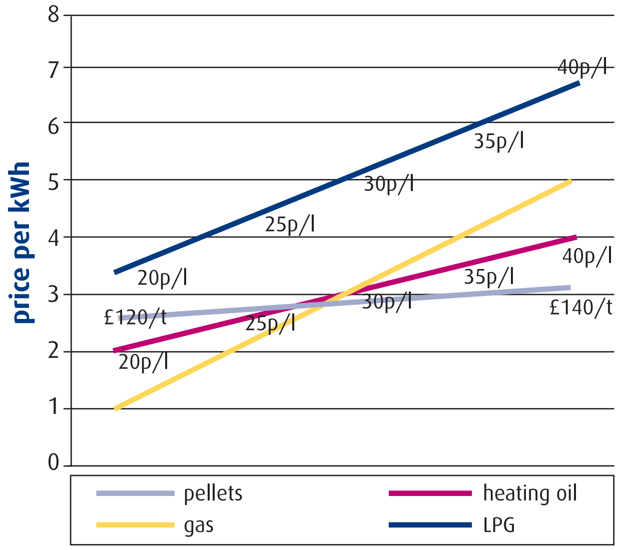
Figure 5.5 Comparison heating costs for wood chips, natural gas, heating oil and LPG



5.4.2 Wood pellets

Figure 5.6 shows the same conventional heating fuel prices as Figure 5.5 but compares these with the cost of wood pellets. It indicates that wood pellets at £140 per tonne equates to natural gas at about 3p per kWh. If pellets become available at less than £140 per tonne and natural gas rises to around or above 3p per kWh then pellets become competitive. At £120 per tonne (2.5p per kWh), wood pellets may be competitive with natural gas provided that the wood pellet price includes delivery charges. It should be noted that £125 per tonne is about the current base price for bulk wood pellets in reasonably accessible areas. However, delivery distances in Scotland are a critical cost consideration until a wider pellet distribution network has been established. The price of £200 per tonne (4p per kWh) shown in Figure 5.6, which represents pellets in 15kg bags or for pellets delivered in a dumpy bag, would be competitive only if natural gas prices rise above 4p per kWh, or heating oil costs rise above 35p per litre. It should be noted that as pellets become more readily available, their purchase price is expected to drop.

Figure 5.6 Comparison heating costs for wood pellets, natural gas, heating oil and LPG



5.5 Cost implications for wood fuel heating in Scotland

The running costs of wood chip-fired heating schemes are encouragingly competitive with the running costs of oil-fired heating systems in most areas of Scotland (assuming a heating oil price of 32 pence per litre in March 2005). Heating with wood chip sourced at below £37 per tonne and burnt in individual boilers is also cheaper than natural gas-fired heating at current prices. When wood chip is burnt in district heating schemes, the unit cost of heat is higher due to the running cost of the ESCO but is still competitive with heating with oil at today's prices in individual boilers. The capital costs of wood fuel heating systems are up to five times more expensive than their fossil fuel-fired equivalent. Hence, it will be appreciated that capital costs are acting as a disincentive to invest in wood fuel heating systems. If fossil fuels stabilise at these current high prices or increase, and in remote rural areas of Scotland where fossil fuels are always expensive, then the prospects for wood fuel heating are promising, and the market looks set to grow provided that capital grants continue to be available. In other more accessible areas of Scotland and if fossil prices continue to fluctuate, potential users will face a difficult decision before committing to wood-fired heating and may need further incentives before investing in this option.

The wood pellet industry is even less developed than that for wood chip supply. The lack of local suppliers and subsequent high transport costs currently places wood pellets at a running cost disadvantage in Scotland. Aside from these present difficulties, however, wood pellets are an attractive fuel and the capital costs of installation are not as high as those of a wood chip heating system. Despite this, they are high enough to act as a disincentive to purchase wood pellet systems to those for whom economics are the key deciding factor. In contrast, the market which is currently developing seems to be mainly composed of those who want to avoid reliance on fossil fuels and are prepared to buy a pellet system despite its immediate higher running costs (this could be equated with purchasers of Aga cookers who buy for non-cost reasons, such as ambience, cosiness, tradition, looks, etc., and certainly not because such cookers are the most economical type of cooking appliance). Under existing market conditions, the capital cost disincentives of wood fuel and the running cost disadvantage of wood pellets would need to be overcome by effort with raising awareness of the non-monetary benefits of wood fuel heating. The attractions of ambience, security of supply, community, local jobs creation and the significant advantage of combating global climate change would need to be widely promoted. However, these issues become somewhat less prominent if fossil fuel prices continue to rise and the economic advantages of wood pellets increase so that this important wood fuel can expand outside current niche markets.

6 Wood fuel heating supply chain

6.1 Elements of the wood fuel heating supply chain

The supply chain for wood fuel heating covers a wide range of separate industries, including forestry, transport, farming and land ownership, sawmills, forest and woodland equipment suppliers, heating plant suppliers and installers, central heating firms, ESCOs and O&M companies, consultants, advisory and funding services. Figure 6.1 illustrates the basic elements that need to be drawn together to provide an operational wood fuel heating supply chain. The system involves action at many levels. On one hand, strategic action is needed to design and implement effective supply chain solutions. On the other hand, specific services need to be developed to interact directly with users who want to install, maintain and run wood fuel heat systems. Between these extremes, facilities such as supply depots and billing and metering systems are needed as part of a wood fuel supply infrastructure. The options for producing and delivering wood fuel are very diverse, and Figure 6.2 illustrates the main production routes in more detail.

Further information on technical aspects of the supply chain is presented in Appendix G whilst key aspects are summarised here. The technology for fuel processing (e.g. chippers and pellet mills) is well-developed and used in other parts of Europe. However, it is not necessarily readily available or in use for fuel production in Scotland. Locally-produced wood chips and imported pellets are available. Transport distances should be minimised for these fuels to be economical. Fuel distributors require large buildings for bulk fuel storage to ensure a supply of suitable fuel throughout the winter. The associated high capital costs and a small market are deterrents to potential investors. Fuel storage is also an additional cost for the consumer, especially if chips are delivered by tipping vehicle (the most widely used delivery method, which requires an underground store). Alternative delivery vehicles are available but these are expensive. Again, with a small and dispersed market, there is little incentive for a fuel distributor to invest heavily in delivery equipment. High quality wood fuel boilers and stoves are available, mainly imported from Europe. Installation is, at present, carried out by a small number of specialist companies, because demand is as yet insufficient for non-specialist heating engineering firms to commit to necessary training. Installers need to be familiar with issues which arise when integrating imported equipment into UK plumbing systems, and high quality imported controls should be used to ensure optimal performance of wood fuel heating equipment. Installation, servicing and maintenance are currently carried out by a few small companies (the largest Scottish company has four staff), each covering a wide area.

Figure 6.1 Essential elements of the wood fuel heating supply chain

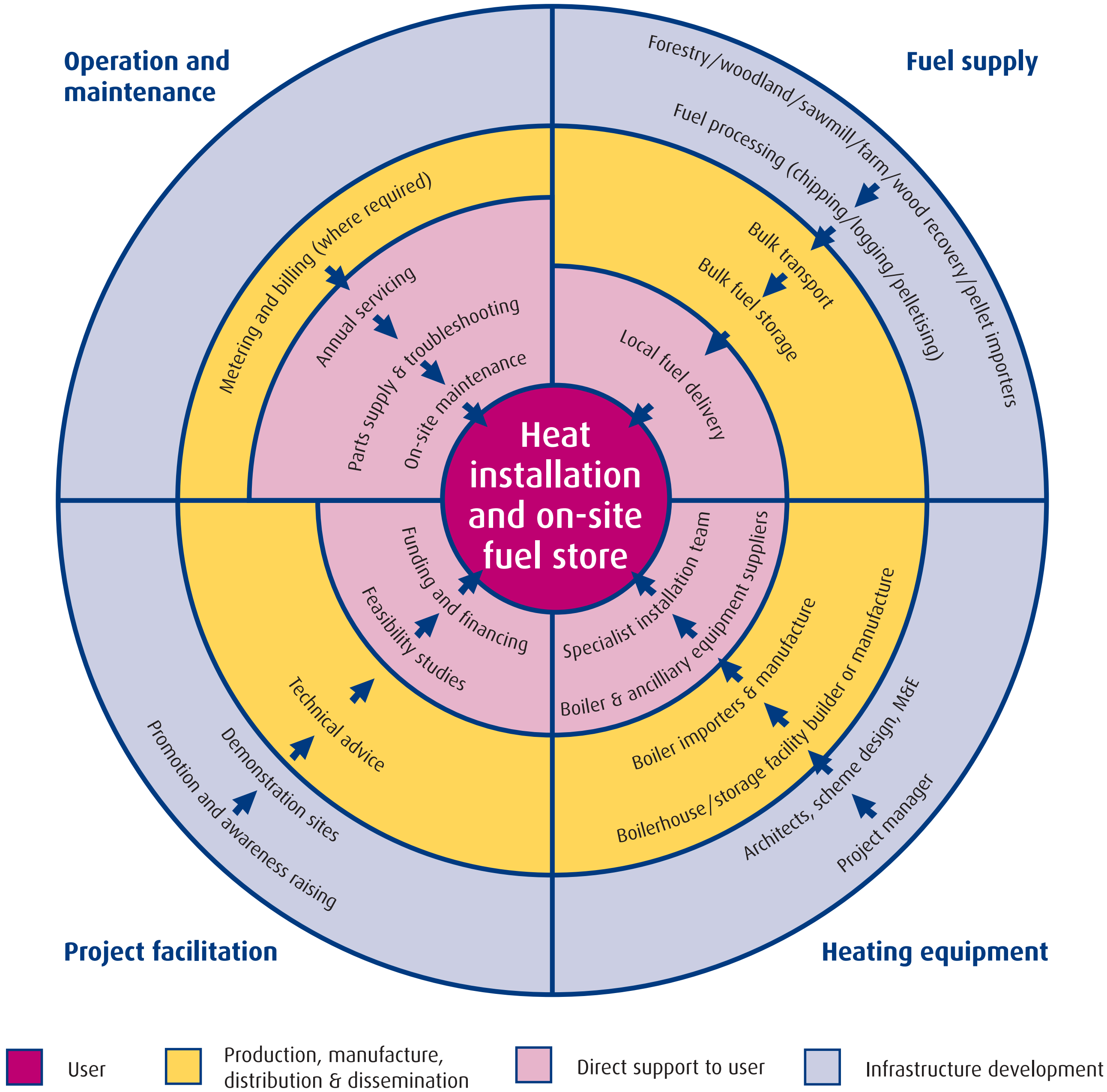
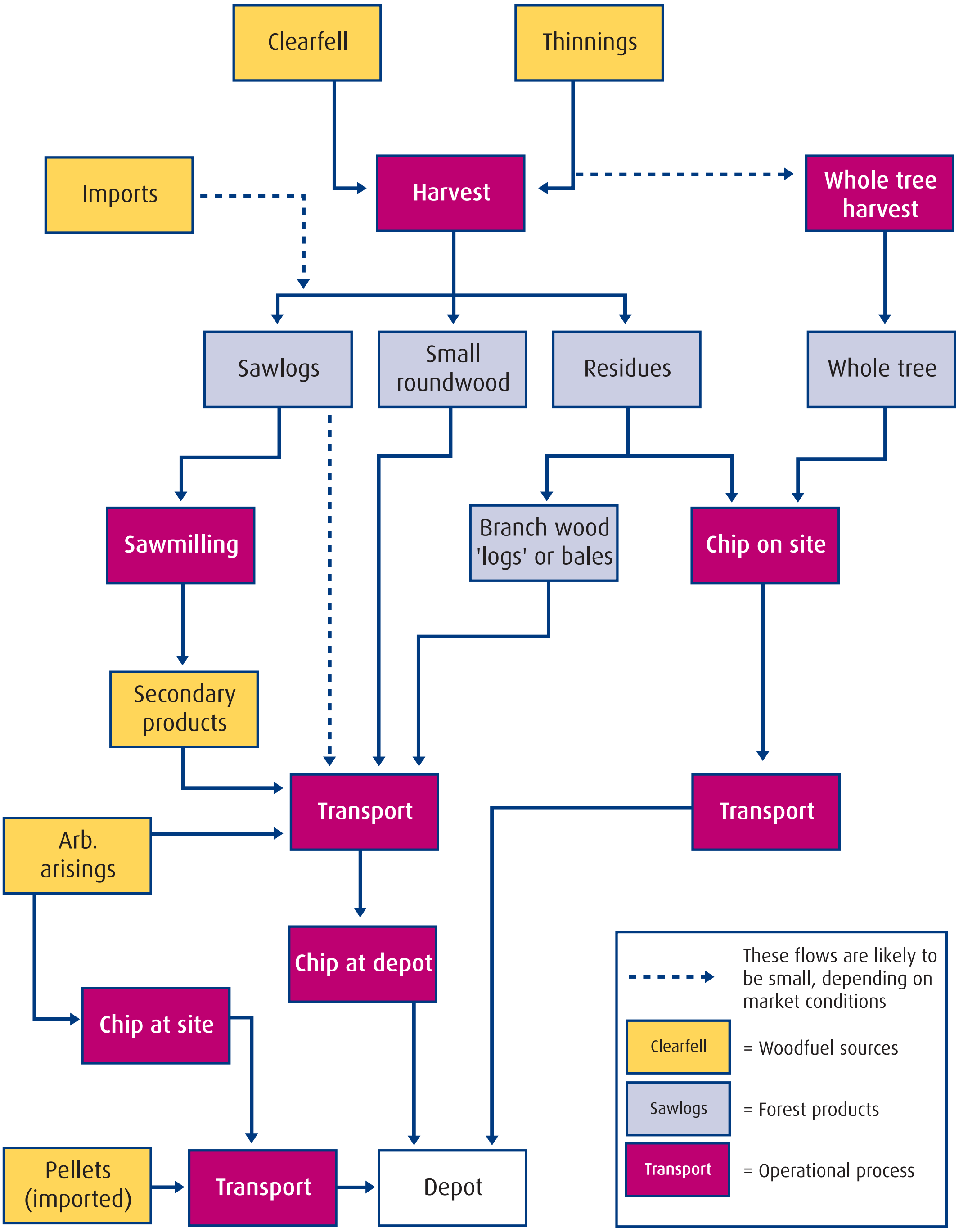


Figure 6.2 Main production and supply routes for wood fuel



6.2 Considerations for the wood fuel heating supply chain

Successful development of the wood fuel industry depends on the whole supply chain being in place. This needs to be complete even to deliver heat at one small installation. For a "self-supply" situation, this can be relatively straightforward but the cost of setting up the full supply chain can be considerable if new buildings and vehicles are involved. There are ways of addressing this issue and current examples in Scotland can be summarised as follows:

- Heating plant is installed on sites where there is a wood fuel supply readily available under the control of the same owner. Actual examples of this include installations at sawmills and on estates or farms with forestry.
- Once a wood fuel supply is available in, for example, a "self-supply" situation, then that supplier is able to supply other installations nearby. Promotion and awareness-raising in a tight geographical locality to form a wood fuel cluster can be effective for developing new installations.
- ESCOs, which can be commercial or social enterprises, assume responsibility for the whole supply chain and, sometimes, even take care of the financing of the capital cost.

Other options, which are not yet represented in Scotland but have potential, consist of:

- Project engineering groups which specialise in 'whole' project management. Such companies have a range of expertise and will install, build and project-manage at almost any scale, across a range of applications, which could include heating schemes. The best example in relation to wood fuel in the UK is West Dean College in Sussex which has been operating successfully for 20 years.
- Contract energy management companies which take over the full management of energy use and energy supply in a building or group of buildings. These are normally large corporate companies which can finance energy saving measures, new boilers, etc., and purchase energy at advantageous rates. New plant and equipment is usually paid for from savings in running costs over a period. In principle, such companies could install wood fired boilers, although no examples are yet known in the UK.
- Public Private Partnership consortia comprising of commercial companies which group together to contract for the design, building and day-to-day running of public sector buildings such as hospitals and schools. They are committed to such projects for the long term and some Scottish consortia have already expressed interest in using wood fuel heating because of the potential savings in long term running costs.

A possible suggestion for the more densely populated areas of the Central Belt of Scotland is a strategically located "wood fuel refinery". Such a development could accept clean, untreated wood from a variety of sources and in different forms and moisture contents and process it to a given fuel specification. It could also invest in a variety of delivery equipment to facilitate lower capital cost boiler and fuel store installations, manufacture wood pellets, briquettes and soil conditioner, undertake ash collection and disposal, and, if required, provide full ESCO or O&M functions.

The development of "wood refineries" could also offer a very important opportunity for engaging with the existing wood-using industries and growers in Scotland. Sawmills, boardmills and paper mills already represent sophisticated centres for processing wood into a range of products. These processors are well placed to make a key contribution in the development of more comprehensive wood refineries, producing and supplying a range of wood fuel types alongside other wood-based products.

The concept of clustering is an important one in wood fuel heating. It is generally accepted that, from a commercial perspective, the transport distance of low value, high bulk fuels like wood chip or logs should be minimised. This requires each fuel supplier to supply a group of heating installations. In order to ensure that such clusters develop fast enough to provide a viable business for the fuel supply chain then pro-active promotion and technical advice is essential. The process can be facilitated by a number of organisations which are already offering advice and undertaking promotion. The Forestry Commission is currently appointing Woodfuel Project Officers and the first is already in post in the Highland Region. A list of organisations providing wood fuel energy advice is given in Appendix H.

The supply chain for automated wood fuel heating is at an early stage. With only approximately 50 heating installations in Scotland, it is obvious that, up to now, the market has not provided a great incentive for the existing wood fuel industry to prepare for growth. However, as fossil fuel prices are rising, concern about climate change increases and government target dates for reduction in greenhouse gas emissions get nearer, the incentives to install wood fuel heating are starting to become stronger. In areas where advice, encouragement and financial incentives exist, there is a growing interest in wood fuel heating. This suggests that, with the same conditions elsewhere, successful replication is possible. Anecdotal evidence suggests opportunities for a number of proposed wood fuel heating developments, for example, along the A9 corridor where there is good access to potential wood fuel supplies. However, the equipment supply chain is limited by the capacity of the small firms supplying and installing equipment. The fuel supply chain, although functioning well in some locations, is certainly embryonic or non-existent in many places. There is little choice for the consumer and often no alternative if the initial wood fuel supply should fails for any unavoidable reason. The disincentives to preparing for wood fuel supply expansion, in terms of capital costs, are significant and, if it is to happen, considerable practical and financial support will be needed for the infant wood fuel industry to enable it to become fully commercial against a currently-competing fossil fuel background of fluctuating yet steadily-rising prices.

7 Emission and employment benefits

7.1 Greenhouse gas emissions

One of the major advantages of wood fuel heating systems is that they can achieve significant reductions in total emissions of greenhouse gases, principally carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O), which are implicated in global climate change. It is necessary to determine the net savings in greenhouse gases of wood fuel heating systems relative to current conventional heating systems that are reliant on fossil fuels in order to evaluate benefits appropriately for policy-makers and to demonstrate these benefits to a wide audience. Thorough and systematic analysis which takes into account the main wood fuel heating systems and key considerations, such as thermal efficiency, heat output rating and wood transportation distance, is required to provide reliable and convincing estimates of relative savings. This helps to underpin one of the main arguments in favour of wood fuel heating systems and to dispel misleading myths used as objections to major schemes.

7.1.1 Basis for evaluating emissions

Conventional heating systems which consume coal, heating oil, LPG and natural gas emit greenhouse gases directly as a consequence of the combustion of these fossil fuels. Heating systems which are based on electricity are responsible for indirect emissions of greenhouse gases due to the combustion of fossil fuels in power stations that supply the national grid. Additionally, indirect greenhouse emissions arise for all other aspects of the complete life cycle of any heating system, mainly as a result of fossil fuels being used in fuel extraction, processing and transportation, as well as the manufacture, installation and eventual decommissioning of equipment, plant and machinery. These considerations also apply to wood fuel heating systems. Direct emissions, in the form of CH_4 and N_2O, arise from the combustion of wood fuel. However, whilst CO_2 emissions also occur, an equal amount of this particular greenhouse gas will have been absorbed during the growth of the trees which provide the wood fuel. Hence, in this regard, wood fuel heating systems are often referred to as being “carbon neutral”. Strictly speaking, within a global economy which is still dominated by fossil fuels as the main sources of energy, indirect greenhouse gas emissions, especially CO_2 emitted by the use of fossil fuels in the production and transportation of these fuels, as well as direct CH_4 and N_2O emissions, must be taken into account in any complete assessment of the benefits of wood fuel heating systems. This results in the evaluation of net savings of greenhouse gases by assessing the difference between total (direct and indirect) greenhouse gases of wood fuel energy systems and those of the conventional heating systems which they replace or displace.

In order to simplify the interpretation and comparison of such savings, separate estimates of CO_2, CH_4 and N_2O emissions are converted into equivalent amounts of CO_2 emission by means of their global warming potential (GWP). This takes into account the effectiveness of CH_4 and N_2O as greenhouse gases relative to CO_2. Within the framework and timescale used to investigate current measures to address global climate change, the GWP of CH_4 is 21 kilograms of equivalent CO_2 per kilogram of CH_4 (kg eq CO_2/kg CH_4) and the GWP of N_2O is 310 kg eq CO_2/kg N_2O (IPCC, 2001). It can be seen that, as reflected by their higher GWPs, both CH_4 and N_2O are “stronger” greenhouse gases, weight for weight, than CO_2. However, the total emissions of CH_4 and N_2O are usually significantly lower than the total emissions of CO_2 from both conventional and wood fuel heating systems.

7.1.2 Evaluation of net emission savings

The practical evaluation of net savings of greenhouses gases is normally based on the basic principles of life cycle assessment (ECS, 1997). These principles have been incorporated into work on estimating total greenhouse gas emissions from a range of wood fuel energy technologies, including wood fuel heating systems, in the UK (Elsayed, Matthews and Mortimer, 2003). It is a particular feature of this work that calculations are performed in a systematic and transparent manner based on explicit flow charts which represent the essential features of the system under consideration. This work has been adopted here to derive the net savings of greenhouse gases of current and possible future wood fuel heating systems relevant in Scotland compared with appropriate conventional heating systems.

7.1.3 Comparison of total greenhouse gas emissions

The systems selected to represent conventional heating in Scotland and to provide a baseline against which to compare wood fuel heating systems are summarised in Table 7.1.

Table 7.1 Summary of conventional heating systems

Type of heating system	Seasonal thermal efficiency (%)
Coal-fired boiler and central heating	70
LPG-fired boiler and central heating	80
Oil-fired boiler and central heating	80
Natural gas-fired boiler and central heating	90
Electric radiant heating with thermostats	100

In this evaluation, typical values have been adopted for the seasonal thermal efficiency which equals the amount of useful space and water heating produced by these systems per unit of delivered energy input over a typical heating season. A range of fuel delivery round trip distances have been assumed to cover actual experience in Scotland. The round trip distance is the length of the outward and return journey taken by a vehicle to deliver the relevant fuel to the consumer from the point of supply. In all instances, it is assumed that individual heating systems are used in separate or stand-alone buildings. The range of current and possible future wood fuel heating systems for stand-alone buildings and group building schemes in Scotland are represented by the options listed in Table 7.2.

Table 7.2 Current wood fuel heating systems in Scotland

Options	Heating System	Stand-Alone Buildings	Group Buildings
Current	Stoves and boilers burning logs from woodland management (small roundwood)	✔	
	Stoves and boilers burning logs from arboricultural activities (prunings)	✔	
	Boilers burning wood chips from forestry operations (small roundwood)	✔	✔
	Stoves and boilers burning wood pellets from sawmill operations (offcuts and sawdust)	✔	✔
Future	Boilers burning wood chips from forestry operations (branchwood and thinnings)	✔	✔
	Boilers burning wood pellets from forestry operations (branchwood and thinnings)	✔	✔

Estimates of the net savings in total greenhouse gas emissions from wood fuel heating systems depend, mainly, on the type of system and the conventional heating system with which it is compared, the assumed seasonal thermal efficiency and the fuel delivery distance. Examples are shown in Figures 7.1 to 7.4 and in Appendix J.

Figure 7.1 Comparison of total greenhouse gas emissions from fossil fuel heating systems and a 460 kW wood fuel boiler for a group of buildings using wood chips from forest small roundwood

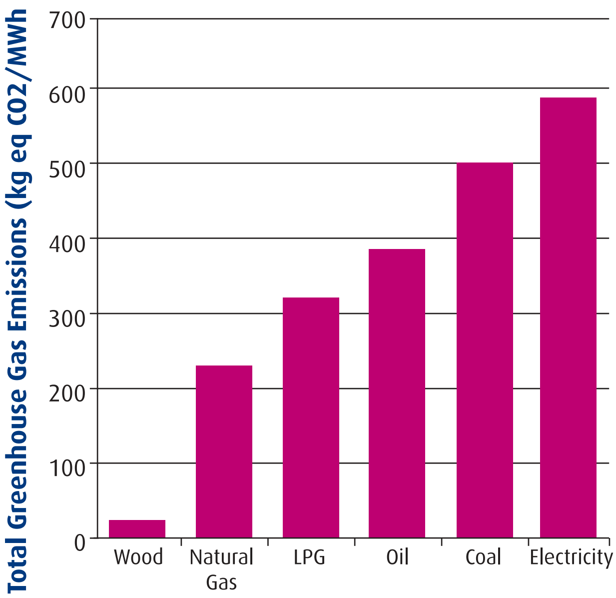


Figure 7.2 Comparison of total greenhouse gas emissions from fossil fuel heating systems and a 150 kW wood fuel boiler in a single building using wood chips from forest small roundwood

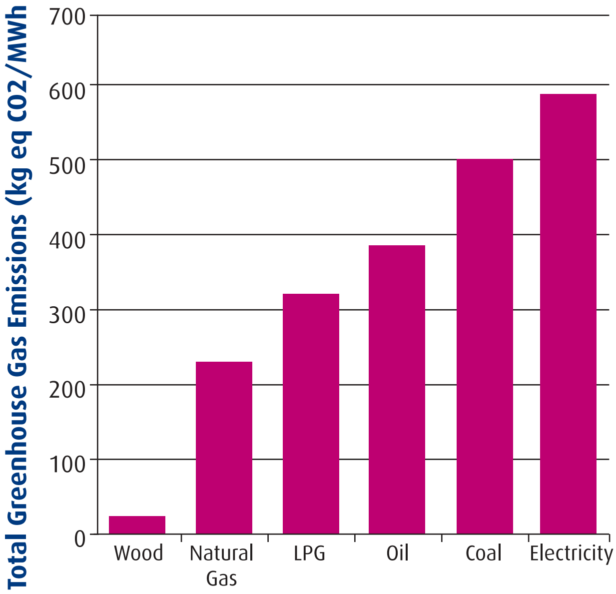


Figure 7.4 Comparison of total greenhouse gas emissions from fossil fuel heating systems and a 30 kW wood fuel boiler in a single building using logs from arboricultural prunings

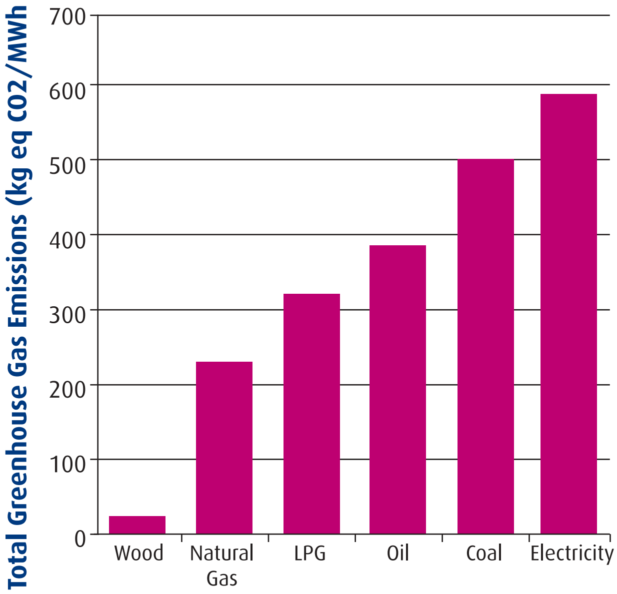
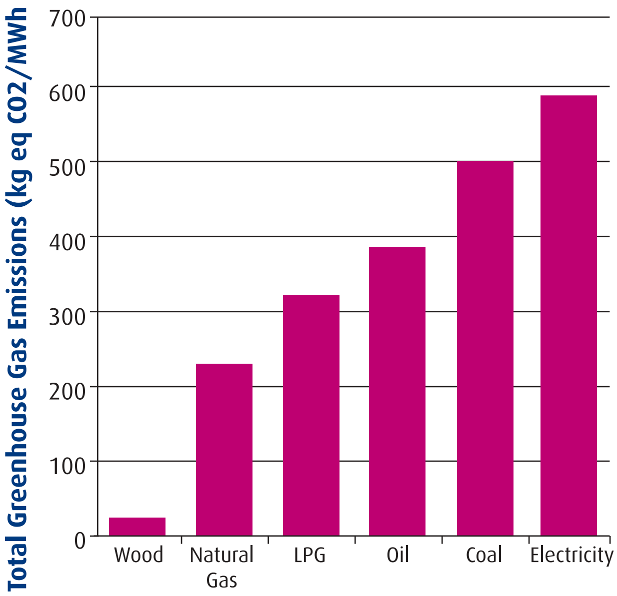


Figure 7.3 Comparison of total greenhouse gas emissions from fossil fuel heating systems and a 7 kW wood fuel stove in a single building using wood pellets from sawmill offcuts and sawdust



The largest net savings in total greenhouse gas emissions, ranging from 89 % to 96 %, can be achieved when wood fuel heating systems replace or displace electric radiant heating supplied by the national grid and coal-fired heating systems. In comparison with LPG- and oil-fired heating, wood fuel heating systems can deliver savings between 80% and 94%. The smallest savings, of between 73% and 90%, are made relative to natural gas-fired heating systems. In all cases, these represent significant reductions in greenhouse gas emissions. Even when very large transportation distances are assumed for wood fuel, positive and large net savings are recorded for wood fuel heating systems. By utilising the wood fuel resource available in Scotland in appropriate wood fuel heating schemes, it is estimated that between 0.6 and 1.4 x 10^6 tonnes of CO_2 emissions could be avoided annually, amounting to between 7% and 23% of total CO_2 emissions from domestic space and water heating in Scotland.

7.2 Employment

Another potential benefit of wood fuel heating schemes is that jobs will be generated, often in rural areas, throughout the supply chain. A Scottish Forestry Industries Cluster (SFIC) report states that megawatt for megawatt wood fuel heating creates between five and ten times more jobs than other renewables technologies which collect energy passively and therefore do not create fuel supply chain employment. In Northern Ireland, Balcas, based in Enniskillen process sawdust and wood chips. They state the plant gives a secure customer for the forestry sector and help protect over 1000 jobs in rural Northern Ireland. In the Republic of Ireland, Sustainable Energy Ireland (SEI) state that current potential for wood fuel heat can create over 1,700 new jobs in construction and installation and over 500 new long term jobs in O&M, in Ireland. SEI predict that by 2020 construction and installation jobs rise to 17,200 and 4,300 jobs in O&M

A report to the Scottish Executive by Future Energy Solutions (Evans, 2004) assessed the direct, indirect and induced employment benefits of the development of wood fuel plant in Scotland. Estimates were made using the BIOSEM model, which was developed specifically to estimate the socio-economic impacts of small wood fuel schemes. Results from this study are reproduced in Table 7.3. It was stated that there will also be temporary jobs associated with construction of equipment, ranging from a few days for a small boiler installation to 5 jobs per MW(electricity) over a period of two years for a power plant.

Table 7.3 Estimated jobs created by development of the wood fuel industry

Option	Jobs created
Smaller CHP	1.5 jobs/MWe for an external fuel supply chain plus 0.5-2 jobs per CHP installation.
Industrial/Commercial Heating	1 job/ boiler (typically 200kW).
Co-firing	1.5 jobs/MWe within the fuel supply chain plus 3 jobs/power plant installation
Merchant Power	1.5 jobs/MWe within the fuel supply chain plus 2-4 jobs/MWe at the power plant.

A subsequent report to the Scottish Executive by the Wood fuel Energy Group (Scottish Executive, 2005a) also quoted estimates of the employment impacts of wood fuel, giving 16 to 18 jobs per MW for industrial, commercial and domestic heating systems. A report on gap analysis for the renewable energy industry in the UK (DTI, 2004d) estimated current employment associated with various renewable energy technologies. In particular, this estimated that jobs sustained by wood fuel energy obtained from forestry products (that is, from forest residues, roundwood, sawmill co-products, etc., rather than energy crops) are currently 19 to 25 jobs per MW generated. Within this, it was estimated that 0.5 jobs per MW could be attributed to the development phase, 15 to 20 jobs to the construction phase and 3.5 to 4.5 jobs per MW to the operational phase. The report also estimated that, in 2003, the total number of jobs sustained by wood fuel in Scotland was 90.

8 Current Government policies

8.1 International context

Global climate change, as the most prominent environmental issue of current times, has the greatest potential for exerting influence on policy-making for any major measure which reduces greenhouse gas emissions, ranging from energy efficiency improvements to renewable energy developments, such as wood fuel heating. The Kyoto Protocol is the mechanism which creates the framework for the policy responses to global climate change. The legally-binding international treaty came into force on 16 February 2005. Globally, the Kyoto Protocol sets a target of reducing greenhouse gas emissions by 5.2% from 1990 levels by the period between 2008 to 2012. In recognition that this is only a very initial step in limiting the worst excesses of global climate change, it has been proposed that greenhouse gas emission reductions of 60% on 1990 levels will be necessary by 2050. The previous 15 Member States of the European Union agreed to a collective target for a 8% reduction in GHG emissions (equivalent to 336 million tonnes of CO_2 per year) from 1990 levels by the period between 2008 – 2012. The official target reduction of greenhouse gas emissions for the UK is 12.5% of 1990 by the period between 2008 and 2012.

8.2 European Union initiatives

The Kyoto Protocol and other major considerations affect the European Union policy framework which can influence the expansion of wood fuel heating in Scotland. Explicit policy on renewable energy for the European Union is based on the White Paper on a Community Strategy and Action Plan on Renewable Energy Sources: COM(97)599 (EC, 1997). Whilst this White Paper has generated specific actions, in the form of European Union Directives that are intended to promote electricity generation from renewable energy sources (OJEC, 2001) and biofuels for mainly transport use (OJEC, 2003), it is widely-recognised that insufficient attention has been paid to encouraging the production of heat from renewable energy sources. Partly in response to this, the European Commission has recently conducted a consultation exercise on a proposed Community Plan for Biomass (EC, 2004a) which it hopes to introduce by the end of 2005. It is intended that this Plan will orientate and optimise Community financial mechanisms for wood fuel, re-direct effort within relevant policies and address barriers. It is recognised that targets for using renewable energy sources, generally, for heating purposes are difficult to establish because "there is no single heating supply industry to whom they could be addressed" (EC, 2004a). However, it is thought that Member State implementation of the existing Directive on the energy performance of buildings (OJEC, 2002) and the Directive on cogeneration (OJEC, 2004) will encourage the greater use of renewable energy for heating. It is felt that additional initiatives will be necessary and it has been suggested that targets could be set for suppliers of heating oil and natural gas to supply fuels from wood fuel, such as wood pellets. Although it is clear that this is a challenging subject for policy-makers, it is equally apparent that concerted and effective action is urgently needed to ensure that renewable heat, in general, and wood fuel heating, in particular, fulfils its undoubted potential throughout the European Union in the very near future. One area where immediate action could be taken is in clarification of definitions as they affect wood fuel under the Waste Incineration Directive (EC, 2000) at the level of Member State implementation. In essence, ambiguity over strict definitions has the potential to cause problems for the potential use of forestry and wood processing industry co-products which would be the subject of unnecessary yet more costly emissions controls if they are inadvertently classed as “wastes”.

8.3 Emissions Trading Scheme

One recent specific measure which provides some assistance to the economic development of schemes which save greenhouse gas emissions, such as wood fuel heating systems, is the European Union Greenhouse Gas Emissions Trading Scheme (ETS). Based on a European Directive (EC, 2003), the ETS was launched on 1 January 2005 and its first phase will run until 2007, followed by further phases over five year intervals. By fixing progressively decreasing limits to greenhouse gas emissions within each Member State and emissions allowances for individual installations, a market in carbon dioxide has been created. Companies which emit less carbon dioxide from their installations than their allowances can sell their surplus to companies which have exceeded their allowances. The ETS oversees transactions which, through the balance of supply and demand, establish a price for carbon dioxide emissions. This has created the opportunity to offset emissions by means of savings generated by schemes such as wood fuel heating systems. Hence, initially small payments are starting to be offered to the operators of some wood fuel heating systems in order to “buy up” their carbon dioxide savings. This provides another form of economic support to current and planned wood fuel heating systems whilst contributing to overall reductions in carbon dioxide emissions. The extent of this support should grow as the price of carbon dioxide increases in the future.

8.4 UK Government policies

In addition to the government’s commitments under the Kyoto Protocol, there is an aspiration to achieve a 60% reduction in greenhouse gas emissions in the UK by 2050. As a result, numerous measures and incentives have been put into place to encourage energy efficiency improvements and to substitute fossil fuels with alternative ‘low carbon’ technologies and systems. The majority of these measures and incentives are aimed at electricity generation. In particular, the Renewables Obligation targets utilities to provide electricity from renewable energy sources with penalties for those which do not comply. This policy instrument, which is generally regarded as a positive development, has created an active market for electricity-producing renewable energy sources, through trading in Renewables Obligation Certificates (ROCs). As a single effective measure, it is making a relatively rapid and discernible impact by modifying the operation of private companies within a regulated market. However, some concerns are now being raised about the importing of large quantities for wood fuel from very distant sources by the larger utilities, which is allowable under current arrangements. Additionally, it is recognised that similar reactions by electricity generators in Scotland could cause competition with prospective large-scale wood fuel heating scheme operators for access to the Scottish wood fuel resource.

8.5 Scotland

Although it is clear from the sheer number of initiatives available and range of organisations involved that there is some commitment to the development of wood fuel heating in Scotland, the current extent of incentives available to individuals, communities and businesses is confusing and unclear. Incentives exist for the production of wood fuel (for example, the DEFRA Bio-energy Infrastructure Scheme) and the purchase of wood fuel-burning boilers and similar plant (for example, DTI Bio-energy Capital Grants Scheme; BECGS). Unfortunately the links between these schemes and their differing eligibility criteria and goals may discourage individuals, communities and companies from considering wood fuel heating schemes at the planning stage. The current polices and incentives can lead to a ‘chicken and egg’ situation where grants may be available to develop, say, a wood fuel supply network but not a community heating system that can make use of such a network. Examples of projects that have overcome this problem include the Wood Fuel Development Programme that has been set up with funds from Scottish Community and Householder Renewables Initiative (sponsored by the Scottish Executive). However, this scheme is not accessible to most potential users as it is limited to establishing ‘clusters’ of wood fuel suppliers and end users only in the Highlands and Islands Region of Scotland. In order to make use of the potential of wood fuel as a renewable source of heat, a review of the current policies and incentives should be undertaken and a more cohesive set of initiatives devised that develop wood fuel supply and end use projects simultaneously.

In contrast with policy development and implementation for electricity generation from renewable energy sources, there is a much less coherent and effective approach to the promotion of wood fuel heating. Instead there is a range of measures, incentives and support mechanisms which are currently being used to assist renewable heating schemes, in general, and wood fuel heating, in particular. A summary of current support mechanisms for wood fuel heating in the UK, generally, and Scotland, in particular, can be found elsewhere (see Appendix I). Although such support is welcome, it is not adequate as a basis for the necessary major expansion of the wood fuel heating industry in Scotland. The main drawback of current support appears to be that it is confusing and difficult for potential applicants to access, and, crucially, insufficient for the ambitious growth which the available wood fuel resource in Scotland warrants. A simpler, more focused and more integrated package of effective measures is required. This would be given more impetus if it were set in a clear policy framework, specifically addressing wood fuel heating, with targets for progress.

It would be incorrect to suggest that the demands of combating the causes of global climate change are the only consideration for government policy in this area. Whilst security of supply is another current concern, which reflects the focus of existing European Union energy policy (EC, 2004b), the broader context is practical commitment to sustainable development. Whilst recognising the importance of concerted national action, the UK’s Shared Framework for Sustainable Development emphasises the need for each devolved administration to establish its own priorities and separate strategies for achieving sustainability (Defra, 2005). This would appear to provide opportunities for Scotland to pursue its own specific advantages such as the targeted development of its substantial wood fuel resources for economic, social and environmental benefit. Apart from contributing to the reduction of CO_2 emissions, such a strategy would promote economic regeneration in rural areas and, depending on how wood fuel heating was applied, assist social progress by addressing fuel poverty and community wood fuel heating scheme development. In this latter instance, the role of social enterprises is clearly recognised, although the essential importance of cultural background as well as the fundamental framework of coherent policy and effective means of implementation does not seem to be fully appreciated. This is apparent from the somewhat limited understanding of co-operative approaches to successful energy development elsewhere (DTI, 2004). More appropriate means of achieving community renewable energy development through social enterprises in the UK have, in fact, already been explored (Mortimer and Brindley, 2005).

Whichever ways are adopted to accomplish the economic, social and environmental goals of sustainable development, the Partnership for a Better Scotland (Scottish Executive, 2003) has commitments that that the growth of wood fuel systems link into. Commitments on sustainable growth of the economy, with specific reference to the growth of renewable energy industries, the recently realised commitment to develop a green jobs strategy and the commitment to the diversification of the use of forests and timber are strongly linked to our agenda to see a growth in the wood fuel energy sector.

9 Major barriers and solutions

9.1 Experience of the wood fuel industry

Drawing on the experience of the existing wood fuel industry is essential for identifying the barriers that are hindering the development of the wood fuel heating industry in Scotland. Progress is being made at an increasing pace but, as the wood fuel industry is at such a young stage, there are numerous barriers to more rapid development. Due to the complications of the wide supply chain of wood fuel heating, a somewhat simplified approach has been taken to the analysis of the key barriers and solutions. In practice, there are significant differences in the support offered to the wood fuel industry in different geographical areas. Hence, it is more developed in some places than others. Subsequent analysis identifies generic barriers but it should be borne in mind that some will apply more in some geographical areas than others.

The wood fuel industry, so far, has developed largely due to enthusiasts and champions. These have mainly been individuals and very small firms with a "green agenda" or a need to find a use for low value timber. In the recent past, public organisations such as DEFRA, the Forestry Commission and the Scottish Executive have encouraged and facilitated the use of wood fuel, initially for electricity generation and, now, also for heating. The motivation for this seems to have been twofold: a need to regenerate the rural economy and a commitment to reduce greenhouse gas emissions in order to protect against global climate change.

The supply chain for wood fuel heating covers several previously separate industries: forestry, transport, farming and landowners, forest and woodland equipment suppliers, heating plant suppliers and installers, central heating firms and O&M companies. These industries are backed up and controlled by different and entirely separate support and administrative systems, often with no areas of overlap, and in some cases with policy (particularly around funding) which actually prevents overlap.

The pressure to reduce the emission of greenhouse gases is now bringing the potential of wood fuel into the limelight. Some piecemeal and rushed actions have begun to take place to encourage its use for heating. This has resulted in points of activity in some parts of the country either where funds have been made available or where there is a cluster of enthusiasts. What it is not doing is to address, in a comprehensive and strategic way, the need for steady solid development of a whole new industry. The subsequent list of barriers and potential solutions illustrates the problem, and forms the basis of future strategy and recommendations (see Section 10).

9.2 Analysis of barriers and solutions

This list of barriers and possible solutions has been drawn up has been grouped together and summarised below. Many of the comments on barriers and solutions are also confirmed in other reports (see, for example, North Energy, 2003 and 2005; Ilex Consulting, 2003; NIFES Consulting, 2004; Wood fuel Energy Group, 2005). The barriers can be grouped under five main headings:

- Regulatory barriers
- Barriers relating to cost and funding

- Barriers relating to size of industry, and corresponding availability of skills and advice
- Barriers of perception
- Technical barriers.

9.2.1 Regulatory barriers

A major economic and regulatory barrier is that there is currently no reward or recognition for using wood fuel for heating, as there is for electricity from renewable sources under the Renewables Obligation. Also VAT on domestic wood fuel heating appliances is charged at 17.5%, whereas for all other domestic renewable technology a reduced rate of 5% is charged. There is ambiguity in VAT legislation relating to VAT charged on wood fuel fuel itself. There is confusion and uncertainty relating to classification of certain types of wood feedstock in relation to the Waste Incineration Directive. There is also confusion among potential customers regarding emissions legislation. There is a high cost for boiler suppliers associated with the certification of equipment under the Clean Air Act and pollution legislation, as well as meeting the eligibility criteria for Enhanced Capital Allowances (ECAs). ECAs are unavailable to many organisations wishing to install wood fuel heating (because they do not pay tax), and ESCOs do not qualify for the grant because although they install the boilers, they are not the organisation in receipt of the carbon dioxide savings. UK building regulations (England and Wales) require all newly-installed domestic boilers high efficiency (86% efficient) from April 2005. Wood fuel boilers need to comply with this efficiency level. In Scotland, Building Standards do not specify efficiency ratings.

9.2.2 Potential solutions to regulatory barriers

These barriers could be addressed by introducing heat ROCs or a similar mechanism to encourage wood fuel heating Clarification and information dissemination is needed in several areas of VAT legislation in particular relating to wood fuel and heating systems. Wood has multiple uses and clarification is also needed urgently to establish that wood co-product is not regarded as waste material. Clarification is also need to establish if clean-burning wood appliances can be installed in Smoke Control areas. An alternative support system to ECAs is required for carbon dioxide-saving wood heating plant.

9.2.3 Barriers relating to costs and funding

The initial cost of wood fuel equipment throughout the supply chain (processing, delivery, storage, boilers) is a deterrent to investment. Existing funding of wood fuel schemes is piecemeal, often short-term, and can be difficult to access. There is no funding scheme that provides a widespread, easily-accessed capital grants throughout the supply chain. Information from the Energy Savings Trust Scotland states that in the last round of the Community Energy Programme, 6 public sector wood fuel schemes from Scotland totalling £2 million were turned down. All of the schemes had completed business plans and on the whole demonstrated a good case for grant funding. The problem was a competitive bidding round with limited funding, and the schemes which demonstrated the best value in carbon and cost savings were the ones which received funding. The Community Energy Programme 1 has now ended and there is no funding stream apart from SCHRI in place to facilitate wood fuel district heating in Scotland.

9.2.4 Potential solutions relating to costs and funding

The current funding schemes need to be comprehensively overhauled in order to provide a single generous long-term package of support both for fuel supply equipment and storage facilities and for combustion plant, on site-fuel storage, boilerhouse buildings and district heating infrastructure. A Capital Grants Scheme, such as the Scottish Community and Householder Renewables Initiative (SCHRI) and the Community Energy Programme (CEP), is extended significantly over time to reduce the capital cost of wood fuel heating. Grant funding, such as the Community Energy Programme, that local authorities can bid into, to help the development of relatively large scale schemes which act as nuclei for creating clusters of wood fuel heating users, is needed. Additional grant funding that can be used in conjunction with Public Private Partnerships (PPP) in the wider public sector is vital.

9.2.5 Barriers relating to skills

At present the wood fuel industry consists of a small number of small firms. A lack of trained staff is limiting to firms who wish to expand to meet growing demand. Outwith the existing firms there is a lack of experience with wood fuel systems throughout all aspects of the supply chain. For example, if systems have been poorly installed or maintained by inexperienced personnel or if poor quality chips have been supplied as fuel, customer confidence is undermined.

9.2.6 Potential solutions relating to skills and industry size

In-house training schemes and “apprenticeships” for graduates and experienced engineers are required. Training packages will eventually be required for operators throughout all aspects of the supply chain, concerning, for example, plumbers, fuel suppliers, designers, consultants and advisory staff. Such training needs to be developed slowly, until there are adequate numbers of qualified trainers and jobs for the trainees. Support is needed for the emerging small firms in Scotland who are struggling to develop in a new marketplace (wood fuel fuel suppliers, heat plant suppliers/installers, ESCOs) and which are also currently forced to act as free information services.

9.2.7 Awareness barriers

Wood fuel heating is commonly viewed as old-fashioned and labour intensive. The technology, although widely used throughout Europe, is viewed as being new and, therefore, risky, because it is unfamiliar within the UK. The range of options for using wood fuel for heating can seem confusing. People perceive that paybacks, in terms of fuel cost-saving, are too long-term compared to the initial outlay for equipment and installation.

9.2.8 Potential solutions relating to awareness barriers

Demonstration schemes, with good interpretation, are needed in public places to show how successful wood fuel heating schemes can be. Good quality advice and feasibility studies are required to convince potential users of the benefits of wood fuel heating.

9.2.9 Technical barriers

Fuel delivery systems dictate the type of fuel storage required and, at present, are not sufficiently well developed to allow flexibility in fuel storage. Wood fuel heating equipment imported from Europe can be difficult to integrate into UK heating systems.

9.2.10 Potential solutions to technical barriers

Work needs to be done to develop fuel delivery options that allow flexibility of fuel storage, which would reduce storage costs and increase the number of sites where wood fuel could be used. Training and funding are required to familiarise non-specialist heating engineers with installation of wood fuel heating systems.

9.3 Conclusions

There may be numerous barriers to wood fuel heating in Scotland, yet in the period since 2000 at least 50 wood fuel heating schemes have been installed (totalling over 4 MW), at least 10 fuel suppliers have set up and another 12 organisations are producing their own wood fuel and may potentially be able to supply others. A further 3 to 4 MW of wood fuel heating plant is in the planning or construction stage. Much of this progress can be attributed to the enthusiasm and commitment of a small number of key players, to risk-taking entrepreneurs, to availability of public funding towards capital costs and to increasing anxiety about global climate change. Coupled with this is a lack of natural gas supplies in large areas of Scotland, rising fossil fuel prices and concern about security of supply. The tide seems to be turning and, from a start mainly in the agricultural and forestry sectors, there is now increasing interest in the commercial sector[1] in making use of wood fuel heating in new public sector buildings. If this scale of heating plant is installed in reasonable numbers, there seems to be a consensus that there will be sufficient commercial motivation for fuel suppliers to respond accordingly. In the immediate short term, however, in order to assist the expansion of widespread wood fuel heating all over Scotland, a comprehensive strategic approach is needed to tackle the key issues.

1 Personal communication with a PFI consortium building schools in Central Scotland

10 Future strategy and key recommendations

10.1 Future strategy

Clearly, there is considerable resource potential to support a relatively high level of wood fuel heating in Scotland. Currently, the local coincidence of comparatively cheap sources of wood fuel with consumers who do not have access to the natural gas supply network creates niche markets which can be served by the growing wood fuel heating industry. This industry has been established as a consequence of the commitment, enthusiasm and determination of a small number of companies and a small yet increasing number of customers. However the policy framework in Scotland is likely to change a result of the consultation on the Forestry Strategy, development of an Energy Strategy and the Scottish Sustainable Development Strategy, along with the review of the Scottish Climate Change Programme. We strongly believe that now is the time to significantly develop wood fuel for warmth.

Current expansion is based on the ability to identify and exploit opportunities where a combination of economic circumstances and government policies have fostered favourable market conditions. Obviously, rising prices for fossil fuels, especially natural gas, will enhance the economic advantages of wood fuel heating and we believe it is clear that the wood fuel industry would be able to respond positively to any market growth. This would enable wood fuel heating to make a significant contribution to indigenous energy supply and greenhouse gas emission reductions in Scotland whilst, at the same time, realising important local and regional economic and employment benefits which underpin sustainable development.

10.2 Recommendations

Recommendations can be grouped into two distinct parts: recommendations which are essential for realising the immediate potential, and those recommendations which are necessary to consolidate growth and expand the market for wood fuel heating in Scotland.

To consolidate growth and stimulate significant expansion, we recommend that:

1 A clear and coherent Renewable Heat Strategy is formulated for wood fuel heat.

In order to achieve gradually increasing and sustained growth the wood fuel industry needs a stable commercial environment. What is required is a strategy for wood fuel heating in Scotland which can:

- reduce the margin of capital costs between wood fuel heating systems and fossil fuel-fired heating systems
- enhance and expand the economic advantages of wood fuel heating systems so that they can compete effectively with fossil fuel-fired heating systems, particularly off the natural gas network and address fuel poverty issues
- clarify the fiscal and regulatory measure
- minimising any supply conflict between the use of wood fuel resource in Scotland by electricity generation, wood fuel heating and existing markets for wood
- promote secure supplies for wood fuel heating systems

- raise awareness of the economic, environmental and related advantages of wood fuel heating amongst both rural and urban populations, and
- create and maintain a consistent and supportive policy framework for wood fuel heating.

2 A Renewable Heat Obligation or similar measure should be explored to provide the means to achieve targets for renewable heat.

Appropriate mechanisms for realising targets for the use of renewable heat need to be identified and implemented. It is recommended that consideration should be given to a Renewables Obligation for heat, or similar measure, to provide a realistic yet simple economic support measures which can deliver expansion for wood fuel heating in a rapid and efficient manner. Whilst recognising that this may require the development of a series of appropriate measures, it is emphasised that they need to be devised and implemented in a complementary and integrated manner. This applies, particularly, to the modification and extension of existing measures.

3 The concept of 'wood fuel refineries' should be investigated and promoted to introduce economies of scale into wood fuel supply. The opportunity should be seized to involve existing wood processors in this initiative, to build on existing expertise and to minimise potential for conflict between sectors of the industry.

Apart from measures which further improve the relative economic advantages of wood fuel heating, there is a need to foster the development of local wood fuel supply chain clusters which can begin to take advantage of economies of scale and access to larger markets of wood fuel users. In order to achieve this, it is necessary to promote the large-scale production of wood fuels, especially in chip and pellet form, and large-scale users. From the perspective of wood fuel supply, it is recommended that the concept of the "wood fuel refinery" is investigated in more detail to ensure that low-value wood co-products can be converted into a widely-acceptable and generally-available fuel.

The importance of involving existing wood processing industries in developing wood fuel refineries is emphasised. This is an important opportunity to build on existing infrastructure and expertise in wood processing, while supporting integrated wood production, processing and consumption and minimising the risks of conflicts between wood-using sectors. In relation to wood fuel demand, it is recommended that measures should be put in place which encourage owners of large housing and other stocks and groupings of houses and other buildings to adopt wood-fired heating systems, for example, a grant mechanism targeted at housing associations to assist the development and replication of community wood fuel heating schemes.

To realise immediate potential for wood fuel heating in Scotland, we recommend that:

4 The capital grants available under the Scottish Community and Householder Renewables Initiative (SCHRI) should be increased and be secured over time to progressively reduce the capital cost of wood fuel heating.

To date, wood-fired heating schemes have been limited to relatively small niche markets, either where competition from cheap fossil fuels, especially natural gas, is limited or where non-economic factors are a prominent feature of the decision-making process. Although the current situation of steadily increasing fossil fuel prices is clearly improving the economic market for wood-fired heating systems, significant uncertainty afflicts the implicitly numerous and diverse decision-makers who could be potential users. There is clear concern over the future economic advantages of wood-fired heating systems in relation to the previously-low and currently-erratic price of conventional heating fuels. The relative capital cost of wood-fired heating systems is high and this is a major obstacle in the which has created a significant economic disincentive to the majority of potential users who could be involved in developing and expanding the market for wood fuel. Consequently, it is recommended that financial assistance, in the form of an expanded and fully-resourced capital grants available under the Scottish Community and Householder Renewables Initiative (SCHRI), is available to a wide range of potential users in Scotland.

5 The definition and application of VAT to wood fuel heating appliances and fuels should be clarified to avoid confusion and uncertainty among prospective customers.

The main problem over VAT concerns ambiguity and lack of clarity in definitions by HM Customs and Excise. Hence, it is recommended that the definition and application of VAT to wood fuel heating is clarified and any subsequent conflicts are identified and removed so that wood fuel heating competes fairly as a renewable energy source against conventional heating fuels.

6 Grant funding should continue to be available through the Community Energy Programme for community scale biomass schemes. Such relatively large-scale schemes can act as nuclei for creating clusters of wood-fuel heating users. Additional grant funding is necessary, to be used in conjunction with Public Private Partnerships (PPP).

A number of local authorities have played an important role in the current early stages of development of the wood fuel market in Scotland through their enthusiastic support for wood-fired heating. However, their enthusiasm and that of other large organisations who have committed themselves to wood-fired heating is tempered by uncertainty over availability and continuity of funding sources as well the need to bring together adequate finance from a range of different sources of funding. The involvement of such large organisations is essential for the process of developing local niche markets and providing a nucleus for local clusters of wood fuel supply and demand. We recommend that a more secure and certain framework for financial involvement is provided for local authorities and the wider public sector by ensuring that targeted and ring-fenced funds are available for implementing major wood fuel heating schemes in Scotland. Grant funding, such as the Community Energy Programme, that local authorities can bid into, to help the development of relatively large scale schemes which act as nuclei for creating clusters of wood fuel heating users, is needed. Additional grant funding that can be used in conjunction with Public Private Partnerships (PPP) in the wider public sector is vital.

7 Establish directly supported domestic and large scale demonstration projects.

Finally, it is essential to address confidence-building measures so that a large and increasing number of potential users and customers can be attracted to wood fuel heating. Effective awareness-raising needs to be a fundamental part of any promotion campaign. Practical demonstration can clearly have an impact on those considering the purchase, installation and operation of any renewable energy technology, especially when there are issues of apparent novelty and unfamiliarity. Consequently, it is recommended that there is direct support to establish between 25 and 100 domestic and medium-scale demonstration schemes which incorporate wood-fired heating throughout Scotland

Appendix A: Whitegates district heating scheme, Lochgilphead

Background


©Fyne Homes

Whitegates is the first large wood fuel heating scheme in Scotland. Owned by the local housing association, Fyne Homes, it is a development of 50 residential properties situated in Lochgilphead. In addition there is a respite care facility built by Fyne Homes and leased to Argyll and Bute Council. The development was built as a partnership project between Fyne Homes and the Lochgilphead based construction company M & K MacLeod. The district heating scheme was originally designed, installed and run by the Energy Supply Company (ESCO) Torren Energy, who unfortunately ran into difficulties and was not able to continue beyond November 2003. Since then the purchase of wood fuel and the administration of the scheme have been done by Fyne Homes. Fyne Homes have achieved national recognition for the development being:

- Scottish Green Energy Award winner for Best Project in 2003
- Chartered Institute of Housing Envirobuild Award
- Recommended as Good Practice on the Royal Commission of Environmental Pollution Report on Wood fuel 2004.

District heating

The district heating system consists of an Energy Centre (the boiler house and fuel storage) and a network of four underground heating circuits delivering metered hot water to 51 properties. The Energy Centre houses a Finnish built 460 kW LAKA wood chip boiler with Veto feeding mechanism and a 40 m^3 integrated wood chip storage hopper. Also within the Energy Centre is a 300 kW Italian built ICI Caldae oil boiler with a Riello burner and an external 5000 litre oil tank. The flow temperature of the water from the boiler is around 77°C and returns at about 50°C.

Inside each property there is an AVG hydraulic interface unit (or heat exchanger) that takes heat from the hot water of the district heating network and supplies this heat to a separate and independent central heating and domestic hot water supply within each house. All ground floors are heated by underfloor heating circuits and, where there are two storey houses, the upper floors are heated by wall mounted wet radiators with individual TRVs. Domestic hot water is supplied from an insulated tank.

There is spare capacity with the system, as in practice the boiler has not been required to produce more than 260 kW. There are two buildings in close proximity that could be included within the system. These are:

- The Forestry Commission offices at Whitegates that are presently heated by electric storage heaters
- The Whitegates Adult Learning Centre owned and operated by Argyll and Bute Council, presently using an oil fired central heating system.

Operation and Maintenance

After the collapse of Torren Energy, Fyne Homes turned to Vital Energi of Bolton to reassess the performance and operation of the community energy system. The outcome of the reassessment was the agreement that:

- Fyne Homes would pay directly for the supply of all wood fuel and domestic heating oil delivered to the boiler house as well as the cost of all electricity consumed within the Energy Centre
- Vital Energi would carry out a substantial program of capital improvements and would provide local on-site personnel to deal with the operation of the Energy Centre and provide local liaison with the residents.

At the time of writing a new contract is being negotiated with Vital Energi to provide annual maintenance and servicing of the system.

Heat sales

As a major part of the improvements, Vital Energi was responsible for the design, installation and administration of the ‘smart’ card prepayment system that enables residents to purchase heat credit from a Sales Counter Prepayment Unit (SCPU) located in the local SPAR supermarket. Each property has been fitted with a new heat meter, a domestic credit unit (DCU) and a motorised valve that will operate in the event of the emergency credit within the DCU being used up resulting in hot water from the district heating network being shut down. Each tenant is issued with a prepayment plastic card that is unique to each individual residence.

The system works whereby the tenant visits the local SPAR shop, and hands over their card and their money (usually £10 or £20). The card is entered into the slot of the SCPU and the appropriate amount of heat credit is then transferred onto the card. A till receipt is issued to each customer at each transaction. The tenant then returns home, puts the card into the DCU and the illuminated display immediately shows the new revised amount of residual credit left in the system. When the credit reduces down to £3.00, an audible warning is bleeped to remind the tenant to top up the system with more credit as soon as possible. If this does not happen and the emergency credit is all used up the motorised valve will operate and close the whole system down.

This system is popular with the tenants. There are no invoices issued; no tenants get into debt and tenants can control their use of heat with an eye on their remaining credit. The system was commissioned in October 2004 and so far there has been only one complaint of a faulty card that was immediately replaced by Vital Energi.

Fuel supply

Originally under Torren Energy, wood chips were produced in Skye and delivered to Lochgilphead in 0.7 m^3 bags. When this supply chain was terminated, a new wood chip supplier was identified by Argyll, Lomond and the Isles Energy Agency (ALIenergy). The new supplier is Ewan Johnston and Sons, a small family business near Campbeltown, who have diversified from farming and established Auchencorvie Sawmill. Wood fuelis delivered in full loads on the basis of 10 x 1.4 m^3 every trip. There are approximately three bags to the tonne and this quantity maximises the payload capacity of a new purpose built 7.5 tonne GVW Mitsubishi Canter truck with an 18 foot long aluminium dropside body complete with a lorry mounted hydraulic crane.

The feedstock for the wood chips is the slabwood that arises from the sawmilling process and from the purchase of small roundwood that has been felled and air dried in the local Kintyre forest. At present the timber is chipped straight into bags normally on the day before delivery to Lochgilphead. Achencorvie have now obtained 50% grant assistance towards the construction of a new shed for the storage and drying of wood chips. The grant funding is provided jointly by the Forestry Commission Scotland, and Argyll and the Isles Enterprise Company, as part of the Highlands and Islands Woodfuel Cluster Program, to help build the capacity for wood energy supply chains and markets in the Highlands.

The moisture content of the wood chip is not controlled and in the main supplies have been satisfactory, but on occasion there has been difficulty experienced with chips that have had a higher moisture content. This means that the boiler may not reach its desired operating temperature, flue gas temperatures are lower and flue gas emissions are more noticeable. It is hoped that moisture content will be more stable once the new drying shed becomes available.

Fuel used

The wood chips are delivered at 30% moisture content with an approximate calorific value of 12 GJ/t. Assuming a boiler efficiency of 90%, although the boiler will be down rated in the summer months, the amount of fuel used is estimated to be about 301 tonnes per year. This is based on an average heat load of about 903 MWh.

Fuel store and boiler house

The fuel store consists of a 40 m^3 silo situated inside the central boilerhouse. The wood chips are delivered in ‘dumpy’ bags that have a drawstring at the bottom of the bag. The wood chips are released into a small hopper at ground level and then blown into the silo which is fitted with a rotating spring. The wood chips are delivered from the silo to the boiler by a twin auger system. The boiler house is about the size of a domestic garage with a flue for each boiler.

Capital costs

The total installation costs were £230,000.

Running costs

The wood chips cost £45 per tonne including delivery. This means that the total cost of wood chip per year for 301 tonnes is around £27,544. Other costs such as operation and maintenance (O&M) also need to be taken into account. As the maintenance contract with Vital Energi has not yet been agreed, it not possible to put an exact figure into the running cost calculation. A rule of thumb for district heating schemes is that the O&M cost is roughly 5% of the capital cost of the pipework. As this is not known, typical cost of £14,000 has been assumed. The amount of electricity used to power the motors, drives, controls and pumps in the system is about 30,290 kWh per year at a cost of £909 (at 5p/kWh). The overall running cost is about £28,453 per year. On a kWh basis, this works out at 3.15p/kWh. The cost of heat to the occupiers, 3.7p/kWh, was decided by setting the price to just below that of the then price of electricity. The difference is 0.55p/kWh i.e. £4,960 per year. Assuming that the system used oil instead of wood chips, the cost, with a decreased O&M charge of £11,000 and 32p/litre, would be about £37,980 per year i.e. 4.31p/kwh. This is more expensive than the wood chip system even though the O&M costs are less.

Carbon savings

Burning wood chips would save around 226 tonnes of carbon dioxide, assuming that the wood chips replace oil and the oil boiler is not used at any time. Offset against this would be the amount of fuel used in deliveries. The sawmill is 52 away from Lochgilphead, a round trip of 104 miles per delivery.

Funding

In addition to other funding sources, grant funding was obtained from the Scottish Communities and Household Renewables Initiative. A grant of £20,000 enabled Fyne Homes to purchase the wood chip boiler as their own, from the Co-operative Bank, who funded the purchase and building of the boiler before Torren Energy went into the hands of the Receiver.

Contacts

Owners: Fyne Homes
Janet McAllister, Maintenance Director,
Fyne Homes Housing Association
81 Victoria Street
Rothesay
Isle of Bute PA20 0AP
Tel. 01700 504668

Operation & maintenance: Vital Energi
Helge Wonsbek
Design and Proposals Manager
Burnden Works
Burnden Road
Bolton Lancs
Tel. 012204 554500

Grant funding: Argyll & the Isles Enterprise
Paul O'Brien, Development Officer
Argyll & the Isles Enterprise
Enterprise House
Kilmory
Lochgilphead

Fuel supply: E G Johnstone & Co.,
Auchencorvie
Campbeltown
Argyll PA28 6PH

With grateful thanks for information received: Bob McIlwraith, Energy Advisor, Argyll Lomond and the Isles Energy Agency (ALIEnergy), Argyll and Bute Council Offices, Kilbowie House, Gallanach Road, Oban, PA34 4PF.

Appendix B: Log-burning boiler, Fort Augustus

Background

The boiler is installed in a private house in Fort Augustus in the highlands of Scotland at the southern end of Loch Ness. As well as providing domestic hot water, the boiler heats 14 radiators in a property measuring 156 square metres. Mr & Mrs Di-Duca chose to burn wood fuel as they are environmentally conscious and wished to stop using fossil fuels. There was also a good supply of wood available locally.

Fuel

The boiler burns both softwood and hardwood logs. The maximum log length is 0.5 metres, with a diameter in the range 10 cm to 15 cm. About 10 to 12 tonnes of fuel are used each year, depending upon the species. The fuel, which ideally should already have been cut for around a year, is obtained locally from forest management and tree surgery in gardens. It is collected by Mr Di-Duca, using a small trailer, and cut to length with a chainsaw before splitting. The logs are split using an axe or a small hydraulic log splitter with a five tonne splitting force up to 0.5 m length. After splitting, the logs are stacked for six months to a year, depending on the time of year and the weather. The log splitter cost in the region of £700 to buy. If wood fuel is collected from Forestry Commission land, a permit must be obtained and, if using a chainsaw, a chainsaw certificate and insurance is also required.

Equipment installed

A Danish Baxi Solo Innova 30, 32 kW log boiler with two accumulator tanks has been installed, one tank of 750 litres and a second, fitted with internal hot water tank, of 500 litres. The tanks store sufficient hot water to keep the house warm during the night. When the boiler needs to be refuelled and relit depends upon the temperature of the hot water in the tanks. The boiler is loaded only when the storage tank temperature is below 45°C and only the amount of fuel needed to bring the water temperature to around 90°C should be put into the combustion chamber.

The boiler burns forest wood and briquettes and is constructed to burn dry wood at 15-25% moisture content (mc). Air dried wood fuel, however rarely gets below 30-35% mc, which means that the boiler will lose efficiency. The boiler was supplied by Foundation Firewood and installed by a local plumber / electrician.

Maintenance

The ash pan is emptied every two to three weeks depending on the amount of wood fuelused. The flue is cleaned every three months and the air tubes and impeller every six months. There is very little ash, and no build up of tar deposits due to the very high burning temperature. The gases are re-burnt in the burning process.

Fuel Store

Logs are stored in a covered woodshed and around the house under cover. The volume of fuel to be accommodated is around 10 to 15 cubic metres a year.

Running costs

As much of the wood is residue the costs are minimal and mainly relate to cutting the wood.

Small roundwood is available straight from the forest at around £15 a tonne. One rigid load of around 12 tonnes would last a year at a cost of approximately £200 delivered. At 20% mc, a tonne of logs would give about 3,500 kWh of heat energy. At £15 per tonne this give a unit cost of about 0.5p per kWh. This is considerably less than fossil fuel. For example, at the time of writing domestic oil prices are around 3.2p per kWh (32p per litre). Assuming that logs had to be bought at about the average cost of £50 per tonne, the cost per kWh would rise to 1.92p, which is still cheaper than oil.

Other costs to be taken into consideration include the electricity used in running the two standard water pumps on the system and the small fan which impels air into the boiler during combustion. It is not known how much electricity is used. Boiler maintenance and servicing would also incur a charge.

Capital costs

The house is a new build and so the VAT on the installation of the system was reclaimed. The costs in the table below do not include VAT.

Item installed	Capital cost
Boiler house	£3,850
Electrical connection	£420
Plumbing costs	£980
Boiler	£1,677
750 litre tank	£533
500 litre tank	£583
Pipe set	£360
Delivery (imported)	£450
Commissioning	£1,100
Total capital expenditure	£9,953

The comparative cost of an oil boiler and tank, installed, (which would have fitted in the house, and therefore saved the cost of the boilerhouse) would be in the region of £3500-£4000.

Funding

The installation received a 30 % grant from SCHRI of £2,986. This brought the cost down to £6,967.

Carbon savings

The fuel most likely to be used instead of wood fuelis oil. Burning one tonne of logs at 35% mc instead of oil, based on 2,500 kWh per tonne, would save 625 kg of carbon dioxide. About 10 to 12 tonnes of logs are used per year, giving a total saving of around 7.5 tonnes of carbon dioxide per year.

Sources of information

Owners: Mr & Mrs Di-Duca
Willow Bank
Bunoich Brae
Fort Augustus PH32 4DG

Boiler supplier: Foundation Firewood
Unit 39B
Park Farm Industrial Estate
Buntingford
Herts SG9 9AZ
Tel. 01763 271271
www.fbcgroup.co.uk
email info@fbcgroup.co.uk.

Grant information: Scottish Community and Householder Renewables Initiative (SCHRI)
www.est.org.uk/SCHRI.

Appendix C: Pellet stove in log cabin, Aviemore

Background

The two bedroomed log cabin near Aviemore is owned by Alastair Lyon and his wife and is let out to holidaymakers throughout the year, mostly weekends in the winter. A pellet stove has been installed as a space heater. Mr Lyon chose a pellet stove as he is keen to promote wood energy and to increase the energy efficiency rating of the cabin. Because of the wooden construction of the building a log stove was ruled out on safety grounds. The pellet stove is easy to use and the visitors are not required to fill the hopper or empty the ash. The stove is mounted on a slate plinth and makes an attractive feature in the sitting area. Mr Lyon is pleased with his stove and is keen to promote wood burning systems.

Fuel

Wood pellets are made of compressed clean sawdust and fines and have a moisture content of around 5%, which makes the fuel energy-dense. One kg can provide 5 kWh of heat energy. The 15 kg bags of wood pellets were originally supplied by 3G Energi of Kelso. Since then, Highland Wood Energy in Fort William have started to supply pellets, which will give Mr Lyon the choice between suppliers. As pellet fuel becomes more popular this choice should expand.

Equipment installed

An Italian Extraflame Preziosa 5 kW stove, supplied by 3G Energi, has been installed. The stove is rated at 5 kW with an approximate efficiency of 90%. The heat output can be turned down to around 2 kW. The stove is self-lighting using electric ignition. A timer and thermostat are included in the controls. The stove is cool to the touch and distributes the heat by means of an integral fan which is quiet in operation. The hopper holds 11 kg of pellets and due to the nature of the short term lets does not require filling very often. If the stove were in constant use, the hopper would need to be filled every three days. An air wash system keeps the glass clean. The ash is removed every two months.

Flue and fuel store

The stove is fitted with a stainless steel flue which goes through the wall behind the stove and up the outside of the cabin. Flues for pellet stoves are generally smaller than flues for other wood burning appliances and are not obtrusive. The flue passed building control once the recommendation by 3G Energi had been accepted. The pellets are stored in a shed at Mr Lyon's house and taken up to the cabin as needed.

Capital costs

The price paid for the stove was £1,495.00 and the flue was £499.23 making a total of £2343.22 including 17.5% VAT. Mr Lyon installed the stove himself, thus saving the installation costs.

Running costs

The price paid for pellets at the time of ordering was £4 for a 15 kg bag and 30 bags were purchased making a total of £126 including 5% VAT. Over the past year almost all the pellets have been used. One bag will provide 75 kWh of heat energy. This makes the unit cost of the pellets 5.9p/kWh, although there is an additional annual cost of £60 for cleaning the flue. It is not known how much electricity is used to operate the fan. If the pellet stove had not been installed, the alternative fossil fuel would be electricity. Standard rate electricity is about 9p/kwh at the time of writing making heating with pellets an attractive option.

Carbon savings

Assuming that the 2,250 kWh per year that the pellets provide were replaced by electricity, 968 kg of carbon dioxide would be saved per year.

Funding

As Mr Lyon installed the stove himself, to reduce overall costs, grant funding was not available. For eligible applicants, grants may be obtained from the Scottish Community and Householder Renewables Initiative (SCHRI) www.est.org.uk/schri

Sources of information

Owner: Alastair Lyon

Stove supplier: Gavin Gulliver Goodall
3G Energi
Unit 3
The Knowes
Kelso TD5 7BH
Tel. 01835 824201
www.3genergi.co.uk.

Pellet stove information and picture:
The Organic Energy Company
www.organicenergy.co.uk

Pellet supply: 3G Energi (above) and Highland Wood Energy
Unit 2
Old Mart Industrial Estate
Corpach
Fort William PH33 7NN
Tel. 01397 773000
www.highlandwoodenergy.co.uk

Appendix D: Estimation of potential wood fuel resource in Scotland

Background

The starting point for estimating the potential wood fuel resource was a database of forest wood fuel forecasts maintained on a website by the Forestry Commission (McKay et al., 2003). This website can generate estimates of wood fuel availability from both public and privately owned forests in regions of Britain for a range of time periods. The periods most relevant to this study were: 2005-2006; 2007-2011; and 2012-2016.

For each of these periods, the website can provide forecasts expressed on an annualised basis in units of oven dry tonnes of wood per year. The website allows the land area of Scotland to be partitioned into regions according to FC Forest District boundaries. Forest Districts represent the various operational areas through which the FC carries out direct management of forests. At present there are 15 distinct Forest Districts in Scotland and these tend to reflect reasonably faithfully the geographical distribution of forest areas. These districts form distinct zones in terms of demographics, agroclimatic conditions, forest composition and style of forest management practised now and over the last 90 years. The wood fuel resource website also breaks forecasts down into the major elements of forest wood fuel. First of all wood fuel is reported for the major species groups in Scotland:

- Pines
- Spruces
- Other conifers
- Broadleaf trees.

Secondly, forecasts are presented for different tree components:

- Tree main stems (further divided according to diameter of stem material and quality)
- Stem tips
- Branch wood
- Foliage
- Arboricultural wood (wood fuel arising from tree maintenance in urban and peri-urban areas, notably land flanking railway lines)
- Secondary wood from sawmills (i.e. low value coproducts from manufacture of sawn timber).

The wood fuel estimates provided by the wood fuel resource website are based on a carefully constructed methodology and make access to the best available data and systems (McKay et al., 2003; Matthews and Duckworth, 2005; Halsall et al., 2005; Gilbert et al., 2005). They include an allowance for environmental and technical constraints on potential for harvesting. However the form of the estimates presented on the website is still not ideal for this study. The biggest problem is that no allowance is made for existing markets for woody material that would compete with demand for wood fuel. This means that the forecasts presented by the website are of total available wood fuel, when in fact significant quantities will be taken up for manufacture of sawn timber, board, paper and similar products. This required assumptions to be made about levels of consumption of Scottish-grown wood by different industries alongside a growing wood heat industry in the future. These assumptions were based on available data on the types and quality characteristics of wood harvested in different regions of Scotland over the next 10 years (McKay et al., 2003; Edwards and Christie, 1981; Mochan et al., 2002; Stirling et al., 2000) in combination with the judgements of project team members and other experts (A. Leitch, E.D. Mackie, J.C. Proudfoot, personal communications). Key assumptions involved:

- Proportions of forest area in each region either thinned or unthinned
- Amounts of wood produced from early thinnings in young stands (very suitable for use as wood fuel)
- Extent of stands of low quality leading to large fractions of stem material being unsuitable for use as sawn timber.

Further assumptions were made about the potential for wood fuel demand to draw on these different types of wood in competition with other markets. Three scenarios were devised, the first representing the wood fuel that might become available immediately if there was a step change in demand for wood fuel, the second including additional wood fuel that might become available if there was significant growth in the wood fuel market. The third scenario ignored other markets. This scenario is purely theoretical, summarising the total wood resource in Scotland over the next decade and is included for comparison.

For the purposes of this study, slightly revised summary product categories were defined:

- Arboricultural wood
- Secondary wood
- Harvesting residues (branch wood and stem tips)
- Wood from early thinnings and stands of low quality
- Roundwood (stem wood in 7-14 cm and 14-16 cm categories)
- Sawlog material (stem wood in 16-18 cm and 18+ cm categories).

Producing estimates based on these categories required some recalculation of values presented on the wood fuel resource website. Details of the key assumptions made in calculating estimates under scenarios 1 and 2 are summarised in Table D.1. Additional assumptions needed to be made when reworking the original estimates for one set of product categories into another in order to avoid double counting of wood fuel. These fine-detail assumptions are not documented here.

The resultant forecasts of wood fuel availability, broken down by FC Forest District, type of material and production period are shown in Table D.2 (‘Immediate’ scenario) and Table D.3 (‘Growth’ scenario). For comparison Table D.4 gives the values for scenario 3, i.e. estimates of the total wood fuel resource. The analysis suggests that over 700,000 odt per year of wood fuel resource might become immediately available to a new wood fuel market, rising to 800,000 odt per year by 2012. This constitutes between 20% and 25% of the estimated total wood fuel resource available over the period from 2005 to 2016. The available wood fuel resource might exceed 1 million odt per year by 2012 if the market was to grow - representing about 30% of the total wood fuel resource. This potential increase is partly due to assumptions about relative demand for wood in different markets. However it is also assumed that increased demand for wood fuel could result in untapped resources becoming available. For example, at present, there are no practical systems or infrastructure in place to harvest forest branch wood; these could be developed in response to higher demand.

Under the ‘Immediate’ scenario, wood traditionally feeding the roundwood (pulp, board and pallet) markets is estimated to make a very important contribution to the potential wood fuel resource (about 60%) with very low grade sawlog material contributing most of the remainder (about 30%). This suggests that actions which secure the availability of these sources for use as wood fuel will be critical in the early stages of developing a stable wood fuel supply and market. Under the ‘Growth’ scenario, the main contributions to the available wood fuel resource are due more equally to roundwood (about 25%), low grade sawlog material (about 30%) and branchwood (about 30%). This indicates that, in the medium term, measures that support the development of effective wood fuel supply chains based on branchwood could be important for building flexibility in the wood fuel market.

Table D.1 Summary of assumptions made in calculating available wood fuel

Variable / quantity	'Immediate' Scenario	'Growth' Scenario
Proportions of forest areas thinned	Dornoch: 0.6; Inverness: 0.6; Fort Augustus: 0.4; Moray: 0.8; Buchan: 0.8; Lochaber: 0.5; Kincardine: 0.8; Lorne: 0.4; Tay: 0.7; West Argyll: 0.5; Cowal and Trossachs: 0.4; Scottish Lowlands: 0.4; Scottish Borders: 0.6; Galloway: 0.5; Ae: 0.4.	Same as 'Immediate' scenario.
Proportion of total production arising from early thinnings	12% of stem wood production over a typical rotation assumed to arise from early thinnings.	Same as 'Immediate' scenario.
Wood fuel production from early thinnings	20% of production of early thinnings used for wood fuel.	100% of production of early thinnings used for wood fuel.
Availability of roundwood (7-14 cm category)	Pines: 0.1; Spruces: 0.1; Other conifers: 0.1; Broadleaves: 0.5.	Pines: 0.3; Spruces: 0.3; Other conifers: 0.3; Broadleaves: 1.0.
Availability of roundwood (14-16 cm category)	Spruces: 0.1; Pines: 0.1; Other conifers: 0.1; Broadleaves: 0.5	Spruces: 0.75; Pines: 0.75; Other conifers: 0.75; Broadleaves: 1.0.
Extent of low quality sawlog material	Proportions of spruce stand areas producing very low quality sawlog material (grade E): Cowal and Trossachs, Scottish Lowlands, Galloway and Ae: 12%; Other districts: 11%. For other species spruce estimates were adjusted by the following factors: Pines and other conifers: 0.5; Broadleaves: 2.0.	Proportions of spruce stand areas producing low quality sawlog material (grade D): Cowal and Trossachs, Scottish Lowlands, Galloway and Ae: 19%; Other districts: 12%. Adjustments for other species as in 'Immediate' scenario.
Availability of sawlogs (16-18 cm category and 18+ category)	100% of areas producing grade E sawlog material assumed to be used for wood fuel.	Same as 'Immediate' scenario but in addition 50% of areas producing grade D sawlog material assumed to be used for wood fuel.
Extent of oversize material (25+ cm category)	Assumed to make up 0.5 % of material in 18+ cm stem wood category.	Same as 'Immediate' scenario.
Availability of oversize material	20% of oversize material assumed to be used for wood fuel.	Same as 'Immediate' scenario.
Low quality timber (FC) estate)	50% of potential production from low quality stands used for wood fuel.	100% of potential production from low quality stands used for wood fuel.

Table D.2 Summary of wood fuel availability under Scenario 1 ('Immediate'). Values show oven dry tonnes of wood fuel available from six product categories on an annualised basis. A definition of categories is given in the text

Forest district	Period	Arb. wood	Secondary wood	Low quality trees and early thinnings	Harvesting residues	Round wood	Sawlog material	Total
Dornoch	2005-2006	0	0	25,689	0	10,564	2,887	39,140
	2007-2011	0	0	27,193	0	11,320	4,026	42,539
	2012-2016	0	0	23,978	0	12,587	6,031	42,596
Inverness	2005-2006	0	1,614	15,953	0	17,222	9,989	44,778
	2007-2011	0	1,614	15,213	0	17,839	12,339	47,006
	2012-2016	0	1,614	11,813	0	17,113	13,569	44,108
Moray	2005-2006	0	404	5,724	0	12,736	6,103	24,968
	2007-2011	0	404	5,597	0	13,627	7,830	27,458
	2012-2016	0	404	3,270	0	13,780	9,174	26,628
Fort Augustus	2005-2006	0	0	12,655	0	13,889	5,705	32,249
	2007-2011	0	0	11,473	0	12,359	5,818	29,650
	2012-2016	0	0	9,407	0	14,532	8,124	32,063
Buchan	2005-2006	0	404	709	0	17,126	8,185	26,425
	2007-2011	0	404	597	0	13,143	7,166	21,310
	2012-2016	0	404	605	0	14,066	8,569	23,643
Lochaber	2005-2006	0	404	16,082	0	15,005	6,058	37,549
	2007-2011	0	404	19,875	0	13,632	6,131	40,042
	2012-2016	0	404	18,549	0	15,535	7,976	42,464
Kincardine	2005-2006	0	807	2,253	0	11,845	6,586	21,491
	2007-2011	0	807	2,296	0	11,419	7,139	21,661
	2012-2016	0	807	1,948	0	11,603	8,183	22,541
Lorne	2005-2006	0	0	10,722	0	17,372	6,915	35,009
	2007-2011	0	0	9,376	0	21,045	8,638	39,058
	2012-2016	0	0	10,453	0	24,845	11,545	46,842
Tay	2005-2006	0	807	12,845	0	27,719	12,444	53,814
	2007-2011	0	807	11,516	0	27,095	13,956	53,374
	2012-2016	0	807	13,419	0	27,115	16,840	58,181
West Argyll	2005-2006	0	0	6,047	0	31,908	11,436	49,391
	2007-2011	0	0	5,905	0	41,971	16,854	64,730
	2012-2016	0	0	4,711	0	39,031	17,489	61,230
Cowal and Trossachs	2005-2006	0	0	9,279	0	36,258	16,154	61,691
	2007-2011	0	0	10,947	0	37,187	19,540	67,674
	2012-2016	0	0	10,797	0	34,672	21,110	66,578
Scottish Lowlands	2005-2006	0	2,018	13,923	0	33,355	14,427	63,723
	2007-2011	0	2,018	13,628	0	37,212	19,665	72,522
	2012-2016	0	2,018	14,693	0	42,516	26,600	85,826

Table D.2 *continued*

Forest district	Period	Arb. wood	Secondary wood	Low quality trees and early thinnings	Harvesting residues	Round wood	Sawlog material	Total
Galloway	2005-2006	0	0	8,158	0	60,384	20,608	89,150
	2007-2011	0	0	7,789	0	58,537	24,334	90,660
	2012-2016	0	0	9,917	0	56,836	26,714	93,466
Ae	2005-2006	0	1,614	5,238	0	46,406	21,995	75,252
	2007-2011	0	1,614	6,415	0	40,525	24,409	72,962
	2012-2016	0	1,614	10,421	0	40,500	29,001	81,536
Scottish Borders	2005-2006	0	0	5,730	0	45,597	17,080	68,407
	2007-2011	0	0	5,993	0	42,091	20,124	68,207
	2012-2016	0	0	6,752	0	44,705	26,007	77,465
Totals	2005-2006	0	8,072	151,006	0	397,385	166,573	723,036
	2007-2011	0	8,072	153,813	0	399,001	197,968	758,854
	2012-2016	0	8,072	150,731	0	409,435	236,930	805,168

Table D.3 Summary of wood fuel availability under Scenario 2 ('Growth'). Values show oven dry tonnes of wood fuel available from six product categories on an annualised basis. A definition of categories is given in the text

Forest district	Period	Arb. wood	Secondary wood	Low quality trees and early thinnings	Harvesting residues	Round wood	Sawlog material	Total
Dornoch	2005-2006	2,314	0	39,074	4,244	21,435	2,887	69,954
	2007-2011	2,314	0	41,056	3,060	22,648	4,026	73,104
	2012-2016	2,314	0	37,925	2,941	33,107	6,031	82,317
Inverness	2005-2006	2,314	1,614	18,782	8,323	51,621	9,989	92,644
	2007-2011	2,314	1,614	17,983	8,791	53,578	12,339	96,619
	2012-2016	2,314	1,614	14,563	8,844	55,261	13,569	96,164
Moray	2005-2006	2,314	404	14,022	4,173	19,337	5,705	45,956
	2007-2011	2,314	404	12,675	3,611	17,975	5,818	42,797
	2012-2016	2,314	404	10,910	4,165	22,135	8,124	48,052
Fort Augustus	2005-2006	2,314	0	13,395	5,008	33,257	6,103	60,077
	2007-2011	2,314	0	13,027	5,842	31,542	7,830	60,555
	2012-2016	2,314	0	8,305	7,218	34,653	9,174	61,664
Buchan	2005-2006	2,314	404	3,136	5,488	22,879	8,185	42,407
	2007-2011	2,314	404	2,455	5,988	19,135	7,166	37,462
	2012-2016	2,314	404	2,703	6,606	24,239	8,569	44,834

Table D.3 *continued*

Forest district	Period	Arb. wood	Secondary wood	Low quality trees and early thinnings	Harvesting residues	Round wood	Sawlog material	Total
Lochaber	2005-2006	2,314	404	20,000	3,638	13,478	6,058	45,892
	2007-2011	2,314	404	24,233	3,685	9,513	6,131	46,279
	2012-2016	2,314	404	22,833	4,801	12,421	7,976	50,748
Kincardine	2005-2006	2,314	807	4,146	9,489	22,045	6,586	45,387
	2007-2011	2,314	807	3,837	8,157	17,575	7,139	39,829
	2012-2016	2,314	807	3,422	8,230	16,624	8,183	39,580
Lorne	2005-2006	2,314	0	11,652	6,165	7,882	6,915	34,928
	2007-2011	2,314	0	10,523	8,458	9,580	8,638	39,512
	2012-2016	2,314	0	11,817	10,369	13,701	11,545	49,746
Tay	2005-2006	2,314	807	16,352	34,654	38,664	12,444	105,235
	2007-2011	2,314	807	14,601	34,761	32,646	13,956	99,086
	2012-2016	2,314	807	16,360	36,367	30,523	16,840	103,211
West Argyll	2005-2006	2,314	0	8,473	8,431	15,471	11,436	46,125
	2007-2011	2,314	0	8,969	11,892	19,539	16,854	59,568
	2012-2016	2,314	0	7,432	11,061	15,056	17,489	53,351
Cowal and Trossachs	2005-2006	2,314	0	11,242	15,709	17,945	16,154	63,364
	2007-2011	2,314	0	12,885	16,866	16,820	19,540	68,424
	2012-2016	2,314	0	12,700	19,383	20,540	21,110	76,046
Scottish Lowlands	2005-2006	2,314	2,018	15,909	15,442	22,646	14,427	72,756
	2007-2011	2,314	2,018	15,718	17,114	21,128	19,665	77,957
	2012-2016	2,314	2,018	17,065	20,675	23,286	26,600	91,958
Galloway	2005-2006	2,314	0	9,396	22,006	18,639	17,080	69,435
	2007-2011	2,314	0	9,280	22,851	16,350	20,124	70,918
	2012-2016	2,314	0	10,278	25,816	17,985	26,007	82,401
Ae	2005-2006	2,314	1,614	12,579	7,237	32,403	20,608	76,755
	2007-2011	2,314	1,614	11,976	6,880	30,440	24,334	77,557
	2012-2016	2,314	1,614	13,999	8,102	29,635	26,714	82,378
Scottish Borders	2005-2006	2,314	0	7,672	16,571	16,241	21,995	64,793
	2007-2011	2,314	0	8,478	17,104	15,285	24,409	67,590
	2012-2016	2,314	0	12,544	17,569	18,607	29,001	80,035
Totals	2005-2006	34,710	8,072	205,832	166,578	353,943	166,573	935,708
	2007-2011	34,710	8,072	207,695	175,060	333,753	197,968	957,258
	2012-2016	34,710	8,072	202,854	192,147	367,772	236,930	1,042,485

Table D.4 Summary of wood fuel resource under Scenario 3 ('Total resource'). Values show oven dry tonnes of wood fuel available from six product categories on an annualised basis. A definition of categories is given in the text

Forest district	Period	Arb. wood	Secondary wood	Low quality trees and early thinnings	Harvesting residues	Round wood	Sawlog material	Total
Dornoch	2005-2006	2,314	0	39,074	4,244	34,005	34,245	113,882
	2007-2011	2,314	0	41,056	3,060	36,831	50,366	133,627
	2012-2016	2,314	0	37,925	2,941	48,206	79,453	170,839
Inverness	2005-2006	2,314	1,614	18,782	8,323	69,015	116,559	216,607
	2007-2011	2,314	1,614	17,983	8,791	70,753	146,847	248,302
	2012-2016	2,314	1,614	14,563	8,844	72,007	166,411	265,753
Moray	2005-2006	2,314	404	14,022	4,173	37,736	60,608	119,257
	2007-2011	2,314	404	12,675	3,611	34,175	63,088	116,267
	2012-2016	2,314	404	10,910	4,165	41,430	86,249	145,472
Fort Augustus	2005-2006	2,314	0	13,395	5,008	46,052	77,904	144,672
	2007-2011	2,314	0	13,027	5,842	46,390	96,488	164,060
	2012-2016	2,314	0	8,305	7,218	49,405	111,340	178,582
Buchan	2005-2006	2,314	404	3,136	5,488	45,934	86,400	143,676
	2007-2011	2,314	404	2,455	5,988	35,928	78,078	125,167
	2012-2016	2,314	404	2,703	6,606	40,994	96,289	149,310
Lochaber	2005-2006	2,314	404	20,000	3,638	35,370	53,664	115,390
	2007-2011	2,314	404	24,233	3,685	29,858	56,470	116,964
	2012-2016	2,314	404	22,833	4,801	36,557	74,778	141,686
Kincardine	2005-2006	2,314	807	4,146	9,489	34,710	70,638	122,104
	2007-2011	2,314	807	3,837	8,157	29,402	79,740	124,257
	2012-2016	2,314	807	3,422	8,230	29,148	94,126	138,047
Lorne	2005-2006	2,314	0	11,652	6,165	36,006	58,509	114,646
	2007-2011	2,314	0	10,523	8,458	44,787	75,268	141,350
	2012-2016	2,314	0	11,817	10,369	54,044	103,941	182,485
Tay	2005-2006	2,314	807	16,352	34,654	73,715	123,717	251,559
	2007-2011	2,314	807	14,601	34,761	67,306	137,547	257,336
	2012-2016	2,314	807	16,360	36,367	66,073	165,880	287,801
West Argyll	2005-2006	2,314	0	8,473	8,431	73,707	101,955	194,880
	2007-2011	2,314	0	8,969	11,892	95,039	154,319	272,533
	2012-2016	2,314	0	7,432	11,061	86,128	158,636	265,571
Cowal and Trossachs	2005-2006	2,314	0	11,242	15,709	76,798	138,539	244,602
	2007-2011	2,314	0	12,885	16,866	77,014	165,353	274,432
	2012-2016	2,314	0	12,700	19,383	76,565	177,316	288,278

Table D.4 *continued*

Forest district	Period	Arb. wood	Secondary wood	Low quality trees and early thinnings	Harvesting residues	Round wood	Sawlog material	Total
Scottish Lowlands	2005-2006	2,314	2,018	15,909	15,442	77,500	119,785	232,968
	2007-2011	2,314	2,018	15,718	17,114	83,995	157,664	278,823
	2012-2016	2,314	2,018	17,065	20,675	96,256	210,090	348,418
Galloway	2005-2006	2,314	0	9,396	22,006	95,563	167,341	296,620
	2007-2011	2,314	0	9,280	22,851	87,652	195,218	317,315
	2012-2016	2,314	0	10,278	25,816	94,984	250,187	383,579
Ae	2005-2006	2,314	1,614	12,579	7,237	135,252	182,503	341,499
	2007-2011	2,314	1,614	11,976	6,880	131,110	211,049	364,943
	2012-2016	2,314	1,614	13,999	8,102	128,809	229,593	384,431
Scottish Borders	2005-2006	2,314	0	7,672	16,571	96,959	195,835	319,351
	2007-2011	2,314	0	8,478	17,104	84,083	216,236	328,215
	2012-2016	2,314	0	12,544	17,569	87,412	252,190	372,029
Totals	2005-2006	34,710	8,072	205,832	166,578	968,319	1,588,202	2,971,713
	2007-2011	34,710	8,072	207,695	175,060	954,323	1,883,731	3,263,591
	2012-2016	34,710	8,072	202,854	192,147	1,008,019	2,256,479	3,702,281

Appendix E: Estimated wood fuel heating potential in Scotland

Specific evaluation of the potential for wood fuel heating in Scotland, and associated net savings in CO_2 emissions, requires a considerable amount of information on existing fuel use and its possible replacement by wood-fired heating systems which is not generally available. However, an approximate estimate can be derived by combining information from a variety of relevant sources and incorporating simplifying assumptions. In this particular evaluation, attention is focused on space and water heating for the domestic sector in Scotland. In the absence of any detailed data on the breakdown of delivered energy consumption by fuel type, and associated CO_2 emissions, for the domestic sector in Scotland, it is necessary to rely on a general assessment which was conducted in 2002 (Wright, 2005). This assessment addressed the estimation and projection of primary energy demand and associated CO_2 emissions for all sectors in Scotland between 1990 and 2020.

In this assessment, current domestic primary energy demand is estimated to be approximately 4 million tonnes of oil equivalent per year (mtoe/a) which, with a conversion factor of 11.63 x 10^6 MWh/mtoe (DTI, 2005), is equal to 46.52 x 10^6 MWh/a. This compares with a total primary energy demand for Scotland of 14 mtoe/a or 162.82 x 10^6 MWh/a. It is necessary to convert this estimate of primary energy demand into delivered energy consumption. A detailed breakdown of fuel use is required to do this precisely but such information is not directly available. Instead, a breakdown of fuel use by the number of households has been evaluated (Cormack et al., 2004), as summarised in Table E.1.

Table E.1 Breakdown of fuel use by number of households (Cormack et al., 2004)

Type of fuel	Number of households	Percentage of households
Natural Gas	1,561,000	71%
Electricity	444,000	20%
Other Fuels[a]	187,000	9%
Total	**2,192,000**	**100 %**

Note (a) Coal, LPG and oil.

Applying the simplifying assumption that the breakdown of fuel use by number of households is directly reflected in delivered energy consumption and that national statistics can be used to convert primary energy demand into delivered energy consumption, then the approximate composition of delivered energy consumption for the domestic sector in Scotland in provided in Table E.2.

Table E.2 Approximate breakdown of primary energy demand and delivered energy consumption for the domestic sector in Scotland

Type of fuel	Primary energy demand (106 MWh / a)	Delivered energy consumption (106 MWh / a)
Natural Gas	25.0	27.7
Electricity	18.3	7.1
Other Fuels[(a)]	3.2	3.5
Total	**46.5**	**38.3**

Note (a) Assuming equal split between coal, LPG and oil.

General data for the breakdown of domestic energy use for Great Britain (Shorrock et al., 1992) suggests that the space and water heating account for 82% of total delivered energy consumption. Hence, approximate estimates of the delivered energy consumption by domestic space and water heating in Scotland can be derived, as shown in Table G.3. Additionally, total carbon coefficients (BRE, 2000) can be used to convert these estimates into CO_2 emissions for domestic space and water heating in Scotland, as also indicated in Table G.3.

Table E.3 Approximate estimates of delivered energy consumption and total carbon dioxide emission for space and water heating by the domestic sector in Scotland

Type of Fuel	Domestic space and water heating delivered energy consumption (10^6 mwh / a)	Total carbon dioxide emissions from domestic space and water heating (10^6 t CO_2 / a)
Natural Gas	22.7	4.4
Electricity	5.8	3.1
Other Fuels[(a)]	2.9	0.8
Total	**31.4**	**8.3**

Note (a) Assuming equal split between coal, LPG and oil

It should be noted that it has been estimated that the domestic sector accounts for 12% of current total CO_2 emissions of approximately 57 x 10^6 t CO_2/a in Scotland, resulting in 6.9 x 10^6 t CO_2/a. Applying the assumption that space and water heating account for 82% of domestic delivered energy consumption, the associated CO_2 emissions are 5.7 x 10^6 t CO_2/a. Hence, this suggests that, at the moment, total CO_2 emissions from domestic space and water heating in Scotland are between 6 and 8 x 10^6 t CO_2/a.

The amount of wood required to provide space and water heating depends on the type of wood fuel and the seasonal thermal efficiency of wood-fired heating system. In the likely worst circumstances, 0.46 odt of wood would be needed to produce 1 MWh of space and water heating in a system with a seasonal thermal efficiency of 50%. In the likely best circumstances, 0.29 odt of wood would be required to produce 1 MWh of space and water heating in a system with a seasonal thermal efficiency of 80%. Assuming that between 700,000 and 1,000,000 odt of wood are available for energy purposes in Scotland, then this could provide between 1.5 and 3.4 x 10^6 MWh/a of domestic space and water heating. This is equivalent to between 5% and 11% of domestic space and water heating in Scotland.

Potential net savings of CO_2 emissions depend on the actual conventional heating fuel which is displaced by wood and the total CO_2 emissions of the alternative wood-fired heating system. The likely range of total CO_2 emissions from wood-fired heating systems ranges from 22 to 55 kg CO_2 emissions per MWh of space and water heating. Assuming that the most likely current market for wood fuelis in displacing an equal mix of coal (460 kg CO_2/MWh), electricity (543 kg CO_2/MWh), LPG (317 kg CO_2/MWh) and oil (384 kg CO_2/MWh), mainly in rural areas without natural gas supplies, then possible net savings from using the wood resource available in Scotland amount to between 0.6 and 1.4 x 10^6 t CO_2/a. This is equivalent to 7% and 23% of estimated CO_2 emissions from domestic space and water heating in Scotland.

Appendix F: Details of heat cost comparisons

Seasonal wood boiler efficiency has been set at 85%. This is based on manufacturers information for modern Austrian and Scandinavian boilers. The effective boiler output is the fuel consumption in kWh multiplied by the boiler efficiency. The cost of fuel is the number of units multiplied by the cost per unit of fuel. The assumed fossil fuel prices are as follows:

- **Oil:** 32p per litre delivered
- **LPG:** 31p per litre delivered
- **Coal:** £158 per tonne delivered
- **Anthracite:** £204 per tonne delivered
- **Gas:** 2.2 per kWh (unit)
- **Electricity:** 5.4/kWh (75% economy 7 and 25% day rate)

The assumed wood fuel prices are as follows:

- **Wood chip at 35% moisture:** £45 per tonne delivered
- **Wood pellets at 5% moisture:** £160 to 230 per tonne delivered
- **500 mm logs:** £50 per tonne delivered by a typical log supplier a (although in practice the user of the case study equipment has a "free" supply of log wood which he collects himself from the forest floor.)

Wood chip delivery prices cover the felling and extraction of the timber (or other sourcing), air drying it for one year, its transport to the processing location, chipping, storage, loading to delivery vehicle and transport to the site and unloading. Variables are involved in all the stages, for example whether or not rent must be paid for a store, costs of various distances involved, whether or not the supplier owns a suitable delivery vehicle or has to hire one, whether the on-site fuel store is large enough to take full loads of fuel, accessibility of the site and the amount of manual labour involved versus additional machinery. It should also be borne in mind that fuel chips at 35% moisture are lighter than newly felled trees at 55% moisture. Every tonne of chip at 35% requires nearly 1.6 tonnes of newly felled timber.

The maintenance cost for each site has been estimated and includes any regular servicing (at £10 per hour) such as ash removal plus an annual service. The annual maintenance cost has been assumed at £100 per boiler and £14,000 for Lochgilphead district heating. For the district heating scheme, normal practice is to include the cost of running the heat supply company, maintenance organisation or ESCO. Industry practice[1] is to use a standard figure of 4.5% of pipe costs for this and covers such items as insurance, O&M, replacement of parts, electricity for pumps, meter reading, trouble shooting, administration and billing.

The total cost and the cost per kWh both include the maintenance cost. The comparative fossil fuel usage assumes that the same amount of heat is delivered from a similar plant using a fossil fuel boiler. For the log and pellet systems there is in reality a labour cost for refuelling the stove/boiler but at this scale the user normally does not cost his time for so doing. To give a true picture the heat cost comparators show two figures, one without a re-fuelling labour cost and one with (costed @£10 per hour).

1 The Energy Savings Trust Community Energy training programme for community heating schemes recommends this practice.

Appendix G: The wood fuel heating supply chain

Elements of the supply chain	Description and cost	Level of technical development / availability	Coverage / gaps and weaknesses	Response required
Fuel processing equipment: Chippers	Chippers are used to produce wood chips from forestry input material (e.g. stemwood, branches). They range in cost from under £5000 for a small mobile unit to over £200,000 for a large static unit. The more expensive equipment is higher quality and can take larger diameter timber and process it faster. A new chipper capable of producing consistent fuel-quality chips would cost about £15,000.	Chipper technology is well established, and available on the market but there are few examples of fuel-quality chippers in Scotland (and most of those are not used for producing fuel).	The relatively high cost of chippers, and the small market for chips is a deterrent to purchasing equipment. Fuel-quality chips are most easily produced from good quality input material. With appropriate material and a trained operator, many chippers could produce a year's supply of chips for a school or small housing scheme in a week. This means that chippers used for fuel chips are often underused.	Support for investment in equipment. Clustering of activities to ensure a local market for chips. Industry-wide specification on acceptable fuel quality, so the customer is assured of what they are buying. EU CEN 335 is in process but is complex so a simple derivative standard is required.
Fuel processing equipment: Pellet mills	Small pellet mills are available on the market but depend on a local fuel supply and availability of screening and bagging plant.	None known in Scotland yet.	Economics of home produced pellets difficult to gauge in the light of still low fossil fuel prices. Difficult to get adequate regular supplies of clean sawdust feedstock. Difficult to compete with price of imported pellets from Baltic states. There are no working systems in UK which can be studied for costs / outputs but the operation costs are known from Europe, and studies are ongoing in the UK.	Imported pellets are starting to kick-start the market. Importers / distributors would benefit from help with the cost of transport while the market is still small and decentralised.

Elements of the supply chain	Description and cost	Level of technical development / availability	Coverage / gaps and weaknesses	Response required
Fuel delivery equipment	Tractors with tipping trailers are the most commonly used fuel delivery system for wood chips. They require expensive below ground fuel store or ramp access to enable tipping. A range of more specialised delivery options exist. Pellets are mostly delivered in sacks on pallets at present. This requires a pallet handling vehicle. Pneumatic delivery preferable for large loads and to deliver to inaccessible locations.	Tractors with tipping trailers are widely available. Other specialist equipment is more limited, with e.g. a single grab discharge lorry based in the Borders region and supplying the area from Dumfries to the Lothians. Pneumatic delivery not available yet in Scotland though animal feed wagons are in use elsewhere but this is not a long term solution for animal hygiene reasons and because of cleaning costs.	Specialised fuel storage requirements for tippers add to capital cost for customer. Until there is sufficient demand, no haulage or fuel distributor is likely to invest in specialist vehicles. Fuel is not stocked or held for distribution so all chip fuel is either diverted from the board and paper supply or chipped to order, which leaves clients exposed to risk and is a major disincentive to investment in wood fuelled heating. Pellet distribution very limited because of distances.	Support for investment in delivery vehicles. Clustering of activities to ensure a local market for chips and pellets. Capacity building of the fuel resource so that clients can have confidence of a reliable and affordable fuel supply.
Fuel storage equipment	Bulky fuels need large distribution depots and large machines to move the fuel. These are expensive to build and operate. Chip and pellets stores adjacent to the boilers are also large compared to oil tanks and need mechanical extraction equipment, which is also expensive.	Large stores and large vehicles are common in the bulk handling industry. Fuel storage and extraction technology for the boilers is well developed and equipment is supplied by the existing boiler suppliers.	Issue is demand and supply based. Sheds are expensive and wood fuel storage must compete against the high value products that can pay higher rent. Few buildings on the market have below ground storage.	Capacity building by support for space rentals and capital costs of machines during the start up phase of wood fuel fuel supply chain development. Again the concept of wood fuel refineries / distribution depots where wood is received and converted into fuel and stored prior to delivery. Issue is volume throughput required to make a profit on this activity and getting to that critical volume in any one geographical area.

Elements of the supply chain	Description and cost	Level of technical development / availability	Coverage / gaps and weaknesses	Response required
Mechanical handling of chips and pellets	Loading of delivery vehicles requires equipment such as tractor and loader. Onsite fuel stores need walking floors and feed augers. Pellet storage needs a mechanical discharge from a building with a stirrer.	Fuel storage and extraction technology for the boilers is well developed and equipment is supplied by the existing boiler suppliers.	Adds considerable cost to the installation.	Grant or support schemes need to cover all ancillary equipment.
Combustion equipment: Wood chip combustion equipment	A good range of equipment is available. Up to five times the price of an equivalent fossil system because of higher quality long life plant and need for fuel storage and handling equipment.	Good quality efficient heat plant available from about 8 UK suppliers of whom four are in Scotland.	Geographical coverage is all of Scotland. Small firms with limited resources. The biggest of the Scottish firms has four staff. Difficulty in getting experienced personnel.	Need steady incremental growth and time to gain experience. Grants or other support required to establish the market.
Combustion equipment: Pellet combustion equipment	Smaller and cheaper plant than for wood chips. More often used for small scale and domestic heating. Installed cost 3 to 7 times equivalent performance fossil fuel boilers.	Many high quality manufacturers in western Europe plus some lower specification equipment from eastern Europe. Most quality European manufacturers now represented in the UK (about 15 brands). Three Scottish companies actively involved in the market plus some interest from retail outlets.	Due to lower total installed costs of pellet plant it is difficult for the suppliers to install Scotland wide and keep costs at an appropriate level.	SCHRI grant has raised awareness and interest. However, the lack of local fuel resource and Scottish production discourages customers. A network of installers / service engineers would be ideal, however heating engineers are already in short supply and few are minded to retrain to install pellet appliances.

Elements of the supply chain	Description and cost	Level of technical development / availability	Coverage / gaps and weaknesses	Response required
Combustion equipment: Log combustion equipment	Log boilers are 5 to 10 times more expensive than equivalent fossil fuel boilers, and the equipment is much larger too.	There are 4 importers of log appliances of this type in the UK with 2 represented in Scotland. Some of the suppliers do not fully understand the technical requirements of a log heating system and do not provide sufficient product support and heating system design advice.	Log boilers are ideal for people with access to low cost wood fueli.e. landowners and forest workers. There are insufficient specialist installers for this equipment.	The SCHRI grant has raised awareness but because of the high capital cost of systems the client still has to find a large proportion of the cost.
Ancillary equipment	High quality and therefore high price equipment is required for optimal operation of wood fuel heating systems, whether newly installed or retrofitted.	Equipment is often imported, e.g. boiler controls and accumulator tanks.	UK heating industry (both suppliers and consumers) are slow to appreciate the need for this level of quality.	Education of both the public and the heating industry may increase the demand for high quality tanks and controls, which if used correctly will improve efficiency of all types of heating boilers and enhance user comfort.
Containerised systems **(Ready plumbed and connected boilerhouse cum fuel store)**	These are available from the main boiler suppliers. They have the advantage of ease of installation and reduced planning issues.	One has been installed in Scotland.	Disadvantage is that fuel store is normally accessed from above and will require specialist delivery vehicle unless the container is situated below ground.	

Elements of the supply chain	Description and cost	Level of technical development / availability	Coverage / gaps and weaknesses	Response required
Installer and maintenance firms	Installation and maintenance of wood fuel boilers and heating plant needs considerable specialist training. High cost as a few specialists have to travel long distances even to install or maintain a small domestic appliance.	Three boiler suppliers in Scotland and small number of others able to install and maintain plant at present. Very few independent specialists in UK; most are importers as mentioned above.	Limited demand for their services and high level of training and breadth of knowledge required. UK-wide shortage of plumbers and heating engineers means that few existing firms are interested in new areas of work.	Funding to support in house training of engineers and plumbers. Support growth of sector so that real jobs can be created for skilled workers.
Energy supply / O&M services	Can deliver heat cheaper than from fossil fuels. Provide "one point of contact" for installation, operation, fuel supply and maintenance.	Five embryonic firms in UK specialise in serviced wood heating. One in Scotland.	Limited by capacity of small firms and need for local fuel supply but great potential.	Opportunities for steady growth, help with capital costs.
Wood fuel suppliers	Best practice is for chips to travel a maximum of 15 miles from supplier. Suppliers need a large depot store and in some cases specialist delivery vehicles are required.	At present there are several chip suppliers and at least two pellet suppliers in Scotland. Several of them are supplying more than one location.	The economics are such that in the early stages of development of the market, chip and pellet fuel supply needs to be associated with another income-generating activity and help is often needed with the high capital costs of processing equipment and delivery vehicles.	A network is needed throughout Scotland's off-gas areas. Support for the set up of fuel supply needed in the early stages of market development.

Elements of the supply chain	Description and cost	Level of technical development / availability	Coverage / gaps and weaknesses	Response required
Wood chip suppliers	Chips are readily available at low cost from many sources. Chips are bulky to transport and cannot be hauled far before the transport cost exceeds the value of the fuel. Handling and preparing chips for burning is costly for small volumes.	Most available chips are too wet to be used as fuel except in specialist boilers and will need further processing to make a good fuel (some larger boilers can accept wetter fuel). Many potential fuel resources (e.g. arboricultural residues) are contaminated during production and storage e.g. with soil, or are produced from an unsuitable machine (chips too small or too large).	Chip production needs to be LOCAL to the fuel consumer. Chips need to be specially prepared for fuel use. Few chip makers (sawmills, foresters, arboriculturalists) understand chip fuel market or are able / prepared to do the extra work required to make a fuel quality chip.	Although chips are cheap and plentiful preparation for fuel use is expensive on a small scale. Further support to set up local "wood fuel refineries" is required but this has to be hand in hand with boiler uptake.

Elements of the supply chain	Description and cost	Level of technical development / availability	Coverage / gaps and weaknesses	Response required
Wood pellet suppliers	Pellets are expensive in the UK due to importing in low volumes with high transport and storage costs. Pellet production requires expensive high volume machinery and the current UK market does not warrant this scale of investment yet. Global commodity values for pellets are low.	There are many wood pellet machine suppliers and many pellet manufacturers across Europe. UK developers seem keen to re-invent the process in a cheaper fashion which is inadvisable- from the US experience low quality pellets will destroy the wood heating market. (US pellet industry – started in 1980s and crashed in early 1990s due to mix of poor fuel and poor appliances. It then took 10 years of industry self-regulation and promotion with fuel and appliance standards to recover. See PFA website.)	There is no national distribution infrastructure and no one importing in sufficient volume to bring the price down enough to compete with low UK fossil fuel prices. Smaller importers are struggling and competing for a small market.	Support for regional capacity building by underwriting costs of bulk import and storage to enable the market for fuel to develop to a point where demand is such that a Scottish pellet mill can be funded against existing sales.
Wood chip dryers	Wood is commonly air dried in the round before chipping to avoid the expense of artificial drying. No proprietary dryers on the market in Scotland yet.	Two local firms have developed wood chip dryers, one in Ardnamurchan and one in the Borders. In England a few examples of chip drying using grain drying floor methodology etc.	The cost and need for double handling are disincentives to use chip dryers. For schemes where the boiler is very sensitive to fuel moisture they could be invaluable in bad weather. Grain type drying floors work but are very labour intensive involving double handling of all the fuel.	Development work on dryers could be useful. Wet chip boilers could be used in situations requiring over 150kW heat but have even higher capital cost and require greater volume of fuel and fuel storage.

Appendix G: The wood fuel heating supply chain

Elements of the supply chain	Description and cost	Level of technical development / availability	Coverage / gaps and weaknesses	Response required
Log supplies	The domestic log market is such that seasoned logs are a much higher price than oil when the heat values are compared. The amount of manual handling of logs means that the costs cannot be competitive with fossil fuels if labour costs have to be accounted for in full.	Log splitters, cutters and baggers are available which can speed up production and reduce handling. However most log suppliers have other main incomes and do not therefore invest in mechanised log production –mainly because the current local market cannot support that level of production.	Fuel quality control is an issue. Log boilers make sense economically where the boiler owner has a ready supply of his own fuel or when a low cost supply of high quality seasoned long logs is locally available.	Co-operative purchase of mechanised log preparation machines would benefit log boiler users and possibly allow an expansion of the market to neighbours etc. Or the Wood fuel refinery idea would be a solution.

Appendix H: Wood fuel advisory services in scotland

Service provider	Contact details	Type of service
Rebecca Carr Wood fuel Project Officer (Highland)	01349 866004 07717 618650 rebecca.carr@forestry.gsi.gov.uk	Advice on wood fuel supply chain, heating systems and availability of grants.
Forest Research	01889 586844 research.info@forestry.gsi.gov.uk www.forestresearch.gov.uk / woodfuel	Advice on growing and processing wood fuel and burner systems.
SCHRI Scottish Community and Householder Renewables Initiative	www.est.org.uk / schri /	Grants, advice and project support to assist the development of new community and household renewable schemes in Scotland, including wood fuel.
Highland Birchwoods Littleburn, Munlochy, Ross-shire IV8 8NN	01463 811 606	Highland Birchwoods are involved in the development of wood fuel supply chains. Currently running an Interreg. EU project on wood fuel supply chains.
Northern Woodheat	www.northernwoodheat.net / scotland.php	
Cluster Support Unit Scottish Forest Industries Cluster Confederation of Forest Industries Ltd 5 Dublin Street Lane South Edinburgh EH1 3PX	0131 524 8097 www.forestryscotland.com / pages / bio.asp	The Cluster promotes the use of bioenergy. Their website has links to quite a lot of information and reports.
Forestry Contracting Association Dalfling, Blairduff Inverurie Aberdeenshire AB51 5LA	members@fcauk.com	
Highland Wood Energy Ltd Unit 2 Old Mart Industrial Estate Corpach Fort William PH33 7NN	01397 773000 www.highlandwoodenergy.co.uk	
3GEnergi Ltd Unit 3, The Knowes Kelso TD5 7BH	Tel: 01573 229198 Fax: 0870 706 2555 www.3genergi.co.uk	

Appendix I: Initiatives for wood fuel heating

Source: Wood fuel energy group, 2005

Funding source	Description	Eligibility	
Scottish Forestry Grants Scheme	Funded and managed by the Forestry Commission. Schemes using forest residues or material from woodland being brought back into active management may be applicable under the developing community involvement objective.	Woodland owners and managers, community groups.	www.forestry.gov.uk/website/pdf.nsf/pdf/flyer.pdf/$FILE/flyer.pdf
Loan Action Scotland	Funded by Scottish Executive, managed by the Scottish Energy Efficiency Office in support of the Action Energy. Although this is primarily an energy efficiency scheme wood fuel heating equipment may be eligible.	Companies based in Scotland with up to 250 employees. Companies need to demonstrate proposed actions will deliver energy efficiency benefits.	www.energyefficiency.org/howto/help/loan/index.html
Enhanced Capital Allowances Scheme	This is part of the Climate Change Levy Programme introduced in 2001, sponsored by Treasury, Defra and the Carbon Trust. It is designed to encourage businesses to invest in low carbon technologies. Wood fuel boilers are included as 'energy saving plant and machinery.'	All businesses in the charge of UK tax.	www.eca.gov.uk/
Bio-energy Infrastructure Scheme	Funded and managed by Defra. Designed to develop supply chains from wood fuel source to end user via the establishment of 'Producer Groups'. Applies to energy crops and forestry wood fuel.	Growers, farmers, woodland managers.	www.defra.gov.uk/farm/acu/energy/infrastructure.htm
Bio-energy Capital Grants Scheme	Funded by DTI and the New Opportunities Fund with input from Defra. Provides investment support for schemes struggling to compete in the Renewables Obligation. Geared towards energy crops schemes although support is also available for heating schemes.	UK Industry.	www.dti.gov.uk/energy/renewables/support/capital_grants.shtml

Appendix I: Initiatives for wood fuel heating

Funding source	Description	Eligibility	
Develop Low Carbon Technologies	Funded by the Carbon Trust which aims to reduce GHG emissions and move to a low carbon economy. They seek to support innovative projects and ground breaking projects.	Any UK organisation.	www.thecarbontrust.co.uk/carbontrust/low_carbon_tech/dlct2_1.html
Scottish Community and Householder Renewables Initiative (SCHRI)	Sponsored by the Scottish Executive, managed by EST and HIE. Aims to assist the development of new community and household renewable schemes in Scotland.	Community groups and householders.	Energy Savings Trust, Scottish Community and Householder Renewables Initiative
Farm Business Development Scheme	Grant assistance for farmers wishing to diversify, cover processing of forest products	Farmers in Scotland.	www.sled.org.uk/ruralsup.htm
Woodfuel Development Programme	Set up by the Highlands and Islands Wood fuelGroup via SCHRI funds. Aims to assist with the development of 6 clusters of local wood fuelsuppliers and end users.	Small and medium businesses in the Highlands and Islands.	www.hie.co.uk/aie/wood-fuel.html
Community Energy Programmes	Funded by Defra. Managed by Energy Saving Trust and Carbon Trust. Aims to deliver a sustainable community heating market. Heat can be supplied from CHP, boilers using conventional or renewable fuels including wood, and waste heat from industry.	UK Public sector customers are eligible although schemes can also supply private sector customers in a secondary capacity.	www.est.org.uk/communityenergy/aboutenergy/

Organisations and government departments involved in funding and managing incentives for wood fuel heating schemes and related infrastructure:

DEFRA
Carbon Trust
Scottish Executive
Action Energy
DTI
HIE
Inland Revenue

Energy Saving Trust
Forestry Commission
Scottish Energy Efficiency Office
Treasury
New Opportunities Fund
Scottish Community and Householder Renewables Initiative

Appendix J: Net greenhouse gas emissions savings

Generic cases for total greenhouse gas emissions from wood-fired heating systems and conventional heating systems

Wood-fired Heating System	Total Emissions (kg eq CO_2 / MWh)					
	Wood	Electricity (a)	Natural Gas (b)	Oil (c)	LPG (d)	Coal (e)
30 kW Boiler in Single Building using Logs from Woodland Small Roundwood (f)	39	580	234	389	320	503
30 kW Boiler in Single Building using Logs from Arboricultural Prunings (f)	36	580	234	389	320	503
150 kW Boiler in Single Building using Logs from Woodland Small Roundwood (f)	35	579	232	386	319	500
150 kW Boiler in Single Building using Logs from Arboricultural Prunings (f)	33	579	232	386	319	500
5 kW Stove in Single Building using Chips from Forest Small Roundwood (g)	33	582	237	396	323	509
60 kW Stove in Single Building using Chips from Forest Small Roundwood (h)	27	580	233	388	320	501
60 kW Boiler in Single Building using Logs from Woodland Small Roundwood (h)	29	580	233	388	320	501
150 kW Boiler in Single Building using Chips from Woodland Small Roundwood (h)	26	579	232	386	319	500
150 kW Boiler in Single Building using Chips from Forest Branchwood and Thinnings (h)	27	579	232	386	319	500
460 kW Boiler in Single Building using Chips from Forest Small Roundwood (h)	24	579	231	385	318	498
460 kW Boiler in Single Building using Chips from Forest Branchwood and Thinnings (h)	26	579	231	385	318	498
460 kW Boiler in Group Buildings using Chips from Forest Small Roundwood (h)	28	579	231	385	318	498
460 kW Boiler in Group Buildings using Chips from Forest Branchwood and Thinnings (h)	29	579	231	385	318	498
7 kW Stove in Single Building using Pellets from Sawmill Offcuts and Sawdust (i)	58	581	236	394	323	508
7 kW Stove in Single Building using Pellets from Forest Branchwood and Thinnings (i)	63	581	236	394	323	508
30 kW Boiler in Single Building using Pellets from Sawmill Offcuts and Sawdust (i)	53	580	234	389	320	503
30 kW Boiler in Single Building using Pellets from Forest Branchwood and Thinnings (i)	57	580	234	389	320	503

Notes

(a) Assuming a 100 % seasonal thermal efficiency of radiant electric heaters with thermostats in a single building.

(b) Assuming a 90 % seasonal efficiency for a condensing natural gas-fired boiler and central heating system in a single building.

(c) Assuming a 80 % seasonal thermal efficiency for a conventional oil-fired boiler and central heating system for a single building and a fuel delivery round trip distance of 200 km.

(d) Assuming a 80 % seasonal thermal efficiency for a conventional LPG-fired boiler and central heating system for a single building and a fuel delivery round trip distance of 200 km.

(e) Assuming a 70 % seasonal thermal efficiency for a conventional coal-fired boiler and central heating system for a single building and a fuel delivery round trip distance of 200 km.

(f) Assuming a seasonal thermal efficiency of 50 % and a fuel delivery round trip of 50 km.

(g) Assuming a seasonal thermal efficiency of 80 % and a fuel delivery round trip of 50 km.

(h) Assuming a seasonal thermal efficiency of 80 % and a fuel delivery round trip of 150 km.

(i) Assuming a seasonal thermal efficiency of 80 % and a fuel delivery round trip of 300 km.

References

ASPO (2005) "*Association for the Study of Peak Oil and Gas*" www.peakoil.net, accessed 24 February 2005.

BRE (2000) "*Methodology for Environmental Profiles of Construction Materials, Components and Buildings*", Centre for Sustainable Construction at the Building Research Establishment Ltd., Garston, Watford, UK.

Cormack, D., Friel, K., Grainger, S., Millen, D., and Robinson, A. (2004) "*Fuel Poverty in Scotland: Further Analysis of the Scottish House Condition Survey*" House Condition Survey Team, Communities Scotland, Edinburgh, UK, www.shcs.gov.uk.

Deffeyes, K. S. (2001) "*Hubbert's Peak*"*: The Impeding World Oil Shortage*", Princeton University Press, Princeton, New Jersey, United States of America.

DTI (2004a) "*Trends in Energy Prices Between 2003 and 2010*" Department of Trade and Industry, London, UK, www.dti.gov.uk/publications.

DTI (2004b) "*Quarterly Energy Prices, December 2004*" Department of Trade and Industry, London, UK, www.dti.gov.uk/publications.

DTI (2004c) "C*o-operative Energy: Lessons from Denmark and Sweden*" Global Watch Mission Report, Department of Trade and Industry, London, UK, www.dti.gov.uk/publications.

DTI (2004d) "*Renewable Energy Industry Gap Analysis: Summary Report*" Department of Trade and Industry, London, UK, , www.dti.gov.uk/publications.

DTI (2005) "*Energy Trends, March 2005*" Department of Trade and Industry, London, UK, www.dti.gov.uk/publications.

EC (1997) "*Energy for the Future: Renewable Sources of Energy – White Paper for a Community Strategy and Action Plan*" COM(97)599, European Commission, Brussels, Belgium, www.europa.eu.int.

EC (2000) "*Directive on the Incineration of Waste*" COM(2000)76, European Commission, Brussels, Belgium, www.europa.eu.int.

EC (2003) "*Establishing a Scheme for Greenhouse Gas Emission Allowance Trading within the Community*" COM(2003)/87, European Commission, Brussels, Belgium, www.europa.eu.int.

EC (2004a) "*Communication on the Development of the Contribution of Renewable Energy Sources in the European Union and Proposals for Concrete Action*" COM(2004)366 Final, European Commission, Brussels, Belgium, www.europa.eu.int.

EC (2004b) "*Towards a European Strategy for Security of Energy Supply: Green Paper*" COM(2004)769, European Commission, Brussels, Belgium, www.europa.eu.int.

ECS (1997) "*Environmental Management – Life Cycle Assessment – Principles and Framework*" European Standard ISO 14040, European Committee for Standardisation, Brussels, Belgium.

Edwards, P. N., and Christie, J. M. (1981) "*Yield Models for Forest Management*" Forestry Commission, Edinburgh, UK.

Elsayed, M. A., Matthews, R., and Mortimer, N. D. (2003) "*Carbon and Energy Balances for a Range of Biofuels Options*" Report URN 03/836, Project No. B/B6/00748/REP for the Department of Trade and Industry by the Resources Research Unit, Sheffield Hallam University, Sheffield, UK.

Evans, S. (2004) "*Financing the Development of a Wood fuel Energy Industry in Scotland*" Future Energy Solutions/AEA Technology Report for Scottish Executive Social Research, Edinburgh, UK.

Gilbert, J., Matthews, R. W., Johnson, D (2005) "*Development of an Inventory-based Production Forecasting System for Predicting Timber Availability from Public and Private Sector Forests in Great Britain under Alternative Forest Policy Scenarios*" Forest Research (in preparation).

Halsall, L., Matthews, R. W., Kennelly, C., Vials, C. and Duckworth, R. R. (2005) "*Development of a GIS-based Production Forecasting System for Predicting Timber Availability from the National Forest Estate in Great Britain under Evolving Silvicultural*

Practice" Forest Research (in preparation).

Heaton, R. and Matthews, R. W. (2005) "*Greenhouse Gas Benefits of Small-scale Wood fuel Heating Systems in the UK*" Information Leaflet, International Energy Agency Bioenergy Task 38 on Greenhouse Gas Balances of Wood fuel and Bioenergy Systems, Graz, Austria.

Ilex Energy Consulting (2003) "*Possible Support Mechanisms for Wood fuel-generated Heat*" Scoping Study Report for the Department for Environment, Food and Rural Affairs, Report No. 2004 / 039, prepared by Ilex Energy Consulting, Oxford, UK.

IPCC (2001) "*Third Assessment Report*" Intergovernmental Panel on Climate Change, www.grida.no / climateipcc_tar / wg1.

Jaako Poyry Consulting (2003) "*Scottish Forest Industry Investment Opportunity*" Briefing Note, Leadership Group, Scottish Executive, Edinburgh, UK.

Laherrère, J. H. (2001) "*Forecasting Future Production from Past Discovery*" Organisation of Petroleum Exporting Countries Seminar.

Lavers, M., and Moore, G. L. (1983) "*The Strength Properties of Timber*" Building Research Establishment Ltd, Garston, Watford, UK.

Luker, S. (2004) "*Woodfuel Prices for Heating*" Information Paper, Scottish Forestry Cluster, Glasgow, UK.

Matthews, R., Robinson, R., Abbott, S., and Fearis, N. (1994) "*Modelling of Carbon and Energy Budgets of Wood fuelCoppice Systems*" Report ETSU B / W5 / 00337 / REP, Energy Technology Support Unit, Harwell, UK.

Matthews, R. W. and Robertson, K. A., editors (2001) "*Answers to Ten Frequently Asked Questions about Bioenergy, Carbon Sinks and Global Climate Change*" Information Leaflet, International Energy Agency Bioenergy Task 38 on Greenhouse Gas Balances of Wood fuel and Bioenergy Systems, Graz, Austria.

Matthews, R. W. and Duckworth, R. R. (2005) "*BSORT: a Model of Tree and Stand Wood fuel Development and Production in Great Britain*" Forest Research (in preparation).

McKay, H., Hudson, J. B. and Hudson, R. J. (2003) "*Woodfuel Resource in Britain*". Contract Report FES No. B / W3 / 00787 / REP / 1, Department of Trade and Industry Publication URN 03 / 1436, prepared by Forestry Contracting Association with Forestry Commission. Department of Trade and Industry, London, UK.

Mochan, S., Hubert, J. and Connolly, T. (2002) "*Log Quality Assessment in Sitka Spruce: Final Report on the Stem Straightness Survey: Wales*" Internal Report, Forest Research, Alice Holt, UK.

Mortimer, N. D., and Brindley, J. (2005) "*Sustainable Energy - A Social Enterprise Response*" North Energy Associates Ltd for Social Enterprise East Midlands, Nottingham, UK, www.seem.co.uk.

NIFES Consulting (2004) "*Addressing National Barriers in the UK*". BIOHEAT II Report GLR 1294 / 12b.

North Energy Associates (2003) "*Wood fuel Mapping Study of North East England*" Report for the Environmental Industries Federation, by North Energy Associates Ltd., Morpeth, UK.

North Energy Associates (2005) "*Study of Public Sector Attitudes to Wood Heating*" Report for OneNorthEast, by North Energy Associates Ltd., Morpeth, UK.

OJEC (2001) "*Directive 2001 / 77 / EC on the Promotion of Electricity Produced from Renewable Energy Sources*" Official Journal of the European Communities, L283 / 33, 27 October 2001, Brussels, Belgium.

OJEC (2002) "*Directive 2002 / 91 / EC on the Energy Performance of Buildings*", Official Journal of the European Communities, L1 / 65, 4 January 2003, Brussels, Belgium.

OJEC (2003) "*Directive 2003 / 30 / EC on the Promotion of Biofuels*" Official Journal of the European Communities, L123 / 42, 17 May 2003, Brussels, Belgium.

References

OJEC (2004) "*Directive 2004/8/EC on the Promotion of Cogeneration*" Official Journal of the European Communities, L52/50, 21 February 2004, Brussels, Belgium.

ORC International (2004) "*Competition Commission: Domestic Bulk LPG*" www.competition-commission.org.uk, accessed 24 March 2005.

RCEP (2004) "*Biomass as a Renewable Energy Source*" Report by the Royal Commission on Environmental Pollution, London, UK.

Scottish Executive (2005a) "*Promoting and Accelerating the Market Penetration of Wood fuel Technology in Scotland*" prepared by the Forum for Renewable Energy Development in Scotland for the Scottish Executive, Edinburgh, UK, www.scotland.gov.uk.

Scottish Executive (2005b) "*A Partnership for a Better Scotland: Partnership Agreement*", Scottish Executive, Edinburgh, UK, www.scotland.gov.uk.

HM Government, Scottish Exeucutive, Welsh Assembly Government, Northern Ireland Office (2005) "*One Future -Different Paths: The UK's Shared Framework for Sustainable Development*" Defra, London, UK, www.defra.gov.uk.

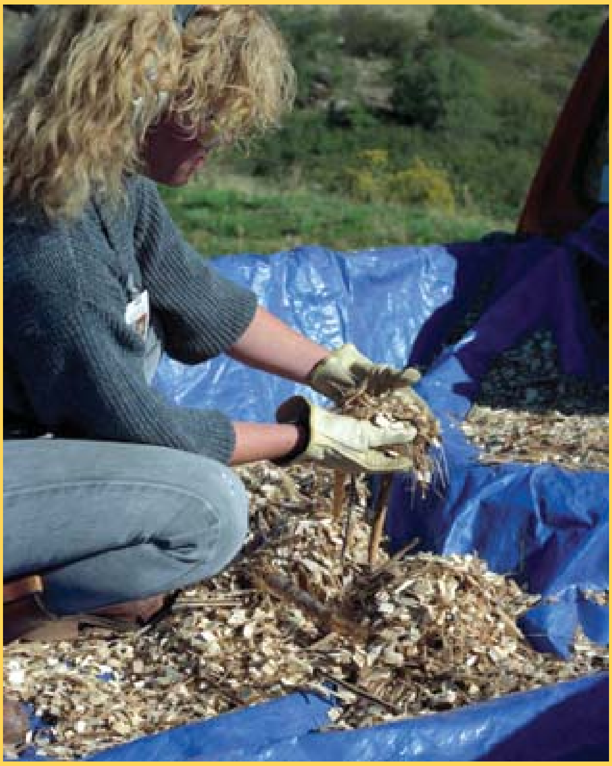
Shorrock, L. D., Henderson, G., and Brown, J. H. F. (1992) "*Domestic Energy Fact File*" Building Research Establishment Ltd, Garston, Watford, UK.

Stirling, G., Gardiner, B., Connolly, T., Mochan, S., Macdonald, E. (2000) "*A Survey of Sitka Spruce Stem Straightness in South Scotland*" Internal Report, Forest Research, Edinburgh, UK.

Wright, J. (2005) "*Energy and Carbon Dioxide Emissions Projections for Scotland, 1999 – 2020: Summary and Discussion of AEA Technology Research*" Scottish Economic Report, Scottish Executive, Edinburgh, UK, www.scotland.gov.uk, accessed 28 March 2005.

UKWAS (2000) "*Certification Standard for the UK Woodland Assurance Scheme*" Forestry Commission, Edinburgh, UK.

Sustainable
Development Commission
Scotland



©NREL

The Sustainable Development Commission

The Sustainable Development Commission (SDC) is the Scottish Executive's independent advisory body on sustainable development and reports to the First Minister in Scotland and the Prime Minister at UK level. The Commission works with government departments, local authorities and businesses put sustainable development at the heart of what they do.

For more information on the work of the SDC or to download a copy of this report, please visit our website at

www.sd-commission.org.uk