Queen's University Belfast

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Inspiring
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The QUESTOR Centre
Renewable Energies

Cluster Newsletter

Recycling facility, Germany

European Technical Visits

In the past eighteen months staff from the QUESTOR Centre Applied Technology Unit have visited some of the most innovative companies and sites across Europe. In many cases staff have acted as technical advisors, travelling with local companies who are seeking new technology to address the waste treatment and renewable energy markets.

Ciaran Prunty joined the RICS Biogas Study Tour of Sweden and Denmark, visiting a

- Farm-scale anaerobic digester treating slurry from pig production where there was careful recycling of the excess nutrients back to the surrounding farmland.
- Municipal waste handling facility where the digestible fraction of domestic waste was anaerobically digested for biogas production.
- District-scale integrated anaerobic digestion project where grass (harvested from the surrounding farmland) is used for generation of the biogas used to run the town's bus fleet and generate electricity.

Dr Elaine Groom travelled to Israel and to Germany with Natural Energies Ltd to assess waste separation and handling equipment and plants for the generation of renewable energy from organic waste.

Travelling to Norway with B9 Energy Ltd, Elaine also visited a sewage treatment plant and a municipal waste composting and biogas facility as well as having extended discussions with host company Cambi about their thermal hydrolysis waste treatment technology.

ArrowBio Anaerobic Digester, Tel Aviv,

ArrowBio 'Dirty MRF' materials separation facility Tel Aviv

Cambi thermal hydrolysis plant, Norway

Royal Chartered Institute of Surveyors Biogas Study tour to Sweden

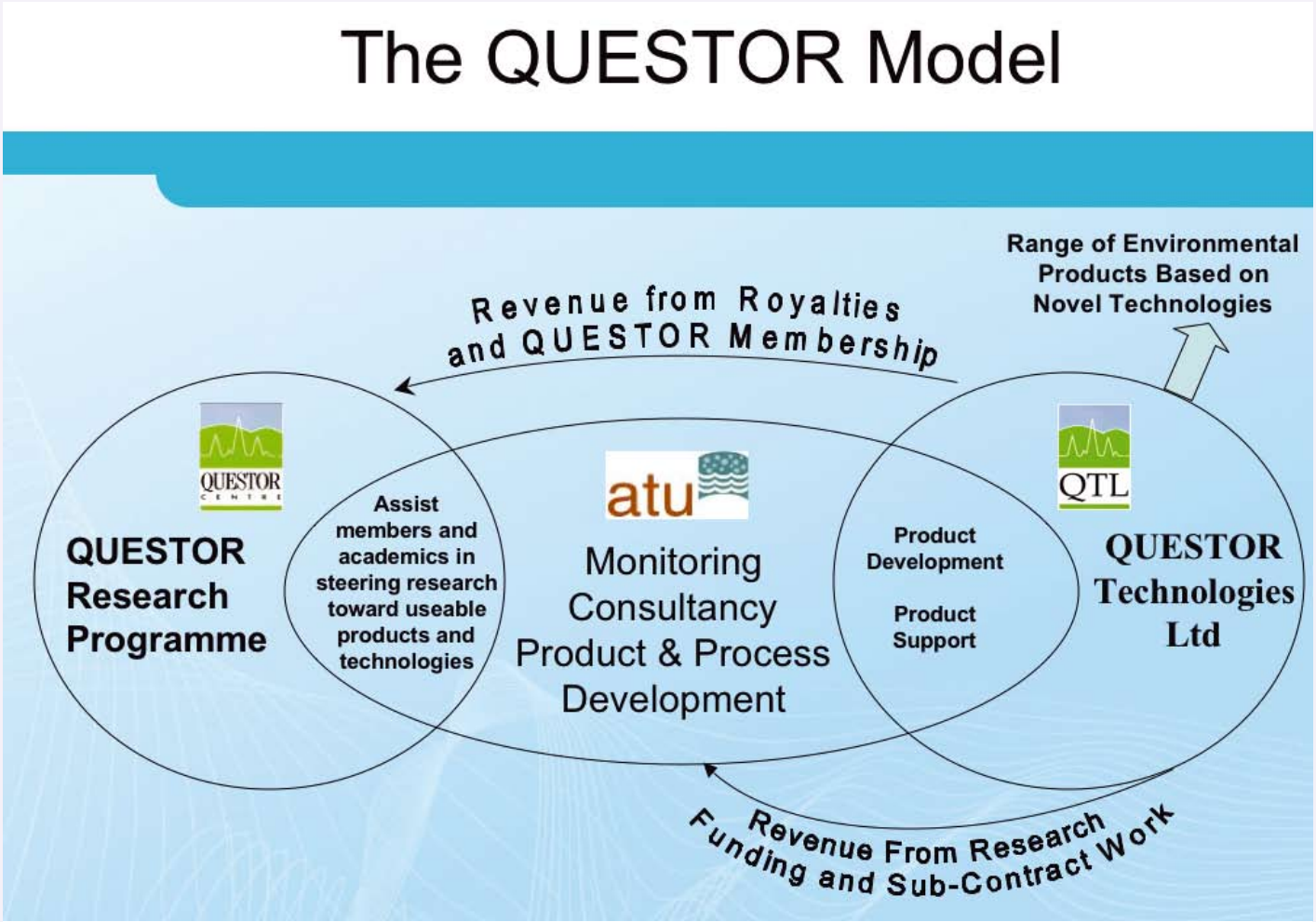
The QUESTOR Centre at Queen's University Belfast was the first Industry-University Environmental Research Cooperative to be set up outside the USA.

The Centre's member companies sponsor research across a range of environmental disciplines. The main areas of expertise within the Centre are water and wastewater treatments, clean production and manufacturing, waste minimisation, computer modelling of odour and pollutant dispersal and environmental communication.

The QUESTOR Applied Technology Unit (ATU) provides immediate assistance to SMEs regarding environmental issues that affect their business. The main activities of the unit are the provision of an environmental consultancy service, new environmental product and process development, as well as execution of research and development contracts. ATU expertise covers the fields of waste and energy minimisation, water efficiency, water and wastewater treatment, clean production and manufacturing. In total the ATU has contacts with several hundred small companies from Northern Ireland, the United Kingdom and the Republic of Ireland. The ATU is a financially self-sustaining unit.

The third part of the QUESTOR family is QUESTOR Technologies Ltd. QUESTOR Technologies Ltd is an independent commercial organisation with the objective of identifying research with commercial potential being carried out at the QUESTOR Centre and bringing this research through to commercial realisation. The other aim of the company is to identify market opportunities where environmental products or services could be developed. Such opportunities are developed through the expertise and facilities of the QUESTOR Centre and the Applied Technology Unit.

QUESTOR has a high profile among local businesses in Northern Ireland and has many contacts with individual SMEs, with local trade organisations, local development agencies and indeed the environmental regulators. We regularly visit current and past client companies, host seminars and training workshops and present at seminars, conferences and trade events organised by other bodies.

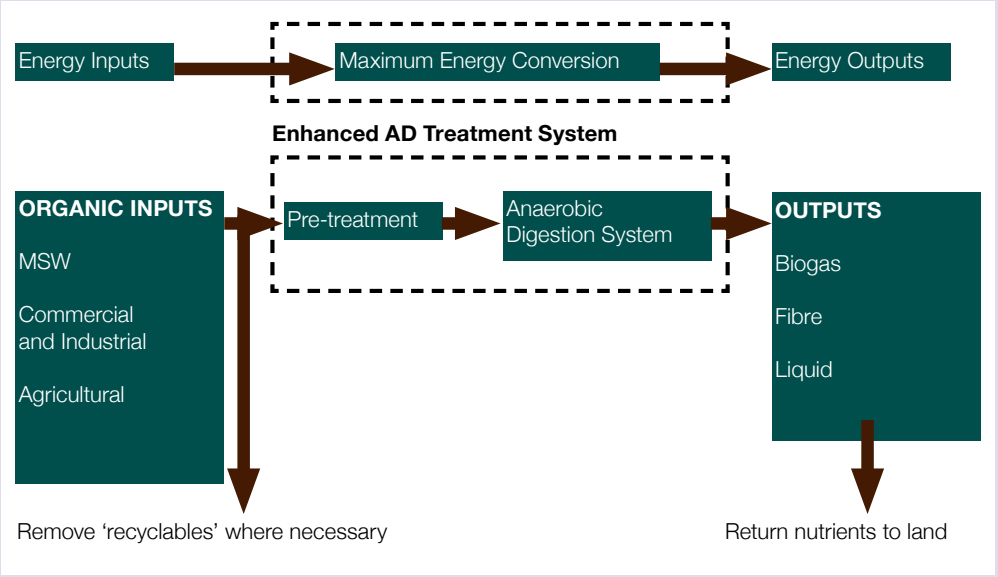


The Questor Model; showing the inter-relationships of the Basic Research Programme, Applied Technology Unit, and QUESTOR Technologies Ltd

Knowledge Transfer Partnership with B9 Energy Ltd

The QUESTOR Applied Technology Unit and B9 Energy Ltd have recently completed a two-year Knowledge Transfer Partnership to optimise energy production from organic materials.

The project aimed to 'define and optimise PRETREATMENT conditions' for the process of Anaerobic Digestion (AD). The target was to define the most cost effective and robust system which will convert long chain polymers to monomers, regardless of waste source. The intention was to reduce typical retention times and maximise both quality and quantity of biogas (renewable energy) production available from organic wastes.



Regional issue: Waste or Resource?

Anaerobic digestion (AD) is widely accepted and used worldwide for the treatment of organic wastes, including those from agricultural slurries, industrial wastewaters, sewage sludge and the organic fraction of municipal solid wastes (OFMSW).

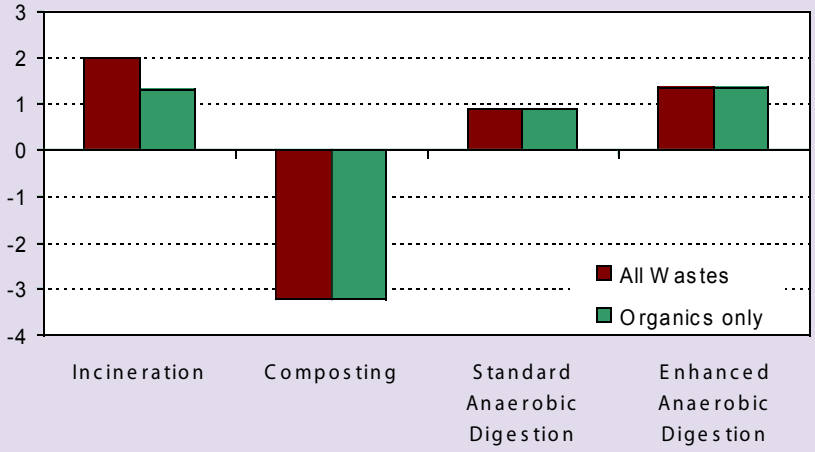
Northern Ireland's agricultural-based economy produces a much higher tonnage of organic waste than other regions in the UK. Centralised AD systems in NI have the potential to contribute up to 146MW to renewable power generation, while also providing a safe disposal route for biodegradable waste diversion from landfill. The full potential of AD as a treatment process has been utilised in NI.

Table: **Potential for renewable energy production from organic wastes in Northern Ireland.**

	Millions of Tonnes p.a.	Power Potential (MW)	Electricity Potential (MW)	Millions of BOE (Barrel of Oil Equivalent)
Agricultural	9.7	219	73	0.64
Industrial/ Commercial	1.5	156	52	0.46
Municipal (Household)	0.6	63	21	0.18
Totals	11.8	438	146	1.28

References (Rounded Figures)

Biogas production estimated from "Feedstocks for Anaerobic Digestion" – Steffen, R, et al. (1998) www.AD-Nett.org ;
Calorific Value of Biogas = 6.36kW/m3 ;
Electricity Potential = 1/3 of Power Potential ;
Barrel of Oil Equivalent is a standard unit of 1700 kWh (energy)



Energy From Waste: Net Energy Output.
Data from the Environment Agency Waste Technology Data

New technology: Enhanced Digestion
Standard AD is competitive with incineration for OFMSW in terms of energy generation (and with much lower capital cost), providing a net energy output of almost 1Gj/t. In contrast industrial scale composting requires significant energy input for forced aeration and/or moving of compost piles. Data from research and from enhanced AD plants (with operational pre-treatment systems) shows that even higher rates of net energy production are possible.

Well known as a renewable energy company and wind farm operator, B9 has set up a new company, B9 Organic Energy Ltd as a result of the KTP project. Dr David McKee, a graduate from QUB School of Chemical Engineering who worked with the company on the two year project, has been rewarded with a directorship of the new company. B9 Energy Ltd has also joined QUESTOR as a member company and anticipates continued collaboration with QUESTOR and the ATU.

RE-WISE.

QUESTOR is about to begin a two year project entitled RE-WISE, which aims to support EU policies in the field of energy – by providing a new integrated strategy for decentralised production of electricity and/ or heat. This has been funded through Intelligent Energy Europe within EU Framework Programme 6.

The full title of RE-WISE is 'Promotion of sustainable energy communities contributing collectively to biomethanisation of organic food waste as a decentralised renewable energy source for Europe, by exploiting the existing built environment'. The strategy of RE-WISE foresees the production of bioenergy from biogas, whereby:

- the biogas is produced through anaerobic co-digestion of organic food waste in district wastewater treatment plants (WWTPs) equipped with a primary clarifier and sludge digestion facilities
- the organic food waste is conveyed to the WWTP through the sewerage system after having been ground through food waste disposers, for anaerobic conversion to biogas
- the ground food waste disposed at each site (household, small industry) is quantified, and the associated rate of biogas production calculated, thus enabling stakeholders to be rewarded for their effective contribution to the increased production of bioenergy.

It is also proposed that processing of organic food waste through food waste disposers (in-sink garbage grinders) would enable disposal through the drain and sewerage systems, thus bypassing the need for transportation, and reducing associated environmental (greenhouse gas emissions) and resource (fuel, maintenance) costs. The avoidance of complex and expensive practices of waste management such as source-separate collection, or collection followed by separation and sorting of waste streams, would also provide significant cost savings.

The RE-WISE consortium is comprised of six partners from Italy, Spain and the UK. The project is led by d'Appolonia S.p.A., of Genoa, Italy.

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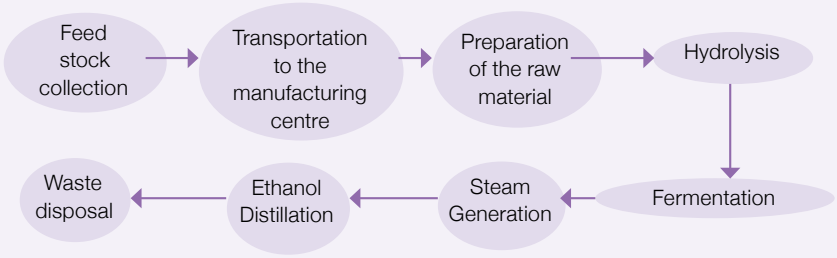
Conversion of Municipal Solid Waste to Bioethanol

Municipal Solid Waste is any material sent to the municipal landfill, including household waste and industrial waste (i.e. newspaper, wood waste, garden waste, etc.)

A substantial percentage of municipal waste is composed of lignocellulosic biomass - carbohydrate polymers known as cellulose, hemicellulose and lignin contained in the cell wall. These biopolymers can be broken down into sugars (glucose and xylose) then fermented to obtain bioethanol.

Bioethanol can be used as a fuel when blended with gasoline up to 10% or in its original state. It can also be used as a raw material in various industrial processes. Production of bioethanol from renewable sources of lignocellulosic biomass can improve energy security, decrease urban air pollution, cut materials going to landfill by over 75% and reduce accumulation of carbon dioxide in the atmosphere.



Bioethanol Production: Steps involved in Production

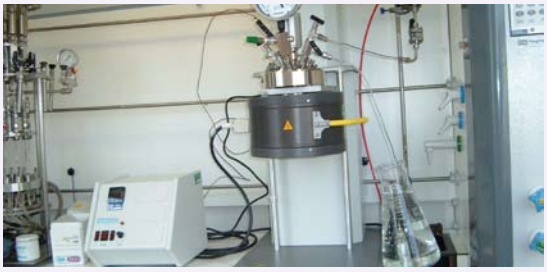
There are several options for hydrolysis of the biomass to obtain sugars:

- concentrated acid,
- dilute acid
- enzymatic hydrolysis.

The disadvantages of enzymatic hydrolysis are that the enzyme is very expensive and the process is still in a development stage. Toxicity and corrosion are issues in using concentrated acid hydrolysis. QUESTOR's research in the production of bioethanol has used dilute acid hydrolysis (with phosphoric acid), because of the advantages of this technique, which include decreased equipment corrosion problems, simplicity and efficiency.

The research has focussed on three wastes: newspaper, wood chips and hay and the following yield of sugar was obtained for each of the materials:

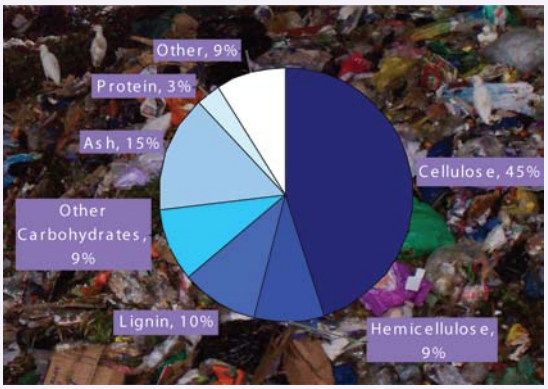
	Xylose	Glucose
Newspaper	59%	23%
Hay	80%	15%
Wood chips	95%	25%



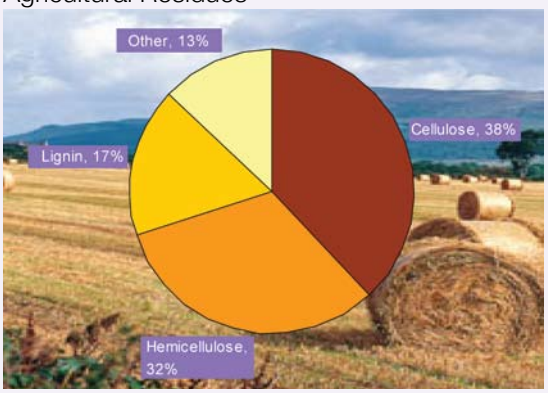
Pressurised reactor to conduct the acid hydrolysis

Composition of lignocellulosic biomass

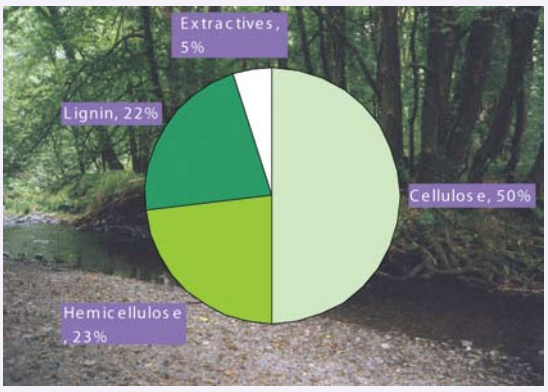
Sorted Municipal Solid Waste



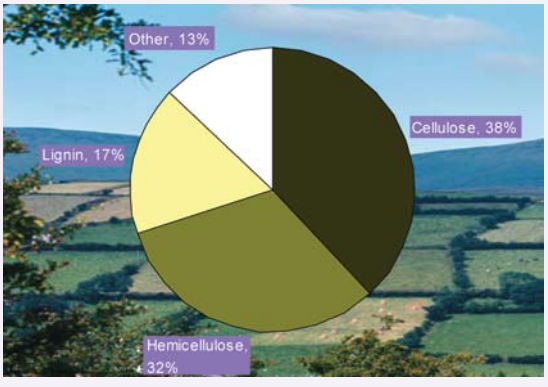
Agricultural Residues



Short Rotation Hardwoods



Herbaceous Energy Crops



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