An insights report by the
Energy Technologies Institute

Bioenergy
Enabling UK biomass

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Key headlines

- Using sustainable biomass as a source of energy (bioenergy) can reduce the cost of meeting the UK's 2050 carbon targets by more than 1% of GDP – helping make low carbon energy more affordable for consumers and businesses
- The high value of bioenergy lies in its versatility to provide energy for a mix of low carbon heat, power, gas and liquid transport fuels
- Biomass combined with carbon capture and storage (CCS) is the only credible route to significantly reduce atmospheric carbon (negative emissions) – unlocking the ability to meet national carbon targets at a much lower cost
- The UK has a strategic opportunity to produce its own domestic biomass for secure and sustainable low carbon energy – land can be made available without undermining food production, soil carbon stocks, local ecosystems or amenities
- Growing biomass in the UK (energy crops & short rotation forestry) can increase energy security by complementing imports and provide economic value to the UK
- For farmers – growing biomass for energy can be a highly productive land use generating new income streams
- Strategic and long-term commitment will be needed to establish and develop the sector
- Agricultural and energy policies can be joined up to promote growing sustainable biomass – in ways that improve overall land use productivity

Introduction

Many future scenarios for the UK energy system suggest that bioenergy could play a crucial role in meeting our green house gas emission reduction targets by 2050. But while using biomass for energy is commonplace in many countries, the availability and sustainability of biomass feedstocks is also often seen as controversial or difficult.

The UK's small size, dense population and limited forest cover creates doubt that we can grow sufficient sustainable biomass ourselves. Land use and agricultural policy typically prioritises domestic food production, and land is implicitly assumed to be too scarce to allow significant planting of biomass for energy without undermining food production. Therefore, if the UK is to realise the significant benefits from bioenergy, there are important questions around the sourcing of feedstocks. Should the sector continue to develop predominantly relying on imported feedstocks; or can domestic production play a significant role too?

This paper seeks to explore these issues and initiate a constructive dialogue amongst stakeholders. It sets out the case for a pro-active policy to develop a sustainable UK biomass production capability to complement imported biomass. There is a strong case for joining up agricultural, land use and energy policies in ways that support domestic biomass production, both to increase land use productivity and to enable us to meet carbon targets affordably.

ETI analysis robustly points to the potential for expanding UK domestic capability to produce sustainable biomass (mainly through perennial energy crops and short rotation forestry (SRF)) as a hugely valuable strategic opportunity. Therefore ETI argues that significant efforts should be made to support and expand the current fledgling industry by incentivising the production of sustainable feedstocks in the UK in ways that fit with current farming and land management systems, while maximising land use and value chain productivity. Alongside promoting our domestic biomass production capability, further work should be done to measure, monitor and verify the sustainability of imported feedstocks, to build confidence in the capability to deliver sustainable bioenergy.

The central elements of our case are:

- Sustainable biomass can reduce the cost of meeting the UK's 2050 carbon targets by more than 1% of GDP. This makes it a highly productive land use capable of generating income for farmers and making low carbon energy more affordable for consumers and businesses. It is worth noting that the potential savings for a low carbon UK economy are worth more than the agriculture sector's entire current output (circa 0.7% of GDP in 2014).
- Sustainable biomass can deliver high value as a feedstock for scalable and cost effective bioenergy, generating a flexible mix of low carbon heat, power, gaseous and liquid transport fuels.
- Biomass combined with CCS is the only credible route to significantly reduce atmospheric carbon (i.e. net 'negative emissions'). This unlocks the ability to meet national carbon targets at a much lower cost to the taxpayer, and therefore should be enabled through strong Government support.
- Developing a domestic biomass sector at scale offers the greatest benefits in terms of security of supply and sustainability (in terms of control over impacts across the land use system and value chain).

This paper complements a series of recent ETI insights papers[1] which set out our learnings including those from modelling both the UK energy system[2] and UK bioenergy value chains[3].

[1] ETI insights publications are available via the ETI website www.eti.co.uk/category/available-materials/?restrict=insights

[2] Options, choices, actions: UK scenarios for a low carbon energy system transition, by Scott Milne http://www.eti.co.uk/wp-content/uploads/2015/03/Options-Choices-Actions-Hyperlinked-version-for-digital.pdf

[3] Insights into the future UK Bioenergy Sector, gained using the ETI's Bioenergy Value Chain Model, by Geraldine Newton-Cross (2015) http://www.eti.co.uk/wp-content/uploads/2015/03/Bioenergy-Insights-into-the-future-UK-Bioenergy-Sector-gained-using-the-ETIs-Bioenergy-Value-Chain-Model.pdf

Understanding the potential role of UK biomass

How valuable is bioenergy to a low carbon UK?

The ETI uses a range of evidence, science and engineering expertise and sophisticated modelling to develop a balanced view of the UK's long term options for low carbon energy. This body of work clearly points to bioenergy as a hugely valuable option for affordable low carbon energy:

- Bioenergy combined with CCS could deliver more than 50 million tonnes of CO_2 negative emissions per annum by 2050 – i.e. 50% of allowable emissions
- Bioenergy can cut the annual cost of low carbon energy by more than 1% of GDP by 2050[4]
- On a per household basis this is equivalent to a combined average saving of more than £1000 per annum off the annual cost of electricity, heat and transport services
- Sustainable biomass (with a majority grown in the UK, but also utilising imports) can provide up to 10% of our primary energy needs by 2050

These benefits for consumers and taxpayers represent costs that they would otherwise have to pay to meet carbon targets if bioenergy were not deployed. For example, without flexible bioenergy, we would need to spend more on costly ultra-low emissions vehicles, or power generation capacity which would run relatively infrequently. If the future bioenergy sector is based on no biomass imports and a small niche UK biomass feedstock supply base only, it would cost the UK tens of billions more each year to reach its national carbon targets in 2050

The high value of bioenergy lies both in its versatility to produce heat, power, gaseous and liquid fuel applications flexibly and cost effectively; and in its ability to make carbon budgets easier to meet by removing CO_2 from the atmosphere (so called 'negative emissions') when combined with CCS. CCS is used to permanently store the carbon that growing plants have absorbed from the atmosphere, when their biomass is used for energy.

Bioenergy is also key to the UK's future energy infrastructure choices. Without access to flexible bioenergy, deeper emissions cuts will be needed in transport, with big implications for electricity and potentially hydrogen infrastructure needs.

Given long lead times and slow turnover of long life assets, we will need to make major infrastructure choices and investments from the mid 2020's to hit carbon budgets, so we need to invest now to learn how we can realise the large scale potential role of bioenergy, and domestic biomass in particular.

FIGURE 1

The case for biomass for energy in UK decarbonisation?

ESME analysis shows that enabling use of biomass for energy can reduce the cost of meeting 2050 carbon targets by more than 1% of GDP

Biomass can underpin a wide range of versatile and flexible energy vectors, conversion technologies and end uses in heat, power, gas and liquid transport fuels

Biomass with CCS can reduce atmospheric carbon (net negative emissions) – this is hugely valuable because it enables continued use of some fossil fuels in heat and transport

Intuitively this reflects characteristics of UK energy system (need for flexible sources of low carbon energy, high costs and intermittency of other renewable options)

This relies on the ability to demonstrate convincingly that biomass for energy value chains do not lead to emissions elsewhere which outweigh emissions reductions in energy production

[4] ETI's latest modelling using ESME actually estimates these savings at circa £90bn (equivalent to nearly 3% of projected GDP). Figures based on comparison of modelled scenarios extending over 35 years into the future must always be used with caution and provide an indication of broad orders of magnitude. For these reasons we quote a more conservative order of magnitude estimate 'more than 1% of GDP'. Implicitly this allows for the potential that a very steep abatement cost curve in a high cost 'no biomass' pathway would induce significant unanticipated innovation and efficiency improvements.

Understanding the potential role of UK biomass

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ESME
Energy System Modelling Environment

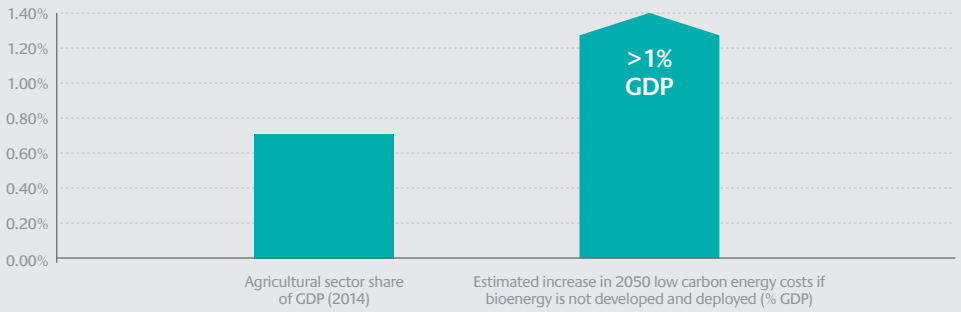
BOX 1

The ETI's internationally peer reviewed national energy system design and planning capability (the Energy System Modelling Environment or 'ESME') is now used by the Department for Energy and Climate Change (DECC), the Committee on Climate Change (CCC), academics and ETI members. ESME allows robust, evidence-based analysis of the least cost combination of technology choices to deliver future energy needs and meet 2050 carbon targets.

ETI's scenario analysis[5] for the UK energy system clearly shows the potential benefits of deploying bioenergy at scale, with UK and imported biomass providing around 10% of the primary energy inputs from 2040 onwards.

FIGURE 2

Scaling the value of bioenergy

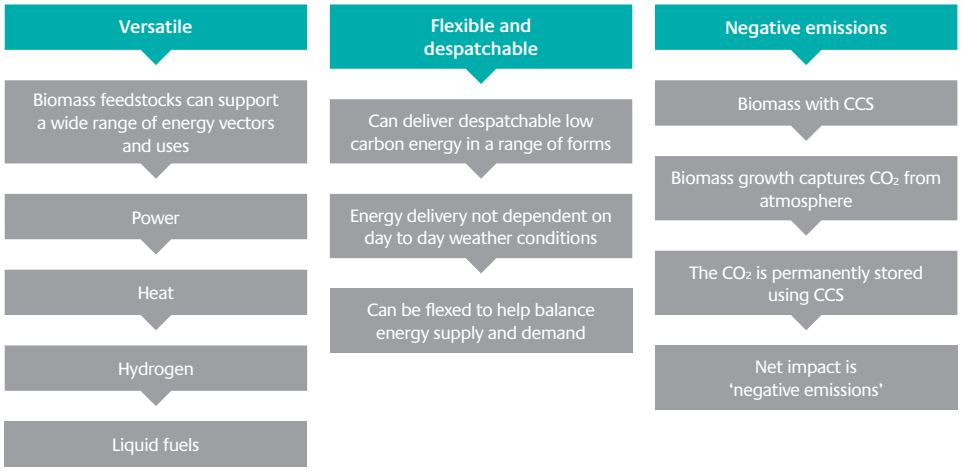


Estimating the value of bioenergy

The value delivered by bioenergy is assessed by comparing the modelled costs of an optimised energy system with bioenergy deployed against those for a system where it is not available. ETI's current core 2050 scenario estimates this value at in excess of 1% of GDP per annum by 2050, or an Net Present Value (NPV) in excess of £300bn to 2050.[5]

FIGURE 3

Why is biomass valuable to the energy system?



[5] See footnote 2, Page 05

Understanding the potential role of UK biomass

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Can the UK develop a sustainable bioenergy sector?

The Government's 2012 UK Bioenergy Strategy rightly adopted as its first two principles that:

- Policies that support bioenergy should deliver genuine carbon reductions;
- Support for bioenergy should make a cost effective contribution to UK carbon emissions objectives.

The ETI's work on bioenergy aligns strongly with these two key principles. Both DECC and ETI have recently undertaken work to understand the relative importance of emissions from producing and / or using biomass for energy (see Box 2).

DECC undertook a life-cycle analysis of the carbon impact of using imported biomass in the UK for electricity generation, comparing it to different counterfactual management practices and alternative uses[6]. Whilst this modelling work highlighted indicative impacts of different scenarios, it didn't assess the probability of the different scenarios occurring.

ETI commissioned and funded its ELUM project to measure and model the direct emissions arising from land use change to biomass feedstock production in the UK (see Box 3). Projects like these can help inform policy and governance frameworks to ensure sustainable practices in biomass value chains, by identifying the 'low risk' land use transitions (where impacts are either beneficial or minimal), whilst further scientific evidence and understanding is being developed in other areas.

BOX 2

Understanding the emissions impacts of using biomass for energy

Impacts on emissions which arise directly from biomass production include:

- Changes in stocks of carbon held in soil and biomass (above and below ground)
- Emissions associated directly with the practices of biomass production, transportation and processing

Impacts which may arise elsewhere as an indirect result of biomass production include:

- Emissions arising from indirect land use changes (or 'ILUC') – most obviously associated with displacing agricultural production onto land elsewhere
- Emissions arising from changing the use and destination of biomass (e.g. reducing wood available for construction, leading to greater use of other materials)

[6] BEAC tool. Stephenson, A & Mackay, D (2014), Life cycle impacts of biomass electricity in 2020, DECC report.

BOX 3

ETI's Ecosystem Land Use Modelling (ELUM) project

Over the past four years ETI has invested in its ELUM project with a range of partners to improve evidence around the sustainability of UK biomass production. The ELUM project has directly measured emissions and soil carbon impacts for a range of land use transitions at commercial sites across the UK, and developed predictive models for assessing future land use emission impacts from biomass production.

Together with the ETI's Bioenergy Value Chain Modelling (BVCM) toolkit (see footnote 3), we are gaining a richer picture of how the UK can create a sizeable, and demonstrably sustainable, biomass feedstock production capability. Further insights from this work will be published later in 2015.

In broad terms analysis using the ELUM results suggest that biomass for energy can be produced sustainably across large parts of the UK, but that a targeted approach should be taken.

- The direct soil carbon emission impacts vary across transitions and across the UK
- First generation (typically arable, starchy or oily) crops have less potential to deliver soil carbon savings than second generation (typically more woody) feedstocks
- Production shouldn't be viewed in isolation – it is important to assess where and how the biomass material is being converted to energy, to judge the scale of impact / carbon savings potential across the whole value chain.
- Land use emissions can be material in some areas, but they are of second order importance when the biomass is used in bioenergy value chains with CCS.

elum

Understanding the potential role of UK biomass

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Delivering the value suggested by ETI's energy system analysis depends to a large degree on our ability to source sufficient biomass from sustainable sources, either domestic or imported. Domestic sources offer the greatest energy security and sustainability benefits in the longer-term, but the reality is we just don't have enough of our own biomass feedstocks today to supply a commercially-viable bioenergy sector in the UK. However, basing the development of the sector purely on imports in perpetuity, could expose the UK to market risks in terms of access to a valuable traded commodity or sustainability risks around the impacts of value chains.

Therefore, the pragmatic and strategic solution is to develop the sector now based on biomass imports derived from sustainable sources, so the key actors in the supply chain can 'learn by doing' in terms of logistics, handling, and designing and operating optimal bioenergy conversion technologies. This sector development in turn provides a reliable market pull over the next 10-15 years for an emergent domestic supply chain, which could realistically become the dominant source of biomass feedstocks by 2040.

If either domestic biomass production or market-pull from bioenergy conversion plants are unsupported, then a significant domestic bioenergy supply chain is unlikely to develop. Suppliers and growers will not invest unless there is a reliable market, and project developers will struggle to reach financial close unless they can contract for at least 10 years supply of feedstock upfront. There is a clear need for strategic and long-term commitment to help the sector through this establishment phase.

BOX 4

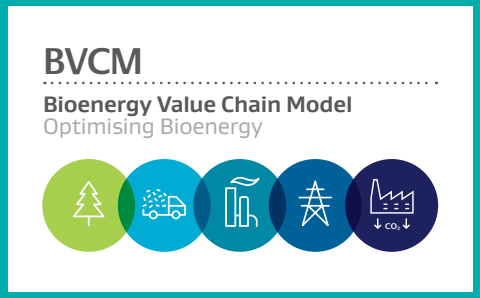
ETI's Bioenergy Value Chain Model (BVCM)

The ETI has developed its BVCM toolkit in partnership with some of the UK's leading bioenergy experts.

The BVCM enables analysis of the best way to deliver long-term bioenergy outcomes taking into account the available biomass resources, UK geography, time, technology options and logistics networks.

ETI is uniquely placed to analyse how the UK bioenergy sector may develop spatially and temporally, in order to deliver the levels of bioenergy and emissions savings identified by ESME at the energy system level. We have published a separate insights paper based on this work[7], but key points from this analysis include:

- Confirmation of the importance of biomass with CCS as the only credible route to deliver negative emissions, with ports and imports a key influence on technology deployment and location
- Bio-hydrogen and bio-electricity appear key options in preference to biofuels and bio-methane
- The importance of bio-heat, particularly as a scale-up route in early decades
- Gasification is a key enabler, as a flexible, scalable, cost-effective and efficient technology
- Production of SRC willow is optimal in the west / north-west of the UK with Miscanthus and SRF in the south and east of the UK, based on yields, demands and logistics
- UK land is finite and valuable, but with the right prioritisation, it can support sufficient sustainably-produced biomass feedstock to make a hugely important contribution to meeting our carbon budgets



[7] See footnote 3, Page 05

Understanding the potential role of UK biomass

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How significant a contribution could UK biomass make?

Modelling analysis of the UK energy system points to the merits of biomass for energy, but can it be produced sustainably under real world conditions and at a significant scale in the UK's agricultural landscape?

The most obvious challenge is releasing sufficient suitable land for biomass production, without damaging food production, carbon stocks, local ecosystems or amenity. This raises the questions – which land, and what do you grow on it? ETI's ELUM project is providing insights around the former question, and will be discussed in more detail in a separate insight report. An increasing body of evidence from ETI projects and other work[8] suggests the most attractive biomass feedstocks today are short rotation forestry species (e.g. Scot's pine and poplar) and perennial energy crops (miscanthus and short rotation coppice willow or poplar (SRC)). These feedstocks are most likely to provide the optimal combination of yield, cost effective production and soil carbon / GHG savings (the latter due to lower fertiliser inputs).

ETI has worked with its membership, advisors and partners to build realistic assumptions around the achievable scale of UK biomass production. These assumptions are captured in all our bioenergy and energy system analyses, such as those highlighted in the BVCM Insights paper (see Box 4) and the ESME 'Clockwork' and 'Patchwork' scenarios (Table 1), both published by the ETI in March 2015.

[8] TSec-Biosys, CarboBiocrop, Bio-TINA, CCC Bioenergy Review and UK Bioenergy Strategy

TABLE 1

Potential scale of UK biomass production: assumptions in ETI Clockwork and Patchwork energy system scenario analysis[9]

Item	2030s	2050s
UK biomass energy inputs (2010 = 29 TWh largely forestry residues & waste)	~ 55 to 85 TWh (2.8 – 3.8% of UK total)	~ 85 to 140 TWh (4.5 – 6.3% of UK total)
Biomass tonnage (oven dried tonnes)	~ 5 to 12 million odt	~ 12 to 23 million odt
Land utilisation for biomass (assuming yields of 10 odt/ha rising to 12.5 odt/ha)	~ 0.5 to 1.2 million ha (equivalent to 2.7 – 6.5% of UK agricultural land)[10]	~ 1 to 1.8 million ha (equivalent to 5.4 – 10% of UK agricultural land)

6% of UK energy

UK energy inputs from domestic biomass production in 2050 in ETI Clockwork scenario

[9] All TWh figures are shown on a pre conversion basis (ie the energy content of biomass as an input to energy production)

[10] Total UK Agricultural Land accounts for 18.4 million hectares as of October 2014 (Defra: www.gov.uk/government/uploads/system/uploads/attachment_data/file/364157/structure-jun2013prov-UK-16oct14.pdf), of which 17.2 million hectares was classified as 'utilised'.

Understanding the potential role of UK biomass

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These assumptions are in line with others' estimates, such as those developed by the CCC in its UK bioenergy supply scenarios, or the DECC UK Bioenergy Strategy (2012)[11]. The potential value to the UK provides a strong strategic case for considering land use change on this scale. Historical experience during and after the second world war, and with the introduction of oil seed rape over the past 30 years (over 0.75 million hectares by 2012[11]) suggest that large scale land use change is possible and acceptable with strong enough policy and economic drivers.

A range of work supports the potential to release land area of this magnitude for biomass production without a major negative impact on food production. The Food and Environment Research Agency and the agricultural consultants ADAS[12] identified over 0.85 million hectares (Mha) of 'idle' non-agricultural land, along with up to 2.9 Mha of agricultural land where perennial energy crops could be competitive. Similarly the CCC reviewed estimates in its 2011 bioenergy review and suggested a top range of 0.8 Mha in its assessment. Taking a different approach, Lovett et al (2014)[13] identified over 9 Mha of land potentially suited for biomass production based on the successive application of land suitability constraints (this did not consider impacts on current food production).

ETI's BVCM model incorporates Lovett et al.'s work as starting constraint masks, and we then apply our own data and assumptions around other demands for land (e.g. land for food and feed production); establishment rates; yield improvements; and annual planting rates etc. This enables us to assess the impact of different levels of land availability on the amount of biomass feedstock that could be produced in the UK. As can be seen from Table 1, a significant volume of biomass will be needed to enable bioenergy to deliver its potential value to the energy system. There is a case for aiming to develop UK domestic production to provide the majority share of feedstock by 2050, but at this stage it is clear that sustainable and affordable supply chains for both imported and domestic feedstocks should be developed.

A variety of land management actions could release land for biomass production in the UK, such as bringing idle and under-utilised land in to production, increasing the efficiency of existing land use, targeting 'problem' areas such as arable land with black grass which require significant chemical and management interventions, and re-introducing agro-forestry practices at the farm level.

[11] Bioenergy Review, Committee on Climate Change, (December 2011)

[12] Assessment of the availability of marginal or idle land for bioenergy crop production in England and Wales (2009)

[13] Lovett, A. et al. (2014) The availability of land for perennial energy crops in Great Britain, GCB Bioenergy 6, 99-107.

The challenges for scaling-up UK biomass production

Building a significant UK biomass sector will not be easy: a range of real world challenges will need to be overcome to unlock its potential. Domestic biomass production cannot be developed in isolation from support for biomass conversion technologies, which provide the end uses and market-pull.

Building from a low starting base and bumpy history

Over the past decade the UK's small energy crop sector has struggled to grow, with a number of false starts and intermittent policy support (see Box 5). In 2013 over 50,000 hectares of UK agricultural land were used for bioenergy (comprising 8,000 hectares of oilseed rape, 8,000 hectares of sugar beet, 26,000 hectares of wheat, 7,000 hectares of miscanthus and 3,000 hectares of short rotation coppice[14]). More than 80% of this domestic feedstock is currently destined for biofuel production (biodiesel and bioethanol) for UK road transport markets.

Biomass production (energy crops and forestry) features only marginally, if at all, in mainstream debates about agricultural policy and land use. Achieving something close to the average feedstock output envisaged in ETI's scenarios by 2030 would require both a focus on second generation feedstocks such as Miscanthus, SRC and SRF for use in more strategically valuable bioenergy value-chains; and something like an 85-fold increase on the current area of second generation bioenergy cropping. This level of increased planting will require a step by step development of the sector based on viable business models and value chains, at progressively larger scales.

A targeted approach to promotion of plantings would maximise carbon benefits, and by increasing land use productivity, minimise additional pressure on land resources.

[14] Defra UK agricultural statistics: www.gov.uk/government/uploads/system/uploads/attachment_data/file/434098/nonfood-statsnotice2012-10jun15.pdf

The challenges for scaling-up UK biomass production

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BOX 5

The Energy Crop Scheme

The Energy Crop Scheme provided establishment grants (from CAP[15] rural development funding) for energy crops from 2000-2012 before finally closing to new applications in 2013. The scheme suffered from low uptake, and its popularity reflected the fluctuating fortunes of end use outlets – with new plantings and confidence heavily dependent on one or two key outlets. A two year gap in establishment grants in 2006-08 interrupted industry momentum, and many farmers felt that the scheme was not strongly promoted by Natural England, with quite demanding administrative arrangements.

Making biomass for energy commercially attractive

Domestic biomass might have high potential value, but a number of features of the current market inhibit growth.

» **Uncertain rewards for carbon benefits**
Since carbon prices are currently too low, the carbon benefits of bioenergy (like any low carbon energy) need to be rewarded through various policy incentives, including the renewables obligation and Contracts for Difference (for electricity) and the Renewable Heat Incentive (RHI). But investors don't know whether these incentives will still be offered in future years, inhibiting long term investment in building sector capability, especially in light of the recent cuts announced by DECC[16].

» **Challenges in achieving competitiveness**
Significant policy support has already been channelled into developing imported biomass value chains, making for a challenging competitiveness position for domestic biomass. Investment will be needed in UK production capacity, capability and supporting infrastructure, such as densification and distribution equipment. It is likely that policy support will need to reward the additional benefits of energy security and sustainability that could accrue from a domestic production sector, to enable it to achieve competitiveness.

Short run market development opportunities include blending into existing bulk volume markets like bio-power, where users are currently using imported wood pellets; and opening up new market niches where domestic supply can quickly realise a competitive advantage. For example, better margins may be achieved by developing higher value end uses, most obviously heat demands which currently benefit from RHI support.

[15] Common Agricultural Policy

[16] www.gov.uk/government/news/controlling-the-cost-of-renewable-energy

The challenges for scaling-up UK biomass production

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» **Barriers to entry**
Through market analysis and discussions with growers, key barriers to entry for potential producers were identified:

- Delayed cashflows: the significantly longer lead times (two – three years) for a revenue return present real cashflow problems for many new growers used to annual cropping.
- Long term commitment and reliability of markets: immature markets and uneven policy support have undermined grower confidence in future markets and returns. The physical and financial challenges of entering (or exiting) energy crop production are significant, and there are a relatively small number of reliable market outlets for new growers.
- Cultural barriers and fears: many farmers are used to making annual business decisions, with flexibility to respond to market trends in successive years. Making a long term commitment to a land use which requires less intensive management inputs can be a cultural challenge for some, yet a welcome change in practice for others, e.g. as part of a retirement plan.

To begin attracting new growers, early market players could target farmers who may value income diversification and stabilisation, who want to reduce their labour inputs, or who might gain from other services (such as providing habitat for game birds) that energy crops could provide. There is also a strong case to build on existing geographic clusters close to promising market outlets (e.g. sources of heat demand or Combined Heat and Power (CHP) schemes).

» **Economies of scale**
In common with many immature sectors, co-ordination challenges make it difficult to realise economies of scale in a range of functions (e.g. nursery-stock production and distribution, planting and specialist harvesting equipment, haulage and processing). All this depends on developing the value chain 'ecology', with end use markets of sufficient scale to support a critical mass of plantings within a geographic area which is economic for transport, distribution and support services.

» **Investment challenges in building value chains**
The need for long term commitment on feedstock supply raises risks for investors. Without a reliable feedstock supply of consistent quality and volume, heat or power projects are perceived to be more risky for investors. This increases both the return on capital required and the level and length of capital commitment needed to build the value chain (through extended commitment to servicing and contracting with growers). Aggregators and brokers could help to address some of these challenges.

Public acceptability

There are potential public and political acceptability challenges around devoting more land to energy crops and forestry, often linked to generalised perceptions around 'food versus fuel' concerns, or in relation to possible impacts on ecosystem services, biodiversity or water resources. Strong evidence will be needed to address these concerns, ideally informing the development of a transparent and robust measurement, monitoring and verification scheme, established to ensure sustainability standards are met.

Aesthetic concerns around landscape change to taller perennial crops or forestry are sometimes anticipated, however research by Dockerty et al (2012)[17], suggests relatively relaxed attitudes to the appearance of energy crops themselves, with concerns more likely about the site-specific visual impact of infrastructure (e.g. biomass power stations). Again, historical experience with oil seed rape suggests that public attitudes can accommodate significant visual impacts from new crops.

[17] Dockerty, T, Appleton, K and Lovett, AA (2012) Public opinion on energy crops in the landscape: considerations for the expansion of renewable energy from biomass. Journal of Environmental Planning and Management, 55 (9). pp. 1134-1158. ISSN 0964-0568

Potential future business models

Growing the UK biomass sector over the next two decades is likely to require a range of transitional business models to encourage sustainable production in the right areas; promoting new end use demands capable of offering higher returns; whilst maintaining the strategic trajectory towards the longer-term high-value benefits of negative emissions from bio-hydrogen or bio-power with CCS. Transitional opportunities include the use of biomass in heat applications in the 2010s and 2020s, since this pathway offers good carbon savings relative to some fossil-fuel equivalents, and can provide a local market stimulus for domestic biomass production.

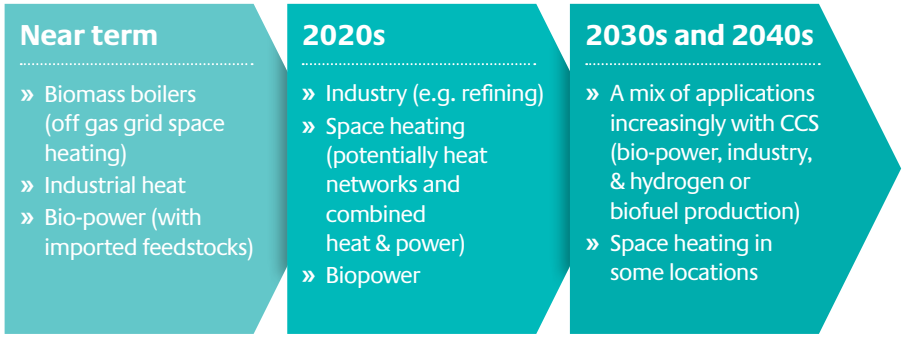
More specific suggestions for important transitional business models include:

» **Off Grid Heat markets – supported by Renewable Heat Incentives**

Off grid heat appears to offer promising new local markets because the RHI provides enhanced rewards and off grid heat has been relatively costly (although recent falls in the oil price have diluted this). A range of business models with varying degrees of vertical integration could be developed, enabling domestic biomass to supply a higher proportion of off gas grid heat demand. Early opportunities could be developed in small and community scale applications in rural areas, with the option then to build scale (e.g. heat networks) as greater confidence in logistics and supply chains develops.

FIGURE 4

Outline phasing for biomass energy in UK



» **On farm heat self-supply**

Farmers with on farm heat loads (e.g. poultry enterprises) can produce biomass to meet their own energy needs. At present this would compete with anaerobic digestion which enjoys policy support for farm-level bioenergy. Support service providers (e.g. upfront financing packages, installation and servicing of boiler equipment, provision of planting material and advice on energy crops) could stimulate investment by interested farmers.

» **Integrated heat and power projects with a mix of imports and local production**

A number of biomass CHP projects are in operation or planned within the UK, relying mainly on imported biomass (mostly wood pellet). These projects offer the immediate opportunity to provide market-pull for locally-produced biomass feedstocks, and where possible, could provide heat for local building or industrial heat loads, horticulture or fish farming.

Such projects can benefit from the Renewables Obligation, Contracts for Difference, or the non-domestic RHI and could help to develop and scale up local biomass production over time, by providing an anchor demand. However, some form of targeted reward (or a condition attached to a contract for difference) may be needed to incentivise optimal value chains from a security, sustainability and affordability perspective.

» **Aggregators, intermediaries and grower service providers**

As the sector transitions, aggregators and grower service providers are likely to play a crucial role in linking growers into more efficient and developed value chains. These businesses will need to finance investment in logistics and equipment, and to develop attractive financial packages for new growers (for example, by advancing revenues to reduce cashflow constraints for new growers).

A range of business models could develop, offering permutations of financing, planting material and services, agronomic advice, harvesting services, marketing, market making, price risk management, processing, and transportation. The key will be to find commercially viable offerings and the capability to serve progressively larger scale end uses.

Different models could suit different regions with larger scale and more capital-intensive value chains in lowland Britain serving larger end uses, while more compact local value chains in less accessible, hilly (mainly western) regions might serve a range of enduring community-scale end uses.

Building the sector: policy and market challenges

The current policy environment

Currently there is no direct support for SRF or perennial energy crops, and domestic biomass hardly features in current agricultural or energy policy discourse.

Domestic biomass and agricultural policy

Concerns around energy crops tend to focus on the risk of displacing food production (although similar issues can also apply to oilseed rape destined for bio-diesel or maize for anaerobic digestion). In 2013 Department for Environmental, Food and Rural Affairs (Defra) Ministers explicitly ruled out Common Agricultural Policy (CAP) funding support for energy crops, stating that they wished to see greater use of waste in bioenergy[18]. Current policy support for farm or rural bioenergy focuses on anaerobic digestion.

The CAP framework agreed for 2014-2020 makes a 30% share of farm support payments conditional on 'greening measures', but in the UK these exclude energy crops thus placing them at a major disadvantage when growers consider new crop options. Member states are also required to ensure that grassland does not fall by more than 5%, reinforcing a blanket perception that conversion of any grassland is environmentally undesirable.

Finally, in the UK the axing of the Energy Crops Scheme (Box 5) means there is currently no ready-made route for support through CAP funding for rural development programmes (known as 'pillar 2' in CAP terms)[19]. Despite this, however, good quality projects to build biomass value chains, with sound evidence of rural development benefits, could be designed to fit within pillar two funding (see Box 6).

Domestic biomass and current energy policy

Most policy support for biomass (via Renewables Obligations (RO) and Electricity Market Reform (EMR) and RHI) is currently focused on the conversion technology side of bioenergy production. Due to the immature status of the UK biomass feedstock supply base, current investments by energy conversion companies have focused on overseas supply chains.

[18] Defra 'CAP reform in England – Status report on the New Rural Development Programme, August 2013

[19] Under CAP, 'Pillar 1' refers to support for farmers' incomes through direct payments or market interventions

BOX 6

Policy support for biomass: could we afford it?

The analysis set out here briefly considers the scale of some existing policy support and compares these against the potential costs of promoting UK biomass under some stylised assumptions. The assumptions / stylised policy measures are for illustration only.

Example of current levels of bioenergy conversion support under existing energy policy:

- Annual cost of support under Contract for Difference for 1 GW of biomass electricity (e.g. Drax conversion) would be approx. £295m based on a strike price of £105/MWh, a projected wholesale price of £62/MWh, and a load factor of 0.8
- Annual subsidy under RO for a 300 MW biomass scheme at 0.8 load factor (e.g. Lateral Power Holyhead scheme) would be approximately £95m.

How much might be needed to support domestic biomass feedstock production?

In the example scenarios given in Table 1, the mid-point volume of biomass feedstock required was 8.5m tonnes per annum by 2030 (i.e. approximately 850,000 ha).

Commercial establishment costs are approximately £1000/hectare[20] for dedicated energy crops and woodland creation[21]. This area would require planting an average of circa 60,000 hectares a year, with total cumulative establishment costs circa £850m by 2030.

To support commercial competitiveness and reflect the carbon, sustainability and strategic security benefits a subsidy of, say, £50 per oven dry tonne (odt) of domestic biomass produced would cost:

- Circa £430m per annum by 2030 for 8.5m tonnes of sustainable biomass (sufficient for circa 35 to 40 TWh)
- Approximately £2.3bn cumulative policy cost to 2030.

These figures are presented not as recommendations for the levels of subsidy support required – arguably grants covering 100% of establishment costs and ongoing subsidies of £50 per odt would constitute generous levels of policy support. Relatively generous policy support may be justified at the early stages of market development, with opportunities to reduce subsidies as the market develops.

Continued »

[20] Terrevesta's 2015 Planting package £1050/ha http://www.terravesta.com/Growing

[21] Farm woodland creation ~£1150/ha (Biomass Energy Centre)

Building the sector: policy and market challenges

Continued »

BOX 6 CONTINUED

However, even under these generous assumptions, the total average policy support requirement for the period to 2030 would be circa £225m per annum.

Energy system modelling suggests that bioenergy use at this scale could unlock cost savings worth tens of £billions in the 2030s and 40s, with significant potential for pre-2030 cost savings for consumers and business. Developing a domestic biomass production sector would enable the UK to access these benefits, increase energy security and generate new sources of farm income. In time this could reduce the need for general farm income support (as currently provided under the CAP single payment system).

How does this compare with current agricultural policy support measures?

The budget for the UK under the CAP 'Pillar 2' Rural Development Programme between 2014-2020 is £3.5 billion. This equates to £500m per annum over the seven years for activities which enhance the environment, farming, forestry, business and communities in rural areas.

Thus the costs of providing 100% establishment grants and a per odt subsidy of £50 to develop a 850,000 ha UK biomass sector by 2030 is less than CAP pillar 2 funding for the current 2014-2020 window (approx. £3.1bn compared to £3.5bn).

"Policy support to develop a 850,000ha UK biomass sector over the period to 2030 is affordable and could unlock big savings"

Policy challenges

Policy to develop UK biomass needs to deliver against both agricultural and low carbon energy policy objectives. The key to aligning these two sets of objectives is to reward growers for delivering verifiably low carbon biomass for energy (including land use emissions impacts), while maintaining incentives to maximise their income from other agricultural production. Agricultural subsidies, sustainability standards and low carbon energy policies need to be looked at together and carefully aligned to encourage growers to release land for biomass while improving overall land use productivity. This would in turn help to contain any ILUC risks.

Incentivising efficient biomass value chains will require a policy framework that addresses a number of difficult challenges.

» **Overcoming early market failures**
Early biomass markets are affected by the market failures common in emerging sectors (e.g. illiquid and missing markets, information failures etc). Policy intervention and support is likely to be needed to help early investors to develop markets, support services, financing mechanisms as well as standards and market conventions (such as standard contract terms, quality measures and pricing approaches).

» **Incentivising the right land use decisions**
Direct emissions impacts vary depending on the choice and location of land use conversion. Policy needs to incentivise the most advantageous land use conversions and production practises, while minimising overall impacts on land use productivity. Market forces will not do this without some intervention, for example through sustainability standards or targeted financial incentives.

» **Incentivising multiple and diverse decision makers**
Developing biomass production at scale will depend on the decisions of potentially thousands of land owners and users under diverse circumstances. Policy interventions will need to be designed carefully, taking into account the motivations of different groups (e.g. tenants, owner occupiers, arable, mixed or livestock farmers and foresters).

Building the sector: policy and market challenges

Continued »

- **Careful geographic targeting without undue bureaucracy**
  The desirability and sustainability of using land for biomass production varies spatially, so blanket measures and incentives are unlikely to deliver sustainable outcomes. Incentives will need to be carefully designed and targeted, while also minimising burdensome bureaucracy which adds cost or stifles markets and innovation.

- **Promoting a viable transition to larger scales**
  Long-term strategic policy support is required to maintain growth of the sector along the trajectory required to deliver the maximum benefits of bioenergy use within the UK energy system. This requires support to be balanced across the supply chain – developing the feedstock production, logistics, pre-processing and conversion sub-sectors of the bioeconomy. Long-term support and vision enables actors to be more agile in responding to shorter-term opportunities and threats that may arise along the way.

Exploring potential solutions

While we are clear that there is a strong case for strategic and long-term policy commitment to support the development of a large scale UK capability to produce sustainable biomass, we also acknowledge that more work will be needed to develop policy proposals that are realistic and deliverable. There is clearly an opportunity to join up agricultural, land use and low carbon energy policies more coherently.

The ideas set out here are only sketches of the broad directions in which solutions may lie. The ETI is keen to understand stakeholders' views and to work collaboratively to develop more concrete proposals.

- **Explore potential for pillar 2 support**
  One of the key immediate priorities is to retain and attract growers by improving confidence in markets and developing appropriate value chains. Innovation in support measures and services for growers (e.g. planting material production and distribution, access to planting and harvesting equipment, and transport and processing services), along with funding from agri-environment or the CAP rural development programme, could help develop markets and confidence among growers.

- **Adapt RHI support**
  Policy makers should consider the case for adapting RHI support to offer incentives to promote domestic biomass with robust sustainability credentials. Regulatory requirements should not be overly onerous for an emerging sector, but incentivise clear demonstration of sustainability credentials. For example, efforts could be made to include dedicated energy crops in the 'Biomass Suppliers List' to help support early development of the market.

- **Link support to emissions impacts**
  As discussed, simple market-wide or price incentives will not incentivise the most advantageous emissions impacts (both direct and ILUC risk). One option would be to develop an approach linking policy rewards for domestic biomass to a 'sustainable land use UK biomass' accreditation scheme. In the short-run RO or EMR support for biomass could be linked to sourcing a proportion of feedstock from sustainable domestic sources.

- **Deliver support to develop both end uses and growers**
  A key challenge is to develop business models and policy measures which support simultaneous development of both ends of the value chain. Relying on incentives to 'trickle back-up the supply chain' from end uses looks unlikely to succeed, but stimulating new plantings without end uses may equally be futile.

- **Integrate biomass for energy measures with wider land use initiatives**
  Integrating support for biomass with wider land use initiatives (e.g. agri-environment support or catchment sensitive farming) could secure better overall outcomes, by maximising secondary benefits (e.g. on nitrates control and biodiversity) and avoiding negative impacts.

Conclusions

The evidence about the UK's options for reaching 2050 carbon targets is clear that sustainably sourced biomass is a hugely valuable option and that the UK has the potential for a sizeable domestic biomass resource base. With focused policies the UK has credible routes to produce around 10% of its primary energy needs from sustainable domestic and imported biomass; while also capturing carbon, and supporting rural incomes and economies. Early analysis of the potential costs of policy support (see box 6) suggest that it is both affordable and can deliver good value for money.

Currently this opportunity is neglected by both agricultural and energy policies. Agricultural policy on biomass for energy appears driven by 'worst case' risks, while energy policy support is focused on downstream conversion technologies, which currently have to utilise imported biomass to meet the scale of demand quickly. Without specific focus on all parts of the UK biomass supply chain, there is a real risk that the UK's nascent biomass sector will largely disappear, and the additional benefits of energy security and sustainability associated with domestic biomass feedstocks will be missed.

The opportunity is there. It needs to be more widely recognised. Now is the time to act and create momentum in the sector. We need to create an enabling environment for biomass value chains, by developing joined-up energy, agricultural, and land use policy.

"Now is the time to act and create momentum in the sector. We need to create an enabling environment for biomass value chains, by developing joined-up energy, agricultural, and land use policy."

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