



EUROPEAN
COMMISSION

Community Research

Biogas from energy crops and biowastes

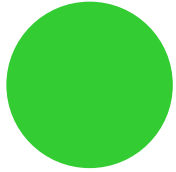
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EUROPEAN CONFERENCE on BIOREFINERY RESEARCH

Helsinki, 19 and 20 October 2006

Old technology - new application

- **The technology of biochemical methane generation is well established**
- **Traditionally it has been used for waste stabilization**
- **Current focus is on energy production**
- **To be cost-effective in this role may require**
 - **engineering and technical improvements to increase conversion efficiencies**
 - **Selection and production of biomass feedstocks from a variety of sources**
 - **including novel and multi-use crops and agro-wastes from integrated farming systems, commercial and industrial wastes and by-products.**



HYDROLYSIS

ACID FERMENTATION

ACETOGENESIS

METHANOGENESIS

**BIODEGRADABLE ORGANIC MATERIAL
(CARBOHYDRATES, FATS, PROTEINS)**

SIMPLE SOLUBLE ORGANICS

ACETIC ACID

**PROPIONIC ACID
BUTYRIC ACID
LONG CHAIN VFA**

ACETIC ACID

H₂ + CO₂

**ACETOCLASTIC
METHANOGENIC
BACTERIA**

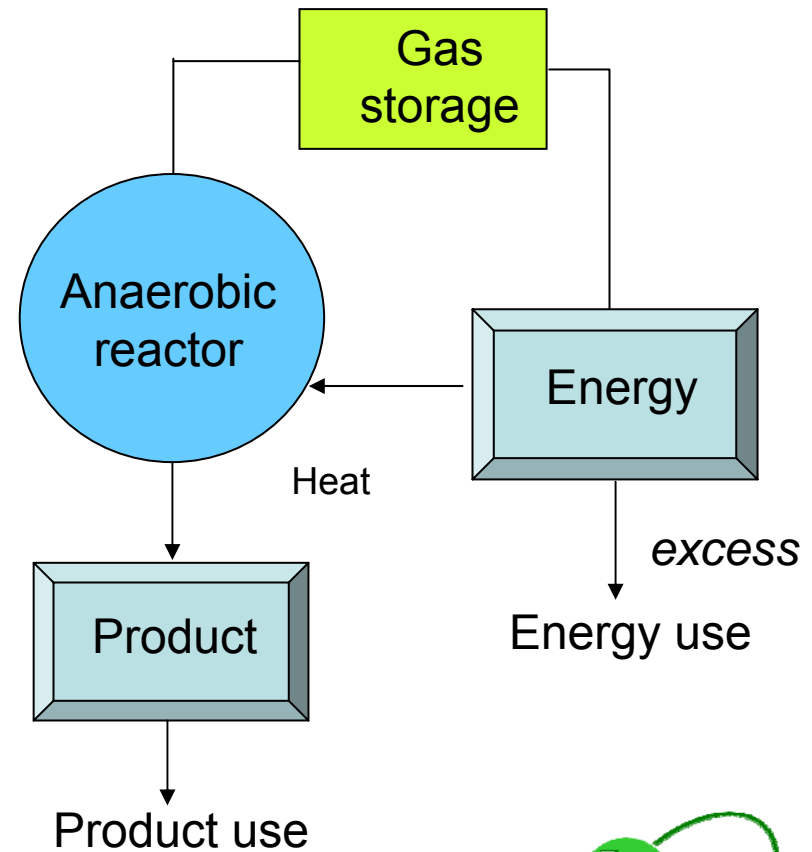
**HYDROGEN-USING
METHANOGENIC
BACTERIA**

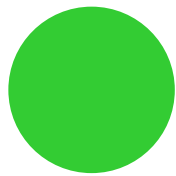
CH₄ + CO₂



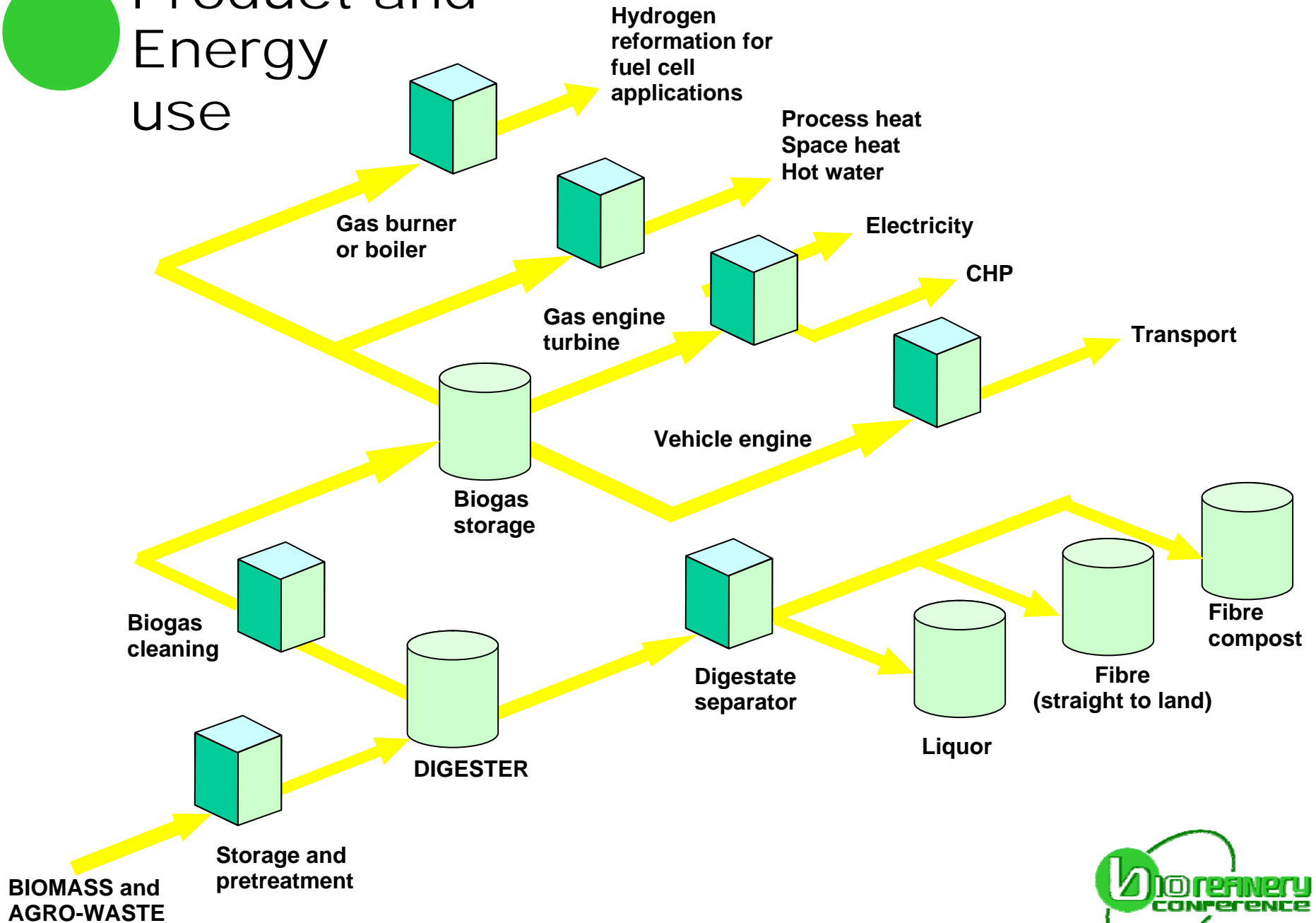
Anaerobic digestion in its simplest form

- Closed reactor
- System of gas collection
- Production of biogas
- Production of digestate





Product and Energy use





Process types

Wet

One stage

Mesophilic



Dry

Multi-stage

Thermophilic

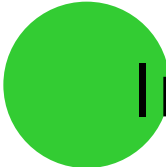
Process differences

Wet Process

- less than 15 % feedstock solids concentration
- one or several stages
- usually operate at 35°C
- requires water addition or recycle
- larger reactor
- proven technology for sewage sludge digestion
- more applicable to co-digestion with other waste

Dry Process

- more than 15% feedstock solids concentration
- usually one stage
- can operate at 35°C or 55°C
- minimal water addition
- smaller reactor
- becoming most popular choice for MSW
- more data and reference plants needed



Instantly recognisable!

Wet digester



mesophilic

Dry digester

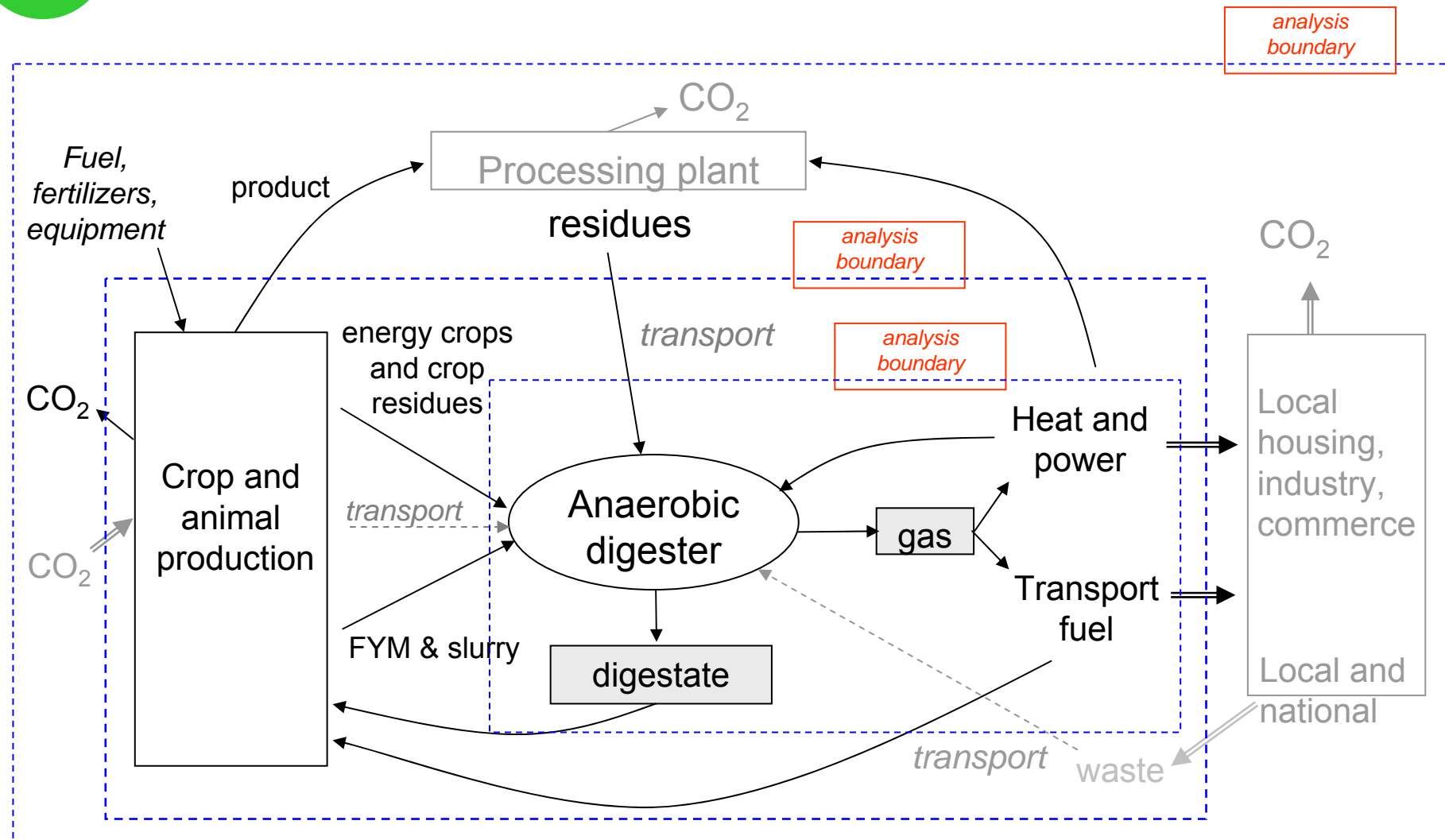


thermophilic

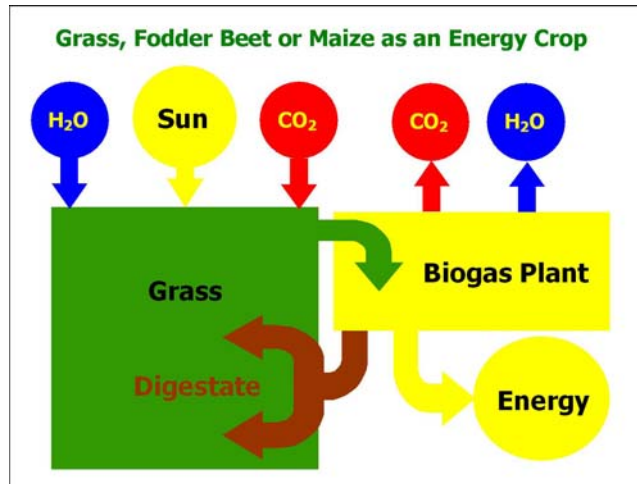
Dry digester



Biogas as a renewable energy source



Energy models



FormViewCrops : Form

EnglishCommonName: *Helianthus tuberosus* 47
 other names: Jerusalem artichoke

type: **crop** Legume propagation: tubers

RegionalDistribution:
 Most temperate and boreal regions with a variety of temperature and rainfall regimes. Tolerates

Growth requirements:
 soil type:
 Adapts well to most soil types, prefers slightly alkaline. Yields poor on heavy days particularly if th

Fertiliser inputs:

nitrogen:	phosphate (P2O5):	potash (K2O)
40-60 kg/ha	90-140 kg/ha	240-300 kg/ha

soilpt: 5.5-7 requiredRainfall: <1270 mm

sowingPeriod: tubers planted in Spring harvestedTime: Sept (tops) Jan (tubers) lengthGrowingSeason:
 soil Temp: 7 C growthTemperature: 125 days

cultivationMethod:
 Similar to potato, ridge, cover with 50-100 mm soil. Harvest: remove tops, harvest with modified potato harvester. (smaller tubers)

rhizobium:
 nutrients extracted from soil: nitrogen phosphate potassium

recorded yields 1DM/ha

Finland:	UK:	Austria/Germany:	Spain:
9-16	14.7	4.6(tops)*-16 1DM/ha	

Nfixation:
 alternative crop uses:
 human food, alcohol, fructose and forage production

comments:
 higher yield when planted as annual. Tubers can be stored in ground at 0C if soil moist.
 recorded biogas yields:

year	part	TS %	VS/TS (%)	Biogas (m3/kg VS at)	%CH4	CH4 yield (m3/kg VS at)	stage	rt
1986	tops	13.6	83	0.505±0.0145	61.1	0.309	Fresh	2
1986	tops	13.6	83	0.440±0.0107	68.4	0.301	silage	3

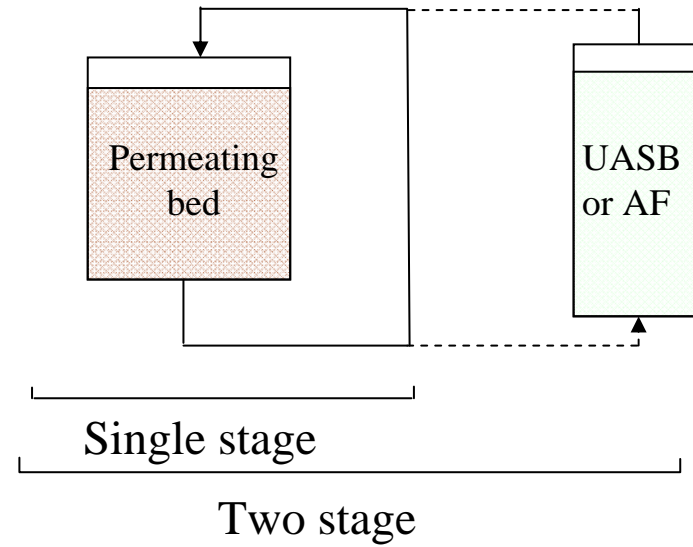
Record: 11 of 95

- Database of energy inputs into the cultivation of different crop types established
- Factors affecting energy use in the process have been identified
- Equations developed to account for energy usage in the digestion process
- Energy usage model developed based on typical anaerobic digestion plant configurations and substrates

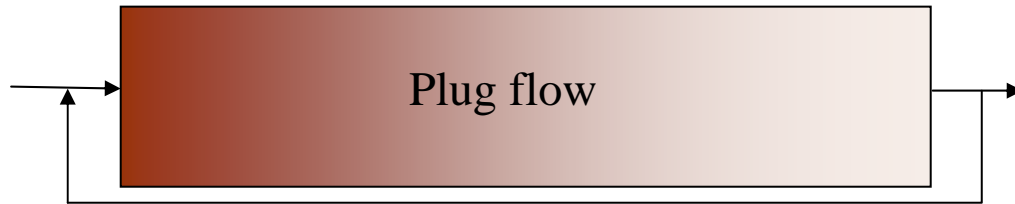


Phase separation innovations

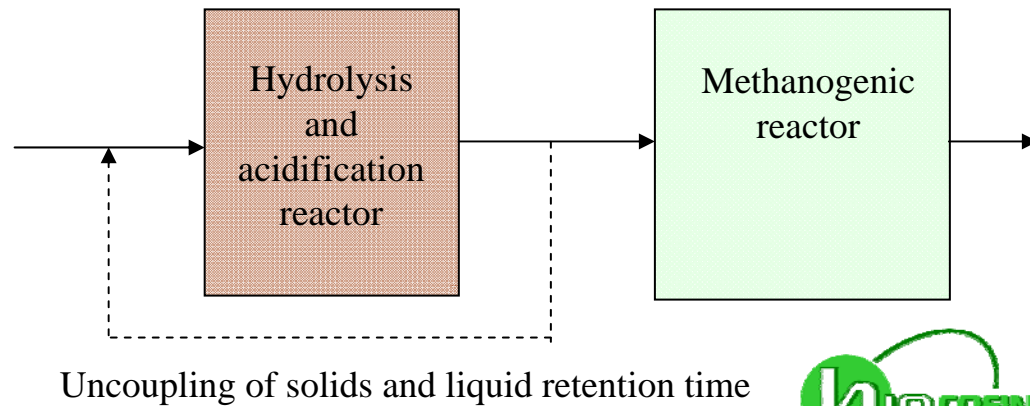
Permeating beds



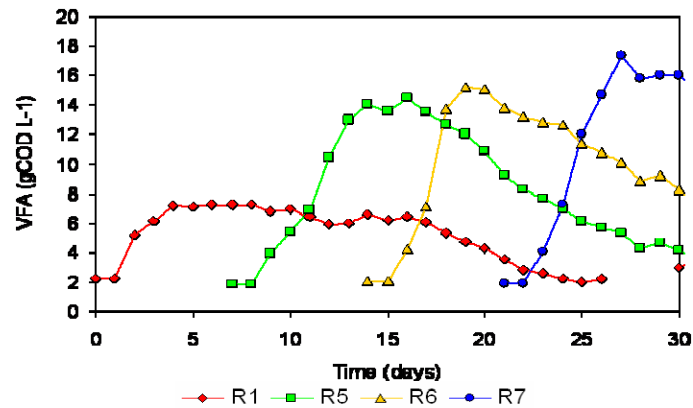
Plug flow reactors



Two phase systems (coupled and uncoupled)

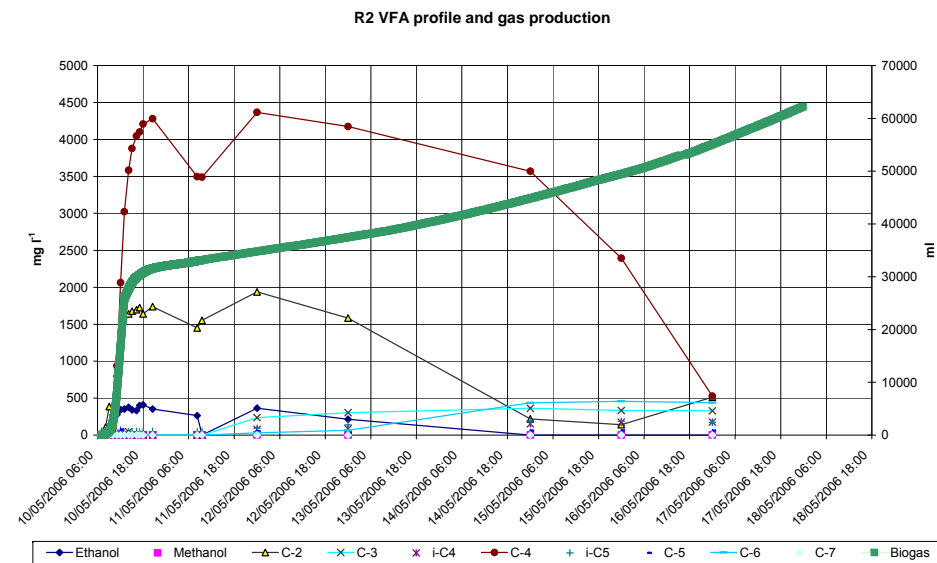
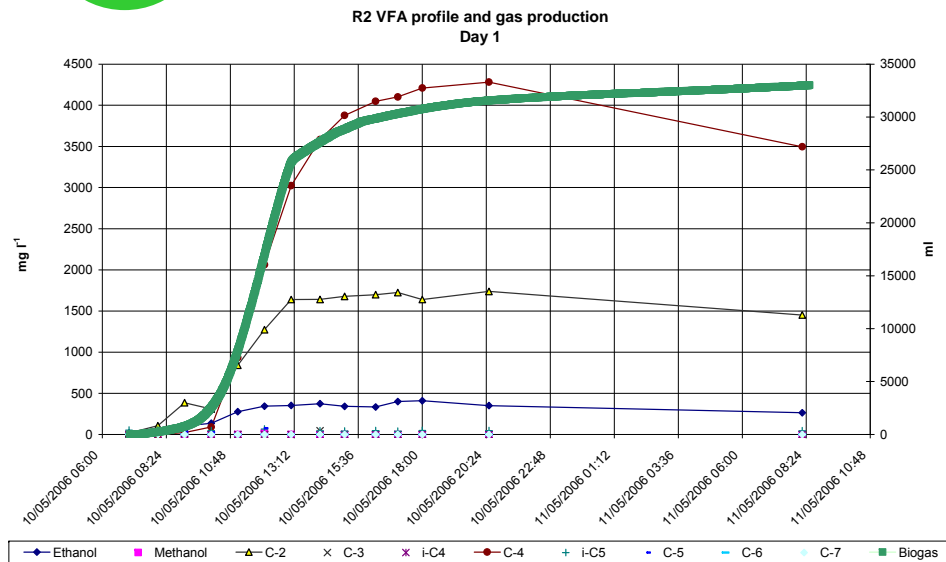


Permeating bed reactors



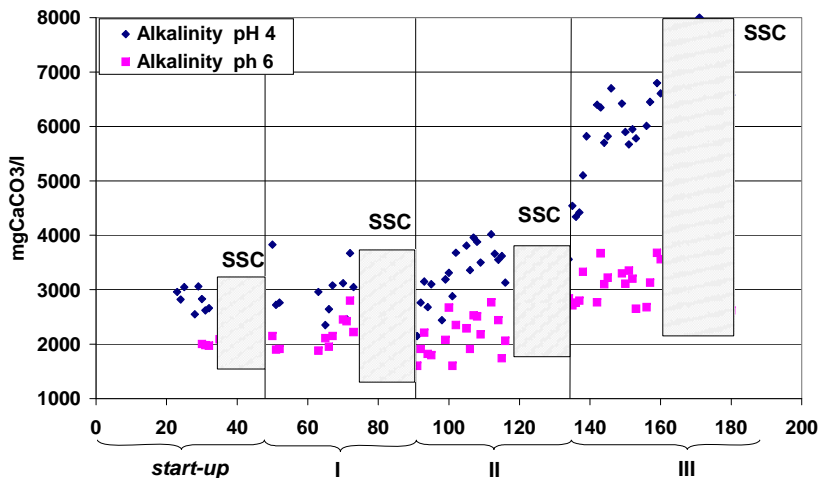
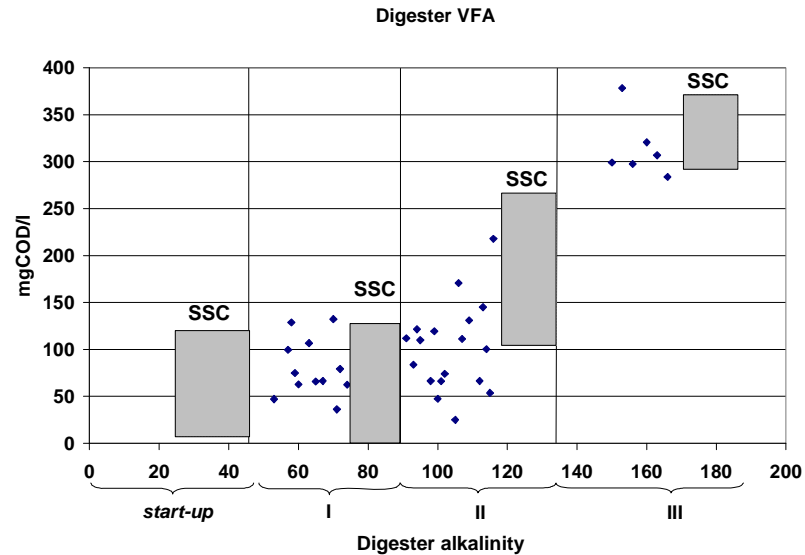
- Single bed systems using grass and maize have given poor results even with pH control
- Permeating bed with second stage high rate methanogenic reactors gives greater potential for stable operation and biogas production
- May be some potential for certain crop types but preliminary results indicate that overall process efficiency is likely to be poorer than for single phase mixed reactors
- Potentially an interesting mix of fermentation products

Plug flow systems



- Result from a high initial loading in the reactor
- Plug flow may limit the overall loading that can be achieved
- Interesting gas and acid production profile (H₂)
- May have potential for certain waste types and concept could be further exploited for refined fuel production and biorefinery intermediates
- Still to explore very high solids systems with high recycle rates

Two phase systems



- Overall performance for the treatment of market wastes at thermophilic temperatures and the loading used shows no advantage in process stability or performance compared to single phase controls
- Uncoupling of solids and liquids retention time in a first phase mixed reactor using maize as a substrate failed to improve rates of hydrolysis and solids destruction

Acknowledgements - Current project

Acronym: **CROPGEN**

Title: Renewable energy from crops and agrowastes

Contract: **SES6-CT-2004-502824**



Duration: 1 March 2004 – 28 February 2007

Total cost: 2.5 M€ EC funding: 2.1 M€

website: www.cropgen.soton.ac.uk

