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. The main sources of domestically produced energy crops are Miscanthus and willow or poplar grown as Short rotation coppice (SRC). 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.

The research 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 emissions abatement?
• What are the relative benefits of providing incentives to farmers or energy producers?
• What are the trade-offs between subsidy levels and the rate and level of market uptake, and hence carbon abatement?

Methods

An agent-based model was used to investigate behaviour of the UK energy crop market and examines the cost of emission abatement. The model simulates farmers’ decisions to grow energy crops, instead of conventional agricultural activities, with farmer making decisions based on their location specific crop yields, preferences and previous experiences. Farmers interact to communicate their experiences, influencing other farmers’ choices. Investors choose to build biomass power stations where they believe a sufficient return on investment can be made. The biomass market price is adjusted based on the imbalance of supply and demand, see Figure 1.

The model was run from 2010-50 under various scenarios. In each scenario the subsidy rate was reduced over 10 years from 2014 to reach a constant level, which 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.

Results

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. Significant time-lags (-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 considered the cost of carbon abatement, calculated from the total carbon dioxide equivalent (CO₂e) emissions abated and the total cost of subsidies in each simulation. Figure 3 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-effectiveness 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.

The energy crop scheme, providing farmers with 50% establishment grants, fulfilled an important role in stimulating market development and increasing the cost-effectiveness of carbon abatement. The ending of the scheme in August 2013 could have implications for the size and efficiency of the energy crop market, if no replacement is put in place. Even with higher subsidy levels for 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. 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.

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References


P Alexander1,2, D Moran1 and MDA Rounsevell2
1SRUC, West Mains Road, Edinburgh, EH9 3JG, Scotland
2University of Edinburgh, Drummond Street, Edinburgh, EH8 9XP
Email: peter.alexander@sruc.ac.uk

Figure 1. Schematic representation of the main agent processes and interactions within the perennial energy crop market model.

Figure 2. 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 CO₂ equivalent abatement cases from 1.2 & 1.4 ROC MWh -1 minimum ROC rates runs.

Figure 3. Cost of carbon abatement against annual emission reduction for various subsidy policies, assuming replacement of coal generation. The values below each point show the minimum ROC rates (ROCs MWh -1) used in that scenario.

Cost and potential of carbon abatement from the UK perennial energy crop market

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