# THYME Project

Teesside, Hull and York - Mobilising Bioeconomy Knowledge Exchange

A collaboration between the Universities of York, Hull and Teesside to boost the bioeconomy across Yorkshire, the Humber region and the Tees Valley.

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There's now huge interest in moving away from a fossil-fuel-based economy and its associated problems - such as plastic pollution - to a circular economy based on biorenewable materials.

The Government's Science and Innovation Audit of the Bioeconomy of the North of England showed that the region has the potential to lead this change and the THYME Project has played a fantastic role in driving this forward.

Through THYME, the universities of York, Hull and Teesside have found new and innovative ways to work together and to reach out to bio-based businesses and other regional stakeholders. The links they have forged and the best practice in knowledge transfer they have developed will make a lasting contribution to the region's bioeconomy.

Joe Ross

Joe Ross
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## Introduction

The fast-growing bioeconomy represents a major economic opportunity for the UK and particularly for the North of England, which has world-class bioeconomy assets and research. THYME is funded by Research England's Connecting Capability Fund in 2018, it is an innovative collaboration between the universities of York, Hull and Teesside. Its aim is to build the bioeconomy sector across Yorkshire, the Humber and the Tees Valley. The project has brought together the research and commercialisation capabilities of the three universities. With the help of local innovation clusters, they have reached out to bio-based industry and other stakeholders to overcome identified barriers to growth and advance the regional bioeconomy.

Through a range of activities such as networking events, proof-of-concept grants, bio-based workshops, secondments, entrepreneurship support and knowledge transfer materials the project has galvanised research and innovation activity with key themes proving to be:

- increasing productivity by reducing waste and energy use
- adding value to by-products
- developing better products using industrial biotechnology.

The innovations kick-started by THYME will not only help to boost economic growth but also pave the way to a more sustainable future where industry uses renewable sources of raw materials, such as plants and microbes, rather than petrochemicals. Read on to discover more about what the THYME project has achieved in its first three years.

THYME is supported by Research England's Connecting Capability Fund.

# Supporting innovation for the anaerobic digestion (AD) industry

THYME has galvanised research into AD: a vital process that uses microbes to turn sewage, food waste and farming waste into energy. Although a well-established technology, AD's productivity is low, presenting a major opportunity for THYME-catalysed research to impact on our economy and our sustainability.

*" Our AD research has benefited hugely from expertise provided by the universities of Hull and Teesside. "* Alex Jukes, University of York.

## New research partnerships

THYME has funded five proof-of-concept studies aimed at improving the AD process. These projects have brought together microbiologists, chemists, ecologists and logisticians from the universities of York, Hull and Teesside, along with industrial partners, many of them working together for the first time.

## Managing the microbes

The microbial processes behind AD are complex and poorly understood. With THYME funding, researchers are using high-throughput genetic techniques to study the combined genome of thousands of microbe species from AD tanks. Their research promises to transform our understanding of AD and increase its waste recycling potential.

## De-risking innovation

THYME researchers are using data sets from commercial AD to create a 'digital twin': a mathematical model that can be used to explore the impact of different interventions without risk. Another approach under investigation is the possibility of repurposing a no-longer-needed AD site as an open-access facility for testing new innovations at commercial scale.

## Finding new AD feedstocks

New feedstocks for AD will increase our sustainability and enable the AD industry to expand. THYME funded researchers are testing the use of pharmaceutical waste in AD, to generate renewable energy and avoid expensive and environmentally problematic disposal. In other work, researchers are using clippings and mowings from nature reserves and other wildlife habitats in AD, and assessing the potential this offers in terms of effective biodiversity management and as a source of income to offset conservation costs.

## Specialist workshops

Working with BioVale's Special Interest Group on AD, THYME has put on four workshops, bringing researchers and industry together to discuss best practice, share new knowledge and build innovation partnerships. The workshops have included research showcases, AD site visits, discussions on environmental issues associated with using the digestate from AD and presentations of new technologies to deal with problematic feedstocks.

## Key facts

- **5** proof-of-concept projects funded
- **17** research partnerships catalysed
- Total of **£239,716** funding
- **4** AD workshops
- **188** delegates at our AD workshops in 2018-2019

# Delivering knowledge exchange workshops

THYME has initiated 'intercluster' events, with the region's bioeconomy-related clusters, working together for the first time to deliver events that transfer knowledge from local universities and drive up academia-business collaboration, cross-fertilisation and innovation.


*" The flavours and fragrances event was exceptionally useful to me. I need this type of highly focused, science-based nuts and bolts event and the contacts made have certainly yielded value. "* Clara-Challoner Walker, Cosy Cottage Soap. Company.



## Three clusters working together

With the support of THYME, three regional cluster organisations have been working together on knowledge transfer events: BioVale – a bioeconomy cluster (York), the North East of England Process Industry Cluster- NEPIC (Teesside) and CATCH (the Humber) which supports the process, energy, engineering and renewable industries. By finding workshop topics of mutual interest, the clusters have been able to deliver a successful series of bioeconomy workshops and webinars that have brought together researchers and companies from across the region.

## Natural ingredients: innovation

In response to consumer pressure, industry is increasingly looking to source natural ingredients for use in flavours and fragrances. Hosted by multinational chemical company Croda, at their headquarters near Selby, the focus was on innovation around natural feedstocks, novel process solutions, new products and improved sustainability. The workshop brought together researchers, growers, industry and technology providers and the partnering opportunities were maximised with speed networking and a working lunch.

## Anaerobic Digestion (AD): new innovations for existing technology

A series of workshops has supported the THYME region's thriving AD sector, backed by BioVale's special interest group on AD. The workshops have shared the latest advances and sought to generate innovation that solves industry problems and boosts its productivity, tackling topics such as: the issue of plastic pollution; digestate and the environment; and making use of difficult feedstocks.

## Innovation in sustainable food manufacturing

The THYME region has a high concentration of major food manufacturers and specialist food research at its universities. This event explored the opportunities for the food manufacturing sector to improve its financial and environmental sustainability by developing the production of higher value products such as chemicals, materials and fuels from by-products and waste streams, with particular emphasis on bakery products, poultry rearing and fruit and vegetable processing.

## Sustainable waste-water treatment

CATCH and THYME led an industry-focused webinar exploring bio-based solutions to waste-water treatment. Participants gained inspiration for how business could benefit from bio-based solutions for waste-water treatment, such as innovative uses of pollen spore grains and common club moss to remove selected Watch List chemicals and inorganic phosphate from water.

### Key facts

**3** regional universities and three regional clusters involved

Involve three clusters bring together over **500** regional members

**8** knowledge exchange workshops and webinars, so far

Over **400** participants

# Improving productivity in energy generation from biowaste

THYME is driving productivity through process improvements in the generation of energy from bio-feedstocks. Bio-based energy production is a growing element of the renewable energy mix with massive potential for economic growth via sustainable divestment from fossil fuels.

*“ Through THYME we are bringing together regional partners, to accelerate bio-based technologies that improve the performance of local industry. ”* Jenny Spear, University of Hull.

## Improving energy production from biomass

The University of Hull is exploring the use of catalysts in the gasification of biomass feedstocks to produce low carbon fuels with cleaner emissions. This novel process reduces costly tar blockages that currently cause production stoppages. The team are also investigating the treatment of waste tar molecules as 'platform chemicals' that can be converted into high-value by-products.

## Low energy production of biofuels

High-value products such as acetone, ethanol and particularly n-butanol (butane gas) can be produced by the distillation of fermented bio-waste. However, this is an expensive, high-energy process. THYME is trialling innovative low-energy methods to separate out these high-value green chemicals.

## Converting biofuel production waste into bioenergy

Current production methods for making bioethanol from biomass, although efficient, result in a lignin-rich sludge that is usually discarded. THYME is investigating various pre-treatment technologies for this waste with the aim of generating an additional solid fuel for energy production.

## Maximising income streams from biofuel production

Argent Energy specialise in the manufacture of commercial biofuels. Advanced chemical process simulations and mathematical modelling are developing a method for the extraction and purification of short-chain methyl esters from their own bio-waste stream to create high-value chemicals for the flavours and fragrances market.

## Optimising biomethane production via Anaerobic Digestion (AD)

The universities of York and Teesside are working with Amur Energy to optimise their South Milford AD installation, which processes 50,000 tonnes of food waste a year to produce upgraded biomethane. The researchers are using a ‘digital twin’ to recommend process interventions that have been pre-tested in a metabolic model.

## Improving bioethanol productivity

THYME researchers are genetically altering yeast strains to improve the efficiency of ethanol production via biomass fermentation. Their lab-based results are being applied to manufacturing processes by industry partner Ingenza, to assess commercial viability.

## Driving future research in Bioenergy, Solid Fuels and Catalysis

The University of Hull and the Biorenewables Development Centre are creating a new Special Interest Group (SIG) bringing together international academia and industry to explore future research activity, as a legacy to THYME. The SIG uses green chemistry to address key challenges around the shift away from fossil fuels. A symposium on Bioenergy, Solid Fuels and Catalysis will help shape future collaborative research to address these challenges.

### Key facts

- **5** proof-of-concept projects funded
- Total of **£251,769** funding
- **28** research partnerships instigated
- Network launched with international reach

# Improving the efficacy of probiotics to treat disease

THYME is supporting research to make probiotics work more effectively to combat a range of health disorders. Probiotic products use 'good' bacteria to help improve and maintain gut health and the probiotics market has huge potential for economic growth.

*" Through THYME we have strengthened our research links, developed new experimental protocols and obtained results that could lead to patents and long-term collaboration with the probiotics industry. "* Dr Claudio Angione, Teesside University.

## The challenge for probiotics

The microbial community of the human gut is highly complex and dynamic, making it difficult for scientists to study and understand. It contains many different types of bacteria, which often form robust structures called biofilms. A key challenge for all probiotics is how to infiltrate these biofilms in order to colonise the gut.

## Combining computational and microbiological techniques

With the help of THYME funding, Dr Claudio Angione from Teesside University and Dr Georgios Efthimiou from the University of Hull are combining their expertise to optimise culture conditions for probiotics. They have constructed digital models that enable them to examine the interplay among biofilm-forming bacteria under different conditions.

Machine learning and optimisation algorithms are being used to predict the steps needed to encourage the formation, growth and stability of gut biofilms. This improved understanding will help to develop probiotics that can colonise the gut more effectively, leading to greater health benefits. Using digital technology to analyse the expected behaviour of the probiotics reduces the need for lengthy laboratory experiments and speeds up the testing process.

## Sustainable protein production

THYME is also funding research into the production and use of molecules released by the probiotic bacterium Lactobacillus rhamnosus GG. This bacterium secretes proteins, which are able to regulate the immune response of human cells in the gut. Proteins such as these have potential to provide a safe, side-effect free complement to current medication for diseases such as Crohn's disease and ulcerative colitis.

Dr Mosharraf Sarker from Teesside, Dr Joe Bennett and Dr Deborah Rathbone from the Biorenewables Development Centre at the University of York are scaling up the production of two such proteins from *L. rhamnosus* and testing their effects in managing the body's inflammatory processes. To make the production of these proteins as sustainable as possible, they are also looking into ways of utilising the waste and by-products of the production process.

## Strong commercial relevance

A potential commercial partner is CHAIN Biotech which is developing a platform for targeted gut delivery of therapeutic peptides. Their *Clostridium*-Assisted Drug Development (CADD™) platform targets the immuno-oncology and oral vaccine markets.

### Key facts

**2** proof-of-concept projects funded

Total of **£99,997** funding

Probiotics world market projected to reach **$64.02 billion** by 2022

Gut microbiome linked to a variety of diseases including diabetes and autoimmune disorders

# Inspiring entrepreneurship in the bioeconomy

Using interactive workshops and inspiring mentors from regional businesses, THYME has been firing up the entrepreneurial ambitions and developing the start-up business skills of university staff and students from across the THYME region.

*“ Well designed and insightful, the workshops provided a first-person overview of what is required to start a business as well as the ability to engage with and ask questions to successful entrepreneurs. ”*

Chun Keat Yew, University of Hull.



## A comprehensive programme of workshops

Industries in the bioeconomy consistently report a lack of entrepreneurial awareness and skills as a barrier to growth. THYME has been addressing this with a series of workshops covering all aspects of the entrepreneurship journey: how to recognise and capitalise on entrepreneurial opportunities; the key tools and steps to building a successful start-up; and the critical business issues that impact commercial organisations in the bioeconomy. The workshops delivered training in key entrepreneurial skills, such as communications, understanding financing, human resources, business scale-up and business problem solving. They were designed and delivered in collaboration with skills training provider Skillfluence. Their popularity was such that several participants attended more than one.

## An inspiring range of speakers and mentors

At the workshops, key insights and advice were provided by almost forty bioeconomy experts and thought leaders from both business and academia, who could share their wide-ranging experience of entrepreneurship and research commercialisation. Examples include:

- Providing an overview of the bioeconomy and advice on fostering research / academia interactions: Professor Ian Graham, Director of BioYork at the University of York and Professor Daniel Parsons, Director, Energy and Environment Institute at the University of Hull.
- Representatives from important regional industry players: Christine Parry, Head of Development and Innovation at AB Agri, Rob Johnson, Science Manager at Quorn Foods.
- Sharing the high and lows of their own entrepreneurship journeys: Dr Monika Tomecka from UFraction8 and Dr Tom Simmons from Stem Sugar.
- Mentors, providing tailored business advice at one-to-one meetings with participants included: Steve Dougan and Louis Lamontagne from Teesside Launchpad and Tina Crombie from TCR UK Solutions.

## Pitching to the experts

Each workshop ended in a live pitch to a panel of experts which provided an opportunity for the participants to put into practice what they had learned on developing and communicating a compelling business case.

## Emphasis on networking

The workshops attracted potential entrepreneurs from all career stages (post-graduates and staff), from a range of academic disciplines (including Social Science, Engineering and the Natural Sciences) and from all three THYME region universities. Participants were encouraged to use this opportunity to broaden their networks and to work together on group exercises. Many of the participants discovered knowledge and expertise amongst fellow participants that complimented their own, creating partnerships that would form the basis of consortia applying for THYME proof-of-concept grants.

### Key facts

**5** entrepreneurship workshops held

**75** hours of content delivered

Total of **62** delegates trained

**39** speakers and mentors

# Engaging pupils and the public with the bioeconomy

THYME has delivered an innovative range of activities and resources to educate pupils, students and the wider public about the bioeconomy: what it is and why it is vital to our economy and our sustainability.

*“ The THYME schools materials are great at showing kids that science is so much more than what they learn at school. ”* Terry Kirk, STEM Ambassador.

## A dedicated bioeconomy venue for engagement

The Biorenewables Development Centre and BioVale have developed the Bioeconomy Outreach Centre, which provides a unique educational learning space for school groups and teachers, as well as space for other bioeconomy-related outreach activities, events and meetings. Visitors to the Centre can be inspired by its permanent exhibition of everyday products made from renewable materials, such as shoes made of seaweed and coffee cups made from coffee grounds. Users of the space so far include schools' groups, the Association of Science Education, the Knowledge Transfer Network and the Bank of England.

## Encouraging participation with gamification

Working in association with Focus Games, BioVale has developed a bioeconomy board game and an electronic quiz. Players are divided into teams that represent different communities in a city. Their objective is to create value from waste by reusing and recycling it in new ways, rather than sending it to landfill. Over a thousand people have played the online version of the game and it has gained fans from as far away as Canada.

## Workshops for schools

Workshops for school pupils have delivered a programme of fun, interactive, curriculum-based activities that enable pupils to explore the global switch to a bioeconomy as well as informing pupils about possible careers in the bioeconomy. Activities have included making bioplastic and soap from natural ingredients, matching biobased products to the raw materials they are made from and touring the laboratories of the Biorenewables Development Centre. Some of the workshops were delivered in partnership with the Widening Participation Team at the University of York.

## Support for young entrepreneurs

THYME delivered a one-day workshop to a group of young entrepreneurs who won the University of York's 2019 Big Deal Enterprise competition. Four students from St Wilfrid's Catholic High School in Pontefract designed a hydroponic plant growth system called BIO-HEX which allows customers to grow plants using less water than conventional growing methods. The BIO-HEX team were given mentoring and advice from staff at the Biorenewables Development Centre.

## Out and about

THYME has worked with wider audiences at public engagement events in York at both the Café Scientifique and the Pint of Science events. THYME research was selected for the Royal Society's prestigious Summer Science exhibition for schools, VIPs and the public.

## Sharing our schools' resources

We have worked with teachers to develop a range of educational materials that link to the National Curriculum in a variety of topic areas. These are available to download on the THYME website, for use by teachers and parents.

## Key facts

**150** pupils from **42** schools at our workshops

**31** events in the Bioeconomy Outreach Centre

Over **1,000** players of the online bioeconomy quiz

Total audience of **150** for public engagement

# Supporting innovation in fermentation technologies

Industry is increasingly turning to microbes to produce chemicals for use in sectors such as: food and drink, personal care, pharmaceuticals and biofuels. THYME has brought together academics from the universities of York, Hull and Teesside, along with industry partners, for new research that is generating exciting innovations across the whole fermentation process.

*“ THYME has brought together a unique set of skills and expertise to provide real benefits for a biotech company which is making an impact globally. ”* Muhammad Safwan Akram, Teesside University.

## Improving process efficiency

A microbioreactor under development at Teesside University will help to improve bioprocesses and reduce the cost of future innovation. With miniaturised data collection and analytical systems, it can rapidly and cheaply obtain high-quality information on growth conditions, cell density, physiology and productivity. The Biorenewables Development Centre (BDC) is testing the system, with the help of industrial partners Unilever, Quorn and Croda. Researchers at these two institutes are also collaborating on a second project, which is using an established process modelling system - the Britest Toolkit - to optimise the production of lactic acid through fermentation of woody waste.

## Developing more sustainable feedstocks

Researchers from the BDC and the University of Hull and collaborating with GlaxoSmithKline to look at producing future medicines from food waste. The microbes that make antibiotics are currently fed on high-grade materials, such as wheat. THYME is looking to see if such feedstocks can be replaced by starchy by-products from food manufacturing.

## New membranes for the recovery of solvents

Researchers at the University of Hull and the BDC are developing novel, membrane-based processes for the recovery of solvents or other high-value compounds from processes such as fermentation or cell culturing.
The membranes would replace existing, energy intensive methods for solvent recovery and are being assessed by the industrial partners, Nanjing Industrial Technology Research Institute of Membranes.

## Better microbes for improved fermentation

Researchers at the universities of Teesside and York are working on two projects to make fermentation more productive and efficient by improving the microbes that drive the process. One project is selecting better yeast strains for use in the production of bioethanol, drawing together synthetic biology, metabolomics and proteomics expertise across these universities and at industrial partner Ingenza. A second project is working with Fujifilm Diosynth to better understand and enhance protein production by the bacterium *Escherichia coli*.

## Revolutionising operator training

Operator error can lead to significant losses within biopharmaceutical processes, with the potential to cost millions of pounds in lost batches. Researchers at Teesside University, are developing the use of virtual reality to train process operators and so avoid costly mistakes, reduce waste and improve productivity.

## Key facts

**6** proof-of-concept projects funded

Research fellowship funded at Teesside University

**24** research partnerships catalysed

Total of **£249,596** funding

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