

# Potential of anaerobic digestion for mitigation of greenhouse gas emissions and production of renewable energy from agriculture: barriers and incentives to widespread adoption in Europe

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7<sup>th</sup> International Symposium on Waste Management  
Problems in Agro-Industries

Amsterdam 27-29<sup>th</sup> September 2006



# Biomass resources in Europe suitable for anaerobic digestion

- Animal slurries
- Agricultural residues
- Energy crops
- Biodegradable commercial and industrial waste
  - Food processing wastes and agro-industry wastes
- Sewage sludge
- Organic fraction of municipal solid waste



# Benefits in using anaerobic digestion for agricultural and other wastes

- Provides a source of renewable energy
- Improves nutrient management and soil structure
- Can help to abate greenhouse gas emissions

So why are anaerobic digesters not a common site on farms across Europe ?



# More importantly :

- How do we change the current situation?
- What drivers would be effective?
- What will be the benefits?



# Biogas yields

Manures and slurries	Biogas yield (m <sup>3</sup> tonne <sup>-1</sup> wet wt.)	Industrial and commercial wastes and residues	Biogas yield (m <sup>3</sup> tonne <sup>-1</sup> wet wt.)	Agricultural energy crops	Biogas yield (m <sup>3</sup> tonne <sup>-1</sup> wet wt.)
Dairy cattle	20	Potato distillery	35	Meadow grass	98
Fattening cattle	34	Vegetable processing	35	Maize silage	190
Pig	18	Rape seed cake	612	Grass silage	183
Poultry	93	Canteen residues (high fat)	90	Milled grain	597
		Canteen residues (low fat)	44	Corn cop mix (5.3% fibre)	391
		Flotation fat	108	Total plant grain silage	195



# Incentives and disincentives to the adoption of AD technology

- Some examples of on-farm and centralised AD digestion facilities across Europe
  - What has made these schemes work
  - Why some schemes are running into difficulty
  - What are the benefits of the schemes
- How have EU and regional policies influenced these?



# Finland



Kalhari Farm



## Kalmari Farm digester







# Incentives

- EU Nitrates Directive (91/676/EEC)
- Environmental Protection Act (2000/86) and Government Decree No 931/2000
- Applies to the whole national territory of Finland
- Provisions on good agricultural practices, storage of manure, spreading and allowable quantities of fertilizers
- Requirement to provide covered slurry storage for 12 months of the year
- Manure may not be spread on frozen land or snow
- Farmers must be signed up to the **General Agricultural Environmental Protection Scheme (GAEPS)** to receive subsidies



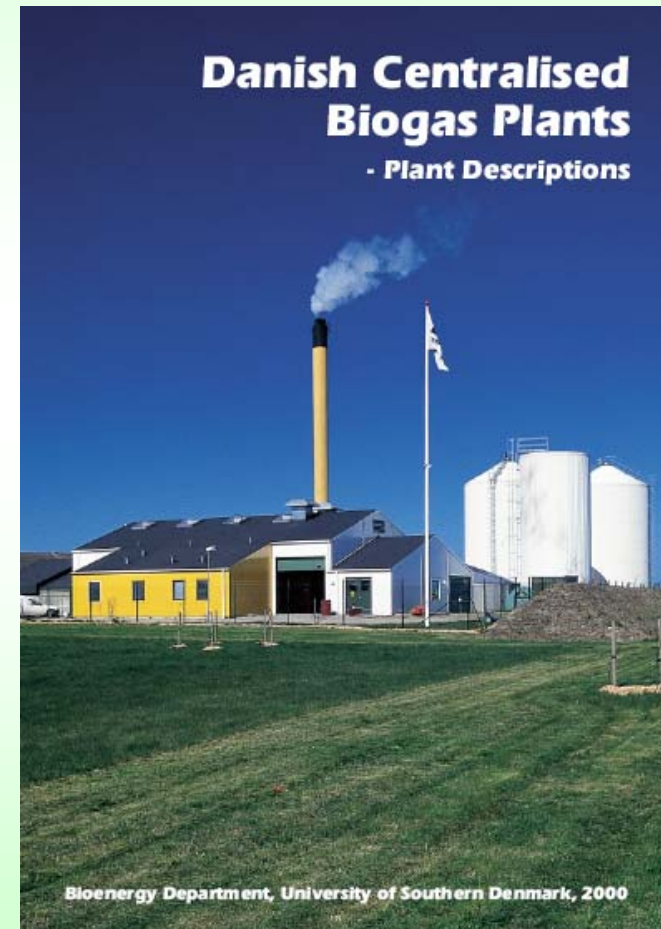
# Disincentives

- 78 000 farms in the GAEPS scheme
- 1 875 000 hectares (91% of field area)
- The total amount of agricultural waste accumulated in Finland is around 20 million (wet) tonnes, of which cattle dung is 8 million (wet) tonnes
- Only 2 farms currently digest such waste
- Development has relied heavily on individual effort
- No government funding forthcoming and the incentive has been lost



# Denmark

- Currently 18 centralised biogas plants large enough to be included in the survey carried out by the Bioenergy Department of the University of Southern Denmark
- Plants are mostly co-operatives involving farmers, municipalities and/or private organisations, with 5 - 80 farmers involved.



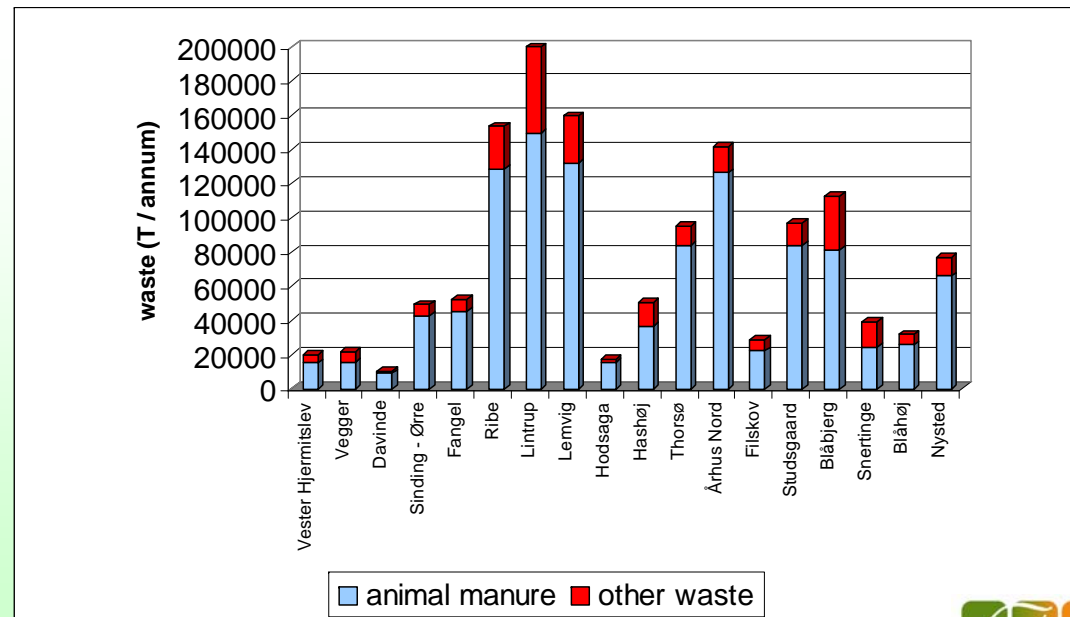
# Centralised Anaerobic Digestion

- The Danish Biogas Programme is a good example of an ambitious and consistent government policy for farm management and nutrient control.
- This includes 6-9 month manure storage capacity, plus restrictions on application and on landfilling organics.
- Economic incentives included grants, low-rate long-term loans, tax exemptions and subsidies for bio-electricity currently of 0.079 €kWh<sup>-1</sup> for established plants (but reducing to 0.053 €kWh<sup>-1</sup> in 2014).
- Heat sales are also possible through widely available district heating networks for 6-9 months per year.



# Type of plant and capacity

- Plants supplied by different manufacturers but all based on a single-phase completely-mixed wet digestion system at either mesophilic or thermophilic temperatures.
- Sizes range from 10,000 to 200,000 tonnes in relation to the waste tonnage that can be accepted.
- Feedstock mainly animal slurry from pigs and cattle, supplemented in all cases by other organic wastes from food processing.



# Economics depend on the import of food waste

- These include animal wastes such as intestinal contents (27%); fat and flotation sludge from food or fodder processing (53%); and wastes from fruit & vegetable processing, dairies and other industries.
- On average about 23% of waste is not from farms, but this ranges from 12 to 64% for individual plants.
- Approximately 1.1 million tonnes of manure is treated with 255,000 tonnes of other organic waste.
- This gives 50 million m<sup>3</sup> of biogas with an average yield of 36.8 m<sup>3</sup> tonne<sup>-1</sup> (wet weight).
- Biogas yield is therefore considerably higher than the normal 20 m<sup>3</sup> tonne<sup>-1</sup> for slurry alone.



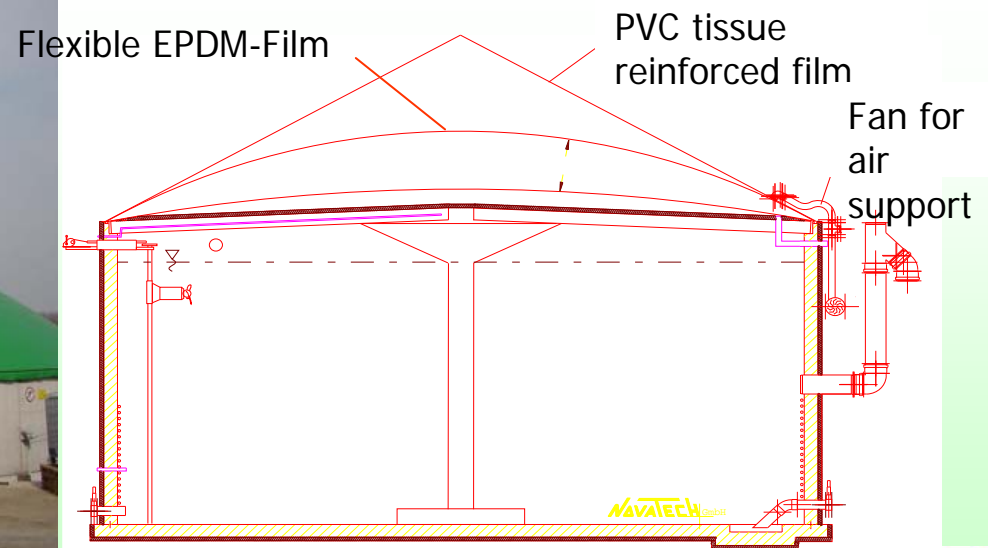
# Danish CAD plant





# Germany

- 2500 installed farm digesters, with current expansion expected to reach 4000 soon
- Installed electrical generating capacity of 980 MW expected by end of 2005



# Incentives

- Renewable energies resource act ('feed in laws')
- Guaranteed purchase of biogas (and other renewable) electricity at preferential rates for a 20-year period
- Base price ranges from €0.084 – 0.115 kWh<sup>-1</sup>
- Bonuses for energy produced from energy crops
- Bonuses for use of heat from CHP
- Bonuses for the use of 'new technologies'
- Scale down of subsidies from the end of 2005 to encourage efficiency and process development



## Dairy cow slurry



## Dairy cow slurry + added maize



Organic Dry Matter	4	8	tonnes/day
Organic Matter Reduction	2	5	tonnes/day
Mass of Biogas	2	5	tonnes/day
% CH <sub>4</sub>	55	55	%
Volume of Biogas	1801	3913	m <sup>3</sup> /day
Specific Loading Rate	1.48	2.96	kgODM/m <sup>3</sup> /d
Digester Capacity	2700	2700	m <sup>3</sup>
Hydraulic Retention Time	54	54	days
Volumetric Biogas Production	0.67	1.45	day <sup>-1</sup>
Specific Methane Production	0.25	0.27	m <sup>3</sup> CH <sub>4</sub> /kgODM

# Another German digester!



## Problems:

As experience grows with digestion of energy crops so the proportion included in the mix has risen. Some digesters now work without slurry to maximise volumetric gas potential!

Have the Germans been too generous in their subsidies ?

Is the financial model based on 'green energy' production the right one to pursue?



# United Kingdom

## Holsworthy centralised anaerobic digestion plant



# Technical specification

- 140 m<sup>3</sup> reception pit
- 2500 m<sup>3</sup> mixing tank – internal impellers
- 84M double helix heat exchangers
- 3 x 20 m<sup>3</sup> pasteurisers – 70°C for 1 hour
- 2 x 4000 m<sup>3</sup> digesters
- 3000 m<sup>3</sup> site digestate storage
- 2 x biological de-sulphurisation units
- 800 m<sup>3</sup> gas storage
- 2 x 1048 kW Jenbacher 320 gas engines
- 40,000 m<sup>3</sup> digestate storage
- **State of the art system following the Danish Co-operative model for a centralised facility ( 25 farmers – 140,000 tonnes of slurry per year)**



# Disincentive = regulation

- Under UK regulations if non-farm wastes are included then the whole digestion mix becomes classified as controlled waste
- Use of the material back on the farm is controlled by the Animal By-Products Regulations and Waste Management Licensing Regulations
- All land on which controlled waste is spread must receive an exemption – a process that can take 35 days
- Licensing fee £545 (794 €) for every 50 hectares = 115 - 145,000 € every year



# Disincentive = regulation

- In addition have to comply with Cross Compliance, Single Farm Payment, Water Framework Directive, Nitrates Directive, COGAP
- Perception of the farmer that material he previously spread on the land is now a waste and he needs a license!
- No guaranteed price for energy sales in the UK – scale is variable under the Renewable Obligation Certificates (ROCs) scheme.





# Experience

- The material is processed to a very high standard
- The plant is fully compliant with the EU Animal By-Products Regulations
- Regular analysis of digestate and storage until it is most beneficial to be used
- Nutrient value of the digestate is such that many farms now use no mineral fertiliser
- Most of the farmers comment how much their nutrient management has improved since operation of the biogas plant started.



# Greenhouse gas emissions as an incentive?

- EU<sub>15</sub> agriculture contributes about 10% of GHG emissions
- Manure management is the only economically viable measure for reducing GHG
- This accounts for about 66.4 million tonnes of CO<sub>2</sub> equivalents each year.
- Current target price is €20 per tonne but this could rise to €65 by 2030



# The way forward

- Currently a major factor in influencing European policy
- Indirect subsidy for digestion under the Directive for Rural Development – and in particular axis 3 criteria
- Potential for methane from agriculture in the ETS for carbon – possible 2008
- Replacement of fossil fuel could lead to further GHG reductions



# Summary

- Incentives for biogas production using agricultural slurries:
  - Nutrient management
    - Particularly important in NSZs
    - Increased slurry storage may present opportunities
  - Renewable energy production
    - Only economic with the import of other wastes or by growing energy crops
    - Has relied on grant aid or subsidies for capital investment where energy prices are not guaranteed
    - Can be financially profitable to farmers where prices are guaranteed and attractive to bankers for capital investment
  - GHG reductions
    - Currently top of the agenda and this is likely to be the area where subsidies will arise



Thank you for your attention

