



OH<sub>2</sub>

BIOENERGY

# APPLICATION OF SUSTAINABLE BIOMASS AND WASTE RESOURCES FOR FLEXIBLE AND AFFORDABLE LOW CARBON ENERGY

## WHY BIOENERGY?

### WHAT WE ARE DOING?

- » BUILDING AN EVIDENCE BASE TO ASSESS THE SUSTAINABILITY OF LAND USE CHANGE TO BIOMASS PRODUCTION IN THE UK
- » DEVELOPING MODELLING TOOLS TO IDENTIFY OPTIMAL BIOENERGY VALUE CHAINS FOR THE UK
- » DEVELOPING LOW CARBON ENERGY TECHNOLOGIES THAT DELIVER CARBON SAVINGS WHICH COULD BE MAXIMISED IF COMBINED WITH CCS

Assessments of the future UK energy system using a variety of tools, including ETI's ESME model – an internationally peer reviewed national energy system design and planning capability – and the UK TIMES/ MARKAL models, indicate a prominent role for bioenergy in the coming decades as a means of meeting our Green House Gasses emission reduction targets by 2050, especially when

combined with carbon capture and storage (CCS). The bioenergy sector is complex, yet immature, and the success of bioenergy's utilisation and growth will depend heavily on the route to deployment. Deployed properly, it has the potential to help secure energy supplies, mitigate climate change, and create significant green growth opportunities.



**DEPLOYED PROPERLY, BIOENERGY HAS THE POTENTIAL TO HELP SECURE ENERGY SUPPLIES, MITIGATE CLIMATE CHANGE AND CREATE SIGNIFICANT GREEN GROWTH OPPORTUNITIES**



# WHAT HAVE WE DONE TO DATE?



## CHARACTERISATION OF FEEDSTOCKS

- » Forest Research & E.ON delivering the project
- » Research project to investigate the variability of UK-produced biomass properties
- » Project involves the sampling and analysis of different types of UK-produced biomass

The project will provide an understanding of UK-produced “2nd generation” biomass properties how these vary and relate this variability to the origins of the samples tested. It will involve the sampling of several types of biomass from across the UK under various planting, growing, harvesting and storage conditions. The results will be analysed to understand the scale of variation and what impacts different production and storage methods have on biomass properties.

Forest Research is one of the world’s leading centres of research into woodlands and forestry and an executive agency of the Forestry Commission conducting world-class scientific research and technical development relevant to forestry to support and inform the policies for sustainable forest management. E.ON UK is part of the E.ON group – one of the world’s largest investor-owned power and gas companies generating electricity and retailing power and gas.

# £375k

The project will provide an understanding of UK-produced “2nd generation” biomass properties, how these vary and relate this variability to the origins of the samples tested

## WASTE GASIFICATION

- » Project to design the most efficient, economical and commercially viable gasification demonstrator plant
- » Three companies selected for the competition
- » Plant designs will need to operate at a net electrical efficiency of at least 25% at 5-20MW scale

We selected three companies to design efficient, economic and commercially viable gasification demonstrator plants.

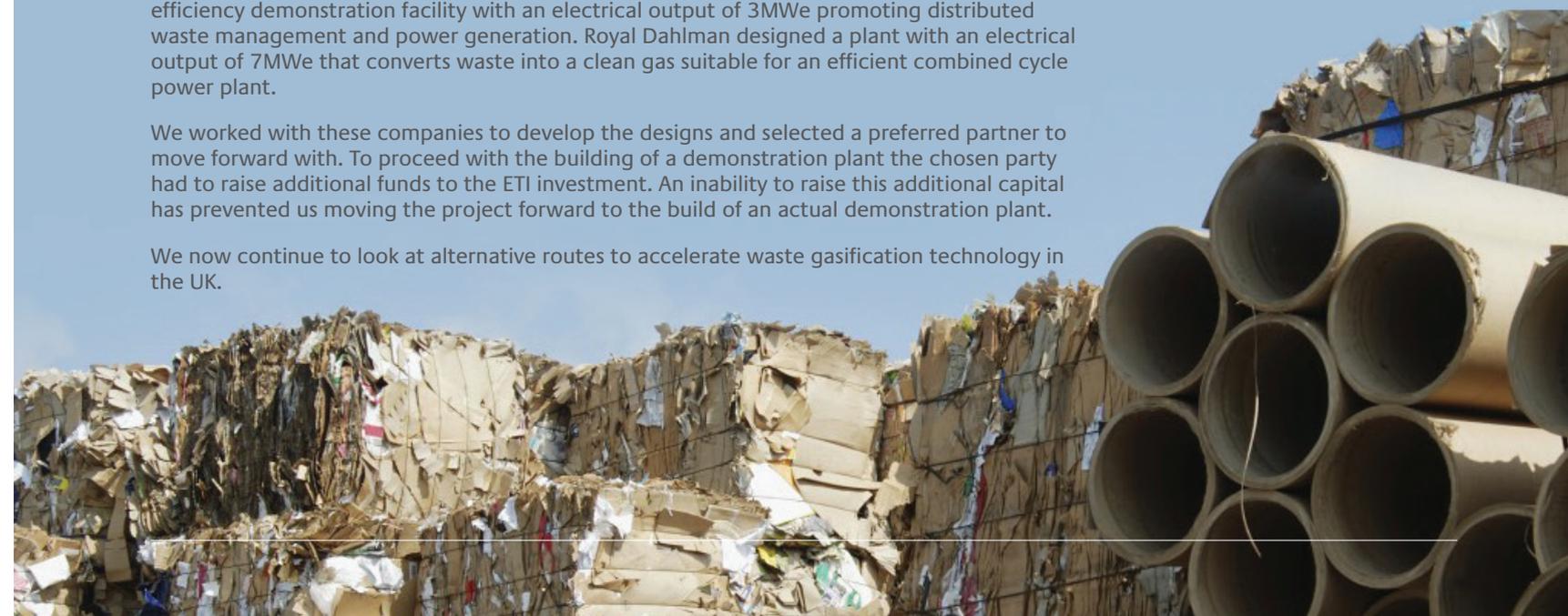
The challenge for the shortlisted companies was to design demonstrator plants that could operate a net electrical efficiency of at least 25%. Advanced Plasma Power designed a demonstration facility with an electrical output of 6MWe to produce a clean syngas as a fuel for high efficiency power generation. Broadcrown Renewable Energy Ltd designed a high efficiency demonstration facility with an electrical output of 3MWe promoting distributed waste management and power generation. Royal Dahlman designed a plant with an electrical output of 7MWe that converts waste into a clean gas suitable for an efficient combined cycle power plant.

We worked with these companies to develop the designs and selected a preferred partner to move forward with. To proceed with the building of a demonstration plant the chosen party had to raise additional funds to the ETI investment. An inability to raise this additional capital has prevented us moving the project forward to the build of an actual demonstration plant.

We now continue to look at alternative routes to accelerate waste gasification technology in the UK.

# £2.8m

The challenge for the shortlisted companies is that plant designs will need to operate a net electrical efficiency of at least 25%



# WHAT HAVE WE DONE TO DATE?

CONTINUED »



## BIOMASS SYSTEMS VALUE CHAIN MODELLING

- » Research project linking bioenergy crop growth with technology options for logistics, pre-processing and final use as heat, power or transport fuel
- » Development of a value chain model
- » Examination of the economic and carbon impact of sustainably developing UK biomass resources whilst converting them to various energy vectors

Led by E4Tech with Agra Ceas Consulting, EDF, Eifer, this project was delivered by a consortium from academia and industry, with Forest Research, Imperial College London, Rothamstead Research and The University of Southampton

This project has developed a spatial model that links bioenergy crop production with the technology options required for logistics, pre-processing and final use as heat, power or transport fuel.

It has developed a value chain optimisation framework and has looked at the economic and carbon impact of sustainably developing UK biomass resources whilst converting these to various energy vectors. It has also analysed the relevant agronomic, techno-economic and geographic factors associated with the cultivation, collection, processing, transmission and utilisation of biomass.



The key insights from this project have been published as 'Insights into future UK Bioenergy sector gained using the ETI's Bioenergy Value Chain Model:  
[www.eti.co.uk/project/biomass-systems-value-chain-modelling/](http://www.eti.co.uk/project/biomass-systems-value-chain-modelling/)

## BIOMASS TO POWER WITH CCS

- » Engineering study on biomass to power with CCS as a combined technology
- » Assessment of the technology gaps and likely time scales for implementation
- » Informing both our Bioenergy and CCS programmes

This project was a high-level engineering study on biomass to power with CCS as a combined technology.

It assessed the technology gaps and the likely time-scales involved for implementation. The findings have informed further work and projects in both our Bioenergy and CCS programmes. Biomass conversion to power combined with CCS could provide the UK with substantial net negative CO<sub>2</sub> emissions.

The project was delivered by a consortium from academia and industry – CMCL Innovations, The University of Cambridge, Doosan, Drax, EDF, E4Tech, Imperial College London and The University of Leeds.

# £450k

The project was delivered by a consortium from academia and industry – CMCL Innovations, The University of Cambridge, Doosan, Drax, EDF, E4Tech, Imperial College London and The University of Leeds



# WHAT HAVE WE DONE TO DATE?

CONTINUED »



## ECOSYSTEM LAND-USE MODELLING (ELUM)

- » Multi-site field trial
- » Studying the impact of bioenergy crops on soil carbon levels and greenhouse gas emissions to air
- » Assessing second generation bioenergy crops (short rotation Coppice, Willow, Miscanthus grass and short rotation forestry)

This project has studied the impact of bioenergy crop land-use changes on soil carbon stocks and greenhouse gas emissions.

It has developed a model to quantitatively assess changes in levels of soil carbon, combined with the greenhouse gas flux which results from the conversion of land to bioenergy in the UK.

The categorisation and mapping of this data using geographical information systems will allow recommendations to be made on the most sustainable land use transition from a soil carbon and GHG perspective.

# £4.2m

The consortium who delivered the project are The Centre for Ecology & Hydrology, Aberystwyth University, Forest Research, The University of Aberdeen, The University of Edinburgh, The University of Southampton and The University of York



# WHAT HAVE WE DONE TO DATE?

CONTINUED »

## TECHNO-ECONOMIC ASSESSMENT OF BIOMASS PRE-PROCESSING

- » **Consultants E4tech are leading a consortium delivering ETI's bioenergy project**
- » **This techno-economic analysis will review the economic and performance benefits and trade-offs associated with pre-processing bioenergy feedstocks**
- » **Project will run in parallel with another ETI project that is characterising UK grown feedstocks**

E4tech has been selected to lead a consortium that will deliver the latest project in ETI's bioenergy programme – a techno-economic assessment of biomass pre-processing.

This project will provide 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.

Pre-processing technologies assessed will include drying, blending, chipping, pelleting, torrefaction and pyrolysis, amongst others. Using process modelling and sensitivity analysis, the project will compare different bioenergy system approaches with, and without, pre-processing steps between feedstock production and an energy conversion plant. The analysis will use feedstock data from a parallel ETI project that is characterising feedstocks grown in the UK.

# £467k

This techno-economic analysis will review the economic and performance benefits and trade-offs associated with pre-processing bioenergy



## ENERGY FROM WASTE

- » **Project profiling waste arisings in the UK**
- » **Evaluated different conversion technologies**
- » **Identified technology development opportunities in the area of gasification and gas clean up**

Energy from Waste represents an opportunity to produce clean, renewable energy from local sources that were previously destined for landfill sites. This £1.4m project profiled the waste streams in the UK, the potential energy available from them and how this might change in the future.

The project also evaluated different conversion technologies to extract the energy from key waste streams. Delivered by a consortium of industry and academia – Caterpillar, EDF, Cranfield University, CPI and Shanks Waste Solutions – the project has identified a significant technology development opportunity in the area of gasification and gas clean up. This is now progressing through our Waste Gasification Project.



# INSIGHTS ARISING FROM THE PROGRAMME



THE ETI HAS CREATED A SOFTWARE TOOL

**BVCM** is capable of modelling the end to end processes of Bioenergy value chains

# BVCM

Bioenergy Value Chain Model  
Optimising Bioenergy

**BVCM** reaffirms the importance of combining CCS and Bioenergy to deliver **negative emissions**, indeed it is the only credible route for doing so

**BVCM** tells us **what, where** and **how**

<p><b>WHAT</b> ARE THE BEST COMBINATIONS OF FEEDSTOCK AND CONVERSION TECHNOLOGY</p>	<p><b>WHERE</b> OPTIMAL LOCATIONS FOR BIOMASS PRODUCTION AND TECHNOLOGY DEVELOPMENT</p>	<p><b>HOW</b> BEST TO USE BIOMASS IN THE UK ENERGY SYSTEM</p>
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IMPROVING ENERGY SECURITY AND CREATING JOB OPPORTUNITIES

Bioenergy sources could provide 10% of UK energy needs by 2050

# 10%

UK LAND IS FINITE AND VALUABLE

Optimisation of land use, including for biomass will be important

LOCATIONAL PREFERENCES FOR BIOENERGY PRODUCTION WITH CCS

Scale indicator  
Major production Minor production

**With imports**

**Without imports**

## ABOUT THE ETI

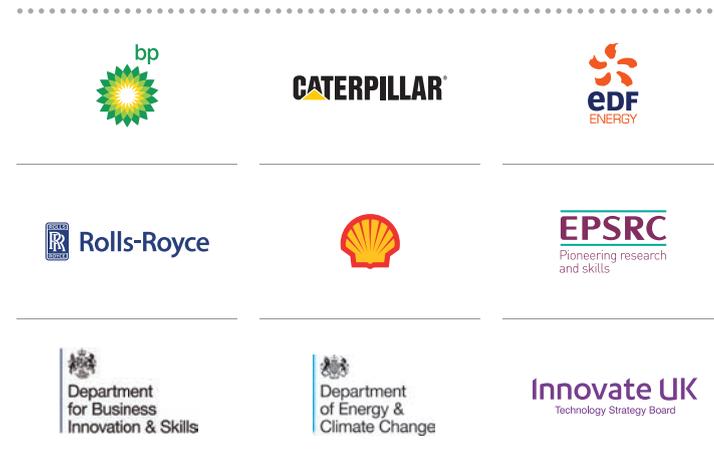
The Energy Technologies Institute is a partnership between global energy and engineering companies and the UK Government.

Its role is to act as a conduit between academia, industry and government to accelerate the development of low carbon technologies.

It brings together engineering projects that develop affordable, secure and sustainable technologies to help the UK address its long-term emissions reduction targets as well as delivering nearer term benefits.

It makes targeted investments in a portfolio of nine technology programmes across heat, power, transport and the infrastructure that links them.

### ETI Members



### ETI Programme Associate

**HITACHI**  
Inspire the Next

## PROJECT TEAM



**Geraint Evans**  
Programme Manager – Bioenergy  
01509 20 20 38  
geraint.evans@eti.co.uk



**Geraldine Newton-Cross**  
Strategy Manager – Bioenergy  
01509 20 20 52  
geraldine.newton-cross@eti.co.uk



**Paul Winstanley**  
Project Manager – Bioenergy  
01509 20 20 45  
paul.winstanley@eti.co.uk



**Hannah Evans**  
Strategy Analyst – Bioenergy  
01509 20 20 40  
hannah.evans@eti.co.uk



Energy Technologies Institute  
Holywell Building  
Holywell Way  
Loughborough  
LE11 3UZ

 01509 202020

 [www.eti.co.uk](http://www.eti.co.uk)

 [info@eti.co.uk](mailto:info@eti.co.uk)

 @the\_ETI