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Prospects and developments in bioenergy

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11th January 2016



The Energy Technologies Institute (ETI)



- The ETI is a public-private partnership between global energy and engineering companies and the UK Government.
- Targeted development, demonstration and de-risking of new technologies for affordable and secure energy
- Shared risk

ETI members



ETI programme associate





Knowledge building to:

- » Inform industry decision making through robust, shared evidence and commercially available projects
- » Build a better understanding of decarbonisation potential in developing industries
- » Inform policy debate

Developing technology to:

- » Build supply chain capability
- » Create economic opportunities
- » Exploit UK technology knowledge and skills



Demonstrating technology to:

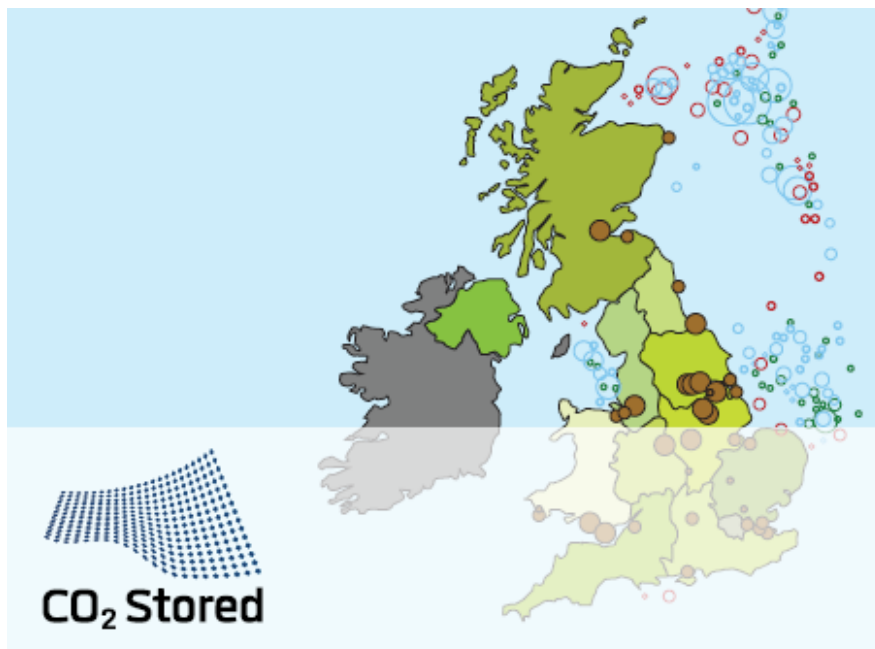
- » De-risk new systems
- » Focus and accelerate low carbon innovation
- » Build investor confidence

Strategic analysis and planning to:

- » Develop an internationally peer-reviewed national energy system design and planning capability
- » Identify the lowest-cost decarbonisation pathways for the UK energy system
- » Produce technology and industry sector insights and develop whole system modelling capability



Knowledge Building / Modelling Projects



CO₂ STORED

The UK's first CO₂ storage appraisal database



SMARTtide

A software model of the UK continental shelf and North European Waters, 100 times more accurate than existing data



Technology Demonstration Projects



WET-MATE CONNECTOR

A low cost high voltage generic Wet-mate connector to link offshore energy sources to the cables transmitting electricity to shore



ReDAPT

A 1MW buoyant tidal generator

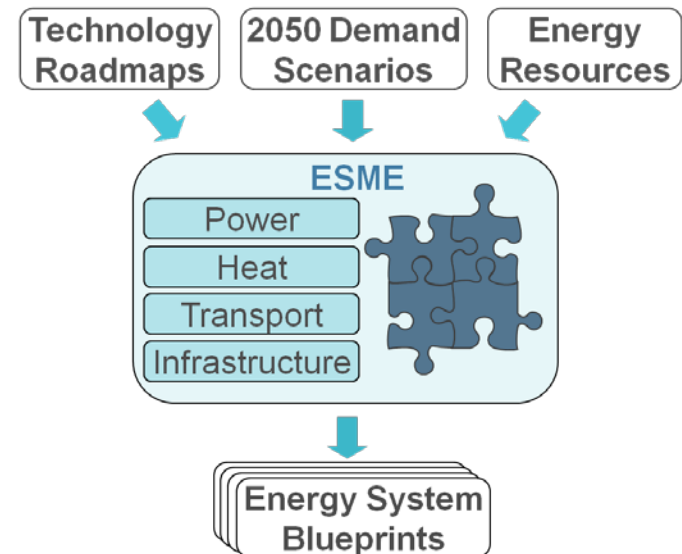


ETI's 'ESME' model of the UK energy system



A national energy system design tool with sufficient spatial and temporal detail to understand system engineering challenges.

- A least-cost optimisation, policy neutral tool
- Can model pathway and supply chain constraints out to 2050
- Probabilistic treatment of key uncertainties enables less mature technologies to be assessed



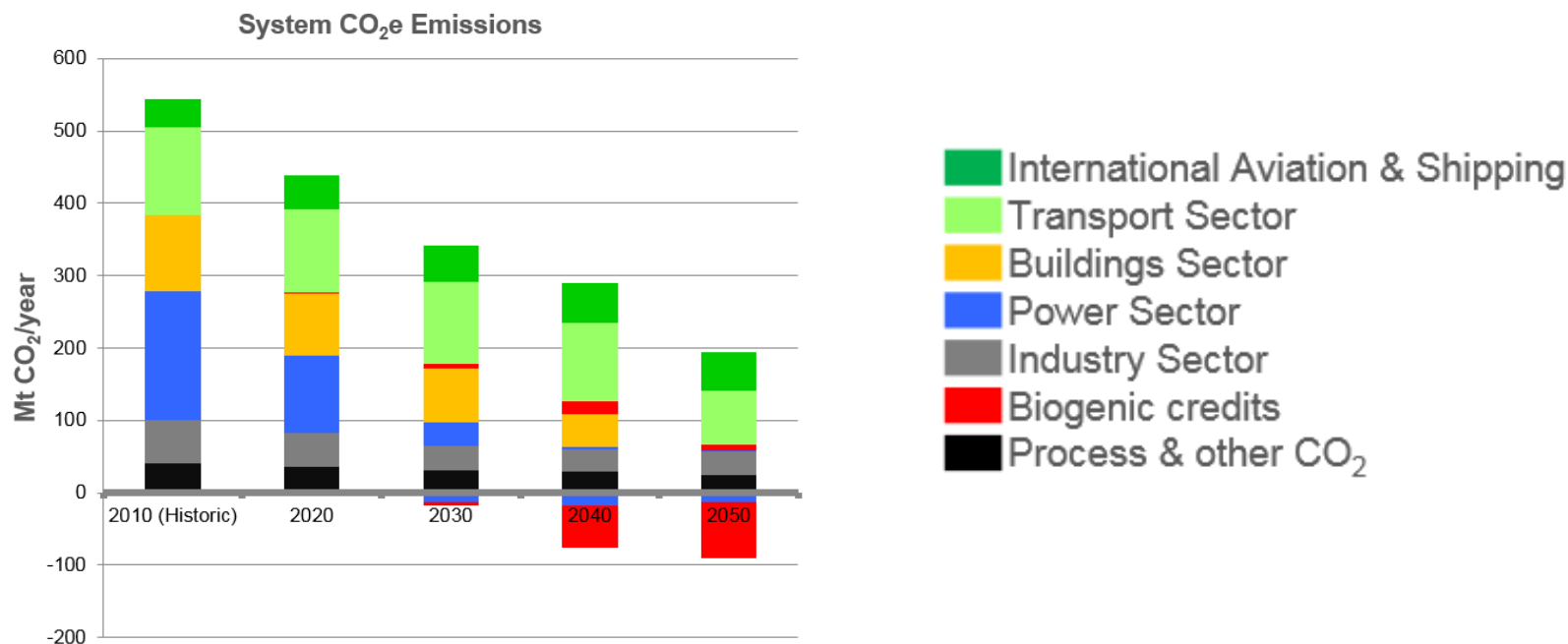
Example questions ESME would be used to inform...

- *What might be 'no regret' technology choices and pathways to 2050?*
- *What is the total system cost of meeting the energy and emission targets?*
- *Where should new generating capacity optimally be located?*
- *What are the opportunity costs of individual technologies or sectors (e.g. bioenergy)?*



The role of bioenergy in the UK energy system

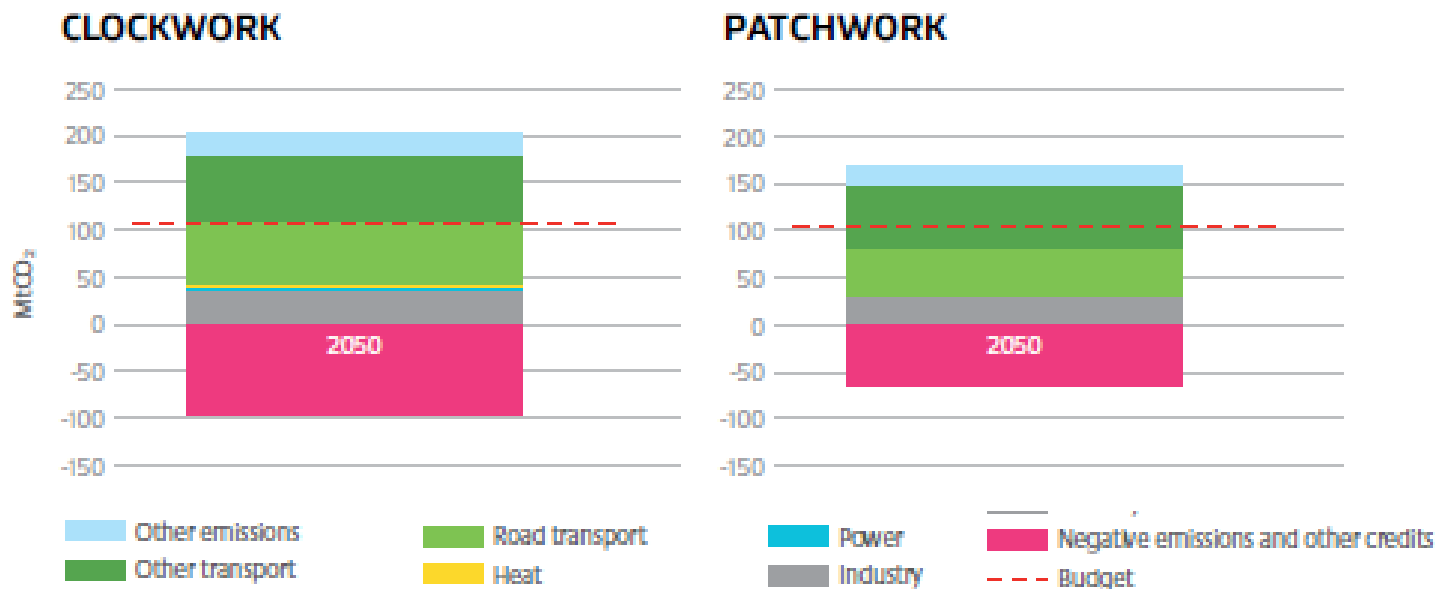
- ESME analysis indicates that negative emissions from bioenergy with CCS offsets the need for expensive interventions elsewhere in the energy system (e.g. transport)
- This role is highlighted in our ESME Monte-Carlo analysis and in two scenarios (deterministic runs) published in the 2015 report 'Option, Choices, Actions' – UK scenarios for a low carbon energy system transition'.
- The chart below shows the results of our Monte-Carlo analysis. It indicates that decarbonisation in power, industry and buildings may offer the lowest cost route and that bioenergy in combination with CCS can deliver negative emissions which offset some of the need for more expensive decarbonisation options in aviation, shipping and passenger vehicles





The role of bioenergy in the UK energy system

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- This role is highlighted in our ESME Monte-Carlo analysis and in two scenarios (deterministic runs) published in the 2015 report 'Option, Choices, Actions' – UK scenarios for a low carbon energy system transition'
- Clockwork – characterised by coordinated, long term investments in energy infrastructure (predominantly electricity and heat) allowing steady decarbonisation and requiring fewer changes in transport to meet 2050 targets
- Patchwork – initially characterised by less national, and more regional energy strategies. Individuals become more actively involved in decarbonisation and decarbonisation takes part across all sectors. Over time central government begin to integrate the solutions to provide national solutions

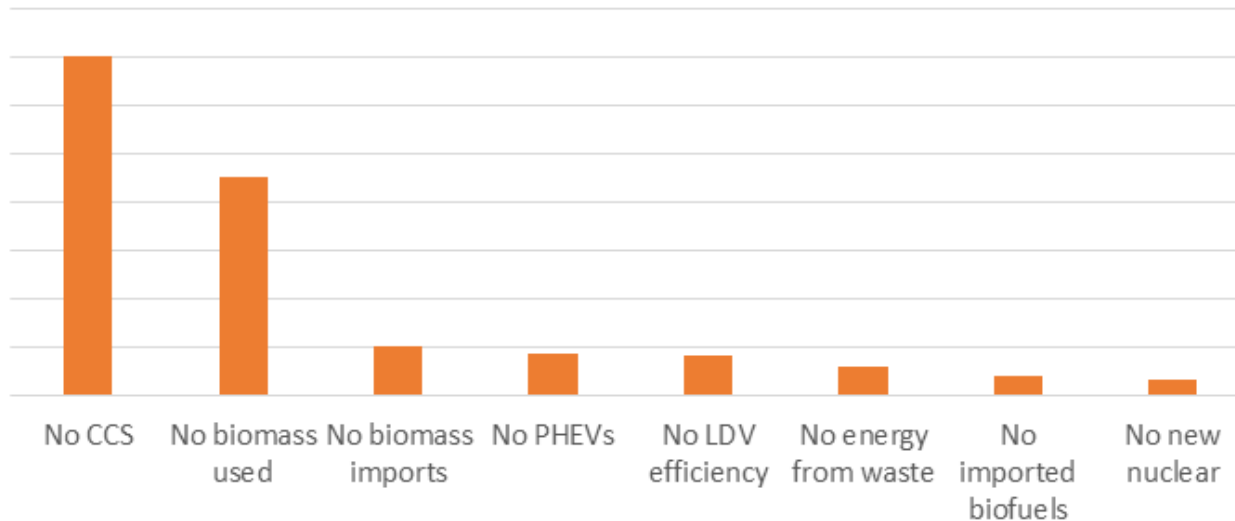




The role of bioenergy in the UK energy system

ESME enables us to assess the likely cost of different future UK energy systems, and the opportunity costs of not pursuing particular pathways:

Relative option values for key sectors
in 2050



- Biomass used to generate hydrogen, power, heat, transport fuels and negative emissions
- It is likely to be very hard to deliver an *affordable* low carbon energy system without Bioenergy or CCS



The role of bioenergy in the UK energy system

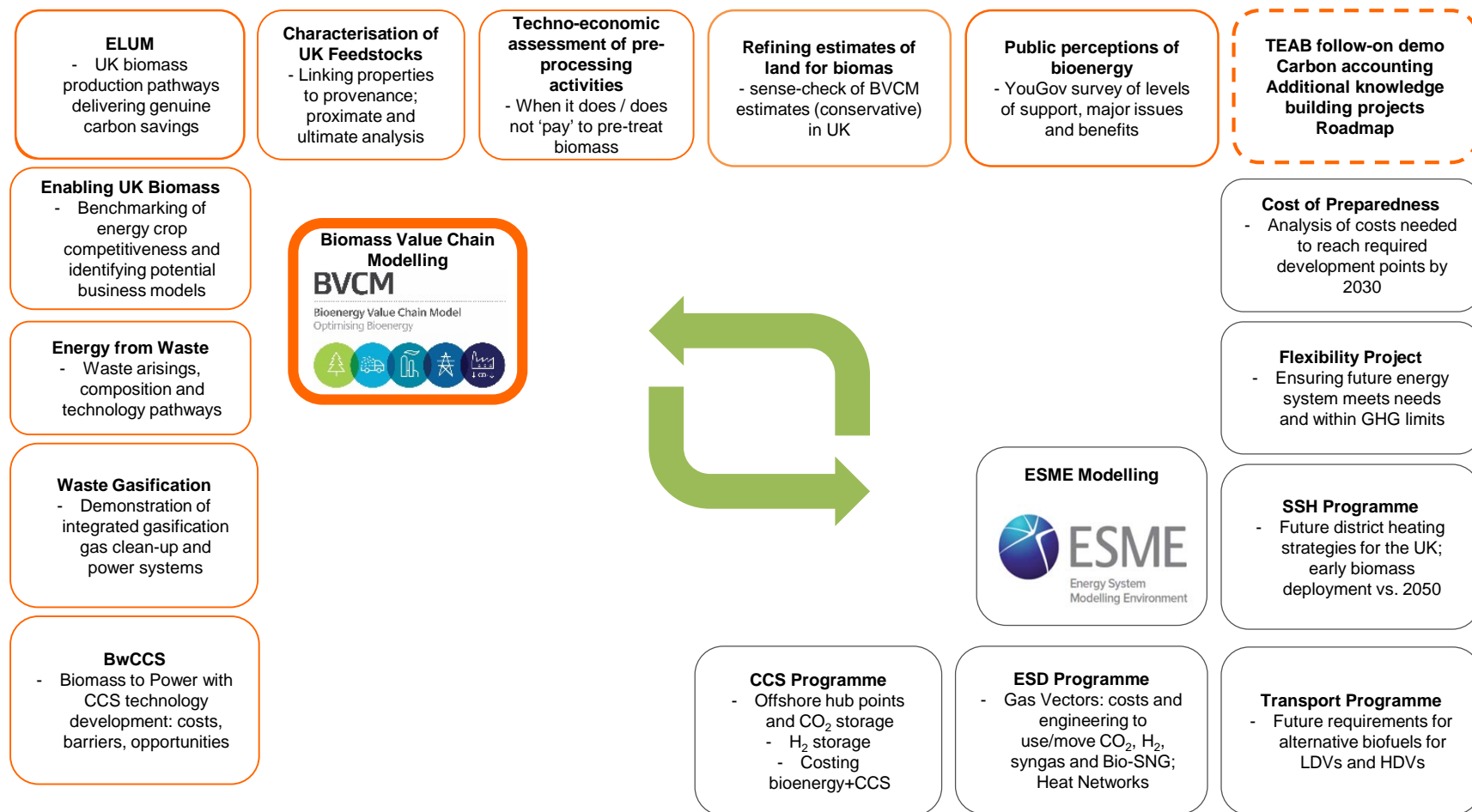
- 50-100 MtCO₂e negative emissions with CCS¹
- Could deliver 10-12% UK energy by 2050^{2,3}
- Flexibility in terms of end vectors
- Scalability of application
- Multiple feedstocks – potential supply chain benefits
- Energy security if part of a diverse mix of energy sources



- 1 – ESME analysis
2 – UK Bioenergy Strategy
3 – CCC Bioenergy Review



Integrated analysis of the role of bioenergy within wider UK energy system





The Bioenergy Value Chain Modelling (BVCM) Project

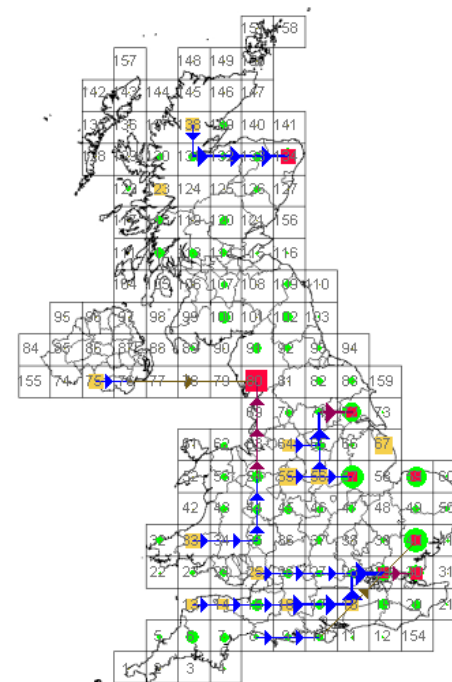
Problem
definition:

What is the most effective way of delivering a particular bioenergy outcome in the UK, taking into account the available biomass resources, the geography of the UK, time, technology options and logistics networks?

Development of a comprehensive and flexible toolkit for whole system biomass value chain analysis and optimisation

Project
commissioned:

- Pathways optimised based on: **minimum cost**, **minimum GHG emissions**, **maximum energy**, **maximum profit** or a combination
- 93 'Resources' and 69 distinct 'Technologies' at different scales and with multiple feedstocks
- UK production factors (land constraints; yields); imports; logistics
- 157 cells (50km x 50km); 5 decades and 4 seasons



BVCM

Bioenergy Value Chain Model
Optimising Bioenergy





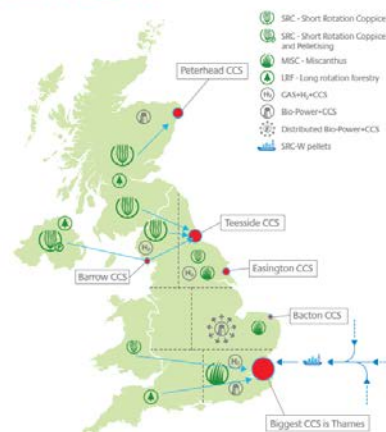
Key insights from Bioenergy Value Chain Modelling

- ESME analysis suggests that the UK is looking for around 130TWh/yr of bioenergy and GHG emissions of around - 55MtCO₂/yr in 2050s

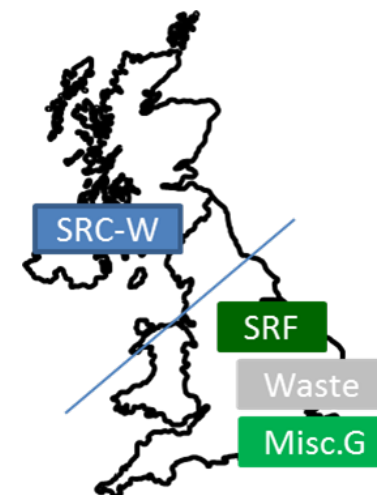
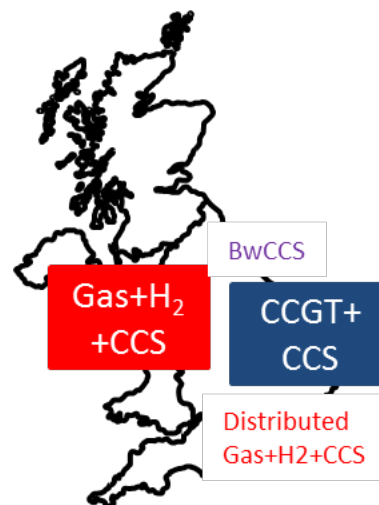
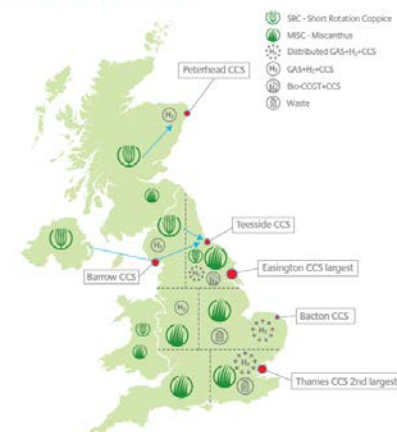
BVCM findings:

- Biomass combined with Carbon Capture and Storage (CCS) only credible route to deliver negative emissions
- Bio-hydrogen and bio-electricity produced in preference to biofuels and bio-methane
- Bio-heat is deployed across the UK, especially in earlier decades, and has key role in stimulating local markets for biomass production
- Gasification technology is key bioenergy enabler: flexible, scalable, and cost-effective, producing both hydrogen and syngas
- Locational and deployment preferences for resources, technologies and CO₂ shoreline hubs have been identified
- With the right land use optimisation and prioritisation, UK could deliver sufficient sustainably-produced biomass to make hugely important contribution to UK's future emission targets and energy demands
- 1.3 – 2.3 million hectares provides enough feedstock to meet around a third of feedstock requirements (based on 130TWh/yr final energy target), meaning that imports are likely to play a significant role out to 2050.

Summary diagram of system differences between scenarios *with* imports



Summary diagram of system differences between scenarios *without* imports





Programme focused around four questions

How much of the theoretical negative emissions could be realised through bioenergy deployment in the UK?



What would be the best ways to produce and use this bioenergy in the future UK energy system?



What are the right combinations of feedstock, pre-processing, and conversion technologies?

Critical issues:

- Availability / sustainability of UK biomass production
- The use of bioenergy in conjunction with CCS

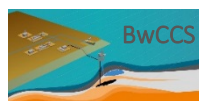
Critical issues:

- Interaction of bioenergy with the rest of the UK energy system
- Technology & infrastructure roll out across all sectors

Critical issues:

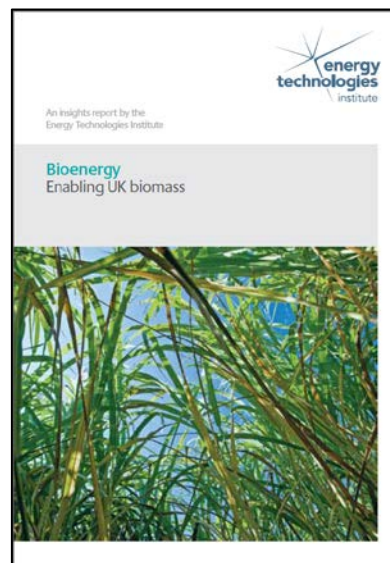
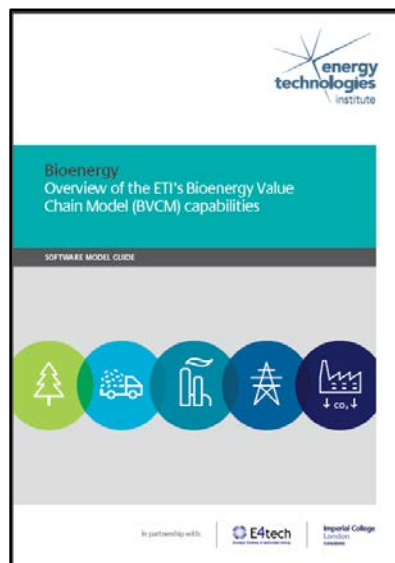
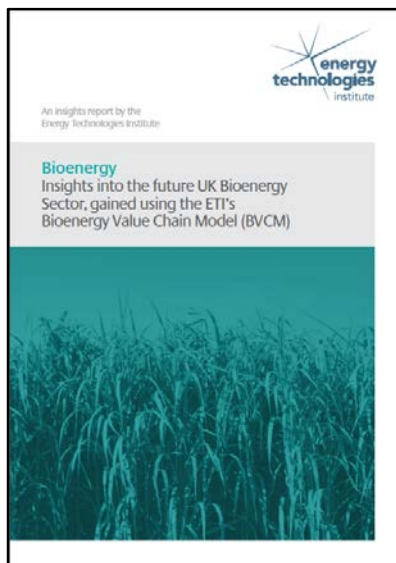
- System-level assessment and demonstration
- Cost and performance improvements

Are the right policy and regulatory mechanisms in place and are there public acceptability issues that need addressing?





Bioenergy publications in 2015 - 16



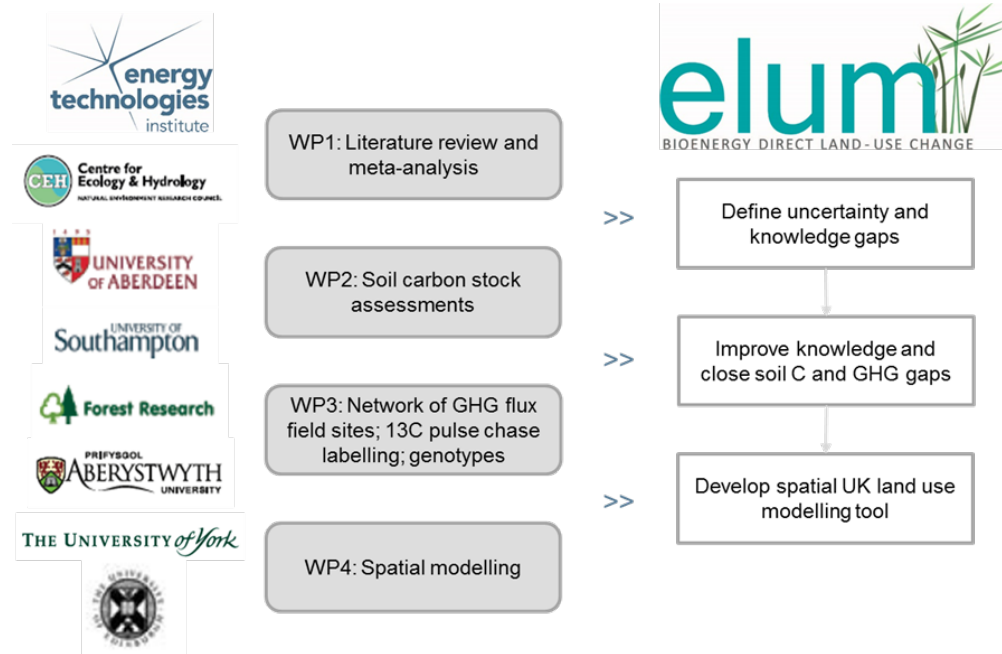


Ecosystem Land Use Modelling (ELUM)

“What are the dLUC emissions associated with growing bioenergy crops in the UK? Can they be predicted, and if so, what is best to grow and where?”

ELUM sought to quantify the level of variability associated with soil carbon and GHG impacts of biomass production in the UK across different land use transitions and locations (soil type, yield, climate).

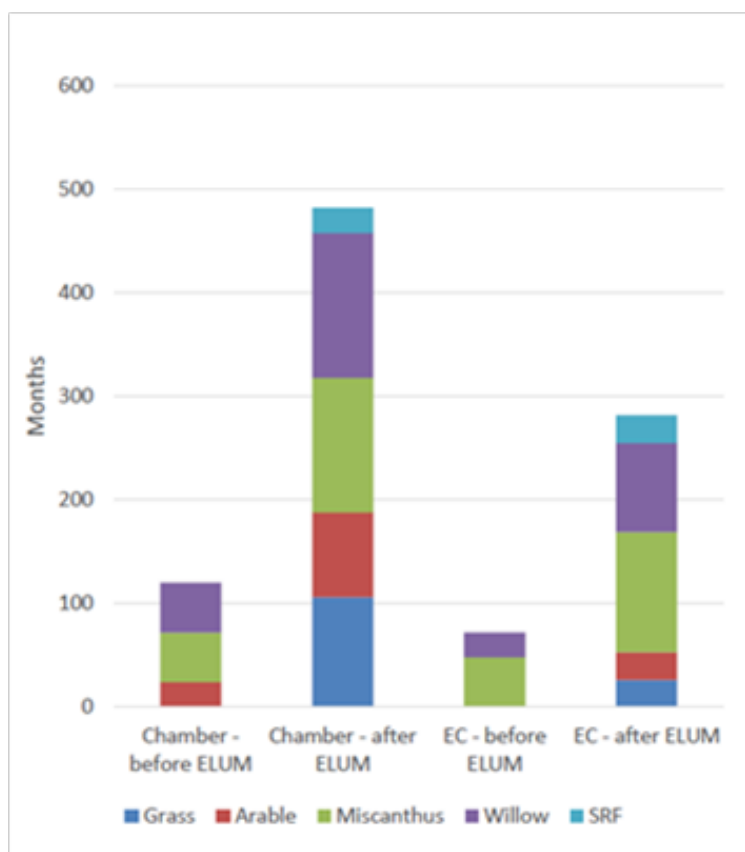
Used a ‘measured and modelled’ technique combining 2.5 years of fieldwork with development and refinement of process models



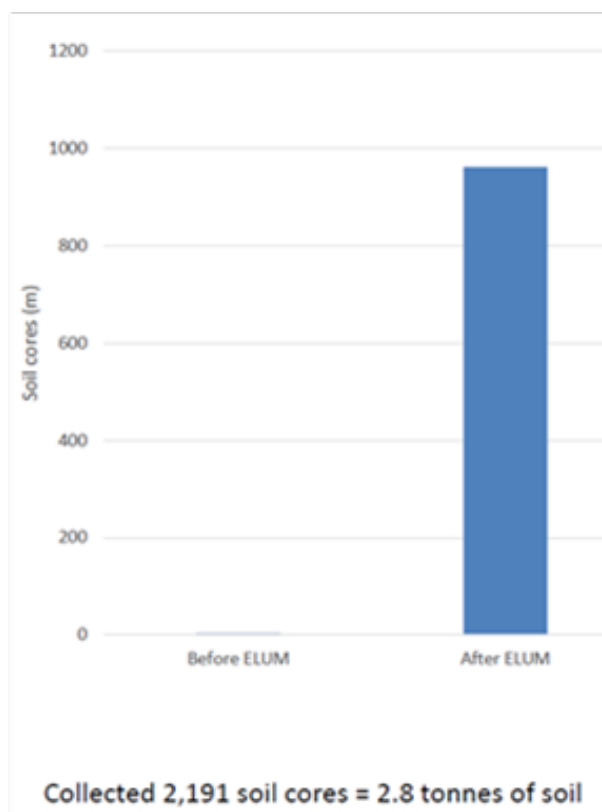


ELUM produced lots of data!

GHG Measurement Data



Soil Core Sampling





Contextualising ELUM Results



- Insights paper due to be published this month
- Uses BVCM modelling and LCA (EU RED methodology) to set the ELUM results in context
- Results show that dLUC (Direct Land Use Change) emissions from changes in both the soil carbon and above ground biomass stock as well as GHG fluxes have a material effect on whole chain emissions
- Transitions from arable land to bioenergy cropping generally result in negative dLUC emissions (GHG savings) while transitions from forestry to a non-forestry crop lead to dLUC emissions (higher GHG emissions).
- The picture is more mixed for transitions from grassland with location, crop type and value chain all important



Characterisation of Feedstocks

Problem: The properties of biomass feedstocks vary by type, management practices and during storage. This can affect performance in biomass technologies

- Characterisation of Feedstocks Project is looking to understand more about the extent to which the properties of feedstocks can vary and the factors affecting this
- Led by Forest Research and e.on
- Currently sampling second generation biomass feedstocks:
 - in different locations
 - at different harvest times
 - after different lengths of storage
- Due to report back later this year
- Preliminary results are feeding into another project, a Techno-Economic Assessment of Pre-Processing (TEABPP)...



Techno-Economic Assessment of Biomass Pre-Processing

Problem: The variability of biomass feedstock can negatively affect technology performance

- Improving the performance of biomass conversion technologies could come about through:
 - Pre-processing feedstocks to improve their consistency and performance in conversion technologies
 - Improving conversion technologies to better cope with raw feedstock variability
- This project is providing an assessment of the economic and performance trade-offs associated with pre-processing options, and the value they provide compared with more conventional technology improvement approaches
- Project team is a consortium of industry and academic partners, led by E4tech
- Currently finalising the value chains to be modelled
- Due to report back later this year



Energy from Waste – Waste Gasification



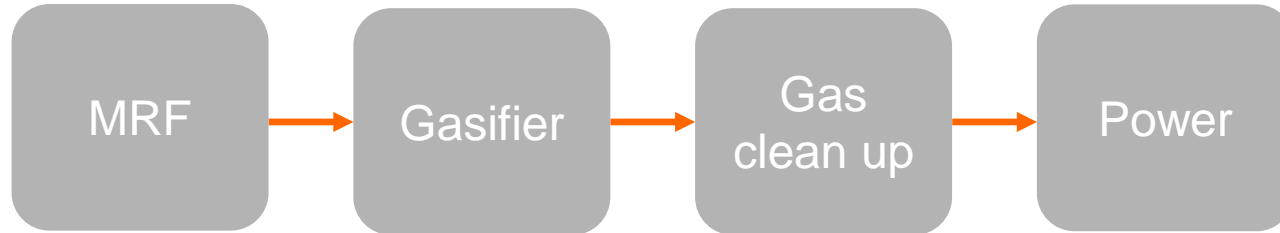
Energy from Waste project (2011-12) looked at waste arisings in the UK and the existing and developing technologies that could be best placed to generate energy from residual waste.

Highlighted small scale (town) waste gasification with gas clean up as a potentially important technology:

- Flexible (can produce electricity, heat and transport fuels)
- Scalable
- Some elements proven (gasification) but others novel (gas clean up)
- Can make efficient use of residual waste



Waste Gasification



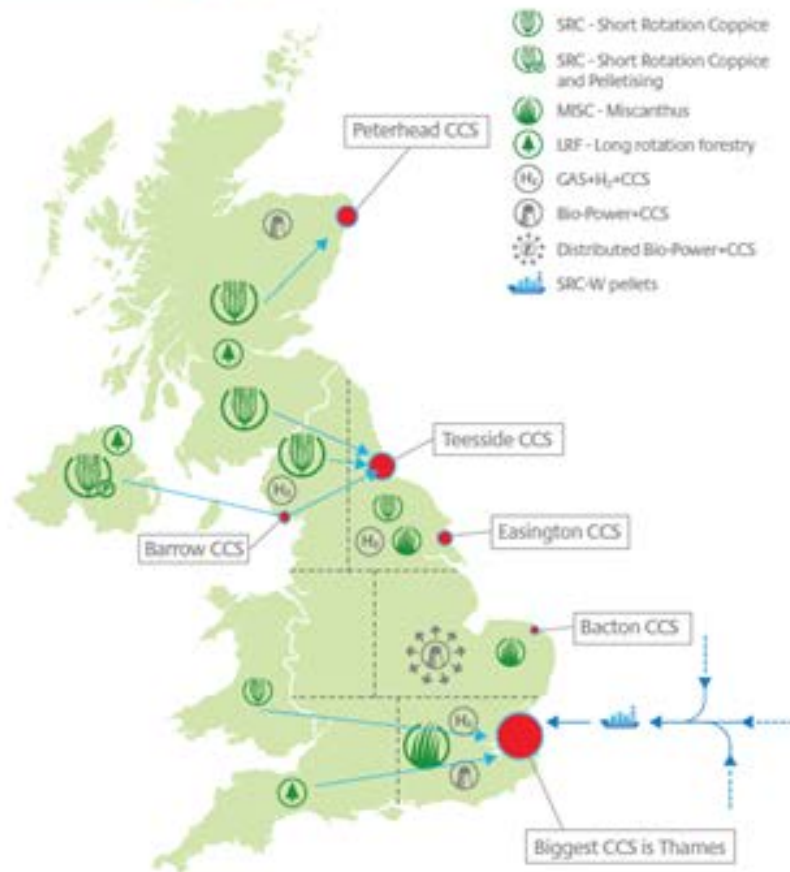
- Commissioned three companies to develop FEED (Front End Engineering Design) studies and business plans for their chosen sites.
- The designs had to exhibit >25% net electrical efficiency over the whole system (from MRF to electricity production) including accounting for parasitic loads
- Availability >80%
- The companies tested their designs using laboratory testing and modelling to understand how performance may change using different waste feedstocks (MSW, C&I and waste wood) and at different scales.



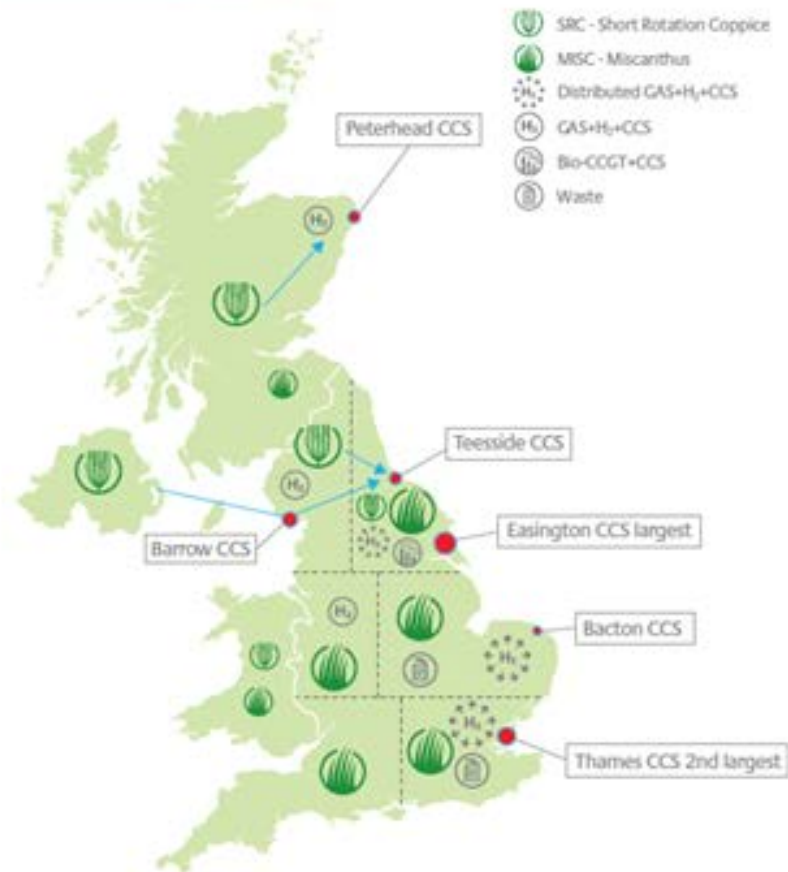


Bringing it all together

Summary diagram of system differences between scenarios with imports



Summary diagram of system differences between scenarios without imports



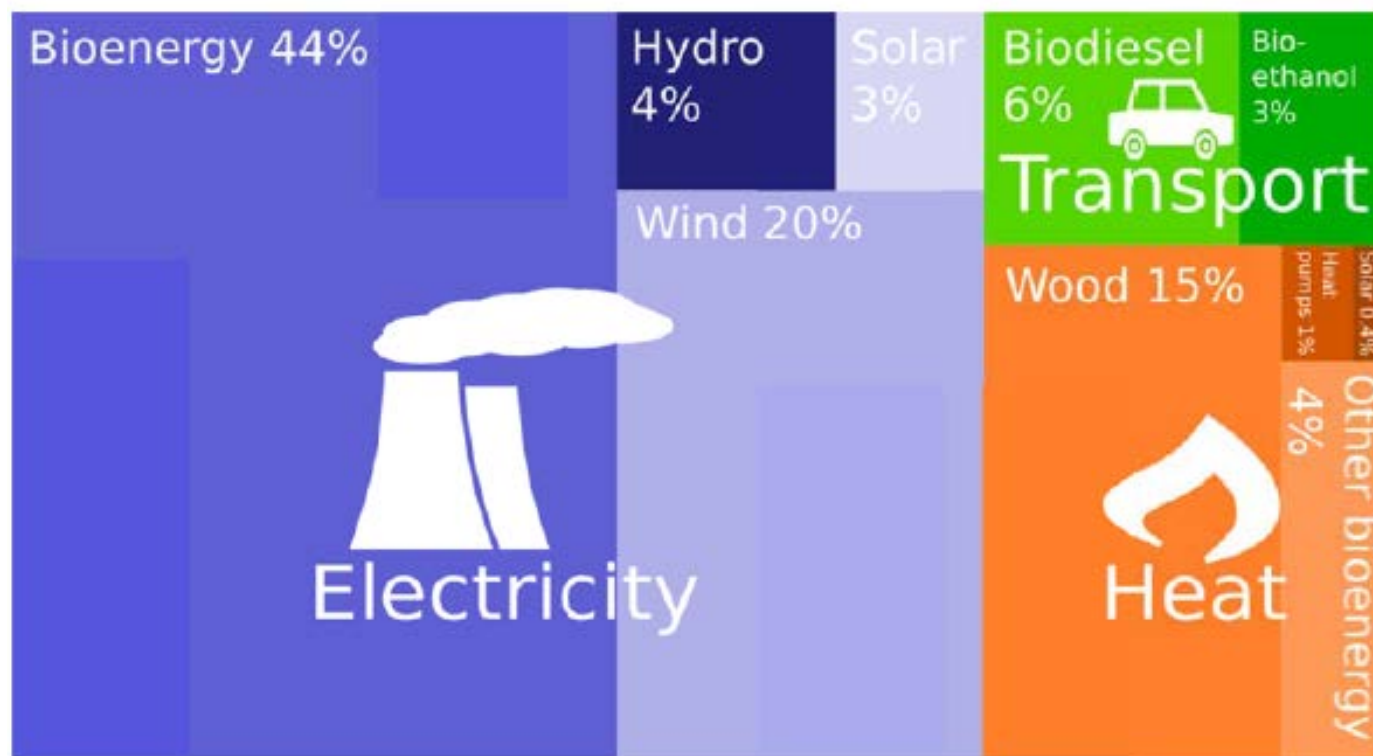


So how do we get there?



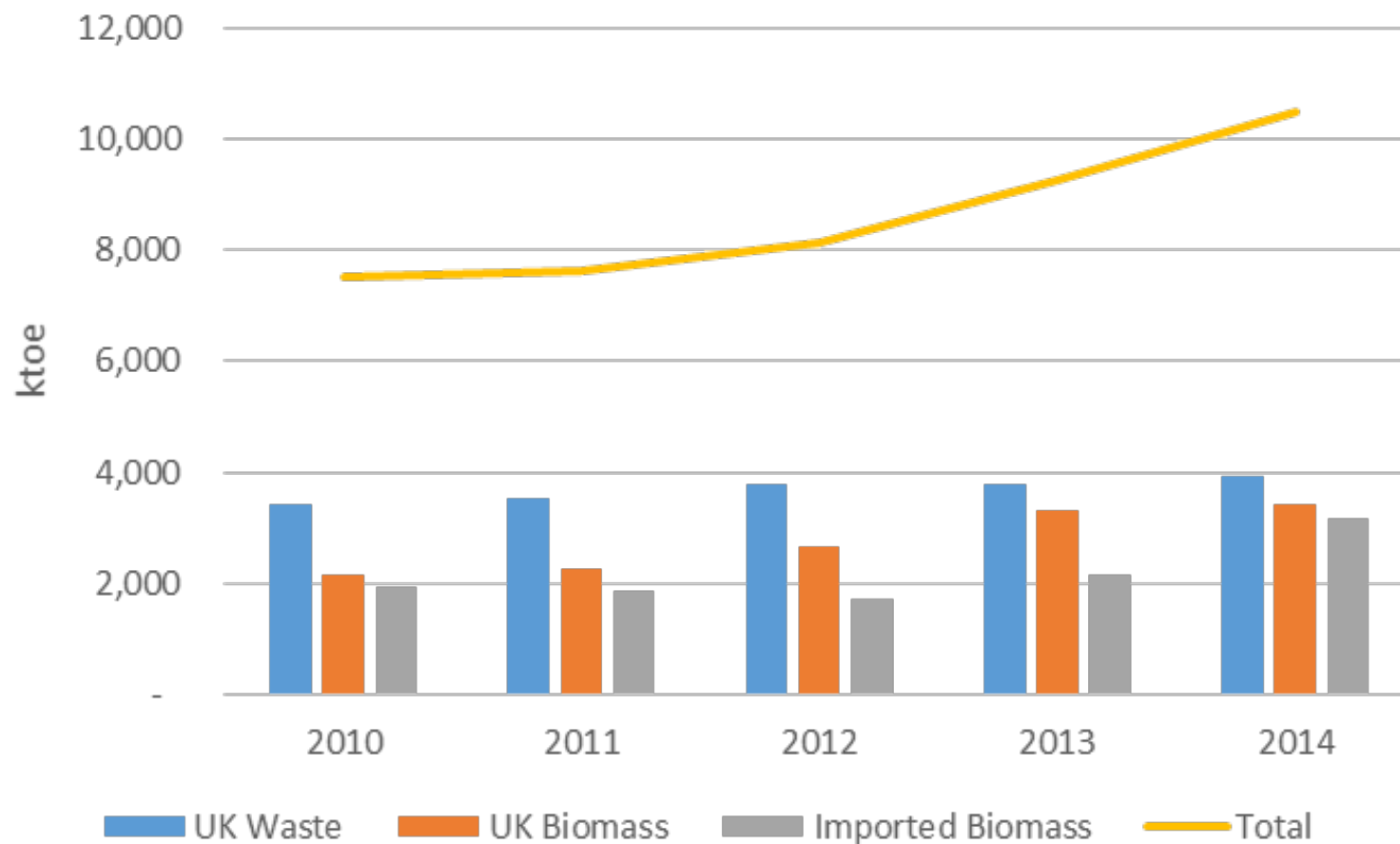
Current Picture – What forms does bioenergy take?

Share of renewable energy in 2014



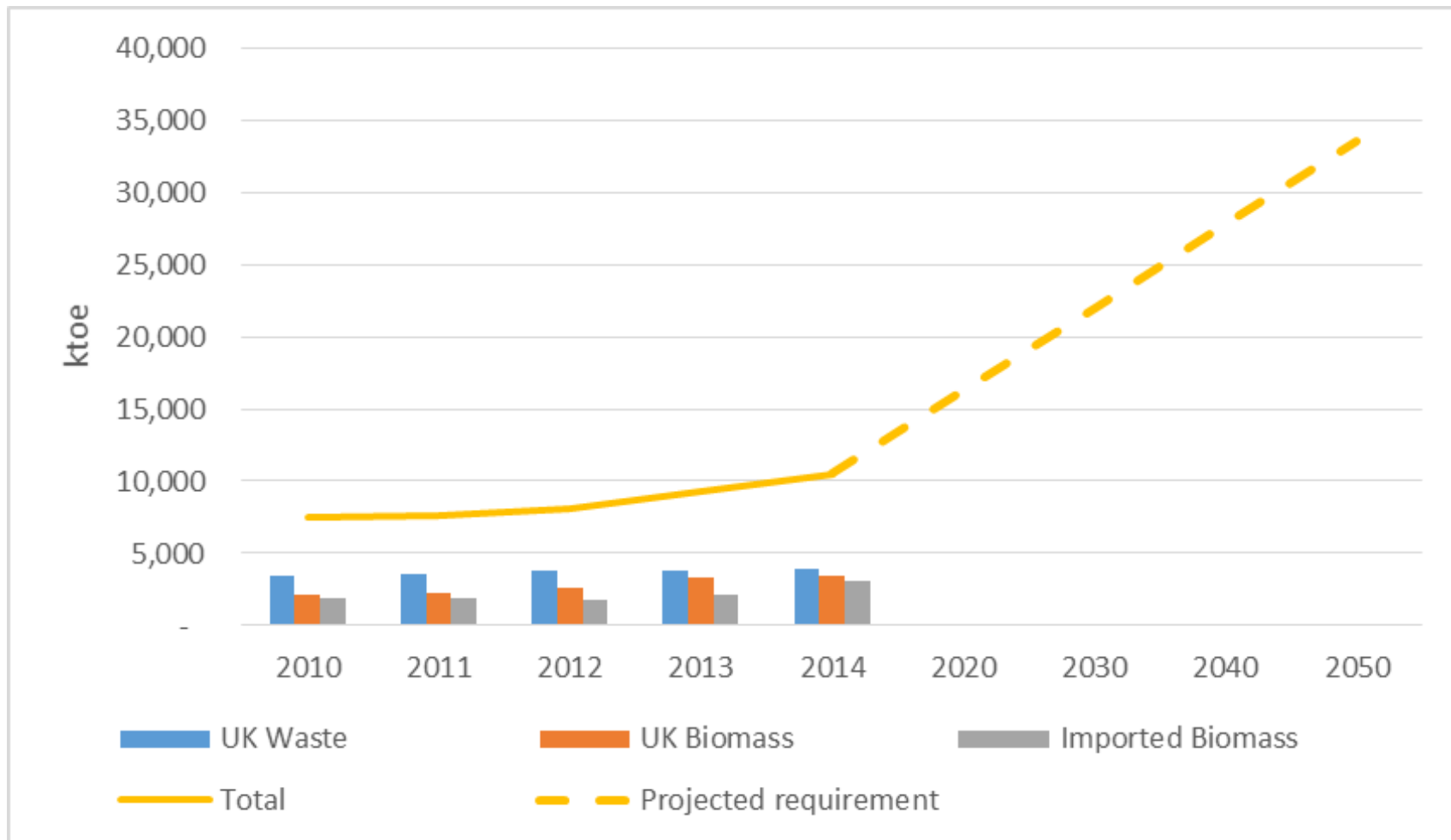


Current picture – Feedstock availability





Feedstock availability



© DECC (DUKES, 2015. Data from Tables 6.1-6.3 (Commodity Balances)) , projection based on BVCM results



Feedstock availability

Locational map showing examples in the 2050s of regions producing SRC-Willow and Miscanthus

Locational map showing examples in the 2050s of regions producing SRF

Planting locations important to maximise yields and establish economic supply chains

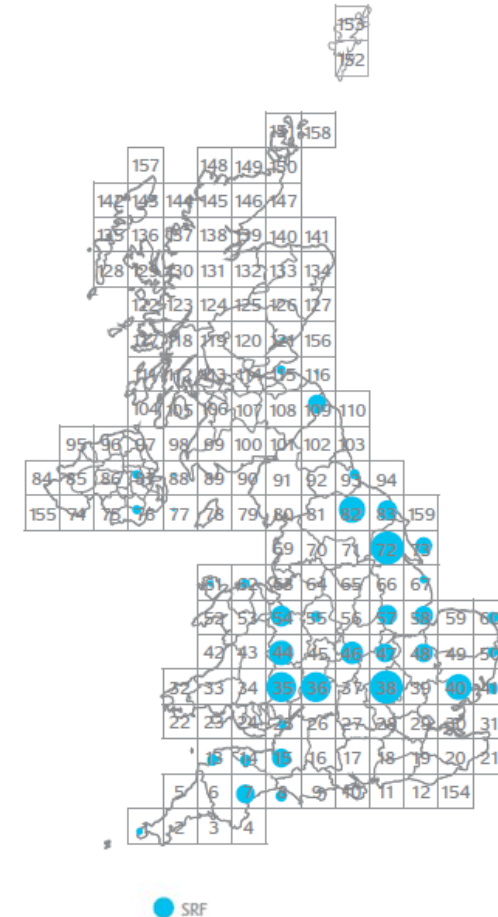
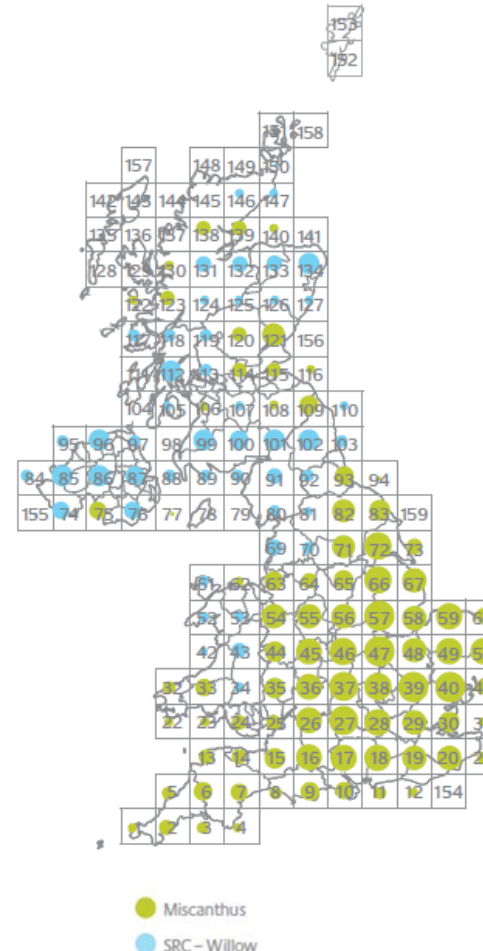
Miscanthus broadly favoured in South and East of England, SRC Willow preferred in North West and Scotland. With CCS, planting tends to cluster around the nearest CCS hub

SRF plantations are preferred in the Midlands

BVCM doesn't model improvements to existing woodland management, but this will be important for increasing feedstock availability as well as new SRF plantations

Imports (at ports near CCS hubs) will be important if we are to meet the energy requirements suggested by ESME

Residual waste will continue to play an important roll but availability is expected to decrease as reuse and recycling improve



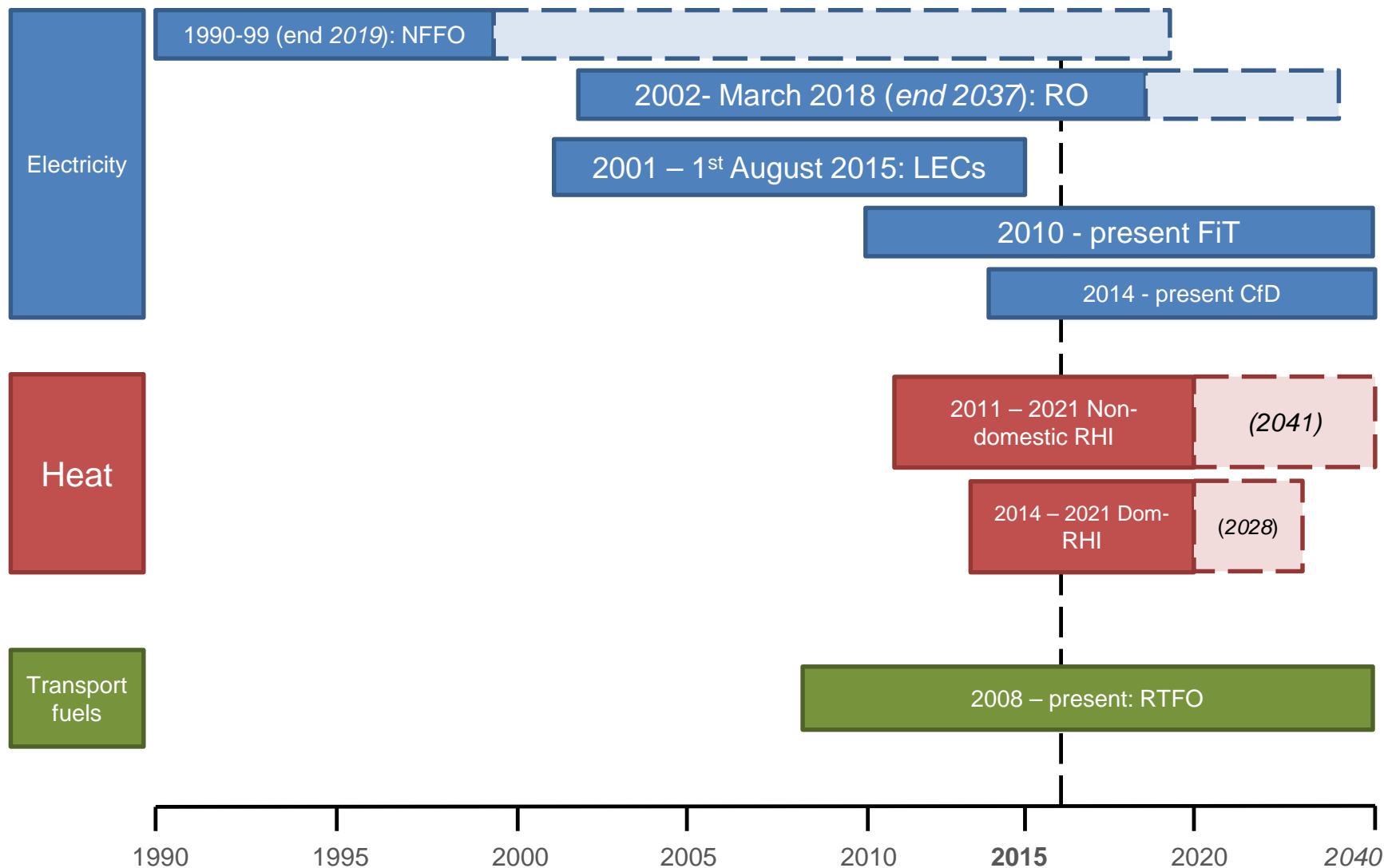


Technology development

- With CCS, power and hydrogen are key end vectors
- Recent decision to remove funding for a CCS demonstration plant has likely delayed the roll out of CCS in the UK
- In the near term, bioelectricity can still deliver significant carbon savings. However it is important to consider siting of new plants with a view to developing a future CCS and CO₂ pipe network.
- Heat is also an important vector. In the near term biomass can be used directly to generate domestic and industrial heat. In the longer term we see an important role for district heating using biomass boilers and waste heat
- The recent government announcement extending the RHI budget to 2020/21 will play an important part in increasing the role of bio-heat
- Gasification is an important technology due to its flexibility and scalability. Syngas can be produced from a wide variety of feedstocks and can be used to produce a range of products including heat, power, liquid and gaseous fuels. It is therefore a technology we can progress now given its flexibility in several future energy scenarios

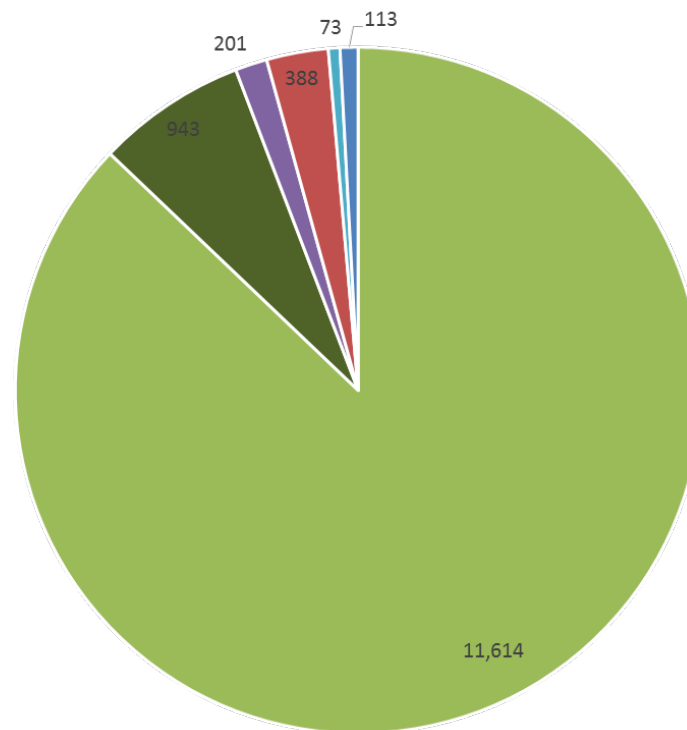
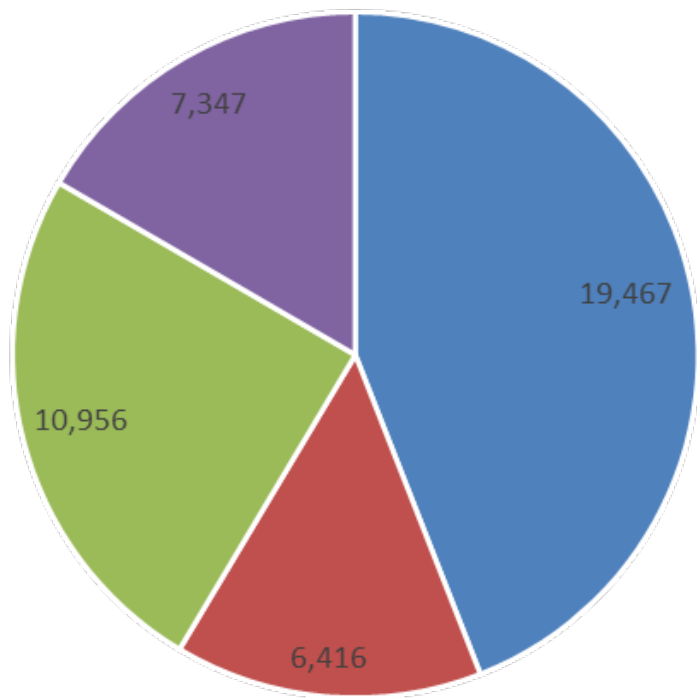


Current Picture - Policy Incentives





Renewable Heat Incentive (2011 -)



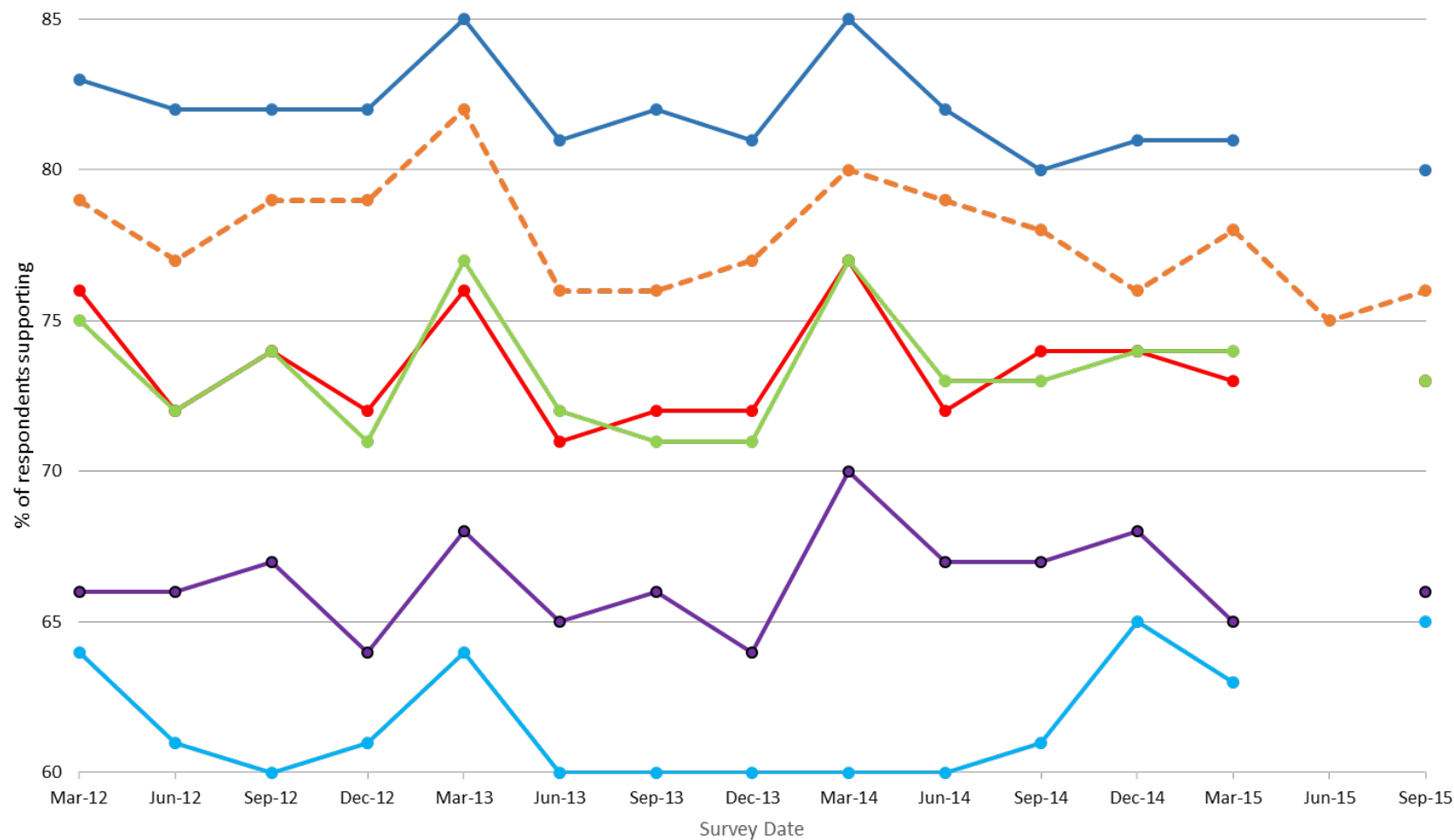
■ Air source heat pump
 ■ Ground source heat pump
■ Biomass systems
 ■ Solar thermal

■ Small Solid Biomass Boilers (< 200 kW)
 ■ Medium and Large Solid Biomass Boilers
■ Small Solar Thermal (<200kW)
 ■ Water or Ground Source Heat Pumps
■ Biomethane or Biogas
 ■ Air Source Heat Pumps



Current Picture – Public support

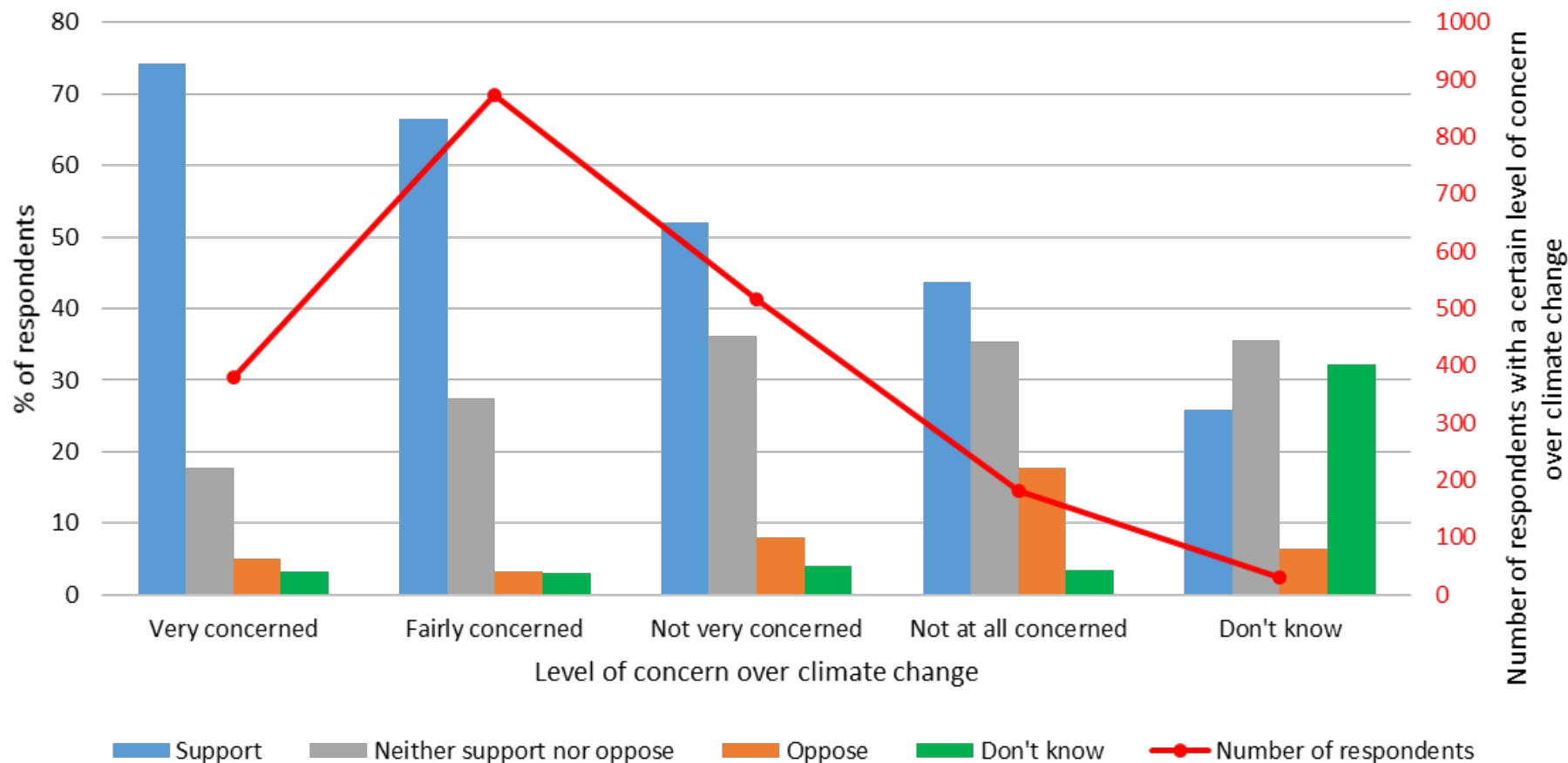
% of respondents in support of different renewable energy sources





Current Picture – Public Opinion

Relationship between level of concern over climate change and support for bioenergy





Summary

- ESME modelling suggests that Bioenergy is key to reaching our 2050 targets in a cost effective way
- With CCS, bioenergy is the only credible means of delivering negative emissions, offsetting the need for more expensive decarbonisation in other sectors
- The removal of funding for the CCS demonstrator has likely delayed deployment of CCS in the UK. Therefore decisions made today need to be mindful of how the sector could develop – for example power stations and other key infrastructure need to consider how CCS may be retro-fitted
- Even without CCS, sustainably sourced biomass can still make an important contribution towards meeting GHG reduction targets
- Bio-heat is an important vector – both produced directly for use in homes and industry but also through district heating
- The continuation of the RHI provides an opportunity to develop and grow the UK bioenergy sector and provides an opportunity to develop supply chains in both the UK and abroad
- Sustainable feedstock availability will be key to developing the bioenergy sector. There is potential to increase UK feedstock stock, but imports will continue to be important. The coming years provide an opportunity to ‘learn by doing’ and refine and enhance sustainability standards to ensure the sector is ready for wider roll-out in later decades



Any Questions?



Links

ETI Overview Booklet <http://www.eti.co.uk/eti-briefing-booklet/>

ETI 'Options, Choices, Actions' report

<http://www.eti.co.uk/options-choices-actions-uk-scenarios-for-a-low-carbon-energy-system/>

ETI Bioenergy publications <http://www.eti.co.uk/category/available-materials/?restrict=bio>

UK Government, UK Bioenergy Strategy <https://www.gov.uk/government/publications/uk-bioenergy-strategy>

CCC, Bioenergy Review <https://www.theccc.org.uk/publication/bioenergy-review/>

LCICG, Bio-TINA http://www.lowcarboninnovation.co.uk/working_together/technology_focus_areas/bioenergy/

DECC, Digest of UK Energy Statistics (DUKES)

<https://www.gov.uk/government/collections/digest-of-uk-energy-statistics-dukes>

Ofgem, Environmental Programmes <https://www.ofgem.gov.uk/environmental-programmes>

DECC, Public Attitudes Tracker <https://www.gov.uk/government/collections/public-attitudes-tracking-survey>

HM Treasury, Comprehensive Spending Review <https://www.gov.uk/government/publications/spending-review-and-autumn-statement-2015-documents>

London Stock Exchange, CCS Announcement <http://www.londonstockexchange.com/exchange/news/market-news/market-news-detail/other/12597443.html>



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