energy technologies institute

A report by the Energy Technologies Institute

# BIOENERGY CROPS IN THE UK: CASE STUDIES OF SUCCESSFUL WHOLE FARM INTEGRATION EVIDENCE PACK

RELB Refining Estimates of Land for Biomass

# Contents



# Key headlines

- All three case studies demonstrate that planting energy crops can increase the profitability of the land over a 23-year lifetime. Initial investment costs are expected to be paid back within the first six to seven years.
- When optimising the use of land across the farm, impacts on food production can be minimised or avoided. In two case studies, food impacts were minimised by using land which delivered poor arable yields, and by minimising the reduction in sheep numbers through higher stocking densities (the number of sheep per hectare). In the third case study, the crop was planted on unused land so no food production was displaced.
- Land which is less suitable for food production or grazing can be suited to energy crops as they can be successfully planted on poorer quality soils, and land which is more prone to waterlogging or weed problems. They are also suited to less accessible fields as they require less intensive management than arable crops.
- The farmers in these case studies chose to grow energy crops for a variety of reasons – making better use of difficult or underutilised land, diversifying income and reducing workload. In addition, all farmers cited the importance of obtaining secure fixed-term contracts with buyers in their decision making. This reinforces findings from previous ETI work on enabling UK biomass.
- Discussions with land agents suggest that land used to grow biomass crops should not be valued differently to other agricultural land, as land should be valued on its productive capacity. However, the specific price offered by a buyer will be affected by their objectives in buying the land and their understanding of bioenergy crops. The presence of a profitable contract for the crop and a willingness from the buyer to continue with bioenergy cropping may have a beneficial impact on the land value. If the buyer wishes to change the land use, is uncertain how to manage a bioenergy crop, or if there are limited market outlets for the crop, the land value may be lower than if it weren't planted with a bioenergy crop.
- Qualitative evidence from the Miscanthus farmers indicate an increase in wildlife, particularly birds, since growing the crop. In the Short Rotation Coppice (SRC) Willow case study, the farm carried out an Environmental Impact Assessment (EIA) before planting.

# Context

## Why bioenergy?

Bioenergy can play a significant and valuable role in the future UK energy system, helping reduce the cost of meeting the UK's 2050 greenhouse gas (GHG) emissions reduction targets by more than 1% of gross domestic product (GDP).

The ETI's internationally peer-reviewed Energy System Modelling Environment (ESME), a national energy system design and planning capability, suggests that bioenergy, in combination with Carbon Capture and Storage (CCS), could provide around 10% of projected UK energy demand whilst delivering net negative emissions of approximately -55Mt $CO_2$ per year in the 2050s. This is roughly equivalent to half the UK's emissions target in 2050 and reduces the need for other, more expensive, decarbonisation measures. Even in the absence of CCS, bioenergy is still a cost-effective means of decarbonisation and should play an important role in meeting the 2050 emissions target.

## How much change is required?

Delivering 10% of projected energy demand in the 2050s will require around three times as much bioenergy to be generated as today[1]. Bioenergy is already the largest source of renewable energy in the UK using a mixture of wastes, UK-grown biomass and imported biomass feedstocks. Historically, waste feedstocks have been the dominant bioenergy feedstock source, but to meet the 2050s target the increase in feedstock is expected to come primarily from imported and domestic biomass.

Currently the contribution of UK-grown second generation (2G) energy crops (perennial grasses and woody crops such as Miscanthus, Short Rotation Coppice (SRC) Willow and Short Rotation Forestry) is small, with only 10kha grown in England[2] and 0.5kha grown in other parts of the UK. Including first generation energy crops, such as oilseed rape used to make transport fuels, the total area of energy crops in the UK is 122kha. By comparison, in 2015, the UK grew 1,832kha of wheat[3]. The ETI's recent insights paper, 'Delivering greenhouse gas emission savings through UK bioenergy value chains'[4] demonstrated that UK grown 2G biomass feedstocks can deliver genuine system-level carbon savings across heat, power and fuel production, both with and without CCS. Our insights paper suggested that the UK could deliver significant volumes of biomass by the 2050s by planting 30kha of 2G bioenergy crops each year (~1.2Mha of new planting by 2055, which together with the existing area of energy crops, brings the total area to ~1.4Mha); a steady increase which would maximise the opportunity for the sector to 'learn by doing' – developing and sharing best practice knowledge.

## What drives farmers to plant 2G bioenergy crops?

The ETI's Enabling UK Biomass project[5] surveyed over 100 farmers about the motivations behind their decision to plant energy crops. This found that farmers most often chose to plant energy crops to make more productive use of low quality land in order to generate a higher profit from that land. The availability of long-term contracts was also often an important factor in their decision making.

## The Case Studies

To understand more about how farmers have integrated 2G energy crops into their wider farm business, the ETI commissioned ADAS[6] to carry out three case studies of successful transitions to 2G energy crops, examining the financial impact of the crop and understanding how farmers have optimised the way they use their land to minimise any impact on food production. This document provides the evidence behind each case study and details how the financial costs and benefits and food production changes were calculated. A summary of the case studies is provided in the accompanying ETI Perspective.

1 BEIS (2016). Digest of UK Energy Statistics (DUKES). Available from: https://www.gov.uk/government/collections/digest-of-uk-energy-statistics-dukes

2 Defra (2015). Area of crops grown for bioenergy in England and the UK. Available from: https://www.gov.uk/government/statistics/area-of-crops-grown-for-bioenergy-in-england-and-the-uk-2008-2014

3 Defra (2015). Structure of the agricultural industry in England and the UK at June. Available from: https://www.gov.uk/government/statistical-data-sets/structure-of-the-agricultural-industry-in-england-and-the-uk-at-june

4 ETI (2016). Delivering greenhouse gas emission savings through UK bioenergy value chains. Available from: http://www.eti.co.uk/delivering-greenhouse-gas-emission-savings-through-uk-bioenergy-value-chains/

5 ETI (2015). Enabling UK Biomass. Available from: http://www.eti.co.uk/bioenergy-enabling-uk-biomass/

6 ADAS. http://www.adas.uk/

# What are second generation energy crops?

Second generation (2G) energy crops are perennial grasses, such as Miscanthus, and woody crops including SRC Willow.

Miscanthus is a perennial energy crop that can grow to heights of 8-12ft. Rhizomes (an underground stem or bulb) are planted in spring at a density of 10,000 – 15,000 per hectare. After its first year of growth it can be harvested annually for biomass for 20 years or more. New shoots emerge around March each year, growing rapidly in June-July, producing bamboo-like canes. The Miscanthus dies back in the autumn/winter, when the leaves fall off, providing nutrients for the soil, and the dry canes are harvested in winter or early spring. It can be grown successfully on marginal land in all soil types, in both wet and dry conditions[7].

Willow (Salix spp.) is planted as rods or cuttings in spring using specialist equipment at a density of around 15,000 per hectare. The willow stools readily develop multiple shoots when coppiced and several varieties have been specifically bred with characteristics well suited for use as energy crops. During the first year it can grow up to 13ft in height, and is then cut back to ground level in its first winter to encourage it to grow multiple stems. The first crop is harvested in winter, typically three years after being cut back, again using specialist equipment. The crop is harvested every three years subsequently, giving a total of seven harvests over a typical 23-year crop life[8].

7 Biomass Energy Centre. Miscanthus. Available from: http://www.biomassenergycentre.org.uk/portal/page?_pageid=75,18204&_dad=portal&_schema=PORTAL

8 Biomass Energy Centre. SRC Willow. Available from: http://biomassenergycentre.org.uk/portal/page?_pageid=75,18112&_dad=portal&_schema=PORTAL

# Summary of case study findings

Table 1

| The farm | Friars Farm | Abbey Farm | Brackenthwaite Farm |
|---|---|---|---|
| Farmer | David and Chris Sargent | Bill Lewis | Terry Dixon |
| Location | Norfolk | Norfolk | Cumbria |
| Size of farm (ha) | 734 | 473 | 323 |
| Energy crop planted | Miscanthus | Miscanthus | SRC Willow |
| Area (ha) | 18.4 | 30.0 | 29.5 |
| Year planted | 2010 & 2011 | 2013 & 2015 | 2015 |
| Counterfactual land use | Arable | Sheep | Surplus (rental + Higher Level Stewardship (HLS) scheme income) |
| **The Buyer** | | | |
| Buyer | Terravesta | | Iggesund |
| Use | Converted to pellets for use in the heat and power sector | | SRC Willow chips are used to power Iggesund's 50MW Combined Heat and Power (CHP) plant |
| Contract length | 5-year, index-linked contract | 10-year, index-linked contract | 22-year (7 harvests – harvested every 3 years once established), index-linked contract |
| **Finance** | | | |
| Establishment cost (£/ha) | £2,153 | £2,151 | £1,739 |
| Planting grant (Energy Crops Scheme) | Yes – 50% of establishment costs | Yes – 50% of establishment costs | No |
| Lifetime of crop (years) | 23 | 23 | 23 |
| Payback period (years) | 7 | 6 | 7 |
| Change in Equivalent Annual Net Margin of land planted with 2G bioenergy crop (£/ha/yr) | +£403 | +£214 | +£185 |
| **Food** | | | |
| Food impact minimisation strategy | The crop was planted on economically marginal arable land which yielded less than half national yield for arable crops | The farm intensified sheep production to minimise the reduction in flock size. Moved from 600 ewes on 90ha to 500 ewes on 60ha | Land was surplus to requirement so no actual food production was displaced |
| **Biodiversity** | | | |
| On-farm biodiversity impacts (reported) | Both farms reported an increase in wildlife, particularly birds | | It is too early to see any effects |
| Environmental Impact Assessment undertaken? | No | No | Yes – permission granted by the Forestry Commission |

# Growing Miscanthus at Friars Farm
## Generating a reliable income from economically marginal land

## The problem
David Sargent and his brother, Chris, manage 734ha of land at Friars Farm in Norfolk. While the majority of the land is arable, the farm also comprises around 80ha of grassland, 80ha of woodland, as well as land for duck and pig farming. On the arable land, an area of the farm suffers from difficult soils (heavy clays and gravel) and a rabbit problem, which has hampered past efforts to produce both arable crops and grass, making the land uneconomic to farm.

## The solution
After learning about Miscanthus at the Cereals event (an annual farming event to promote new technologies and ideas), the Sargents planted two fields with Miscanthus in 2010, with a further three fields planted in 2011, totalling 18.4ha. They obtained a grant for 50% of the establishment costs under the Energy Crop Scheme (ECS).

## Impact
Based on yields to date, and an expected future yield profile, the Miscanthus crop is expected to payback after 7 years. It is estimated that, over the 23-year lifetime of the crop, the equivalent annual net margin of the land will be £403/ha/yr higher than if the land had continued under an arable rotation. There has been little impact on food production because the Miscanthus was planted on the poorest yielding arable land which was uneconomic to farm without subsidies.

Planting Miscanthus has fitted into the wider farm well and enabled the Sargents to generate a reliable income from this previously uneconomic land. David comments:

> "We've tried growing a variety of different crops on my awkward fields, but they actually became a cost to the farm business because they were so inefficient. The fields were making a loss, so we were bold and tried Miscanthus and haven't looked back. We now farm 18.4 hectares of Miscanthus on our marginal land, and it's making a reliable income."

## Financial comparison
A discounted cash flow was used to compare the costs and revenues of planting Miscanthus over its 23-year lifetime with the counterfactual land use (arable rotation). The assessment did not include any Basic Payment Scheme (BPS) payments under the Common Agricultural Policy (CAP) as the land is eligible for the same level of subsidy under both scenarios.

This section sets out the data used in each cash flow and presents the results of the cash flow comparison.

### The counterfactual – arable rotation
For this analysis, the assumption was made that the land would be planted in a five year rotation of:

wheat, wheat, oilseed rape, wheat, oats

Due to the poor yields previously obtained on this land, it was assumed that the yield for each crop would be 50% of the average UK yield between 2010 and 2014[9]. Growing costs were based on the 2013/14 Farm Business Survey (FBS)[10]. Arable prices for wheat and oats were based on Defra commodity price statistics[11]. For oilseed rape, AHDB (Agricultural and Horticultural Development Board) market data were used[12]. It was assumed that there would be no impact on wider farm overheads given the limited land area involved.

Table 2 shows that the arable crop rotation makes a loss before BPS payments.

**Table 2**
Estimated net margin from arable cropping at Friars Farm (2015 prices – excl. BPS payments)

| £/ha/yr | Winter Wheat | Oilseed Rape | Spring Oats | Weighted Average |
|---|---|---|---|---|
| Revenue | 576 | 549 | 391 | 534 |
| Materials cost | 391 | 371 | 283 | 365 |
| Planting, management and harvesting costs | 262 | 258 | 250 | 260 |
| **Net margin** | **–77** | **–81** | **–142** | **–91** |

9 Defra (2016). Agriculture in the UK datasets. Available at: https://www.gov.uk/government/statistical-data-sets/agriculture-in-the-united-kingdom
10 Farm Business Survey. Available at: http://www.farmbusinesssurvey.co.uk/
11 Defra, Commodity Prices. Available at: https://www.gov.uk/government/statistical-data-sets/commodity-prices
12 AHDB, Market Data Centre. Available at: http://cereals-data.ahdb.org.uk/demand/physical.asp

## Growing Miscanthus

The Terravesta contract

The Miscanthus was initially established and maintained by International Energy Crops (IEC), but the farm's current contract is a 5-year index-linked contract with Terravesta, a company with a network of growers who sell Miscanthus to the UK heat and power markets.

Under the contract, the Sargents are responsible for harvesting, baling and loading the crop while Terravesta arrange haulage as well as providing advice and support to growers. Crop and bale specifications need to be met and adjustments are made to the sale price depending on moisture content and contamination, providing an incentive to growers to establish the crop well and carefully manage the harvesting operations.

Establishing the crop

The establishment period for Miscanthus is three years (pre-planting, planting, and post-planting). Using data from Friars Farm, the establishment costs were calculated to be £2,153/ha (actual cost in 2010/11 prices). As shown in Figure 1, nearly three-quarters of the cost is associated with buying and planting the Miscanthus rhizomes. In this case, the majority of the remaining cost was spent erecting rabbit fencing, which protects the crop during the establishment phase. Table 3 shows when the costs were incurred over the establishment period.

The Miscanthus was planted with the assistance of an Energy Crop Scheme (ECS) grant, a government funded scheme (now closed) which paid 50% of the cost of establishing the Miscanthus crop, with the remainder paid by the farm business.

Operational Costs

Table 4 shows the operational costs (in 2015 prices) incurred by the farmer after the establishment period. Under the contract with Terravesta the farmer must harvest, bale and load the Miscanthus. Terravesta arrange for haulage from the farm and deduct the cost from the gross price. The gross price paid by Terravesta is dependent on the moisture content of the crop; therefore, in 2015, the Sargents chose to dry the Miscanthus for one week using their grain dryer during the daytime only. An estimated cost for this process is included in Table 4.

**Figure 1**
Establishment costs for Friars Farm (farm data – 2010/11 prices) (£/ha)

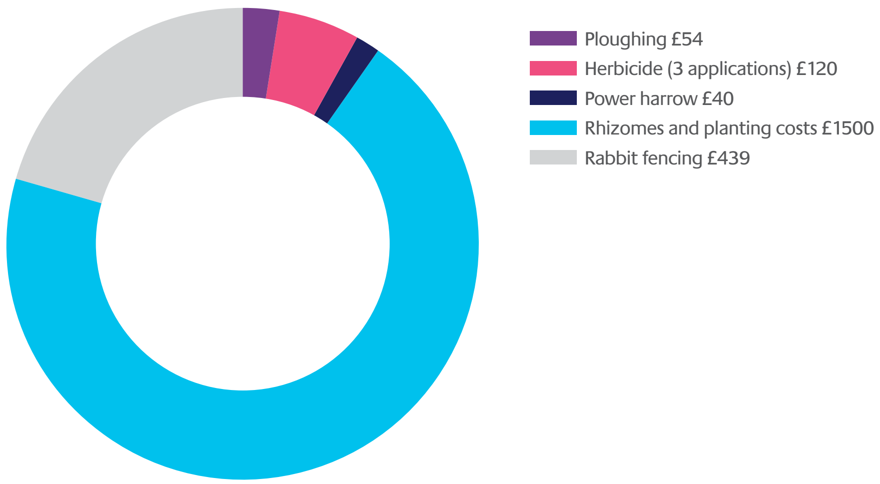



**Table 3**
Friars Farm – establishment costs over time (farm data – 2010/11 prices) (£/ha)

| Item (£/ha) | Year 0 (pre-planting) | Year 1 (planting) | Year 2 (post-planting) |
|---|---|---|---|
| Ploughing | 54 | | |
| Herbicide | 40 | 40 | 40 |
| Power Harrow | | 40 | |
| Rabbit Fencing | | 439 | |
| Rhizomes and planting costs | | 1,500 | |
| **Annual Total** | **94** | **2,019** | **40** |
| **Total over 3-year establishment period** | **2,153** | | |

**Table 4**
Operational costs for Miscanthus grown at Friars Farm (2015 prices)

| Item (2015 prices) | Cost | Lifetime cost (per ha) | Assumptions/Data Source |
|---|---|---|---|
| Harvesting | £60/ha | £1,200 | 20 harvests. Farm data |
| Bale and load | £10/bale | £4,768 | 20 harvests and 600kg/bale. Farm and Terravesta data |
| Drying costs | £1.50/bale | £715 | Farm estimate |
| Transport | £16.40/fresh tonne | £4,692 | 20 harvests – arranged by Terravesta. Deducted from gross price paid. Terravesta data |
| Miscellaneous | £15/ha/yr | £345 | ADAS estimate |
| Return to arable production (after 23 years) | £100/ha | £100 | ADAS estimate – spray and heavy discing |
| **Total operational cost (£/ha)** | | **£11,820** | |

Income

In 2015, the gross price paid by Terravesta was £73.80/fresh tonne which included a Movement and Barn bonus of £1.80/ fresh tonne, that the Sargents earned by storing the crop in a straw barn until midsummer when it was more convenient for Terravesta to collect it. This price (adjusted for inflation) was used in the discounted cash flow and applied to the yield profile in Figure 2. The yield profile is based on actual yields to date (Table 5), information from Terravesta and evidence from previous ETI projects which examined Miscanthus yield profiles.

In 2014, the yields were impacted by a very dry season and it is expected that this will be the case periodically over the lifetime of the crop. As the crop was planted in 2010/11 it is now reaching the end of its establishment phase and the Farms Advisory Manager at Terravesta anticipates that peak yield will be around 15-16 fresh tonnes per hectare across this site, taking into account location, soil type, and some areas of poorly established crop. Terravesta expects that the crop should be able to maintain this yield for the remainder of the lifetime of the crop. However, based on information from ETI's Enabling UK Biomass project, the yield profile used in the cash flow assumes a gradual decline in yield from Year 14.

**Figure 2**

Miscanthus yield profile used in cash flow analysis

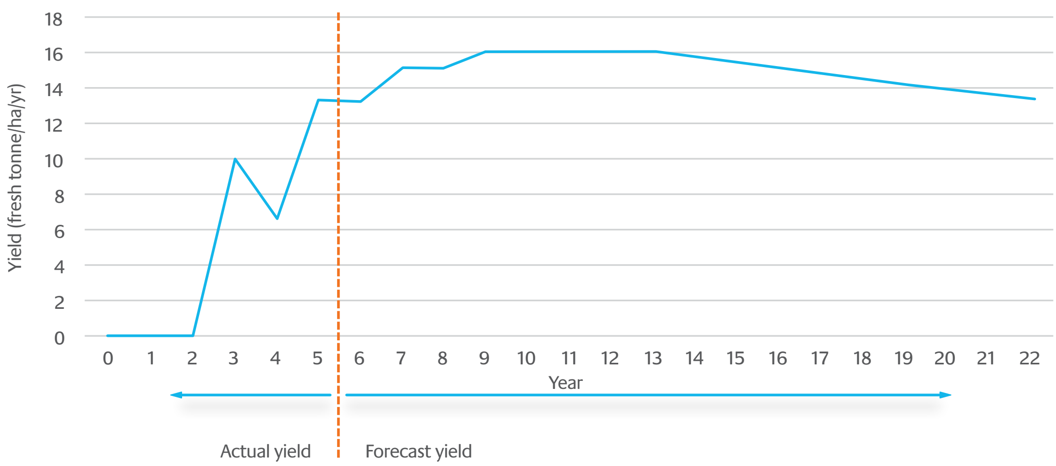



**Table 5**

Friars Farm – Miscanthus yields, 2013-2015

| Year | Yield (fresh tonnes/ha) |
|---|---|
| 2013 | 10.1 |
| 2014 | 6.7 |
| 2015 | 13.4 |

**Financial comparison**

A discounted cash flow forecast for both the displaced land use (arable cropping) and the Miscanthus crop was used to provide an assessment of the net economic return from planting Miscanthus.

Key assumptions:

- Cash flow covers 23 years (the lifetime of the Miscanthus crop from land preparation to land remediation including 20 harvests)
- Inflation rate is 2% per annum (based on November 2015 OBR forecast for CPI inflation)[13]
- Discount rate is 5% (based on November 2015 OBR forecast for bank rate plus 3% risk)[14]
- Cash flow does not include any Basic Payment Scheme (BPS) payments under the Common Agricultural Policy (CAP) as the land is eligible for the same level of subsidy under both scenarios

Table 6 and Figures 3 and 4 show that continuing with the arable rotation would result in the land making a loss (before BPS payments). Switching to Miscanthus results in the land generating a profit and is expected to increase the Equivalent Annual Net Margin of the land by £403/ha/yr. The investment in establishing the Miscanthus crop is projected to payback after 7 years taking into account the ECS grant received. Without the ECS establishment grant, the payback time would be expected to be 10 years (Table 6 and Figure 4).

**Table 6**

Summary of the economic analysis comparing Miscanthus and arable cropping (excl. BPS payments)

| 23 years (2% inflation, 5% discount rate) | Miscanthus (with ECS) | Miscanthus (without ECS) | Arable Rotation |
|---|---|---|---|
| Net Present Value (18.4 ha) | +£76,395 | +£56,782 | -£28,415 |
| Internal Rate of Return | 25% | 15% | |
| Payback Period | 7 years | 10 years | |
| Equivalent Annual Net Margin | +£294/ha/yr | +£218/ha/yr | -£109/ha/yr |
| **Change in Equivalent Annual Net Margin** | **+£403/ha/yr** | **+£328/ha/yr** | |

13 Office of Budget Responsibility, Economic Forecasts. Available at: http://budgetresponsibility.org.uk/publications/

14 ibid

**Figure 3**
Discounted net margin (£/yr) of Arable and Miscanthus planting (with and without ECS) across the 18.4ha planted

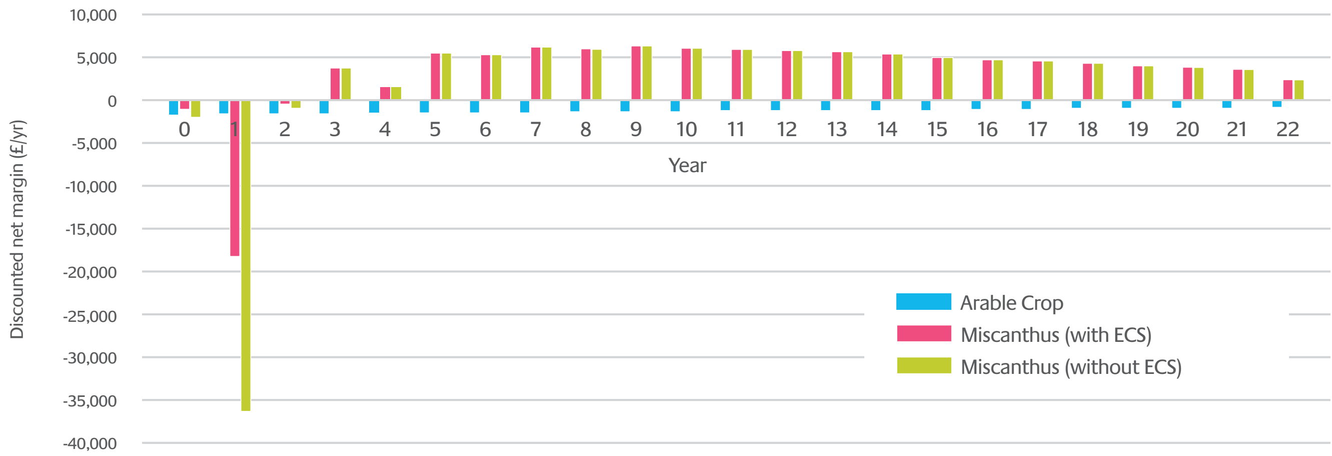
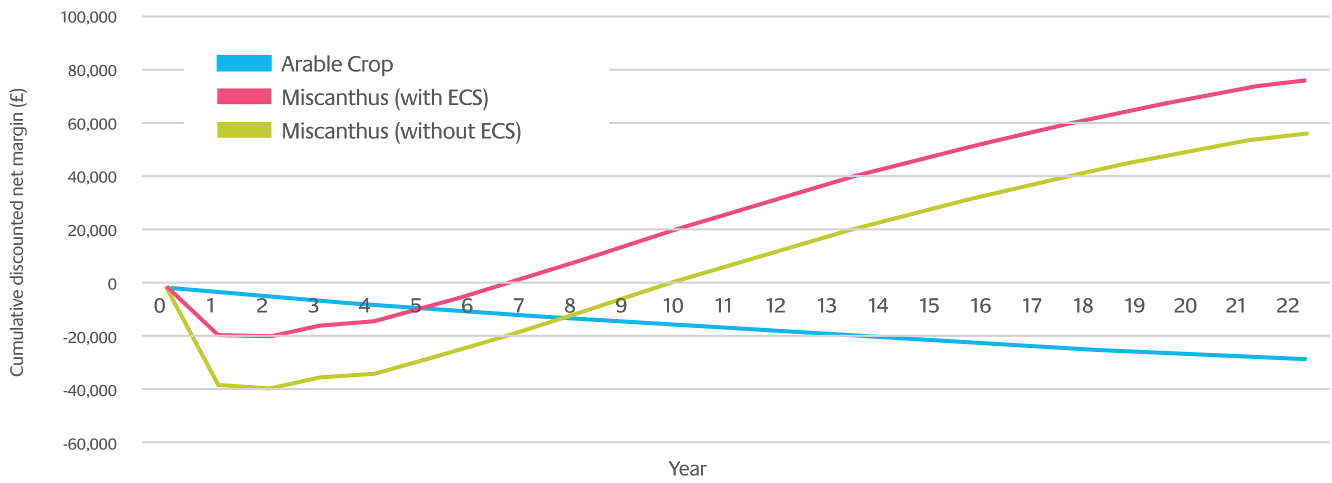



**Figure 4**
Cumulative discounted net margin (£) of Arable and Miscanthus planting (with and without ECS) across the 18.4ha planted




## Minimising food production impacts

The loss in food production by converting land to Miscanthus has been proportionately less than the reduction in the arable cropped area because the land now planted with Miscanthus had previously achieved much lower arable yields than the rest of the farm due to the difficult soils and rabbit problems.

Based on the counterfactual, which assumed a 5-year rotation of wheat, wheat, oilseed rape, wheat and oats achieving 50% of the UK average yield[15] (calculated between 2010 and 2014), planting Miscanthus has displaced 58.4 tonnes of food crops per year (Table 7). The 18.4ha planted with Miscanthus represents 3% of the total cropped area of the farm. Given that this land was the poorest yielding arable land, delivering less than half the expected yield, the total reduction in farm food production as a result of planting Miscanthus is much less than 3%.

## Biodiversity Impacts

No specific monitoring of biodiversity has been undertaken in relation to the Miscanthus crop but anecdotal evidence suggests that wildlife, especially birds, have become more abundant since planting the crop.

None of the land planted with Miscanthus was previously under any Environmental Stewardship scheme but 15ha of other land on the farm is part of a Higher Level Stewardship (HLS) scheme.

## Wider farm impacts

David Sargent feels that Miscanthus has fitted in well with the wider farm business as it is harvested at a different time of year to the arable crops. He has also identified synergies with other parts of the business, including storing the Miscanthus prior to haulage in a straw barn which is not otherwise used at that time of year, enabling the Sargents to earn the additional Movement and Barn bonus of £1.80/fresh tonne, and using the grain dryer to dry the Miscanthus. The crop was successfully dried in 2015 for one week (with the driers running in daytime only) and David aims to repeat this next year and monitor costs.

## Conclusion

Planting Miscanthus has enabled the Sargents to generate a reliable income from previously unprofitable land. By siting the crop in the poorest yielding parts of the arable farm, impacts on food production have been minimised.

**Table 7**
Estimated food production under counterfactual land scenario

| | Winter wheat | Oilseed rape | Spring Oats |
|---|---|---|---|
| Average area of crop across the rotation (ha) | 11.0 | 3.7 | 3.7 |
| Assumed yield (tonnes/ha/yr) | 3.80 | 1.74 | 2.77 |
| **Total food production displaced (tonnes/yr)** | **41.8** | **6.4** | **10.2** |

15 Defra, Agriculture in the UK data sets. Available at: https://www.gov.uk/government/statistical-data-sets/agriculture-in-the-united-kingdom

# Growing Miscanthus at Abbey Farm
## Optimising land use to increase productivity

### The problem
Bill Lewis and his family manage 473ha of land at Abbey Farm in Norfolk. The farm is a family-run business and is largely comprised of arable crops along with pasture for sheep grazing. In addition, 49ha of land is let to an independent pig company. Over recent years the family have been looking for ways to make the farm more efficient and reduce the overall workload, in particular making productive use of a part of the farm which is low lying and floods in winter making it unproductive for arable cropping and poor as grassland.

### The solution
In 2013, with the assistance of an Energy Crop Scheme (ECS) grant which paid for 50% of the establishment costs, 15ha of temporary grassland were planted with Miscanthus with a further 15ha added in 2015. At the same time Bill changed the management of his sheep flock, moving from a flock of 600 ewes grazing 90ha of land to 500 ewes on 60ha.

### Impact
The first harvest from the 2013 crop was in 2015 and recorded a yield of 8.82 fresh tonnes per hectare, which, according to the Farms Advisory Manager at Terravesta, is the largest yield documented to date for a second year crop.

Based on actual and forecast yields, the Miscanthus crop is expected to payback 6 years after converting the land. The combination of planting Miscanthus and intensifying livestock management is calculated to increase the equivalent annual net margin of the 30ha planted with Miscanthus by £214/ha/yr.

Bill feels that the crop has fitted in well with the wider farm business, allowing a reduction in sheep numbers, making the enterprise more efficient and reducing the overall workload.

### Financial Comparison
A discounted cash flow was used to compare the costs and revenues of planting Miscanthus over its 23-year lifetime with the counterfactual land use (sheep farming). The assessment did not include any Basic Payment Scheme (BPS) payments under the Common Agricultural Policy (CAP) as the land is eligible for the same level of subsidy under both scenarios.

This section sets out the data used in each cash flow and presents the results of the cash flow comparison.

**The counterfactual – sheep farming**

To release the land for Miscanthus growing, Bill Lewis decided to intensify his sheep farming operation by moving from a flock of 600 breeding ewes on 90ha (equivalent to 6.67 ewes/ha), to 500 ewes on 60ha (8.33 ewes/ha). Therefore the counterfactual scenario is the difference in net income from sheep farming before and after Miscanthus planting. Table 8 is based on farm financial records and shows how the reduction in sheep numbers and the change in management practice have affected revenues and costs associated with sheep farming.

The reduction in the number of sheep from 600 to 500 has reduced income from lamb and cull (ewe) sales as well as wool. However, there has also been a reduction in fixed costs (wages and machinery operation & maintenance costs) due to the reduced workload and some variable costs associated with replacement stock and maintaining 30ha of grassland (the area now planted with Miscanthus) have also decreased. However, some variable costs have risen as the intensification of grazing coupled with the earlier finishing of lambs (more creep feeding and worming) has increased the need for feed and vet costs.

Overall, Table 8 shows that the reduction in the size of the sheep flock has reduced the net income from sheep farming by £5,552/yr. Apportioning this across 30ha of land means that the displaced land use has a net margin of +£185/ha/yr (based on farm financial records – market prices are assumed to be constant between years).

**Table 8**
Changes in revenue and costs associated with sheep farming before and after planting Miscanthus (based on farm financial records – assuming market prices stay constant between years 2013 – 2015)

| | Assumptions | Before | After | Net Change |
|---|---|---|---|---|
| **Flock** | | | | |
| Breeding ewes | | 600 | 500 | -100 |
| Rams | | 13 | 11 | -2 |
| Replacements (per year) | | 110 | 90 | -20 |
| Lamb sales | | 1,020 | 875 | -145 |
| **Annual income** | | | | |
| Lamb sales | £85/lamb | £86,700 | £74,375 | -£12,325 |
| Cull sales | £100/sheep | £10,560 | £8,640 | -£1,920 |
| Wool | ~1.7kg per sheep @£1.08/kg | £1,361 | £1,134 | -£227 |
| **Total change in annual income** | | | | **-£14,472** |
| **Annual variable costs** | | | | |
| Replacements | £113/sheep | £12,375 | £10,125 | -£2,250 |
| Home-grown feed | | £3,000 | £4,000 | £1,000 |
| Purchased feed | | £3,000 | £4,000 | £1,000 |
| Vet and medicine costs | | £1,100 | £1,200 | £100 |
| Other livestock costs | | £750 | £2,000 | £1,250 |
| Fertilisers (30ha) | | £4,500 | £0 | -£4,500 |
| Crop protection – herbicide (30ha) | | £600 | £0 | -£600 |
| Other crop costs – fertiliser distribution and rolling | | £120 | £0 | -£120 |
| **Annual fixed costs** | | | | |
| Wages | Farmer estimate | | | -£3,000 |
| Machinery repairs | Reduced Fieldwork | | | -£1,000 |
| Machinery fuel and oil | Reduced Fieldwork | | | -£800 |
| **Total change in costs** | | | | **-£8,920** |
| **Net change in margin resulting from change in sheep farming management** | | | | **-£5,552** |

## Growing Miscanthus

The Terravesta Contract
Bill Lewis has signed a 10-year index-linked contract with Terravesta for his Miscanthus crop.

Under the contract the Lewis family are responsible for harvesting, baling and loading the crop while Terravesta arrange haulage as well as providing advice and support to growers. Crop and bale specifications need to be met and adjustments are made to the sale price depending on moisture content and contamination, providing an incentive to growers to establish the crop well and carefully manage the harvesting operations.

Establishing the crop
Using actual data from Abbey Farm (averaged across the 2013 and 2015 plantings) the establishment costs were calculated to be £2,151/ha. As shown in Figure 5, 85% of the establishment costs were associated with purchasing and planting the Miscanthus rhizomes. Table 9 shows when the costs were incurred over the establishment period.

Bill Lewis benefited from an Energy Crop Scheme (ECS) grant, which paid 50% of the establishment costs.

**Figure 5**
Establishment costs for Abbey Farm (average of farm data from 2013 & 2015 planting £/ha)

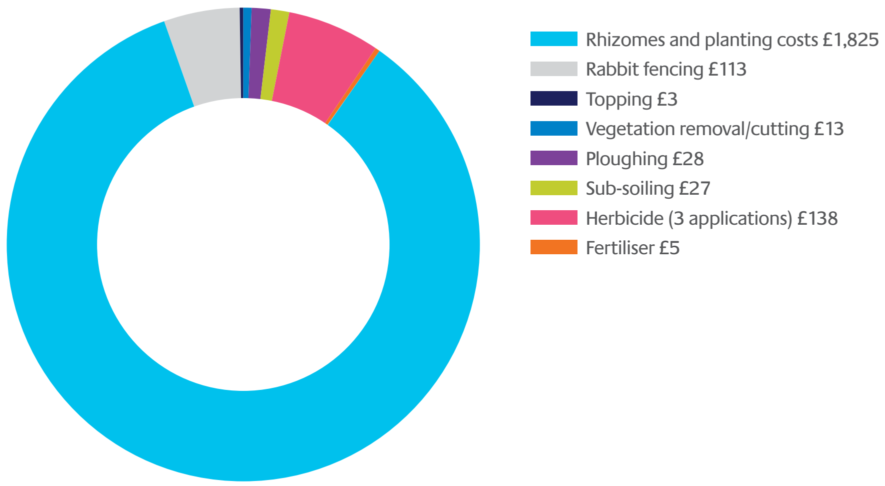


**Table 9**
Abbey Farm – establishment costs over time (average of farm data – 2013 & 2015 prices £/ha)

| Item (£/ha) | Year 0 (pre-planting) | Year 1 (planting) | Year 2 (post-planting) |
|---|---|---|---|
| Vegetation removal/cutting | 13 | | |
| Ploughing | 28 | | |
| Herbicides | 46 | 46 | 46 |
| Sub-soiling | | 27 | |
| Rhizomes and planting costs | | 1,825 | |
| Rabbit fencing | | 113 | |
| Fertiliser | | 5 | |
| Topping | | | 3 |
| **Annual Total** | **87** | **2,016** | **49** |
| **Total over 3-year establishment period** | | **2,151** | |

In addition to the establishment costs associated with the crop itself, there was a one-off investment of £600 in barn repairs to store the crop. This cost was incurred in Year 2 and is included in the discounted cash flow.

Operational Costs
Table 10 shows the operational costs incurred by the farmer after the establishment period. Under the contract with Terravesta the farmer must harvest, bale and load the Miscanthus. Terravesta arrange for haulage from the farm and deduct the cost from the gross price.

**Table 10**
Operational costs for Miscanthus grown at Abbey Farm (2015 prices)

| Item (2015 prices) | Cost | Lifetime cost (per ha) | Assumptions / Source |
|---|---|---|---|
| Harvesting | £60/ha/harvest | £1,200 | 20 harvests. Farm data |
| Baling | £9/bale | £4,881 | 20 harvests and 600kg/bale. Farm and Terravesta data |
| Loading | £20/ha/harvest | £400 | 20 harvests. Terravesta data |
| Transport | £16.60/fresh tonne | £5,402 | 20 harvests – arranged by Terravesta and deducted from gross price paid. Terravesta data |
| Miscellaneous | £10/ha/yr | £230 | ADAS estimate |
| Return to sheep production (after 23 years) | £100/ha | £100 | ADAS estimate – spray and heavy discing |
| **Total operational cost (£/ha)** | | £12,213 | |

Income
In 2015, the gross price paid by Terravesta was £73.80/fresh tonne which included a Movement and Barn bonus of £1.80/fresh tonne which was added because the crop was stored in the lambing barns until midsummer when it was more convenient for Terravesta to collect it. This price (adjusted for inflation) was used in the discounted cash flow and applied to the yield profile in Figure 4. The yield profile is based on the first year yield data, information from Terravesta and evidence from previous ETI projects which examined Miscanthus yield profiles.

The first harvest from the 2013 crop yielded a record 8.82 fresh tonnes per hectare and the Farms Advisory Manager at Terravesta anticipates that the peak yield will be around 18 fresh tonnes per hectare. Based on this information and previous analysis of Miscanthus yield profiles, Figure 6 shows the yield profile used to calculate revenue from the Miscanthus crop in the discounted cash flow.

## Financial comparison

A discounted cash flow forecast for both the displaced land use (sheep farming) and the Miscanthus crop was used to provide an assessment of the net economic return from growing Miscanthus.

Key assumptions:

- Cash flow covers 23 years (the lifetime of the Miscanthus crop from land preparation to land remediation including 20 harvests).
- Inflation rate is 2% per annum (based on November 2015 OBR forecast for CPI inflation)[16]
- Discount rate is 5% (based on November 2015 OBR forecast for bank rate plus 3% risk)[17]
- Cash flow does not include any Basic Payment Scheme (BPS) payments under the Common Agricultural Policy (CAP) as the land is eligible for the same level of subsidy under both scenarios

Table 11 and Figures 7 and 8 show that switching to Miscanthus is expected to increase the Equivalent Annual Net Margin of the land by £214/ha/yr and the investment in establishing the Miscanthus crop is expected to payback after 6 years. Without the ECS establishment grant, the payback time would be expected to be 8 years. Figure 8 also shows that cumulative net margin of Miscanthus exceeds that of sheep farming after 10 years (with ECS) and after 13 years (without ECS).

Adjusting only the discount rate, over a 23-year lifetime the Net Present Value (NPV) for Miscanthus (with the ECS grant) remains higher than the displaced land use (sheep farming) at discount rates up to 13%. Without the ECS grant, the tipping point is lower at around 8%.

**Figure 6**
Miscanthus yield profile used in cash flow analysis

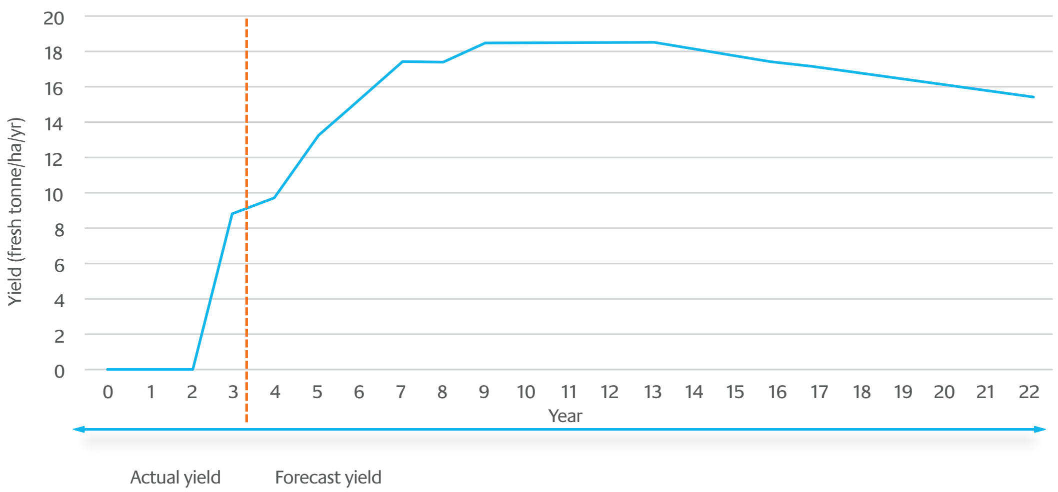



**Table 11**
Summary of the economic analysis comparing Miscanthus and sheep farming (excl. BPS payments)

| 23 years (2% inflation, 5% discount rate) | Miscanthus (with ECS) | Miscanthus (without ECS) | Sheep farming |
|---|---|---|---|
| Net Present Value (30ha) | +£185,607 | +£153,805 | +£94,554 |
| Internal Rate of Return | 32% | 20% | |
| Payback Period | 6 years | 8 years | |
| Equivalent Annual Net Margin | +£437/ha/yr | +£362/ha/yr | +£223/ha/yr |
| **Change in Equivalent Annual Net Margin** | **+£214/ha/yr** | **+£139/ha/yr** | |

16 Office of Budget Responsibility, Economic Forecasts. Available at: http://budgetresponsibility.org.uk/publications/
17 ibid

**Figure 7**
Discounted net margin (£/yr) of sheep farming and Miscanthus planting (with and without ECS) across the 30ha planted

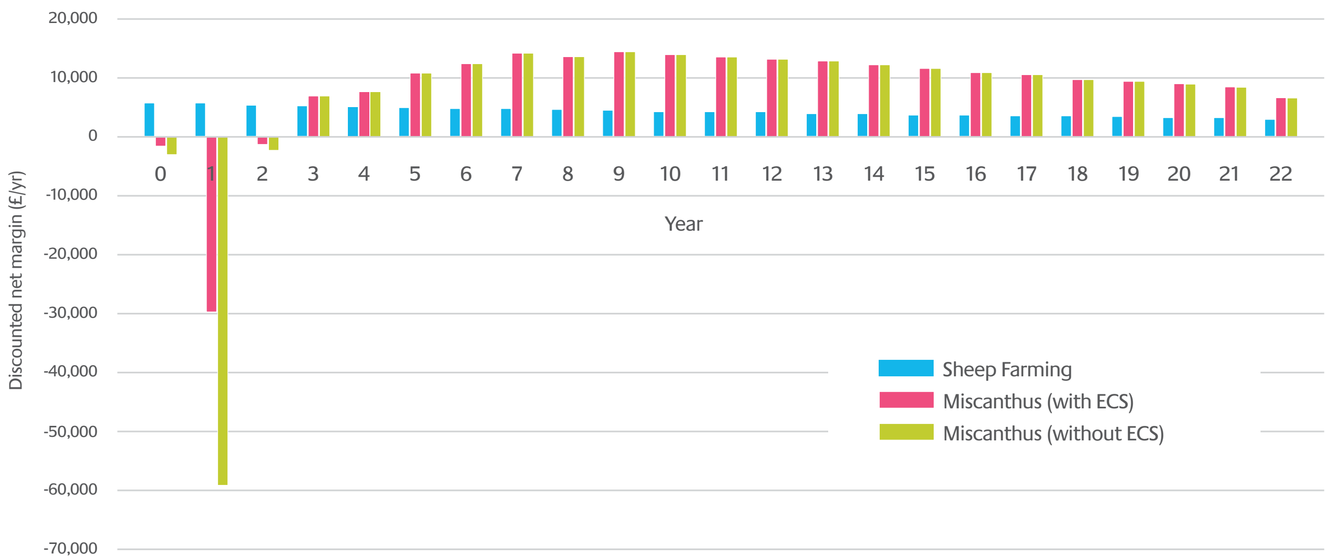
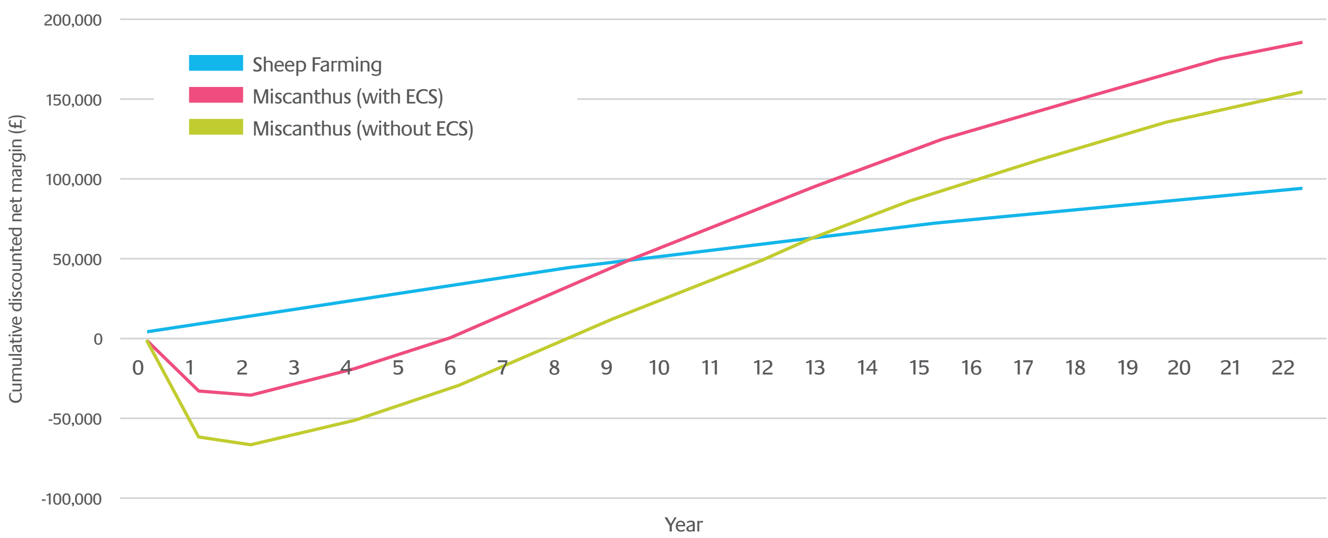



**Figure 8**
Cumulative discounted net margin (£) of sheep farming and Miscanthus planting (with and without ECS) across the 30ha planted




## Intensifying livestock management to maximise productivity

The loss of food production by converting land to Miscanthus has been proportionately less than the reduction in the land used for sheep farming because of the more intensive grazing regime introduced – 500 ewes now graze 60ha of land (8.33 ewes/ha), whereas previously 600 ewes grazed 90ha land (6.67 ewes/ha). The reduction in lambs produced is approximately 145 per year (from 1,020 to 875) and there will be a reduction in the sale of cull ewes (mutton) of around 20 each year (from 110 to 90).

## Biodiversity Impacts

No specific monitoring of biodiversity has been undertaken in relation to the Miscanthus crops but Bill comments that the crop attracts birds and the leaf litter returns nutrients to the crop.

Across the rest of the farm 4km of hedgerows and ditches and 2ha of non-cropped habitats are being managed sympathetically for wildlife.

## Conclusion

Planting Miscanthus and changing sheep management practices has allowed Bill Lewis to diversify income streams, reduce workload and increase the productivity of his remaining grassland.

# Growing SRC Willow at Brackenthwaite Farm
## Using underutilised land to diversify farm income

### The problem
Terry Dixon and his son Thomas run Brackenthwaite Farm in Cumbria. The farm comprises 323ha of mainly Severely Disadvantaged Area (SDA) land used for dairying with a small area used to grow spring barley and triticale for on-farm use. The farm previously practiced organic farming but in 2013, due to reductions in the price of organic milk, the Dixons chose to move back to a non-organic dairy system leaving the farm with surplus land.

### The solution
The Dixons considered expanding their dairy enterprise, but this would have required a significant investment in livestock and infrastructure (such as milking parlours), as well as taking on additional labour. In view of the volatility of milk prices, the Dixons decided to look for an alternative income stream with less uncertainty.

The Dixons settled on growing Short Rotation Coppice (SRC) Willow after meeting Neil Watkins, Iggesund's Alternative Fuels Manager, at a local farmers group meeting. Iggesund run a paperboard mill in West Cumbria powered by a 50MW Combined Heat and Power (CHP) plant fuelled by SRC Willow and timber-processing by-products.

In 2015, after visiting the paperboard mill and demonstration fields of established SRC Willow crops, Terry planted 29.5ha of willow.

### Impact
Based on expected yields and prices provided by Iggesund, the willow crop is expected to payback within 7 years and it is estimated that over the 23-year lifetime of the crop, the equivalent annual net margin of the land will be £185/ha/yr higher than a counterfactual of renting the surplus land for grazing, plus income from the 7.7ha of the land which was previously part of a Higher Level Stewardship agreement (removed from the scheme with the agreement of Natural England). At the time of planting the land was surplus to requirements so no actual food displacement has taken place.

On his decision to plant SRC Willow, Terry commented that:

> "Iggesund offered a convincing case for willow plantations in our region, and portrayed a complete picture of planting through harvesting, as well as compelling financial returns over a 22-year timespan."

## Financial comparison

A discounted cash flow was used to compare the costs and revenues of planting SRC Willow over its 23-year lifetime with the counterfactual land use (land rental and income from Higher Level Stewardship schemes). The assessment did not include any Basic Payment Scheme (BPS) payments under the Common Agricultural Policy (CAP) as the land is eligible for the same level of subsidy under both scenarios.

This section sets out the data used in each cash flow and presents the results of the cash flow comparison.

**The counterfactual – Income from land rental and Higher Level Stewardship (HLS) agreements**

Prior to planting SRC Willow, 7.7ha were part of a Higher Level Stewardship (HLS) agreement to maintain grassland for targeted features, generating an annual income of £80-£130/ha (2015 prices)[18]. Under the counterfactual it is assumed that this land continues under the HLS agreements. The remaining 21.8ha is assumed to be rented to neighbouring farms for grazing because, at the time of planting, the land was surplus to on-farm requirements. The expected annual rental income, based on estimates from Mitchells (a local land agent), is £150/ha with a nominal cost of land maintenance of £15/ha/yr (2015 prices).

Table 12 shows that, on average, the land generates an income of £128/ha (2015 prices) under the counterfactual scenario.

**Table 12**

Income under the counterfactual land use scenario (2015 prices – excl. BPS payments)

| 2015 prices | Area (ha) | Annual Income (Cost) (£/ha) |
|---|---|---|
| HLS agreement – HK15 (Maintenance of semi-improved or rough grassland) | 4.49 | 80 |
| HLS agreement – HL8 (rough grassland management for birds) | 3.18 | 130 |
| Land rental – income | 21.83 | 150 |
| Land rental – cost | 21.83 | (15) |
| **Total (Weighted)** | **29.50** | **128** |

18 Natural England (2015) Environmental Stewardship Handbook. Available at: https://www.gov.uk/guidance/environmental-stewardship

**Growing SRC Willow**

The Iggesund contract

Under the 22-year (seven harvest) index-linked contract with Iggesund, farmers are responsible for land cultivation, fertiliser, weed and pest control, paying for willow canes and planting (by contractor), cutback after the first year and land use at the end of the crop (either replanting or land use change). Iggesund undertake harvesting, given the need for specialist equipment, and provide haulage to the processing site. They also offer planting advice and ongoing support on crop management.

The price paid to farmers reflects both the scale of planting and the location (haulage distance).

Establishing the crop

The establishment period for Willow is three years (pre-planting, planting, and post-planting). Using actual data from Brackenthwaite Farm where possible, and estimates from Iggesund for Year 2 cutback and inter-row spraying, the establishment costs were calculated to be £1,739/ha (2015 values). Figure 9 gives a breakdown of these costs and Table 13 details how the establishment costs are spread over the three-year period. Paying for SRC Willow cuttings and the planting contractor is the single biggest expense (66% of total establishment costs). Combining this cost with additional land preparation costs means that 77% of establishment costs are incurred in Year 1. It should be noted that drainage costs were only incurred because the land did not have an existing drainage system.

**Figure 9**

Establishment costs for Brackenthwaite Farm (Farm data/Iggesund estimate – 2015 prices £/ha)

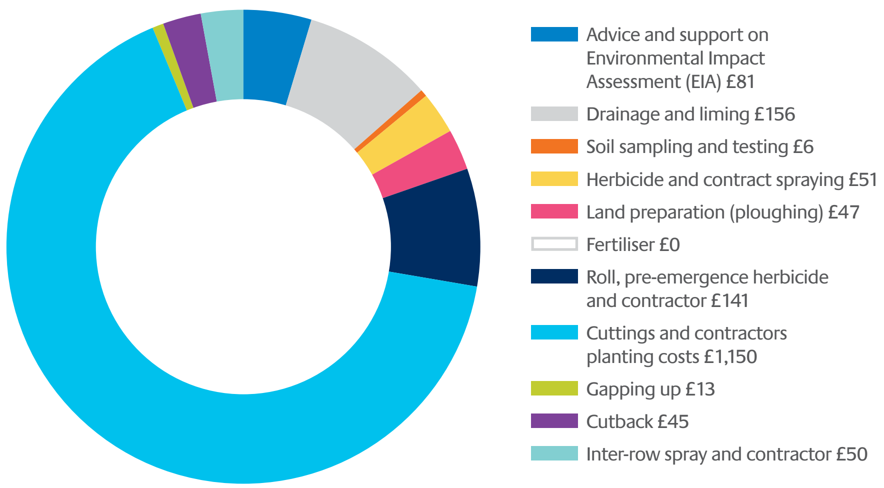


**Table 13**
Establishment costs over time (2015 prices – Farm data and Iggesund estimates £/ha)

| Item (£/ha) | Year 0 (pre-planting) | Year 1 (planting) | Year 2 (post-planting) |
|---|---|---|---|
| Soil sampling and testing | 6 | | |
| Advice on Environmental Impact Assessment (EIA) | 81 | | |
| Draining and liming | 156 | | |
| Herbicide and contractor spraying | 51 | | |
| Fertiliser (sewage sludge – provided and spread free of charge) | 0 | 0 | |
| Land preparation (ploughing) | | 47 | |
| Cuttings and contractor planting | | 1,150 | |
| Roll and pre-emergence herbicide (contractor spraying) – shortly after planting | | 141 | |
| Inter-row spray – herbicide application and contractor (Iggesund estimate) | | | 50 |
| Gapping up (planting SRC Willow in any gaps where it has failed to establish) | | | 13 |
| Cutback (to ground level to encourage multiple stems) (Iggesund estimate) | | | 45 |
| **Annual Total** | **294** | **1,338** | **108** |
| **Total over 3-year establishment period** | | **1,739** | |

Operational costs
Because harvesting and haulage are arranged by Iggesund, ongoing costs to the farmer are limited to periodic soil sampling and miscellaneous land management expenses. There is also a cost associated with reverting the land to grass (if desired) at the end of the crop life cycle (Table 14).

**Table 14**
Operational costs for SRC Willow grown at Brackenthwaite Farm (2015 prices)

| Item (2015 prices) | Cost | Lifetime cost (per ha) | Assumptions |
|---|---|---|---|
| Soil sampling and testing | £182 per testing round (29.5ha) | £43 | Every 3 years (7 samplings). Farm data |
| Miscellaneous land management | £15/ha/yr | £345 | ADAS estimate |
| Return to grassland (after 23 years) | £250/ha | £250 | ADAS estimate based on other sites. Includes cost of spray and heavy discing |
| **Total operational cost (£/ha)** | | **£638** | |

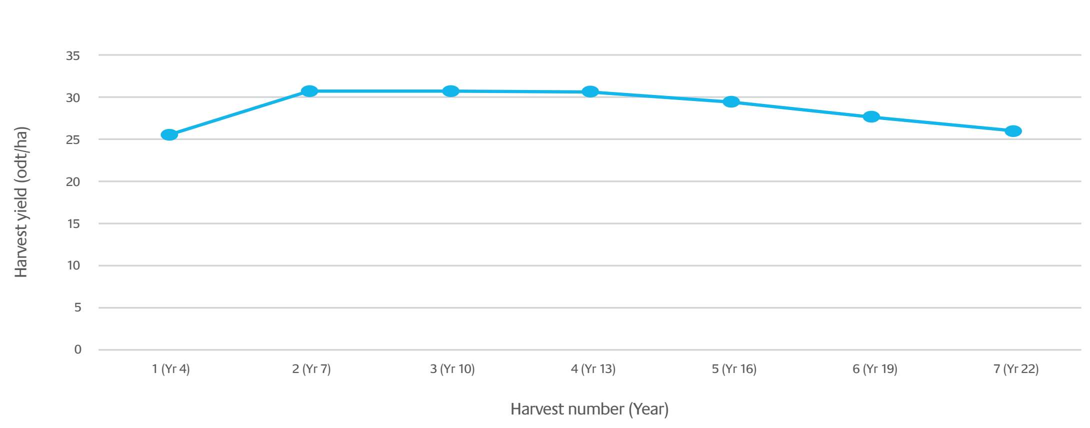
Income
As the crop was only planted in May 2015, no harvest data is available. However, Neil Watkins, Alternative Fuels Manager at Iggesund, estimates that this site should yield 60-75 tonnes/ha/harvest (fresh weight with 55-60% moisture content, equivalent to 24-34 odt/ha/harvest (odt = oven dry tonne)).

The price received for the crop will be based on a nominal price per tonne (fresh weight). Allowing for variation in yield and haulage costs across sites, Neil Watkins forecasts an income for this site of £1,335-1,500/ha/harvest (2015 pricing) after harvesting and haulage are deducted.

For the cash flow analysis, a price per oven dry tonne (odt) was calculated using the mid-point from Iggesund's estimate (£1,418/ha for a yield of 67.5 fresh tonnes/ha/harvest with 57.5% moisture). This equates to £49.41/odt.

Based on the yield information from Iggesund and information from a previous ETI project which examined SRC Willow yield profiles, Figure 10 shows the yield profile used in calculating the revenue from the SRC Willow crop.

**Figure 10**
SRC Willow yield profile used in discounted cash flow



**Financial Comparison**

A discounted cash flow forecast for both the counterfactual land use (HLS payments and land rental) and the SRC Willow crop was used to assess the net economic return from SRC Willow farming.

Key assumptions:

- The discounted cash flow covers 23 years (the lifetime of the willow crop from land preparation to land remediation including 7 harvests)
- Inflation rate is 2% per annum (based on November 2015 Office of Budget Responsibility (OBR) forecast for Consumer Prices Index (CPI) inflation)[19]
- Discount rate is 5% (based on November 2015 OBR forecast for the bank rate plus 3% risk)[20]
- Cash flow does not include any Basic Payment Scheme (BPS) payments under the Common Agricultural Policy (CAP) as the land is eligible for the same level of subsidy under both scenarios

Table 15 below shows that planting SRC Willow is anticipated to increase the Equivalent Annual Net Margin of the land by £185/ha/yr and the investment in establishing the crop is expected to payback after 7 years (no ECS grant was received). Figure 12 also shows that the cumulative net margin of Willow exceeds land rental and HLS payments in year 10.

Adjusting only the discount rate, over a 23-year lifetime the Net Present Value (NPV) for Willow remains higher than the displaced land use (land rental and HLS) at discount rates up to 14%.

**Table 15**

Summary of the economic analysis comparing SRC Willow and the displaced land use (excl. BPS payments)

| 23 years (2% inflation, 5% discount rate) | SRC Willow | Land Rental/HLS |
|---|---|---|
| Net Present Value (29.5ha) | +£141,813 | +£64,466 |
| Internal Rate of Return | 22% | - |
| Payback Period | 7 years | - |
| Equivalent Annual Net Margin | +£339/ha/yr | +£154/ha/yr |
| **Change in Equivalent Annual Net Margin** | **+£185/ha/yr** | **-** |

**Figure 11**

Discounted net margin (£/yr) of land rental/HLS and SRC Willow planting across the 29.5ha planted

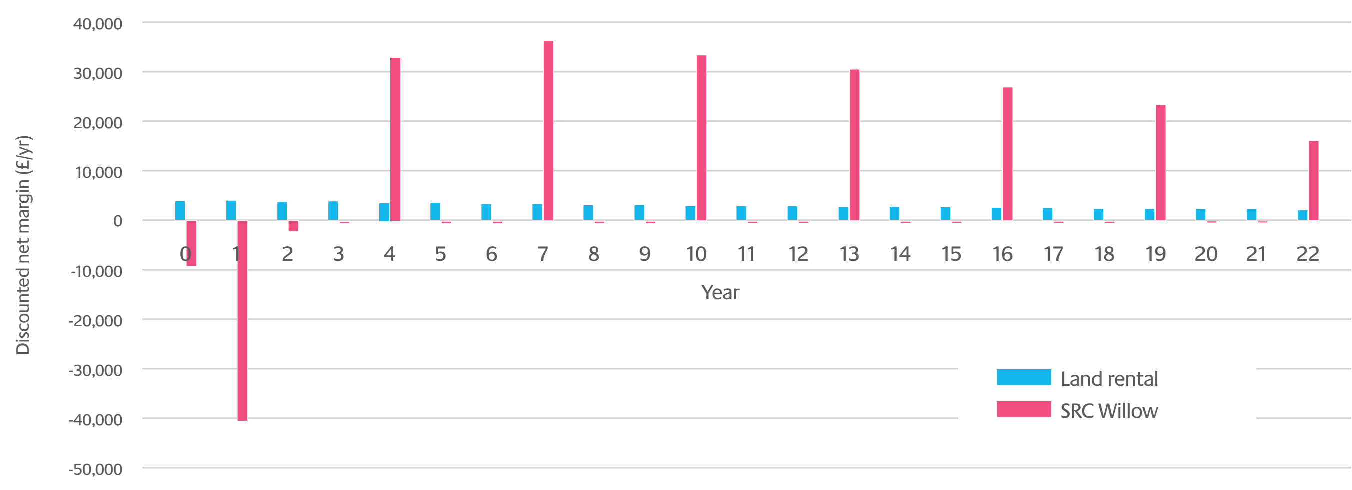
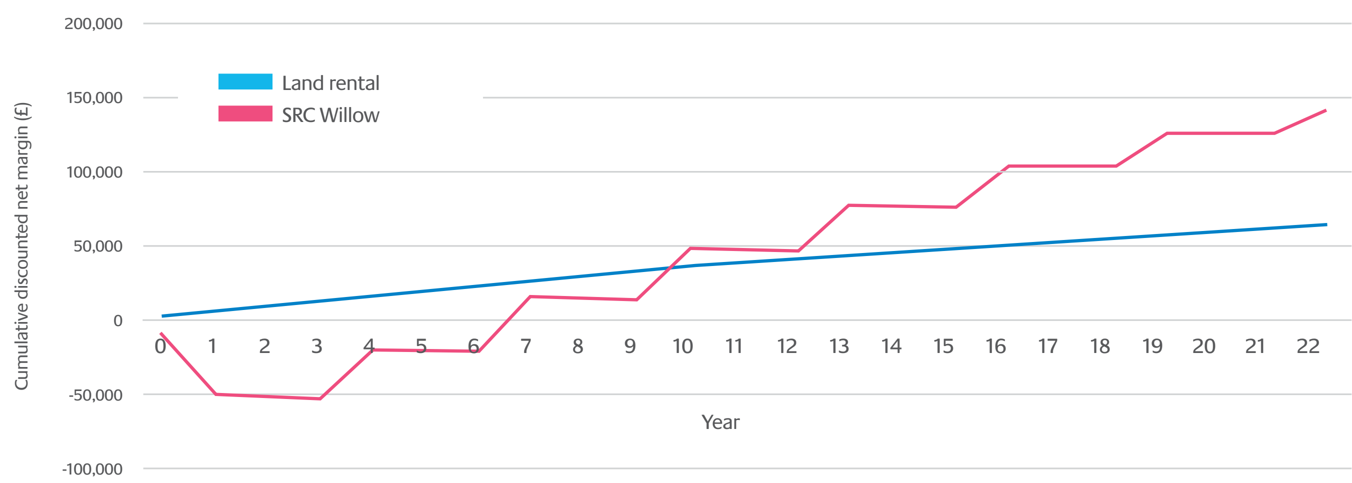



**Figure 12**

Cumulative discounted net margin (£) of Land Rental/HLS and SRC Willow across the 29.5ha planted




19 Office of Budget Responsibility, Economic Forecasts. Available at: http://budgetresponsibility.org.uk/publications/

20 ibid

## Making productive use of land
The land at Brackenthwaite Farm was surplus to requirements following the return to non-organic dairy farming so no absolute food displacement has taken place and planting willow has enabled the Dixon family to diversify their income streams.

If the Dixons had chosen to rent the land for grazing it could expect to stock 13 cattle and 80 breeding ewes based on regional data from the Farm Business Survey[21].

## Land use change – Environmental Impact Assessment
Before planting the SRC Willow, the Dixons, with the assistance of a land agent, undertook an Environmental Impact Assessment (EIA). The EIA process is designed to protect uncultivated and semi-natural areas from being damaged by agricultural work and involves working with Natural England and the Forestry Commission to understand the impact of planting willow, as well as consulting with local councils, wildlife groups and residents on the proposed planting. The whole process took 3-4 months.

Part of Brackenthwaite Farm is under a Higher Level Stewardship (HLS) scheme based around two sites:

- Cleator – a bird management habitat
- Haile – a mixture of habitats including grassland, woodland, bog and shrub which contains Sites of Special Scientific Interest (SSSI)

In consultation with Natural England, it was agreed not to apply for permission to plant willow on any area with high environmental value or any Site of Special Scientific Interest (SSSI).

Two fields (4.49 ha) under option HK15 Maintenance of grassland for target features (£130/ha) and one field (3.18 ha) under option HL8 Restoration of rough grazing for birds (£80/ha) were removed from the HLS agreement in order to plant willow as Natural England felt that there would be no loss of biodiversity. Other fields, which Natural England was content could be planted with willow, were not taken out of the agreement as payment rates were higher, meaning the commercial case for planting willow would not be as great e.g. HK9 Maintenance of wet grassland for breeding waders (£335/ha)[22].

Cumbria County Council commented on two fields where they felt that willow would impact the landscape value i.e. obstruct the view, and these areas were not planted.

While it is too early to know what direct benefits the willow will have on biodiversity on the farm, the crop is co-existing with the remaining land under the Higher Level Stewardship scheme.

## Conclusion
By planting SRC Willow at Brackenthwaite Farm, the Dixons have diversified their income streams, increased the profitability of their land and are making productive use of otherwise surplus land.

21 Farm Business Survey. http://www.farmbusinesssurvey.co.uk/
22 Natural England (2015) Environmental Stewardship Handbook. Available from: https://www.gov.uk/guidance/environmental-stewardship

## Impact of bioenergy cropping on land value
Across the three case studies there is no direct evidence that the energy crops have had an impact on land value. To test the perception that crops such as SRC Willow and Miscanthus have a negative impact on land value, discussions were held with five land agents in Yorkshire, Lincolnshire, Northumberland, East Midlands, and South West England.

The consensus from the land agents was that there is no reason why land growing biomass crops should be valued differently to land growing other crops. The valuation should be made based on the productive capacity of the land. However, the land may be offered for sale at a lower guide price, or accept a tender based on a lower rent because of:

- the perceived cost of returning the land to arable/grass production
- possible loss of the land to the next growing season
- the impact of the existing contract (or lack of a contract)
- the lack of knowledge of how to grow the crops
- perceived uncertainty of the availability of biomass market outlets.

However, the presence of a profitable contract for the crop and a willingness from the buyer to continue with bioenergy cropping may have a beneficial impact on the land value. Ultimately, the market leads valuation and anything that impacts on the sentiment of the buyers will affect the land value.

## Decision Making
The farmers in these case studies chose to grow energy crops for a variety of reasons – making better use of difficult or underutilised land, diversifying income and/or reducing workload. In addition, all farmers cited the importance of obtaining secure, fixed-term contracts with buyers, in their decision making. This reinforces the findings from the ETI's Enabling UK Biomass project in which 105 farmers were asked about their motivations for planting energy crops. This found that the three most common primary reasons farmers planted energy crops were:

- to make use of low quality land
- to generate a higher profit from the land
- the availability of long-term contracts

## Conclusion
Planting 2G energy crops provides an opportunity for farmers to diversify their income, and increase the profitability and productivity of their land. All three of the case study farms have seen, or expect to see, an increase in profitability from their land after planting energy crops. All three farms have also improved productivity by siting energy crops on land which was either 'surplus' due to changes in livestock management, or of poor quality for arable farming or grazing livestock. This shows that energy crop planting need not be in direct competition with food production but can complement other farming activities. This is an important point when it comes to discussing how land use can be optimised in the UK; a discussion which should take into account all pressures on land use including housing, infrastructure and, renewable energy developments, as well as food, feed, fibre and bioenergy feedstock production. This discussion will be particularly important in the coming years as the UK Government negotiates its exit from the EU and must decide how farming will be supported outside of the EU's Common Agricultural Policy (CAP). This presents an opportunity to join up agricultural and energy policies to support growing sustainable biomass in ways that improve overall land productivity.

# Appendix – Land use conversion

## Overview of land conversion process

Figures A1 to A3 provide an overview of the steps required to convert agricultural land to three second generation energy crops – Miscanthus, Short Rotation Forestry (SRF) and Short Rotation Coppice (SRC) Willow.

Only one of the case studies published alongside this document (planting SRC Willow at Brackenthwaite Farm in Cumbria), required consent from the Forestry Commission following an Environmental Impact Assessment (EIA). This process took 3-4 months in total, including consultations with local stakeholders, the Forestry Commission and Natural England. Recommendations from the consultation process were taken into account when planting the SRC Willow crop.

**Figure A1**

Converting land to SRC Willow – the orange route indicates the more common pathway

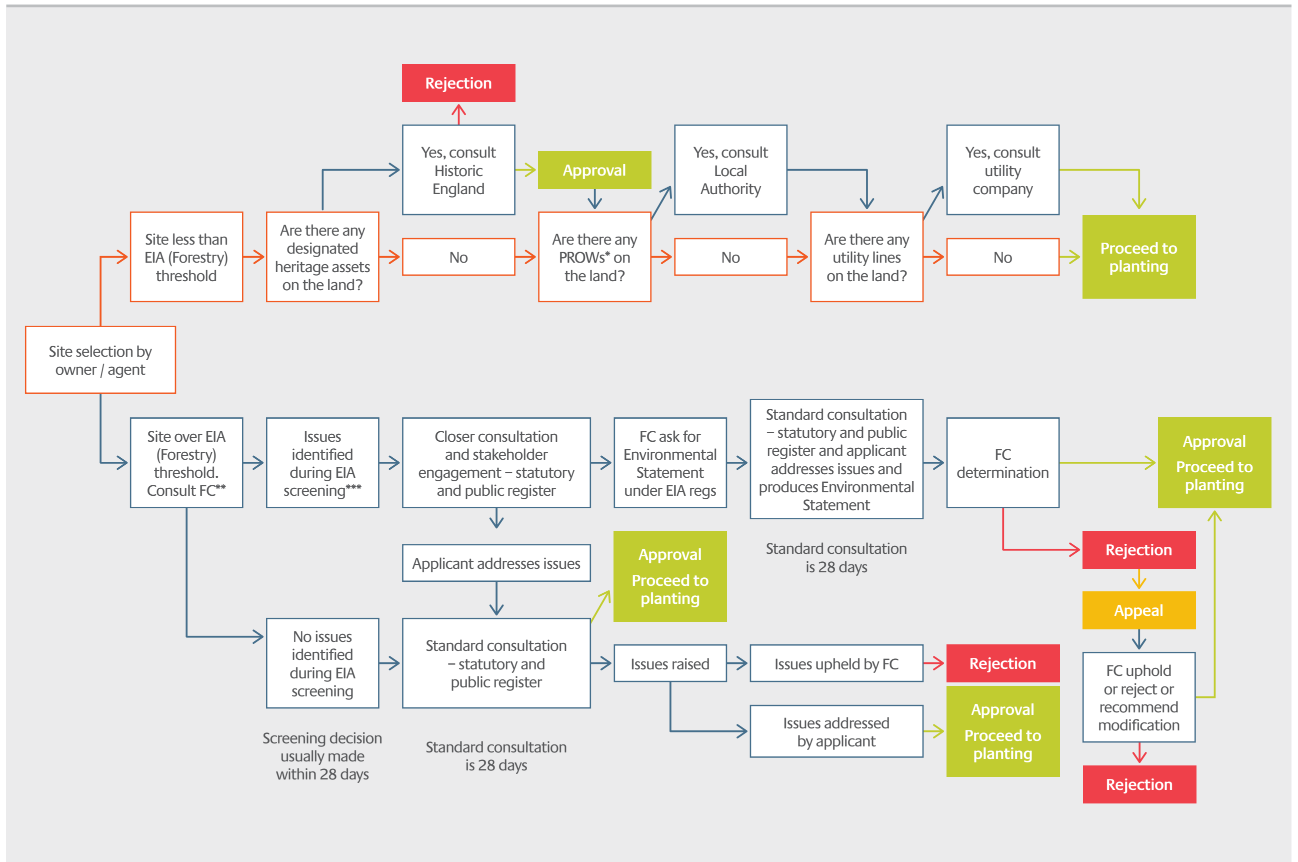
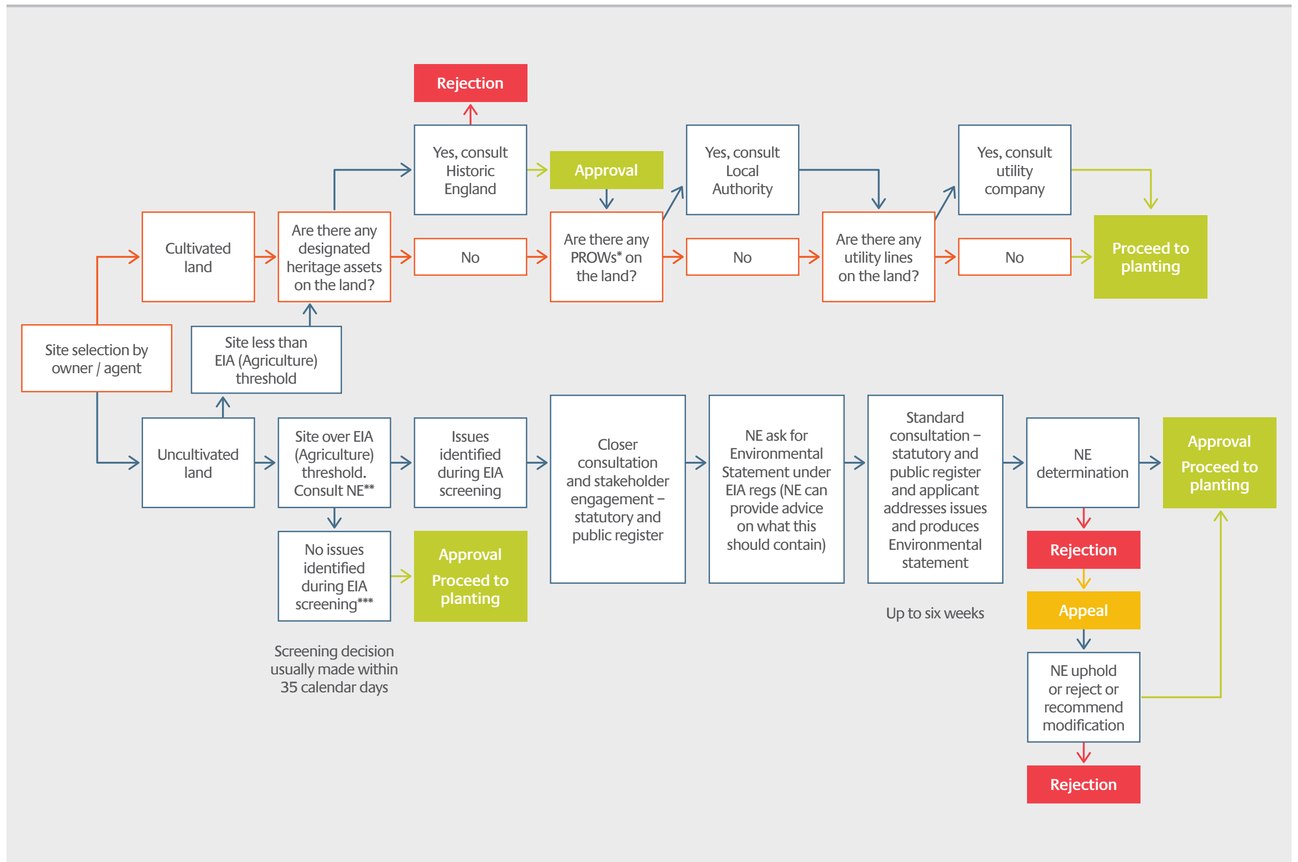



**Figure A2**

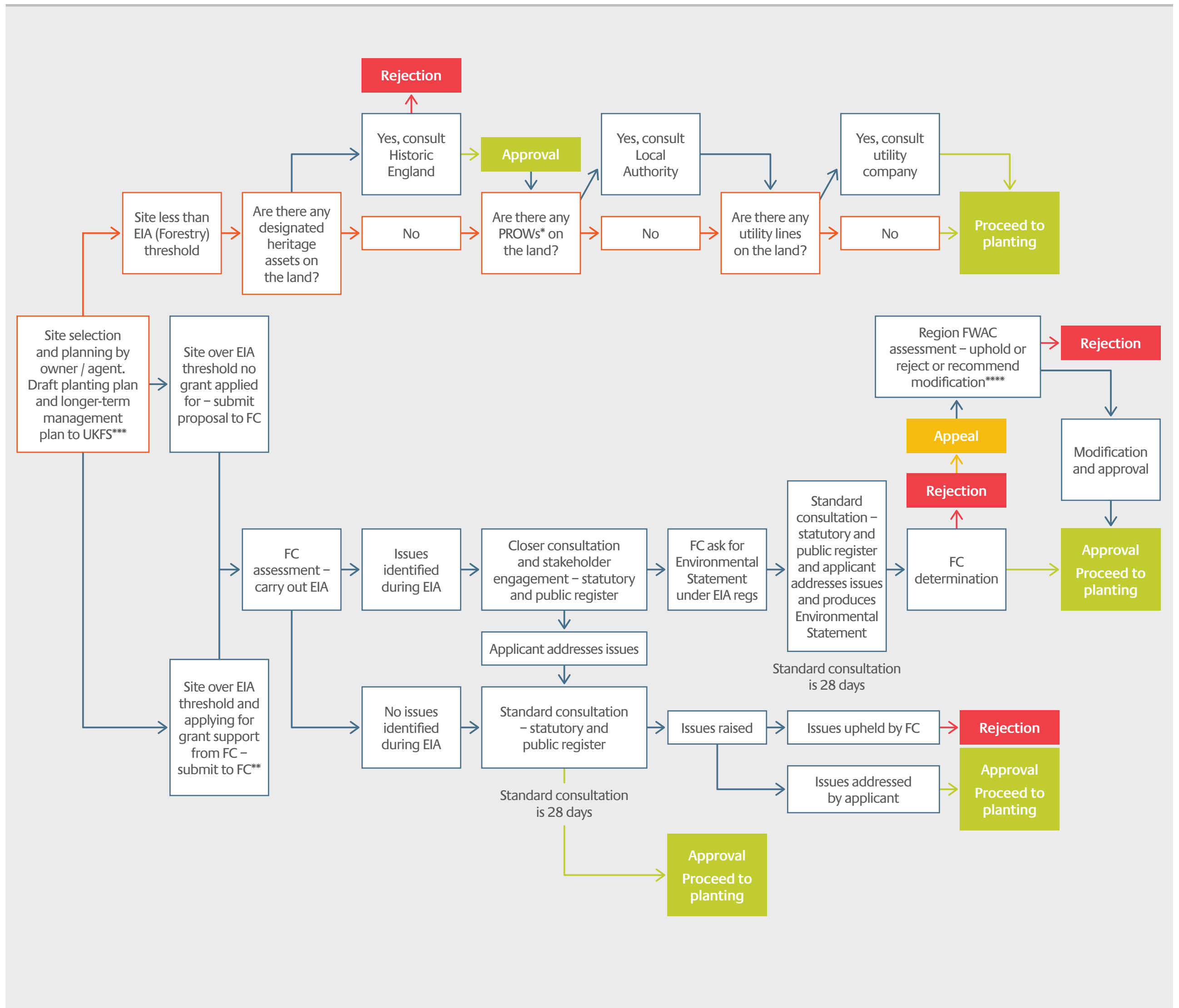
Converting land to Miscanthus – the orange route indicates the more common pathway




* PROW = Public Right of Way
** FC = Forestry Commission
*** Screening = An initial assessment by FC as to whether the proposed planting will have a significant environmental impact

* PROW = Public Right of Way
** NE = Natural England
*** Screening = An initial assessment by NE as to whether the proposed planting will have a significant environmental impact

**Figure A3**
Converting land to Short Rotation Forestry – the orange route indicates the more common pathway




* PROW = Public Right of Way

** FC = Forestry Commission

*** UKFS = UK Forestry Standard

**** FWAC = Forestry and Woodland Advisory Committee

## Environmental Impact Assessment (EIA)

Deciding whether a land use conversion requires an Environmental Impact Assessment (EIA) is a key step in determining the land use change process.

The EIA process (in England[23]) is governed by two sets of regulations:

- The Environmental Impact Assessment (Agriculture) (England) (No.2) Regulations 2006 are designed to protect uncultivated land (land which, in the last 15 years, has not been cultivated by physical or chemical means (e.g. ploughing, harrowing or applying fertiliser)) and semi-natural land from being damaged by certain types of agricultural work. They also prevent the restructuring of rural land holdings from having a significant environmental impact. In England, Natural England are responsible for managing the EIA process. These regulations would be applicable to Miscanthus planted on uncultivated land.

- The Environmental Impact Assessment (Forestry) (England and Wales) Regulations 1999 cover four types of project: afforestation, deforestation, forest roads and forest quarries. The Forestry Commission are responsible for managing this EIA process. These regulations would apply to SRC Willow and SRF plantings on all land types.

Both EIA regulations have thresholds (shown in Table A1), above which an EIA is required. The thresholds differ depending on whether the land is in a sensitive area such as a National Park, Area of Outstanding Natural Beauty (AONB), National Scenic Area (NSA) or a Site of Special Scientific Interest (SSSI)[24]. Plantings below this limit do not require an EIA. In addition, Miscanthus planted on cultivated land doesn't require an EIA.

Natural England or the Forestry Commission can reject an application if they think a project will have a significant detrimental effect on the environment. In making this decision they must take into account the proposed project's impact on the environment in terms of its scale (geographical area and population affected), probability and frequency, magnitude, complexity, duration and reversibility. The decision must take into account not only the individual impacts of the project under consideration but its cumulative effect on the environment alongside other projects.

**Table A1**
EIA Thresholds for a requirement to obtain a screening decision

| | Applicability | Threshold (where no part of the land is in a sensitive area) | Threshold (where project is wholly or partly in a sensitive area) | Consenting organisation (in England) |
|---|---|---|---|---|
| **EIA Agriculture** | Planting Miscanthus or arable crops on uncultivated land | 2ha | 2ha | Natural England |
| **EIA Forestry** | Afforestation: any tree planting including SRC and SRF on all land types | 5ha | 2ha (National Park, AONB, NSA)<br>No threshold for all other sensitive areas (SSSI etc) | Forestry Commission |

23 In the devolved regions different EIA regulations apply and the process is managed by different statutory bodies. However the process is fairly similar across all regions. The bodies responsible for EIA decisions in the devolved administrations are:

Wales (Forestry): NRW (Natural Resources Wales)

Wales (Agriculture): Applications via the Welsh Assembly divisional offices

Northern Ireland (Forestry): Forest Service in Northern Ireland

Northern Ireland (Agriculture): Northern Ireland Environment Agency (NIEA)

Scotland (Forestry): Forestry Commission Scotland

Scotland (Agriculture): Scottish Government Rural Payments and Inspections Directorate (SGRPID).

24 See Forestry Commission, 'Environmental Impact Assessment: projects and thresholds' for a full list of sensitive areas. http://www.forestry.gov.uk/forestry/infd-6dfl55

# Glossary

| | |
|---|---|
| Basic Payment Scheme (BPS) | An area-based support payment to the farming industry as part of the European Union's Common Agricultural Policy (CAP). |
| Common Agricultural Policy (CAP) | The agricultural policy of the European Union, implemented through subsidy payments and other support mechanisms. |
| Creep feeding | A means of supplying extra nutrition, usually grain, to nursing lambs. It is more commonly used for lambs managed in more intensive production systems in which early weaning is practised. |
| Discount Rate | Discounting is a technique used to compare costs and benefits that occur in different time periods. A higher discount rate indicates a stronger preference to receive goods and services sooner rather than later. |
| Equivalent Annual Net Margin | This represents the current value of the annual average margin and is calculated by dividing the NPV of a project by the present value of an annuity factor. |
| Heavy discing | A process of using circular discs to break up the soil. |
| Higher Level Stewardship (HLS) | Environmental Stewardship is a land management scheme in England whereby farmers receive payments for managing land for environmental outcomes. Higher Level Stewardship (HLS) is targeted to more complex types of management. |
| Inflation | A sustained increase in the general level of prices for goods and services. It is measured as an annual percentage increase. |
| Internal Rate of Return (IRR) | The discount rate at which a project breaks even (i.e. when the NPV is equal to zero). |
| Net Present Value (NPV) | This represents the value of an expected income stream over a defined time period. All future cash flows are estimated and inflation applied before they are discounted and added together to give the net present value (NPV). If the NPV is positive, the project is economically viable. |
| odt | Oven dry tonne. |
| Payback Period | This represents the number of years from initial investment after which a project breaks even (i.e. when NPV is equal to zero). |
| Severely Disadvantaged Area (SDA) | Upland areas where poor climate, soils and terrain cause higher costs in agricultural production as well as lower yields and productivity. |

# Further information

Further sources of information on ETI projects, the case study participants, growing second generation energy crops, the land use change process and EIA legislation are listed below.

## 1 ETI Bioenergy Programme

www.eti.co.uk/programme/bio

## 2 Case Study Information

**Iggesund**
www.biofuel.iggesund.co.uk

**Terravesta**
www.terravesta.com

**Cereals event**
www.cerealsevent.co.uk

## 3 Growing Bioenergy

**Information on rural grants and payments (including the CAP and ECS (now closed))**
www.gov.uk/topic/farming-food-grants-payments/rural-grants-payments

**The Biomass Energy Centre (Best Practice Guide)**
www.biomassenergycentre.org.uk

**Forest Research, Short Rotation Coppice Establishment**
www.forestry.gov.uk/fr/INFD-8A5KL3

## 4 Further information on the impact of bioenergy cropping on biodiversity

Desiree J. Immerzeel, Pita A. Verweij, Floor van der Hilst and Andre P. C. Faaij (2013). Biodiversity impacts of bioenergy crop production: a state-of-the-art review. GCB Bioenergy (2013), doi: 10.1111/gcbb.12067

McCalmont, J.P., Hastings, A., McNamara, N.P., Richter, G.M., Robson, P., Donnison, I.S. and Clifton Brown, J. (2015) Environmental costs and benefits of growing Miscanthus for bioenergy in the UK. GCB Bioenergy, August, 2015. 10.1111/gcbb.12294

## 5 EIA Legislation

**Environmental Impact Assessment (Agriculture) (England) (No.2) Regulations 2006**
www.legislation.gov.uk/uksi/2006/2522/contents/made

**Environmental Impact Assessment (Agriculture) (Scotland) Regulations 2006**
www.legislation.gov.uk/ssi/2006/582/contents/made

**Environmental Impact Assessment (Agriculture) (Wales) Regulations 2007**
www.legislation.gov.uk/wsi/2007/2933/contents/made

**Environmental Impact Assessment (Agriculture) (Northern Ireland) Regulations 2007**
www.legislation.gov.uk/nisr/2007/421/contents/made

**Environmental Impact Assessment (Forestry) (England and Wales) Regulations 1999**
www.legislation.gov.uk/uksi/1999/2228/contents/made

**Environmental Impact Assessment (Forestry) (Scotland) Regulations 1999**
www.legislation.gov.uk/ssi/1999/43/made

**Environmental Impact Assessment (Forestry) (Northern Ireland) Regulations 2006**
www.legislation.gov.uk/nisr/2006/518/contents/made

## 6 Details of the EIA process

**Information on Environmental Impact Assessment (Agriculture) Process**
www.gov.uk/guidance/eia-agriculture-regulations-apply-to-make-changes-to-rural-land

**Information on the Environmental Impact Assessment (Forestry) Process in England**
www.forestry.gov.uk/england-eia

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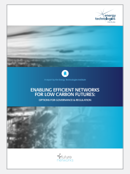
## ACCOMPANYING MATERIAL

**An ETI Perspective**
**Bioenergy crops in the UK. Case studies of successful whole farm integration.**
www.eti.co.uk/library/perspective-bioenergy-crops-in-the-uk

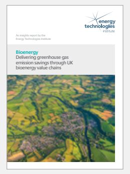
## FURTHER READING FROM THE ETI



**Enabling Efficient Networks**
www.eti.co.uk/library/enabling-efficient-networks-for-low-carbon-futures

**Enabling UK Biomass**
www.eti.co.uk/insights/bioenergy-enabling-uk-biomass/

**Insights into the future UK Bioenergy sector, gained using the ETI's Value Chain Model (BVCM)**
www.eti.co.uk/insights/bioenergy-insights-into-the-future-uk-bioenergy-sector-gained-using-the-etis-bioenergy-value-chain-model-bvcm/



**Delivering greenhouse gas emission savings through UK bioenergy value chains**
www.eti.co.uk/insights/delivering-greenhouse-gas-emission-savings-through-uk-bioenergy-value-chains/

## Disclaimer



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