WHY WE NEED ENERGY CROPS IN THE SOUTH WEST

MAIN REPORT IN SUPPORT OF THE POSITION PAPER

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Disclaimer

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EXECUTIVE SUMMARY

The South West (SW) of England is at the forefront of the UK's drive to produce more electricity, heating and transport fuels from renewable energy resources. However, the region has been slow to embrace woody energy crops such as short rotation coppice (SRC) and miscanthus as a potential woodfuel resource. This report outlines why growing energy crops in the SW is essential to continue the upward trend in biomass heat installations, boost the economy and provide additional environmental benefits. Eight key recommendations are proposed to help meet this potential.

There are around 800-900 hectares (ha) of energy crops planted in the SW but much of this is currently without a market as a result of several proposed projects failing to get planning consent or financial backing. Nevertheless, the Government is committed to producing 15% of our total energy and 12% of our heat from renewable resources by 2020. These are very tough targets and to achieve them will require significant uptake in all renewable technologies.

Biomass energy sources will be crucial in helping the SW meet this target. Currently, biomass boilers comprise about 63% of renewable heat installed capacity and most surveys suggest that woodfuel will provide around 50% of the 2020 target for heat. Estimates suggest a woodfuel resource requirement of over 800,000 oven dry tonnes of woodfuel per year (odt/yr). However, the predicted amount of woodfuel available from all sources is 685,000 odt/yr. This shortfall is exacerbated by the fact that the available resource is not always close to the end user and the cost of transporting woodfuel is rising all the time. In addition, the majority of woodfuel is likely to come from currently untapped sources such as undermanaged woodlands and hedgerows which can have high extraction costs. Importing woodfuel is an option but it may not be sustainable and would mean that most of the revenue benefits are achieved outside of the region.

Energy crops can produce a very high output from a relatively small area. Our calculations suggest that it is possible to produce 37.5% of the renewable heat target from just 3.5% of the agricultural land (65,595 hectares). This is based on achievable average yields of 9.4 odt/ha/yr and assumes best practice on good agricultural land. Particular benefits can be achieved when farmers grow and use their own energy crops for heating their farm buildings. Miscanthus and SRC can be produced for less than 1.5 pence per kilowatt hour (kWh). By replacing oil heating (costing 6p/kWh) with energy crop derived woodfuel could provide growers with a gross return of up to £2,500 ha/yr. A wheat crop yielding 8.35 t/ha and a grain price of £140/t would achieve a gross margin of £673/ha.

The Government's Renewable Heat Incentive (RHI) is likely to bring about a surge in demand for woodfuel. End users such as local authorities should be encouraged to approach local farmers directly to grow energy crops on their behalf. A typical primary school may need 3-4 ha of energy crops whilst an elderly peoples' home may require 10 ha. As the supply is local to the end user, the latter will be largely insulated against future price rises brought about by higher haulage costs.

Energy crops are particularly useful at reducing greenhouse gas emissions. Mitigation is achieved by installing woodfuel boilers to reduce carbon emissions and the crops sequestering carbon in the soil. Growing 65,595 ha of energy crops in the SW could enable the mitigation of 475,200

tonnes of greenhouse gases from fossil fuel replacement and 186,946 tonnes from carbon sequestration. As a result, growing energy crops on 3.5% of agricultural land in the SW could offset 21% of the emissions from the agricultural sector.

Growing energy crops in the SW could also provide an enormous boost to the regional economy. Our analysis suggests that energy crops could stimulate £768 million of investment in biomass boiler projects, save consumers £55 million/yr in fuel costs and provide farmers with profits of £27.8 million/yr. In addition, a thriving energy crops sector could create 671 jobs in biomass production and 3,074 jobs in biomass utilisation. Growing energy crops on just 3.5% of SW agricultural land could therefore increase the number of biomass jobs in the region by 134%.

Energy crops are multifunctional and could be strategically grown to help improve our water quality and provide a low cost form of flood prevention. The SW has more livestock than any other region in the UK. As a result, SW farmers have to deal with around 14 million tonnes of slurry per year and face a major challenge in preventing pollution from their land. At present 39% of the SW is in Nitrate Vulnerable Zones (NVZs) and only one third of water bodies in the SW are classified as having 'good' status under the Water Framework Directive (WFD). Energy crops could provide an effective local measure for reducing nitrate pollution by providing useful barrier strips which intercept sediment and absorb nitrates from the water.

Two of the top ten English local authorities most at risk of flooding are in the SW. The coppice nature of energy crops provides hydraulic roughness which enhances sediment retention and slows down the flow of flood water. They could therefore reduce the likelihood of floods downstream and increase the time available for issuing flood warnings. Using appropriately planted energy crops could provide a low cost option for areas that are too small to justify expensive flood defence measures.

A large body of research suggests that energy crops in general and SRC in particular can significantly increase biodiversity on farms. The crops and the surrounding headlands provide food and habitats for birds, butterflies and other invertebrates. Unfortunately, despite the benefits to wildlife there has been no incentive made available to energy crop growers through environmental schemes. Farmers are unlikely to plant large areas of energy crops unless the venture is economically attractive. An interim payment following crop establishment and before the first harvest would be highly beneficial as it would reduce the farmers risk and enable an improved cash flow in early years.

The revision of the Common Agricultural Policy (CAP) offers an opportunity to stimulate energy crop plantings and reward growers for the biodiversity benefits of the crops by allowing them to be grown as part of Ecological Focus Areas. This proposed measure suggests that farmers should set aside 7% of their land for the benefit of wildlife. If 50% of the potential ecological focus area in the SW was planted with energy crops then that would equal the 66,000 ha required.

In order to achieve the potential for energy crops in the SW the sector needs additional infrastructure for planting, harvesting and processing the crop. To kick start the industry we suggest that there is a specific scheme that provides capital grants for energy crop projects. Based on our findings, around £1.65 million of funding is required from 2013-2020. This could assist the purchase of eight planting and eight harvesting machines and six processing facilities.

1. ENERGY CROPS IN THE SOUTH WEST

The South West (SW) of England is a leading light in the UK's drive to produce more of our electricity, heating and transport fuels from renewable energy resources. The region has excellent resources for wind, wave, tidal, biogas and solar energy and is also the number one English region in biomass heat installations.

However, like the rest of the UK the SW has been slow to embrace woody energy crops as a potential woodfuel resource. Unfortunately in the *dash for biomass* that has been created by the Government's Renewable Heat Incentive (RHI), energy crops have been left in the renewable energy slow lane. This report outlines why growing energy crops in the SW is essential to continue the upward trend in biomass heat installations, boost the economy and provide additional environmental benefits to the region.

1.1 Current situation

There are currently around 800-900 hectares of energy crops in the SW. Table 1 below shows the activity across the region since the launch of the Government's Energy Crops Scheme (ECS) in 2000. ECS 2 which was launched in 2007 offers growers 50% grants towards the cost of establishing the crop. However, there has been a very low take up from SW farmers. So far only 645 ha from 30 applications have been planted under these schemes with the vast majority (99%) being miscanthus. There are probably an additional 100-200 ha of miscanthus planted for rhizome production. Only 5.2 ha of SRC has been planted during ECS 1 and 2. There are however around 150 ha of SRC willow planted on other sites around the region.

Table 1: *Areas of miscanthus in the SW supported by the Energy Crops Scheme (Source: Natural England). Only 5.2 ha of SRC have been planted under both schemes.*

County	ECS 1 (2000-2006)		ECS 2 (2007-present)		TOTAL	
	No. of applications	Area (ha)	No. of applications	Area (ha)	No. of applications	Area (ha)
Gloucestershire	0	0	2	16.8	2	16.8
Former Avon	1	22.8	0	0	1	22.8
Wiltshire	0	0	8	168.7	8	168.7
Somerset	6	288.2	7	56.2	13	344.4
Devon	1	9.1	2	22.9	3	32
Dorset	1	8	2	52.5	3	60.5
Cornwall	0	0	0	0	0	0
TOTAL	**9**	**328.1**	**21**	**317.2**	**30**	**645.3**

A different source suggests that there are 1,423 ha of miscanthus and 42 ha of SRC in the SW[1]. Unfortunately, there is no single reliable source of data for energy crop plantings.

[1] Domestic energy crops; Potential and constraints review. Project 12-021. NNFCC for DECC. April 2012. www.decc.gov.uk/assets/decc/11/meeting-energy-demand/bio-energy/5138-domestic-energy-crops-potential-and-constraints-r.pdf

Energy crop options

Short Rotation Coppice (SRC)

Willow and poplar varieties are planted as 20cm stem cuttings and cut back at the end of the first year to promote multiple stems. The crop is harvested every three years and reaches 7-8 m in height.

Pros

- Excellent multifunctional crop
- Can be grown on a wide range of sites
- Significantly increases farm biodiversity

Cons

- Wet when harvested – needs drying
- Lack of infrastructure (e.g. harvesters) in SW
- Often needs additional processing

Miscanthus

Miscanthus is a woody grass species which originates in SE Asia. It is propagated by rhizomes and grows to 3-4 m in height. It is harvested annually.

Pros

- High yielding
- Uses conventional machinery for harvesting
- Short lead in times

Cons

- Very low bulk density – needs densification
- Lower quality fuel – high ash content etc
- Lower biodiversity value

Short Rotation Forestry (SRF)

SRF involves planting single stemmed trees over rotations of 8-20 years. Native trees and exotics (e.g. *Eucalyptus spp*.) can be grown this way. Exotic species reach up to 20 m after 12 years.

Pros

- Good quality woodfuel (low ash)
- Excellent yields (especially exotic species)
- Uses conventional forestry machinery

Cons

- Very long lead in times
- No grants for planting exotic species
- Lower biodiversity value (exotics)

Broadleaved coppice

Involves growing native species as multi stemmed trees. These are harvested every 10-15 years. Trees reach 8-10 m after 15 years.

Pros

- Excellent biodiversity benefits
- Good quality woodfuel
- Can be grown on a wide range of sites

Cons

- Low yields
- Very long lead in times
- Harvesting is labour intensive

1.2 Why aren't we growing more?

There are numerous reasons why the energy crops industry has struggled to get much of a foothold in the SW of England.

Farming reasons

- High price for food crops makes it hard to argue the case for energy crops
- It is seen as a risky crop by farmers with a 20 year time frame. The majority of farmers are in their late 50's. Many think they are too old for such a long term investment
- This activity ties up land for long periods and farmers worry that they will affect land values
- There are expensive up front costs to establish the crop
- There is very poor cash flow in early years – SRC willow only breaks even after second harvest (Year 7)
- There is a perception that markets don't exist – unfortunately there is a *chicken and egg* situation
- Once established the crops require very little farmer input so they are off putting to farmers who still want to actively manage their land
- Farmers are concerned that energy crops will affect land drains – in fact the roots of SRC and miscanthus are similar in nature and depth to maize and oilseed rape (see reference in Appendix II)
- Farmers are concerned that energy crops will be difficult to get rid of – experience suggests that these concerns are unfounded
- There are, unfortunately, many plantations which are bad adverts for energy crops – poor practice means poor yields
- There is still an ongoing debate about food versus fuel

Non farming reasons

- Several proposed large scale projects did not go ahead in the SW due to lack of finance and/or failure to get planning permission
- Many pioneer miscanthus growers were left out of contract when Bical went bust. Such occurrences make other farmers sceptical about planting these crops
- There are currently no organisations offering contracts to buy energy crops in the SW
- There is a lack of infrastructure – especially machinery for planting and harvesting SRC willow and processing miscanthus
- Frequently energy crop yields have been exaggerated. It is possible to achieve high yields on good land with excellent husbandry. However, many early adopters have been disappointed with the yield performance
- There is a need for more planting but there is no cohesive strategy in place
- There is no energy crops champion within either DECC or Defra
- The energy crops sector is small and there is no industry group lobbying Government. This means that many policies either fail to recognize the significance of energy crops or are counter productive to increased uptake

1.3 Failed projects

Over the years several projects have been proposed which could have provided the necessary impetus to stimulate planting. Unfortunately all of these projects have stalled as a result of lack of finance or failure to achieve planning permission. Without definite markets there have been few reasons for farmers to plant the crop.

Table 2: *Projects proposed in the SW which never got off the ground.*

Project	Location	Capacity (MW)	Crop	Amount required (ha)
Ambient Energy	Wiltshire	5.5	SRC	2,500
Roves Energy	Wiltshire	2.0	SRC	5,000
Winbeg	Devon	23.0	Misc	37,500
Charlton's Energy	Somerset	7.0	Misc	1,200
Bronzeoak	Somerset	2.5	SRC	750
Eco Composting	Dorset	2.5	SRC	60

The business case for these projects was also hampered by the widely publicised collapse of the Arbre project in Yorkshire. This 10 MW power plant was decommissioned in 2003 not long after it was launched, leaving around 50 growers and over 1,000 hectares of SRC without a contract.

1.4 Current markets for energy crops

Bical, the one time market leaders in miscanthus cultivation, were formerly based in Taunton and were responsible for most of the planting in the region. This company went bust in 2009 leaving many farmers out of contract. There are still few current outlets for miscanthus in the SW. A number of farmers are using miscanthus chip or bales to heat their own farms. This is a very lucrative end use if the project gets accreditation from the RHI (see section 2.4).The biggest current regional market for miscanthus is for premium horse bedding. There are two operations producing large volumes of this material in Somerset (Fennington Fibres www.fennington-fibres.co.uk) and Cornwall (Burlerrow Farm www.burlerrowfarmmiscanthus.co.uk).

Burlerrow Farm

James Mutton has been growing miscanthus on his farm in Bodmin Cornwall since 2002. Currently he has 40 ha which is used predominantly to produce horse bedding. In 2011, the operation processed around 2,000 tonnes of bedding providing a market for an additional 121 ha of miscanthus bought from other growers in Cornwall and Devon. The processing facility cost around £400,000 but 40% of the capital was grant funded by the Rural Development Programme for England. Horse bedding is sold for £180-£200/tonne. A drying floor cost an additional £50,000 and this uses heat produced from an Eta Hack 90 kW biomass boiler fuelled with miscanthus chips. The farm also has another 130 kW Eta boiler heating five offices and a farm house.

There are also a number of companies that have established small scale pelleting and briquetting ventures:

- Wadswick Energy Ltd – Wiltshire (Pelleting) www.wadswickenergy.co.uk
- Yeo Valley farms – Somerset (Briquetting) www.yeovalleyorganic.co.uk
- Country Quest – Devon (Briquetting) www.country-quest.co.uk

1.5 Energy crop yield potential

Both SRC willows and miscanthus are capable of producing very high yields in trial plots. However, in our experience this performance is rarely replicated in commercial plantations. There are many reasons for this, some of which can be controlled (see best practice box on page 13) and others that have to be accepted (see assumptions below). Crops for Energy typically factor in a reduction of 20% from the anticipated yield of the crop to allow for losses during harvesting, storage and transport.

Until recently there have been no trials of SRC willows and miscanthus at the same location under the same experimental conditions. However, there are now comparison trials at Rothamsted Research in Hertfordshire and the Institute of Biological, Environmental and Rural Sciences (IBERS) in Aberystwyth[2]. The first data will be made available in 2015. The current viewpoint of most experts is that miscanthus is higher yielding than SRC.

SRC willow

SRC willows have been trialled extensively in the SW of England and Wales as a result of the European Willow Breeding Programme (EWBP) being based at Long Ashton Research Station in Bristol (which closed in 2003). Between 1991 and 2008 there were 21 trials located in Bristol, North Molton in Devon and Aberystwyth in Wales[3]. Most of these trials were harvested twice therefore providing 37 harvests worth of information. These trials included all of the new varieties produced by both the Swedish breeding programme and EWBP.

SRC is planted as mixtures of five or more varieties in order to combat disease and pest issues. In the past there were only one or two high yielding varieties and as a result the mixture would include several lower yielding varieties. However, recent results suggest that the yield of newer varieties is 13% higher after the first harvest and 20% after the second harvest[4]. An unreleased variety called Endurance has been shown to be around 10% higher yielding than the industry standard Tora with mean yields of 12.03 oven dry tonnes per hectare per year (odt/ha/yr) and 14.53 odt/ha/yr for the first two harvests. In addition, this variety and others such as Endeavour and Gudrun have been found to have higher dry matter at harvest, and higher calorific values

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[2] www.bsbec-biomass.org.uk/Research.php

[3] Lindegaard K N, Parfitt R I, Donaldson G, Hunter T, Dawson W M, Forbes E G A & Carter M M (2001). Comparative Trials of Elite Swedish and UK Biomass Willow Varieties. In: *Aspects of Applied Biology* 65, Biomass and Energy Crops II 183-192. www.crops4energy.co.uk/files/pdfs/Trials.pdf

[4] Lindegaard K N, Carter M M, McCracken A R, Shield I F, Macalpine W, Hinton Jones M, Valentine J & Larsson S (2011). Comparative Trials of Elite Swedish and UK Biomass Willow Varieties 2001-2010. In: *Aspects of Applied Biology* 112, Biomass and Energy Crops IV 57-66. www.crops4energy.co.uk/files/pdfs/AAB_paper_2011_final.pdf

and bulk densities[5]. As a result there is scope for significantly increasing the yield and quality of wood chip from SRC plantations.

***Table3**: Average yields for currently available varieties in SW trials.*

Variety name	Breeding Programme	Average Yield (odt/ha/yr)	
		1st harvest	2nd harvest
Beagle	EWBP	11.64	12.54
Endeavour	EWBP	10.11	14.35
Gudrun	SW	8.93	10.94
Inger	SW	9.37	12.59
Olof	SW	12.36	12.58
Resolution	EWBP	11.86	14.13
Sven	SW	11.80	13.25
Terra Nova	EWBP	7.73	9.09
Tora	SW	11.23	13.14
Tordis	SW	10.59	13.42
Torhild	SW	8.99	12.21
.	**Mean**	**10.42**	**12.57**

In this publication we assume a mean annual yield estimate of 8.4 oven dry tonnes per hectare per year (odt/ha/yr). This is based on the following assumptions

- A 22 year crop with a lifetime yield of 231 oven dry tonnes (10.5 odt/ha/yr)
- This is broken down as follows
  - First harvest yield of 28.5 odt/ha (or 9.5 odt/ha/yr)
  - Second and subsequent harvests of 33.75 odt/ha (or 11.25 odt/ha/yr)
- 20% yield losses due to
  - Incorrect height of stem cut
  - Machine operator error such as poor co-ordination between the driver of a forage harvester and driver of the adjacent tractor trailer
  - Spillages from overfilled trailers
  - Material not picked up cleanly from an intermediate source
  - Losses during transportation
  - Dry matter losses due to composting and respiration

[5] Hinton-Jones M & Valentine J (2008).Variety and altitude effects on yield and other characters of SRC willows in Wales. In: *Aspects of Applied Biology* 90, Biomass and Energy Crops III 67-73.

The need for best practice: SRC case study



Doing it right – respecting the crop

- ☑ Best practice adhered to
- ☑ Good land used (grade 2 or 3)
- ☑ Exemplary land preparation
- ☑ Briefing contractors = increased quality assurance
- ☑ Mixture of high yielding varieties with diverse backgrounds
- ☑ Rabbit fencing erected
- ☑ Gapping up perfomed
- ☑ Good weed control
- ☑ Considered harvest – efforts made to harvest all the crop
- ☑ Thinking through storage conditions

Yields and profit

- 1st harvest yield 8 odt/ha/yr
- 2nd harvest yield 10 odt/ha/yr
- Total yield from a 10 ha plot over 22 years = 2,040 odt
- Profit = £45/odt for good quality chip
- Total profit = £91,800
- Net annual profit = £417/ha/yr

Doing it wrong – not respecting the crop

- ☒ Corners cut
- ☒ Low quality land used
- ☒ Late land preparation (due to late approval from the ECS)
- ☒ Lack of care when planting
- ☒ Varieties with narrow genetic base chosen = increased chances of pest and disease problems
- ☒ No rabbit fencing erected
- ☒ No gapping up perfomed
- ☒ Poor weed control – no post harvest sprays
- ☒ Poor harvesting practice – lots of material left in the field
- ☒ Poor storage conditions – outside with poorly constructed heaps

Yields

- 1st harvest yield 4 odt/ha/yr
- 2nd harvest yield 7 odt/ha/yr
- Total yield from a 10 ha plot over 22 years = 1,380 odt
- Profit = £15/odt for poor quality chip
- Total profit = £20,700
- Net annual profit = £94/ha/yr



Miscanthus
Although miscanthus has significantly more commercial plantings, there have been fewer research trials in the SW. Experimental sites have previously been established at Buckfast Abbey, Devon and to a lesser extent at Rosewarne in Cornwall. Table 4 provides yield data over 10 years for the Devon site.

Table 4: *Yield trial figures for miscanthus planted at Buckfast Abbey in Devon*[6].
The harvests were taken in the winter time and include leaf litter. We have estimated this to account for 20% of the total weight of the crop[7].

Year harvested	Actual yield (odt/ha/yr) including leaf litter	Estimated yield (odt/ha/yr) excluding leaf litter
1992/93	1.8	1.5
1993/94	7.3	5.8
1994/95	14.9	11.9
1995/96	19.0	15.2
1996/97	20.2	16.2
1997/98	16.5	13.2
1998/99	19.5	15.6
1999/2000	22.2	17.8
2000/01	17.6	14.1
2001/02	17.8	14.2
Means	**15.7**	**12.6**

One of our clients who has 15.4 hectares of miscanthus planted in Somerset produced a yield of 10.4 odt/ha from a 5 year old crop in 2012[8] whilst a ten year average yield from a farm in Lincolnshire is 11.7 odt/ha[9]. Our considered view is that we are unlikely to see very high yields (15-20 odt/ha) of miscanthus in the SW. A miscanthus breeding programme was established at IBERS in Aberystwyth in 2004 but new varieties with higher yields are still some years off.

Our mean annual yield estimate of 10.4 odt/ha/yr is based on the following assumptions

- A 22 year crop with a lifetime yield of 286 oven dry tonnes (13 odt/ha/yr)
- This is broken down as follows
    - No harvestable yield in year 1
    - Yield of 3 odt/ha in year 2
    - Yield of 6.5 odt/ha in year 3
    - Yield of 9 odt/ha in year 4
    - Yield of 12.5 odt/ha in year 5

[6] Continued assessment of agronomy and yield potential of Miscanthus for industrial cropping in the UK. Project no: NF0405. ADAS for Defra. 2003.
[7] Gezan S A and Riche A B (2008). Over-winter yield decline in Switchgrass and Miscanthus. In: *Aspects of Applied Biology* 90, Biomass and Energy Crops III 219-223.
[8] Total yield 294 bales; Average bale weight of 605 Kg, Average moisture content of 10%.
[9] Miscanthus: A Grower's Perspective. William Cracroft-Eley. Miscanthus Growers Ltd.

    - Yield of 15 odt/ha in years 6-22
- 20% yield losses due to
    - Incorrect height of stem cut
    - Draught losses during baling
    - Machine operator error such as poor co-ordination between the driver of a forage harvester and driver of the adjacent tractor trailer
    - Spillages from overfilled trailers
    - Material not picked up cleanly from an intermediate source
    - Losses during transportation
    - Dry matter losses due to composting and respiration

2. ENERGY CROPS CAN HELP MEET OUR ENERGY NEEDS

KEY INFORMATION

- **The UK has a 12% target for renewable heat by 2020**
- **The predicted heat consumption for the SW in 2020 is 58.6 TWh**
- **If 12% is provided by renewables then 7.03 TWh will be required**
- **In order to meet 50% of this demand would require 804,532 odt of woodfuel/yr**
- **The sustainable woodfuel resource in the SW is only 685,340 odt/yr**
- **Planting just 3.5% of SW agricultural land with energy crops could produce 616,595 odt/yr**

Woody energy crops can provide a rapid source of sustainable woodfuel and enable excellent land use resource efficiency.

Despite the many reasons for the lack of widespread planting of SRC willow and miscanthus there are many good reasons why farmers should be encouraged to grow more energy crops.

2.1 Renewable Heat Targets

The UK has a 12% target for renewable heat by 2020. This is particularly pressing in the SW of England as 16% of the region's 2.1 million homes are off the gas grid (336,000 homes). As a result residents are paying extra for expensive alternatives like oil and electric heating. The predicted heat consumption for the SW in 2020 is 58.6 terawatt hours (TWh)[10]. 12% of this is 7.03 TWh and if woodfuel heating contributes 50% then 3.52 TWh needs to be made available. In order to meet this demand, 804,532[11] oven dry tonnes (odt) of wood would be required per year. The predicted woodfuel resource in the SW is only 685,340 odt/yr[12]. This includes sustainable supplies from woodland, existing energy crops, arboricultural arisings, co-products from sawmills and clean recycled wood waste (see Appendix I).

So, based on these figures, even if all the currently available resource was made available, it would not be possible to meet the predicted demand. In addition, the actual amount of the available resource reaching the marketplace is likely to be much lower than this as there are significant areas of SW woodlands that are small in size and in private ownership. Despite major efforts (such as the Forestry Commission's Woodfuel Woodland Improvement Grant) to increase the amount of woodlands that are managed, a large portion of this resource is likely to remain untapped.

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[10] The Road to 2020. An analysis of renewable energy options in the South West of England. A report by Regen SW, in association with the South West RDA. September 2008. www.regensw.co.uk/projects/archived-projects/the-road-to-2020

[11] Based on a conversion efficiency of 85% and a calorific value of 5,140 kWh/tonne.

[12] Woodfuel Resource in Britain. Final Report, B/W3/00787/Rep, Urn03/1436. Funded By Dti, Scottish Enterprise, Welsh Assembly Government and The Forestry Commission. H. Mckay. December 2003.

UK Bioenergy Strategy

The strategy was published jointly by DECC, Defra and the Department for Transport in April 2012. It says:

"The benefits of energy crops for bioenergy include not only their use for biomass heat and electricity but also their ability to prevent soil erosion, improve biodiversity in the right location and help ensure fuel security."

"….the use of wood and energy crops for bioenergy is a good carbon reduction option compared to alternative uses of the resource in certain circumstances…"

"The greatest growth in domestic biomass supply is expected to come from agricultural residues and perennial energy crops."

"…improvements in energy crop yields, particularly of woody/ grassy crops suited to UK conditions, could lead to significant increases in the availability of sustainable resources."

"…perennial energy crops, such as short rotation coppice and miscanthus, if cultivated in the right place and in the right way, can be better for biodiversity and water quality than arable crops such as wheat and maize."

BUT

"The potential to upscale is currently restricted by UK planting and harvesting capacity, grower acceptance, economics, technology compatibility and social resistance related to concerns around long-term land use change."

It proposes that:

☑ Government will explore ways of removing barriers to energy crop production and steering growth in ways which enhance the wider environment (Defra / DECC)

☑ Government departments will work with industry to explore further opportunities for boosting domestic supplies across a range of feedstocks (Defra/Forestry Commission)

Table 5 below provides various scenarios for achieving 12% heating in the SW based on contributions from different renewable sources. Current biomass heating installations contribute 63% of the total installed capacity of renewable heat in the SW[13] (Table 6). Furthermore, the REvision 2020[14] study suggests that woodfuel heating is likely to account for around 49% of the renewable heat technology mix by 2020 (albeit at a lower adoption rate). Therefore the scenarios below are realistic. It is obvious that energy crops will almost certainly have a large part to play in the future energy mix in the SW. Five of the six scenarios suggest that between 21,000 and 66,000 hectares (ha) of land in the SW will be required for growing energy crops. Although this seems like a large area, in fact, only 1.2-3.5% of the available agricultural land would be required. 3.5% of the agricultural area in the SW is equivalent to around 15% of the arable land in the region.

Table 5: *Potential market for energy crops in the SW of England.*

Scenario	Contribution towards the 12%			Amount of energy crops required			% of SW agricultural land
	Indigenous woodfuel	Energy crops	Other renewables	TWh/yr	Oven dry tonnes/year	Area (hectares)	
1	4.5	0	7.5	0	0	0	0
2	4.5	1.5	6.0	0.88	205,532	21,865	1.2
3	4.5	3.0	4.5	1.76	411,063	43,730	2.3
4	2.75	1.5	7.75	0.88	205,532	21,865	1.2
5	2.75	3.0	6.25	1.76	411,063	43,730	2.3
6	2.75	4.5	4.75	2.64	616,595	65,595	3.5

Assumptions:

- Scenarios 1-3 assume approximately 85% of the woodfuel resource is made available = 585,183 odt/yr.
- Scenarios 4-6 assumes approximately 50% of the woodfuel resource is made available = 357,612 odt /yr.
- Other renewable sources include energy from waste, solar thermal, heat pumps, biogas and imported wood.
- Amount of energy crops based on 50/50 split of miscanthus and SRC.
- Boiler conversion efficiency of 85%
- Assumed realised yields of:
  - Miscanthus 10.4 odt/ha/yr
  - SRC 8.4 odt/ha/yr
- Net calorific values of
  - Miscanthus 4.92 MWh/odt (17.7 MJ/kg)

[13] Regen SW Annual Report 2011. www.regensw.co.uk/projects/support-for-decision-makers/annual-survey
[14] REvision 2020. South West Renewable Electricity, heat and on site generation targets for 2020. Government Office for the South West and the South West Regional Assembly. 2005. www.cse.org.uk/pdf/revision2020_main_report.pdf

- SRC 5.14 MWh/odt (18.5 MJ/kg)
- Chip from roundwood thinnings 5.3 MWh/odt (19.0 MJ/kg)

Table 6: *Current renewable heat installations in the SW (Ref. 13).*

Technology	No of installations	Installed capacity (MW)	% of Renewable Heat capacity in the SW
Biogas	14	11.7	13.1
Biomass	482	56.0	62.7
Energy from waste	3	0.36	0.4
Heat pumps	922	13.7	15.3
Solar thermal	2,545	7.6	8.5
Totals	**3,966**	**89.4**	**100**

2.2 Lead in times for energy crops

When dealing with energy crops it is important to remember that there is a lead in time before the first commercial harvest (Table 7). Hence, if the decision was taken today to plant energy crops, the earliest time that miscanthus would be available for selling to an end user would be the winter of 2015/16 whilst it would be the following winter for SRC willow. SRF and broadleaved coppice would not be available as fuel until the 2022 at the earliest.

Table 7: *Lead in time for energy crops. (* There would be a preliminary harvest after 5-7 years to promote coppicing but this will provide low yields)*

Crop type		Frequency of harvest	Lead in time until 1st harvest
Energy grasses	Reed Canary Grass / Switchgrass	Annually	2 years
	Miscanthus	Annually	2-3 years
SRC	Willow	3 years	5 years
Short rotation forestry (SRF)	Exotics e.g. *Eucalyptus* & *Nothofagus*	8-12 years	10 years
	Poplar	14 years	16 years
Broadleaved coppice	Ash, Sweet chestnut, Alder etc	15-20 years	20 years

Although the target date for 12% heating from renewable sources is 2020, the low level of planting so far achieved will mean that this objective will almost certainly be missed. To achieve a planting area of 21,865 ha by 2020 would require year on year plantings of 3,124 ha/yr. In the whole of the UK in 2012, there were only around 600 ha planted. It is not possible to plant even a fraction of the required amount without a significant investment in planting infrastructure (see section 7.1).

Also, any surge in demand will need adequate supplies of cuttings and rhizomes. Currently available miscanthus varieties are not protected by Plant Breeders' Rights (PBR). As a result any grower can use their own fields to supply a third party which means that there is probably an ample supply of miscanthus within the SW. However, willow varieties are covered by PBR and it is not possible to multiply these without an agreement with the license holder. Crops for Energy distribute SRC willow varieties produced by the European Willow Breeding Partnership. At present this is the only source for UK bred elite SRC willow varieties. This supply chain is capable of producing around 9 million cuttings per annum which is enough to plant 600 hectares.

The Energy Crops Scheme which is administered by Natural England is scheduled to close in September 2013. It is critical that a strong argument is made to continue this scheme under any revisions to the Common Agricultural Policy (CAP) reform.

Recommendation 1

Energy Crops Scheme

- Keep ECS establishment grant at 50%
- Integrate with a system of annual payments to reward growers for wider environmental credentials of energy crops (Recommendation 4)
- Reduce 3 month turnaround of applications
- Include SRF in the ECS but with stricter landscape sensitivity analysis (EIA) for exotics
  - Higher grant rate for natives to reflect low yields
  - Lower grant rate for exotics to reflect high yields
- Remove 3 ha limit to encourage self supply
- Felling grants for harvesting oversize SRC – i.e. crops that were planted before there were markets.

Recommendation 2

Crop production

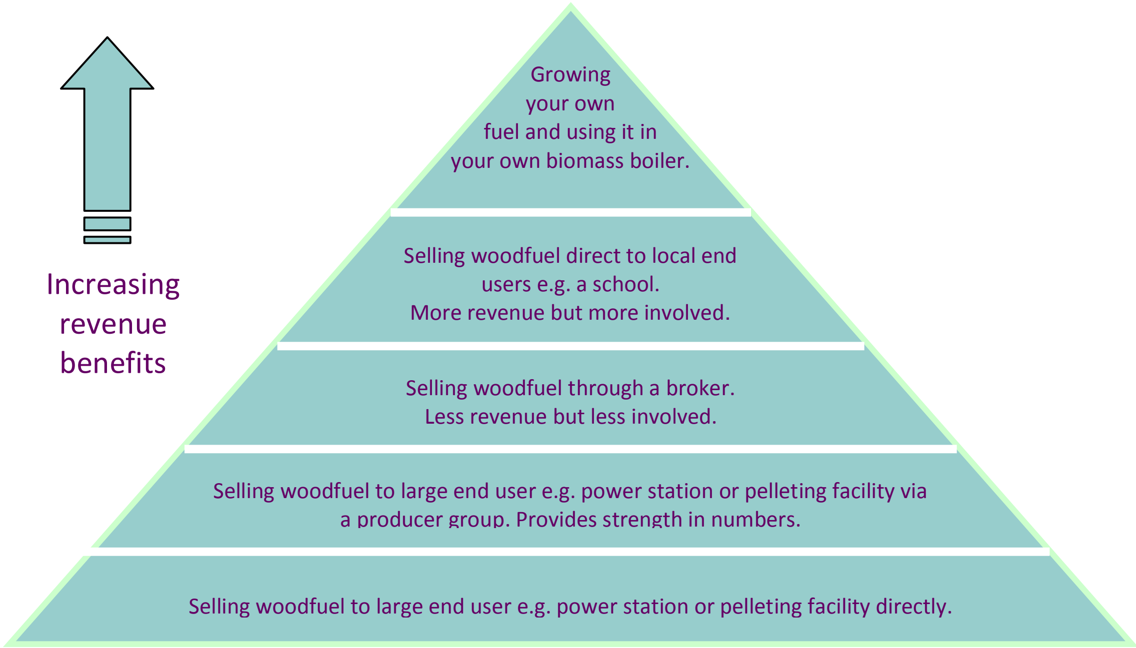
It is a massive investment to breed, select, test, multiply and protect new varieties. Producers need to expand to meet future demand.

- Reduced grant rate for establishment costs for multiplication under ECS 3 (e.g. 25%) or
- Other grant for multiplication in conjunction with favourable loan terms from the Green Investment Bank

Either way, a reduced rhizome / cutting price = reduced establishment costs = a higher take up by growers.

2.3 Heat markets for energy crops

In the SW there are currently no power stations offering grower contracts. Such contracts are available elsewhere in the UK and currently offer around £64/odt. However, this effectively is a high volume, low price model and as a result sits at the bottom of the woodfuel selling hierarchy. The figure below indicates that much better returns are possible when the grower can use the fuel themselves or provide it to a local heat end user. For instance if a farmer can sell SRC woodchip to a local school for £75/tonne @ 30% moisture content, this is equivalent to a price of £107/odt.



2.4 Woodfuel self supply

In the last 36 months the price of diesel has gone up by around 40p/litre[15]. This increase is far greater than the Retail Price Index (RPI). Hence, as the diesel cost increases so will the price of delivered wood fuel. If energy crops are grown and used in the local community then there will be a degree of buffering against this. However, the best way to almost completely insulate a project from future price rises is to grow and use your own fuel.

Of course many projects will not have their own land but farmers and land owners are in an excellent position to benefit from these enhanced savings. If a farmer is currently using oil to heat their farm business they are likely to be paying around 65p a litre which is equivalent to around 6.0p/kWh. Even considering the lost revenue of taking land out of food production, it should be possible to produce miscanthus chip for around £50/odt or 1.02p/kWh. The price of oil is almost six times that of miscanthus chip so the net benefit to the farmer is equivalent to

[15] http://www.theaa.com/onlinenews/allaboutcars/fuel/2009/april2009.pdf
http://www.theaa.com/resources/Documents/pdf/motoring-advice/fuel-reports/march2012.pdf

£244/tonne. Table 8 shows that effectively this provides a massive annual gross margin (£2,533/yr) for a grower using their own fuel. SRC has lower yields and requires drying to produce a premium chip. Even then it is possible to achieve an effective gross margin of £2,061/yr. No food crop can get near these figures. A winter wheat crop sold for feed which yields 8.35 tonnes/ha and achieves a grain price of £140/tonne would realize a gross margin of £673/ha[16].

By comparison, when the crop is sold on to a third party the majority of these revenue benefits are lost. This proves without doubt that if their premises have a significant heat demand then farmers can provide their own market for these crops. Even when grown and sold for heat production from third parties the returns can be worthwhile. However, most of the energy crops produced in the UK are sold to power stations at approximately £64/odt. Based on the yields and production costs below this would give a gross margin of £286/ha for miscanthus and £201/ha for SRC.

Table 8: *Production costs and potential gross margin from miscanthus and SRC self supply and sales to third parties.*

Activity	Miscanthus		SRC	
	Self supply (chip)	Sell to end user (pellet)	Self supply (chip)	Sell to end user (chip)
Establishment (£/odt)	£7	£7	£7	£7
Harvesting/ Nutrition (£/odt)	£19	£22	£18	£18
Processing (£/odt)	£0	£50	£10	£10
Haulage to end user (£/odt)	£0	£7.5	£0	£10
Lost revenue (£/odt)	£24	£0	£28	£0
Total cost to produce (£/odt)	£50	£86	£63	£45
Farmer profit from sales	/	£40	/	£45
Total cost (£/odt)	**£50**	**£126**	**£63**	**£90**
Cost (pence/kWh)	**1.02**	**2.56**	**1.23**	**1.75**
Cost of oil (pence/kWh)	6.00			
Equivalent oil price for self supply (£/t)	£294	/	£308	/
Farmer profit from self supply (£/t)	£244	/	£245	/
Gross margin (£/ha)	**£2,533**	**£416**	**£2,061**	**£378**

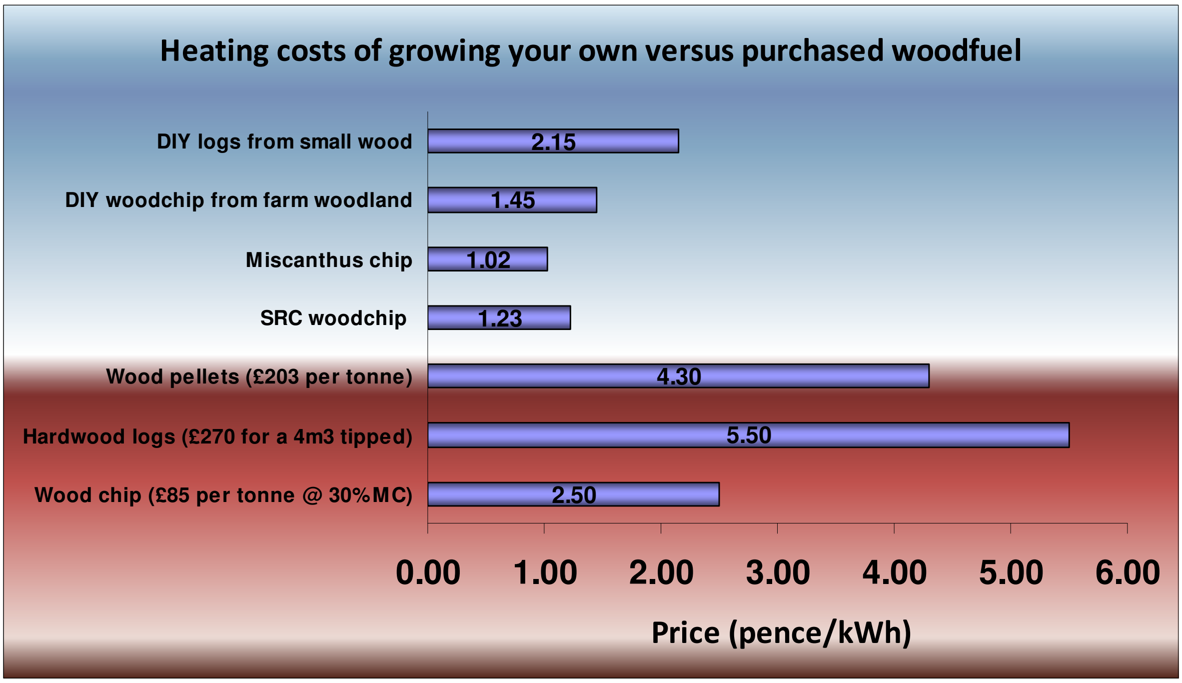
Assumptions:

- Production costs spread over 22 years (20 harvests of miscanthus and 7 of SRC)
- Assumed realised yields of:

[16] John Nix Farm Management Pocketbook. 42nd edition. 2012.

- Miscanthus 10.4 odt/ha/yr
    - SRC 8.4 odt/ha/yr
- Establishment costs of £3,000 for miscanthus and £2,500 for SRC minus 50% grant from the ECS
- Harvesting cost of £200/ha for harvesting miscanthus as a chip; £225/ha for harvesting miscanthus as bales; £450/ha for harvesting SRC as chip
- Processing costs £50/tonne for pelleting miscanthus, £10/tonne for drying SRC
- Haulage costs for miscanthus pellets are lower due to higher bulk density
- Lost revenue from food crops assumed to be £225/ha/yr
- Net calorific values of
    - Miscanthus 4.92 MWh/odt (17.7 MJ/kg)
    - SRC 5.14 MWh/odt (18.5 MJ/kg)

The graph below shows the relative costs of self supply of miscanthus and SRC chip compare to extraction of wood chip and logs from existing farm woodlands or buying woodfuel from third party suppliers.



Below are two examples of farmers already using miscanthus chip to provide their heating. One of these projects has recently gained RHI accreditation (see case study).

Woodfuel self supply using energy crops is therefore an excellent way to maximise farm income through savings compared to fossil fuels and revenue received from the RHI. However, it must be remembered that to achieve these yields and low production costs growers would need to plant energy crops on fairly good land and engage in best practice.

Table 9: *Farmer case studies of miscanthus chip self supply*

		Poultry farmer, Somerset	Holiday cottages, Cornwall
		40,000 indoor reared chickens	8 holiday lets, farmhouse and swimming pool
Fossil fuel replaced		LPG	Oil
Amount used (litres/yr)		32,534	32,000
Amount of miscanthus required	Tonnes at 25% MC	106	89
	Hectares	8	5.7
Boiler size (kW)		130	199
Boiler capacity using miscanthus* (kW)		95	150
System costs		£78,000	£150,000
Estimated rebate from RHI		£16,578	£21,795
Savings compared to fossil fuel		£3,700**	£11,805
Annual savings		£20,278	£33,600
Simple payback		3.8 years	4.5 years

* Boiler size is downgraded when using miscanthus because of the low bulk density of the fuel

** LPG is retained as a back up so savings are likely to be lower

Tredethick Farm Cottages

Tim Reed of Tredethick Farm Cottages in Lostwithiel, Cornwall has recently received full accreditation from Ofgem to receive rebates from the Renewable Heat Incentive (RHI). The project involves the district heating of eight holiday lets, a farmhouse and a swimming pool with a 199 kilowatt Eta biomass boiler fuelled with miscanthus. The project, installed by Fair Energy based in Exeter, is one of the first in the UK to be approved using an energy crop as a fuel.

The district heating scheme requires around 340,000 kilowatt hours (kWh) of heating per year which will be provided from growing 5.7 hectares of miscanthus. The Tredethick project will be completely self sufficient from 2015 onwards. The field growing the miscanthus is adjacent to the barn containing the boiler. As a result, when harvested the miscanthus chip need only be moved 420 metres from the furthest point. Find out more at: www.crops4energy.co.uk/miscanthus-grower-gets-rhi-approval

2.5 Local markets for energy crops

Below are some of the potential local market opportunities for growers of energy crops. The amount of energy crops required for a single project is quite small. An ideal situation would occur when a rural public or private organisation uses their own farm land or links up with a local farmer to supply the fuel. The threshold for support from the Energy Crops Scheme is three hectares so farmers could get a planting grant when they intend to supply to most of these end users.

Table 10: *Energy crop requirements for candidate end users.*

Building type	Annual heat energy consumption (MWh/yr)	Energy crops required			
		SRC (odt/yr)	SRC area (ha)	Miscanthus (odt/yr)	Miscanthus area (ha)
Primary Schools	200	32	3.8	34	3.2
Secondary Schools	800	128	15.3	134	12.9
Elderly Peoples' Homes	600	96	11.4	100	9.7
Golf course club houses	150	24	2.9	25	2.4

2.6 SW Woodfuel Resource assessments

The future shortfall of woodfuel in the SW has been documented in several recent studies[17,18,19]. Indications suggest that based on a predicted rise in demand that local woodfuel supplies may run short in five to ten years time. In certain circumstances e.g. Bristol, already most of the woodfuel is coming from further afield. At least six schools in the city are being supplied from a depot in Thornbury which is 29 km from the city centre.

Table 11 below indicates the amount of indigenous woodfuel from woodlands that is available in two of these study areas and the amount of projects that could be supported by this supply. In each case, within a 40 km radius of the study area the amount of woodfuel is much more significant. Nevertheless, one needs to remember that more remote woodlands will also fall into other catchments and therefore reduce the realistic amount available.

[17] Bristol City Council Biomass Study. Completed by the Centre for Sustainable Energy. 2003. www.cse.org.uk/pdf/pub1055.pdf

[18] Woodfuel Supply and Demand in Dorset. Completed by Crops for Energy and the Centre for Sustainable Energy for Dorset Woodlink. July 2009. www.crops4energy.co.uk/files/pdfs/Dorset%20woodfuel.pdf

[19] South Devon Woodfuel Study. Completed by the Centre for Sustainable Energy and Crops for Energy. March 2012.

Table 11: *Amount of woodfuel available in two SW locations and a 40 km radius around the study areas.*

Study area	Sustainable woodfuel yield in the study area (odt/yr)	No of projects that could be supplied indigenously	No of projects installed by 2012	Est. Woodfuel required (odt/yr)	Sustainable woodfuel yield within 40 km (odt/yr)
Bristol City	378	4	18	3,200	56,000
South Devon	7,622	84	10	300	87,982

Assumptions:
Number of projects is based on:

- 50% of woodfuel potential being made available
- Average project size of 150 kW
- Average capacity factor of 15% (1314 hours/yr)
- Boiler efficiency of 85%
- Calorific value of oven dry wood = 5.14 MWh/tonne (18.5 MJ/kg)

Planting energy crops now would mean that growers would be well placed to meet this future shortfall and enable end users to keep fuel costs low.

2.7 Keeping it local: The influence of the diesel price and delivery distance on woodfuel costs

The total delivery costs for woodfuel range from around 19-36% of the delivered cost[20]. This element of the price includes the price of diesel, the cost of maintaining, servicing, taxing and insuring a vehicle and employing an operative to drive the vehicle and make deliveries.

The price per load can range from £150-£400 per delivery depending on the distance travelled. Although, the price of diesel is almost at an historic high the fuel costs alone are a relatively small part of the overall woodfuel price. However, as the demand for woodfuel increases it will have to be transported longer distances to the end user. This will have a much greater impact on the price of woodfuel especially if the cost of diesel continues to rise. The case study below shows the impact of an increased delivery distance and diesel price. If a grower can produce energy crops close to an end user they can insulate themselves or their customer from these price rises.

Case study – Secondary school requiring 250 tonnes of woodfuel per year
Option 1 below provides an estimate of the current diesel cost of buying woodfuel from a relatively local supply depot. Future scenarios 1 and 2 indicate how much the woodfuel cost might increase as the diesel price continues to rise. Both scenarios assume that the demand for woodfuel will significantly increase meaning that the distance from the source to the end user will become further and further.

[20] Westwoods Woodfuel SW producer group. Based on returned tenders for woodfuel supply to six secondary schools in Bristol. 2010.

Based on these estimates the current cost of diesel for transporting the woodfuel to the school is around £0.61/tonne. However, with future price rises and increased demand this might increase to as much as £2.53/tonne. In addition if the fuel is transported greater distances then the drive time will be longer. A 60 km round trip might have a 2 hour drive time whereas a 20 km round trip could be an hour. So, if we assume driver costs of £20/hour then the longer distance option would cost an additional £2.24/tonne for each 9 tonne delivery. (For more details see Appendix IV).

Table 12: *Option 1 - Woodfuel supplier using a 40 cubic metre tipper truck (28 deliveries per year). (Note the delivery costs are for drive time and diesel only. Other costs such as insurance, tax, maintenance and servicing, loading and delivery time are assumed to be the same).*

	Diesel price (litre)	Round trip distance from depot (km)	**Diesel cost per delivery**	Driver time per delivery (hours)	Driver costs (@£20/hr)	**Delivery cost per year**
Current situation	£1.45	20	**£5.45**	1	20	**£712.60**
Future scenario 1	£1.75	40	**£13.17**	1.5	30	**£1,208.76**
Future scenario 2	£2.00	60	**£22.57**	2	40	**£1,751.96**

In contrast by using a local farmer to grow and supply energy crops the school will not be subjected to future price rises. In this case the farmer belongs in the same locality as the end user and a close relationship is forged. This would mean that the farmer has a long term market and the end user has a reliable and secure local supply. The tractor used for deliveries has a higher fuel consumption than a conventional delivery vehicle. Also, the silage trailer has a lower volume and therefore more deliveries will be required. However, despite this the distance travelled is much shorter and therefore the delivery cost will be lower. Also, it is clear that even with a large rise in the diesel price the delivery cost does not increase significantly.

Table 13: *Option 2 - Local farmer supplying SRC willow chip using a 150 HP tractor with a 30 cubic meter silage trailer (48 deliveries per year)*

	Diesel price (litre)	Round trip distance from farm (km)	**Diesel cost per delivery**	Driver time per delivery (hours)	Farmer costs (@£20/hr)	**Delivery cost per year**
Current situation	£1.45	5	**2.73**	0.5	10	**£611.04**
Future scenario 1	£1.75	5	**3.29**	0.5	10	**£637.92**
Future scenario 2	£2.00	5	**3.76**	0.5	10	**£660.48**

The local woodfuel delivery solution could result in annual savings to the end user of almost £1,100 or £4.37/tonne of wood chip (Future scenario 2).

Recommendation 3

Locality of supply

- Public sector organisations should be encouraged to look at their own estates for opportunities for growing energy crops for their own use.
- Energy managers of public sector buildings that already have biomass boilers or plan to install them should be encouraged to begin a dialogue with local farmers with a view to setting up a long term supply partnership.

3. ENERGY CROPS CAN HELP MEET OUR CLIMATE CHANGE TARGETS

KEY INFORMATION

- **The UK is aiming to cut GHG emissions by 34 per cent by 2020**
- **UK agriculture was responsible for 8.8% of total GHG emissions in 2009**
- **The SW produced 36 million tonnes of GHG emissions in 2009**
- **SW agriculture produces around 3.2 million tonnes of GHG emissions**
- **Growing 65,595 ha of energy crops in the SW (3.5% of agricultural land) could offset as much as 21% of the sectors emissions**

Woody energy crops can help us meet our climate change targets

3.1. Greenhouse gas savings potential

Growing energy crops in the SW could make a significant impact in helping us meet our greenhouse gas (GHG) emissions targets. Table 14 below shows the potential emissions savings by replacing fossil fuel boilers with woodfuel derived from energy crops. The annual savings also includes carbon that is sequestered in the soil as these crops are grown.

Table 14: *Greenhouse gas saving potential of energy crops in the SW.*

Scenarios	Amount of energy crops required			GHG emissions (t CO2 eq/yr)		Carbon sequestration (t CO2 eq/yr)	Annual savings (t CO2 eq/yr)
	Area (hectares)	Yield (Oven dry tonnes/year)	Heat output (TWh/yr)	From energy crops	From Fossil fuels		
2 & 4	21,865	205,532	0.88	39,600	198,000	62,315	220,715
3 & 5	43,730	411,063	1.76	79,200	396,000	124,630	441,430
6	65,595	616,595	2.64	118,800	594,000	186,946	662,146

Assumptions:

- Assumes a 50/50 split of miscanthus and SRC planted
- Fossil fuels replaced are a 50/50 split of heating oil and mains gas
- GHG emissions for energy crops includes cultivation, transport, processing and use
- Carbon emissions factors
    - Oil 270 kg CO_2 eq/MWh
    - Gas 180 kg CO_2 eq/MWh

        - SRC chip 20 kg CO_2 eq/MWh[21] (assumes good practice)
        - Miscanthus pellets 70 kg CO_2 eq/MWh
    - Carbon sequestration potential[22] based on growing energy crops on arable land
        - SRC 1.8-2.7 t CO_2 /ha/yr
        - Miscanthus 2.8-4.1 t CO_2 /ha/yr
        - Avg. rate assuming 50/50 split between crops = 2.85 t CO_2 /ha/yr

In 2009 the SW produced 36 million tonnes of GHG emissions[23]. In the same year UK agriculture was responsible for 8.8% of total GHG emissions[24]. If we assume that the SW reflects this annual picture then 3,168,000 tonnes of CO_2 equivalent are produced in the SW from agriculture. Growing 65,595 ha of energy crops in the SW (just 3.5% of the agricultural land area) would therefore offset 21% of the sectors emissions.

3.2 The influence of local supply on GHG savings

If we consider the case study described in section 2.7 it is possible to see that using locally grown energy crops can also contribute significant GHG emissions savings. If a farmer is supplying fuel with a round trip distance of 5 km compared to a supplier using a depot 30 km away (60 km roundtrip) then the carbon dioxide emissions savings would be 24.30 kg CO_2 per journey. Based on the case study of a school requiring 250 tonnes of woodchip there would be an additional carbon saving of 0.58 tonnes per year.

Table 15: *Carbon dioxide savings from using a local supply of energy crops compared to a regional woodfuel depot.*

	Regional depot	Local farm
Round trip distance from user (km)	60	5
Vehicle type	Tipper truck	150 HP tractor & trailer
Vehicle volume	40 cu m	30 cu m
Bulk density of fuel (kg/m^3)	225	175
Number of journeys/year	28	48
Diesel consumption (litres/km)	0.18	0.36
CO_2 emissions from diesel (Kg CO_2 per litre)	2.7	2.7
CO_2 emissions/journey (kg)	29.16	4.86
CO_2 emissions/year (kg)	816.48	233.3
Annual CO_2 savings (kg)	**/**	**583.2**

[21] Biomass – Carbon Sink or Carbon Sinner. AEA Technology for the Environment Agency. April 2009. www.environment-agency.gov.uk/static/documents/Biomass__carbon_sink_or_carbon_sinner_summary_report.pdf The figures we have used are in keeping with the more in depth report produced in support of the UK Bioenergy Strategy titled: Carbon Impacts of using biomass in bio-energy and other sectors; energy crops. ADAS for DECC project TRN 242/08/2011. November 2011. www.decc.gov.uk/assets/decc/11/meeting-energy-demand/bio-energy/5132-carbon-impacts-of-using-biomass-in-bioenergy-and-o.pdf

[22] Energy crops – achieving a balance. Dr Gary Lanigan, Dr John Finnan, Órlaith Ní Choncubhair and Dominika Krol. TResearch Volume 6: Number 3. Autumn 2011. www.teagasc.ie/publications/2011/1023/TResearch_201109.pdf

[23] http://www.decc.gov.uk/assets/decc/11/stats/climate-change/2749-statis-2009-uk-carbon-dioxide-la-emissons.pdf

[24] http://www.decc.gov.uk/assets/decc/Statistics/climate_change/1218-ghg-inventory-summary-factsheet-agriculture.pdf

4. ENERGY CROPS CAN HELP BOOST THE SOUTH WEST ECONOMY

KEY INFORMATION

- **Total value of renewable energy to the SW economy in 2010/11 is £0.94 billion**
- **There are 7,080 employees and 450 companies in the SW renewable energy sector**
- **There are 870 people involved in biomass production in the SW**
- **There are 1,915 people involved in biomass utilisation in the SW**
- **Growing 65,595 ha of energy crops could lead to £768 million in capital projects and save consumers £55 million/yr in fuel costs**
- **A thriving energy crops sector could create 3,745 jobs**

Woody energy crops can help boost the SW economy

If a greater number of end users can be encouraged to install biomass heating systems and local farmers can be persuaded to grow energy crops to supply this woodfuel demand then the potential economic benefit to the region is significant.

Table 16 below suggests that planting 3.5% of the SW agricultural land with energy crops could potentially increase the economy by over £83 million/yr. Over the 20 year lifetime of these crops the SW economy could benefit by up to £1.66 billion. For every hectare of energy crops grown there would be an annual economic benefit of more than £1,268.

Currently, there is very little economic benefit from fossil fuel sales to individual communities. By contrast, in growing and using energy crops locally, all the economic benefit would stay in the local area. The figure above does not take into account other fringe benefits:

- Potential revenue provided through the Renewable Heat Incentive (RHI)
- Potential income to contractors from establishing, harvesting and transporting the crop
- Additional job creation to maintain and service boilers
- Potential revenue from carbon offsets
- Potential benefits from future agri - environmental schemes that might finally provide a reward for the biodiversity benefits of growing energy crops
- Indirect benefits such as:
  - Reduction in water treatment costs due to improvement in water quality
  - Flood alleviation

Revenue from the RHI has purposefully been ignored as most of the projects envisaged would almost certainly come on stream in later phases of the scheme. As with all support mechanisms later adopters will get a smaller slice of the pie. Nevertheless, later phases of the RHI could bring

Table 16: *How growing and using energy crops for heating could stimulate the SW economy.*

Scenarios	Energy crops required			No. of biomass heating projects	Capital costs (£million)	Expenditure on heating		Annual savings from using energy crops (£million /yr)	Farmer profit from growing energy crops (£million/yr)	Total net increase in economic benefit to the region (£million /yr)
	Area (Ha)	Yield (ODT/ year)	Heat output (TWh/yr)			Energy crop fuels (£million/yr)	Fossil fuels (£million/yr)			
2 & 4	21,865	205,532	0.88	3,795	256	25.5	44.0	18.5	9.25	27.8
3 & 5	43,730	411,063	1.76	7,590	512	51.0	88.0	37.0	18.5	55.5
6	65,595	616,595	2.64	11,385	768	76.6	132.0	55.4	27.8	83.2

Assumptions:

- Assumes a 50/50 split of miscanthus and SRC planted
- Fossil fuels replaced are a 50/50 split of heating oil and mains gas
- The number of projects is based on an average installation of 150 kW and 1314 hours of use per annum and a boiler efficiency of 85% (The current average woodfuel heating installation in the SW region is 116 kW[25])
- Capital costs of boiler installation are £450/kW
- Although most boilers are imported, 50% of the capital costs are installer costs and therefore stay in the region. Hence no net revenue loss is assumed
- Heating energy prices
    - Oil 6p /kWh (64p/litre)
    - Gas 4p / kWh
    - SRC chip 2.9p / kWh (£90/tonne at 35% MC)
    - Miscanthus pellets 2.9p / kWh (£130/tonne)
- Farmer profit of £45/odt
    - Takes into account establishment, management, harvesting, and transport costs.
    - Assumes best practice production methods and local end users

[25] Regen SW Annual report 2011. www.regensw.co.uk/projects/support-for-decision-makers/annual-survey

additional revenue into the area. To illustrate this, if just 50 projects (of the average size previously considered) using energy crops in the SW were accredited under phase 1 of the RHI (rebate value of 8.2p/kWh for the first 1314 hours) then the following benefits could be realised:

50 projects x 150 kW x 1314 hours x £0.082 = £808,110 per year to the regions economy

Over the 20 year lifetime of the scheme this would boost the economy by a further £16.2 million from rebates alone.

4.1 Job creation

A recent study by the Renewable Energy Association (REA) suggests that the total value of renewable energy to the SW economy is £0.94 billion/yr. There are currently 7,080 employees representing 450 companies in the SW. Bioenergy accounts for around 39% of the total employees with 870 people involved in biomass production and 1,915 people involved in biomass utilisation in the SW[26].

Estimates suggest that around four jobs are created for each £1 million of capital invested[27]. Table 17 below gives an indication of the amount of capital invested and jobs created based on the planting of 65,595 hectares of energy crops in the SW.

Table 17: *Capital investment required and number of jobs created from planting, processing and utilisation of 65,595 hectares of energy crops in the SW.*

	Number	Unit cost	Total investment required (millions)	Estimated no. of jobs created	
				Production	Utilisation
Establishment costs	65,595 ha	£2500/ha	£164	656	n/a
Planting equipment	8	£60,000	£0.48	1.9	n/a
Harvesting equipment	8	£120,000	£0.96	3.8	n/a
Grading facilities	5	£30,000	£0.15	0.6	n/a
Drying floors	20	£20,000	£0.4	1.6	n/a
Pellet facilities	6	£300,000	£1.8	7.2	n/a
Biomass boilers (150 kW)	11,385	£450/kW	£768.5	n/a	3,074
		Totals	**£936**	**671**	**3,074**

[26] Renewable Energy: Made in Britain. Renewable Energy Association. April 2012-05-16 http://www.r-e-a.net/news/report-on-employment-and-skills-in-the-uk-renewable-energy-sector-to-be-launched-with-greg-barker

[27] Assumes four jobs per £1 million of capital expenditure. Originally based on the Bain study for the British Wind Energy Association (2008) suggesting four jobs per installed MW of onshore wind capacity. This was adjusted by ClimateChangeMatters to take account of small-scale community technologies generating more jobs. See: Let the People Invest at the following link: http://renewablematters.biz/available-reports.php

An alternative methodology has been produced by the Biosynergy Integrated Project headed up by ECN in the Netherlands[28]. This suggests that the labour required to produce 1 oven dry tonne of miscanthus is 0.000852 full time equivalent jobs (FTE) and SRC is 0.000945 FTE. Taking into account previous assumptions this method gives a figure of 554 jobs for the production of energy crops which is broadly similar to the figure projected in Table 17.

From this analysis we can assume that energy crops could stimulate an additional 3,643-3,745 renewable energy jobs. This equals a 131-134% increase on the current number of jobs in the bioenergy sector.

The REA report suggests that hitting the 15% target for energy from renewable energy sources could create 30,000 jobs in the SW. Hence, planting energy crops on 3.5% of the agricultural land area could possibly enable 12.5% of the renewable energy jobs in the region.

[28] Domestic energy crops; Potential and constraints review. Project 12-021. NNFCC for DECC. April 2012. www.decc.gov.uk/assets/decc/11/meeting-energy-demand/bio-energy/5138-domestic-energy-crops-potential-and-constraints-r.pdf

5. ENERGY CROPS CAN HELP IMPROVE WATER QUALITY AND PREVENT FLOODING

KEY INFORMATION

- Nitrate Vulnerable Zones (NVZs) were introduced to try and improve water quality by reducing pollution from nitrates
- Only 1/3 of water bodies in the SW are classified as having 'good' status under the Water Framework Directive (WFD)
- Agriculture accounts for 70% of nitrate pollution in surface water
- 39% of the SW is in an NVZ, affecting 6,806 farms
- Cost of flood defences and coastal erosion in England is around £0.7 billion/yr
- 1/6 houses in England are at risk of flooding (5.2 million properties)
- Two of the top ten local authorities most at risk of flooding in England are in the SW (North Somerset and Sedgemoor Districts)
- Energy crops provide barrier strips intercepting run off and preventing pollution of water courses
- Energy crops slow down run off and intercept sediment thus assisting flood prevention

Woody energy crops can improve water quality and prevent flooding

Perennial energy crops are multi functional and can be deployed to provide green solutions to many problems. The SW has more livestock than any other English region and accounts for 1.8 million cows, 3.25 million sheep and 500,000 pigs[29]. This means the SW has to deal with more than its fair share of slurry (14 million tonnes based on 1998 figures[30]) and one of the biggest challenges currently facing farmers in the SW is preventing pollution from their land. Currently only one third of water bodies in the SW are classified as having 'good' status under the Water Framework Directive (WFD) and Nitrate Vulnerable Zones (NVZs) were introduced to try and improve this state of affairs. Agriculture accounts for 70% of nitrate pollution in surface water and farmers are required to put in place preventative measures to reduce this. At present 39% of the SW is in an NVZ which affects 6,806 farms[31].

[29] www.nfuonline.com/regions/south-west/

[30] Towards sustainable agricultural waste management. Environment Agency 2001. http://publications.environment-agency.gov.uk/PDF/GEHO0003BIEO-E-E.pdf

[31] http://www.swarmhub.co.uk/downloads/pdf/NVZs/NVZ_supplement.pdf

5.1 Improving water quality

Energy crops can provide an effective local measure for reversing the rising nitrate levels in groundwater. They achieve this in a number of ways:

- Provide useful barrier strips that intercept run off and prevent pollution of water courses from diffuse sources e.g. fertilisers, pesticides etc[32].
- The crop slows down run off and intercepts sediment.
- The less frequent trafficking on the land means that there is a much lower incidence of nitrogen leaching compared to crops under typical arable management.

A 10-20m wide riparian planting could remove the majority of nitrate and phosphate pollutants in surface run off. Although there is potential for leaching in the crops establishment year and during harvesting operations, the losses are low when spread over the whole lifetime of the crop. Nitrate concentrations leaving the root zone average less than 0.2 mg/l during the main growth phase[33] which is much less than from arable crops.

Energy crops can also reduce diffuse pollution from pesticides. A single 7-8 m high shelterbelt could reduce spray drift by 60-90%. SRC can also be used as a final treatment measure for waste water and is used for 'polishing' effluents and leachates (E.g. Fernhill Farm in Mendip[34]).

5.2 Flood prevention

The cost of flood defences and coastal erosion in England is currently around £0.7 billion per year and is likely to increase to 1.04 billion/yr by 2035[35]. 5.2 million properties in England are at risk of flooding. Of all the local authorities in England, two of the top ten most at risk of flooding are in the SW: In North Somerset and Sedgemoor District 40,000 and 37,000 properties are at risk of flooding. With sea levels expected to rise as a result of climate change it is expected that river flows will increase by 20% by 2080.

Energy crops grown as SRC can be particularly useful in reducing the incidence of flooding. This is achieved by their:

- Significant water use (willow coppice can use up to 1 million litres per tonne of dry matter produced per year)
- Greater hydraulic roughness which enhances sediment retention and slows down the flow of flood water thereby reducing the likelihood of floods downstream and increasing the time available for issuing flood warnings

Using appropriately planted energy crops could therefore provide a low cost option for reducing the danger of flooding to areas that are too small to justify expensive flood defence measures. Such an initiative would be an example of climate change adaptation and fit in with the

[32] Woodland for Water: Woodland measures for meeting Water Framework Directive Objectives. Forest Research for the Forestry Commission and the Environment Agency. July 2011. www.forestry.gov.uk/pdf/FRMG004_Woodland4Water.pdf/$file/FRMG004_Woodland4Water.pdf

[33] Aronsson P G, Bergstrom L F and Elowson S L E. Long term influence of intensively cultured short rotation willow coppice on nitrogen concentrations in groundwater. *Journal of Environmental Management*. 58: 135-145. 2000

[34] http://www.geosyn.co.uk/casestudies/Bentotex-Fernhill-Farm.pdf
http://www.mendip.gov.uk/pods/documents/documents%5C113177_004%5Cforms%5C113177_004_App%20(2).pdf

[35] Investing for the future: Flood and coastal risk management in England. A long-term investment strategy. Environment Agency 2009. http://publications.environment-agency.gov.uk/PDF/GEHO0609BQDF-E-E.pdf

Transition Town movement by providing a community based solution to a problem whilst also producing a crop of woodfuel for use in local buildings.

Woodland for Water: Woodland Measures for meeting Water Framework Directive objectives

This report produced by Forest Research in July 2011 suggests that strategically placed energy crops could provide an effective way of delivering WFD objectives. The report says:

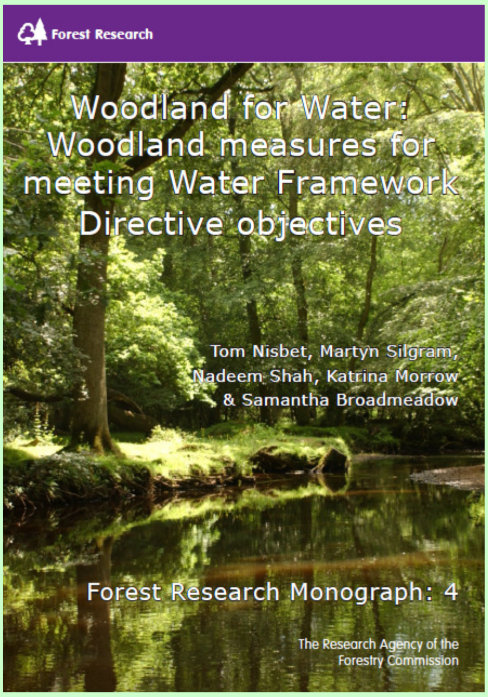
> *"Energy woodland crops such as SRC could be a particularly attractive option for mitigating nitrate leaching in NVZs by maximising nitrogen uptake and providing a high yielding crop for farmers."*
>
> *"….the rapid growth and multi-stemmed nature of these crops makes them ideally suited to flood risk management."*
>
> *"……energy crops can offer additional advantages for water protection, flood risk management and climate change mitigation by enhancing pollutant uptake and sediment retention, more rapid establishment of vegetation roughness (especially for SRC) and increased carbon sequestration, as well as a more attractive and faster economic return for landowners."*

BUT

> ***"….there is no incentive to plant (energy) crops where they could benefit water most."***

It proposes that:

- ☑ Woodland creation and management for mitigating diffuse pollution needs to be given greater prominence in River Basin Management Plans and underpinned by stronger and targeted financial incentives in national Rural Development Programmes, including greater support for riparian woodland buffers.
- ☑ Potential improvements to both Environmental Stewardship and Higher Level Stewardship schemes could consider:
    - Incentives (points or payments) for the creation of tree shelterbelts, hedgerows and riparian woodland buffer areas
    - Weighting of the points system to favour the targeting of these measures to the most effective location within farm landscapes



5.3 Other uses for energy crops

Energy crops provide an option for the rehabilitation of derelict land or sites than are unsuitable for food crops such as restored land fill. The fast growth means that there is a rapid improvement in the visual appearance of such sites. The dense plantations also provide screening and reduce noise from other site activities and discourage access from trespassers.

The leaf litter produced by SRC willow in particular helps improve the soil structure and nutrient status of poor quality soils. Planting this energy crop would therefore provide the first stage in rehabilitation of contaminated sites and in the longer term would enable a wider choice of species to be planted.

SRC and SRF can help improve local air quality by capturing ammonia emissions. Research indicates that 60 meter belts of trees could potentially recapture 10% of the emitted NH_3 close to the source[36]. Energy crops could therefore be strategically planted by land owners to reduce the odour from pig farms, landfills, sewage farms etc.

Finally, the taller energy crops such as SRC and SRF could be used to build biosecurity corridors between farms to reduce the spread of livestock diseases such as Johne's disease and bovine viral diarrhoea (BVD)[37].

Recommendation 4

Agri-Environmental Schemes

Future Agri-environmental schemes should provide energy crop growers with annual payments that recognise the multifunctional benefits provided by these crops. For instance:

- Incentives (points or payments) for the creation of tree shelterbelts and riparian woodland buffers
- Reward growers for water quality improvements
- Reward growers for biodiversity benefits
- Reward growers for Carbon sequestration
- Weighting of the points system to favour the targeting of these measures to the most effective location in the farmed landscape

[36] Dragosits U. et al. (2006) "The potential for spatial planning at the landscape level to mitigate the effects of atmospheric ammonia deposition", Environmental Science and Policy 9: 626-638.

[37] The Multifunctionality of Perennial Energy Crops & their Role in "Sustainable Intensification" of Food Production. Dr John Gilliland OBE. Chairman, Rural Generation Ltd. Perennial Energy Crops within the Reform of the CAP. AEBIOM Workshop December 2011.

6. ENERGY CROPS CAN HELP INCREASE BIODIVERSITY ON FARMS

KEY INFORMATION

- **Populations of wild birds have fallen significantly since 1970 with farmland birds being particularly affected**
- **There are currently 59 species of birds that are classified as priority species and have Biodiversity Action Plans (BAPs) in place**
- **At least 12 priority bird species covered by BAPs are frequently found in and around energy crop plantations**
- **Surveys suggest there are significantly more birds in SRC compared to improved grassland and arable controls**
- **Field margins around energy crops encourage butterfly and other invertebrates**
- **25 species of butterflies have been identified in and around SRC plantations and numbers were found to increase by up to 130% on land previously used for arable crops**

Woody energy crops can significantly increase biodiversity on farms

6.1 Birds

Since the 1970s there has been an alarming reduction in the population of wild birds in the UK. Farmland birds have been some of the hardest hit with Tree Sparrows declining by 95% and Corn Buntings by 85%. There are several reasons[38] attributed to this such as:

- Loss of wild food-plants as a result of herbicide use
- Change from spring-sown to autumn-sown cereals and the subsequent loss of winter stubble
- Insecticide use reducing invertebrate populations
- Conversion of pasture to arable land and the resultant decline in soil invertebrate numbers
- Land drainage making soil dwelling invertebrates less accessible
- Availability of nest sites due to removal of hedgerows

A growing body of evidence suggests that energy crops and SRC willows in particular can boost biodiversity by increasing the numbers of birds and insects in the vicinity of the crop. The Game Conservancy Trust recommends growing several SRC plantations in a staggered fashion so that they are harvested in different years. This ensures that the maximum number of species are

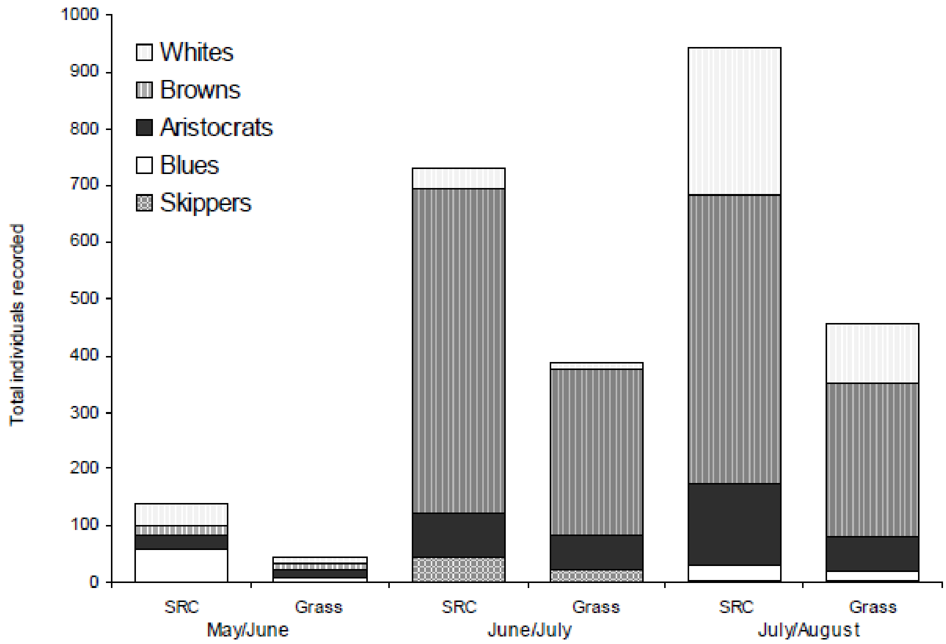
[38] http://www.birdsofbritain.co.uk/features/birds-farming-jun-02.asp

supported and reduces the risk of displacement. For instance, freshly harvested SRC leaves an area of open land each spring. This attracts birds which forage and nest in open fields such as the skylark and meadow pipit[39]. Surveys suggest that there are significantly more birds in SRC compared to the grassland and arable controls[40]. The crop tends to accommodate an under storey of perennial weeds which provides food for over 50 insect species which in turn encourages birdlife especially migrant and resident species whose numbers have been falling in recent years.

Migrant birds tend to inhabit one year old coppice whilst resident birds move into older plantations. In fact, many birds currently listed on national conservation action plans will benefit including snipe, fieldfare, woodcock, reed bunting, yellow hammer, willow warbler and lapwing.

6.2 Butterflies

Headlands around SRC and miscanthus provide an important habitat for butterflies with their numbers increasing by up to 130% on land previously used for arable crops[41]. The four-year study carried out by the Game Conservancy Trust identified a total of 10,180 butterflies comprising 25 species. In each year, in virtually all of the plots surveyed, significantly more individuals and species were seen on the SRC than the grass controls.



Species composition and abundance of butterflies seen on coppice and grass control plots in 2003 (Extracted from Ref 39).

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[39] The Effects on Flora and Fauna of Converting Grassland to Short Rotation Coppice. Four year study involving wildlife monitoring of commercial SRC plantations planted on grassland and grassland control plots. DTI Technology Programme: New and Renewable Energy Contract Number B/W2/00738/00/00. http://webarchive.nationalarchives.gov.uk/+/http://www.berr.gov.uk/files/file30621.pdf

[40] Cunningham, M. Short rotation coppice. Game Conservancy Trust. www.gct.org.uk/text03.asp?PageId=311

[41] Parry B (2005) Ode to Energy Crops. The Biologist Volume 53 No. 1.

Table 18: *Bird species found in and around SRC (✓) and miscanthus (✓) plantations (see ref 39).*

Bird species	Field	Edge	Middle	Conservation status
Barn Owl	✓			Amber
Blackbird	✓✓	✓	✓✓	
Blackcap	✓	✓	✓	
Blue Tit	✓✓	✓	✓	
Bullfinch	✓	✓	✓	Red and UK BAP
Chaffinch	✓✓	✓✓	✓✓	
Chiffchaff	✓	✓	✓	
Corn Bunting		✓✓		Red and UK BAP
Dunnock	✓	✓	✓	Amber and UK BAP
Garden warbler	✓	✓	✓	
Goldcrest		✓	✓	
Goldfinch	✓✓	✓✓	✓✓	
Greater Spotted Woodpecker	✓		✓	
Great Tit	✓	✓✓	✓	
Greenfinch	✓✓	✓✓		
Jay	✓		✓	
Lapwing	✓✓	✓		Amber and UK BAP
Lesser Whitethroat	✓	✓		
Linnet	✓✓	✓✓	✓	Red and UK BAP
Long Eared Owl	✓	✓	✓	
Long Tailed Tit		✓	✓	
Magpie	✓	✓	✓	
Mistle Thrush			✓	
Moorhen	✓	✓	✓	
Nuthatch	✓			
Pheasant			✓	
Reed Bunting	✓	✓	✓✓	Red and UK BAP
Reed Warbler	✓			
Robin	✓✓	✓	✓	
Sedge Warbler	✓✓	✓		
Skylark	✓✓	✓	✓✓	Red and UK BAP
Song Thrush	✓	✓	✓✓	Red and UK BAP
Sparrowhawk	✓			
Stock dove	✓	✓		Amber
Tree Sparrow	✓	✓	✓	Red and UK BAP
Whitethroat	✓✓	✓✓	✓	
Willow Tit	✓		✓	Red and UK BAP
Willow Warbler	✓		✓	Amber
Wood Pigeon	✓✓	✓		
Wren	✓✓	✓✓	✓	
Yellow Hammer	✓✓	✓✓	✓✓	Red and UK BAP
Yellow Wagtail	✓	✓	✓	Amber and UK BAP

Key
Field = species recorded on the edge of the field containing SRC or miscanthus
Edge = species recorded on the edge of the SRC or miscanthus plantation
Middle = species recorded within the SRC or miscanthus plantation
Conservation status
Red = red listed species of conservation concern – over 50% decline in past 25 years
Amber = amber listed species of conservation concern –25-50% decline in past 25 years
UK BAP = species that have a UK Biodiversity Action Plan

6.3 Invertebrates

The canopy of SRC attracts a very diverse insect fauna which makes the crop a good foraging habitat for birds. The four year study conducted by the Game Conservancy Trust identified 15 invertebrate groups colonizing the crop with Hemiptera (true bugs) and beetles being the most abundant.

6.4 Ecological Focus Areas under CAP reform

The Common Agricultural Policy (CAP) is currently under revision for the period 2014-2020 and there is a suggestion that new measures will include a 7% Ecological Focus Area on each farm holding. This aims to take several million hectares of arable land out of production. The European Biomass Association (AEBIOM) and the UK National Farmers Union are lobbying for perennial energy crops to be eligible for planting within this 7% area and their argument is based on the fact that SRC, miscanthus and SRF are multifunctional crops that help to improve water quality, enhance biodiversity, prevent erosion and mitigate climate change compared to traditional annual crops.

There are currently 1,885,692 hectares of farmland in the SW. If we assume that this measure is adopted by the EU and 50% of the farmed area in the SW is planted with energy crops then 66,000 ha would be in production. As we have already seen this could provide 4.5% of the SW's heating needs and reduce greenhouse gas emissions from agriculture by 25%.

Table 19: *Amount of land required for energy crops if planted as part of ecological focus areas.*

% agricultural land area	Number of hectares with energy crops
7	132,000
3.5	66,000
1.75	33,000
0.875	16,500

Recommendation 5

CAP reform

- Stakeholder groups such as NFU, Country Land and Business Association, Regen SW, Environment Agency, Natural England, and the RSPB should lobby the Government and the EU to allow energy crops to be planted as part of Ecological Focus Areas.

7. ISSUES WITH ENERGY CROPS

An emerging energy crops industry in the SW could have a very positive impact. However, there are several key issues that need to be addressed urgently in order to meet this potential.

7.1 Lack of infrastructure

It is not possible to set up an industry if there is a limited supply of local machinery. SRC requires bespoke equipment to plant and harvest the crop. The nearest planting contractors are located in Nottinghamshire whilst the only contractors with chip or billet harvesting machines are located in Warwickshire, Nottinghamshire and Yorkshire. A Bio-baler which is capable of baling SRC is owned and operated by Moor Heat located in Liskeard, Cornwall (www.moorheat.com).

With increased fuel costs, the haulage of this machinery across the country is becoming prohibitively expensive. The cost of transporting a modified forage harvester and SRC header from Retford in Nottinghamshire to Taunton is around £400 in fuel alone for a return trip. Based on a 10 ha harvest this would mean a reduction in profit by £40 per ha. On top of this would be the HGV hire and subsistence for the harvesting operatives. It is no wonder that many pioneer growers are leaving their crops to grow beyond a 3 year rotation in the hope that the harvesting can be done more cost effectively in the future. Aside from the cost implications, by employing contractors outside the SW means that money leaves the region and the knowledge remains elsewhere.

It would be beneficial if there was a local contractor supplying a planting and harvesting service but this is unlikely without crops in the ground. Based on the current situation it would be impossible to justify a business case to take to a bank or other lender. Although there is a lot of interest in energy crops the lack of infrastructure makes it a high risk strategy for a farmer to invest in these crops. Hence, for the industry to develop and break the "chicken and egg" cycle there is an urgent need for regional support for an SRC planting machine and harvester

Miscanthus is easier to harvest than SRC and uses conventional machinery such as forage harvesters, mower conditioners and baling machines. However, it does require specialist planting machinery. There are several automatic planting machines in the SW owned and managed by New Energy Farms (www.newenergyfarms.com) in Marlborough, Wiltshire and SEIL Ltd in Williton, Somerset. However, results with the automatic planters have been patchy and to address this problem a precision planter has been developed by International Energy Crops in Market Drayton, Shropshire (www.energycrops.com). This planting machine is being used for establishing miscanthus crops in New Milton, Hampshire and Loswithiel, Cornwall in 2012.

Table 20 below indicates the amount of infrastructure required to plant and harvest 3,000 ha of energy crops per year. A total investment of around £1.44 million would be required for machinery. As the industry is likely to grow more slowly in the initial years this investment could be spread over the next 8 years. Table 21 indicates the amount of grant funding that would be required to achieve this based on 75% and 40% grants. There is a very strong argument for the initial planting machines and willow header to receive the higher grant rate whilst later projects could revert to the lower intervention rate. By 2020 the industry should hopefully be strong enough to not require further support for planting and harvesting machinery. A total funding pot of £560,000 would be required to achieve this.

Table 20: *The number of planting and harvesting machines and the investment required to plant 3,000 hectares of energy crops per year.*

Crop	Activity	Machine	Window of opportunity	No of days /yr	No of hours /yr	Area/hour (ha)	Potential area /year (ha)	No of machines required	Cost per unit	Total investment required
SRC	Planting	4 Row Step planter	Mid March – Mid May	60	360	1	360	4	£60,000	**£240,000**
	Harvesting	Header for Modified self propelled forage harvester	Mid November – Mid March	60	360	0.5	180	8	£120,000	**£960,000**
Miscanthus	Planting	4 Row Precision planter	Mid March – Mid May	60	360	1	360	4	£60,000	**£240,000**
	Harvesting	Self propelled forage harvester	March – late April	40	320	1.5	480	n/a	/	**/**
										£1,440,000

Assumptions:

- Assumes a 50/50 split of miscanthus and SRC planted
- Number of hours per day allows for breakdowns and repairs
- SRC harvesting is assumed to be possible for only 50% of the available time due to heavy working conditions as a result of wet weather
- Miscanthus harvesting assumes higher work rate because of drier conditions, longer working days and lighter crops (1 year old rather than 3 years old)
- Number of machines required is based on year on year plantings of 3,124 ha/yr to achieve 21,865 ha by 2020
- Unit costs are based on quotes:
  - Step planter – Salisphere
  - Willow Header – Coppice Resources
- It is likely that the overall cost of machinery would be much lower if several units were ordered together
- It is assumed that there are already sufficient machines for harvesting miscanthus in the SW

Table 21: *Possible timetable of investment and grant funding for energy crops planting and harvesting infrastructure.*

Machinery		Year										
		2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	
Step planter		*		*	*	*						
Willow header				*	*	*	*	*	*	*	*	
Precision planter		*		*	*	*						**Total cost (Millions)**
Total investment required		£120,000	/	£240,000	£240,000	£240,000	£120,000	£120,000	£120,000	£120,000	£120,000	**£1.44**
Funding required	75% grant	£90,000	/	£90,000	/	/	/	/	/	/	/	**£0.56**
	40% grant	/	/	£48,000	£96,000	£96,000	£48,000	£48,000	£48,000	/	/	

Assumptions:

- Most planting will take place from 2015 onwards
- One planter each will be sufficient for planting SRC and miscanthus in 2013 and 2014
- SRC willow is generally grown on a three year harvest cycle after a first year cut back. However, if a header was grant aided in 2015 it would enable growers with very high yielding crops to cut after a two year cycle
- The first two planters and willow header are supported with a 75% grant. Mid term projects are supported by 40% grants. Projects from 2020 are self funded

7.2 Energy Crops Scheme under spend

As reported in sections 1.1 and 1.2 there has so far been a relatively low uptake of energy crops by UK farmers. In 2009, it was already obvious that there would be a significant under spend (around £20 million) from the Energy Crops Scheme. The Forestry Commission (FC) were approached by Defra and DECC to explore the potential of utilising this in support of delivering their Woodfuel Strategy. The FC proposed a package of measures to provide support across four key activity areas: support for boiler installation; increasing the supply of timber; support for woodfuel businesses (equipment); and provide facilitation. This ultimately led to the setting up of the Woodfuel Woodland Improvement Grant (Woodfuel WIG). Unfortunately, organisations within the energy crops sector were not consulted on this matter. As a result not a penny was made available to help understand the reasons for farmer indifference and provide funding for essential infrastructure to help develop the energy crops industry in the English regions.

7.3 Processing energy crops

As fuels, both miscanthus and SRC have their flaws. Miscanthus has a very low bulk density and has low quality combustion characteristics. SRC has a high moisture content when harvested and needs to be dried and screened before being used in a biomass boiler. Appendix V shows how SRC willow and miscanthus compare to more typical woodfuel from round wood. Producers of both crops will require grant support in order to produce good quality fuels.

Densification of miscanthus

The low bulk density of miscanthus means that it is expensive to transport and takes up a lot of storage space. This can be overcome by producing pellets or briquettes which can increase the density by up to six times. Pellets are more suitable for domestic and commercial customers with space constraints. They also flow so are much quicker to deliver than chip. The combustion quality of miscanthus pellets can be improved by late harvesting with a forage harvester. This means that winter rains leach out a great deal of the unwanted chemical components whilst direct chipping reduces contamination of the crop. Miscanthus can be improved further by blending with wood shavings or including additives such as lime which reduce the corrosive nature of the fuel.

It is unlikely that the highest grade pellets (Grade ENplus A1) could be produced from miscanthus. However, it should be possible to produce second grade pellets (Grade ENplus A2) through blending and third grade pellets (EN-B) through good practice. The price of pellets varies depending on the grade. It might be possible to get a price of £100/tonne for grade B pellets, £150/tonne for A2 pellets and £200/tonne for A1 pellets. Briquettes tend to be more costly with typical prices ranging from £200-£380/tonne. The prices of single 10-15kg bags can range considerably from around £450-£1000/tonne.

The set up costs for a pelleting operation with a throughput of 1 tonne/hour are around £170,000[42]. A 2 tonne/hour facility would cost in the region of £280,000 whilst larger facilities producing 10,000 tonnes can cost several £millions. Based on a capacity factor of 50% the smaller plants would be capable of producing 4,380 and 8,760 tonnes of pellets per annum. The prices above do not include packing and distribution equipment. A small briquetting operation may cost only £15,000[43] whilst a larger automated system could cost as much as £1 million[44]. Large scale systems have very high energy costs and therefore require a very high output in order to justify the expense.

Drying and processing of SRC

The main issue associated with SRC is the high moisture content when harvested which ranges between 45-55%. Most small to medium scale boilers require the wood chip to be less than 35%. As a result, the harvested SRC needs to be seasoned before it can be sold on to an end user. Unfortunately, if SRC chip is simply left in a field it tends to self heat and compost. This reduces the dry matter of the SRC and reduces the quality still further. There are various harvesting and processing methods that can be deployed in order to effectively dry SRC and produce a good quality fuel (see opposite). If no other options exist it is possible to dry SRC chip by storing it in long, peaked windrows (5-10m high). This requires a telehandler.

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[42] Quote price from Farm Feed Systems www.farmfeedsystems.co.uk
[43] London Energy Partnership. Biomass for London: woodfuel demand and supply chains. www.bioregional.com/files/publications/BiomassforLondon_Dec08.pdf
[44] Forest Research. Small scale Briquetting. Project Report.

Harvesting and processing options for SRC willow

Chip harvesting

Requires the use of a modified header on a self propelled forage harvester. Forage harvesters tend to produce woodchips of around 2.5-7cm long although slivers of up to 30cm are possible.

Processing options

- Ambient air drying - under cover in dedicated barns
- Active drying with a ventilated drying floor
- Mechanical grading system to remove undersize and oversize particles is desirable

Billet harvesting

Requires a modified sugar cane harvester. Billets are around 200 mm long and have a large surface area. The greater air circulation means that billets can be stored successfully in bulk without forced ventilation. Re-chipping is not an option.

Processing options

- Granulated using a hammer mill
- Pulverised and then pelletized

Stick harvesting

Involves the cutting of whole shoots with a rod harvester. Like billets sticks can be successfully dried outside.

Processing options

- Re-chipping is possible but poor quality chip is produced
- Mechanical grading system to remove undersize and oversize particles is essential
- Could be pelletized

Bale harvesting

Involves cutting and baling in one pass. Useful option for poorly established crops. Bales have been shown to dry well outdoors without degradation. Typically used directly in batch fed boilers.

Processing options

- Re-chipping is possible but poor quality chip is produced
- Mechanical grading system to remove undersize and oversize particles is essential
- Could be pelletized

Approximate costs for SRC processing options are as follows:

- Small scale ventilated drying floor in an existing barn - £20,000
- Mobile grading system - £20,000 - £30,000
- Mobile granulating system permanently housed on an HGV lorry- £300,000

To kick start the industry we suggest a grant scheme to support six pelleting, briquetting or granulating facilities, five mobile grading facilities and 20 drying floors. Such an array of machinery should enable the processing of up to 40,000 tonnes of energy crops. Investment in a miscanthus pelleting facility is needed immediately in order to provide a market for the 344 ha of miscanthus currently planted in Somerset. The grant support should take place over a number of years and the majority of funding would be required from 2016 onwards to allow time for the crops to grow. Table 22 indicates the amount of grant funding that would be required until 2020 - a total pot of £1.09 million.

Table 22: *Possible timetable for investment and grant funding for energy crops processing machinery.*

Processing Machinery		Year								Total cost (Millions)
		2013	2014	2015	2016	2017	2018	2019	2020	
Pelleting plant		*			*	*	*	*		
Granulating facility						*				
Grading facility					*	*	*	*	*	
Drying floors					*	*	*	*	*	
Total investment required		£300,000	/	/	£410,000	£710,000	£410,000	£410,000	£110,000	£2.35
Funding required	50% grant	£150,000	/	/	/	/	/	/	/	£1.09
	40% grant	/	/	/	£164,000	£284,000	£284,000	£164,000	£44,000	

7.3 Renewable Heat Incentive (RHI) emissions limits

From the summer of 2013 it is expected that all biomass boiler installations accredited under the RHI must meet new emission limits of 30 grams per Gigajoule (g/GJ) for particulates and 150 g/GJ nitrogen oxides (NOx). It should be possible to achieve this with good quality woodchip in more efficient boilers. By contrast, miscanthus is particularly dusty and produces a high level of particulates (around 100 g/GJ)[45] so is likely to miss this target. However, it might be possible to achieve these stringent requirements by using ceramic filters in the flue. It is suggested that ceramic filters can significantly reduce PM10 (particles measuring 10 micrometers or less) and

[45] Thermal degradation of Miscanthus pellets: kinetics and aerosols characterization. Sophie Dorge, Mejdi Jeguirim and Gwenaëlle Trouvé. WASTE AND BIOMASS VALORIZATION Volume 2, Number 2, 149-155.

PM2.5 from boiler emissions. However, this would add around 10-15% to the installed costs of the boiler[46]. Another option would be the use of a particle precipitator.

Both SRC and miscanthus have higher nitrogen contents than typical woodchip and they might fail to meet the grade on this front as well. This is more likely to be the case when energy crops are used as biofilters or as barriers to prevent nitrate leaching. Currently there is no emissions control technology that is capable of cost effectively reducing NOx emissions from smaller biomass boilers. However, until now there has been no incentive for manufacturers to address NOx emissions. Once addressed it should be possible to achieve these limits.

Recommendation 6

Energy crops infrastructure and processing
There needs to be a dedicated grant scheme for energy crops infrastructure and processing projects. Alternatively, future rounds of the Farming and Forestry Improvement Scheme or Rural Economy Grant should provide specific support for energy crops. Grants should be integrated with favourable terms for loans from the Green Investment Bank.

The following infrastructure is required:

- Planting and harvesting machinery
- Drying and processing equipment e.g. grading, pelleting, briquetting and granulating machinery

Grants for initial infrastructure projects should be up to 75% of the capital costs. 40% would be suitable for most infrastructure projects although an immediate one off 50% grant could stimulate a market for the 344 ha of miscanthus planted in Somerset.

Recommendation 7

Emissions
It is important that the new biomass boiler emissions targets do not hinder the energy crops sector. Innovation grants should be made available for boiler manufacturers to look at ways to cost effectively reduce particulates and NOx emissions from energy crops.

[46] www.environmental-protection.org.uk/assets/library/documents/EPUK_RHI_Response_(Final_190410).pdf

8. SUMMARY OF FINDINGS

The development of a thriving energy crops sector in the SW would bring a great many benefits to the region. These include:

- Helping to meet our energy needs
- Helping to meet climate change targets by offsetting GHG emissions from agricultural food production
- Creating assured local markets which insulate end users from future price rises and provide improved returns for growers
- Reducing the cost of heating, particularly in off gas areas
- Reducing the dependence on imported fuels thereby increasing security of supply and keeping revenue in the local economy
- Creating jobs in both the production and utilisation of biomass
- Potentially helping to reduce fuel poverty
- Improving water quality of watercourses and beaches
- Helping reduce the impact of flooding
- Increasing the biodiversity of farm land

Our analysis suggests that if 3.5% of the SW agricultural area (65,595 ha) was planted with energy crops the following deliverables could be realised:

- 2.64 TWh of energy per year equalling 37.5% of the renewable heat target
- 780,946 tonnes CO_2 equivalent saved each year equalling a 21% reduction in emissions from agriculture
- £768 million of investment stimulated in biomass boiler projects
- £55.4 million/yr saved in fuel costs by consumers
- £27.8 million/year farmer profit
- 3,745 renewable energy jobs equalling a 134% increase on the current number of jobs in the bioenergy sector

8.1. Energy crops wish list

To help achieve this potential we suggest the following recommendations:

1) Retain the Energy Crops Scheme as well as annual payments to improve economics and cash flow in early years
2) Grant aid crop producers enabling them to multiply stocks with less financial risk and achieve greater economies of scale which ultimately lead to lower establishment costs

3) Public sector organisations should be encouraged to look at their own estates for opportunities for growing energy crops for their own use. Energy managers of public sector buildings that already have biomass boilers or plan to install them should be encouraged to begin a dialogue with local farmers with a view to setting up a long term supply partnership

4) Future Agri-environmental schemes should provide energy crop growers with annual payments that recognise the multifunctional benefits provided by these crops

5) Stakeholder groups should lobby the Government and the EU to allow energy crops to be planted as part of Ecological Focus Areas proposed under the CAP reform

6) A dedicated grant scheme for energy crops infrastructure and processing projects is required. Based on our findings, around £1.65 million of funding is required from 2013-2020. Grants for initial infrastructure projects should be up to 75% of the capital costs

7) Innovation grants should be made available for boiler manufacturers to look at ways to cost effectively reduce particulates and NOx emissions from energy crops

8) Improvements in the dissemination of information will help growers understand the crop option that is most suitable for their land, their storage options, their boiler or their end user. Growers guidelines need to be updated and standardised contractor briefs produced in order to encourage best practice

Recommendation 8

Dissemination of information

- Best practice guidelines brought up to date for miscanthus (particularly), SRC, SRF and broadleaf coppice
- Standardised contractor briefs for planting, rabbit fencing, spraying, harvesting – to increase standards
- There is a need for guidance on energy crop self supply so growers can understand issues with storage, transport and utilisation

The SW is already the leading English region for engagement in renewable energy technology. However, the fact remains that we are still importing most of our energy in the form of fossil fuels from abroad. By utilising our own indigenous woodfuel resources and growing energy crops we have the opportunity to create a vibrant and sustainable industry that brings further wealth, prosperity and environmental benefits to our region.

APPENDIX I: ESTIMATED WOODFUEL RESOURCE IN THE SW

Woodfuel type		Sustainable production (odt/yr)
Woodland		463,382
Energy crops	Miscanthus (668 ha)	8,684*
	SRC (155 ha)	1,240*
Arboricultural arisings		34,830
Co-products from sawmills		27,204
Waste wood	Clean recycled wood waste	50,000
	Packaging and pellets	100,000
	Totals	**685,340**

Reference:
Woodfuel Resource in Britain. Final Report, B/W3/00787/Rep, Urn03/1436. Funded By Dti, Scottish Enterprise, Welsh Assembly Government and The Forestry Commission. H. Mckay. December 2003.

* Energy crop resource is based on current plantings

APPENDIX II: KEY INFORMATION ON ENERGY CROP PRODUCTION SYSTEMS

	Miscanthus	SRC Willow	Broadleaved coppice (e.g. Birch)	SRF (e.g. Eucalyptus)
Origin	Asia	Europe, Asia, N. America	Northern Europe	Exotic
Propagation	Rhizomes	Cuttings	Rooted saplings	Rooted saplings
Harvesting	Annually	Every 2-3 years	12-15 years	8-12 years
Harvest method	Mow or forage harvester and bale	Chip or billet	Chainsaw, Forwarder or skidder	
Establishment costs (£/ha)	£2,500	£1,800-£2,000 (£2,500-£2,675 with rabbit fencing)	£2,500	£2,850
Grants	50% of establishment costs through ECS		ECS / Woodland Creation Grant	None
Height at harvest	3m	7-8m	8-10 m after 10 years	Up to 20m
Stocking rate	16,000/ha	15,000/ha	2,500/ha	2000-2,500/ha
Planting depth	20-30cm	20-30cm	> 30cm	45cm
Productivity	15 yrs +	20-30 yrs	30 yrs +	Up to 12 years
Best soils	Sandy soils to high organic matter soils	Sandy loam, loam, clay loam and heavy clay	Moist fertile loams: e.g. ash, hazel Acid: birch, sweet chestnut	Broad tolerance. Poplar requires deep, base rich, loamy soils
pH range	5.5-7.5	5.5-8	5-7.5	
Soils to avoid	Dry sandy soils	Light sandy soils, silty soils	Very wet or very dry soils	Acidic and shallow soils
Rooting depth[47]	2.5m but 75% are in the top 1.2m	2m+ but 70% are in the top 36cm. Long roots are <10mm	4m although 80% are in the top 50 cm	
Yield range (odt/ha/yr	8-20	6-14	3-6	9-15

[47] Miscanthus, short-rotation coppice and the historic environment. J W Finch, A Karp, D P M McCabe, S Nixon, A B Riche and A P Whitmore. Centre for Ecology & Hydrology Rothamsted Research for English Heritage. 2009. http://nora.nerc.ac.uk/7566/1/EngHerit_Report_final.pdf

APPENDIX III: PRODUCTION COSTS OF DIFFERENT WOODFUELS OVER 8 YEARS

	Management	Fuel	8 year yield (odt)	Establish-ment (-grant)	Harvesting £/ha	Process-ing and transport £/ha	Lost revenue over 8 years	Total costs	£/odt	£/tonne @ 35%	£/tonne @ 25%	£/tonne @ 20%	CV (kWh/ tonne)	Cost p/kwh
SRC willow	Fenced	Chip	70	£1,250	£900	£600	£1,800	£4,550	£65	£42.25	/	/	3100	**1.36**
	Fenced	Chip	70	£1,250	£900	£600	/	£2,750	£39	£25.54	/	/	3100	**0.82**
	Fenced	Chip	54	£1,250	£900	£600	£1,800	£4,550	£84	£54.77	/	/	3100	**1.77**
	Fenced	Chip	54	£1,250	£900	£600	/	£2,750	£51	£50.93	/	/	3100	**1.64**
	Unfenced	Chip	33	£900	£900	£600	/	£2,400	£73	£47.27	/	/	3100	**1.52**
	Unfenced	Chip	33	£900	£900	£600	£1,800	£4,200	£127	£82.73	/	/	3100	**2.67**
	Unfenced	Logs	36	£1,250	£1,200	£1,908	/	£4,358	£121	/	/	£96.84	3980	**2.43**
Miscanthus	Unfenced	Chip	91	£1,500	£1,400	/	£1,800	£4,700	£52	/	£38.74	/	3600	**1.08**
	Unfenced	Chip	91	£1,500	£1,400	/	/	£2,900	£32	/	£23.90	/	3600	**0.66**
	Unfenced	Chip	70	£1,500	£1,400	/	£1,800	£4,700	£67	/	£50.36	/	3600	**1.40**
	Unfenced	Chip	70	£1,500	£1,400	/	/	£2,900	£41	/	£31.07	/	3600	**0.86**
	Unfenced	Chip	55	£1,500	£1,400	/	£1,800	£4,700	£85	/	£64.09	/	3600	**1.78**
	Unfenced	Chip	55	£1,500	£1,400	/	/	£2,900	£53	/	£39.55	/	3600	**1.10**
	Unfenced	Bale	91	£1,500	£2,100	£364	£1,800	£5,764	£63	/	£47.51	/	3600	**1.32**
	Unfenced	Bale	91	£1,500	£2,100	£364	/	£3,964	£44	/	£32.67	/	3600	**0.91**

	Management	Fuel	8 year yield (odt)	Establish-ment	Felling		Extraction		Chipping		Log splitting		Total	Production costs		CV (kWh/ tonne)	Cost p/kwh
					Cost/odt	Total cost/ha	Cost/odt	Total cost/ha	Cost/odt	Total cost/ha	Cost/ odt	1.36		£/odt	£/tonne @ 35%		
SRF Eucalyptus	Fenced	Chip	104	£2,500	£20	£2,080	£8	£801	£15	£1,560	/	**0.82**	£6,941	£66.74	£43.38	3100	**1.40**
	Unfenced	Chip	104	£1,800	£20	£2,080	£8	£801	£15	£1,560	/	**2.43**	£6,241	£60.01	£39.01	3100	**1.26**
	Fenced	Logs	104	£2,500	£20	£2,080	£8	£801	/	/	£45	£4,680	£10,061	£96.74	£62.88	3100	**2.03**
	Unfenced	Logs	104	£1,800	£20	£2,080	£8	£801	/	/	£45	£4,680	£9,361	£90.01	£58.51	3100	**1.89**

	Fuel	Felling	Extraction	Chipping	Log splitting	Total product-ion costs	Total product-ion costs	£/tonne @ 20%	CV (kWh/ tonne)	Cost p/kwh
		Cost/ tonne @ 30% MC					£/odt			
Existing woodland	Chip	£20	£10	£15	/	£45	£61.43	/	3100	**1.45**
	Logs	£20	£10	/	£45	£75	£107.14	£85.71	3980	**2.15**

APPENDIX IV: TRANSPORT FUEL COSTS

A: Woodfuel supplier from depot

		Round trip distance (km)							
		1	5	10	20	30	40	50	60
Diesel price (litre)	**£1.35**	£0.25	£1.27	£2.54	£5.08	£7.62	£10.16	£12.69	£15.23
	£1.40	£0.26	£1.32	£2.63	£5.27	£7.90	£10.53	£13.17	£15.80
	£1.45	£0.27	£1.36	£2.73	£5.45	£8.18	£10.91	£13.64	£16.36
	£1.50	£0.28	£1.41	£2.82	£5.64	£8.46	£11.28	£14.11	£16.93
	£1.55	£0.29	£1.46	£2.92	£5.83	£8.75	£11.66	£14.58	£17.49
	£1.60	£0.30	£1.50	£3.01	£6.02	£9.03	£12.04	£15.05	£18.06
	£1.65	£0.31	£1.55	£3.10	£6.21	£9.31	£12.41	£15.52	£18.62
	£1.70	£0.32	£1.60	£3.20	£6.39	£9.59	£12.79	£15.99	£19.18
	£1.75	£0.33	£1.65	£3.29	£6.58	£9.87	£13.17	£16.46	£19.75
	£1.80	£0.34	£1.69	£3.39	£6.77	£10.16	£13.54	£16.93	£20.31
	£1.85	£0.35	£1.74	£3.48	£6.96	£10.44	£13.92	£17.40	£20.88
	£1.90	£0.36	£1.79	£3.57	£7.15	£10.72	£14.29	£17.87	£21.44
	£1.95	£0.37	£1.83	£3.67	£7.33	£11.00	£14.67	£18.34	£22.00
	£2.00	£0.38	£1.88	£3.76	£7.52	£11.28	£15.05	£18.81	£22.57

10 tonne truck

Miles per gallon	15
Miles per litre	3.3
km per litre	5.3
Truck volume (m3)	40
Bulk density of fuel (kgm3)	225
Fuel weight transported (Tonnes)	9.00
Moisture content of fuel (%)	35
Calorific value of fuel kWh/tonne)	3,100

B: Energy crops from local farm

		Round trip distance (km)			
		1	5	10	20
Diesel price (litre)	**£1.35**	£0.51	£2.54	£5.08	£10.16
	£1.40	£0.53	£2.63	£5.27	£10.53
	£1.45	£0.55	£2.73	£5.45	£10.91
	£1.50	£0.56	£2.82	£5.64	£11.28
	£1.55	£0.58	£2.92	£5.83	£11.66
	£1.60	£0.60	£3.01	£6.02	£12.04
	£1.65	£0.62	£3.10	£6.21	£12.41
	£1.70	£0.64	£3.20	£6.39	£12.79
	£1.75	£0.66	£3.29	£6.58	£13.17
	£1.80	£0.68	£3.39	£6.77	£13.54
	£1.85	£0.70	£3.48	£6.96	£13.92
	£1.90	£0.71	£3.57	£7.15	£14.29
	£1.95	£0.73	£3.67	£7.33	£14.67
	£2.00	£0.75	£3.76	£7.52	£15.05

150 HP Tractor and trailer

Miles per gallon	7.5
Miles per litre	1.7
km per litre	2.7
Trailer volume (m3)	30
Bulk density of fuel (kgm3)	175
Fuel weight transported (Tonnes)	5.25
Moisture content of fuel (%)	35
Calorific value of fuel (kWh/tonne)	3,100

	10 tonne truck						
Round trip distance (km)	**5**	**10**	**20**	**30**	**40**	**50**	**60**
CO_2 emissions/ journey kg	2.43	4.86	9.72	14.58	19.44	24.3	29.16

150 HP Tractor and trailer			
1	**5**	**10**	**20**
0.97	4.86	9.72	19.44

CO_2 emissions from diesel (Kg CO_2 per litre)	2.7
10 tonne truck diesel consumption (litres/km)	0.18
Tractor and trailer diesel consumption (litres/km)	0.36

APPENDIX V: COMBUSTION CHARACTERISTICS

Parameter	Unit	Coniferous wood	Broad leaf wood	SRC willow	Miscanthus
Ash	w %	0.3	0.3	2.0	4.0
Bulk Density of chip @ 30% MC	kg/m3	225	330	175	100
Net calorific value	MJ/kg d	19.1	18.9	18.4	17.7
Nitrogen	w %	0.1	0.1	0.5	0.7
Chlorine	w %	0.01	0.01	0.03	0.2
Sulphur	w %	<0.02	0.02	0.05	0.2
Silica	mg/kg d	150	150	500	8000
Ash melting point	^{O}C	1426	1340	1283	973

Miscanthus and to a lesser extent SRC have several issues that can affect storage, transport and utilisation:

- High ash fuels in a boiler will require more frequent ash disposal
- Fuels with a low ash melting point result in clinker, a glass like deposit which builds up in the combustion unit - this restricts air flow which not only leads to less efficient combustion but also prevents the cooling effect of the air flow on the grate leading to rapid erosion
- Fuels with low bulk density require more storage space and more frequent deliveries
- Fuels with a high content of chlorine or sulphur can lead to the corrosion of boiler walls and tubes
- Fuels that are high in nitrogen are more likely to produce higher emissions of nitrogen oxides (NOx) - these will be more closely monitored under Phase 2 of the Renewable Heat Incentive

However, none of these issues are insurmountable as long as an appropriate boiler is used. A miscanthus compliant boiler should have some or all of the following features:

- A step grate or tilting grate
- Stainless steel-lined combustion chamber
- Sophisticated feed system including an agitator and reversible auger and a rotary chopper to cut oversize material
- A lambda probe which adjusts the input of fuel as well as the air intake for combustion according to the energy density of the fuel being used

- An exhaust gas flue recirculation system. This extracts flue gases and recirculates them into the combustion chamber. The gas mix is oxygen poor so this inhibits the burn temperature and thereby reduces clinkering
- Automatic cleaning
- Large volume ash bins meaning longer intervals between emptying
- An alarm which goes off when the ash box is full

An end user must consider the following before installing a miscanthus system:

- The bulky fuel means that much more storage is required
- If the fuel is being delivered from a third party there will be many more frequent deliveries
- Boilers using miscanthus are downgraded in their capacity as it is physically impossible to get enough fuel into the combustion chamber to achieve the rated capacity. Hence a 200 kW boiler can only achieve an output of 150 kW using miscanthus
- The boiler will require more operations and maintenance as a result of its high ash fuel and its low melting point
- In the absence of a stainless steel combustion chamber it is possible to reduce the impact of chlorine damage by adding lime to the boiler combustion chamber. Tests by AFBI in Northern Ireland suggest the need for 3.8 kg of lime for each tonne of miscanthus used[48].

[48] Alistair McCracken, AFBI. Personal communication.

APPENDIX VI: LIST OF RECOMMENDATIONS

1) Energy Crops Scheme

- Keep ECS establishment grant at 50%
- Integrate with a system of annual payments to reward growers for wider environmental credentials of energy crops (Recommendation 4)
- Reduce 3 month turnaround of applications
- Include SRF in the ECS but with stricter landscape sensitivity analysis (EIA) for exotics
  - Higher grant rate for natives to reflect low yields
  - Lower grant rate for exotics to reflect high yields
- Remove 3 ha limit to encourage self supply
- Felling grants for harvesting oversize SRC – i.e. crops that were planted before there were markets.

2) Crop production

It is a massive investment to breed, select, test, multiply and protect new varieties. Producers need to expand to meet future demand.

- Reduced grant rate for establishment costs for multiplication under ECS 3 (e.g. 25%) or
- Other grant for multiplication in conjunction with favourable loan terms from the Green Investment Bank

Either way, a reduced rhizome / cutting price = reduced establishment costs = a higher take up by growers.

3) Locality of supply

- Public sector organisations should be encouraged to look at their own estates for opportunities for growing energy crops for their own use.
- Energy managers of public sector buildings that already have biomass boilers or plan to install them should be encouraged to begin a dialogue with local farmers with a view to setting up a long term supply partnership.

4) Agri-Environmental Schemes

Future Agri-environmental schemes should provide energy crop growers with annual payments that recognise the multifunctional benefits provided by these crops. For instance:

- Incentives (points or payments) for the creation of tree shelterbelts and riparian woodland buffers
- Reward growers for water quality improvements
- Reward growers for biodiversity benefits
- Reward growers for Carbon sequestration
- Weighting of the points system to favour the targeting of these measures to the most effective location in the farmed landscape

5) CAP reform

Stakeholder groups such as NFU, Country Land and Business Association, Regen SW, Environment Agency, Natural England, and the RSPB should lobby the Government and the EU to allow energy crops to be planted as part of Ecological Focus Areas.

6) Energy crops infrastructure and processing

There needs to be a dedicated grant scheme for energy crops infrastructure and processing projects. Alternatively, future rounds of the Farming and Forestry Improvement Scheme or Rural Economy Grant should provide specific support for energy crops. Grants should be integrated with favourable terms for loans from the Green Investment Bank.

The following infrastructure is required:

- Planting and harvesting machinery
- Drying and processing equipment e.g. grading, pelleting, briquetting and granulating machinery

Grants for initial infrastructure projects should be up to 75% of the capital costs. 40% would be suitable for most infrastructure projects although an immediate one off 50% grant could stimulate a market for the 344 ha of miscanthus planted in Somerset.

7) Emissions

It is important that the new biomass boiler emissions targets do not hinder the energy crops sector. Innovation grants should be made available for boiler manufacturers to look at ways to cost effectively reduce particulates and NOx emissions from energy crops.

8) Dissemination of information

- Best practice guidelines brought up to date for miscanthus (particularly), SRC, SRF and broadleaf coppice
- Standardised contractor briefs for planting, rabbit fencing, spraying, harvesting – to increase standards
- There is a need for guidance on energy crop self supply so growers can understand issues with storage, transport and utilisation

MORE INFORMATION

Crops for Energy
www.crops4energy.co.uk

Energy Crops Scheme
www.naturalengland.org.uk/ourwork/farming/funding/ecs/default.aspx

Biomass Energy Centre
www.biomassenergycentre.org.uk

National Non Food Crops Centre
www.nnfcc.co.uk/bioenergy

UK Bioenergy Strategy
www.decc.gov.uk/en/content/cms/meeting_energy/bioenergy/strategy/strategy.aspx

Renewable Heat Incentive
www.ofgem.gov.uk/rhi

Regen SW
www.regensw.co.uk

South West Woodshed
www.southwestwoodshed.co.uk

Forest Programme
www.forestprogramme.com

ABOUT CROPS FOR ENERGY

Crops for Energy was set up in 2004 in order to provide balanced, authoritative and independent information to farmers, land owners, businesses and public sector organisations. With over 15 years experience of biomass and energy crops we are experts in the field. Examples of our work include:

Feasibility studies and project management

- For **Bristol City Council** - Feasibility studies on the potential of installing biomass boilers in five elderly people's homes and five primary schools. Also, successful in bidding for £375,000 of Government funding for biomass projects (Bioenergy Capital Grants Scheme and Bioenergy Infrastructure Scheme)
- For **Tredethick Farm Cottages –** Turnkey project management of the installation of a 200 kW district heating scheme and the planting of 5.7 ha of miscanthus to provide fuel for the boiler.
- For **Business West (Rural Focus)** - Provide advice and guidance and on-farm reviews as part of the South West Agricultural Resource Management (SWARM) programme. Through this and previous involvement in the SW Co-ordinated Woodfuel Initiative we have produced over 20 biomass boiler feasibility studies for farms, households and community buildings.
- For **East Midlands Airport** - Project management of planting 29 hectares of SRC willow over three years. Also, developing lesson plans to help disseminate renewable energy options to local schools.
- For **New Milton Sand and Ballast -** Helping develop biomass options for 60 hectares of farmland and restored landfill sites and creating markets for waste wood.
- For **WH White Ltd** – Project managing the planting of SRC willow on 30 hectares of restored landfill in Dorset.
- For **Bristol University** - Feasibility study looking at the potential for growing different energy crops on 75 hectares of farmland.
- For **Westwoods Woodfuel Producer Group** - Produced woodfuel tenders and negotiated contracts between 10 schools, offices and other public sector buildings and local woodfuel suppliers.
- Currently involved in RHI accreditation applications for a number of clients.

Woodfuel resource assessments

- For **Dorset Area of Outstanding Natural Beauty** – along with the Centre of Sustainable Energy we produced a technical report looking at current and future woodfuel supply and demand in Dorset.
- For **Bristol Airport** – evaluated the local woodfuel resource in the SW of England and identified suitable woodfuel suppliers for their proposed biomass boiler.
- For **Energy Action Devon** – along with the Centre of Sustainable Energy we evaluated the potential for woodfuel supply and demand from existing woodland, arboricultural arisings and energy crops in the South Devon area.

- For **FLOW Community Energy** – Energy crops resource assessment for the North Somerset communities of Failand, Long Ashton and Wraxall.

Training

- For **Duchy College** - Delivered numerous courses in the SW including the Ignite woodfuel course and other courses on energy crops and woodfuel self supply.
- For **Regen SW** - Produced online training modules on biomass site assessment. These can be viewed at: www.southwestwoodshed.co.uk/static/?page_id=765 .
- For **LANTRA Awards** - produced a two day accredited course on energy crops. The course is highly interactive and covers all aspects of energy crop growing, processing, supply and end use.

Research & development / Dissemination

- For **Teagasc** - Produced a booklet providing in depth information on UK and Swedish SRC willow varieties. This will be published in the summer of 2012.
- Published 13 articles on biomass and renewable energy in various publications including **Farmers' Weekly, Horticulture Week, Forestry and Timber News** and **The Guardian**. These can be read at:
  www.crops4energy.co.uk/index.php?option=com_content&view=article&id=50.
- Main author of two research papers outlining results from 20 years of SRC variety trials. These can be read at

  www.crops4energy.co.uk/files/pdfs/Trials.pdf

  www.crops4energy.co.uk/files/pdfs/AAB_paper_2011_final.pdf
- Currently researching and writing a book on woody energy crops for **CAB International**.

Principal, Kevin Lindegaard has held the previous positions:

- Senior Project Manager in Renewable Energy - **Centre for Sustainable Energy** (2008)
- Renewable Energy Development Officer - **Dorset County Council** (2005 - 2008)
- Technical Manager – **Lantmännen Renewable Fuels** (2003)
- SRC willow breeder – **Long Ashton Research Station** (1996 – 2002)