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Modelling the economics of farm-based anaerobic digestion in a UK whole-farm context

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HIGHLIGHTS

- Lack of empirical data on UK farm AD is barrier to investment and policy formulation.
- A modelling approach used to assess economic viability of AD in whole-farm context.
- AD increases dairy and arable farm net margin including by savings in nutrient costs.
- AD margins better for a few crops than other uses, especially wheat and beet crops.
- AD co-exists with dairy, but to obtain best margin displaces conventional cropping.

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ABSTRACT

Anaerobic digestion (AD) technologies convert organic wastes and crops into methane-rich biogas for heating, electricity generation and vehicle fuel. Farm-based AD has proliferated in some EU countries, driven by favourable policies promoting sustainable energy generation and GHG mitigation. Despite increased state support there are still few AD plants on UK farms leading to a lack of normative data on viability of AD in the whole-farm context. Farmers and lenders are therefore reluctant to fund AD projects and policy makers are hampered in their attempts to design policies that adequately support the industry. Existing AD studies and modelling tools do not adequately capture the farm context within which AD interacts. This paper demonstrates a whole-farm, optimisation modelling approach to assess the viability of AD in a more holistic way, accounting for such issues as: AD scale, synergies and conflicts with other farm enterprises, choice of feedstocks, digestate use and impact on farm Net Margin. This modelling approach demonstrates, for example, that: AD is complementary to dairy enterprises, but competes with arable enterprises for farm resources. Reduced nutrient purchases significantly improve Net Margin on arable farms, but AD scale is constrained by the capacity of farmland to absorb nutrients in AD digestate.

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1. Introduction

1.1. The benefits of AD

The UK Climate Change Act, 2008, imposes legally binding targets to reduce GHG emissions by 50% from 1990 levels by 2025 and 80% by 2050 (DECC, 2008). Agriculture contributes about 9% of total UK GHG emissions (Defra, 2011) and anaerobic digestion (AD), a process involving the controlled breakdown of organic material by bacteria in a closed vessel (Weiland, 2010), is seen as a useful means of reducing this total. This could be achieved through the capture of currently uncontrolled GHG emissions from some of the 90 million tonnes of manures and slurries stored and spread on UK land each year (FAO, 2006; Defra, 2010), and through the use of biogas to displace fossil fuel based energy supplies and the replacement of inorganic fertilisers with nutrient-rich digestate. This would also contribute towards the requirements of the EU's renewable energy directive, which mandates that, by 2020, at least 15% of the UK's gross final consumption of energy should come from renewable sources, together with 10% of energy used in transport fuels (European Parliament and Council, 2009; Swinbank, 2009). AD is also seen as a means by which the UK can meet the requirements of the European Landfill Directive (1999/31/EC), which obliges member states to reduce biodegradable municipal waste disposal to landfill to 35% of 1995 levels by 2020. Other recognised benefits of AD include farm income

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generation, employment creation, odour reduction and control of diffuse pollution through improved waste management, i.e. prevention of nutrient-runoff to land and water courses. AD offers a number of advantages over other renewable energy technologies, including continuous and controllable energy generation, unlike wind, tidal and solar power, and the potential to store energy once generated. The AD process is inherently flexible in terms of scale, so that plants can be designed to accommodate locally available feedstocks and output requirements. Statements in diverse government policy documents, such as Defra's Foresight Food and Farming report (GOS, 2011) and AD Implementation Plan (Defra, 2010), reveal UK-Government recognition of the potential for AD to help address, 'synergistically, multiple environmental and political challenges simultaneously' (Defra, 2010).

1.2. Government support for AD

Government support for AD, along with other forms of renewable energy generation, operates under the Renewables Obligation (DTI, 2002). Support has been available since 2001 in the form of Renewables Obligation Certificates (ROCS), with a banding system introduced in 2009, providing double ROCs for AD, increasing their value to 11.5 p/kW h. In 2010 an alternative to ROCS[1], the Feed-In Tariff (FIT), was introduced, followed by the Renewable Heat Incentive (RHI) in 2011, currently available for AD units up to 200 kWth where gas is either injected into the gas grid, or replaces non-renewable heat sources. At the time of the modelling reported in this study (2009) the electricity Feed-In Tariff was set at 11.5 p/kW h for AD units with a generating capacity of less than 500 kW[2] but the RHI was unavailable[3] and so is not modelled. Additional subsidy was available under the guaranteed export price agreement operating in 2009, which typically added a further 3 p/kW h to revenues.

As well as financial incentives, UK Government has also been encouraging the expansion of the AD sector by addressing non-monetary barriers to uptake. Historically, a significant barrier to the development of the UK AD sector has been uncertainty over permitted uses of the digestate. This was resolved in 2010 with the introduction of a Quality Protocol for AD digestate (Environment Agency and WRAP, 2010), allowing digestate to be labelled 'biofertilizer', provided it: is generated using specific source-segregated inputs; meets the requirements of the Publically Available Specifications (PAS)110 standard (record keeping, management and testing) (BSI, 2010); and is destined for use in designated market sectors (including agriculture and horticulture).

1.3. Poor uptake of farm-based AD in the UK

Historically, the level and nature of UK Government support for AD has lagged behind the incentives offered in many other parts of Europe. Consequently, while AD is widely used in waste water treatment in the UK, it has not been exploited to any significant extent for other purposes, either at community level, or on farms, in spite of the fact that the technology has been extensively proven in these contexts in countries such as Denmark, Germany, Sweden and Austria (Hopwood, 2011; Lukehurst et al., 2010). By 2011, there were just 32 AD units operating on UK farms (NNFCC, 2011), compared with 4000 new AD installations in the 10 years to 2009 in Germany (Scurlock, 2009). With only about 40 plants being planned or under construction in the UK as at March 2011, this state of sector under-development is likely to continue, a matter that must be of some concern to policy makers.

A number of recent studies have attempted to understand what continuing barriers to uptake of farm-based AD remain. In a survey of 381 UK farmers Tranter et al. (2011) found that 89% thought the returns from AD were too low, while 93% thought the establishment costs too high and 69% believed there would be difficulties in obtaining planning permission for the plant. Interestingly, over half of the sample thought that AD would in some way disrupt their existing farm operations and 68% felt that there was insufficient data available to allow them to make sound business judgements. Using a case study approach Bywater (2011) identified capital costs and access to capital as significant barriers to adoption, adding that banks were generally unwilling to lend for such poorly understood projects. Other barriers identified were: the perception that only larger-scale AD units are economically viable; the seasonal availability of slurry feedstock in partially housed dairy systems; and the reluctance of dairy farmers to import, or grow, energy crops for co-digestion. The existence of this last barrier may be seen as unsurprising by some in view of the focus of Government support for AD on the digestion of wastes and diversion from landfill, rather than the production of energy crops or farm diversification.

This wide variety of 'perceived' barriers to AD adoption provides a strong sense that the potential adopters of AD, and funding organisations alike, lack both the empirical data and the analytical tools to make informed investment decisions. Simply put, in the data vacuum that exists, perceived risks multiply and money takes fright.

1.4. Existing models of AD

Because the UK AD sector is so small, it is not possible to derive empirical data (i.e. from direct observation) on the viability of AD in a range of farm business and market conditions in the way it is routinely done for other farm-based activities. AD stakeholders therefore have little recourse but to turn to the body of available research and consultancy material. However, this material is of variable quality and of limited scope, i.e. often focussing solely on costs and returns to AD as a stand-alone investment, using budgeting measures such as Internal Rate of Return, or Net Present Value (see for example, Dolan, et al., 2011; Higham, 1998). Case studies of the small number of operating units and equipment suppliers (see, for example, Köttner, et al., 2008) have revealed that no single model of establishment and operating costs applies to the AD sector, as there is great diversity in these costs over farms, according to their local conditions.

To overcome this lack of normative, empirical data, modelling approaches have been undertaken, with evaluation tools being developed that can be tailored to the specific conditions of individual farms, such as the NNFCC AD Calculator[4] (NNFCC, 2010) and the spreadsheet-based anaerobic digestion Analytical Model (ADAM) (Butler et al., 2011) designed to explore AD financial viability accounting for interactions with farm nutrient requirements and 'costed' GHG emissions. Some researchers have used such models to broaden the range of contextual issues explored. For example Hopwood (2011) used the NNFCC Calculator to explore, within a dairy farm context, the impact of use of different types of feedstocks on AD IRR. Mistry and Smith (2010) examined the economics of AD in the context of livestock farms under different market and subsidy

[1] The FIT replaces ROCS where installations generate less than 50 kW of electricity.

[2] A lower FIT of 8 p/kW h was payable for units in excess of 500 kW generating capacity. As of 1 April 2012 the following FIT rates were available: <250 kW–14.7 p/kW h; 250–500 kW–13.6 p/kW h; >500 kW–9.9 p/kW h (Feed-in Tariffs Ltd, 2012).

[3] From 1 April 2012 a Renewable Heat Incentive of 7.1 p/kW h was available on commercial AD units of all sizes up to a maximum of 200 kWth (DECC, 2013).

[4] Produced by Andersons Consulting.

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