

Anaerobic Processes and Biogas Activity at the University of Glamorgan

Status of AD/Biogas/Biomethane in England and Wales

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Bio-Methane Regions Project - Kick off Meeting
24-25th May 2011 – Cardiff, South Wales

Waste and Wastewater Treatment

Bio Energy

Monitoring and Control

Environmental Analysis

Microbial Fuel Cells

Bio Hydrogen

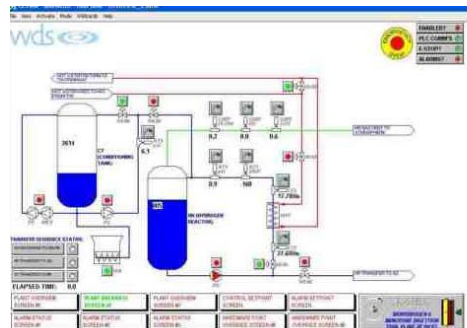
Biocatalytic H₂ Production

Hydrogen Energy and Storage



Anaerobic Processes

R&D at the University of Glamorgan



Anaerobic Processes

R&D at the University of Glamorgan

- Over 40 years of R&D related to Anaerobic Digestion
- Agricultural, municipal and industrial wastes and wastewaters
- Reactor design and pre-treatments
- Monitoring, modelling and control systems
- Integration with other processes



International
Water Association

IWA Specialist Group on Anaerobic Digestion – Western Europe Representative

UK Representative on the IWA-AD Task Group on Harmonisation of Anaerobic Biodegradability/ Activity/ Inhibition Test Methods

Analytical, Monitoring and Modelling Facilities

‘State of the art’ Chemical Analysis Suite

- UPLC MS/MS, SPME-GC MSMS, HS-GC, FTNIR, IC, PFPD, Elementar

Molecular biology Equipment

- Real-time PCR, DGGE

On-line monitoring/modelling and control facility

- Novel on-line instruments, MatLab, LabView, Simapro and Ecolnvent



Past Projects



- **EPSRC AD Research Facility**
(1986-94)
- Ice-cream effluent
(Bird's Eye Wall's)
- Instant coffee wastes
(Nestle)

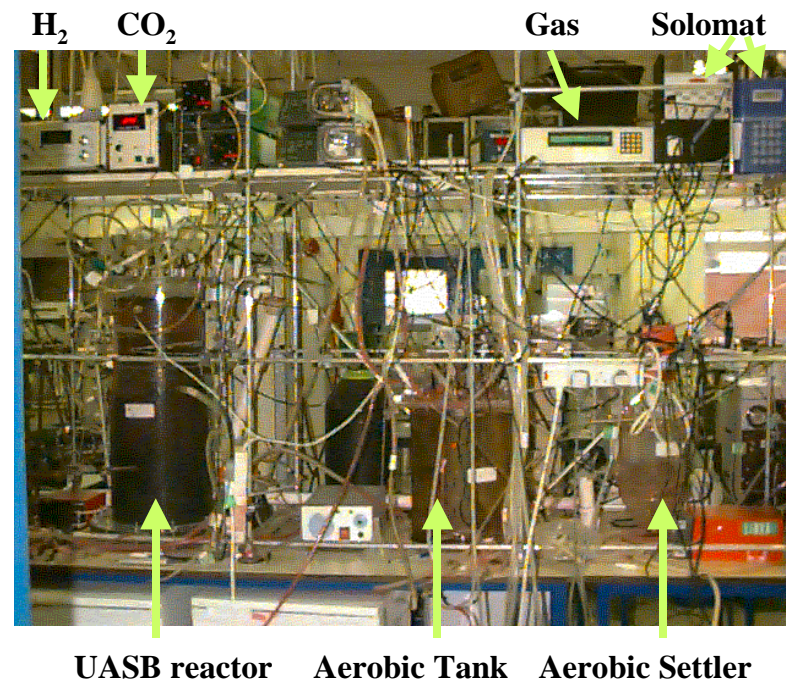
EPSRC

Engineering and Physical Sciences
Research Council

Past Projects

EU FP(4) Projects

- Development of an integrated process control system for a multi-stage wastewater treatment plant - Bakers Yeast Wastewater (1991-1994)
- Integrated water recycling and emission abatement in the textile industry (1996-1999)



Past Projects

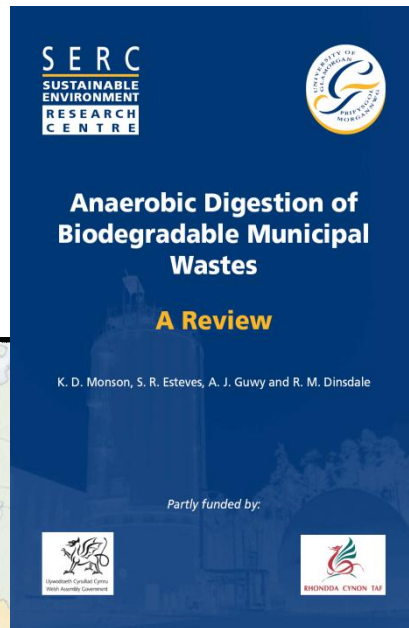


- Anaerobic Digestion of High Solid Content Waste (1994-1996)
 - Novel reactor design tested on market waste
 - Collaboration with ENEA-Italy

Improving the Digestibility and Dewaterability of Sewage Sludge



AD of BMW - Review

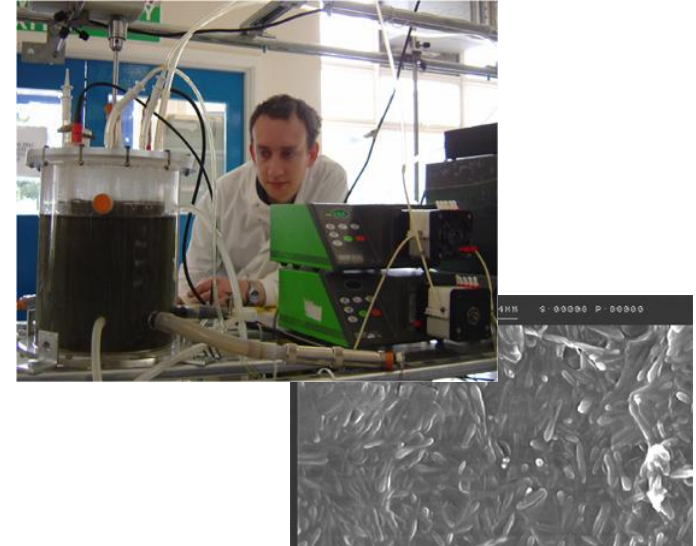


- Review published in May 2007
- Partly funded by WAG and RCT
- Includes a Summary of AD Site Visits
- AD Technology Status and Trends
- 20 European case studies
 - source separated BMW + other wastes – 9 plants
 - OFMSW + other wastes - 8 plants
 - industrial and agricultural organic wastes – 3 plants
- Lessons learned

Hydrogen and Methane Production from Sewage Biosolids

This approach uses:

- inoculum from natural sources
- non-sterile operation and mixed microflora
- batch start-up, then continuous operation
- temperature $\sim 35^{\circ}\text{C}$, operational conditions selecting for H_2 production (especially retention time, pH)
- a second methanogenic stage



Hydrogen and Methane Production from Wheat Starch Based Co-products

- Feasibility of continuous fermentative H₂ production from wheatfeed
- Determine performance envelope including a second methanogenic stage
- Cost-effectiveness
- Contribution to the low carbon economy



Hydrogen and Methane Production from Grass, Maize and Sugar Beet



The Wales Centre of Excellence for Anaerobic Digestion

Start date: April 2008

Project costs: £1.7M

Funders:

Welsh Assembly Government
(£440k)

ERDF Convergence Funding (£753k)

Funding end date: August 2012



Llywodraeth Cynulliad Cymru
Welsh Assembly Government

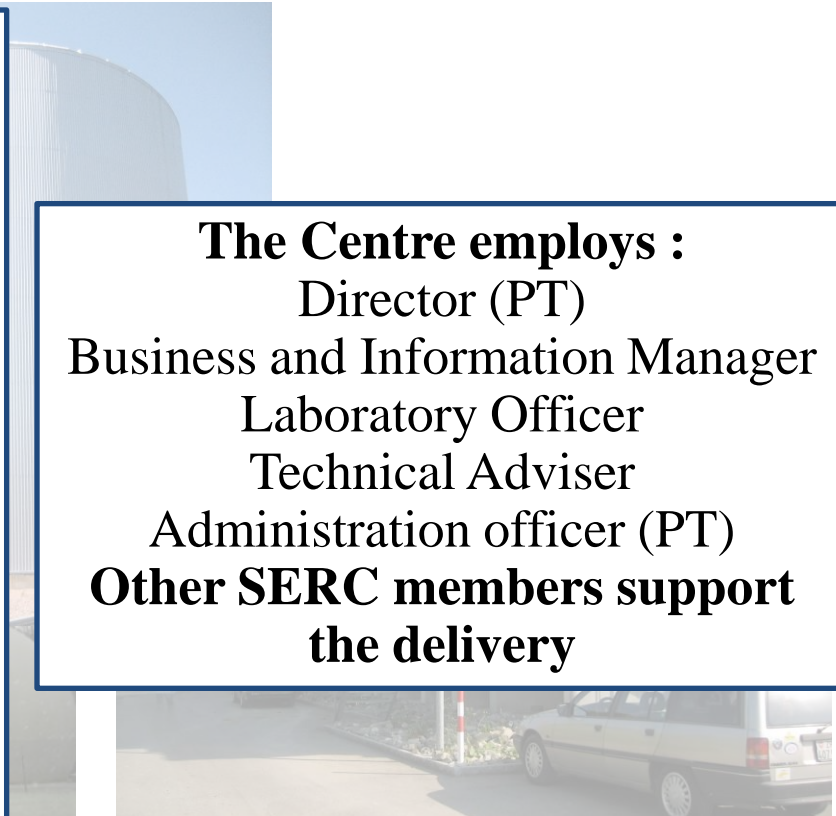


The Centre employs :
Director (PT)

Business and Information Manager
Laboratory Officer
Technical Adviser

Administration officer (PT)

**Other SERC members support
the delivery**



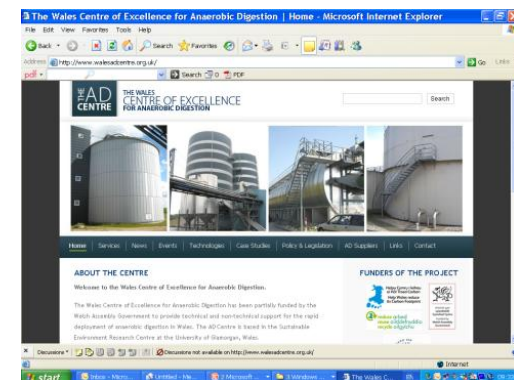
Need and Role Wales Centre of Excellence for Anaerobic Digestion

- Expand knowledge and expertise in AD and related supply chain to help address the barriers for a rapid and successful deployment of AD in Wales
- The Centre acts as a process development platform for delivering:
 - industrial focused research
 - feasibility studies
 - feedstock and digestate analysis
 - system monitoring and diagnostics
 - analytical method development
 - development of new or improved products/processes – funding available to SMEs
 - regulatory and policy development support
 - awareness raising and training events



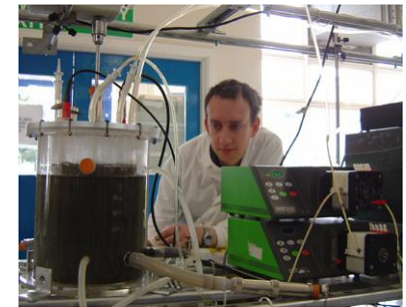
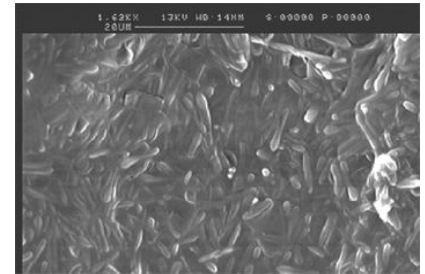
Information and Dissemination Activities

- Seminars, workshops and web portal
<http://www.walesadcentre.org.uk/>
- General project development advice
- Identification and dissemination of best practice
- Policy, standards and permit development support
- Supplier/contractor information –150 companies now registered
- Future technology development
- Bespoke training for plant operators, regulators, planners and financial institutions
- Life Cycle Assessment of AD technologies and biogas utilisation



Technical and Laboratory Based Activities

- Substrate and digestate analysis
- Digestibility trials
- Laboratory and pilot scale work
- System diagnostics
- Digester 'health' checks
- Process control and optimisation
- Monitoring, modelling and data capture
- Procurement support - tendering advice
- Independent design review
- Support plant commissioning & start-up



Wales Centre of Excellence for AD

Example of Deliverables (1)

- Assisted government policy development
- Assisted over 60 companies considering developing AD schemes
- Supporting planning activities for Welsh Local Authorities
- Supporting a variety of activities at UK level
 - Publicly Available Specification 110 development
 - contributed to the development of the standard environmental permits
- Characterisation of municipal food wastes in Wales

http://www.wrap.org.uk/wrap_cymru/about_wrap_cymru/compositional_report.html



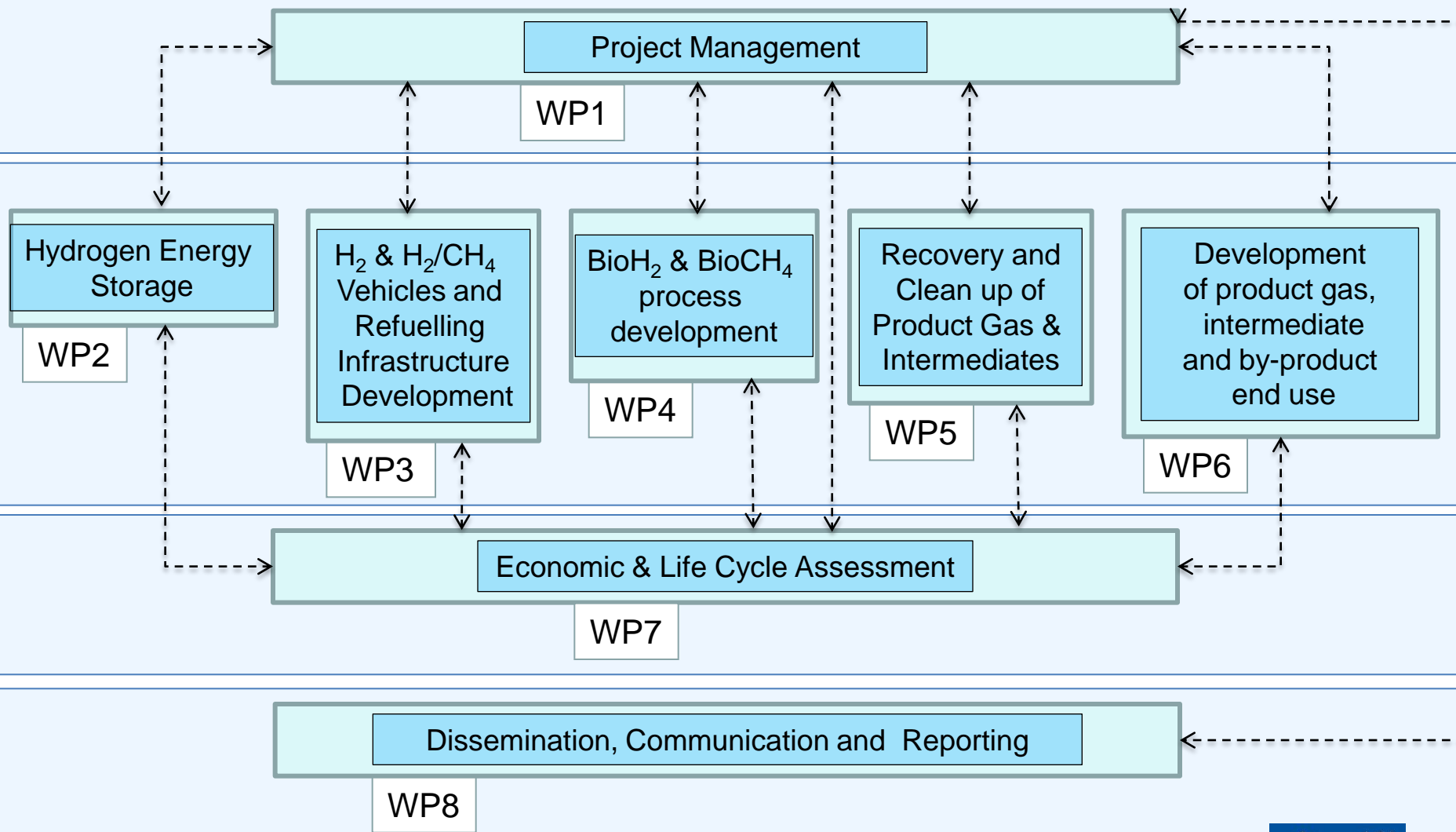
Wales Centre of Excellence for AD

Example of Deliverables (2)

- Completed a number of industry collaborative R&D projects and feasibility studies aimed at addressing specific technical issues
- Developed methodology for laboratory analysis
- Assessing the benefits and impact of digestates – agricultural land use
- Organised and delivered a number of knowledge transfer events

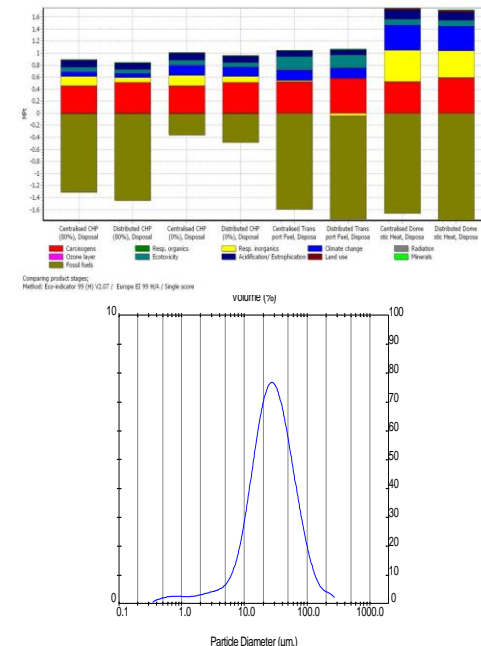
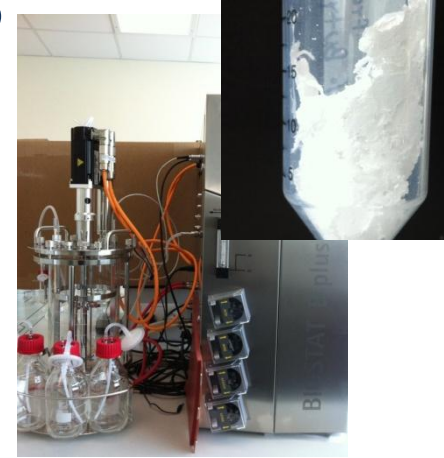


Cymru H₂ Wales



Current R&D Activities

- Biological optimisation and system design
- On-line monitoring and control (new sensor development and benchmarking)
- Biogas characterisation, clean up and upgrading (hydrogen and methane blends)
 - Development of improved technology
 - Modelling techno-economic performance
- Benchmark digestate processing technologies
- Improving the value of fermentation intermediates and digestates
- Integration of anaerobic processes with bioplastics production and microbial fuel cells
- Biogas integration with high temperature fuel cells
- Environmental and economic analysis



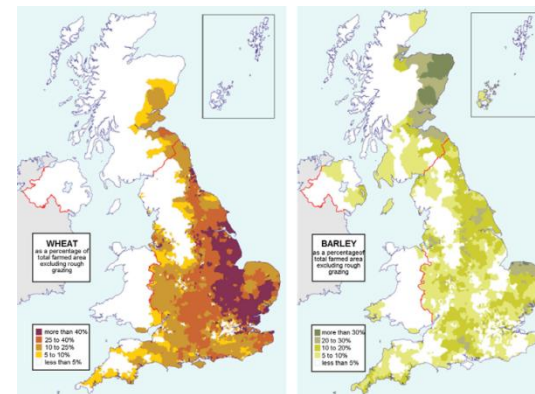
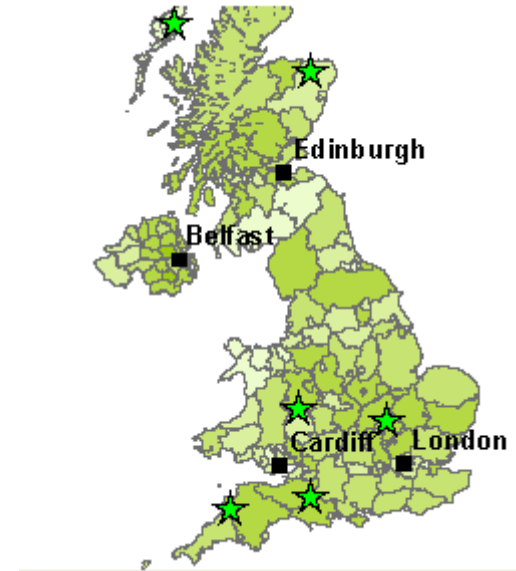
Status of AD/Biogas/Biomethane in England and Wales

UK Commitments and Targets (by 2020)

- Climate Change Act
 - Greenhouse gas emissions 34% below 1990 levels
- EU Renewable Energy Directive
 - 15% of UK's energy from renewable sources
 - Power (30%); Heat (12%); and Transport fuels (10%)
- EU Landfill Directive
 - Biodegradable municipal waste sent to landfill - 35% of that produced in 1995 (and 50% by 2013)

Potential Feedstocks in the UK

- Over 100 million tonnes of organic material per year
 - 12-20 million tonnes of food waste (~ half municipal and half C&I)
 - 90 million tonnes of agricultural material such as manure and slurry
 - 1.7 million tonnes of sewage sludge (dry)
- There is also the potential for growing energy crops such as maize, beet, wheat and grass



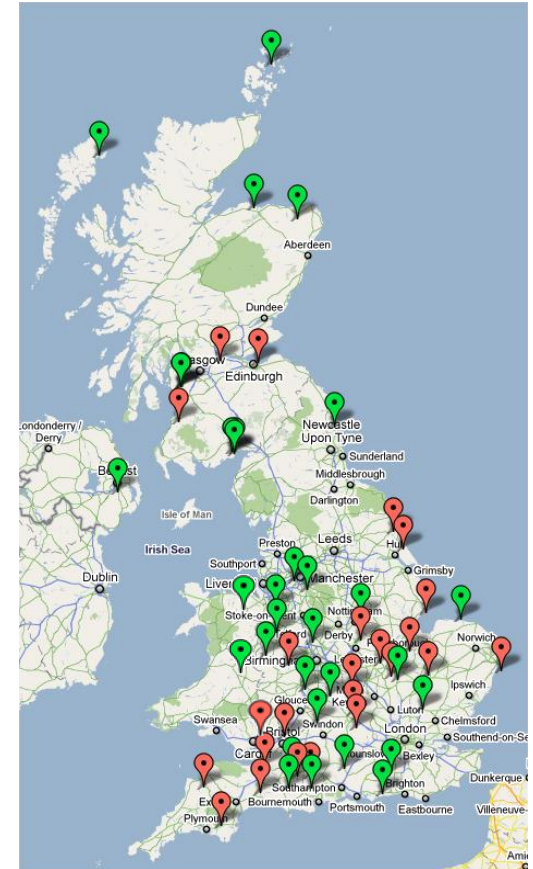
Deployment of Anaerobic Digestion for Sewage Sludge in the UK

- Currently - Over 60% of UK's sewage sludge (> 960,000 tonnes dry sludge)
- Used CHP and produced 515 GWh of electricity in 2008 ~ 110,000 homes
- Future plans for further 260 GWh/y an increase of 38% by 2015 – in many cases centralisation of sewage sludge centres)



Deployment of AD/Biogas in the UK

- Around 54 AD plants operating on domestic and industrial organic wastes, effluents, animal slurries and a minimal proportion of energy crops (maize and grass)
- Mostly built since 2006 and over half built on farm
- Mostly for CHP generation only a couple use the heat for domestic/industrial export



Source: Adapted From NNFFC 2011

Deployment of Biomethane in the UK

- Biomethane to grid (based on exemptions):
 - Thames Water Didcot STWs
 - Adnams Brewery (2010) (also vehicle fuel)
- Demo scale of biomethane for vehicle fuel
- Some grants available for refuelling infrastructure
- A series of vehicles from a number of manufacturers are available in the UK market
 - Biomethane vehicle conversion – UK suppliers
 - Hardstaff Group

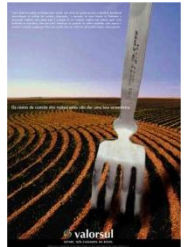
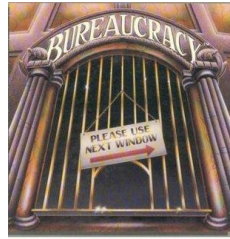


AD, Biogas and Biomethane – Near Future

- Estimation of 50 AD plants currently in planning stages, a number of them awaiting for:
 - Contracts with feedstock suppliers/markets for digestate
 - Finances approval
 - Planning permission
 - Decisions on FITs (lower generation capacity)
 - Decisions on RHI incentive for when over 200 kW_{th}
 - Regulations for gas grid

Future of AD, Biogas and Biomethane in the UK Depends on...

- Planning/Permitting
- Food vs fuel – land availability and cost of crops
- Other feedstocks – source segregation of food wastes and small size herds – cooperation and co-digestion
- Markets for digestate (perception, risks and transport)
- Gas quality standards (further risk assessment , OFGEM response)
- Refuelling infrastructure, improved electricity grid (some cases lack of capacity – high costs) and expansion of the gas network (widespread but old)
- Access to finance and waste contracts
- Incentives – RTFCs and RHI implementation as well as an revisions of FITs and ROCs



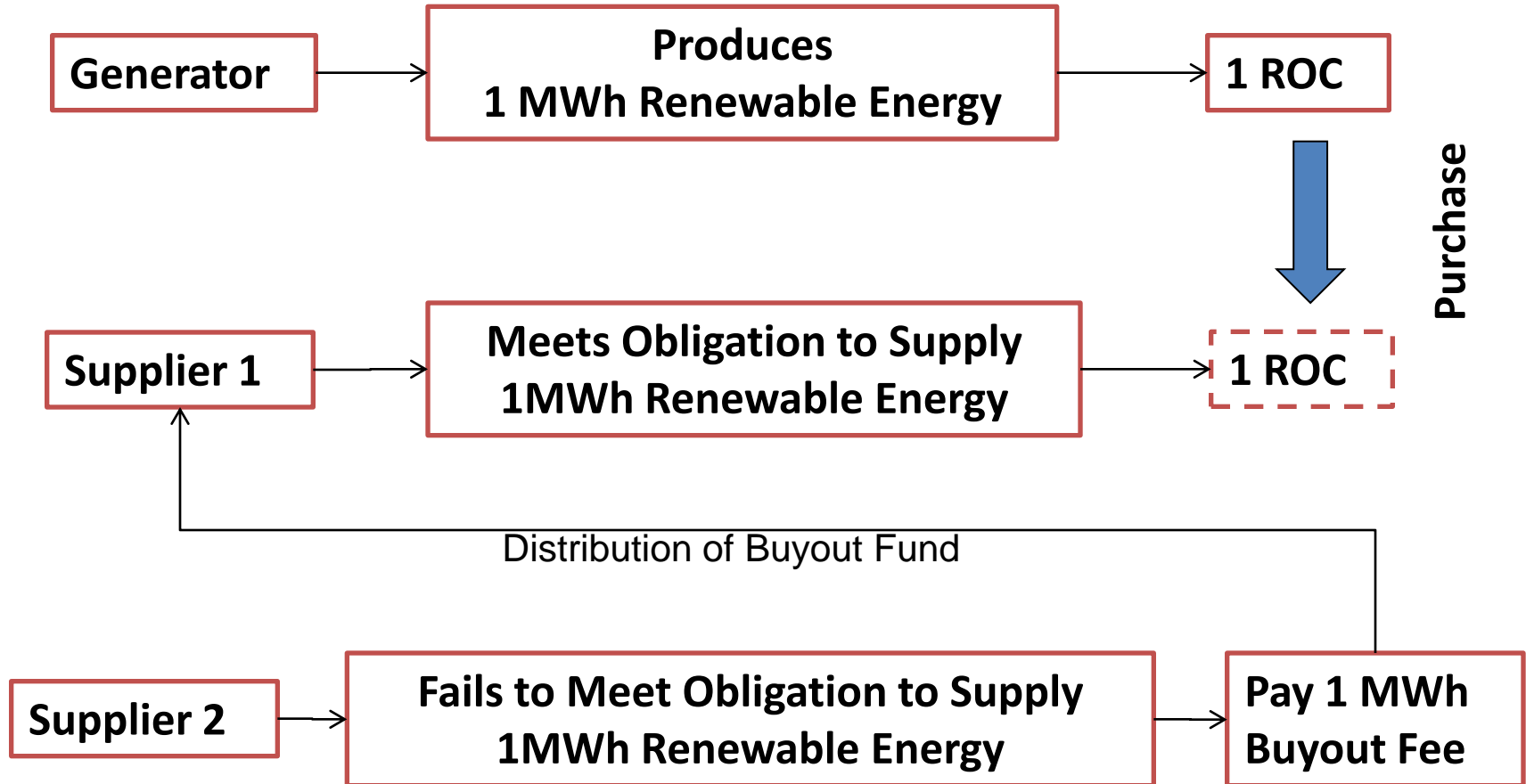
Actions in Support of the Industry

- Voice of the industry – REA Biogas Group and ADBA
- England 's Action/Implementation Plan
- WAG support for AD infrastructure for food waste treatment
- Some capital funding has been provided – novel processes or diversion from landfill
- Dissemination of information to planning officers and consultees
- Permitting regime – relaxed for animal slurries and standard permitting
- QP and PAS 110 for quality digestates and for specific markets – exit of the waste regulation
- Willingness from the gas distribution companies to engage in discussions
- Renewable energy related Incentives.....

Biogas & Biomethane Incentives - ROCs

- A Renewable Obligation Certificate (ROC) is issued to an accredited generator for eligible renewable energy generated and supplied to the market.
- Currently, Anaerobic Digestion attracts x2 ROCs for every MWh of energy supplied to the market.
- The Renewables Obligations Order places an obligation on licensed electricity suppliers to source an increasing proportion of electricity from renewable sources.
- Suppliers meet these Obligations by presenting sufficient ROCs. ROCs can therefore be traded between generators and suppliers.
- If insufficient ROCs have been accumulated, a 'Buy Out' fee must be paid – this fund is recycled to suppliers that have presented sufficient ROCs.

Biogas & Biomethane Incentives - ROCs



Biogas & Biomethane Incentives - ROCs

ROC Auction Prices V Buyout and 90% of Recycle Fund

Price per ROC



	CP1	CP2	CP3	CP4	CP5	CP6	CP7	CP8	CP9
eROC Average	£47.37	£49.06	£46.23	£39.80	£46.65	£51.35	£52.28	£48.13	£48.27
Buyout & 90% of Recycle Fund	£44.35	£51.14	£43.68	£41.52	£47.68	£51.09	£52.45	£50.82	£48.29

•The e-ROC average price is the weighted average price across all e-ROC auctions in the relevant compliance period. For CP9 the price takes account of auctions held between September 2010 and April 2011 only. For e-ROC auctions the full payment is made to the generator within 13 days of the auction.

•For the buyout and recycle payment the generator can wait up to 18 months for payment and does not usually receive the full benefit of the recycle payment (typically the buyer keeps 10% and the generator gets 90%)

•The CP9 estimate of £46.90 is based on the known buyout price of £36.99 and 90% of the unknown recycle fund. The recycle fund element is based on Cornwall Energy's best outturn forecast of £49.54. (£48.29 = £36.99 + 90% of £12.55)

Biogas & Biomethane Incentives - FITs

- The Feed In Tariffs are to incentivise smaller scale (<5 MW) renewable electricity generation
- A fast track review of FITS was held in early 2011 due to high levels of PV uptake and low levels of small scale AD uptake
- A Generation Tariff is paid for every kWh of renewable energy generated
- An Export Tariff is paid for every kWh of renewable energy exported to the Grid

Biogas & Biomethane Incentives - FITs

Description	Tariff Received until March 2011 (p/kWh)	Tariff Received Until 31 March 2012 (p/kWh)
Anaerobic Digestion with a total installed capacity of >500 kW	9	9.4
Anaerobic Digestion with a total installed capacity of <500 kW	11.5	12.1
Anaerobic Digestion with a total installed capacity of 250 – 500 kW	N.A	13 (Proposed)
Anaerobic Digestion with a total installed capacity of <250 kW	N.A	14 (Proposed)
Export Tariff	3	3.1

Biogas & Biomethane Incentives - RHI

- The Renewable Heat Incentive (RHI) is intended to increase the amount of heat generated from renewable sources
- Currently only applies to industrial applications
- It applies to the provision of useful heat (not process heat), cooling, or injection of biomethane to the gas grid
- It is aimed at biogas / biomethane generated from waste

Tariff Name	Eligible Technology	Eligible Sizes	Rate (p/kWh th)	Tariff Duration (Y)	Support Calculation
Biomethane	Biomethane injection, biogas combustion (not LFG)	Biomethane – All Scales Biogas combustion - <200kW th	6.5	20	Metering

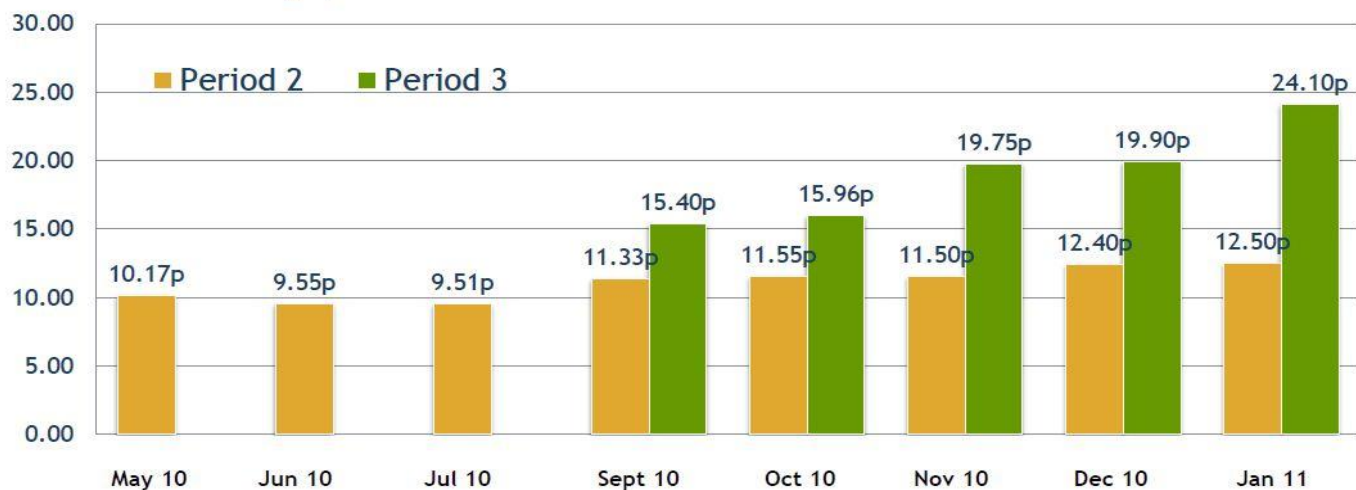
Biogas & Biomethane Incentives - RTFO

- The Renewable Transport Fuel Obligations (RTFO) are intended to increase the supply of renewable transport fuels to the market
- They work in a similar way to RO in that a certificate (RTFC) is issued for each kg (for gases) of eligible fuel supplied to the market
- RTFCs can be traded amongst suppliers as per ROCs
- A Buyout Fee is also set (30 p / kg), although to date the Buyout fund has reached minimal value

Biogas & Biomethane Incentives - RTFO

e-TOC Auction Prices

Price of RTFC (p)



Auction Dates

NFPAS
AUCTIONS

Biogas & Biomethane Incentives - RTFO

- The RTFO is still evolving and will need to accommodate the requirements of the EU Renewable Energy Directive (RED) and Fuel Quality Directive (FQD)
- The proposal is that fuels derived from waste will count twice towards RED targets, and therefore will receive double RTFCs
- Recycling of the buyout fund may be scrapped
- An evaluation of the economic potential of generating biomethane using biogas from the treatment of food waste (generating a gate fee) has been undertaken

Patterson, T., Esteves, S., Dinsdale, R., Guwy, A. An evaluation of the policy and techno-economic factors affecting the potential for biogas upgrading for transport fuel use in the UK. Energy Policy, 39 (3), 1806 - 1816

Economic & Environmental Studies Completed

Patterson, T., Dinsdale, R., Esteves, S. Review of energy balances and emissions of biomass-based transport fuels relevant to the United Kingdom context. *Energy & Fuels*, 2008, 22 (5), p 3506 - 3512

Patterson, T., Esteves, S., Dinsdale, R., Guwy, A. An evaluation of the policy and techno-economic factors affecting the potential for biogas upgrading for transport fuel use in the UK. *Energy Policy*, 39 (3), 1806 - 1816

Patterson, T., Esteves, S., Dinsdale, R., Guwy, A. Life cycle assessment of biogas infrastructures at a regional scale. Submitted to *Bioresource Technology*, 2011.
doi:10.1016/j.biortech.2011.04.063

Thank You

