BBSRC NIBB AD Network
All Business Interaction Vouchers: Titles and Summaries

2014 BIV Titles and Summaries

BIV2014001

Permastore / Dr Sonia Heaven
Testing of anaerobic digester components found in thermophilic digestion of food wastes

Permastore is the world leading manufacturer of Glass-Fused-to-Steel tanks and silos, with more than 300,000 structures installed worldwide in over 110 countries. The wide range of applications already includes anaerobic digestion and biogas and biofuels production. The company's aim is to remain at the forefront of development in this field, and to ensure its continuing ability to provide customers with optimum solutions for their containment requirements, and with secure, long-life systems for an expanding range of applications in both anaerobic digestion and novel anaerobic biotechnologies. The company therefore wishes, in association with the academic group at Southampton, to develop a testing protocol that will allow materials destined for potential use in advanced applications to be validated. This includes operation at thermophilic temperatures and where harsh conditions are likely to arise in digesters, both in normal operation and where the process becomes unstable or fails. The testing will be based on small-scale continuous simulation of the digestion process and will provide comprehensive data that would not be available from simple batch tests. Trials will be carried out using source separated domestic food waste, which is itself an interesting and challenging feedstock under thermophilic conditions. The project will thus allow the partners to draw on their extensive combined expertise to develop and use an appropriate in-vivo testing regime, and to work together on evaluating the results from trials carried out over a period of several months.

BIV2014002

IEA Task 37 / Dr Sonia Heaven
A modelling tool for the UK AD industry

Rapid expansion in the UK AD sector is creating a need for a powerful, flexible and readily-accessible tool for assessment of anaerobic digestion (AD) facilities. To achieve this it is proposed to take an existing model on which extensive development work has already been carried out by the academic partners, and to re-configure it into a user-friendly software package suited to the needs of a wide range of end-users. The task of transferring the model into a high-level programming language was begun in the FP7 VALORGAS programme. The proposed work will extend this to include other parameters, and will tailor inputs and outputs to meet the needs of industry and agriculture in the UK. The model itself allows prediction of detailed energy and nutrient balances for AD plants, which can be further translated in terms of their respective greenhouse gas emissions associated with the process. The combined expertise of IEA Task 37 (UK) and the academic partners will allow the development and testing of a new user interface suitable for industrial and farm-based applications at a range of scales. This will be achieved through close collaboration with industry members of Task 37 offering time and expertise as in-kind contributions to achieve the desired goal. The software will be freely available for download and will be promoted through Task 37. The resulting tool will be widely used by industry and researchers, promoting a common framework for evaluation of new and existing AD plants, and increased collaboration across the UK AD community.

2015 BIV Titles and Summaries

BIV2015002
Lutra Ltd / Dr David Styles **Providing a scientific evidence base for public subsidy support of biomethane for transport from waste**
Life cycle assessment (LCA) shows that food waste digestion achieves large environmental credits (e.g. greenhouse gas emission reductions) through replacement of mineral fertilizers and avoidance of composting or landfilling counterfactuals, in addition to fossil fuel replacement with biogas. Evergreen Gas have developed a cost-effective AD system for food waste linked with biogas upgrade that could improve the energetic and environmental balance of food waste AD by avoiding energy inefficiencies associated with combined heat and power plants typically linked to centralized food waste AD plants, and that could reduce harmful emissions from diesel-powered transport. The proposed two-month project will undertake a detailed LCA of this novel pilot system, called Barrett's Mill Anaerobic Digester (BMAD) to: (i) quantify the environmental balance of the AD system compared with alternative food waste management options; (ii) compare the use of biomethane as a transport fuel with diesel and biodiesel; (iii) evaluate the avoided external costs from the proposed system; (iv) compare the public cost-benefit ratio of BMAD with biofuels; (v) identify areas for further R&D. A research assistant will spend six weeks working closely with Evergreen Gas, mining literature data and adapting the "LCAD Eco Screen" tool to evaluate the BMAD system against alternative waste management and biofuel options. Results are anticipated to demonstrate a more positive energy and greenhouse gas balance for the BMAD system compared with alternative waste management options, and a significant human health credit associated with transport diesel substitution. A case will be made for public support of the BMAD concept.

BIV2015003
Renewable Energy Association / Dr David Styles **Evaluating cost-effective greenhouse gas abatement by small-scale anaerobic digestion**
In Defra project AC0410, Styles et al (2014) quantified the greenhouse gas (GHG) balance for small AD systems on a large indoor dairy farm and an average (150 cow) grazing dairy farm using life cycle assessment (LCA). GHG abatement was significantly higher and more cost-effective for smaller AD units with a higher proportion of slurry feedstock than for larger units with significant crop input; avoided slurry storage emissions led to greater GHG abatement than fossil energy replacement. Yet energy-related subsidies (FiT and RHI) are insufficient to make small units financially viable. "Default" GHG abatement costs reported by Styles et al. (2014) were based on conservative assumptions and uncertain financial information, and were highly sensitive to factors such as type of slurry storage avoided, proportion of bio-heat utilized and AD design and management. A simple heat-only AD system on an average dairy farm led to a GHG abatement cost of £256/Mg CO_2e that reduced by a factor of 10 under a best-case combination of factors, including avoidance of lagoon slurry storage. There is a need to apply detailed financial and life cycle environmental accounting across a wider range of promising small-scale AD scenarios in order to identify specific situations of small-scale AD deployment that can achieve societally-efficient GHG abatement alongside other environmental benefits.

BIV2015007

William Jackson Food Group / Dr Davide Dionisi

Anaerobic digestion of vegetable waste from the food industry

The industrial partner of this project generates thousands of tonnes per year of vegetable wastes from which very little value is currently recovered. This project is aimed at investigating the feasibility of anaerobic digestion of vegetable waste from the industrial partner, in order to convert the waste to biogas, which can be then used for electricity generation at the partner's manufaccturing sites or, after purification, injected to the National Grid. Anaerobic digestion is a relatively established process, however the use of vegetable waste as feedstock presents some issues which need to be investigated at lab scale before a full-scale process can be designed. The main potential issues in the anaerobic digestion of food waste are the following: rapid acidification, due to the generation of volatile fatty acids at a rate higher than the rate at which acetogenic or methanogenic microorganisms are able to convert them; relatively low C/N ratio, with potential high ammonia concentration which could inhibit methanogenesis; possible low concentration of trace elements. With the feedstock provided by the industrial partner, a lab-scale anaerobic digestion process will be run in a completely mixed reactor (CSTR). The reactor will be run under mesophilic conditions (35oC) in a range of hydraulic residence times (HRT), and the volume and composition of the produced gas will be measured. The aim is to determine the minimum value of the HRT which ensures high biogas yield while minimising the possible inhibiting effects due to acidification and ammonia and the possible trace elements limitation.

2016 BIV Titles and Summaries

BIV2016001
Roam Agency / Dr Brenda Parker **Comparison of Biological and Mechanical Processes to Generate Value from Digestate**
The project will compare the performance of two low cost systems involving different processes for the remediation of digestate from small-scale AD plants – a biological cascade and a mechanical separation. The aim of the project is to develop recommendations for the design of cost-effective remediation systems for small AD plants, focused on generating value from digestate, in order to support the viability of decentralized organic waste management.

BIV2016003
Tropical Power / Prof. Charles Banks **Process optimisation of Africa's first commercial grid connected AD plant**
Tropical Power is an Engineering Procurement and Construction company building renewable energy solutions for Africa: its focus is on developing utility-scale sustainable energy technologies including anaerobic digestion (AD) and photovoltaics. The Company plans to build renewable power assets producing over 130 MW of clean, distributed power. The first of these was recently commissioned as Africa's first commercial grid-connected AD plant. It is situated at Gorge Farm Energy Park in Nakuru County, Kenya and is currently fed on corn stover and trimmings from vegetables grown for export, mainly to the UK; future feedstocks will include drought-tolerant coppice plants from non-irrigated areas. Because this type of mixed feedstock has not previously been used elsewhere, there is believed to be scope for optimising the plant's performance in terms of its energy use and overall efficiency in relation to feedstock types. To achieve this, the Company needs a testing and monitoring laboratory and is seeking the University of Southampton's advice to establish this, and to work with Tropical Power on analysis and interpretation of data. The work will involve on-site evaluation of facilities, and discussions with the plant operational and management staff to assess which aspects of the monitoring can be carried out in Kenya, and which analyses require sample shipment to external laboratories. As part of the BIV project an initial range of samples and data will be analysed by the University partner to establish baseline values for benchmarking performance. The Company will assist by setting up site meetings and briefing sessions, provision of operational data and shipping of samples.

BIV2016006
LooWatt Ltd. / Dr Tim Patterson **Evaluation of an integrated aerobic-anaerobic microbial system for enhanced degradation of biopolymers**
Loowatt Ltd. has developed a waterless toilet system which is clean and odourless and uses a patented sealing mechanism to wrap human waste in biodegradable polymer film. The mixture of the film and the waste collected aims to be treated by anaerobic digestion to recover energy and nutrients. The project aims to evaluate the benefit of aerobically pre-treating the biopolymer, in order to facilitate the subsequent anaerobic digestion of the material and its residual intermediates. The project will combine the toilet system and material expertise generated within Loowatt with the expertise in biological conversions and biopolymer

chemistry as well as state of the art reactors and analytical facilities available at the University of South Wales. Whilst chemical pretreatments have been successful in aiding polymer degradation, the sustainability of biological processes only would improve Loowatt's product credentials. Aerobic treatment methods have been used post anaerobic digestion for digestate maturation and organic polishing. Aerobic treatments upfront of anaerobic process are novel and more specifically in what relates to biopolymer degradation. The knowledge gained can be immediately utilized by Loowatt Ltd., but is also relevant to the wider AD community as the existing presence of biopolymer materials in feedstocks, including source segregated food waste, currently causes operational difficulties. In addition, as the use of biopolymers in applications such as food waste caddy liners is likely to increase, treating this material is likely to be a long term challenge of the waste management / AD community.

BIV2016007

G's Fresh / Dr Ralph Noble

Optimising the use of separated anaerobic digestate fibre as a substrate for mushroom cultivation

G's Fresh is a major producer of fresh vegetables and mushrooms. It has a 3 MW, two-stage mesophilic AD plant at Littleport, Cambridgeshire which processes over 50,000 tonnes of maize and rye, 8,500 tonnes of vegetable wastes and 2,000 tonnes of chicken manure annually. This produces over 6,000 tonnes of mechanically separated digestate fibre, accredited to PAS 110, and currently disposed of to land. Adjacent, it has the UK's largest and most advanced mushroom farm, which utilizes 25,000 tonnes of imported substrate to produce 8,000 tonnes of button mushrooms annually. G's wish to collaborate with NIAB EMR to investigate the potential for utilising separated digestate fibre as a component in mushroom substrate. The fibre is pasteurised at >70C during AD, avoiding the need for subsequent pasteurization, a usual step in mushroom substrate production. However, further processing (controlled temperature 'conditioning' at 45-50C and/or addition of gypsum) is probably needed to stabilize the ammonium-N content of the fibre before it is suitable for mushroom cultivation. This project will determine the influence of AD feedstocks on the analysis and suitability of the separated fibre, and the subsequent processing needed for producing a mushroom substrate component. The UK mushroom industry currently uses around 300,000 tonnes of mushroom substrate annually. In Europe, more than 4M tonnes of substrate are produced annually. There are also large markets in North America, Australasia and China. This project has the potential to develop a new, high value market for separated digestate fibre, thus improving the economic viability of AD.

BIV2016009

Beeswax Farming (Rainbow) Ltd / David Stainton - University of Lincoln

Improving the sustainability of Anaerobic Digestion by demonstrating the potential of digestate fibre to reduce peat usage in horticultural growing media.

A consortium of farm AD businesses will work with the University of Lincoln to evaluate the potential for combining their digestate fibre outputs to develop a peat reduction product for use within horticultural growing media. The aim is to convert AD fibre (ADF) disposal from a cost to a profitable element of AD plant operation.
The project will:

1. Analyse the fibre outputs from the individual AD plants to assess the degree of variation in output characteristics and provide the rationale for the fibre blend that will be used in the growth trial.
2. Mix a range of proportions of the blended ADF with commercial peat and compare the growth of selected horticultural plant species in these mixtures against a standard peat based formulation.
3. Analyse the nutritional performance of the growing media during the growth trial focussing on nitrogen and potassium mobility in relation to overhead, trickle and sandbed irrigation systems
4. Review with the commercial consortium the issues and opportunities to improve the sustainability of their AD operations through the forming of a cooperative venture to market ADF into the horticultural sector.

Over 1.3 million m3 of peat is consumed annually and contributes to a market for retail and wholesale horticultural growing media valued at over £400 million.

This proposal should enable AD plant operators to develop a route to that market for ADF that will improve the sustainability of their operations financially, whilst benefitting the environment though a decrease in peat usage by horticulture.

BIV2016011

Youlgrave Community Land Trust (YCLT) / Dr David Styles

Youlgrave Community Land Trust (YCLT) organic waste micro-AD feasibility study and case for support

Community-led projects are a promising way to extend AD, and associated GHG, energy and local economic benefits, to sparsely populated rural areas (supporting EU Horizon 2020, ISABEL project). Owing to unproven novelty & longer payback investors and local authority (LA) planners are presently unwilling to consider them for organic waste treatment. YCLT preliminary research suggests an environmental/economic case exists to replace current LA practice (composting/landfilling) of trade/domestic organic food-waste with community-based micro-AD approaches. Sufficient local trade food-waste appears available to support a micro-AD plant, which could significantly reduce transport (waste miles) whilst providing local energy, bio-fertiliser and reduced GHG emissions, & leading to incremental employment and social innovation. Independent evaluation is needed to validate/develop these findings to support the feasibility of a subsequent micro-AD demonstration project. The evaluation will involve data collection by YCLT from LAs, equipment suppliers etc.to develop realistic deployment scenarios. Bangor University (BU) will undertake expanded boundary life cycle assessment (LCA) of the net environmental consequences of shifting from composting/landfilling to AD treatment. BU will also undertake a basic cost-benefit appraisal of AD scenarios compared with existing waste management, applying sensitivity analyses to test the findings robustness to variation in e.g. rate of source-separation of organic waste, biogas yields, end-use of biogas/digestate. A rigorous evidence-base will be developed to support underpinning YCLT funding applications for a community-led micro-AD demonstration project, to validate recommendations to relevant LAs (and policy makers in general) regarding integration of AD into existing waste strategies.

BIV2016013

Western Isles IWM Facility / Dr Sonia Heaven

Evaluating the feasibility of fish waste co-digestion with MSW in Stornoway

The work will evaluate the potential for co-digestion of wastes from fish farming with municipal biowastes to maximise the energy output from the anaerobic digestion plant currently operating at Stornoway on the Isle of Lewis. The rate of growth in fish farming worldwide makes these wastes an important future resource, yet little is known about the impacts or benefits they may have in waste treatment systems and their potential for energy and resource recovery through nutrient recycling. The work will involve a six-month laboratory-scale simulation of the co-digestion process using a mixed municipal waste feedstock and fish wastes supplied from the Stornoway plant. The aim is to identify and where possible overcome process limitations, including those associated with the use of high protein feedstocks and ammonia toxicity. If successful the trial will establish suitable operating protocols for both mesophilic and thermophilic conditions: these will be of value to the anaerobic digestion (AD) and fish farming industries as a whole, while a decision to implement this at the plant will bring immediate economic and environmental benefit to the island community. The collaboration may lead to further opportunities for the partners to work together on sustainability and energy security issues for island sites, with links to further RCUK-funded work on renewable energy integration by coupling wind energy, electrolytic hydrogen production and biomethanisation of CO2.

BIV2016015

Algal Omega 3 / Professor Orkun S Soyer

Towards engineering microbial communities to treat a defined waste stream

An emerging frontier in synthetic biology and biotechnology is to engineer defined (synthetic) microbial communities for applications in waste treatment and bioproduction. Such defined communities can achieve metabolic conversions not possible in a single species context, and can allow higher stability and productivity.

In this pilot project, we will apply this multi-species engineering approach to treat a specific waste stream of known and stable composition. This waste stream results from an optimised heterotrophic bioprocess, developed by Mara Renewables Corporation (Mara), and performed under license agreement at a UK production facility run by Algal Omega 3 (AO3). Currently, discharge of the said waste stream through standard disposal routes has significant costs due to high concentrations of specific compounds such as sulfate and ammonia.

Using lab-scale reactors, we will quantify the ability of two defined microbial communities, and several natural, complex microbial communities on treating this waste. The defined communities will consist of those already developed in the Soyer group, while complex communities will include those isolated from natural ecosystems and from an anaerobic digestion (AD) reactor. In total, we aim to evaluate at least 5 microbial communities during the course of this short pilot project.

If successful, results from this preliminary study will form the basis for a larger collaborative grant application in industrial biotechnology. Results will also allow Mara and AO3 to make informed decisions about waste treatment strategies as our scientific analysis will provide a comparison of their current approach with biological treatments based on multi-species microbial systems. Finally, our approach can contribute significantly towards developing a defined community that can translate into real world cost reductions for the commercial partner, and paving the way for the engineering of other multi-species systems for well-defined problems arising in waste treatment.

The specific aims of the project are;
- Compare ability of complex and defined microbial communities to treat a defined, industrial waste stream using lab scale reactors.
- Compare performance of this biological approach to more conventional waste storage/discharge in terms of operational costs.
- Use results from this project to further engineer defined, synthetic communities to improve their performance for this specific waste stream.

BIV2016020

John Lewis Partnership / Dr Yue Zhang
Leckford Estate organic waste AD feasibility case study and environmental impact analysis

With a general drive towards improved sustainability, coupled with successive degression of incentives for anaerobic digestion, many businesses are starting to consider a wider social, environmental and sustainability case for introduction of the technology, in addition to purely commercial payback.
Leckford Estate in Hampshire is the 'Waitrose Farm' and is a showcase for the John Lewis Partnership (JLP). It has operated continuously for 87 years providing produce to Waitrose branches.
The Estate is considering the introduction of an AD system but, because their corporate ethos looks at sustainability and 'positive externalities' beyond a pure commercial case, they wish to have an understanding of the wider environmental and other benefits that such a system may provide to their business. Because of this, independent evaluation is needed to assess not only the economic case and scope of the project, but also the positive externalities, with an assessment of the net environmental consequences of various scenarios involved with moving from the status quo to a whole farm based AD system.
As Leckford Estate is a showcase that receives visits from community groups and schoolchildren and as UoS has a thriving bioenergy outreach programme, opportunities for community engagement will also be briefly explored.
The work will not only inform the JLP board of the wider sustainability case for the introduction of the technology but, should they wish to go ahead, it will provide data for any tender application and technology assessment, as well as identifying potential areas of research in the field.

BIV2016021

Kingdom Bioenergy (KBE) Ltd / Dr Lynsey Melville
Optimization of a Counter-Flow Leach Bed (CFLB) AD system for the generation of energy from food wastes.

It is estimated by WRAP that UK households dispose of around 4.2 Million tonnes of avoidable food waste per year.
AD can be implemented as a process to treat organic wastes and generate sustainable biomethane for heat and power. Whilst the process is effective, optimisation of these systems can often be complex. Availability/ variability of feedstocks, storage and pre-treatment of biomass and rate of organic breakdown can impact upon the economics and efficiencies of a process. Biogas production is influenced by the composition of the biomass. Composition can be enhanced using pre-treatments, however many existing processes are energy intensive and

expensive to implement and operate. Leach beds (where liquid flows through waste materials) have been explored as a low tech, inexpensive but effective alternative. The challenge with these systems is to achieve effective mixing of liquid through the material.
This project will determine the optimal design and operation of a counter flow leach bed system where digestate will flow in the opposite direction to the biomass, enhancing mass transfer. A continuously stirred tank reactor will provide liquid digestate to the leach beds. Food waste will be fed into the system and the rate and degree of organic breakdown will be measured.
The findings of this work will be used to determine opportunities for full-scale application in existing plants and to promote the wider adoption of small scale sustainable and commercially viable plants both in the UK and developing countries.

2017 BIV Titles and Summaries

BIV2017001
Western Isles IWM Facility / Professor Mohamed Pourkashanian **Study into the benefits of the integration of biomethanation of green hydrogen with renewable electricity production from anaerobic digestion and wind power at the Creed Enterprise Park in Stornoway.**
This BIV project will assess the potential benefits of the implementation of hydrogen biomethanation in an existing AD plant at the Creed Enterprise Park in Stornoway. The Creed Park site has a variety of energy systems already installed including a waste fed AD plant and CHP, a wind turbine, an electrolyser and a thermal store, and a hydrogen vehicle refuelling station, the combination of which would make this an ideal site for a pilot demonstration of biomethanation. The project will allow development of the newly formed relationship between the University of Sheffield and Comhairle nan Eilean Siar and the hope is that the results of the study will enable the development of a robust business case and potential for future collaborative funding for the pilot. Implementation of biomethanation of green hydrogen at the site could deliver a range of benefits such as improved biogas quality, increased CHP utilisation, increased energy outputs (electricity, hydrogen for vehicle refuelling) and revenue. The study will allow translation of current research at the University of Sheffield to industrial practitioners of AD.

BIV2017003
Northumbrian Water Group Ltd / Prof. Ian M. Head **Development of a Real-Time Water Quality Sensor for Estimation of BOD and Toxicity**
We will determine the feasibility of an innovative microbial fuel cell (MFC)-based biosensor for real-time, online monitoring of organic carbon levels in wastewater treatment and anaerobic digester (AD) influents. Moreover, the same sensor can detect toxicity providing a further dimension for monitoring. These data can be used for process optimization and control. A real 'market need' for such monitoring has been identified in discussions with end-users including Northumbrian Water and Chivas Brothers, who are industrial partners on the project. The MFC biosensor has to-date only been tested in a laboratory environment. Here we propose to understand end-user requirements and begin preliminary trials to demonstrate that the sensor can be used to monitor process streams in the field. MFCs utilise an anodic biofilm of electrogenic bacteria which convert the organic compounds found in wastewater into electricity. The electrical current generated has been correlated with the amount of labile organic carbon (measured as BOD) and therefore can be used as an effluent quality biosensor. Conversely, with presence of toxic compounds the electricity generation by the bacteria is inhibited. The sensor was developed as part of a PhD project by Martin Spurr at Newcastle University (NU) and an improved sensor design has been developed in collaboration with WH Partnership Ltd and the University of South Wales (USW). In this project, preliminary trials with the sensor will begin, standard operational requirements will be identified and we will implement findings into a design specification for a second-generation sensor prototype.

BIV2017004

Blue Sky Bio Ltd / Dr. Andrew Free

DNA Sequence-Based Characterisation of Microbial Community Development in a Novel Six-Stage Anaerobic Digestion System

Biomolecular tools such as metataxonomic and metagenomic DNA sequencing approaches have facilitated our detailed understanding of the microbiology of anaerobic digestion (AD) systems in recent years. However, most studies have focussed on single-stage AD or two-stage systems. Understanding how microbial community composition relates to process parameters and intermediate yields at different stages of the AD breakdown pathway would assist in optimising these stages and controlling the production of the desired end products. In this project, the microbiology of a novel, 6-stage AD system developed by BlueSkyBio will be characterised for the first time. Metataxonomic approaches will identify key organisms in each of the reactor stages, monitor their abundance over time and define their relationships with important operational parameters and product yields. As well as enhancing understanding of multi-stage digestion within the AD community, the results will also form the basis of a new collaboration between the academic partners and BlueSkyBio, which will focus on the modification of reactor design and operational parameters and engineering of relevant microbial species to optimise both biogas yields and production of intermediates (VFAs).

BIV2017005

Carbogenics Ltd / Dr Andrew Free

Investigation of the Role of CreChar® in Direct Interspecies Electron Transfer During Anaerobic Digestion

Anaerobic digestion is a widely-used technology for the treatment of food waste from the retail and domestic sectors and the production of sustainable biogas (methane). A common problem with AD technology is inhibition of methane production by ammonia, which can be observed at levels as low as 2g/l in food waste AD systems. In contrast, typical ammonia loadings in UK food waste AD feedstock are 4-8 g/l, meaning that methane yields are sub-optimal. Carbogenics Ltd. have developed a novel carbon-based additive, CreChar®, made by the pyrolysis of mineral-rich organic wastes, such as paper and sewage waste, which is effective in reducing ammonia inhibition in AD systems. In this project, we will determine the optimal properties of CreChar® applied to the digestion of food waste feedstocks. One likely mechanism of CreChar® action is the stimulation of electron transfer to the methane producing microorganisms via its conductive surface. Here, we will characterise both the microbial species present on activating CreChar® surfaces and the electrochemical reactions they carry out, allowing Carbogenics to develop specific CreChar® products with optimal electrochemical properties for application in the food waste AD industry. Eventually, the development of chars pre-incubated with an optimal community of microorganisms will be possible.

BIV2017006

Lutra Ltd / Prof. Charles Banks

Optimisation of H2 injection for in situ biogas upgrading

Anaerobic digestion produces biogas which is a mixture of methane (CH4) and carbon dioxide (CO2). It has been known for many years that if a supply of hydrogen is provided, CO2 can be

biologically transformed into additional methane, raising the calorific value of the biogas and making it more valuable as a fuel. There has been growing interest in this process over the last few years as the technology for hydrogen production becomes cheaper and as renewable energy sources to power this become more widespread. To date most of the attention has focused on using pure cultures of micro-organisms to convert pure gas streams (such as CO2 from the brewing industry) in dedicated bioreactors, in a process known as ex situ biomethanisation. An alternative approach is direct injection of hydrogen into a digester in order to convert the CO2 in the biogas as it is produced, creating an in situ upgrading process. This opens up opportunities for retro-fitting existing digesters and for designing systems that can upgrade biogas using surplus local renewables at a small scale, e.g. in on-farm or community AD plants. The current project builds on research carried out in an EPSRC-funded project, and aims to take the process on from laboratory to pilot plant scale. Lutra Ltd, the industry partner, has a special focus on developing small-scale systems and its interest in this area led it to approach the University of Southampton to gain the technical knowledge needed to take the process one step closer towards commercialisation.

2018 BIV Titles and Summaries

BIV2018001

CLA Cymru / Prof. Peter Midmore
Spatial optimisation of farm-scale AD and biorefinery developments in Wales

Welsh agriculture is predominantly livestock-based, and production of animal manures forms a significant economic, environmental and amenity challenge for the sector. In total, Welsh farms manage half a million cows, around 12% of the UK national herd; also, about 8 million hens are concentrated into a few very large production units and constitute 5% of the UK flock. Valuable resources could be reclaimed from reprocessing such wastes either through farm-scale AD plant and potential biorefinery development. The Welsh Government, regulators and local AD suppliers are working together to provide a framework which can optimise budgetary and regulatory support, in which nutrient management can be maximised, protection of environmental and animal health assured, and planners provided with necessary data to support development. To do this they need to understand the spatial distribution of farm organic waste arisings in Wales to minimise transport costs, as well as the indirect costs and benefits resulting from its current utilisation and disposal. This BIV would collate, quantify and map, interpret and analyse the AD and IB opportunities associated with these organic materials, including new diversified forms of agriculture on and off the farm. It would also provide contextual information from key informant interviews to establish priorities for policymakers and stakeholders' business strategies.

BIV2018003

Environmental Treatment Concepts Ltd / Dr Yongqiang Liu
Investigation of an economic and non-invasive ultrasonic sludge treatment technology to improve both biogas production from anaerobic sludge digestion and thickening

Environmental Treatment Concepts Ltd (ETC) has recently developed an energy efficient and

non-invasive ultrasonic technology with the primary goal of improving sludge thickening/ dewatering. The application of this technology has been found by accident to be able to boost the biogas yield (e.g. ~ 25% increase) in certain circumstances, when installed at the feeding pipe to the AD unit. Ultrasonic pre-treatment of sludge for enhanced biogas production is a well-known method. However, the technology developed by ETC offers an effective, yet more economical alternative to the existing commercial ultrasonic methods, as it operates at about 1/5 of the cost of conventional ultrasonic transducers. The most important benefit of this technology is that it is non-invasive, meaning it can be easily applied without any change and disturbance to the existing process.

ETC intends to collaborate with the University of Southampton (UoS) to systematically investigate the enhancement of sludge digestion by this technology. The ultimate goal of this work is to determine the operating window of this method according to various sludge characteristics and operational conditions. Moreover, comparisons between non-invasive ultrasonic technology and conventional ultrasonic technologies in regard to cost and environmental impact are to carry out in order to provide a comprehensive analysis of the true value of this technology to the AD industry. The knowledge gained can be immediately utilized by ETC, but is also closely relevant to sewage works as well as the scientific community of anaerobic digestion because the improved sludge destruction rate and biogas production, and reduced polymer dose in the thickening can not only increase the energy recovery from sludge, but also reduce the environmental impact from sewage treatment.