Outputs of EU FP7 VALORGAS Project
Valorisation of Food Waste to Biogas

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Project Aim

“To valorise food waste by efficient conversion into a second generation biofuel with a high-quality digestate output”

– Achieve a stable digestion process
– Optimise systems for collection of food waste
– Beneficial use of process residues
– Maximising the system net energy gains

• Funded by EU FP7 programme
• Grant value from EU € 3.5 M
• Significant CiK from SME partners
Work Packages

Waste Collection & Segregation Systems
- Food waste characterisation & composition
- Efficiency of [food] waste collection schemes
- Best practice collection schemes
- Institutional & community generation rates & applicability of scale
- Residual waste composition

Optimisation of Technology & Nutrient Recovery
- Improvements to process stability
  - Maximise digester loading
  - Trace Element addition
- Mass & Energy balances
- Nutrient recovery through precipitation
- Thermophilic vs mesophilic digestion
- Microbiological / biochemical identification

Small Scale Biogas Upgrade & Storage Systems
- Development of small scale, low cost biogas upgrade and storage systems
- Policy recommendations EU and India

Pre-treatment & Technical-Scale Trials
- Optimisation via pre-treatment
  - Cell disruption
  - Autoclaving
  - Ammonia removal
  - 2 phase biohythane production

Energy, Environmental & Life Cycle Evaluation
- Quality, biosecurity & agronomic usefulness of digestate
- Digestate dewaterability
- Overall energy & emission balance
Consortium Partners

13 Academic & SME partners from across the EU and India
Presentation Agenda

• Dissemination of project findings to scientific, technical groups and the wider public was a key objective
• Can not provide detailed information on all work packages
• Presentation aims to provide a snap-shot overview of the research
• Provide details of sources of further information
Collection & Segregation Systems

Work Package Objectives

• Capture rate and efficiency of different types of collection schemes
• Composition & physico-chemical characterisation of food waste
• Energy and carbon footprint of collection and transport processes
• Impact of separate FW collection on the recovery of recyclable materials
Compositional & Physico-Chemical Analysis

- Compositional & physico-chemical analysis undertaken on waste from 23 rounds, in 15 cities from 4 countries
- Shows key similarities and differences between countries

![Graph showing waste composition in UK, Finland, Portugal, and Italy]

- Residual waste analysis – post introduction of food waste collection scheme
  - Decrease in the residual waste mass of 12 – 34%
  - Decrease in food waste present in residual stream of 26 – 55%
  - Increase in residual waste CV of 9 – 33%
  - Significant proportion of food waste still present in residual waste

- Data helps Operators negotiate contracts, understand ammonia toxicity & assess CV
- Data to be fed into national databases to enhance collection techniques & rates


Scheme Surveys & Modelling

- Comprehensive survey of collection methods in 27 EU member states
  - Major differences between and within countries
  - Only Netherlands has a national policy
  - Collection method may affect complexity of pre-treatment & efficiency of digestion

- Best practice outputs to be referenced in forthcoming IEA Task 37 report on source separation of waste for use in AD

- Development of a powerful, robust, mechanistic model to assess efficiency of collection schemes
  - Model alternative options for new collection schemes
  - Benchmark the effectiveness of a current scheme against a modelled output
  - Provide a decision support tool for planners and operators to determine optimal rounds for their individual situations

- Validated
  - Freely available for use from project website
Pre-Treatment Trials

Work Package Objectives

• To optimise pre-treatment of the source segregated waste stream for biogas production and biosecurity of the residual product
  – Cell disruption (no significant effect for food waste)
  – Autoclaving
  – 2-phase biohythane production
  – Ammonia stripping
Pre-Treatment Trials – Significant Results

Autoclaving (experimental & pilot-scale studies)

- Significant reduction in ammonia in digestate and H$_2$S in biogas
  - Useful for treatment of high protein wastes in thermophilic conditions, or wastes with biosecurity issues
- Slight reduction in biogas yield
- High proportion of FW in lignocellulosic-rich residual waste stream suggests a role for autoclaving

Ammonia Removal (laboratory scale)

- Side stripping successfully reduced TAN by 46 – 70%, controlling NH$_3$ inhibition
- No microbial inhibition of the process
- Potential for stabilisation of thermophilic FW digestion
Process Optimisation

Work Package Objectives

• Optimisation of the AD of food waste & alleviation of operational problems
  – Maximise organic loading rates
  – Enhance process stability
  – Enhance understanding of microbial population structures
  – Enhance nutrient recovery
  – Assess mass & energy balances

Key area where research has led to operational scale enhancement in the UK & Europe
Process Optimisation – Significant Results

Biological stability (mesophilic digestion)

- Identified a number of key trace elements are necessary for the long term stability of FW digestion & are lacking in food waste
- Supplementation with trace elements results in increased tolerance of ammonia

Biological Stability (thermophilic digestion)

- Failure of digester occurs at $\geq 2.5 \text{ g N l}^{-1}$
- Trace element supplementation is not effective in controlling VFA accumulation in thermophilic digesters
- Food waste can be digested thermophilically by dilution with water, but the ratio must be such as to reduce TAN $\leq 2.5 \text{ g l}^{-1}$ which is about a 1:1 dilution

The BIG impact

- Long term, stable operation of food waste digestion is now possible
- Supplementation with trace elements has enabled a 4-fold increase in organic loading rates
- Trace element regime increases biological resistance to variable loadings
- Adopted by a number of UK commercial AD operators
**Process Optimisation – Significant Results**

**Nutrient recovery through precipitation reactions**

- Struvite precipitation is feasible, although requirement for magnesium is high

**Development of mass and energy balances**

- Development of common platform for data collection, handling & analysis
  - Demonstrated through 2 case studies with mass balances of 94 – 96%
- Many inconsistencies in terms in the literature – need clarity for accurate technology comparisons
Small Scale Biogas Upgrade & Storage

Work Package Objective

- To further develop low-cost small-scale biogas upgrading technologies and storage systems for application for:
  - transportation
  - local low-pressure distribution systems
Small Scale Biogas Upgrade & Storage – Significant Results

• Successful development of a low pressure, low cost upgrading system for biogas flows of 10 – 60 m$^3$ hr$^{-1}$
  – Excellent performance and energy efficient
  – Containerised system, utilising plumbing & agricultural fittings to allow local maintenance
  – Commercial viability for small-scale niche markets (rural, off grid locations etc)

• Significantly influenced Indian policy
  – Roadmap for successful development of small-scale biogas upgrading and bottling industry in India

• Automation of a new small-scale system able to meet the new Indian standard for biomethane

• Recommendations for promotion of biomethane in local transportation in the EU
Quality, Biosecurity & Agronomic Value of Digestates

Work Package Objectives

- To determine the quality, biosecurity & agronomic value of digestates

Significant findings

- Rye grass laboratory trials confirm FW digestates of high agronomic benefit
- Autoclaving offers same pathogen protection as pasteurisation
  - Also changed properties of food waste resulting in formation of unmineralised nitrogen & a 30% reduction in fertiliser value
- Post treatments to reduce volume, increase ease of application & digestate properties are of interest
- Results now informing UK approach to EU End-of-Waste policy (particularly important in Southern Europe)
Overall Energy and Emissions Balances

Work Package Objective

- Development of a modelling tool for determining the energy balance from the AD of food and other organic wastes

- Spreadsheet version of ADtool is available and being utilised by industry and community groups to size plant and estimate GHG emissions saving

- Software version will be released once beta-testing is completed

- Promotion as tool for policy-making and research

- When used in conjunction with WasteCAT model = rapid simulation of wide range of waste collection & AD scenarios
Conclusions

• Very successful project
• Wealth of knowledge generated
• Practical results which have already had a large impact in terms of direct uptake in industry & influencing policy
• Production of models, systems and recommendations which are freely available and which can make significant improvements to the AD industry
• In tune with issues - perfect launch pad for Horizon 2020
Dissemination

• Website: www.valorgas.soton.ac.uk

• Refereed journal papers
  – 37 published or in review
  – 30 in draft form or planned
  – 18 refereed conference papers

• JyU Summer School teaching material

• Youtube

• Twitter @VALORGAS

• An ILCD node to go live shortly
Thank you

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