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# Developing a sustainability framework for the assessment of bioenergy systems

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**Abstract**

The potential for biomass to contribute to energy supply in a low-carbon economy is well recognised. However, for the sector to contribute fully to sustainable development in the UK, specific exploitation routes must meet the three sets of criteria usually recognised as representing the tests for sustainability: *economic viability* in the market and fiscal framework within which the supply chain operates; *environmental performance*, including, but not limited to, low carbon dioxide emissions over the complete fuel cycle; and *social acceptability*, with the benefits of using biomass recognised as outweighing any negative social impacts. This paper describes an approach to developing a methodology to establish a sustainability framework for the assessment of bioenergy systems to provide practical advice for policy makers, planners and the bioenergy industry, and thus to support policy development and bioenergy deployment at different scales. The approach uses multi-criteria decision analysis (MCDA) and decision-conferencing, to explore how such a process is able to integrate and reconcile the interests and concerns of diverse stakeholder groups.



*Keywords:* Bioenergy systems; Sustainability; Multi-criteria decision analysis

## 1. Background

Bioenergy represents one of the key elements in the UK energy policy to develop a ''low-carbon'' economy in the future. This is reflected in many recent analytical and policy documents that have addressed the role of bioenergy in the overall economy (e.g. RCEP, 2000, 2004; DTI et al., 2003; Biomass Task Force, 2005; Carbon Trust, 2005; DTI, 2006) and assessed the potential of bioenergy as a primary fuel for heat and electricity (e.g. E4tech, 2003; ICEPT, 2003) and as a feedstock for transport fuels (e.g. Eyre et al., 2002; Hart et al., 2004). The potential is recognised for biomass to contribute to reductions in greenhouse gas (GHG) emissions, to improved energy security and to rural diversification and development.

However, despite the repeated inclusion of bioenergy in future scenarios and Government policy, development of the sector in the UK remains slow. This is true in all applications: heat (including combined heat and power), electricity and transport fuels. This slow development is generally attributed to excessive attention in the past to specific technologies (some of which are characterised by relatively high technological risk), limited attention to promoting specific applications, lack of integration of biomass supply with end uses, and some public resistance and planning delays (RCEP, 2004). An important feature has also been the lack of a coherent cross-sector strategy for bioenergy development and deployment.

In common with other options for reducing GHG emissions, social and economic factors will play a key part in determining how bioenergy develops over coming decades. All new developments in the energy sector are dependent on the willingness of investors, developers and suppliers to enter the market. This willingness is largely based on an assessment of the potential risks and rewards. It is a feature of bioenergy systems that they are complex and may develop at different scales, and involve a number of different market segments, supply chains and actors. Because bioenergy supply chains involve a large number of

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inter-dependencies (growers, biomass intermediaries, plant owners and operators, regulatory authorities and the public), they are particularly vulnerable to risks associated with delays in planning consent, lack of support from the general public and other stakeholder concerns. While reducing carbon emissions and security of energy supply are headline issues at national level, local communities are likely to consider job creation, income improvement, the local environment and regional development as at least equally important in leading to support for or opposition to any new bioenergy plant (Domac et al., 2005).

These differing and potentially competing concerns may be regarded as aspects of assessing bioenergy developments within the framework of sustainable development, generally recognised as having three sets of criteria (e.g. Mitchell et al., 2004): *economic viability* in the market and fiscal framework within which the supply chain operates; *environmental performance*, including, but not limited to, low carbon dioxide emissions over the complete fuel cycle; and *social acceptability*, with the benefits of using biomass recognised as outweighing any negative social impacts.

Key issues for the development of a sustainable bioenergy sector include:

- environmental impacts (not limited to GHG emissions) over the full fuel cycle;
- the potential for biomass to reduce GHG emissions in different sectors, including heat, electricity and transport fuels;
- security and stability of bioenergy supply chains, using both domestic and imported fuels;
- the potential for innovation to lead to more competitive and secure bioenergy chains;
- pathways for the introduction of bioenergy at different scales into different sectors;
- social impacts and public acceptance of bioenergy systems;
- policy measures to promote bioenergy, including policies in the agricultural and waste sectors.

This paper sets out the basis of an approach to assessing sustainability of bioenergy systems. General experience, not just in the biomass sector, shows that the assessment of sustainability cannot be treated solely as an expert analysis: to attain credibility, it is essential to involve an extended peer community with different perspectives (Mitchell et al., 2004). An approach is required which manages uncertainty of all types (Funtowicz and Ravetz, 1990) and to do so with transparency, fairness and competence (Susskind et al., 2001; Renn et al., 1995). The framework is designed to meet these requirements, incorporating stakeholder concerns in decision-making, to guide private sector and local planning decisions and government policies. It is intended to inform best practice guidelines, assurance schemes, policy and regulation, and financial and social risk assessment and communication.

The research is part of the interdisciplinary TSEC-Biosys project to carry out "whole systems analysis" for bioenergy in a timeframe from 2010 to 2050, including (i) the potential role of bioenergy in satisfying UK demand for heat, power and transport energy; (ii) the potential contribution of bioenergy to UK Government energy and environmental objectives; (iii) the economic, environmental and social implications of the large-scale development of bioenergy in the UK. The specific pathways to be examined are (a) small- to medium-scale heat and power plants, using locally grown biomass from energy crops or a range of agricultural and forestry residues; (b) large-scale power generation plants, either fuelled by dedicated biomass or co-fired with fossil fuels; (c) in the transport sector, initially as biodiesel and bioethanol blended with conventional fuels; in the future possible new fuels such as synthetic diesel or hydrogen.

## 2. Methodology for technology assessment

### 2.1. Overall approach

The primary objective of the approach to technology assessment in this project is to develop ways to provide accessible and practically useful information on selected supply chains and scenarios to support short-term planning decisions and long-term policy development. In particular, for any technological supply chain included in the scenarios, it will be necessary to

- determine the contribution of the technology and related supply chain towards sustainable development policy objectives at different scales over time (local, regional and national);
- identify any trade-offs between competing objectives;
- provide insight into the practical drivers and constraints for different actors along supply chains;
- identify any gaps in knowledge and issues which will need to be addressed in future studies.

The approach is designed to develop sets of attributes that will represent the sustainability of bioenergy systems at different scales and capture the concerns of all relevant stakeholders. As for many other public-sector decisions, the range of stakeholders to be involved will be broad (Wrisberg and Udo de Haes, 2002) and the process should ideally be seen as transparent and fair by all stakeholders including:

- biomass feedstock producers and suppliers;
- heat, electricity and biofuel project developers, utilities and transport fuel suppliers, and end-users;
- the financial community;
- technology providers (e.g. processing plant);
- policy makers, regulators and planners;
- members of communities directly affected.

The part of the project introduced in this paper focuses on assessment and decision processes. What is of interest is