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Financial appraisal of wet mesophilic AD technology as a renewable energy and waste management technology

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ABSTRACT

Anaerobic digestion (AD) has the potential to support diversion of organic waste from landfill and increase renewable energy production. However, diffusion of this technology has been uneven, with countries such as Germany and Sweden taking the lead, but limited diffusion in other countries such as the UK. In this context, this study explores the financial viability of AD in the UK to offer reasons why it has not been more widely used. This paper presents a model that calculates the Internal Rate of Return (IRR) on a twenty year investment in a 30,000 tonnes per annum wet mesophilic AD plant in the UK for the treatment of source separated organic waste, which is judged to be a suitable technology for the UK climate. The model evaluates the financial significance of the different alternative energy outputs from this AD plant and the resulting economic subsidies paid for renewable energy. Results show that renewable electricity and renewable heat sales supported by renewable electricity and renewable heat tariffs generates the greatest IRR (31.26%). All other uses of biogas generate an IRR in excess of 15%, and are judged to be a financially viable investment. Sensitivity analysis highlights the financial significance of: economic incentive payments and a waste management gate fee; and demonstrates that the fate of the digestate by-product is a source of financial uncertainty for AD investors.

1. Introduction

The UK Low Carbon Transition Plan (LCTP) presents a significant driver for investment in Anaerobic Digestion (AD) to generate renewable energy and manage waste. The LCTP commits the UK to cut carbon dioxide (CO_2) emissions by 34% of 1990 levels by 2020, 5% of which must come from reduced agricultural, land use and waste emissions. Furthermore, the LCTP requires that 30% of UK energy requirements must be met using a mix of renewable energy technologies by 2020. AD technology produces energy from all types of organic waste including: farm wastes; the organic fraction of municipal waste; sewage sludge; and commercial organic wastes. This makes AD ideally placed to deliver against CO_2 reduction targets, waste management targets and renewable energy targets simultaneously. The importance of AD in a low carbon economy is reinforced by AD's eligibility for UK Government subsidies, such as the renewable electricity feed-in-tariffs and renewable heat incentive tariffs; and the technology's continued eligibility for Renewable Obligation Certificates (ROCs) or Renewable Transport Fuel Obligation certificates (RTFOs).

AD is a closed vessel process that breaks down organic waste using common biological processes to produce a methane rich biogas, a liquid fertiliser and fibrous soil improver. Different technology configurations are used to manage AD under a range of conditions. Important operating variables are process temperature, moisture content of feedstock and the maximum rate at which organic content can be fed into the digester while maintaining process stability. AD plants typically operate in the mesophilic (25 °C–45 °C) or thermophilic (49 °C–60 °C) temperature ranges. The choice of AD technology also depends upon the moisture content of the feedstock material. AD is typically used in two contexts: as a farm-based process, using farm waste and energy crops as feedstock, integrated with an agricultural enterprise, or as a local centralised plant, processing a wider array of feedstocks, including food processing and abattoir waste. The UK has predominantly used wet mesophilic technology to treat organic waste and any future developments are likely to build on the successful application of this technology.

AD technology is widespread in certain countries. For example, Germany has 4000 AD plants, including farm-scale digesters (Smith, 2008); Sweden uses AD biogas from 35 plants to produce biomethane as a transport fuel (Lantz et al., 2007); and Lille, France uses AD as an integrated solution for waste management but also to produce biomethane fuel for the municipality's public transport fleet (Mulholland, 2005). However, AD technology is relatively uncommon in the UK, limited to approximately 30 farm-scale digesters (AFBI, 2011) and, at the time of writing, only four plants using source separated organic waste from municipal and industrial sources. Given that AD can simultaneously

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deliver against different important environmental and economic objectives, this seems like a missed opportunity.

While much work has been done on the viability of small-scale digesters, there is a need to focus on the potential of local centralised plants, which could make a significant contribution to renewable energy production and sustainable waste management. Therefore, this paper uses cash flow modelling to calculate Internal Rate of Return (IRR) values for a wet mesophilic AD plant processing 30,000 tonnes per annum of source separated organic waste from municipal and industrial sources, to assess the financial viability of AD technology in the UK. The objective is to determine whether this technology is viable under current prices, costs and economic incentives and to offer reasons why this technology is more widely diffused in other European countries. The following sections will:

- identify, based on a series of scenarios, the most financially viable configuration of AD technology and available economic incentive payments;
- determine the importance of economic incentive payments to the financial viability of AD;
- model the financial uncertainty associated with the digestate by-product from AD; and
- quantify the importance of a waste management gate fee to AD financial viability.

2. Methodology: financial appraisal model

A model was constructed to calculate cash flows, IRR and Net Present Values (NPV) for an AD investment over a 20 year lifetime. 20 years was selected because this is the lifetime of the proposed renewable energy tariffs and presents the likely planning horizon of investors (Renewable Energy Association, REA and Stakeholder Working Groups, 2009a). Conceptually the financial model of the AD process follows Fig. 1, which illustrates the flows of material and energy through the AD process from the arrival of organic waste at the AD site through to the production of biogas and digestate, and the production of biogas derived products.

Fig. 1 shows Biogas (58% Methane (CH_4)) being used directly in a combined heat and power (CHP) unit to produce electricity and heat. Alternatively, the biogas can be upgraded to produce biomethane (>97% CH_4) for use as a transport fuel or for injection into the national gas grid. The resultant digestate is a secondary product, suitable as a soil improver. It is not within the scope of this paper to explain the AD process in detail. For further information on the technical elements of AD, the interested reader is referred to Monson et al. (2007).

The cash flow model quantifies physical and energy flows through an AD system, based upon the performance of Wet Mesophilic technology and feedstock characteristics for source separated organic waste. The model assumes, using parameters established by Banks et al. (2008), a feedstock solid content of 23% and production of 140m^3 of biogas, with methane content of 58%, per tonne of waste treated. Wet Mesophilic technology is modelled because this is the dominant technology currently available in the UK for treatment of organic waste. The model assesses the financial viability of producing biogas derived products because biogas has a higher market value and greater certainty of realising that value than digestate. Currently, digestate is predominantly used as a fertiliser replacement, soil conditioner, or for animal bedding, so has value to land owners in terms of avoided input costs. However, the sale price of digestate from the AD plant to another land owner is currently negligible. After consultation with industry experts, the decision was made to include digestate in the financial model with no net market value, as this is the situation that currently faces investors in the UK. The financial model also evaluates the importance of economic incentives and the extent to which AD is viable without UK government support. Table 1 details the type and value of economic incentives available to biogas derived products.

The possible combinations for the use of biogas derived products and available economic incentives, shown in Table 1, provide six scenarios, which are detailed in Table 2. Scenarios 1 and 2 based upon the use of a CHP unit with no market for renewable heat represent the most common situation in the UK.

Data on capital and operating expenditures for a 30,000 tonnes per annum AD plant and biogas upgrading facilities were sourced through personal communication with Biogen Greenfinch (personal telephone communication with Phillip Greenaway, Biogen Greenfinch, 29th July 2009) and Chesterfield Gas (personal telephone communication with Stephen McCulloch, Chesterfield Biogas, 20th July 2009) respectively. The model includes capital costs for one wet mesophilic digester, two CHP units with sound proofing, one biogas conversion unit of appropriate capacity, and one gas grid injection kit, it is assumed that the National Grid will pay for connection to the power grid. Operating costs include full time and specialist staff, and maintenance on all plant infrastructures, including replacement. Wherever possible, heat and electricity requirements are met from production by the AD plant and,

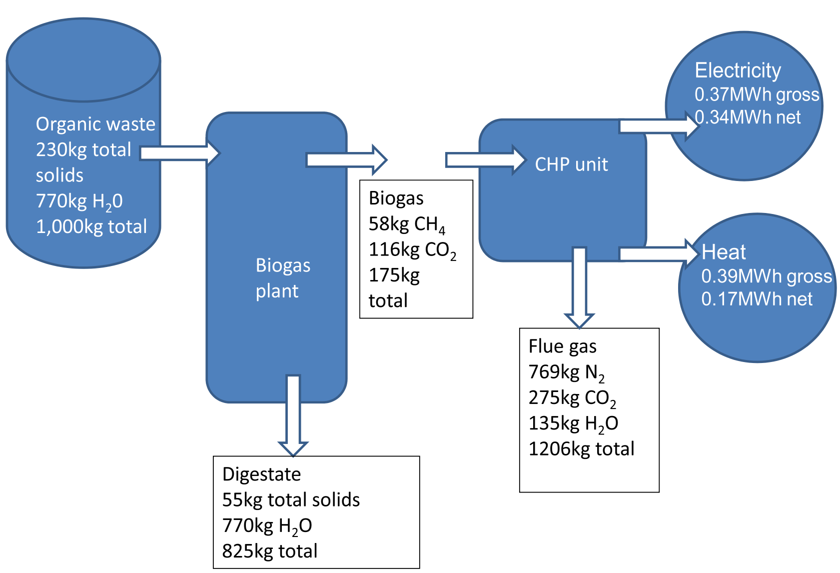

Fig. 1. Mass energy balance of wet mesophilic anaerobic digestion processing 1,000 kg of organic waste.
Source (adapted from REA, 2009b) based upon biogas yield of 140m^3/t at 58% CH_4, 42%CO_2 Banks et al. (2008).