

# Outputs of EU FP7 VALORGAS Project

## Valorisation of Food Waste to Biogas

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Biogen

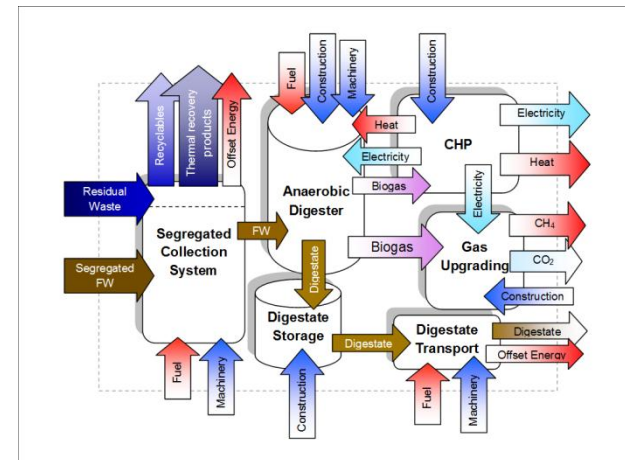
*ABDA R&D Forum  
Guisborough 12<sup>th</sup> November 2013*



# 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



**VALORGAS**

# 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

## Energy, Environmental & Life Cycle Evaluation

- Quality, biosecurity & agronomic usefulness of digestate
- Digestate dewaterability
- Overall energy & emission balance

## Pre-treatment & Technical-Scale Trials

- Optimisation via pre-treatment
  - Cell disruption
  - Autoclaving
  - Ammonia removal
  - 2 phase biohythane production



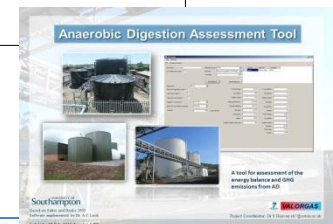
# Consortium Partners

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

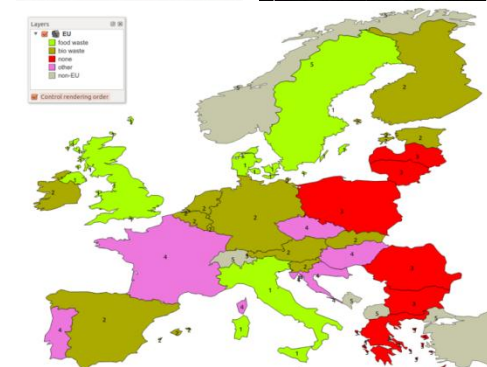
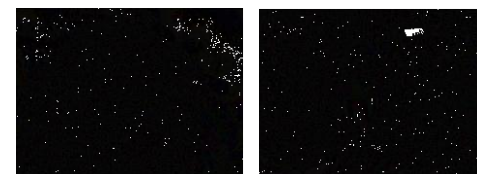




# Collection & Segregation Systems

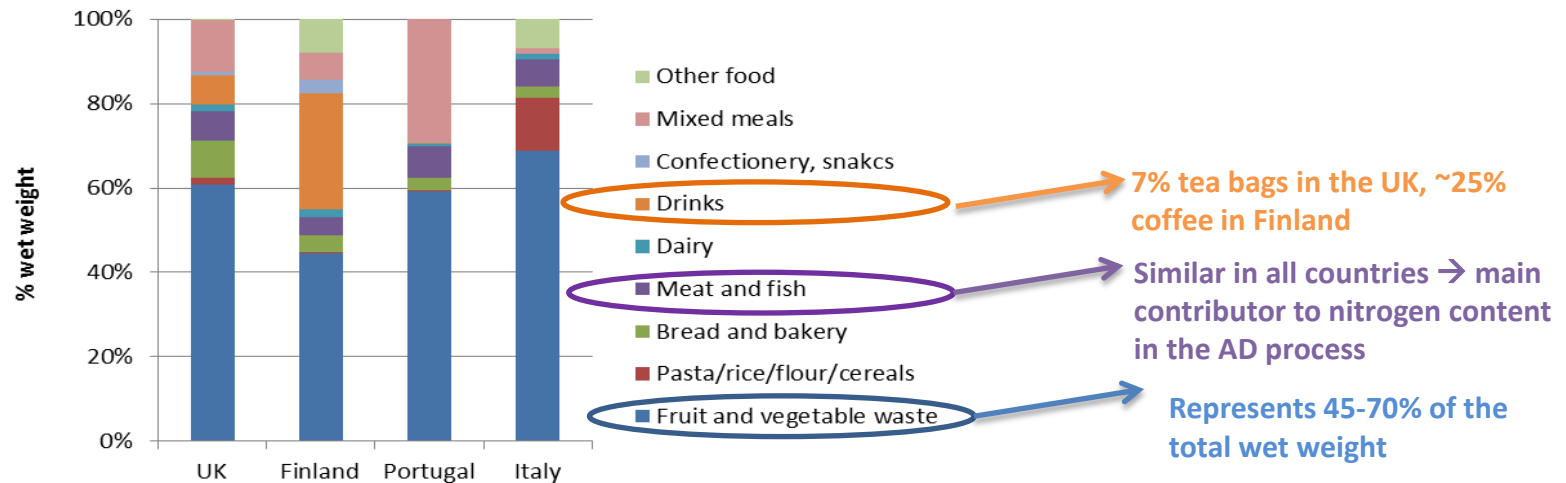
## Work Package Objectives

- 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



- 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<sub>2</sub>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)

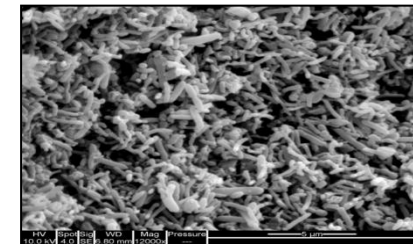
- Side stripping successfully reduced TAN by 46 – 70%, controlling NH<sub>3</sub> inhibition
- No microbial inhibition of the process
- Potential for stabilisation of thermophilic FW digestion

# 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)

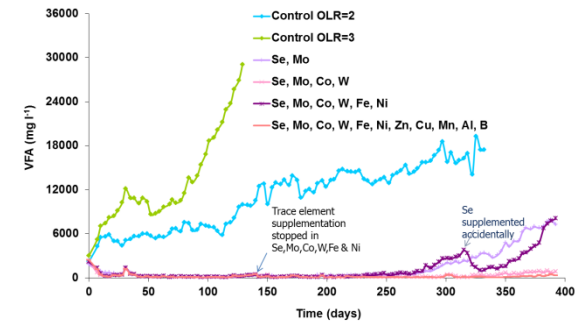
- Identified a number of key trace elements are necessary for the long term stability of FW digestion & are lacking in food waste
- Supplementation with trace elements results in increased tolerance of ammonia

## 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  $\text{TAN} \leq 2.5 \text{ g l}^{-1}$  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



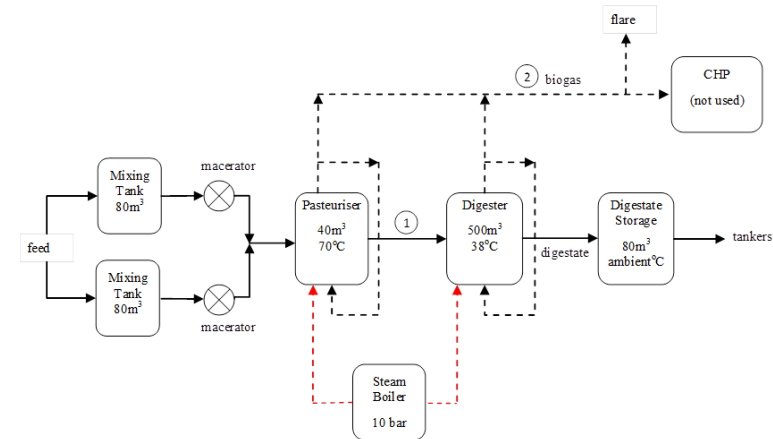
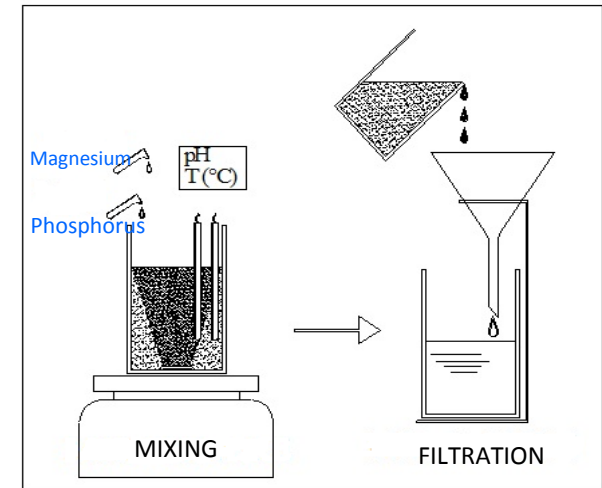
# Process Optimisation – Significant Results

## 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



System control interface



Volvo S60 Bi-fuel receiving biomethane



# Small Scale Biogas Upgrade & Storage – Significant Results

- Successful development of a low pressure, low cost upgrading system for biogas flows of 10 – 60 m<sup>3</sup> hr<sup>-1</sup>
  - 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



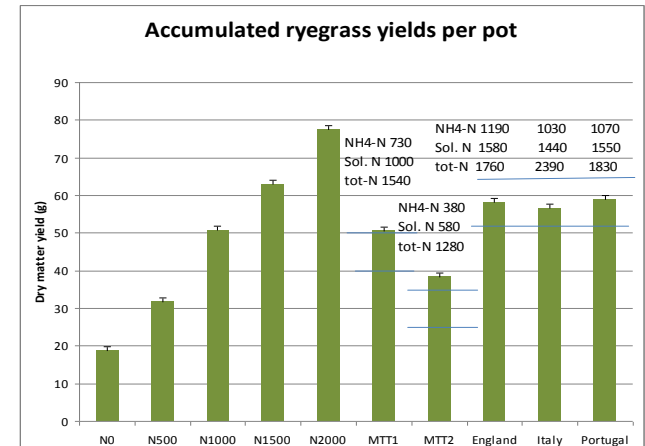
# Quality, Biosecurity & Agronomic Value of Digestates

## Work Package Objectives

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

## Significant findings

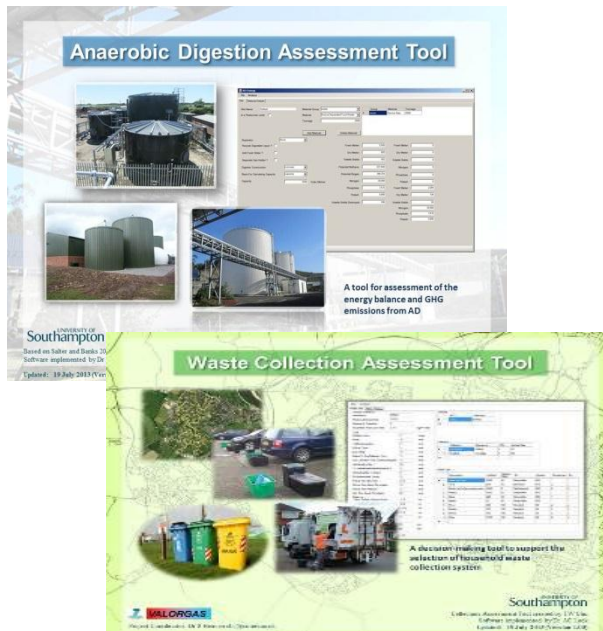
- Rye grass laboratory trials confirm FW digestates of high agronomic benefit
- Autoclaving offers same pathogen protection as pasteurisation
  - Also changed properties of food waste resulting in formation of unmineralised nitrogen & a 30% reduction in fertiliser value
- Post treatments to reduce volume, 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

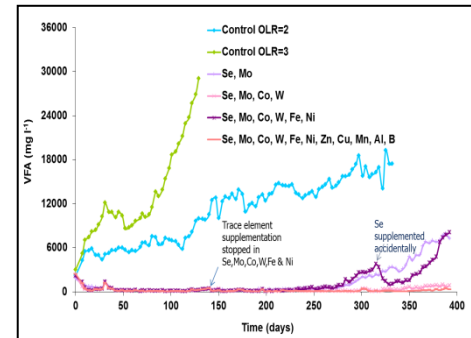
- Development of a modelling tool for determining the energy balance from the AD of food and other organic wastes



- 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

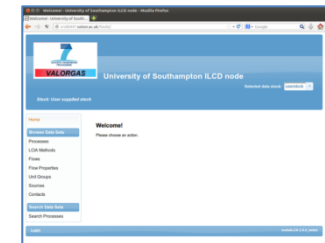
# Conclusions

- 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](http://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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