energy technologies institute

An ETI Perspective

Increasing UK biomass production through more productive use of land

ETI 10 TEN YEARS OF INNOVATION 2007 — 2017

INTRODUCTION

Bioenergy from biomass and waste already plays a significant role in delivering low carbon heat, power and transport fuels in the UK, and ETI analysis consistently highlights the continued importance of developing the bioenergy sector to deliver cost-effective emissions reductions. Until recently bioenergy production has been dominated by waste feedstocks, but demand for more sustainable UK-grown and imported biomass to support emissions reduction targets has risen and, to further increase supplies of UK-grown biomass, more energy crops and forestry need to be planted.

A focus of the ETI has been to develop a better understanding of how much sustainable biomass could be produced, through identifying suitable land, and estimating how much could be dedicated to bioenergy crops, taking into account other demands for land. This perspective brings together those findings to set out a suggested approach to delivering a substantial energy crops sector in the UK.

KEY HEADLINES

- UK-grown biomass can deliver genuine, system-level, greenhouse gas savings.
- Planting around 1.4 Mha of second generation (non-food) bioenergy crops, such as Miscanthus, Short Rotation Coppice (SRC) willow and Short Rotation Forestry (SRF), by the 2050s would make a significant contribution to delivering a cost-effective, low carbon energy system. This is equivalent to ~7.5% of the total agricultural area of the UK.
- Steadily increasing the area of bioenergy crops in the UK (averaging around 30-35 kha/yr of new planting out to the 2050s) would allow the sector to ‘learn by doing’ and develop best practices, as well as monitor and manage impacts on other markets and the wider environment.
- Delivering a substantial energy crops sector whilst balancing the demand for land from other sectors will require an increase in land productivity and a reduction in food waste throughout the supply chain.
- The market for second generation energy crops is nascent. As the UK prepares to leave the European Union, there is an opportunity to restructure farming support in a way which provides long-term clarity and support to farmers and encourages the sustainable growth of the UK biomass sector.

Why bioenergy?

Bioenergy is a hugely valuable source of low carbon renewable energy because it can be stored and used flexibly to produce heat, power, liquid and gaseous fuels. When combined with carbon capture and storage (CCS), it has the potential to deliver negative emissions which the ETI anticipates are needed to deliver a cost-effective, low carbon energy system in 2050. The ETI's internationally peer-reviewed Energy System Modelling Environment (ESME)[1], a national energy system design and planning capability, suggests that bioenergy, in combination with CCS, could provide around 10% of projected UK energy demand (~130 TWh/yr) whilst delivering net negative emissions of approximately -55Mt CO_2 per year in the 2050s. This is roughly equivalent to half the UK's emissions target in 2050 and reduces the need for other, more expensive, decarbonisation measures.

Using bioenergy in this way could reduce the cost of meeting the UK's 2050 greenhouse gas (GHG) emissions reduction target by more than 1% of gross domestic product (GDP). Even in the absence of CCS, bioenergy is still a cost-effective means of decarbonisation and should play an important role in meeting the UK's 2050 emissions target.

Delivering 130 TWh/yr of bioenergy

ETI analysis using the Bioenergy Value Chain Model (BVCM)[2] indicates that producing ~130 TWh/yr by the 2050s will require around three times more feedstock (on an energy basis) than is currently used. While there are opportunities to use residual waste feedstocks more effectively in the UK, their availability is limited meaning that the majority of this increase will need to be sourced from biomass feedstocks.

The UK bioenergy sector relies on both imported and UK-grown biomass and will continue to do so if it is to generate 130 TWh/yr by the 2050s. This presents an opportunity for the UK to further develop its biomass sector and to reduce the risk of sustainable biomass availability becoming a limiting factor in the growth of the sector. Increasing production of biomass in the UK could deliver:

- An increase in land productivity and the creation of opportunities for farmers and woodland owners to diversify their income. Three case studies published by the ETI demonstrated the value to farmers of planting energy crops on poor quality and/or under-utilised land[3].
- Genuine greenhouse gas emissions savings and biodiversity benefits. The ETI's Ecosystem Land Use Modelling (ELUM) project demonstrated that, when planted sensitively, for example by avoiding soils already rich in soil organic carbon and applying minimal fertiliser, second generation energy crops can increase soil carbon sequestration. Wider research has also identified increased biodiversity and other environmental benefits of incorporating second generation crops into the current farming landscape[4,5].
- Job creation in biomass feedstock production. A report commissioned by the ETI found that, due to the seasonal nature of bioenergy crop production, the majority of job opportunities will be part-time, but are complimentary to the seasonal demands of other roles in the agricultural and forestry sectors, particularly arable farming.

In the UK, Defra estimate that around 93 kha of land were planted with energy crops in 2015, of which 10 kha were second generation crops (Miscanthus and SRC willow), 50 kha were first generation arable crops such as wheat and sugar beet for use in transport fuel production, and 34 kha of maize for use in anaerobic digestion plants. Whilst first generation crops currently make up the majority of the energy crops grown in the UK, ETI analysis indicates that second generation crops can deliver greater GHG emissions savings across a range of end vectors[6]. In addition to energy crops, it is estimated that ~2 million tonnes of wood were used as woodfuel and 4% of cereal straw production was used in power stations[7].

The ETI's analysis indicates that the UK could convert a total of 1.4 Mha of UK land to second generation bioenergy crops (Miscanthus, SRC willow and SRF) by the 2050s. Achieving this level of planting would make a significant contribution towards the 130 TWh/yr target – roughly equal to the contribution of imported feedstocks. In reaching this figure, ETI analysis has considered both the areas of land suitable for bioenergy crops, and how land could be made available for bioenergy crops given competing demands.

1 ETI (2017). ESME [online]. Available at: http://www.eti.co.uk/programmes/strategy/esme
2 ETI (2015). Overview of the ETI's BVCM Capabilities [online]. : http://www.eti.co.uk/library/overview-of-the-etis-bioenergy-value-chain-model-bvcm-capabilities
3 ETI (2016). Bioenergy crops in the UK. Case studies of successful whole farm integration [online]. Available at: http://www.eti.co.uk/library/an-eti-perspective-bioenergy-crops-in-the-uk-case-studies-of-successful-whole-farm-integration

4 Immerzeel, D. J., Verweij, P. A., van der Hilst, F. and Faaij, A. P. C. (2014), Biodiversity impacts of bioenergy crop production: a state-of-the-art review. GCB Bioenergy, 6: 183–209. doi:10.1111/gcbb.12067
5 McCalmont, J. P., Hastings, A., McNamara, N. P., Richter, G. M., Robson, P., Donnison, I. S. and Clifton-Brown, J. (2017), Environmental costs and benefits of growing Miscanthus for bioenergy in the UK. GCB Bioenergy, 9: 489–507. doi:10.1111/gcbb.12294
6 Newton-Cross, G. (2016). Delivering greenhouse gas emission savings through UK bioenergy value chains [online]. Available at: http://www.eti.co.uk/insights/delivering-greenhouse-gas-emission-savings-through-uk-bioenergy-value-chains
7 Defra (2016). Area of crops grown for bioenergy in England and the UK: 2008-2015 [online]. Available at: https://www.gov.uk/government/statistics/area-of-crops-grown-for-bioenergy-in-england-and-the-uk-2008-2015

Excluding unsuitable land types

When modelling future bioenergy scenarios in BVCM, land which is unsuitable for bioenergy crops or forestry, such as steep slopes or natural habitats, is excluded. This constraint mask is called UKERC 9w and was developed as part of the UKERC spatial mapping project[8]. The result of this mask is that the total area of suitable land (using CORINE[9] categories of arable, grass and forest land) drops from 17.10 Mha to 10.95 Mha.

In 2015, the ETI commissioned its Refining Estimates of Land for Biomass (RELB) project to assess whether any additional constraints should be added to the UKERC 9w mask to better reflect the suitability of land on the ground. The project selected five 50 x 50 km cells around the UK and calculated the impact on total land area of adding additional geographic information system (GIS) data sets, such as Biodiversity Action Plan (BAP) priority habitats, semi-natural woodland and parks & gardens. In each of three of these cells, field surveyors also assessed around 200 1km^2 sub-cells, noting whether or not they would be suitable for energy crop planting. The results from the field and desk surveys were analysed to understand which additional GIS datasets improved the accuracy of the land constraint mask in predicting on-the-ground land suitability. The final recommended constraint mask included the three datasets mentioned above as well as additional constraints for altitude, land with high agricultural productivity and buildings & water bodies (an update to a constraint already used in UKERC 9w). This revised constraint mask reduced the area of 'suitable' land in each of the five cells by an average of 16%, compared to the area of suitable land under the UKERC 9w constraint.

In addition to land constraint masks, BVCM restricts land use transitions to reflect existing sustainability requirements and/or best practice. Existing forest must continue to be forested. New forestry and second generation energy crops can be planted on arable or grassland, but first generation (food) crops can only be planted on existing arable land.

8 Lovett, A., Sünnenberg, G. and Dockerty, T. (2014). The availability of land for perennial energy crops in Great Britain. GCB Bioenergy, 6: 99–107. doi:10.1111/gcbb.12147
9 EEA (2017). CORINE Land Cover [online]. Available at: https://www.eea.europa.eu/publications/COR0-landcover

Accounting for Direct Land Use Change emissions – the ELUM project

Converting land to bioenergy crops results in direct land use change emissions (dLUC). These emissions result from changes in soil carbon stock levels or other soil GHG fluxes, and changes in the average amount of carbon stored in the biomass grown on that land.

The ETI's ELUM project, a four year, £4m project led by the Centre for Ecology and Hydrology (CEH), measured and modelled changes in soil carbon stock levels across a number of different land use transitions. Setting the results from this project in the context of numerous bioenergy value chains, as shown in the ETI's insights paper, 'Delivering greenhouse gas emission savings through UK bioenergy value chains,'[6] demonstrated that UK-grown biomass can deliver genuine system level carbon savings across the key vectors of power, heat, gaseous and liquid fuels. Emissions savings are greatest when second generation energy crops are grown on arable or temporary grassland (less than five years old), and while emissions savings can be delivered when crops are planted on permanent grassland, the spatial results from ELUM indicate that greater care is needed to select appropriate sites. However, when used in conjunction with CCS, biomass grown on both arable and grassland can deliver very significant emissions savings.

Having identified land which may be suitable for bioenergy, the RELB project then focused on identifying land that may become available for bioenergy cropping in the short, medium and long term. Land use within the agricultural sector is dynamic; constantly changing to meet demand – the average annual absolute change in the cereal production area is 141 kha and the area of oilseed rape has more than doubled over the last 30 years[10]. Despite this variability, there is little truly 'spare' land in the UK, but there are opportunities to use land more productively. RELB identified between 1.0 and 1.8 Mha of land that could potentially be made available for other uses, including bioenergy planting, without impacting on the level of UK-grown food consumed. In the short term, planting should focus on economically marginal land, permanent fallow land and areas of cereal overproduction. In the longer term, reductions in on-farm and consumer food waste and more efficient management of grazing livestock could make additional land available for bioenergy crop planting without impacting the quantity of UK-grown food consumed[11].

In bringing together the work from the ETI's ELUM, BVCM and RELB projects, Figure 1 demonstrates how land use change for biomass feedstock production in the UK could be targeted strategically over the next 40 years.

10 From 269 kha in 1984, to 675 kha in 2014. Defra (2016). Agriculture in the United Kingdom, Table 7.1, 1984-2015 [online]. Available at: https://www.gov.uk/government/statistical-data-sets/agriculture-in-the-united-kingdom
11 ADAS (2016). Route map to 1.4 Mha of bioenergy crops [online]. Available at: https://d2umxnkyjne36n.cloudfront.net/teaserImages/160519_BI2012_D12_Extension-report_v2-1_FINAL.pdf?mtime=20170714162203

Representation of a strategic approach to targeting land use change for biomass feedstock production

An average planting rate of 30-35 kha/yr could deliver up to 1.4 Mha of second generation energy crops in the 2050s.

*ETI analysis indicates that direct land use change emissions from converting UK grassland to second generation energy crops are of second order importance relative to the negative emissions that can be achieved through bioenergy with CCS.

DELIVERING A THRIVING UK BIOENERGY CROP SECTOR

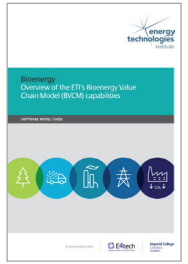
The ETI's work has demonstrated that UK-grown bioenergy crops can deliver genuine carbon savings and that there is sufficient suitable land to plant around 1.4 Mha of energy crops. Delivering this level of planting will require changes to land management in order to increase overall productivity and balance competing demands for land use. This will take time and long-term commitment – a steady increase in the planting rate of second generation energy crops (averaging 30-35 kha/yr out to the 2050s) would be sufficient to put the UK on the trajectory to deliver a substantial bioenergy sector, whilst also allowing sufficient time for the sector to 'learn by doing' - developing new establishment techniques, and understanding how best to manage crops to maximise greenhouse gas savings. It will also enable the wider agricultural sector to monitor and manage impacts on other markets and the wider environment.

While the use of UK-grown biomass for energy is increasing, the sector (particularly the second generation energy crop sector) is nascent and requires support to grow. With higher establishment costs, a longer lead time for a revenue return (2-3 years for energy crops, longer for forestry) and a limited number of buyers at present, farmers need long-term certainty that there will be a market for their bioenergy crops. As the UK prepares to leave the European Union, there is an opportunity to restructure farming support in a way which encourages the sustainable growth of the UK biomass sector. This could place a value on the wider environmental benefits growing second generation energy crops can make to the farming landscape, reducing the risk to farmers by providing a degree of income security.

FURTHER READING

Insights into the future UK Bioenergy sector, gained using the ETI's Bioenergy Value Chain Model (BVCM)

http://www.eti.co.uk/insights/bioenergy-insights-into-the-future-uk-bioenergy-sector-gained-using-the-etis-bioenergy-value-chain-model-bvcm

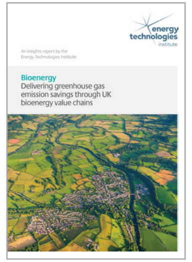


Overview of the ETI's Bioenergy Value Chain Model (BVCM) capabilities

http://www.eti.co.uk/library/overview-of-the-etis-bioenergy-value-chain-model-bvcm-capabilities

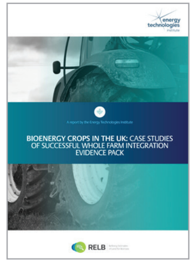
Enabling UK Biomass

http://www.eti.co.uk/insights/bioenergy-enabling-uk-biomass



Delivering greenhouse gas emission savings through UK bioenergy value chains

http://www.eti.co.uk/insights/delivering-greenhouse-gas-emission-savings-through-uk-bioenergy-value-chains



Bioenergy crops in the UK: Case studies of sucessful whole farm integration evidence pack

http://www.eti.co.uk/library/bioenergy-crops-in-the-uk-case-studies-on-successful-whole-farm-integration-evidence-pack

An ETI Perspective - Bioenergy crops in the UK: Case studies of sucessful whole farm integration

http://www.eti.co.uk/library/an-eti-perspective-bioenergy-crops-in-the-uk-case-studies-of-successful-whole-farm-integration energy technologies institute

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