Royal Agricultural College

South West Region Biomass and Biofuels Review

By

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on behalf of the Knowledge West project

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The Knowledge West Project

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Funding advice, initiatives and training

One of the major factors inhibiting the development of biomass energy systems in the South West region (as well as nationally) appears to be the lack of clear and comprehensive guidelines both about how they should be developed and about the financial support available. This conclusion has been reached by other researchers (BEG 2005; FTA 2005).

Severn Wye Energy Agency, Rural Enterprise Gateway, South West Biofuels, and the Gloucestershire Wood Fuel Group, for example are all providing a useful service, helping to raise awareness and providing general advice on useful contacts and sources of funding etc. However representative bodies need to ensure that they co-ordinate learning and information sharing and provide expert advice and information. There is a need for a biomass energy network which brings together those in both the supply and demand sides, as well as the responsible public sector agencies. Co-ordination of activity is vital. There is a need to facilitate links between suppliers, processors and generators.

In addition there is likely to be a clear need for one on one advice to provide bespoke guidance and support on a range of issues, including financial incentives available, type of energy system, the feedstock, the supply chain and infrastructure and feasibility studies etc. The development of detailed case study fact sheets using actual projects to illustrate these issues and in turn disseminate best practice would also assist.

There is also a lack of training available within the biomass and biofuels sectors, both a national and regional level. Without a trained, knowledgeable workforce there is a risk that these emerging sectors will not develop in line with regional aspirations.

The markets and supply infrastructure for wood biomass

Wood can be used to generate heat electricity (including co-firing), CHP and biethanol, and thus substitute fossil fuels, including oil, gas and coal. However, there is currently a lack of a formal market and supply infrastructure for the supply of wood biomass, particularly for the routine supply of wood fuel for heating applications. Any wood fuel supply chain development needs to take account of market conditions and requirements, site factors, harvesting methods and transportation. In turn this will require investment in harvesting methods and equipment and transportation, and in turn business and skills development.

The wood biomass resources are low value bulky products, so location relative to the end user is a critical factor. The greater the supply requirement the greater the catchment area and in turn transport distance required. Thus small-scale schemes, where the biomass resource is located close by provides opportunities to reduce costs and environmental impacts of distribution.

The moisture content of wood biomass affects its burning efficiency (and its potential suitability to end users) and hence its value. Both forest material and energy crops (such as Short Rotation Coppice) have a high moisture content following harvest which may involve subsequent drying and storage costs. Furthermore there are also other quality issues including chip size and contamination. All of these quality issues have a potentially significant affect on the logistics and supply infrastructure and in turn on viability – these issues require further investigation, particularly for the heat market.

Biomass wood used for heat generation appears to be competitive with fossil fuel heat systems, particularly if a landowner's own biomass supplies are used to supply their wood heat boiler. The running costs for woodchip heating are potentially lower than fossil fuelled systems. However the capital cost of installation is larger. So in many cases, woodchip currently makes sense versus oil for new build, but is uncompetitive versus gas in a retrofit small heat load.

Potential Supply of Wood Biomass

There is a large potential supply of timber in the South West region from existing woodlands in the form of low value timber and by-products to generate significant energy. A recent report estimates that there is sufficient total wood biomass resource from trees in the region to provide up to 200,000 oven dried tonnes (odt)[1] per year. This could provide over 4 million gigajoules of heat, enough for 50-60,000 homes[2]. The use of wood from this resource (particularly for the heat market, poses few planning and land use issues and offers a non-intrusive way of providing heat energy in rural areas.

By contrast there are limited areas of energy crops (both SRC and miscanthus), thus future supplies will be dependent on whether areas are planted. Whether landowners are willing to commit their land and resources to this new and long-term venture will depend on the costs of production versus the returns offered by the energy markets as well as the profitability of existing agricultural enterprises which in turn will be affected by the Common Agricultural Policy and the grants and incentives offered.

Timber Markets

Timber prices remain depressed – in particular demand for low quality wood (traditionally sold to the pulp and board industries), has dropped with incentives being provided for recycled fibre in the pulp, paper and board industries. A number of the smaller wood processing plants in the region have closed down in the last 20 years. The recent closure of St Regis pulp mill (in

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[1] odt = oven dry tonnes (i.e. 0% moisture content). Woodfuel would never be delivered at this level of moisture content. The measure is used as a baseline to compare fuels of different moisture content.

[2] Based on 20kj/kg and a heat requirement of 70-80 gigajoules per average 196/70s 3-4 bedroom house.

South Wales), will increase the pressure on woodland owners to find alternative markets for their low value broadleaved timber.

Traditionally much of the timber grown in the region was processed locally – now an estimated 60% of the region's timber is being hauled outside the region, particularly to the Welsh Borders, and the Midlands. This not only results in a substantial added cost for long distance transportation (which can account for as much as 50% of the delivered price), it also has a detrimental impact on energy consumption and environmental pollution. There are thus strong arguments and opportunities for maintaining and developing a more sustainable local market – energy generation is seen by some public sector agencies and woodland owners as one such market.

There is however a high degree of fragmentation in the timber production and processing industries with few linkages between the different parts of the woodland chain, particularly in the private sector. Harvesting systems and the general supply infrastructure would need to adapt if wood for energy generation is to be developed sustainably on a large scale – this has already been recognised in the various previous studies.

Trees and woodlands - the economics of supplying wood biomass for energy generation

There are many factors that affect both the cost of supply and the returns sought by timber producers. The prices currently being offered by the energy users generally offer woodland owners little or no incentive over the rewards offered by the traditional timber markets. Furthermore the costs of supply, particularly from the smaller under-managed woodlands are likely to exceed the prices offered.

However only a relatively small increase in prices offered may make the energy market attractive to a number of woodland owners and contractors. If for example, timber producers were able to achieve delivered prices of £20 - £25/green tonne for timber in the round, (approximately equivalent to £40 - £50/odt), this may exceed the returns offered for the low value products traditionally sold to the pulp and board industries. If the end user has a requirement for the timber to be delivered as chipped material, prices would need to be increased to £60 - £80/odt to reflect the increased costs of having to chip as well as the potentially increased transport costs.

Balanced against this, prices for wood fuel are likely to increase, as firstly fossil fuel prices are expected to rise in the medium to short term and secondly the usage of wood boilers is expected to be more widespread. Furthermore if wood fuel usage becomes more widespread, the harvesting industry are more likely to be more prepared to invest into better suited harvesting systems for wood fuel, which in turn will help reduce supply, costs, as is the case in other countries. Further trial work on selecting and using modern harvesting equipment and systems, as well as tackling issues such as reducing moisture content, storage, chipping and transport and in turn publish better guidelines is also expected to assist.

Energy crops – the economics of supplying wood biomass for energy generation

The South West region contains a significant amount of land (over 50%), that is potentially suitable for growing energy crops. However based on current costs of production and the market prices being offered, they remain uneconomic for most farmers, particularly if they are sold to large-scale energy markets. Previous studies have estimated the costs of production, including chipping, storage, drying and transport are in the region of £50 - £100/odt. Prices offered by Didcot power station are believed to be only £40 - £50/odt.

Consideration would need to be given to the environmental and visual impacts involved, if large areas of the countryside are to be planted with a monoculture of SRC or Miscanthus.

Trees and woodland versus energy crops

The failure of energy crops to develop, despite Government support, has resulted in some criticism and a suggestion that support should not be aimed at energy crops at the expense of alternative resources, particularly forest residues. It was also found that the costs of supplying forestry material were, on average, cheaper than for energy crops.

Liquid Biofuels

The South West region has the potential to supply a significant tonnage of wheat for renewable petrol replacements bioethanol and biodiesel and Oil Seed Rape(OSR), and to a lesser extent as a renewable diesel replacement. Currently, most of these crops are sold for human and animal consumption. I turn, the supply infrastructure already exists, unlike for biomass. The farmers have been growing and harvesting these crops for many years, and likewise the biofuel companies, have been purchasing these crops from the farmers and processing them – thus the growing, harvesting, storage, transport systems etc are already in place.

To date production of biofuels in the UK has been limited, but looks set to increase significantly. There have been more than 20 announcements of planned biofuel factories in the UK – five are at the build or completion stage. However most of these existing and proposed factories are located at large ports and mainly in the north east region. The reasons for locating close to ports include the opportunity to import cheaper raw materials eg soya and palm oil, as is currently happening, to minimise dependence on UK seasons and to reduce costs and the environmental impact of distribution, by being able to ship the biodiesel around the coast. The north east region, also has a large arable area. Furthermore there is a more developed supply infrastructure, including blending and distribution facilities.

Small on-farm production of biodiesel is also attracting interest across the country. However the costs of producing rapeseed oil at farm scale level are likely to be uncompetitive with large-scale factories. Furthermore oil from OSR is currently more expensive than using recycled vegetable oil. In addition, the costs of producing it into biodiesel, (even with a 20p reduction in fuel duty), appear to offer no financial advantage to farmers over buying fossil fuel diesel. However if production costs can be reduced, using cheaper and more efficient technology and/or fossil fuel diesel prices continue to increase, such an enterprise may prove attractive to farmers. Furthermore the process of producing biodiesel results in by-product wastes of cake, glycerine and straw. While there are already markets for these by-products, helping farmers to better harness these markets and achieve better prices would further improve its viability.

Despite the potential attractions, whether food crops should be used to produce fuel rather than food, and if so how much, is an important issue for policy makers to consider. Furthermore, in the longer term cellulose production from straw and other sources of biomass may replace grain as a substrate for bioethanol – this is already recognised by some, but is thought to be 10 or more years away.

Farm Waste Fuel Sources

On farm waste digestion has three potential benefits to farmers – the opportunity to generate electricity/heat, producing fertilizer and soil conditioner and the reduction of nitrogen run-off through the application of the treated sludge by-product instead of the slurry. However the capital costs are considerable and currently they are considered to be generally unviable.

Future Strategy?

Biomass heat and CHP are well established in several countries around the world – the technology is proven and the supply infrastructure in place. Furthermore energy generation particularly from small-scale heat schemes are already potentially finically competitive with fossil fuel systems in the right locations. The focus should be establishing this sector through the use of proven technology, whilst simultaneously developing new technologies and demonstration plants.

It is important to more fully assess the relative economic and environmental benefits that the different sources of biomass can offer, and in turn consider the amount of land that it might be prudent to use to produce fuel both now and in the future. Thus greater research into the relative costs of production, the supply chain and the carbon balance, based on a range of probable scenarios over the next 15 – 20 years is considered desirable.

1.0 Introduction

Developing the use of renewable energy resources is part of European Union, UK and the South West region environmental policies to displace the emissions of greenhouse gases from the combustion of fossil fuels, and so mitigate the impacts of climate change. Furthermore, it has been concluded that biomass and biofuels should be playing a significant role in the energy mix.

Considerable research has been undertaken examining the technical and environmental implications of using biomass for energy generation. There is also a growing interest amongst potential energy end users, renewable energy policy makers and possible wood fuel suppliers. However the use of wood biomass and biofuels to generate energy in both the UK and the South West has been limited to date. Various market boundaries are believed to be continuing to frustrate their development – these include lack of formal market supply, infrastructure, economics, as well as advice and training.

This study has been commissioned for The Knowledge West Project to review these issues and in turn consider those aspects that would benefit from further funding promotion and research, so that future resources can be directed accordingly. In addition it is hoped that this study will help provide the basis for a new potential Flagship Initiative.

For the purposes of this study, the South West Region comprises Gloucestershire, Wiltshire, Avon, Somerset, Dorset, Devon and Cornwall.

Aims and Objectives

This study therefore analyses the following:

- A review of the current initiatives to promote greater use of biomass and biofuels for energy generation including the provision of grants, incentives and training requirements.
- The markets and the supply infrastructure for wood biomass for heating, transport biofuels and farm wastes.
- The economics of growing energy crops for biomass and arable crops for biofuels - relatively little work has been undertaken on the likely impact of the adoption of energy crop production at farm level. Thus the costs of the main crops (short rotation coppice, Miscanthus, wheat, sugar beet and oil seeds) and the returns necessary to mobilise resources in agriculture to produce these crops and the implications for the profitability of farming are assessed.

Definitions and Sources of Biomass Considered in this Study

The term biomass is used to cover a broad range of biologically derived resources. Biomass is defined in the Energy White Paper (EWP) as "anything derived from plant or animal matter [including] agricultural, forestry or wood wastes/residues and energy crops" (EWP 2003). The DTI divides biomass into 3 groups, as shown in Table 1 below.

Table 1 Biomass Sources

Group	Description	Examples
Dependent Resources	Co-products and wastes from agricultural, commercial and industrial processes	Forest residues, waste woods, straw, slurry, chicken litter, biodegradable portion of industrial and municipal wastes (e.g. from food processing)
Energy Crops	Crops grown specifically to provide biomass fuel	Miscanthus or short rotation coppice (SRC) e.g. willow, or occasionally, poplar
Multi-functional Crops	Crops that can be used to provide different energy sources	e.g. wheat-ears can be used to produce fuels such as bioethanol and biobutanol for biodiesel whilst straw can be used for electricity generation

Source: (DTI 2005)

For the purpose of this study, the following sources of biomass are to be considered;

1) Wood from primary, secondary and tertiary sources. Primary wood sources are those that arise directly from harvesting trees and forests. In addition purpose grown energy crops, in particular short rotation coppice and Miscanthus can be primary wood sources. Secondary sources include wood and wood residues arising from primary processing (e.g. sawmills and boardmills) and secondary processing (e.g. joinery and furniture manufacturing). Tertiary sources can be defined as waste wood, such as pallets. The main focus for this study is however the primary sources of wood. (This source of biomass is subsequently referred to as wood biomass for the purpose of this study)
2) Arable crops that can be grown for transport biofuels. The main transport biofuels that are of interest to UK farmers are biodiesel, bioethanol and biobutanol, since the crops that are suitable for conversion into these fuels are widely grown in the UK – oilseed rape, wheat and sugar beet. (The source of biomass is subsequently referred to as liquid biofuels for the purpose of this study)
3) Farm animal wastes, such as slurry which are currently being used to produce energy via anaerobic digestion. Other farm wastes such

as rubber tyres and plastics are not considered as part of this study. (This source of biomass is subsequently referred to as farm waste energy for the purpose of this study)

There are a range of technical options for converting biomass into usable energy such as heat, electricity or transport fuels. For heat and electricity, these conversion options include combustion, gasification, pyrolysis and co-firing. The grain from arable crops can be converted into transport biofuels. There is also scope for cellulosic production from wood biomass and straw for transport fuels, and in the longer terms these sources may be seen as a preferable option to using grain. However the technical and economic aspects of these conversion options are beyond the scope of this study.

Biomass for energy generation can be used at a number of different scales – ranging from domestic heating systems to large power stations. There are no standard definitions of 'micro', 'small' and 'large' renewable energy projects; indeed many studies have not attempted any definitions. However, for the purpose of this study the definitions shown in Table 2 will be used (unless indicated otherwise).

Table 2 Scales of Renewable Energy Project

Scale	MW or capacity	Notes	Source of Numerical Definition
Microgeneration (power and heat)	<1MW	Defined as "homes and small commercial developments/public sector buildings" (DTI 2005)	DTI 2005
Small-scale	1-20MW		DTI 2005
Larger-scale	>20MW		DTI 2005

2.0 Current Initiatives Promoting Biomass for Energy Generation

Current Financial Incentives and Advice

There are an array of support schemes and incentives for biomass available from a wide range of sources. They are also fast changing. These main schemes have been investigated for the purpose of this report and are summarised in Table 3 below.

As a result these support measures are seen understandably as complex, and can conflict with each other (RCFP 2004). In turn landowners and other stakeholders are often not aware of these different potential sources of funding, and how to access them.

Table 3 Major Biomass Energy Grant, Support and Information Schemes

Technology	Scheme	Description	Notes
General/ Biomass	The community Energy Programme (2002-2008)	£50million programme to fund district-heating projects through capital grants	To date, of 49 schemes offered funding, 4 are biomass district heating projects with 1 potentially moving to biomass
Biomass – Forestry	English Woodland Grant Scheme (2005 onwards)	A collection of grants for planting and maintaining woodland	Woodland Creation Grant excludes woodland intended to be used for the creation of biomass fuel. Woodland Harvesting, Processing and Marketing Grant Pilot Scheme provides grants of up to £50,000 in some areas for activities including undertaking wood-fuel feasibility studies
Biomass – energy crops	Energy Crops Scheme – Planting Grants (2000-2006) The Energy Crops Scheme closed on 30 June 2006, but new schemes are expected to be in place by January 2007	One-off establishment grants of up to £1000/ha for establishing short-rotation coppice (SRC) (50% of establishment costs) and £920/ha for establishing Miscanthus (40% of establishment costs)	Growers have to show that they have an end-user for the crops within 25 miles. This scheme is part of the England Rural Development Programme (ERDP). N.B. Support for SRC planting is available through the Woodland Grant Scheme in Wales and Northern Ireland and Scottish Forestry Grants Scheme.
Biomass –	Energy Crops	50% grants of up to	This scheme is also part of the

energy crops	Scheme – Producer Grants (2000-2006) (now closed - see below)	£200,000 for the establishment of SRC Producer Groups (to fund costs such as specialists machinery and staffing)	ERDP programme and thus currently under review. Also subject to the '25 mile' guidelines
Biomass – electricity/CHP systems	Bio-energy Capital Grants Scheme (2002-2004)	£66million offering capital allocated grants to project developers and organisations investing in biomass-fed electricity/CHP projects	Grants were allocated during a bidding round in 2003. To date, progress on these developments has been slow
Biomass – energy crops, forestry, straw	Bio-energy Infrastructure Scheme (2004 onwards) (currently closed to new applications, second application round planned)	£3.5million scheme offering grants to farmers of foresters setting up producer crops to supply eligible biomass	Maximum grant ceiling of £200,000 per producer group or business. This is a UK wide scheme but does not cover SRC ain England (as this is covered by the Energy Crops Scheme). Miscanthus is eligible
Biomass – energy crops scheme	Annual Energy Crops Payment (2005/6 onwards)	Payment of €45/ha/pa (approximately £30) for energy crops grown on non-set aside land	This scheme operates European wide and payments are capped. Hence, if targets are exceeded the payment will fall
Small-scale solar, wind, hydro, geothermal, biomass	Clear Skies (2002-2006) (N.B. now closed to new grant applications)	£12.5million aiming to raise public awareness of renewable energy by offering capital grants for installation of household and small-scale community renewables. To date (2005) it has supported installation of renewables at 6000 individual installations and 309 community projects	Community grants are available for 50% of installed costs up to a limit of £100,000. Householder grants cover 20%+ of costs and vary with technology. Solar panels, small wind turbines, ground source heat, room heaters/stoves with automated pellet feeding systems and wood fuelled boiler systems are supported
Small-scale community schemes – all renewables	The Community Renewables Initiative (and Scottish	£1million scheme offering information and support for community-based	Covers solar, biomass and wood hest schemes, farm waste schemes and wind

	Equivalent)	small-scale renewable initiatives	
All carbon-lowering technologies	The Carbon Trust (2001 onwards)	Grants supporting research and developing of carbon-lowering technologies	Grants of up to £250,000 to “innovative” projects. Total committed thus far is £9.8million (1% on biomass)
Microgeneration	Other Small Schemes	A number of small support schemes covering renewable generation exemplars and research	e.g. Rural Enterprise Scheme diversification grants supporting on-farm developments and the Solar scheme supporting the installation of solar PV in schools

(BSTF 2005a; Clear Skies 2005; DEFRA 2003a; DEFRA 2004b; DEFRA 2005; DEFRA 2005; DEFRA/ERDP 2005; 2005; Forestry Commission; DTI 2005; DTI 2005; Energy Saving Trust 2005; The Countryside Agency 2005; Nix 2005)

There have been a range of recent Government initiatives, in particular, giving increasing policy emphasis and support for greater use of wood for energy generation. These include:

New Grants and Funding

1) The DTI now has a budget of £80million over 3 years to provide capital grants for domestic renewable energy systems including wood boilers.
2) The Carbon Trust has launched a new £5million five year project to accelerate the commercial development of biomass heat in the UK.
3) The Big Lottery Fund is to reallocate a minimum of £2million of unspent money to support small-scale biomass heat and combined heat and power projects.
4) VAT on new wood boilers has been reduced to 5%.
5) The DTI are to launch a new five year capital grant scheme for biomass boilers. It is to be launched with funding of £10-£15million over the first two years.

Government Initiatives

1) In response to the Biomass Task Force report, the Forestry Commission propose to prepare a strategy plan for the development and use of wood for energy generation over the next five years.
2) The public estates are being urged to take the lead in installing biomass technology and consider installation in their buildings.

Several examples of this have already taken place (e.g. Worcestershire County Council building).

3) There are guidelines recommending a minimum percentage of renewable energy to be incorporated in new developments. Furthermore including of renewable energy in new developments is likely to receive more favourable consideration by the planning authorities.

There is also a wide range of sources of advice from the public sector agencies and funded organisations. For the purpose of this report, the main ones are summarised in Table 4 below.

Source: (REG 2006)

Table 4 Sources of Advice and support
Severn Wye Energy Agency (SWEA) - http://www.swea.co.uk/
National energy Foundation - http://www.nef.org.uk/greenenergy/biomass.htm
Rural Enterprise Gateway (REG) – maintains a listing of grants and advice available throughout the South West – http://www.sw-gateway.com/index.html?grantproject_tree.cfm~mainframe
Business Link – has experts to advise on business development opportunities for Gloucestershire - http://www.glos.businesslink.co.uk/
Forestry Commission – Biomass Energy Centre - http://www.forestresearch.gov.uk/fr/INFD-6P8G8E
Energy Saving Trust – will provide links to accredited equipment suppliers for Low Carbon Buildings grants – http://www.est.org.uk/myhome/generating/types/biomass/
RegenSW – this is a Government funded renewable energy agency for the South West region. It provides information and business advice and has compiled a directory of project developers, consultancy services, manufacturers and installers. In 2007 a range of promotional events and funding are planned to try to kick start renewable energy in the region – http://www.regensw.co.uk/
National Energy Foundation – promotes and aids the use of wood as a energy source – http://www.nef.org.uk/logpile/index.htm
Renewable Energy Association (conference in September). It has a number of interest groups including Primary Biomass and Renewable Transport Fuels – http://www.r-p-a.org.uk/home.fcm
Cotswolds Conservation Board, Sustainable Development Fund – which includes developing the use of renewable energy in the community or on the farm
Gloucestershire Woodfuel Group – promotes and aids the use of wood as an energy source

As can be seen from this table, there is a wide range of support and advice.

However advice at all stages of supply (from farm level to end user), will need to be considered. This will thus include the growing, harvesting, processing, type of equipment and its operation, markets for other outputs/byproducts of the process and the changing technologies.

It is difficult to determine which source of support and advice is best suited to the needs of the biomass producers, the processors and the energy producers and the range of different projects. Furthermore the individual needs within the fuel supply chain are seldom understood by any single individual.

Raising Awareness

Whilst organisations like SWEA, REG, RegenSW and the Gloucestershire Wood Fuel Group exist to advertise and promote biomass and biofuels, there still appears to be a low level of awareness at all levels of the demand infrastructure. This includes architects, builders, heating engineers, building maintenance companies, council planning depts, developers and domestic householders. Specific issues to be addressed would include the financial feasibility of using biomass versus fossil fuels in new build and replacements scenarios (including the capital cost, running costs, the expected lifecycle and payback material etc), the availability, logistics and cost of the fuel supply, the choice of system and operational issues.

Skills and Training Needs

A comprehensive skills and training needs analysis for the biomass sector was undertaken in the northeast region by “Northwoods” in 2004 (Northwoods 2004). It is claimed that that there has been no similar piece of work undertaken anywhere in the UK to date. Their findings indicate that, with one or two exceptions, there is an almost total lack of training provision for the sector, although there are a range of training courses in allied secors that may offer opportunities for modification. Compiling a comprehensive database of available training in the South West region is beyond the scope of this report, however, it expected that similar conclusions would be reached.

The lack of training available in the sector at national and regional level is seen as a serious threat to the emerging biomass sector (Northwoods 2004). Without a trained, knowledgeable and competent workforce there is a risk that the biomass sector will not develop in line with the region’s aspirations. The alternative, it is claimed, is an over-reliance on other UK Regions or EU states for expertise, and in turn the over-pricing of biomass services, (in particular installation) and the slow development of the sector in general.

3.0 Wood Biomass Markets

Wood biomass can be used to generate heat, electricity (including co-firing) and combined heat and power and therefore substitute for fossil fuels including oil, gas and coal. It also has the potential to produce bioethanol for transport fuels. The technologies for these applications are at different stages of development. Wood as a heating fuel using modern boilers is well established whereas electricity and combined heat and power (CHP) applications are less advanced and not yet commercial in the UK (without subsidy). A wide range of factors will limit penetration of the markets; not only capital costs, but also suitability of the system (particularly in urban areas), the location and cost of the fuel supply, personal preferences and environmental pressures, policies, regulations and incentives.

Electricity/CHP

The majority of the electricity produced in the UK is generated at large thermal power stations throughout the country which uses coal, gas or nuclear fuel. Wood fuel can also be used. To date, the main interest has been focused on electricity. This interest in the production of electricity from non-fossil fuels (including wood) was largely brought about by firstly the non-Fossil Fuel Obligation (NFFO) and the Renewables Obligation (RO) Both NFFO and RO are market based support mechanisms (DTI 2005)

The NFFO ran through the 1990’s and subsidised non fossil fuel electricity generation (including nuclear). Companies were invited to tender for contracts in five rounds and were paid a higher than average price per unit of electricity. However, it was felt that this system was not consistent with a privatised electricity market and it ceased in 2002 (DTI 2005). The RO, which replaced the NFFO, has operated in England and Wales since 2002. Under the RO, eligible generators receive Renewables Obligation Certificates (ROC’s) for each MWh of electricity they generate from renewable sources. These ROC’s are then sold to suppliers (the price is dictated by the availability of renewable electricity). All licensed electricity suppliers in the UK are required to provide the Gas and Electricity Markets Authority (OFGEM) with ROC’s showing that they have supplied a specified proportion of renewable electricity to customers. It is through this system that the renewable electricity generation targets are implemented.

However despite such a drive, there are still no large scale wood biomass power stations in the UK. The only large scale biomass plant currently operating is the Elean plant at Sutton near Ely in Cambridgeshire. This is fuelled by waste straw, with an approximate £20 per tonne ex-farm price. Furthermore there have been previous false starts – the most notable being “Project Arbre” and Border Biofuels. Project Arbre in South Yorkshire was contracted to supply 8MW of electricity from wood (mainly SRC), however, the plant only generated for 8 days before closing leaving around 50 farmers with a total of 1500 ha of SRC without an apparent market (Strawson 2005: Guardian Unlimited 2003). Project Arbre has now been sold but its future is unclear (DTI 2005). This was accompanied by the company Border Biofuels (who were developing a number of pyrolysis plants using forest residues) going into liquidation. The failure of these two projects has been blamed on their use of limited technology and inappropriate scale (Guardian Unlimited 2003).

These two high profile failures have clearly shaken confidence in the sector. More recently there has been a move towards more local “low tech” schemes often using CHP technology for maximum efficiency. However there are currently few working examples of CHP in the UK – the most notable large scale project being Slough Heat and Power Station.

The future is now, however, looking more promising. Eleven schemes using wood, totalling 160MW capacity have been awarded grants under the Bio Energy Capital Grants Scheme (DEFRA 2005). A number of these projects are in the South West, including Penisula Power in Devon, Charlton Energy Ltd, and Bronzeoak in Somerset. However it should be noted that many such projects have a long lead time – the large-scale projects typically require a 5 to 7 year lead time.

Co-Firing

Since 2002, co-firing (the mixing of biomass – usually wood or energy crops in the form of sawdust – with coal for use in a conventional power station) has been eligible for ROC’s.

One of the aims of this scheme is to allow markets and supply chains for biomass to develop, and in particular the planting of crops. From 2009, at least 25% of biomass fuel used in co-firing must be from energy crops rather than other wood biomass such as a forestry material. This proportion is set to rise to 50%in 2010 and 75% from 2011 to 2016 as shown in Table 5 below.

Table 5 Energy Crops Co-firing Percentages

Date	Percentage of Co-fired Biomass which must be Energy Crops
To date –March 2009	0%
April 2009 – March 2010	25%
April 2010 – March 2011	50%
April 2011 – March 2016	75%
April 2016	Co-firing ceases to be eligible for ROC’s

Trials of Co-firing are being undertaken at a number of power stations including Drax in Yorkshire and Didcot in Oxfordshire. However, there have been a number of administrative barriers to the development of co-firing in the UK. These include a requirement for the biomass and coal to be blended on site (which means that generators have to invest in biomass storage) (RCEP 2004). Furthermore, farmers have proved reluctant to plant energy crops. These issues mean that “large scale planting of energy crops has yet to commence” and that progress by power stations is “patchy” given that there is now a relatively short window remaining in which to develop supplies of energy crops (BSTF 2005c). However, co-firing is currently the cheapest way for generators to gain ROC's (Oxera 2005). Currently, there is no co-firing in the South West region, however, Didcot Power Station may represent an opportunity for potential suppliers located in the East of the region.

Heat

Logs, chips, bales and densified fuels can all be used to provide space and water heating at all scales from domestic room or central, to utility scale district heating. The use of logs for domestic heating, using open fires and stoves has occurred for many centuries. However, open fires are generally inefficient (much of the heat goes up the chimney) and are now rarely used as a primary heat source. Stoves are generally more efficient than open fires, but not commonly used as a primary source. At the top of the hierarchy are wood boilers; giving greater efficiency and the capability to provide the primary source of heat for both domestic and non-domestic users.

Domestic users to date include farms and estates; for example the Batsford Estate in Gloucestershire are considering replacing the old oil-fired boiler with a new wood-chip boiler. The estate would supply its own wood chip fuel from forest residues, by-products of their forestry enterprise.

Non-domestic users are potentially very diverse, including rural located businesses, such as farm buildings, glasshouses, schools, community centre and public buildings. For example a number of schools and county council buildings in Gloucestershire are all currently considering wood heat projects (Glos wood fuels 2006).

Whilst there are no reliable estimates on the amount of wood used for heat generation, it is believed to be limited. Despite the growing interest in wood boilers, the total UK wood chip volumes for these installations are less than 10,000 tonnes per annum at present (Forestry and Timber Association 2006) which is considerably less than the traditional firewood market. Yet there is believed to be considerable potential to increase the use of wood for heat generation. Indeed the DTI suggests that there is a potential market of 1.1million rural households that could use biomass for energy, largely for heat (DTI 2005f). Furthermore, in many European Countries such as Austria and Sweden, wood used for heating enjoys a much greater significance at all levels from domestic use through to large scale domestic heating.

Modern wood boilers are now clean burning and are reported to have combustion efficiencies of up to 85-90% (British Biogen 2005). Wood chip and wood pellet burning systems are typically fully automated with automatic ignition, thermostatic control and automated de-ashing systems. However they have a number of drawbacks. These include their size (they tend to be larger than fossil fuel boilers), the requirement for a large fuel storage area, and the need for the ash to be removed every 2-3 weeks –so limiting their domestic use to larger rural properties. In addition the capital costs of the boiler system are around two to three times higher than fossil fuel alternatives.

Other barriers to investment in wood fuel heating systems are concerns about convenience, security of wood fuel supply and system maintenance. However to overcome these barriers, companies such as Econergy are introducing the concept of Energy Service Companies – they provide a complete service including design and installation, operation and maintenance and supply of wood fuel. In effect they sell the heat – they charge a unit price for the heat, that would include the delivered fuel cost, maintenance and can also include a boiler lease or repayment of the capital cost of the boiler. Providing the overall cost is less than fossil fuels, this concept should provide an attractive option – indeed Econergy already have a number of contracts including the County Hall at Worcester.

Types of Wood Fuel and Specifications

Each type of energy market will have its requirements with regard to the types of wood fuel required. There are four main types: logs, chips, bales and densified wood fuels such as pellets are used in automated heating systems as this allows them to be automatically fed by auger or, in the case of pellets, pneumatically. The larger scale CHP and electricity plants also require chips. In turn, the type of wood fuel and end use will determine the specification requirements for the wood fuel such as moisture content, particle size and contamination.

Moisture content is a particular issue. Freshly harvested timber (both forestry and SRC) may have a moisture content of up to 60% (Mitchell et al 1993). The moisture content of freshly harvested timber varies depending on species, age and time of harvesting. The moisture content may also rise or fall depending on the storage and treatment after felling. If stored in reasonable conditions there is likely to be a reduction in moisture content, but if kept in the open, in some cases, the moisture content may actually rise. Wood fuel boilers may have limits on the moisture content of the material accepted, typically most wood chip boilers require the wood chips to have a moisture content of around 30%. For the production of pellets, a maximum moisture content of 10% is required. Furthermore the price of the wood fuel is likely to be related to its calorific value which in turn is determined by the moisture content. There are however operational and logistical costs in reducing moisture content. Further research is required and the additional costs factored in.

Whilst there are currently no official UK standards for chips and pellets, there are however the following voluntary, recommended specifications:-

- British Biogen developed a voluntary code of good practise and with the formation of the British pellet club, there is a progress towards standardisation of the wood pellet industry in the UK.
- There are Austrian specifications for different grades of wood chip, and boiler installers and manufacturers will recommend a specific grade for optimum performance.

The limited use of wood for heat generation in the UK is arguably surprising due to its perceived benefits. However it is this limited uptake which has meant that biomass heat has not reached a sufficient critical mass to have a formal market, adequate support structure or public awareness.

The Market and Supply Infrastructure

Whilst there has always been an informal market place in rural areas for firewood recovered from tree felling and tree maintenance, there is no formal market as yet in the UK, for wood fuel. In turn there is no infrastructure for the routine supply of wood fuel for heating applications at residential or commercial, nor for the supply of large electricity power stations. By contrast countries like Finland and Sweden have a tradition of using wood for energy generation, and have developed wood fuel markets. In turn there are companies dedicated to the processing and resale of sawmill industry co-products, (including low value timber and residues, sawmill co-products and recycled waste woods as wood fuels to standard fuel specifications for these products including moisture content, particle size and contamination).

The economics of forestry operations are bound up with effective logistics and optimised use of mechanical plant and labour, and this applies equally to wood fuel production. Thus to develop an effective wood fuel supply chain in the UK, will require significant adaptation and development of the existing harvesting processing and transport resource. It follows that any wood fuel supply chain development needs to take account of market conditions including species, location, ground conditions, harvesting methods and costs, distance from the forests to end users, haulage methods and costs and competing end-use prices and opportunities. In turn this will require investment in business development, recruitment and skills training as well as developing machinery standards and methods etc.

4.0 Economic Factors in the Supply of Wood Biomass for Energy Generation

'Wood energy' is a young industry, and market prices and specifications for different energy uses, to a large extent have yet to be determined. However, whether a particular wood feedstock will be suitable for the energy market will depend not only on quantity but also the quality of the feedstock. The quality and thus the suitability of the feedstock will be influenced by the type of wood fuel and specification requirements such as moisture content, particle size and contamination, which will in turn determine the price paid to producers. Whether it is financially advantageous for potential producers to supply wood biomass to the energy markets will depend on the price they are offered. The prices that the market are likely to offer in the future is likely to be influenced by the existing prices, the cost of alternative fuels, the alternative markets for the wood–based feedstocks and the cost of supply. These factors are considered below:-

Factor 1 The price offered by the existing wood fuel supply markets

The market and in turn the prices for wood to be used for energy generation are still to be established. The price will however, be clearly dependant on the end user and the quality of the materials required, the type of wood fuel and its quality.

The main demand for wood to be used for energy generation is currently for co-firing and heat generation. Trials of co-firing are being undertaken at a number of stations including Drax in Yorkshire and Didcot in Oxfordshire. The price that farmers are expected to receive for SRC chips is £35/o.d.t (ex-farm) and £25/o.d.t for Miscanthus (ex-farm) (Nix 2005; ABC 2006). These power stations have also been purchasing forest material , including forest residues and small diameter roundwood timber. Drax for example have been offering £12/green tonne at roadside (which is equivalent to approximately £25/o.d.t ex farm but unchipped).

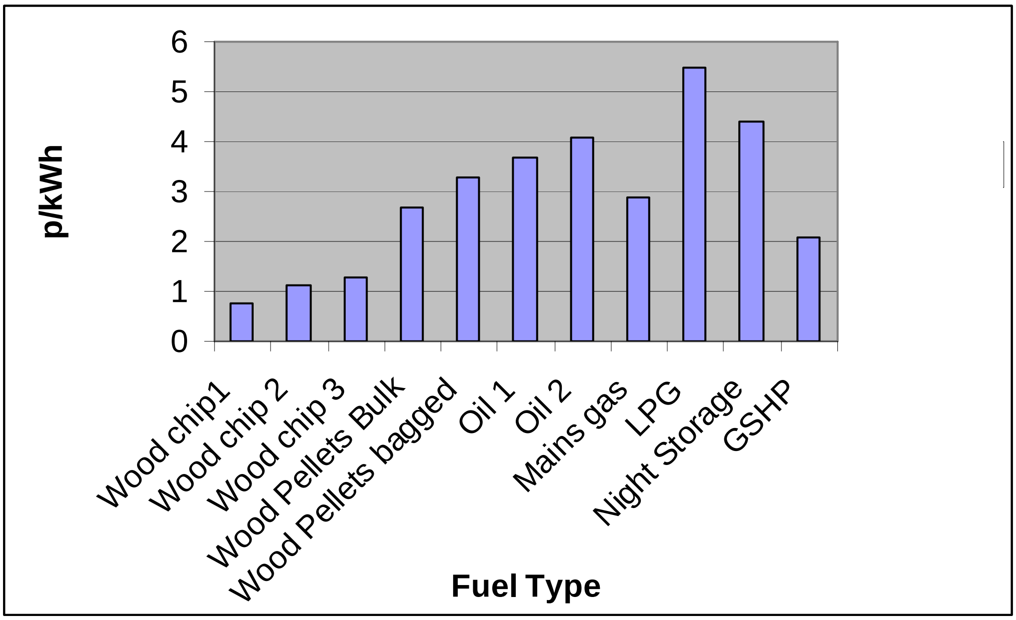
Small boiler installations have increased significantly over the last five years. For example, Marches Wood Fuel currently supply just over 2,000 tonnes of wood chip per year. It is understood that they charge £35/tonne at approximately 25-30% moisture content which equates to a price of £45/o.d.t.

Factor 2 Cost of alternative fuels

The main source of 'fuel' for both heat and electricity is still oil, coal and gas. Thus if wood fuel is to be used as an alternative to these fossil fuels (assuming no distortion to the market by financial incentives, regulations, political or personal preferences etc), then it will need to be competitive.

Graph 1 below compares heating costs of wood fuel against other heating fuels.

Graph 1 Costs of Heating Fuels
Source: Severn Wye Energy Agency 2006



Assumptions

- Wood chips at 25%moisture content and (1) £25/tonne (2) £40/tonne (3) £50/tonne
- Wood pellets “ in bulk” at £110/tonne
- Wood pellets bagged at £135/tonne (excluding delivery)
- All biomass systems are modern 90% efficient systems
- Oil at (1) 30p/litre (2) 35p/litre
- Mains gas at 2.5p/kWh
- LPG at 33p/litre
- Delivered heat in LPG, Oil and Gas considering boilers with standard 85% efficiencies
- Night storage – based on a night tariff of 3.62p/kWh
- GSHP – Ground Source Heat Pump based on a domestic electricity tariff of 8.45p/kWh

As can be seen from this graph, wood chips, even at £50/tonne (equivalent to approximately £75/o.d.t.) appear competitive with fossil fuel heat sources. However the above comparison ignore the higher capital costs of wood boilers, and the increased maintenance as discussed earlier.

Factor 3 Alternative markets for wood-based feedstock

Wood-based feedstocks currently have a range of alternative markets, including wood pulp and wood-based panel boards, mulching, animal bedding and charcoal. The sizes and prices offered by these non-energy markets will also have a large influence on the availability of that feedstock and the cost of purchase. If the non-energy markets offer higher prices and returns to producers of those wood-based feedstocks, then the likelihood is that they will sell to these markets. The alternative markets available and the prices offered will therefore have a major impact on the potential feasibility of using any particular feedstock. For example, wood from the forest sector have a range of alternative markets. To obtain this feedstock is likely to result in having to pay higher prices by outbidding the competitors. Other feedstocks, such as demolition timber, are often landfilled which will represent a cost to the producer. Hence, in this instance the feedstock would have a negative value and, in theory at least, the producer will be prepared to pay for the disposal of this by-product of the business, and would represent an additional source of income to the energy producer. In practice, however, this may not be the case, as if such producers believe that their ‘waste’ (of negative value) has value to another, they may attempt to negotiate to receive a share of that value.

Factor 4 The Cost of supply

The cost of supply includes both the cost of purchase and cost of collection. The type and availability of alternative markets will influence the cost of purchase and hence the costs of supply.

The cost of collecting the feedstock will be influenced by such factors as the cost of collecting from the site itself, the need for communication, storage and drying, and the transport cost from the site (via any intervening depots) to the end user. The transport cost is considered to be a particularly significant component of the overall cost of collection, as the wood-based feedstocks being considered tend to be low value and generally bulky products. Thus the distance to the end user as well as the type of transport and its related capacity will very much influence the transport cost.

Where the costs of supply exceed the price offered, there will be no supply (assuming no market distortions). Hence the cost of supply is a critical factor to review for each wood-based feedstock.

The Potential for Wood Fuel Markets

As can be seen from the above review of the types of energy and the type of fuel, the important elements to consider for the utilisation of wood-based feedstocks are a follows:

1) The potential quantities available – when assessing whether it is feasible to set up a large wood-fuelled power or pelletizing plant, an important element of that pre-investment feasibility study is to determine the potential quantities available within a specific location or catchment area.
2) The suitability of the feedstock – with particular regard to the extent and type of contamination. Other aspects such as moisture content and particle size are also important.

3) The continuity and reliability of supply – essential to the success of the larger project, such as a power station or a pelletizing plant is a secure supply of wood fuel.
4) The purchase price – this will be indicated by alternative markets for existing wood-based feedstocks.
5) The costs of supply – (in addition to the purchase price) including the cost of collection, comminution, drying, storage and transport.

5.0 The Potential Supply of Wood Fuel from Woodlands in the South West

Both timber and forest residues are produced from the forest resource as a result of forest management operations, in particular harvesting and thinning. The main interest to date has been focussed on forest residues which until recently have been an unexploited resource (Forest residues comprise unwanted branches, tree tops and foliage). Furthermore, conifer residues have been considered to offer greater opportunities than broadleaved residues. However research undertaken by Lewis 2001, suggests that broadleaved residues may actually offer greater potential than conifers. Furthermore small diameter roundwood has been excluded from much previous research on the assumption that competing markets offer higher prices. (Coniferous small roundwood includes all merchantable stem wood between 7-14cm diameter over bark. Broadleaved small roundwood includes merchantable stem wood between 7-25cm diameter over bark (Hart 1991, Lewis 2001). However initial economic analysis undertaken by Lewis in 2001, suggests that this may not necessarily be the case. The potential supply of small diameter roundwood for the energy markets is dependent on firstly the cost of supply and secondly the prices offered by competing markets. The main competing markets for small roundwood are pulp and chipboard – world and national prices for these products still remain depressed.

Notwithstanding the above, it is important to try to determine the potential sources adequately of timber that may be available for the energy market. Indeed, a number of reports have highlighted the desirability of quantifying the sources of timber and in turn the potential supplies of wood for fuel. Various studies in the past have attempted to assess the potential supply of wood that could be available for use as a wood fuel. For example the Forestry Contracting Association/Forestry Commission (FCA/FC) estimated that 630,000 o.d.t./annum of timber is potentially available from the woodland resource in England, and 200,000 o.d.t/annum in the South West region. (McKay et al 2003).

This estimation attempts to give an indication of potential resource taking account of existing industries and markets. However, it is important to note that these estimates are based on what is operationally available in the absence of competing markets' (FC 2006). The actual amount available will be influenced by factors such as transport costs, harvesting costs, timber prices and process paid by competing markets. Hence the inclusion of, for example, 100% of unmarketed arboricultural arisings is a reflection of the lack of current market for them rather than an assumption that all could be fed into the wood fuel market.

Whilst these figures give a useful guide to available resource (which may be useful to potential biomass plant operators) there are a number of weaknesses with them, which are acknowledged within the report. Firstly, only around 22% of the forestry output comes from the public sector forest managed by Forest Enterprise with the remaining being in the private ownership (McKay et al 2003). Private owners may have ownership objectives e.g. environmental, recreation etc, which do not include management for wood production. Similarly, changes in silvicultural systems or technological advances in multiple product harvesting (i.e. for timber and wood fuel) may change availability (McKay et al 2003). Forestry management is affected by policy decisions (for example, the recent announcement of a 20year programme to replace conifers and non-native species in England with broadleaves) (FC 2005c) or changes in landfill policy which may alter the availability of arboricultural arisings (McKay et al 2003).

The South West region is one of the most densely wooded and forested regions in England, with an estimated 212,022ha of woodland, equivalent to an average woodland cover of 8.9% (Forestry Commission (2001). This is above the English average of 7.63%. However significant variations in the extent of tree cover exist within the region. This is particularly noticeable within certain AONB's like the Quantocks and Blackdown Hills that have double the regional average. Broadleaved species make up nearly 57% of the woodlands with mixed species at14% and conifers accounting for 23% and the balance comprising filled areas or open space (Forestry Commission 2001), 77% of all woods (by area) are in private ownership, mainly on estates or farms.

Large woodlands (defined as over 20ha) account for over 65% of the forested area and constitute the main timber production areas. The majority of the smaller woodlands are found on estates and farms - many are believed to be under-managed or unmanaged. These woodlands are often believed to be an unexploited resource and in turn have scope to supply the energy industry. However it should be remembered the current timber prices make many of these woodlands uneconomic to thin or fell. Unless prices improve considerably, say from £25 to £35/green tonne delivered, many of these woodlands will remain uneconomic to manage (without other assistance). Various studies (Lewis and Manley 2004; Clegg and Co 2003) have clearly all indicated that many private woodland owners are reluctant to manage their woodlands if it results in a cost.

The potential supply of timber in the South West region will depend on a range of factors including the physical resource, annual quantities of timber to be harvested, as well as operational, environmental and economic constraints. This, by the nature of the many variables is an involved process and subject to inaccuracies, as has been the case with the previous studies. Whilst the author has undertaken such an estimate for another region of the country (Lewis 2001), it is noted that the Forestry Commission have declared that they propose to develop a more detailed assessment of the potential available resource. Whilst this is to be a national study, "implementation will essentially take place in regional and sub-regional level" (FC 2006). Thus such an assessment is expected to include an assessment for the South West. Hence to avoid potentially duplicating such a study, no attempt has been made to quantify the potential resource in the South West at this stage.

The Supply Chain and Costs of Supply

The supply chain fro wood fuels consists of three stages, each with associated costs as follows:-
1) Harvesting and collection; 2) Storage and communition; 3) Transport

The type of site, type of woodland and scale of operation will all have an impact on the harvesting systems adopted which in turn will affect the costs of collecting both small roundwood and forest residues. The requirements of the energy user in terms of fuel medium (chips, logs, densified fuels etc), moisture content and degree and type of contamination will also impact upon the communition costs and in turn the transport costs.

1) Harvesting and collection

The harvesting industry in the UK is currently committed to shortwood and tree length harvesting systems and is equipped for the operation of these systems (Forestry Contracting Association Ltd 1997; Forestry and Timber Association 2006). In both these harvesting systems, the trees are felled and delimbed at the stump and extracted to roadside, where they can then be loaded on to a lorry and transported to the end user. In the shortwood operation the trees are further processed by cross cutting at specified lengths before being extracted by forwarder. In tree length systems the whole stem length is extracted to the roadside by ground ‘skidding’. The cost of harvesting and extracting the roundwood timber to roadside vary according to site type, scale of operation, tree size etc, but is likely to be in the range of £8-20/green tonne – thus in certain cases the current energy market may appear attractive. In both systems the residues are left in the stump area and so will need to be collected by a ‘second-pass’ operation. While these two harvesting systems are suited to harvesting and extraction of round timber, the practicalities and in turn the cost of recovering the forest residues mean that it is often not worthwhile at current prices.

An alternative is to adopt an integrated harvesting system – this is where the harvesting of the wood fuel (including the small diameter timber as forest residues) is an integral part of a one pass whole tree operation often referred to as whole tree harvesting. Whilst this system has been trialled in the UK by the Forestry Commission and others, its use is very limited. Furthermore much of this trial work is over ten years old, and so did not study modern equipment and systems. The published costs of using such a harvesting system are thus unreliable. However this harvesting system is widely used in other countries such as North East America, Denmark and Germany – state of the art harvesting machinery is used, and outputs of 100tonnes per day with a team of three, rather than 20-40tonnes per day achievable from the traditional harvesting teams employed in this country (Forestry and Timber Association 2006). However the capital cost of this state of the art harvesting machinery, including road licensed trailers is reputedly in excess of £500,000 for each team (Forestry and Timber Association 2006). Furthermore these systems will need adaptation for the UK (due to different sit conditions etc). Issues such as reducing moisture content and storage also need to be considered.

Solutions exist, but insufficient demand holds back capital expenditure and further trials.

2) Storage and Comminution

Comminution is a major factor in determining the cost and quality of wood fuel. The main options for comminution include chipping, shredding and crushing. The specification of comminution residues will be determined primarily by the requirements of the end user. It is essential that the comminuted product is suitable for both the energy generation equipment (eg boiler or gasification system) and the associated handling equipment.

The wood may be comminuted at the forest roadside, transported to a central depot or direct to the end user. Whilst it would be cheaper to comminute the residues at a central point, the transport costs will inevitably increase. Most of the work relating to the comminution of forest residues to date has concentrated on in-forest chipping or chipping at roadside. The availability of large-scale communiation equipment in the UK is currently limited. The cost of chipping ranges from £5-30/o.d.t. The experience gained by Severn Wye Energy Agency suggests in-forest chipping and/or chipping at roadside is in the region of £10/tonne 30% moisture content, equating to a cost of approximately £15/o.d.t.

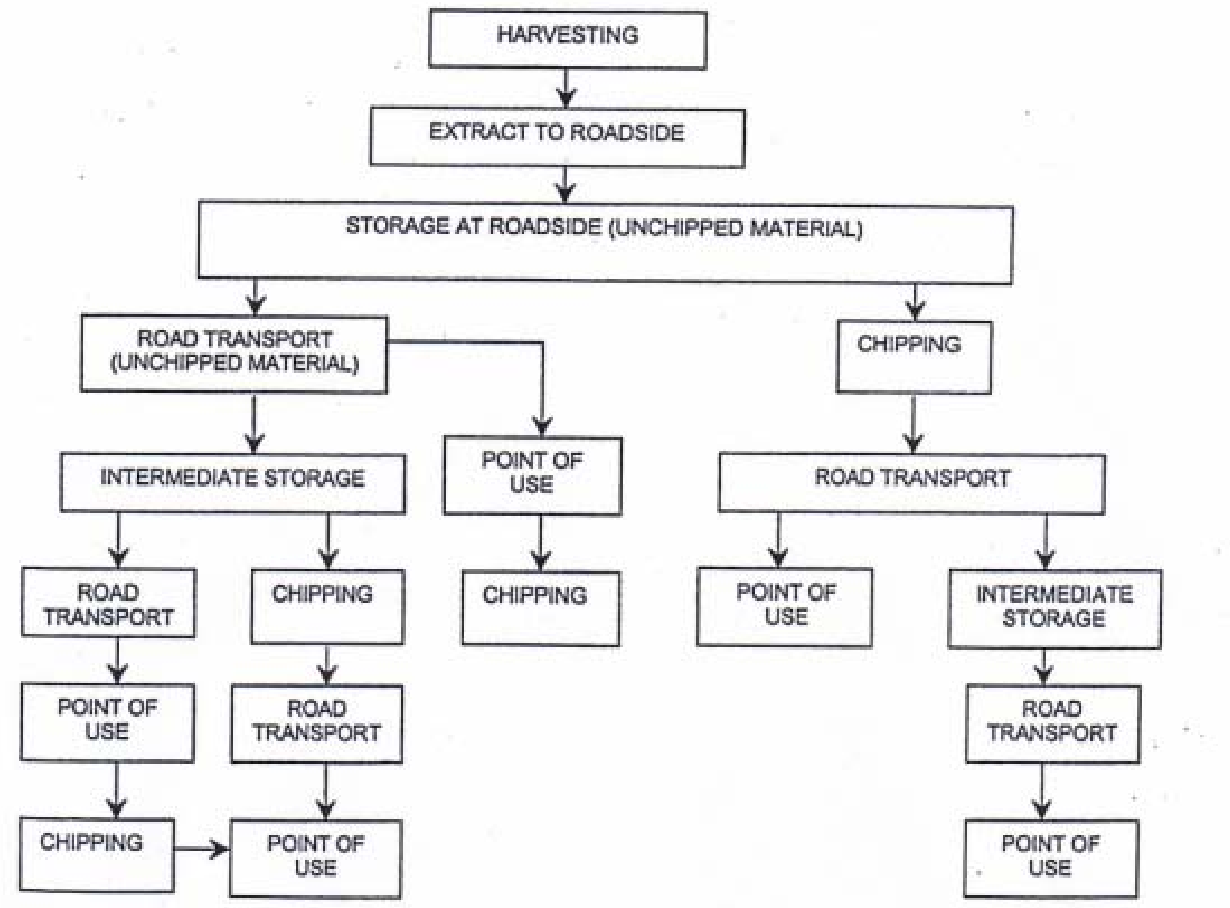
3) Transport costs

Woodfuel is a low value bulky product, so transportation is a significant element of the overall supply cost. Most woodland (and agricultural land) is not located close to railway lines, so the additional work in transferring loads between road and rail would add cost. Thus it is likely that most wood (and biomass in general) will be transported by road.

The moisture content, whether the product is comminuted and if so, how, will impact upon the type of vehicle used and in turn the cost. For example freshly felled and chipped timber may have a density of only about 0.15 t/m^3 compared to dry wood densities of around 0.4 – 0.5 t/m^3. The transport costs will be further influenced by the distance and road types (which affect travel time and fuel costs), which in turn will be determined by the location of the energy user in relation to the wood fuel resource. Thus the transport costs could vary from £5 – 40 /o.d.t.

The main supply options and the interaction with road transport systems are shown in figure 1 below.

Figure 1 Transport supply options for wood fuel at roadside



Source: Allen *et al* (1996); adapted by the author

Market Prices

Both timber and forest residues are produced from the forest resource, both of which have different markets and in turn values.
The traditional timber markets for small diameter roundwood derived from the forest resource are the pulp and wood panel board markets. Prices achieved depend on a range of factors, including location and proximity to the potential end market, as well as general market conditions. The point of sale is also important - woodland owners/producers can sell their timber standing, at roadside or “delivered” to the end user. Many smaller woodland owners elect to sell their timber standing, due to lack of skilled labour, machinery and market knowledge – this timber is in turn often purchased by a “timber merchant”, who in turn sources appropriate markets for the timber. There is a lack of published data on markets and prices, particularly for broadleaved timber – this however can be to the timber merchants advantage! Whilst published data on prices is patchy, anecdotal evidence suggest that in 2006 the following prices were being paid by the two main wood processors for the region.

The main wood processors are located outside the region with transport charges amounting to approximately £12-13/tonne, resulting substantial cost for long distance transportation which can account for as much as 50% of the mill gate price.

1) St Regis, a hardwood pulp mill, based in South Wales, and an important market for small diameter broadleaved timber in the South West region was paying £17/green tonne at roadside (equivalent to approximately £35/o.d.t.) before its closure in May 2006.
2) Kronospan, a wood panel board based mill, based in the Welsh borders (and again a potential market for small diameter in the in the South West region), is currently paying £12-13/green tonne at roadside (equivalent to approximately £25/o.d.t).

Whilst these prices remain depressed, and often do not cover the costs of felling and extracting the timber to roadside, the prices offered by the large-scale energy generators generally appear no more attractive to woodland owners. For example Drax power station is only paying £12/green tonne at roadside (equivalent to £24/o.d.t) and Peninsula Power £13/green tonne (equivalent to £26/o.d.t) (Forestry and Timber Association 2006).

Prices offered by the small and medium energy users are however greater. There is some anecdotal evidence of woodchip delivered prices being £45-55/tonne at 25-35% moisture content (equivalent to approximately £65-70/o.d.t.). However it should be noted that these prices are based on small load deliveries of >5tonnes, hence increasing transportation costs, and that the material is chipped. Hence the additional cost to the woodland owner supplying these smaller scale markets often only offers little advantage.

By contrast, the firewood market is long established and in turn potentially offers woodland owners (and timber merchants) easier and more lucrative markets. The cost to purchase firewood varies from area to area and supplier to supplier, the quality of the loads is variable in terms of log size, species and moisture content, but equates to £75-120/o.d.t. delivered. Although the woodland owner only receives £15-25/green tonne (equivalent to approximately £30-50/o.d.t.) at roadside, the rewards are still greater than selling to the pulp and wood panel board mills or energy generator. The price differential between firewood logs and timber for energy generation, can be explained largely by the economics of scale and the purchasing power of a large buyer. It should be remembered that users of firewood tend to buy in small amounts and generally order by the load (usually in the range of 0.75-1.5tonnes).

Forest residues and market prices

Forest residues are the product of harvesting and thinning operations and consist of the unwanted branches and tree tops that have been removed during management operations. Quantities of residue from both conifers and broadleaved woodlands can make up a significant proportion of the total yield of the crop – 25-50% of the tree volume. This resource has had no conventional timber market and so has traditionally been left on site to rot down or burnt. There has thus been interest in this resource as a potential feedstock for the energy sector. However despite considerable research and work by the Forestry Commission and others over the years, very little of this resource is used for this purpose. Furthermore the logistics and costs of using this resource are still to be established in the UK.

6.0 Energy Crops

There are currently two main energy crops being grown in the UK – Short Rotation Coppice (SRC) and Miscanthus. Grants that were available to assist with the establishment of energy crops and for setting up of producer groups though the Energy Crops closed on 30 June 2006, but new schemes are expected to be in place by January 2007, subject to European Commission approval. Annual Energy Crops payments are also available – a payment of €45/ha/yr for energy crops, not grown on set-aside land, was introduced as part of the reforms of the Common Agricultural Policy – payments commenced in 2004, and as yet there is no specified end date for this policy.

SRC consists of densely planted willow, or less commonly poplar, which is normally harvested every 3 years and is likely to have a plantation life of up to 30years (DEFRA 2004c). It can be established on a relatively wide range of soils although it has been suggested that wetter areas of the country (i.e. the west) may be more suited to growing willow SRC (RCEP 2004). It has the potential advantages in Nitrogen Vulnerable Zones as nitrate leaching tends to be lower than from fertilized arable or grassland (DEFRA 2004c). SRC is, however, a relatively new crop and there are a number of uncertainties surrounding it. Some of the early commercial sites are producing yields below the estimates of 7 - 12o.d.t./ha/yr (DEFRA 2004). Furthermore, there have been problems with stored fresh woodchip heating up and decomposing, thereby loosing calorific (energy) value (DEFRA 2004). However, as a new crop it is plausible that advances will be made in storage and yields (Ilex 2003).

Miscanthus are woody rhizomatous fast growing grasses. Unlike SRC they offer the potential for harvesting, and therefore income, every year over a lifetime of around 15 years and can be harvested using conventional machinery. Yields on the UK experimental sites for long growing Miscanthus have been around 13o.d.t./ha/yr and it is suitable for growing on most lowland soils. (Although an annual crop, on most sites, yields are too low to justify harvesting in the first year and peak yields are not reached until the third year which may, like SRC, have cashflow implications for farmers/landowner (DEFRA 2001; RCEP 2004). Miscanthus may thus prove more attractive to farmers than SRC, because it is a more familiar crop with existing uses outside energy, including animal bedding (Nix 2005).

Despite Government support for energy crops, the total area of SRC planted ‘for energy use’ was only 1,822ha in 2003 (providing an estimated 24,000o.d.t. of fuel) (DEFRA 2004; Ilex 2003). Approximately, 1,500ha of this is SRC willow mainly grown for the ARBRE plant (RCEP 2004). By contrast, there are currently 10,000ha of Miscanthus in England, and the area is set to expand (Nix 2005).

On the surface of it, the 2005 reforms of Common Agricultural Policy (CAP) appear to make the prospect of growing energy crops on areas beyond set-aside more attractive for farmers/landowners. To date, set-aside (a defined area (at 2005, 5%) of all but small holdings where the only production of non-food crops, including energy crops, is permitted) has been the most attractive area of farms on which to produce energy crops. The decoupling of subsidy payments (i.e. the removal of the requirement that an arable crop is grown on non-set aside land to claim Arable Area Payments) means that farmers should be able to look to the land use that will provide the best returns, which may include energy crops.

However, given the lack of experience of marketing energy crops there is a relatively limited amount of information regarding their economics. The high establishment costs (estimated to be up to £1000/ha after Energy Crops Scheme planting grants of £1000/ha) mean that care needs to be taken when comparing gross margins (which often do not include these costs). Furthermore, the lack of income for the first three years, and the triennial harvesting pattern of SRC need to be accounted for in terms of interest and opportunity costs.

The Potential Supply of Wood Fuel from the South West Region

The potential quantities from energy crops for the energy market will be dependant upon firstly the areas grown and secondly upon the yields achievable. Reliable estimates of the areas of land currently planted with SRC and Miscanthus in the South West are not easily obtainable. However, it is believed that less than 100ha of SRC have been planted, and less than 1000ha of Miscanthus. Thus, existing suppliers are currently very limited and future suppliers will be dependent upon landowners making the commitment to plant the crop.

Whilst most areas of agricultural land may potentially be able to grow energy crops not all areas will be suitable. For example, various reports have concluded that planting energy crops in less intensively managed areas and areas of high conservation interest should be avoided. Furthermore energy crops will need to be at least as profitable as conventional agricultural enterprises, in particular arable crops, if landowners are to make the commitment to such a venture.

To establish whether energy crops are likely to compete with conventional agricultural enterprise, it is necessary to firstly establish the costs of harvest and transportation. Secondly it is necessary to assess the market price of the material sold from the energy crops.

The Supply Chain and Costs of Supply

The supply chain for energy crops consists of four stages, each with associated costs as follows:-
1) Establishment 2) Harvesting and collecting 3) Storage and comminution 4) Transport

The type of site, scale of operation and location in relation to the end user will all have an impact on the harvesting, storage and transport system used, which in turn will impact on the costs.

1) Establishment costs

The main variables that affect the costs of establishment are firstly the fencing costs (assuming the need to fence) and secondly the costs of the cuttings. Not only do these cost form the greatest proportion of the overall costs, and thus their effects on costs will be more significant but also these costs can vary significantly due to the shape and size of the site and its typical characteristics. Specialist or adapted machinery is required to mechanically plant SRC, whereas Miscanthus can be planted using conventional agricultural machinery.

2) Harvesting and collecting

Like wheat and other arable crops, Miscanthus is harvested annually. It can also be harvested and stored using existing farm equipment and methods. It is cut and baled with a straw baler and stored in barn whereas for SRC, adapted or specialised equipment is required which in turns requires capital investment or the need for a suitable contractor/joint venture arrangement.

For SRC, there are two main systems for harvesting. Each of these systems is associated with a distinct type of harvester, which in turn impacts on the collection, storage, drying and potentially the transportation. These are ‘cut and chip’ harvesters ‘whole stick’ harvesters. The cut and chip harvesters cuts the coppice, chips it and blows it into a trailer. Stick harvesters cut the coppice as sticks. Generally, the sticks are left to dry before being chipped. The costs of harvesting will depend on the size and type of the harvester as well as the site itself, including ground conditions, the area and yield of coppice as well as the field layout.

3) Storage and drying of chips

SRC will be harvested at moisture contents of 45-50%. Depending on the system of harvesting, coppice will be provided in two basic forms: as wood chips or sticks. These in turn will impact upon the storage and drying.

Following cut and chip harvesting, it will generally be necessary to transport and store the chips in an accessible location on the farm with space for loading and manoeuvring of vehicles for subsequent road transport to the point of use. Problems can arise with both decomposition and achieving the desired reduction in moisture content. By contrast, the sticks produced from whole stick harvesters do not deteriorate in the same way as the chips and can be stored on the field and left to dry to 20-25% moisture content after 6-12 months.

4) Transport

Like forest material, the wood chips are a low value bulky item and so transport is likely to be a significant cost.

Cost of Production

The total cost of production from SRC and Miscanthus using standard assumptions concerning yields and input costs are set out in Table 6 below.

Table 6 The production Costs of SRC and Miscanthus

	SRC		Miscanthus	
Costs	£/ha	£/o.d.t.	£/ha	£/o.d.t.
Harvesting	100-300	10	100	8
Annual cost of weed control and fertilizer	50	5	65	5
Sundries	10	1	10	1
Total	160-360	16-36	175	14
Annuity Costs	40	40	105	8
Handling and Drying costs	100	10	0-100	0-8
Transportation costs	100	10	125	10
Total	400-610	40-60	405-505	32-44

Assumptions

1) Cost per hectare are based on a yield of £10/o.d.t./ha/yr for SRC and £12.5/o.d.t./ha/yr for Miscanthus
2) Annuity costs for SRC are based on establishment cost of £600/ha (after deduction of £1000 planting grant) and a lifespan of 20yrs and an interest rate of 5%. Annuity costs for Miscanthus are based on establishment cost of £900/ha (after deduction of £920 planting grant and a lifespan of 15yrs and an interest rate of 5%.
3) Transport charges are based on a transport distance of no more than 25miles.
4) The other costs have been derived from Nix 2005 and ABC 2006. Regards has also been taken of previous studies. It should be noted that these costs are based on limited data sets and are potentially variable as a consequence.
5) The above figures ignore the Energy Crops Supplement of 45 euros/ha/year, which equates to approx £2.80/odt.
6) Preview studies over the last 3 years have estimated the costs of production including chipping, storage, drying and transport are in the region of £50-100 /o.d.t, so the above costs in the table are at the low end of the range.

Market Prices

The price for SRC, delivered to the end user (i.e. co-firing with coal in power stations) is currently reported to be £45/o.d.t. This equates to approximately

£35/o.d.t. ex-farm – a widely quoted figure (Nix 2006, ABC 2006 etc) and is based on £45/o.d.t. delivered less £10/o.d.t. for haulage. It is however more than the £26/o.d.t. ex-farm, quoted by ESD Biomass for supply to Didcot power station. (It should be noted however, that the price from ESD Biomass is index liked, and includes harvesting charges at a fixed price of £10/o.d.t).

Prices for Miscanthus are currently reported to be £35/o.d.t. delivered (Nix 2006, ABC 2006), and the published budgets for the Winbeg power station at Winkleigh in Devon report a price of £25/o.d.t ex-farm, which again equates to a delivered price of approximately £35/0.d.t. Like forest material, there is also the potential to supply a number of small-scale heating schemes.

Cost of Production versus Market Prices

Under the assumptions used in this study, energy crops are currently considered to be unviable on the basis of current production costs and market prices as shown in Table 7 below.

Table 7 Costs of Production versus Market Prices

Crop	Production cost £/o.d.t.	Market Price £/o.d.t.	Net Margin £/o.d.t.	Net Margin £/ha
SRC	40-60	45	5 to -15	50 to -150
Miscanthus	32-44	35	3 to -9	37 to -112

Cost of production is greater than the current market price and thus do not break even in many cases. Furthermore whilst profitability of conventional arable crops remain depressed, gross margins are still as high as £300/ha. Whilst comparisons between energy crops and conventional arable crops are problematic, (due to the lifespan of the crops, dealing with fixed costs etc), the above comparison does demonstrate, that in many cases, energy crops are unlikely to prove financially advantageous for landowners in the current economic climate. Furthermore other research (unpublished) also indicates a similar picture.

However, it should be noted that the economics at the moment are likely to be very farm specific. Furthermore yield improvements of up to 30% are expected in the future (LEK 2004) and production costs, in particular harvesting, storage, handling and transporting, are expected to decrease as machinery and supply systems develop. The above comparisons also ignore potential fixed cost savings. Energy crops are relatively low maintenance and machinery can be shared in co-operatives, as in the case with the ex-Arbre growers who are now selling into co-firing (Strawson 2005). Furthermore, if market prices were to increase to £50/odt, Miscanthus would start to look attractive for a number of farmers (not only breaking even, but comparing with other arable crops producing relatively low gross margins), and at £60/odt, both SRC and Miscanthus could compare favourably in a number of cases.

Other Factors

Beyond returns from the crops there are a number of other considerations which may affect farmers' decisions. Energy crops require a 15-20year commitment with no guaranteed market (DTI 2005b). The 3-4year delay before harvesting for SRC, as well as having cash flow implications, means farmers may have to plant in a leap of faith that they will have a market to supply in 3 or 4years. The confidence to do this has been shaken by the failure of the ARBRE plant (RCEP 2004). Farmers may also have to become actively involved in developing markets (through producer groups who have stronger negotiating positions with generating companies etc). This contrasts with other crops with existing markets and may not be something that farmers wish to become involved in.

The length of commitment may also have other implications which may deter some farms, affect land values and raise landlord and tenant issues. However, there are some indications this may not be as large a problem as envisaged. The initial commitment is likely to be for the 5 years stipulated by Energy Crops Scheme planting grants and farmers/landlords/surveyors are relatively used to dealing with long agreements and via agri-environment schemes. There is also evidence from Denmark and Sweden that, if necessary (i.e. were prices to fall), then Miscanthus can be removed without extensive damage (although SRC may be more difficult as it has a deeper root structure. (RCEP 2004) Furthermore there is potential to sell to alternative markets. These factors my mean that long-term commitment may be less of an issue.

7.0 Liquid Biofuels for Transport

The main transport biofuels that are currently of interest to UK farmers are biodiesel and bioethanol, since the crops that are suitable for conversion into these fuels are widely grown in the UK – oilseed rape, wheat and sugar beet. More recently oil/biofuel companies have announced plans to produce biobutanol from sugar beet. These three types of transport biofuels can be used in conventional engines - a 5% blend with conventional fossil based transport fuels can be used with no engine modification (DFT 2004). During the past year the interest in such crops has been increased dramatically as a result of publicity, rising oil prices and new project announcements by small and large biofuel companies.

The EU Biofuel Directive requires that Member States set indicative targets for use of biofuels and have proposed indicative targets of 2% replacement by 2005 (in blends or as total replacement fuel), rising by 0.75% per annum to a target of 5.75% replacement by 2010. In response to this Directive, the UK has introduced a Road Transport Fuel Obligation (RTFO), that requires 5% of all road fuels to be biofuels by 2010. (This is comparable to the Renewables Obligation imposed on electricity generation). In addition there has been has been a 20p/litre reduction in duty on biodiesel since 2003, and on bioethanol since 2005.

Current use of biofuels in the UK and Worldwide

Biofuels are already produced and used widely in a number of countries. For example, Brazil has developed a large bioethanol industry (derived from sugarcane), accounting for 35% of domestic petrol use (CLA 2005). It also produces considerable exports. The US have also invested in bioethanol production (largely from maize) and accounts for around 1% of petrol use (USDA 2004; CLA 2005). In Europe, the most important biofuel is biodiesel (representing approximately 80% of biofuel production). Within Europe, biodiesel is mainly produced from rapeseed, which is then blended in various proportions with conventional diesel or as a direct substitute. Germany is Europe's largest producer, followed by France – in both countries, domestically produced biofuels accounted for over 1% of the fuel sales in 2003 (USDA 2004).

By contrast, the UK is still a very low user of biofuels. Transport biofuels accounted for only 0.04% of the UK's 2004 road fuel sales, although this had risen to 0.25% by May 2005, largely due to imports of bioethanol from Brazil (DFT 2005). Furthermore the UK target for the end of 2005 was only 0.3% (Nix 2006).

Potential Supplies of Biofuels in the UK

To date production of biofuels in the UK has been limited. However the factors discussed above, would appear to indicate a large potential market and production links set to increase significantly. There have been more than 20 announcements of planned biofuel factories in the UK. Five are already at the build or completion stage. The potential of this biofuel market is illustrated below.

The current market for diesel in the UK is approximately 18million tonnes a year. To supply 5% of this as biofuel would require 0.9million tonnes of biodiesel, the equivalent of over 800,000ha of oilseed rape (assuming a yield of 3tonnes/ha and an extraction rate of 37%). Alternatively the petrol market is 20million tonnes, 5% of this is 1million tonnes, the equivalent of nearly 400,000ha of wheat (assuming a yield of 7.5tonnes/ha and an extraction rate of 30%). Other studies have also attempted to estimate the area of land required to achieve a 5% inclusion of biofuel component, they range between 1.2million and 1.8million ha of land (ADAS 2006).

To achieve the above, would mean that the current production of oilseed rape would need to be increased from 600,000ha to 800,000 ha and all used for biodiesel rather than for feed. 400,000ha of wheat of the 1.9million ha currently grown would be required. This could be grown on either set-aside land utilising land deemed surplus to current requirements or on arable land, either diverting the same crops currently grown for food use to fuel use or alternatively replacing other food crops in the rotation.

However, in reality, such an expansion in the cropping in biofuels is unlikely to be achieved in practise. For example, much of the feedstock could be imported from other countries (as is currently the case). The proportion of biofuels supplied by UK farms will very much depend on Government policy as well as the comparative returns achievable from growing conventional arable crops (as is the case for arable crops). The use of set-aside land with OSR is also seen as potentially environmentally detrimental. It is also important to consider the ethical debate of using food crops to produce fuel. Whether food crops should be used to produce fuel rather than food, and if so, how much is an important issue for policy makes to consider.

Biodiesel

Biodiesel can be made from a wide range of vegetable oils, including rape oil, as well as soy, sunflower and palm oil. It can also be derived from waste/recycled vegetable oils (RVOs). Department for Transport figures (confirmed also by other studies), suggest that biofuels from RVOs are considerably cheaper than those from agricultural crops such as OSR (DfT 2004). Consequently most of the biodiesel currently produced in the UK is from RVOs. However the amount of RVOs available is limited. Thus if the UK is to meet its targets, significant areas of OSR grown for biodiesel will be required and/or the feedstock will need to be imported.

Large scale biodiesel production.

Until recently all biodiesel production in the UK was confined to small-scale processors. However a number of new biodiesel plants are at various stages of development in the UK. In 2006 the first of these plants came into production – the Biofuels Corporation plant at Teeside with a capacity of 250,000 tonnes of fuel output per year. The combined demand of all these plants is believed to be 430,000 tonnes of biodiesel, requiring 400,000 ha of rapeseed, if this were the raw material used. Most of these proposed biodiesel plants are located at large ports focused in the north east region. Thus a proportion of production is expected to be imported soya and palm oil. Other advantages of a port location are likely to include opportunities to reduce costs and environmental impact of distribution, by shipping volumes of biodiesel around British coasts and the option to export finished products. Furthermore the existing infrastructure, (eg for transportation, processing etc.) already exists, and the northeast is a predominantly arable area.

Small-scale biodiesel production and its viability.

There is growing interest in producing biodiesel from OSR at a local or farm scale level. Two Gloucestershire companies for example, have teamed up to provide the necessary equipment. Alvan Blanch has made and supplied crushing equipment all over the world for a number of years and they have formed a partnership with Green Fuels who supply esterification equipment that converts pure OSR oil into biodiesel. The kits that they are publicising range from 150 litres to 600 litres of biodiesel per day. Their sample costings show that biodiesel can be produced for approximately 65 pence/litre including fuel duty. (Alvan Blanch 2006). If that is possible, then small-scale biodiesel production does indeed offer a promising opportunity for farmers. However these costings appear optimistic. Whilst it is not known how these figures have been derived, the current cost of biodiesel production from OSR is expected to be greater. To assess the cost of production, it is necessary to know the cost of the rape seed, the amount of oil it produces, less the sale of any by-products. The costs of production are also required. The cost of deriving biodiesel based on published data are shown below.

1. Cost of oil from OSR

Current crop of 1 tonne of rape seed	=	£160/t
Cost of rape seed oil (based on 1 tonne Producing 0.35 tonnes of oil)	=	£457/t
Less cost of rape cake (based on 0.65@£80/t)		£ 52/t
Net cost of rape oil/tonne (say)		£400/t
Net cost of oil/litre		£ 40 p/l

2. Costs of production – pressing and conversion of oil to biodiesel

conversion of oil to biodiesel	£ 27-35/l
Total cost/litre	£ 67-75p/l

Notes

1. Rapeseed price of £160/t, derived from current market prices.
2. One tonne of rapeseed produces up to 0.35 tonnes of oil (Alvan Blanch 2006).
3. Cost of rape cake based at £80/t, on the basis that it is sold as animal feed. Based on anecdotal evidence from local farmers, they claim that prices for rape cake range from £80 - £110/t. However if the production of rape cake increases as a result of increased biodiesel production, its price is likely to fall.
4. Production costs are taken from published reports, (eg Turley et al 2003). It is likely that these production costs have been derived from large-scale operations- the use of small-scale operations (like the equipment supplied by Alvan Blanch) is likely to increase production costs particularly if labour is included in the costings. It is however acknowledged that information on small-scale production costs is currently sketchy. This area would benefit from further research.

As can be seen from these calculations, the cost of rapeseed oil is 40p/litre whereas RVO costs 20-25p/l delivered. If the costs of production to biodiesel are as much as 30p/litre, then the cost of biodiesel, even with 20p reduction in duty will be approximately £1/litre giving no financial advantage over fossil fuel diesel.

There are however other by-products that could be further exploited including the rape straw and the glycerine. Furthermore if production costs can be reduced to as low as 15-20p/litre, then such as enterprise may prove attractive to farmers.

Bioethanol and Biobutanol

Bioethanol is a high octane liquid fuel made from plant material and can be used as a petrol additive or substitute for use in petrol engines. It can be made from crops such as cereals, oilseeds, sugar beet, fodder beet, corn and maize. In the UK, the main interest has been in using wheat. In future it may be possible to produce it economically from wood, straw and even household waste.

There are a number of new bioethanol plants at various stages of development in the UK. In the South West region, Wessex Grain, through their subsidiary Green Spirit, has received planning permission and will start construction in 2006 on a plant that will convert 340,000 tonnes of wheat into 130 million litres of bioethanol a year, commencing in 2007. It will also produce as a by-product, 125,000 tonnes of cattle feed. It is due to commence production in 2007. The company aims to build up to another 5 plants across the UK within it’s next 5-8 years (Wessex Grain 2006). Humber Biofuels (also a subsidy of Green Spirit) has also started construction of a 260 million litre plant.

In December 2005, British Sugar began construction of a plant at Wissington, Norfolk. Originally it was designed to produce 70 million litres of bioethanol each year from sugar beet that was previously exported, but it has announced that the plant will be converted to produce biobutanol instead. A feasibility study on larger production facilities is in hand jointly with BP and Du Pont. Biobutanol has a higher energy content and can be produced from the same raw materials. The output will go to Greenenergy Fuels Ltd which already supplies bioethanol-blended petrol to various retailers.

In the longer term, wood and straw may prove to be more economical feedstocks, but major technological advances are still needed to reduce manufacturing costs. Current indications suggest that the cost of producing bioethanol will make it difficult for it to compete with fossil fuels. Thus political intervention through taxation and incentives may be required to help the market expand.

The Economics of Growing Crops for Food Versus Fuel Use

OSR for Biodiesel

Most of the OSR is currently grown for human or animal consumption – the main uses for the rapeseed oil being in cooking oils or margarines with the rape meal being used for animal feed. OSR can be grown as a non-food crop on set-aside (where the major use of the crop is not human or animal consumption) - the main uses include feedstocks for pharmaceuticals and hydraulic oil. To be eligible to be grown on set-aside there must be a direct contract with a processor. Secondly, the non-food product must be worth more than the total value of any food by-products.

Industrial/biofuel contracts are available for OSR both on set-aside land and ‘normal land.’ Prices for biodiesel have been approximately £10/tonne lower than food uses, so there is little incentive currently to supply such a market. However, OSR grown on set-aside land for such a use has attracted an Energy Crops Supplement – for 2006 it was €45/ha (as is the case for Miscanthus) which equates to approximately £28/ha.

Using the data from farm costings books (eg Nix and ABC), the relative profitability (expressed in gross margins) of growing OSR for conventional markets and biofuels are shown in Table 8 below.

Table 8 Gross Margins for OSR (ABC 2006)

Crop	Yield (tonne/ha)	Price (£/ha)	Output (£/ha)	Total Variable Costs (£/ha)	Gross Margin (£/ha)
Winter OSR - ‘oo’ variety	3.5	150	525	244	281
Winter OSR -	3.0	160	480	249	231

‘HEAR’ variety					
OSR - Biodiesel contract	3.5	140	511*	244	266

*they include an Energy Crop Supplement of £28/ha

There is currently little incentive to grow OSR for non-food uses or for biodiesel contracts. It should however be noted that OSR prices do fluctuate – over the last year prices have fluctuated between £125-150/tonne.

Wheat for Bioethanol

Like OSR, most wheat is grown for human and animal consumption. Biofuel contracts are available for wheat on set-aside and ‘normal land’. Prices for wheat have been lower than for food uses, so again there has been limited incentive to currently supply such a market.

Wheat generally provides farmers with a greater gross margin than OSR. Rather OSR is used as a ‘break-crop’ in combinable crop rotations, such as cereals.

Using the data from the costing books, as above, the relative profitability (expressed in gross margins) of growing wheat for conventional markets and biofuels are shown in Table 9 below.

Table 9 Gross Margins for Wheat (ABC 2006)

Crop	Yield (tonnes/ha)	Price (£/ha)	Output (£/ha)	Total Variable Costs (£/ha)	Gross Margins (£/ha)
Feed Wheats *	7.8-8.8	68	530-598	268	215-336
Milling Wheat	8.1	75	608	298	309
Durum Wheat	5.9	102	602	295	307
Wheat – Bioethanol contract**	7.8	62	511	295	226

*higher yield assumes a ‘first’ wheat after a break-crop or set-aside. Lower yields are achieved for second and continuous wheats.
**this includes an Energy Crop Supplement of £28/ha.

As can be seen from the above table, the returns for supplying wheat for bioethanol are again less attractive than for the conventional markets.

Other Crops

Ethanol production from sugar beet is also possible. However there is very little sugar beet grow in the South West, so this is unlikely to have any potential. Bioethanol can also be derived from lignocellulose. Forest material and energy crops such as SRC and Miscanthus could be potential commercial sources of lignocellulose in the future. Limited data suggests they currently have considerably higher costs than for bioethanol from say wheat or sugar beet – these costs could fall, with expected technical improvements.

The Market and Supply Infrastructure

Unlike the biomass sector, there is potentially an existing supply infrastructure already in place. The production of liquid biofuel is a very similar supply process to any other crop use.

The factories built to process the crops into fuel are expected to be built at points with a large crop supply base, existing tankage, blending and distribution facilities. Furthermore, the biofuel companies that have formed are used to purchasing the crops required from farmers for feed use. In turn, the farmers have been growing these agricultural crops for feed for many hundreds of years. The logistics of growing and supplying these crops for fuel remains unchanged, so form a farmers perspective, it makes little difference whether their crop is sold and used for feed or fuel – the key issue for most, will be the overall return.

The farmers thus have a number of options and in turn potential opportunities. Firstly they need to decide whether to grow their crops for feed or for fuel. Secondly if they grow their crop for fuel, should they sell it direct to a biofuel manufacturer or process it on the farm. At current levels of support and prices offered by the biofuel manufacturers, the economics of growing crops for biofuels are still marginal compared with the returns from the conventional food markets. However longer term, increased demand for use of crops for the biofuel market will in turn increase the demand for these crops, which in turn is likely to increase prices generally. Furthermore there is scope to develop crops that are better suited for energy conversion. Desirable attributes of such varieties would include higher yields, less nitrogen for the same yields and more efficient conversion. There are also other potential opportunities – the bio-products of biothanol and biodiesel production can also be used for energy generation – the straw can be burnt for energy, and for OSR, the rape cake and glycene may also be used.

However balanced against these longer term opportunities for both farmers and biofuel companies, there are a number of potential threats. Firstly, it is reported that bioethanol and biodiesel or their feedstock can still be imported at lower prices than UK based production (DFT 2004). Indeed, most existing and proposed UK plants for bioethanol and biodiesel are located by ports, allowing them to easily access potentially cheaper imports. It should be remembered that the UK has relatively high employment costs, high population density and poor land availability relative to countries such as

Brazil. Secondly whilst there is increasing interest in biofuel development in the UK, the industry are currently claiming that fuel derogation if 20p is still not enough, and a further derogation in the range of 7-10p / litre is still needed to encourage investment (NaREC 2006). Extracting existing oil from the ground is still likely to be considerably cheaper in the foreseeable future.

Implications for the South West region

South West farmers could supply a significant tonnage of wheat for bioethanol and biobutanol, and OSR to a lesser extent for biodiesel. However the South West region has a higher percentage of it's land under grass, which in turn is used for livestock production, than any other region in England. Thus it has less land available for growing crops for biofuels. In addition, whilst there is scope to use the straw and other bi-products such as rape cake for energy generation (which may provide attractions to other more arable orientated regions) it is more likely that they will be used for the livestock sector. Thus it is important for the farmers in the South West region in particular, to consider whether food crops should be used to produce fuel rather than food, and if so, how much.

8.0 Farm Waste Energy

The Potential Supply of Farm Waste Energy in the South West Region

The South West has more cattle and calves, and sheep and lambs than any other region; and the region's dairy and beef herd accounts for almost one-third of the national stock (see Table 10 below). In line with national trends, dairy cow numbers in the South West have fallen recently while the beef herd has increased.

Table 10 Livestock on agricultural holdings: June 2004, '000.

	South West	England
Dairy Cows	496	1,375
Beef Cows	195	730
Sheep and Lambs	3,305	15,873
Pigs	473	4,236

(DEFRA Census Data (2005)

Farm waste occurs in three main forms:

- Slurry and farmyard manure from cattle and pigs and as slurry and litter from poultry units
- Dirty water from rainwater run-off from concrete yards and from cleaning of dairy facilities and pig and poultry houses
- Silage effluent – plant juices and water

Manure and slurry are not a waste when used as a fertiliser, as agricultural waste contains organic material, which may be livestock manure, slurry, crop residues and silage effluent. In total some 150 million wet tonnes (cattle and pigs) of excreta are produced in the UK, of which approximately 105 million tonnes are returned to the land by grazing, with 3.5 millions of wet tonnes of used poultry litter and excreta (1.8 millions dry tonnes) are produced (DEFRA 2005).

Of the farm feedstocks available, slurry is more suitable for anaerobic digestion than farmyard manure and poultry litter, as these both have high DM percentages

Anaerobic Digestion in the UK

AD involves the conversion of organic matter to energy by microbiological organisms in the absence of oxygen, which is placed in an insulated container (digester), which creates conditions for bacteria (mesophilic or thermophilic) to ferment the organic matter. This produces biogas (methane) and which can be used as a fuel source for heating, electricity or fuel, and fibrous compostable solids.

Plants have been installed on UK farms since the late 1970's for research, commercial, practical or management reasons. The adoption of AD has been quite limited from this point, despite the advancement of the technology in terms of packaged plant designs and installation products and vigorous marketing.

Most of the digesters in the UK are based on pig or dairy farms, although some do handle poultry litter of a combination of feed-stocks, and have been between 50 and 1000m³ and generate gas for on-farm heating only, with a few installations have been fitted as CHP units.

There are approximately 25 farm scale plants and one centralized biogas plant operating in the United Kingdom. This number has varied considerably over the years. Initial government support via capital grants saw up to 45 farm-scale digesters being installed.

These digesters have used animal manures as the feedstock and the generated gas was used mainly for on-farm heating. A small number of these biogas plants have installed combined heat and power engines. The significant drop in the number of operating plants can be explained by several reasons including:

- Withdrawal of government capital support grant
- Plants being built to very tight budgets, leading to inadequate design and construction
- High operation and maintenance costs
- Insufficient income (energy cost substitution only)
- Expected income from by-products (digestate and compost) did not materialise
- Lack of operator training
- Poor waste handling systems and equipment failures
- Sedimentation & pH instability
- Poor quality feed-stocks
- Failure to maintain mesophilic temperatures

Estimating the Potential Energy Production form Biogas

Estimating the technical potential is complicated for different reasons. For example livestock manures animals are housed for around 180 – 200 days per year. For the rest of the year the manure is applied to the field and is unavailable for energy production. Nonetheless, previous studies have attempted to assess the biogas production and energy input from various farm wastes as set out in Table 11 below.

Table 11 Indicative Biogas production and energy output from available feedstocks

Feedstock	Livestock required to produce 1 tonne / day	Dry Matter Content	Biogas yield (m^3 / tonne feedstock)	Energy value (MJ/m^3 biogas) [$1m^3 = 20MJ/m^3$]
Cattle slurry	20 - 40	12 %	25	23-25
Pig slurry	250-300	9%	26	21-25
Laying hen litter	8000 - 9000	30%	90-150	23-27
Broiler manure	10000 - 15000	60%	50-100	21-23

Previous studies have also attempted to assess the potential energy production from biogas for both the UK and South West region as set out in Table 12 below.

Table 12 Technical potential of UK and South West Region biomass feed stocks available for AD

Biomass Type	Definition	Estimated	Comments
UK Farm slurries	Three main sources, cattle pigs and poultry (est. 144.1 million)	8,600,000 m^3 / day methane yield, estimated equivalent to 9.4 TWh/y heat if AD is used to generate heat or power).	Currently spread on agricultural land. Increasingly stringent regulations may require some form of pre treatment prior to spreading such as AD. Estimate UK AD market for farm manures is 9.4 TWh/y.
Regional Cattle	Estimated 496,000	228,160 m^3 / day methane yield	$1m^3$ = 20 MJ/m3 equates to 1.7 kWh electricity
Regional Pigs	Estimated 473,000	473,000 m^3 / day methane yield	$1m^3$ = 20 MJ/m3 equates to 2.5 kWh of heat
Regional Poultry	Estimated 2.62 million	20.1 million / day m^3 methane yield	Estimate SW methane production 722,000 m^3 / day Estimated Regional SW AD market 0.8 TWh/y

(DEFRA 2005)

Current Technology, Research & Commercial Projects

AD plants are in operation across the world, including Sweden and America. China has a long tradition of AD systems as an integral part of its smallholdings, and Germany has recently contributed to funding for over 400 on-farm AD units. However there are a few examples in the UK.

The main AD models in current use in the UK are:

1. A centralised facility at operated by Holworthy Biogas Ltd North Tamar Devon, where waste manure from 30 farms local farms, within 5-6 mile radius, is delivered, together with local food waste collected direct from processor across Devon and Cornwall. The German company Farmatic Biotach Energy Ag has built the plant. The company is the main shareholder, with the remaining shares to be held by the owner and the local community, and farm suppliers after full pay on the project.

The plant intends to process 146,000 tons of organic matter each year. There is an installed electrical capacity of 2.1 megawatts. This is a Combined AD plant (CAD) and uses a mixture of poultry manure and liquid (pig and dairy slurries) from farm residues (80%) and waste from food processing (20%). This proportion follows the requirements under the 15 year NFFO Contract (<20% waste input. The total cost of the project was £7.7 million with £3.85 million coming from EU objective 5(b) funding.

2. Walford College, Shropshire operates a profitable AD system, with integral CHP and composter units. The unit was installed in 1994 at a cost of £134,000 this generates electricity utilising methane produced by the College's 210 cow dairy herd, and 160 breeding sows. These produce 3000 tonnes of organic manure per year, which is supplemented in the spring and summer with imported chicken litter

The AD system produces 15m3 per day of treated liquid slurry and 3 tonnes of separated fibre, which is sold for compost.

In practise this now supplements the main boiler, which is fed with 'biomass', comprising used animal bedding and wood waste from the College's estate. The water is pre-heated using geothermic energy via a ground source heat pump. The south facing roof contains photovoltaic cells providing electrical power and a wind generator also supplements this.

3. In order to reduce the risk of diffuse pollution from agriculture in the South West of Scotland, the Scottish Executive commissioned a research project to investigate how a full-scale on-farm biogas and composting plant would aid the reduction.

The reason for selecting the area was due to high numbers of dairy cattle, high summer rainfall, impermeable soils, short river catchments and marine conditions, which inhibit dilution and dispersion.

> A formal agreement was reached with 9 farmers for the installation of 7 biogas and 3 composting AD plants. The license agreement with the farmer is for 5 years after which they may purchase the plant.
>
> The main issue affecting these enterprises is the location, in that they are located well away from residential or commercial buildings, meaning no near market for any of the heat produced. The only heat potential is within the ‘farms’ location, therefore the main market will be electricity, either used locally or sold to the National Grid. The end product from AD is heat-treated compost material that can be spread on to the land as a fertiliser / soil conditioner.

Greenfinch is also looking at ways in which farmers can enhance the use of their anaerobic digesters with particular reference to wet energy crops. This is part of a pan-European research project called Cropgen funded by the European Commission. The project is headed by Southampton University; other partners include seven European Universities and three Small to Medium Enterprises. Cropgen is a three-year project investigating the use of wet crops and agri-waste for the production of energy using biogas technology.

Greenfinch is specifically looking at the anaerobic digestion of energy crops in 500 litre research digesters in Ludlow and the production of a variety of energy crops looking at the application of digestate as a bio-fertiliser and the resulting dry matter yield of the crops. The crops being researched are ryegrass, red clover, Jerusalem artichokes, lucerne, and maize. This research aims to establish the biogas yield for each individual crop per tonne of organic dry matter and per hectare per year. The energy output will be assessed against the energy required to produce the crop giving an overall energy balance.

Anaerobic digestion (AD) has historically been seen as a kind of black box process. Trial and error led to a more or less developed low-cost technology. Traditionally highly polluted wastewater, surplus sludge from aerobic waste water treatment plants or manure is used as substrate for the AD process. The main point is to get rid of pollutants and to produce a stabilized sludge. The resulting biogas is an interesting by-product that can reduce the overall energy costs of the process.

With the new EC-regulations regarding renewable energy and several national “green electricity” laws, a new generation of AD-plants has evolved. These eco-energy-plants use energy-crops, e.g. maize or wheat, as single or main substrate. The crops are planted for the single purpose to be used as feed in an AD-plant. The different nature of these substrates leads to technological problems not known yet. For example: higher viscosity of the anaerobic sludge, due to the high fiber content, lower methane content in the biogas due to the high sugar content of the plants, etc.

The biogas is now potentially a valuable product that can be sold to the national grid. A main cost factor is now the price for the energy crops. Hence it is necessary to optimize the entire technology chain, from cultivation and harvesting, to processing and storage (as silage) to the fermentation process itself. The project CROPGEN aims to tackle these problems by a multi-disciplinary approach. Specialists in agriculture work closely with microbiologists and technologists to optimize the process. It is hoped that one of the results will be a better understanding of the AD-process, due to the mathematical modeling of it.

Environmental Benefits

The AD of farm slurries with a high DM content of 8 –15% is particularly useful for reducing odours by up to 90%, which is weed seed free, with no pathogens, and which can be applied directly to farmland. AD however on its own does reduce biological oxygen demand (BOD) and so it is not a complete treatment for reducing the strength of the slurry. That is the polluting slurry is still 20 times greater than that of raw domestic sewage, and the ammoniacal content which will cause fish to die.

Therefore AD provides a greater opportunity to develop an Integrated Waste Management System, to reduce land and water pollution, the reduction of artificial mineral fertiliser, the need for landfill, use of fossil fuels, gas emissions (methane extraction), and recycles nutrients and preserves natural resources.

AD can also reduce nitrate and phosphate pollution of the watercourse, as run-off is reduced through the greater effective control of nutrient application. In effect it allows farmer to respond to new regulations and public pressure to increase the effectiveness of farm residue management.

By-products

AD produces gas and a digestate. Thus the economic viability of a digester cannot rest with gas production alone. It is therefore important that a financial return is obtained from the digestate.

These options may include composting the digestate for subsequent use as a peat replacement material, an organic manure or soil conditioner.

AD also improves the fertiliser value of the slurry effluent, as it transform a higher proportion of the organic-bound nutrients into a form that makes them more available to the plants.

For example at Holsworthy the bio-fertiliser is to be analysed for N, P and K by Silsoe Research Institute as part of a 3 year monitoring programme, after which the data will be provided to the participating farmers to reduce mineral fertiliser applications.

The Economics of Generating Energy from Anaerobic Digestion

The economics of generating energy from anaerobic digestion will depend on range of factors including the nature of the material, the size and type of the digester, the type of energy produced and it's markets, as well as any bi-products such as digested sales.

As an example a small digester of 10kWe capacity using feedstocks from 100 cattle, or 100 pigs (will require a 150m³ digester) and will cost from £50,000 - £70,000. A CAD plant with a 1MW capacity (will require a 10,000m³ digester) and cost from £3 million to £7 million.

A comparison is made in Table 13 below, between a farm-scale plant and a centralised AD plant reflects the clear difference between commercial supply and build projects and smaller plants where farmers are integral within the construction. The capital cost of an AD plant will therefore vary from £3000 to £7000 per kWe of generating capacity.

Table 13 Generic plant costings for a Farm Scale and a Centralised plant

	Farm scale – 25 kW export capacity	Centralised AD plant – 1MW capacity
Capital cost	£340,000	£6.2 million
Operating cost / yr	£6000	£437,000
Electricity price / kWh	4 p	4 p
Heat price / kWh	0.5 p	0.5 p
Digestate sales / yr	£13,600	£476,000
Gate fee income / yr	0	0
Payback period	20 yrs	15 yrs
IRR	3.1 %	0.2%

The profitability for this project will rely on the following assumptions:

Feedstock 88% agricultural and 12% industrial
Electricity output of 1 MW (8760 MWh/year)
Heat output of 60 Tj/year (17 million kWh/year)
Electrical sales at 8.95/kWh
Sales of hot water and fibre

Markets for hot water and fibre need to be developed, as will maintaining the specific gas output. If these were not achieved then the energy benefits would be significantly reduced, and the venture would be reliant on environmental benefits and co-operation between livestock producers, water companies, electricity producers and managers of the land on which the digested effluent may be more effectively used.

This base case assumption is quite pessimistic, given that there are cheaper types of plant available, thus providing opportunities to improve economic performance.

Furthermore if environmental benefits were factored in to the costs, with regard to the contributions to reducing gas emissions, reduced water and odour pollution odour, plus carbon credits through the ETS, then the payback periods and IRR's will become more attractive.

The financially viability of an AD project will be enhanced if it becomes an integral part of an integrated farm waste management system, in which the feedstocks and the by-products from AD all contribute.

The main income stream will be based on electricity and fibre sales, additionally some waste 'gate fees' will be generated as the enterprise becomes more economic, by those plants who have installed a secondary processing stage, such as pasteurisation. The CAD schemes will also benefit from scale, and therefore the dilution of costs, as will the affect of the core product on the choice of technology.

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