Biogas from Animal Waste and Organic Industrial Waste

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Biogas Plants in Denmark 1973 – 2008

Under changing motivations

1973-1985

Oil crisis - domestic energy supply
Less dependency on imported fuels – especially oil

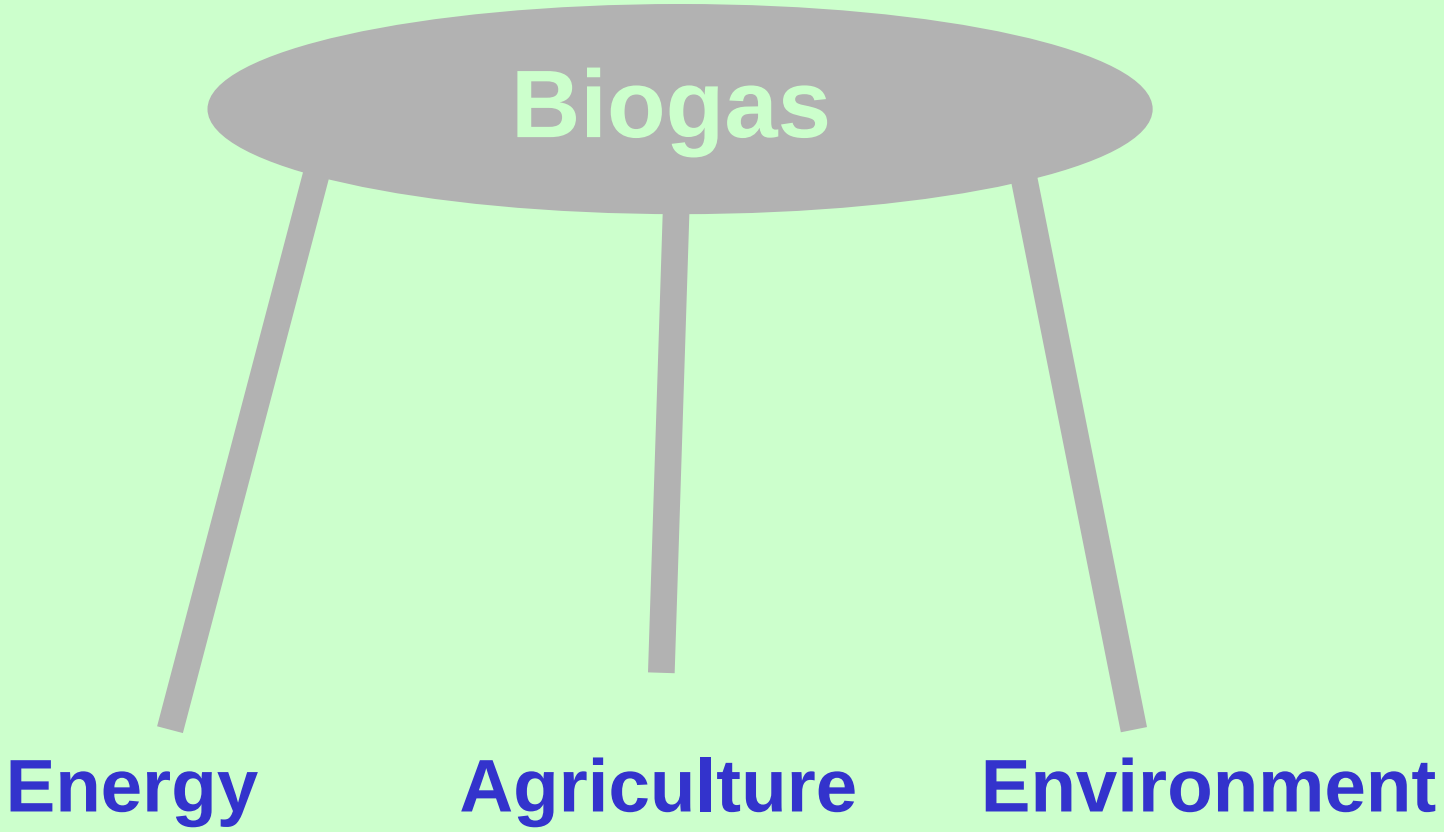
1985-1995

Reduce nutrient losses from agriculture
Renewable energy

1995-2008

Tool for green house gas reduction
Sustainability in livestock production

Biogas rests on three legs



Development of plants

1973-1985

Pilot and farm scale plants – not successful

From 1984 -

Centralised co digestion plants, increasingly successful

2000-2001

Many, now relatively successful, farm scale plants

Future

Centralised Co digestion plants – separation, removal or distribution of surplus manure.

Structure and Activities of the Biogas Demonstration and Development Programmes

PROGRAM ACTIVTIES	Investment grants	New plants received up to 40 % of investment costs as a government investment grant
	Monitoring Program	Production data and results were registered collected and analysed. Economic results were collected and analysed
	Exchange of experience	Results were communicated to plant operators in working papers, reports and in seminars
	RD&D	General problem fields and specieal development tasks were pointed out for closer investigation

Actual situation i Denmark

20 centralised plants in operation

60 farm scale plants in operation

Technically well operating

Economically viable

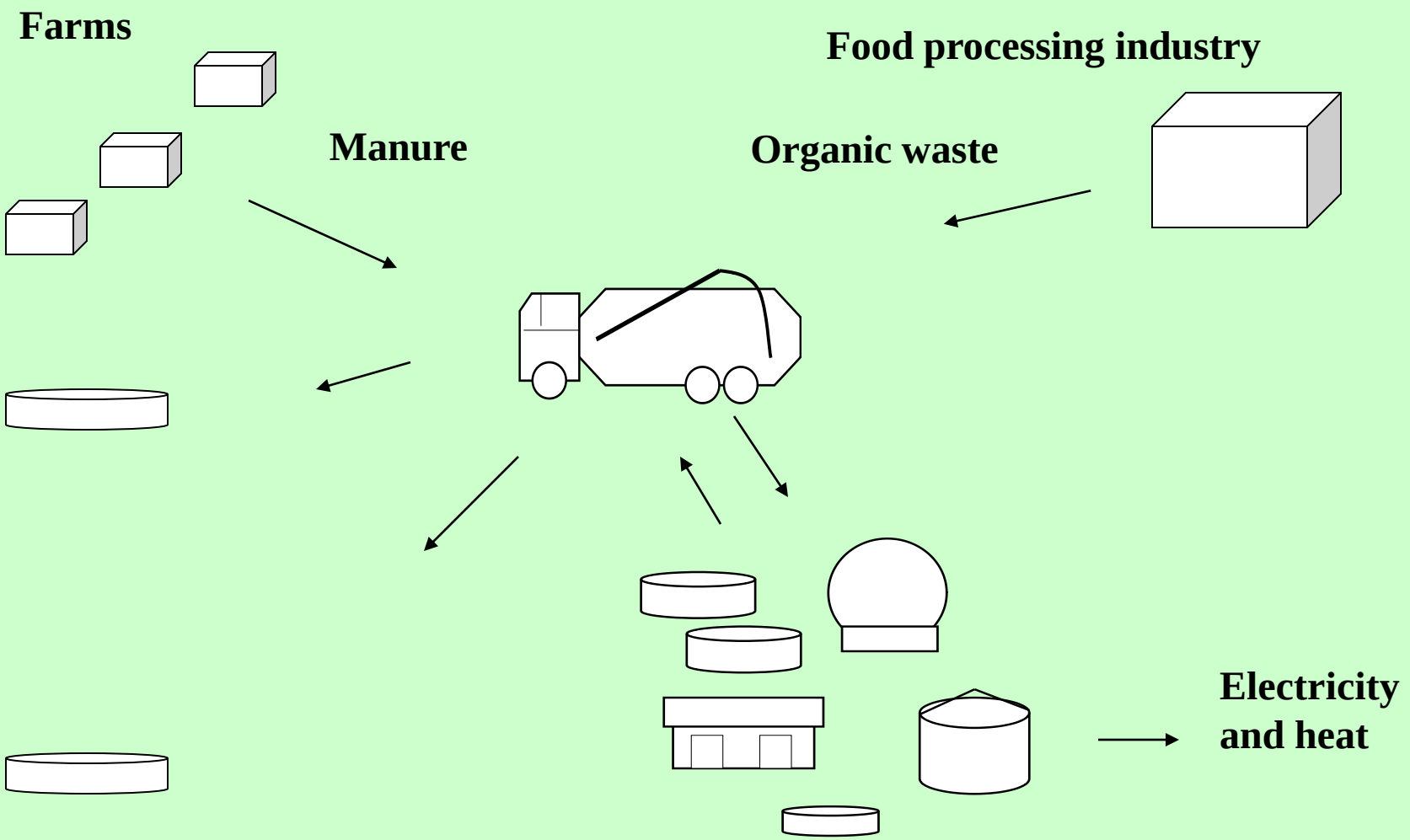
-but co-digestion so far very important.

Production data from centralised co-digestion plants

Animal waste treatment	1.3 mil tonnes per year
Organic industrial waste	0.3 mil tonnes per year
Energy production (2007)	1.7 PJ
Potential based on manure	20-30 PJ

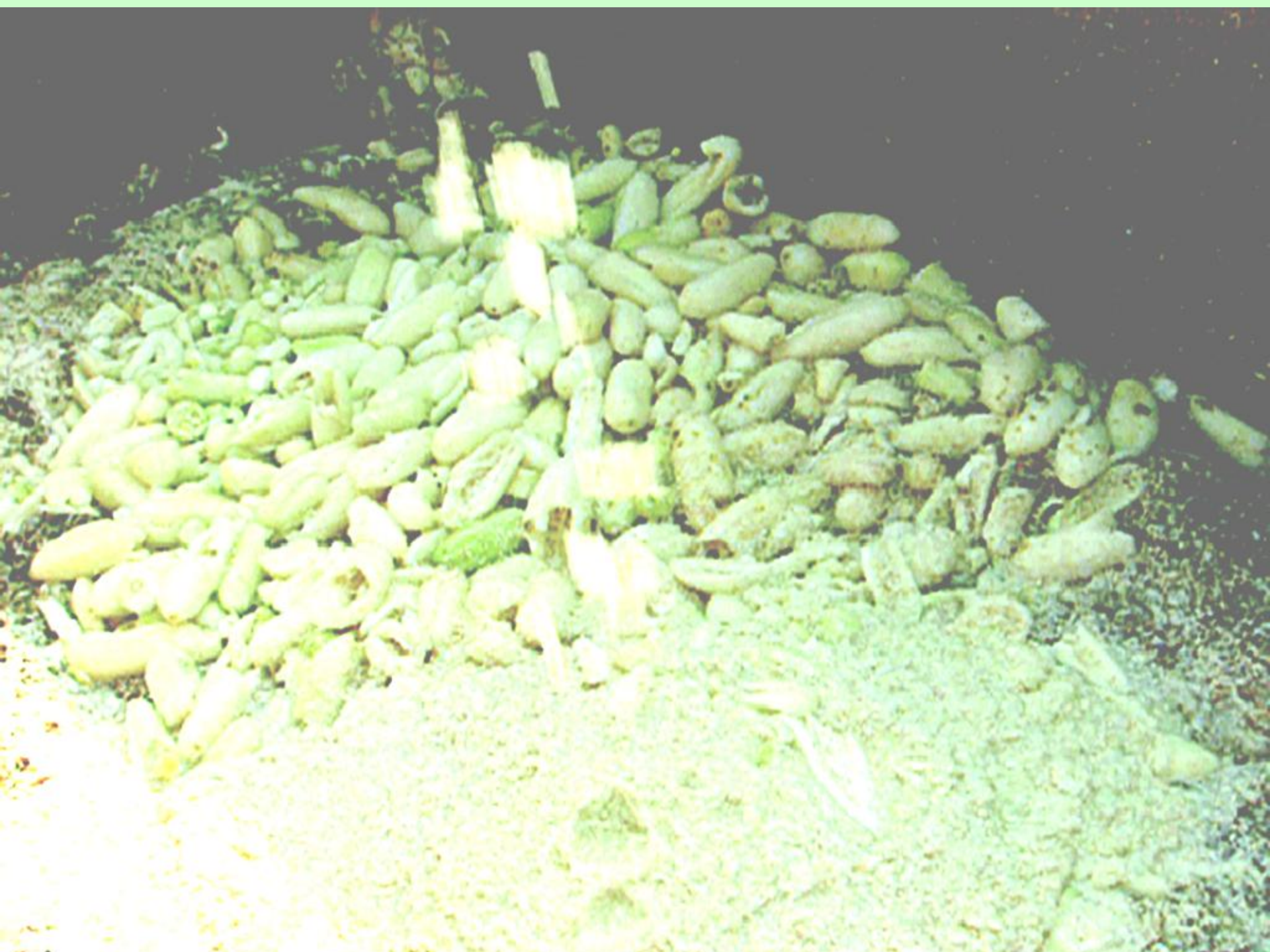

V. Hjermitslev
Vaarst
Vegger
Fjellerad
Lemvig
Thorso
Hodsager
Sinding
Arhus
Studsgård
Blåhøj
Blaabjerg
Fiskov
Snertinge
Revninge
Hashøj
Lintrup
Tangel
Ribe
Davinde
Nysted

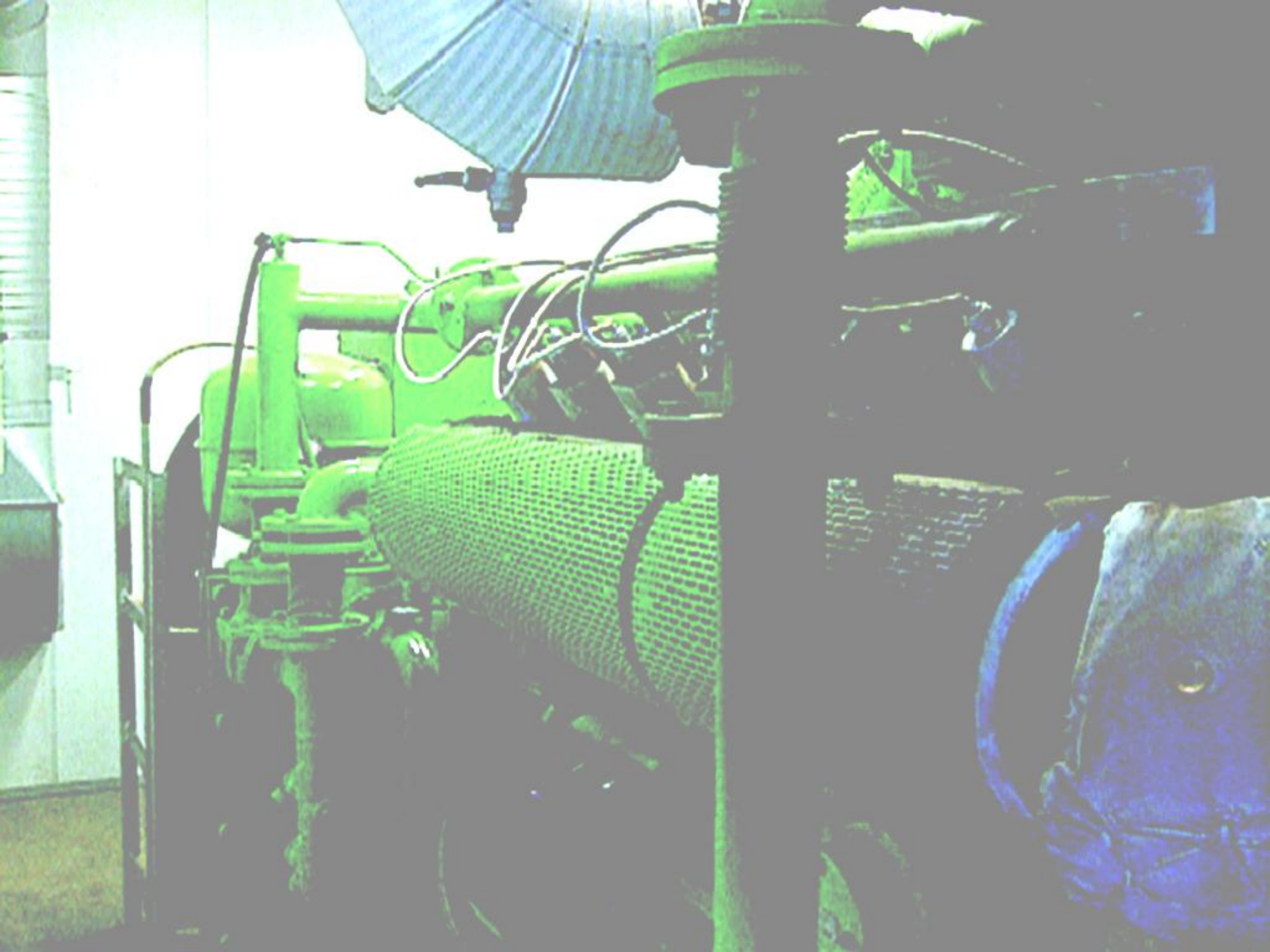
Centralised Co-digestion Plant Concept




BIOGAS


MAN





Energy application – Danish plants

Electricity – sold to the public power grid

Heat sold to district heating systems

Biomass resources

Liquid manure – could be different

Organic waste – 0-20 %, depending on the quality

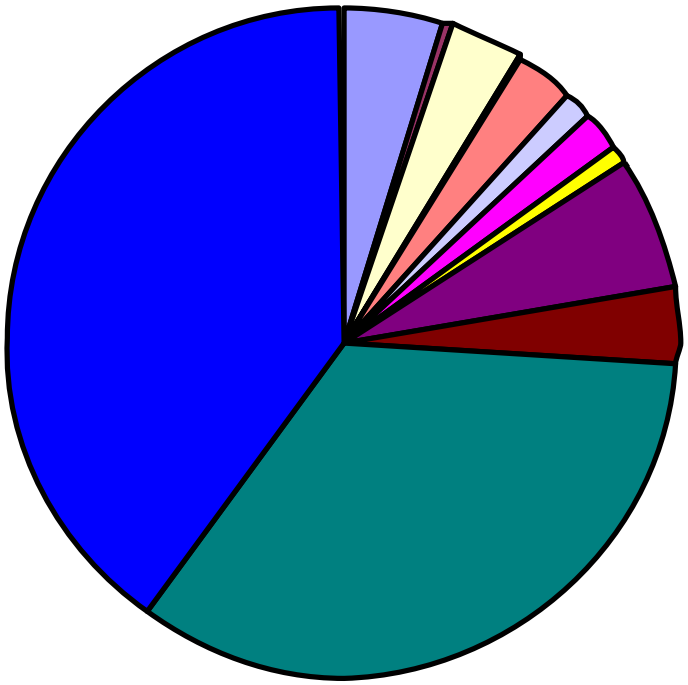
-From food processing industries.

Why is waste important ?

1 tonne liquid manure 5% DM = 20 m3 biogas
1 tonne organic waste = 0 – 1000 m3 biogas

And treatment fees

Biomass used in Danish biogasplants



- Fat/flottation sludge
- Food waste
- Fish waste
- Fruit waste
- Brewery waste
- Dairy
- Sucker industry
- Plantoil waste
- Garverier
- Mucosa
- Medicin industry
- Energy crops
- Slaughter waste
- Other manure
- Cattle manure
- Pig manure

Manure application

(In Denmark)

Spread in the fields and used as a fertiliser

nowadays, nomally by using trailing hoses.

What's in it for the farmers ?

In general, it makes it easier to comply with environmental restrictions

-9 months storage capacity
-Maximum amounts of manure to be spread per hectare

The AD plant company provides

-The needed storage capacity
-Redistribution or disposal of surplus manure

Farmers gain cost savings in

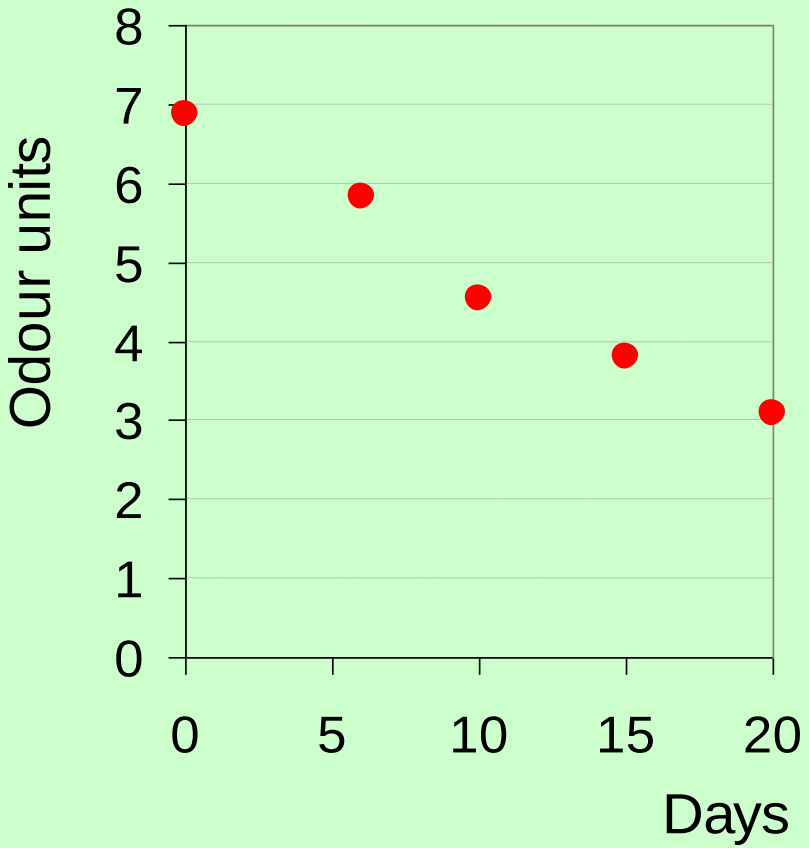
-Manure storage
-Manure transport
-Manure spreading
-Fertiliser purchase

-In Denmark, 0,7 € per tonne manure treated

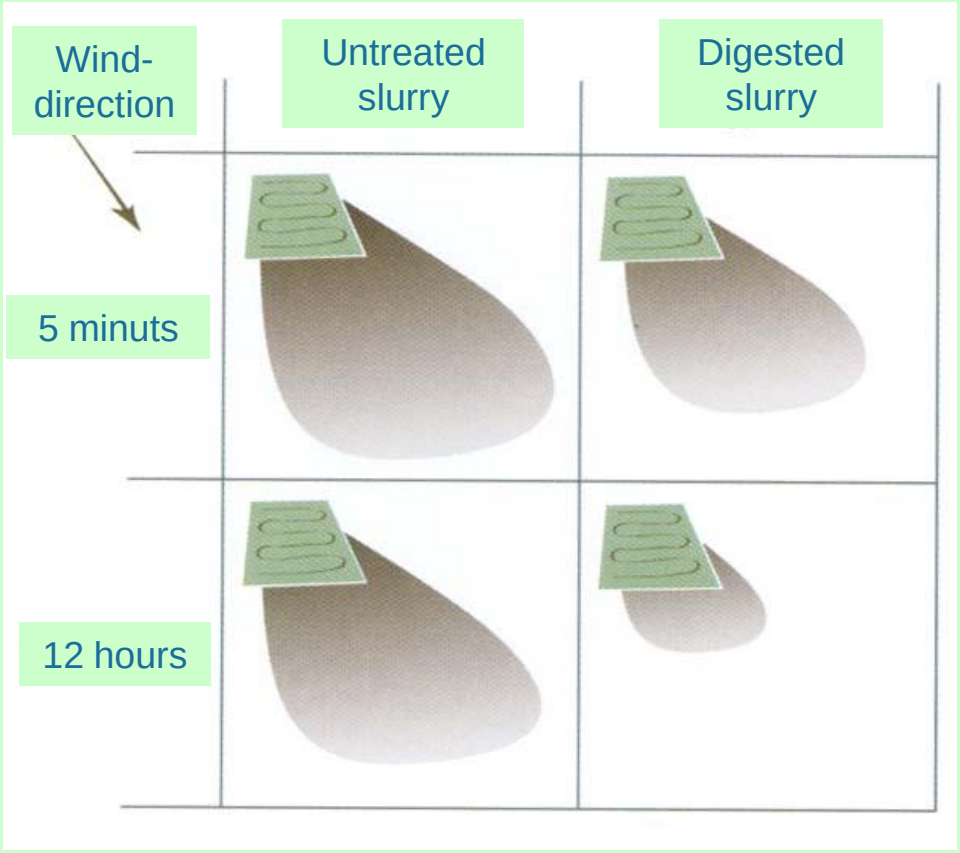
Fertilizer plan for nitrogen for 1 ha grass

Per hectare	Case 1: Cattle slurry	Case 2: Digested slurry
N-requirement, kg	250	250
N in slurry, kg total	170	170
N-utilization, %	40	60
N in slurry, utilized,kg	68	102
Mineral fertilizer	182	148
Saved, kg	-	34
Saved, €	-	20

Digestion reduces odour



Principles for spreading of odour:



What's in it for food processing industries

-Easy compliance with requirements on waste recycling

- Cheap and easy way to dispose waste

-Improved image

-Environmental friendliness can be used as argument for marketing purposes

-In Denmark, approx. 17 € per tonne waste

What's in it for energy consumers

-Energy from renewable source at competitive prices

-The satisfaction of environmental energy consupmption

What's in it for the businessman

-Market options for green electricity trade

-Market options for heat from renewable sources

-Construction and operation of extensive technical facilities

-Market for financing and insurance of extensive technical facilities.

What's in it for local society

-New business, new local activity

-New jobs, 1-10 directly associated to the plant

-Related business – who knows ???

-Environmental improvements

-Fresh water systems
-Improved hygienic standards due to sanitation of manure
-Less odour nuisances.

What's in it for society in general

-Contribution to meet national environmental targets

-Implementation of green heat and electricity

-Green House Gas reduction

-CO2
-CH4
-N2O

-Increased waste recycling

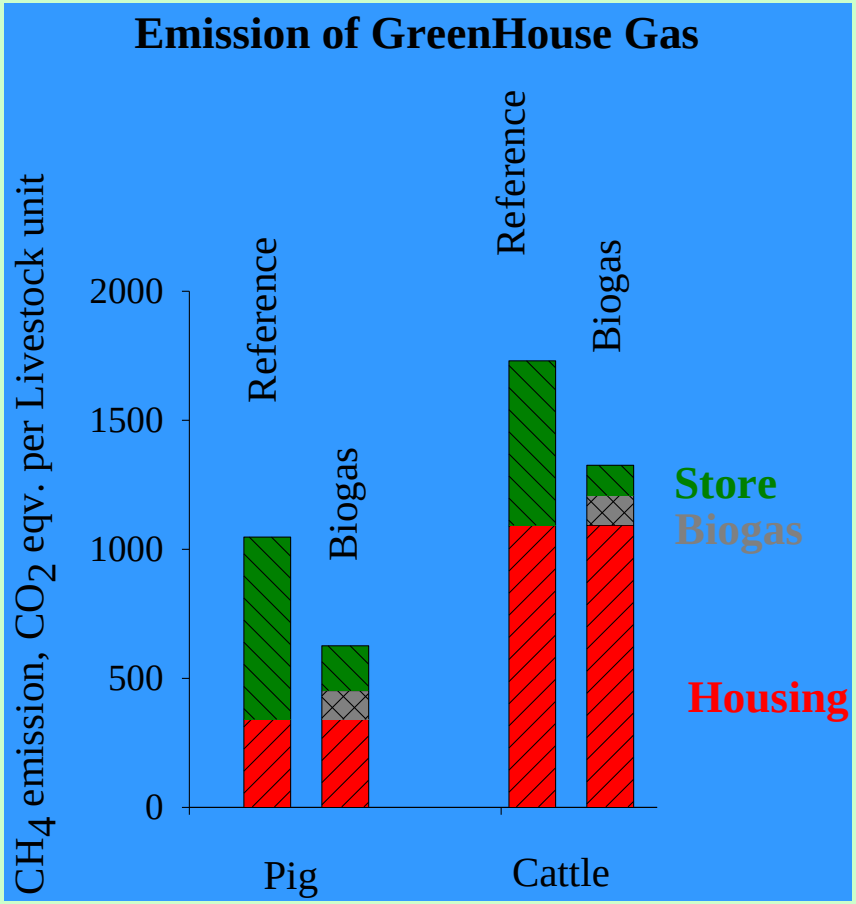
-Improved standards in fresh water systems

-Improved hygienic standards

-Rural development

-New business, new activity in rural areas
-New jobs

Green House Gas emission, with and without biogas production



Economic situation in Danish centralised biogas plants end 2001

	Year of construction	Acceptable	Balance	Under pressure	Unacceptable
V. Hjermitslev	1984		X		
Vegger	1985	X			
Revninge	1989		X		
Ribe	1990	X			
Lintrup	1990	X			
Lemvig	1992	X			
Hashøj	1994	X			
Thorsø	1994	X			
Århus Nord	1995				X
Filskov	1995		X		
Energigr. Jylland	1988/93/96			X	
Blåbjerg	1996	X			
Snertinge	1996				X
Blåhøj	1997		X		
Vaarst-Fjellerad	1997			X	
Nysted	1998				X

Investment and treatment costs, 2000 prices.

	Per day treatment capacity		
Investment costs:	300 m^3	550 m^3	800 m^3
-Biogas Plant	5,5 mil €	7,9 mil €	9,6 mil €
-Vehichles	0,4 mil €	0,6 mil €	1 mil €
Inv. Costs per m^3 biomass treated per year	55 €/m^3	44 €/m^3	37 €/m^3
Treatment costs per m^3 biomass treated per year			
-Transport	2,2 €/m^3	2,2 €/m^3	2,4 €/m^3
-Biogas Plant	7,1 €/m^3	5,5 €/m^3	4,7 €/m^3

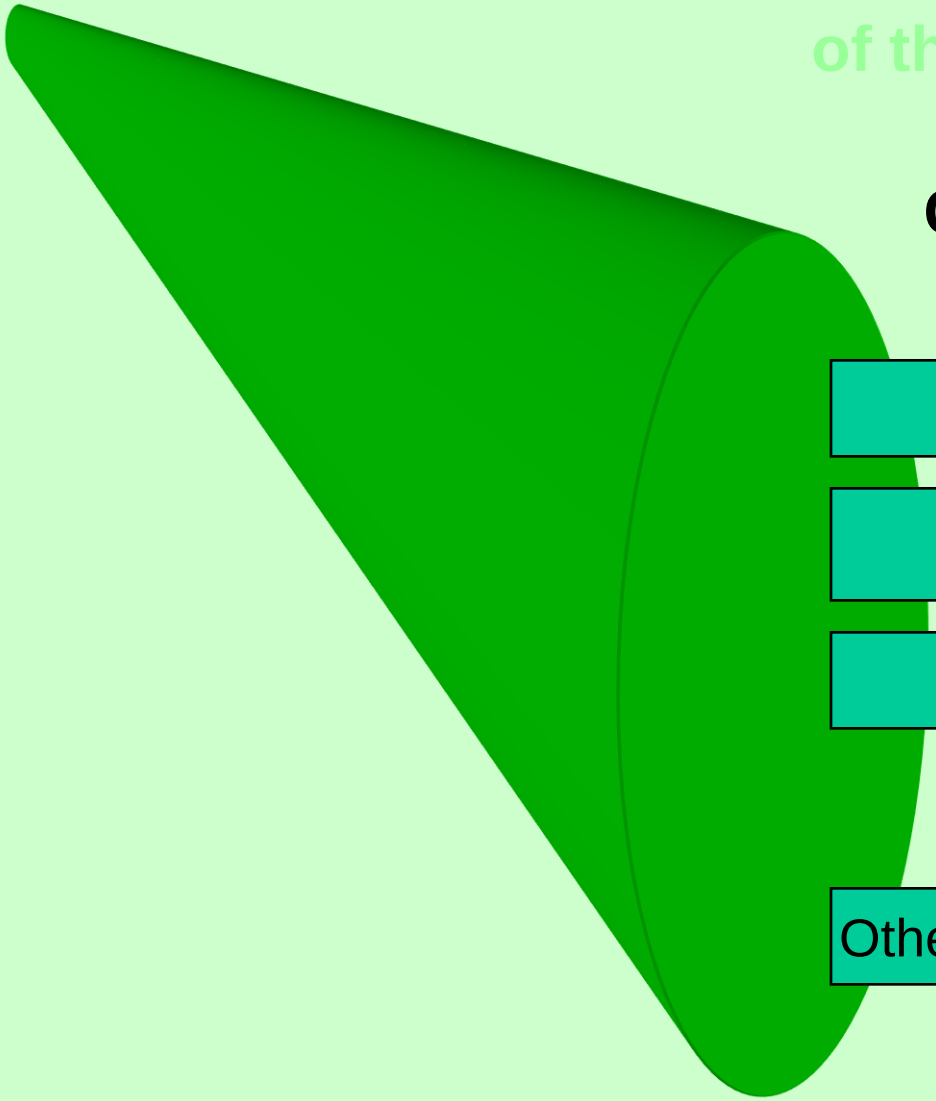
Break even levels of waste admixture and biogas yields

	Per day treatment capacity, m^3 biomass/day		
	300 m^3/day	550 m^3/day	800 m^3/day
Break even level of waste admixture	21 %	13 %	10 %
	m^3 biogas/ m^3 biomass		
Break even biogas yield	34	27	25

Key preconditions:

-Gasyield from manure	22 m^3 biogas/m^3
-Gasyield from waste	75 m^3 biogas/m^3
-Gate fee (receipt of waste)	50 DKK/m^3 waste
-Biogas sales price	2 DKK/m^3 biogas

Socio-economic effects of the CAD plant



Consequences for:

- Agriculture
- Energy-sector
- Industry
- Environment
- Other aspects: Security of energy supply, ..

Alternative

Reference

Monetised Externalities

Biogas plant of treatment capacity:

550 ton/day (20% waste)

Monetised externalities:
Socio-economic value per ton biomass

Results based on biogas plant:
Biogas plant size: 550ton/day (20% waste)

	Monetised	
Agriculture		
Storage, handling and distribution of liquid manure:		
Storage savings for liquid manure	**0.13**	EUR/ton liquid manure
Transport savings in agriculture	**0.07**	EUR/ton liquid manure
Value of improved manurial value (NPK)	**0.73**	EUR/ton degassed
Value of reduced obnoxious smells	**0.67**	EUR/ton liquid manure
Industry		
Savings related to organic waste treatment	**16.82**	EUR/ton org. waste
Environment		
Value of GHG reduction (CO_2, CH_4, N_2O-reduction)	**3.01**	EUR/ton degassed
Value of reduced N-eutrophication of ground water:	**0.39**	EUR/ton degassed
Liquid manure	0.37	EUR/ton liquid manure
Org. waste spread on farm land in reference case	1.64	EUR/ton org. waste
Org. waste not spread on farm land in reference ca	-3.03	EUR/ton org. waste

Annual costs and benefits

Socio-economic results
Annual costs and benefits

Results based on biogas plant:
Biogas plant size: 550ton/day (20% waste)

	Result 0	Result 1	Result 2	Result 3
Costs (levellised annuity)			mio.EUR/year	
Investments, operation and maintenance:	**1.481**	**1.481**	**1.481**	**1.481**
Benefits (levellised annuity)			mio.EUR/year	
Energy production:				
Biogas sales	0.526	0.526	0.526	0.526
Electricity sales	0.061	0.061	0.061	0.061
Agriculture:				
Storage, handling and distribution of liquid manure		0.032	0.032	0.032
Value of improved manurial value (NPK)		0.186	0.186	0.186
Value of reduced obnoxious smells				0.097
Industry:				
Savings related to organic waste treatment		0.675	0.675	0.675
Environment:				
Value of GHG reduction (CO2, CH4, N2O-reduction)			0.605	0.605
Value of reduced N-eutrophication of ground water:			0.079	0.079
Sum:	**0.588**	**1.481**	**2.165**	**2.262**

	Result 0	Result 1	Result 2	Result 3
			mio.EUR/year	
Surplus as annuity: Benefits - costs	**-0.893**	**0.000**	**0.684**	**0.781**

Estimated Environmental Benefits

under Danish Conditions

Reduced Green House Gas emissions

90 kg CO_2 EQ per tonne biomass treated

Reduced Nitrogen leaches to fresh water systems

0,11 kg N per tonne biomass treated

Conclusions

Economically and socio – economically feasible when:

-Organic waste is included, and

-Environmental and economic externalities are taken into account

Very cost-efficient as a tool for Green House Gas reduction

Beneficial for related farmers

Creates jobs and local activity

Why so far (almost) only in Denmark ?

-District heating systems are widespred

-Waste recycling via arable land is/was encouraged

-Legislative push on farmers – regulations on manure application

-Tradition to utilise nutriens from manure in crop production

-Market access and fixed electricity prices.

-Openminded authorities and organisations.

But

Danish centralised co-digestion plants became victims of their own succes.

Demand for suitable organic waste increased, and the market is vacuum-cleaned, so now good waste is hard to find, or too expensive

Treatment fees were reduced or converted into costs.

Since 1998 the enlargement with plants was halted due to a number of barriers;

Reduced public acceptance – fear of smell

-difficult to find sites for construction of plants

Uncertainty about economic performance

-due to reduced average electricity price

-uncertainty about waste supplies

Lack of incentives for farmers

-some farmers wish to redistribute/dispose surplus manure

But now things start moving again because;

-Electricity price increased to 10 eurocents/kwh

-General increase in energy prices makes heat from CHP attractive

-Restrictions on manure handling still increasing

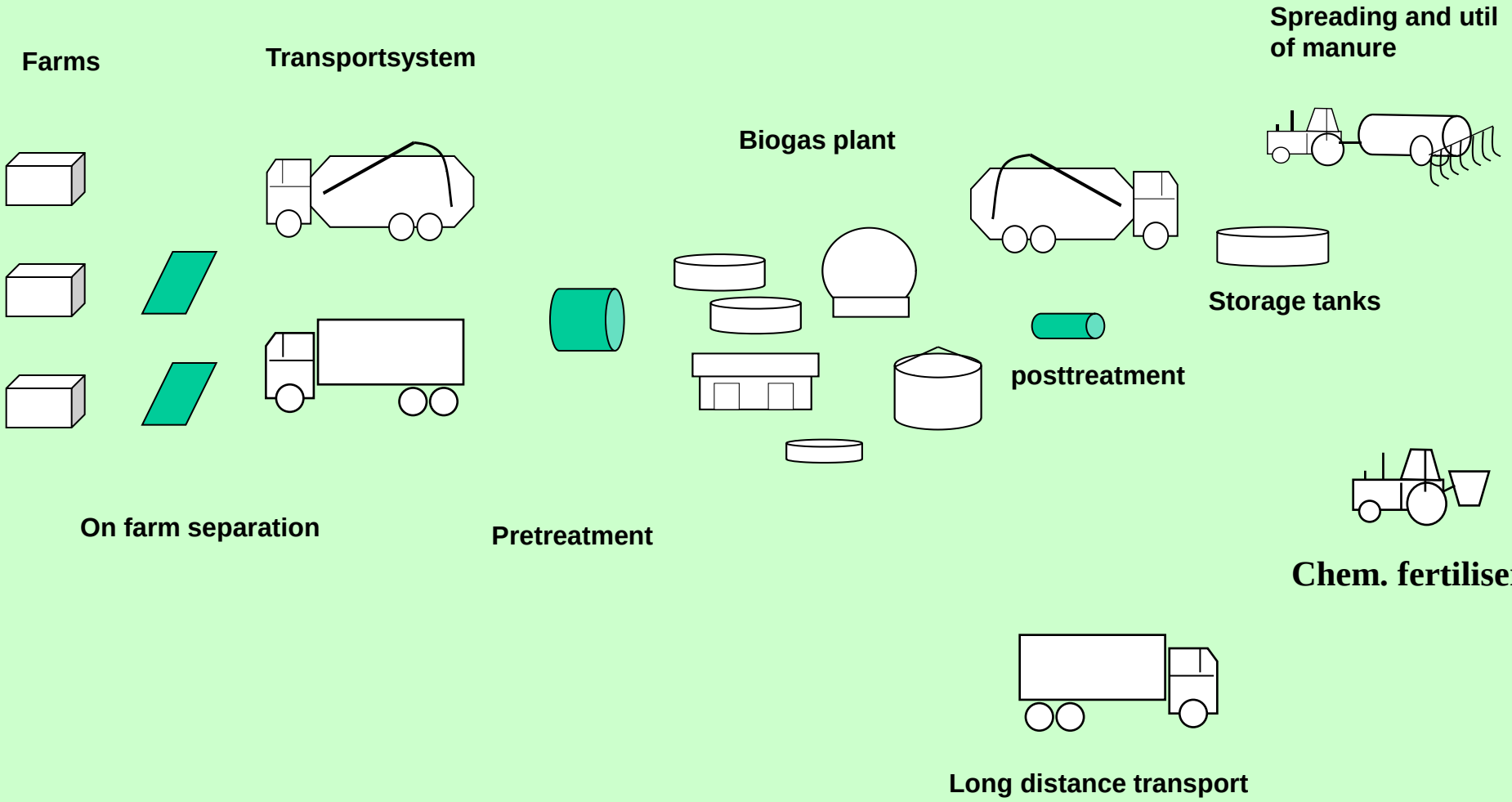
-Farmers wish to supply concentrated animal waste fractions

Government ambition;

3 new large plants every year untill 2025

Potentially up to 75 % of manure in DK

Plant concepts of the future



Aknowledgement

Thanks to Danish Biogas Association for letting us use the pictures in this presentation

www.biogasbranchen.dk

Thank you for your attention