

BIORENEWABLES:

Improving crops and processes
for integrated biorefineries



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CONTEXT

Humanity faces a dilemma: how to escape our dependency on fossil fuels and reduce greenhouse gas (GHG) emissions without further exacerbating the environmental impacts of agriculture.

Biorenewables Fuels and Materials is one strand of the research theme entitled Energy Systems at the Centre for Low Carbon Futures (CLCF). Led by Professor Simon McQueen-Mason, the aim is to develop research projects involving academia and industry providing scientific solutions for the development of cost effective and sustainable lignocellulosic ethanol and biorefineries. Indeed plants can be used to generate energy (biofuels) but also other everyday goods currently made from oil such as plastics and chemicals.

Simon McQueen-Mason (SMM) leads an academic group working in the area of non-food crops and biofuels at the Centre for Novel Agricultural Products (CNAP) at the University of York. He is supported by Dr Alexandra Lanot who is developing projects in the area of biorenewables and biofuels.



DEVELOPING NEW RESEARCH PROJECTS AND COLLABORATIONS

The vision of the Biorenewables Strand is to develop biorefinery crops that are not only used to produce biofuels, but can also be processed to generate valuable materials to replace those derived from petrochemicals.

In this way, a biorefinery is analogous to an oil refinery in which, typically, 85% of the feedstock is used to make biofuels that account for 50% of the income, while the remaining 50% of income is generated from 15% of the feedstock.

To achieve this vision, the Biorenewables Strand brings together world leading scientists from the University of York working in the areas of crop development at the Centre for Novel Agricultural Products (CNAP), biomass processing at the Food and Environment Research Agency (FERA), process engineering at the Centre of Excellence in Green Chemistry, and environmental sciences at the Stockholm Environment Institute. They carry out foundation work and background research to develop new projects and collaborations to help facilitate the transition to a knowledge-based bioeconomy.

As a result of the research carried out within the remit of the Centre for Low Carbon Futures project, CNAP has achieved further funding from the European Commission for two R&D collaborations entitled Sunlibb and Multihemp, bringing £2.6m to the University of York.

SUNLIBB: SUSTAINABLE LIQUID BIOFUELS FROM BIOMASS

Our programme of research is developing cost-effective and sustainable second-generation bioethanol.

First generation biofuel production is rapidly increasing globally and there is significant UK investment in the production of starch-based bioethanol from wheat grain.

While first generation bioethanol can help deal with fuel security issues, there are clear limitations to how much biofuel can be produced. It is important to consider more sustainable ways of producing biofuels, such as the use of the waste material from agricultural production. This lignocellulosic plant biomass is often produced in greater quantities than the food itself. The current problem is that the costs of obtaining fermentable sugars from lignocellulosic materials are too high to compete with fossil fuels or first generation biofuels.

The Centre for Low Carbon Futures' funded work directly laid the foundations for winning a major R&D collaboration between the EU and Brazil. The project, entitled Sustainable Liquid Biofuels from Biomass (Sunlibb www.sunlibb.eu) consists of 13 partners in Europe (seven academic and six industrial) who work together with a similarly sized grouping of academic and industry partners in Brazil, under the title of CeProBio. The programme brings together plant scientists, crop breeders, biofuels producers, process engineers, green chemists and environmental scientists carrying out underpinning work for the development of integrated biorefineries based on lignocellulose from sugarcane and miscanthus.



MULTIHEMP: MULTIPURPOSE HEMP FOR INDUSTRIAL BIOPRODUCTS AND BIOMASS

Developing new research to provide a sustainable alternative to materials derived from petrochemicals.

In recent years, the increasing need for renewable resources and sustainable materials has fuelled interest in natural plant fibres. Hemp is a highly productive crop with low demand for water and agrochemical applications. Future demand of hemp-based products is expected to grow rapidly thanks to the expanding applications that can be addressed using hemp fibres and the other parts of the plants (stem, leaves, seeds and flowers). The existing and emerging markets include essential oils for fragrance, nutritional supplements, high quality fibres for textile and bio-composite, low carbon construction materials, and residual biomass suited for biofuel production. The fact that one plant harvest can generate several products makes hemp an ideal crop for use in an integrated biorefinery. In recent years, hemp has been a minor crop – it was disadvantaged by the subsidy regime and only approved varieties (with low psychoactive molecules levels) can be grown in the UK. To assist with the development of these new markets, it is considered a priority to improve its cultivation, including development of improved varieties and processing techniques.

CNAP has been successful in achieving funding from the European Commission as a major partner in a consortium of 22 partners entitled 'MultiHemp, Multipurpose Hemp for industrial bioproducts and biomass'.



The long-term project objectives are to:

- develop new hemp varieties with improved raw material quality and improved agronomic qualities;
- develop greener extraction methods and integrated processes for multiple value stream from hemp;
- carry out technico-evaluation and environmental assessment of the process necessary for the production of the various hemp products; and
- demonstrate integrated biorefining at pilot scale.

THE CENTRE FOR NOVEL AGRICULTURAL PRODUCTS AS THE CENTRE OF BIORENEWABLES RESEARCH



CNAP has been dedicated to research and outreach into non-food products from plants in a number of areas including, biomass and biofuels, novel and improved plant oils, medicinal and pharmaceutical products, gene and enzyme discovery, biochemical pathway engineering, biocatalysis, bioremediation.

CLCF funding has allowed CNAP to develop close associations with industrial partners with ambitions to innovate in the area of sustainable technologies and renewable materials. The Yorkshire region is ideally situated, being located near the heart of the UK's most productive arable land for feedstock and close to one of the UK's major industrial ports on the Humber.

Within CNAP, SMM also coordinates a programme involving 15 partners in the EU on the topic of biomass/biofuels, entitled Renewall. He is also involved in two programmes for the BBSRC Sustainable Bioenergy Research Centre and, as a result of his biorenewables work, holds a number of influential positions related to biofuels in national Research Councils.

www.york.ac.uk/org/cnap

FUTURE PROJECTS AND FACILITIES

CNAP and SMM are taking part in the Biorenewables Development Centre facility in York and are developing new projects that use the concept of biorefinery to solve specific energy or environment issues nationally and internationally.



SMM developed a new strategic application that involves developing integrated biorefining systems, which bring together biochemical and thermochemical approaches and will align strongly with a number of major biofuel and bioenergy companies in the UK.

CNAP is involved in the development of the Biorenewables Development Centre (BDC) in York (www.biorenewables.org). This facility covers novel extraction and processing technologies and fast track plant breeding. It has been set up as an efficient step to link laboratory scale results to industrial scale production by generating enough products for evaluation by industrial end-users and will be instrumental to the development of biorefineries.

Internationally, SMM attended two workshops in Vietnam and India in the area of biorefinery and biofuels – these led to funding being made available for collaborative research between the UK and these countries. This work is important since Vietnam currently burns 60m tonnes of rice straw per year, producing large quantities of black carbon and tropospheric ozone. As an agricultural waste, rice straw represents a great opportunity to use the biorefinery concept to create new added-value products and decrease pollution. The report from the Indian workshop produced by SMM was used to make the case to BBSRC to co-fund a joint call with the Department of Biotechnology, India and this agreement was formally announced by David Willetts, Minister of State for Universities and Science. The call will support collaborative research that could help both nations develop sustainable alternatives to fossil fuels.

GLOSSARY

BIOECONOMY:
refers to all economic activity derived from scientific and research activity focused on understanding mechanisms and processes at the genetic and molecular levels and its application to industrial process.

BIOETHANOL:
refers to ethanol made from plant biomass and used as fuel.

BIOMASS:
refers to biological material used as renewable energy source.

BIOREFINERY:
a facility that integrates biomass conversion and equipment to produce fuels, power and value-added chemicals. The biorefinery concept is analogous to usual petroleum refinery.

BLACK CARBON:
formed through the incomplete combustion of fuels and a significant cause of global warming.

FEEDSTOCK:
raw material from which a product is manufactured or made.

LIGNOCELLULOSIC BIOMASS:
plant biomass that is composed of cellulose, hemicellulose and lignin. It is constituted of agricultural residues, dedicated energy crops and wood residues.

MISCANTHUS:
perennial grasses native to subtropical and tropical regions of Africa and southern Asia that are used as dedicated energy crop.

RESIDUAL BIOMASS:
biomass remaining in a refinery after the feedstock has been transformed into the desired products.

TROPOSPHERE OZONE:
toxic gas (ozone) accumulating in the lowest portion of Earth’s atmosphere.

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Further information will be available on the CLCF website at:
<http://www.lowcarbonfutures.org/projects/energy-systems/biorenewable-fuels-and-materials>

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SUNLIBB project: ww.sunlibb.eu

ABOUT US

The Centre for Low Carbon Futures is a collaborative membership organisation that focuses on sustainability for competitive advantage. Founded by the Universities of Hull, Leeds, Sheffield and York, the Centre brings together multidisciplinary and evidence-based research to both inform policy making and to demonstrate low carbon innovations. Our research themes are Smart Infrastructure, Energy Systems and the Circular Economy. Our activities are focused on the needs of business in both the demonstration of innovation and the associated skills development. Registered in the UK at Companies House 29th September 2009 Company No: 7033134.

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