The carbon abatement costs and potential from perennial energy crops

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1. Introduction

Biomass could supply 8–11% of the UK's total primary energy demand by 2020, with the greatest growth in UK domestic supply expected to come from agricultural residues and energy crops[1]. The main sources of domestically produced energy crops are Miscanthus and willow or poplar grown as Short rotation coppice (SRC). A significant area of land the United Kingdom could be used for growing such energy crops, without impinging on food production[1]. However, despite policy support for the sector, uptake of these crops has been limited, with an established area of only 11,000 ha in 2011[2]. There is currently no target for the total areas of these crops, although the UK Biomass Strategy suggested 350,000 ha by 2020[3], it is now expected that the actual figure will be much lower[4].

This policy note summarises the findings of agent-based modelling[1] research investigating the potential of various policy mechanisms to achieve cost effective carbon abatement in the UK energy crop market. See Appendix 1 for further explanation of the research methodology.

2. Policy background

2.1 Support policies

The UK energy crop market is supported by government policies targeted at both farmers and energy producers. These include:

- **Energy Crop Scheme**, which offers farmers in England grants covering 50% of the establishment cost of planting perennial energy crops.
- **Renewables Obligations**, which support electricity generators through providing Renewable Obligation Certificates (ROCs), currently 2.0 ROC/MWh for dedicated energy crop generation.
- **Renewable Heat Incentives**, which have also been available for generators of renewable heat.

2.2 Changes to support

- Energy crop scheme closed to new applications in 2013. It is unclear whether there will be a replacement, although there have been calls for one[4,5].
- Renewables Obligation scheme ends in 2017.
- UK Electricity Market Reform proposals have been announced and include a feed-in tariff using Contract for Difference (CfD)[6]. Under this scheme generators revenue from electricity and ROCs, is effectively replaced by a single fixed price level known as the CfD 'strike price'. The draft strike prices are stated to be consistent with the Renewable Obligation scheme. However, there are

[1] Agent-base modelling is an approach that represents decision makers and their interactions. The system behaviour emerges through their interactions with each other and the environment.

number of other differences. Firstly, new biomass plants must be combined heat and power (CHP) facilities to receive support. Secondly, the removal of the ROC rate premium payable for electricity generated from energy crops (0.5 ROC/MWh, equivalent to around £18.50/MWh).

3. Research questions

The research summarised here[7,8] attempts to address the following questions:

- What are the spatial and temporal dynamics of energy crop market?
- Do existing policies for perennial energy crops provide a cost-effective mechanism to stimulate the market to achieve emissions abatement?
- What are the relative benefits of providing incentives to farmers or energy producers?
- What are the trade-offs between increased or decreased subsidy levels and the rate and level of market uptake, and hence carbon abatement?

4. Findings

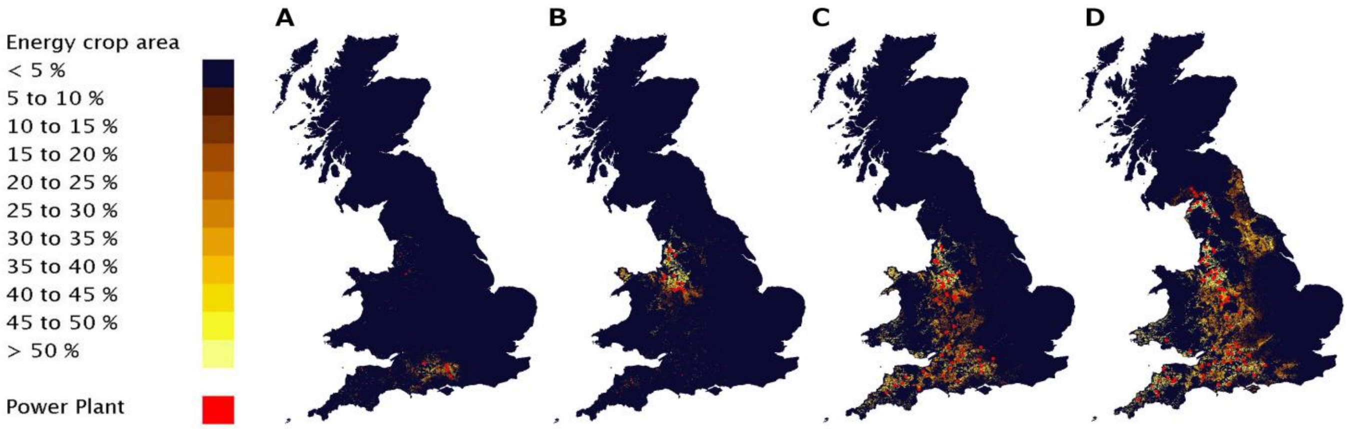

Figure 1. Example distributions of energy crop selection and power plant locations at 2040. A & B from 1.0 ROC MWh^{-1} minimum ROC rate scenario, C & D showing highest CO_2 equivalent abatement cases from 1.2 & 1.4 ROC MWh^{-1} minimum ROC rates runs.

The results suggest the important role that farmers' networks and communication has on the rate of adoption of new crops or technologies, such as energy crops[7]. Significant time-lags (approximately 20 year) are produced by the spatial diffusion of adoption created by the adoption behaviour of farmers. This finding was supported by the model's ability to explain the observed patterns of adoption of oilseed rape from the 1970s.

The work also considered the cost of carbon abatement. This was calculated from the total carbon dioxide equivalent (CO_2e) emissions abated and the total cost of subsidies in each simulation[8]. Figure 2 shows the carbon price plotted against emission reduction for each policy scenario. Varying the electricity generator subsidy, for a fixed establishment grant rate, produces a u-shaped curve. This indicates that there is a subsidy level that offers a maximum cost-efficiency of carbon equivalent abatement. Initially, as the subsidy level increases this causes reduced failure rates (for example crops planted with no market, or power stations built that prove unprofitable), and also supports larger and more efficient plants. However, at some point the increase efficiency eventually is not sufficient to overcome the progressively higher subsidy costs, and the carbon price rises with increasing subsidy rate.

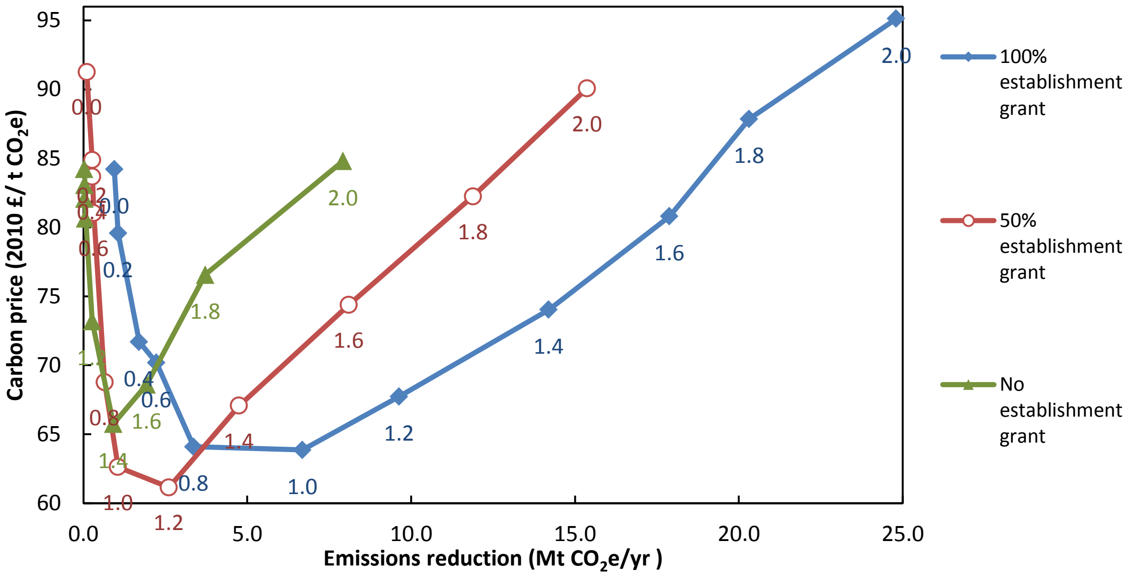

Figure 2. Cost of carbon abatement against annual emission reduction for various subsidy policies, assuming displacement of coal generation. The values below each point show the minimum ROC rates (ROC MWh^{-1}) used in that scenario.

5. Scottish Context

In most scenarios energy crop selection by farmers in Scotland is limited, although some energy crop is selected in southern Scotland at the higher subsidy levels. This is due to the relatively high cereal crop yields coupled with relatively low energy crop yields, contributing to less favourable expected returns on energy crops, and causing Scottish farmers' to continue with conventional crop rotations. The opposite case occurs in parts of North West and South West England, so the model has high levels of energy crop growth in these areas. This suggests that the Scottish bioenergy sector may need to rely on biomass from sources other than energy crop grown in Scotland, such as crop grown elsewhere, forestry, agricultural residues or waste.

6. Conclusions

The current energy crop scheme, providing farmers with 50% establishment grants, appears to fulfil an important role in stimulating market development and increasing the cost-effectiveness of carbon abatement, see Figure 2. There could be implications for the size and efficiency of the energy crop market, i.e. lower uptake, emissions abatement and cost-effectiveness, if no replacement is put in place. Even if higher subsidy levels were available to the power generators, the overall system would achieve less adoption and more costly emissions reductions without direct farmer support. Increasing the farmer support for energy crops, above 50% of establishment cost, increases total abatement from the market, at a relatively small increase in the carbon price. Finally, even with the highest levels of subsidy, the maximum energy crop area obtained was 2.9 Mha, less than the published upper estimate of 3.63 Mha[1] that could be grown without impinging on food production. Overall we conclude that the energy crop market has the potential to deliver significant emission abatement, but that a holistic assessment of all related policies is needed to ensure this is delivered cost-effectively.

References:

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Appendix 1: Methodology

The research uses an agent-based model to investigate behaviour of the UK energy crop market and examines the cost of emission abatement that the market might provide[7,8]. The model simulates farmers' decisions to grow energy crops, instead of conventional agricultural activities, with each farmer making decisions based on their location specific crop yields, preferences and previous experiences. Farmers interact to communicate their experience of these new crops, influencing other nearby farmers' choices. Investors choose to build biomass power stations where they believe a sufficient return on investment can be made, which determines the level of demand. The biomass market price is adjusted based on the in-balance of supply and demand. **Figure 3** shows a diagram of the main interactions.

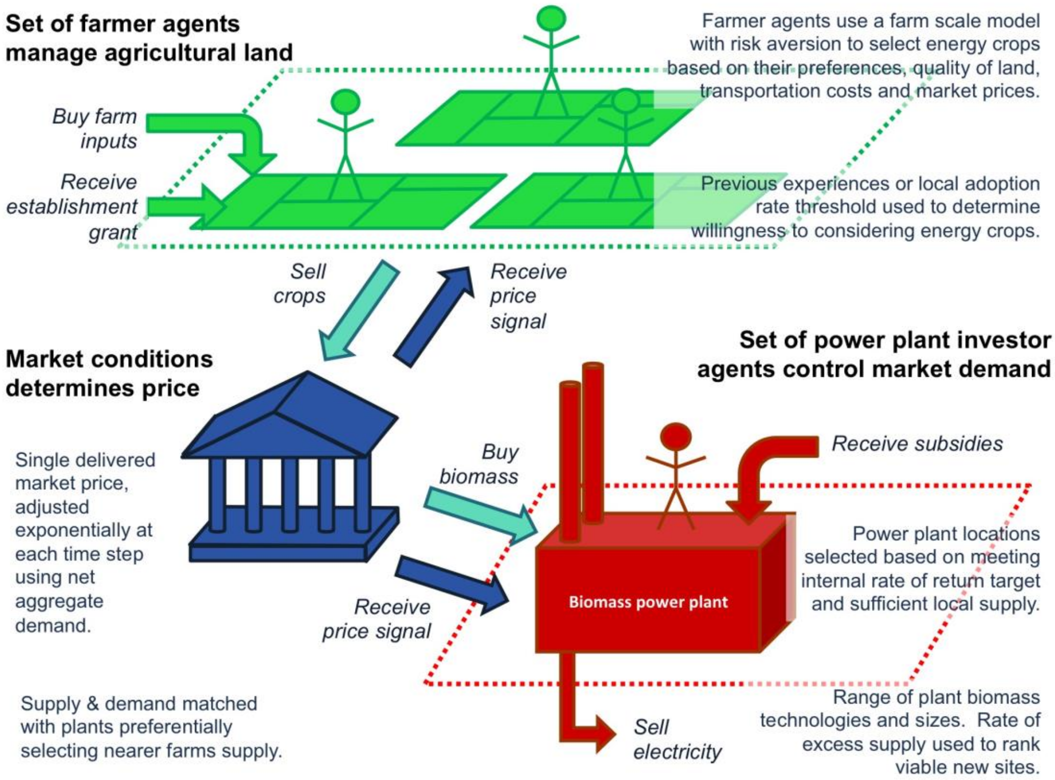

Figure 3. Schematic representation of the main agent processes and interactions within the perennial energy crop market model.

We ran the model from 2010-50 under various scenarios. In each scenario the subsidy rate was reduced over 10 years from 2014 to reach a constant level, this minimum level was varied from the current 2.0 ROC/MWh to zero, with a minimum 1.0 ROC/MWh being the baseline assumption. The rate of farmer establishment grant was also varied. Multiple runs under each scenario were conducted to demonstrate the range of potential outcomes. **Figure 2** shows example results of energy crop selection and power plant location at 2040.

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