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Biogas Technology for Sustainable Bioenergy Production Jyväskylä University, Finland

Biofertilizer optimal recycling! Processing digestate to valuable products

by

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Scenario for the energy future in Denmark

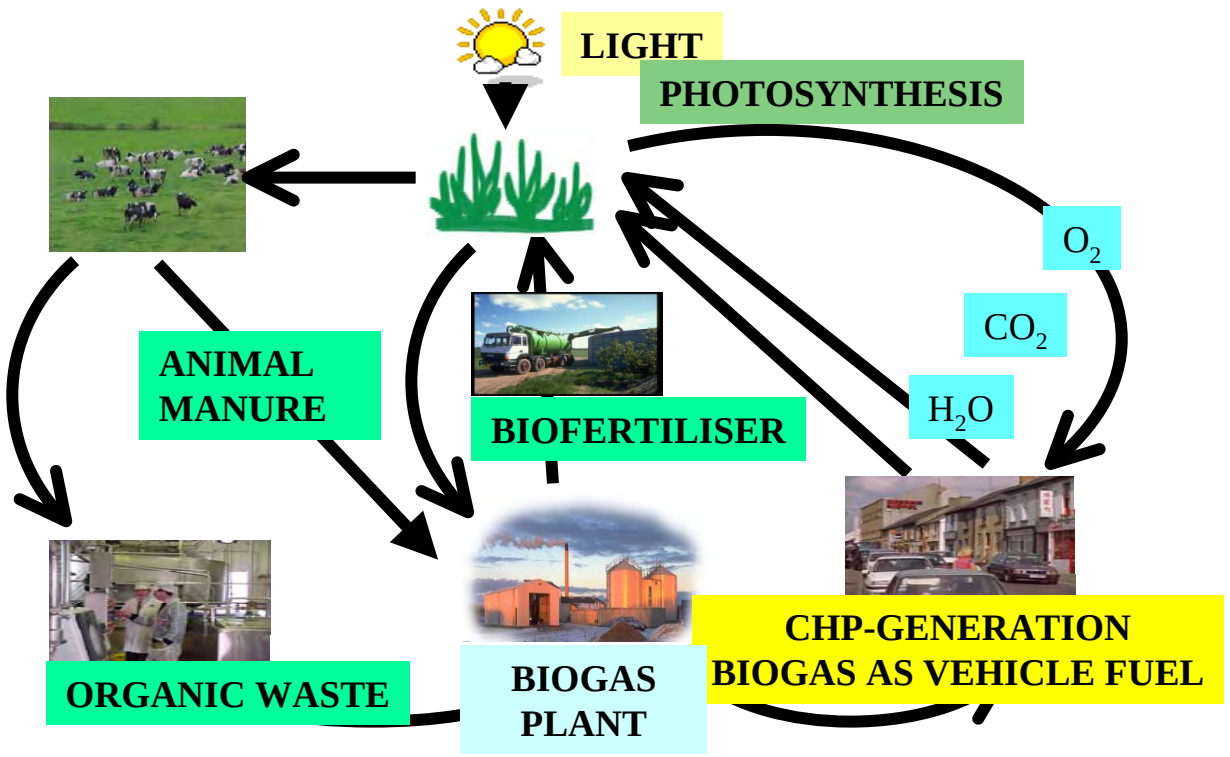
Energy unit: PJ	**2007**	**2025**
Biomass	101	200
Windpower	30	90
Solarpower	~0	75-100
-photovoltaic	~0	
-passive	~0	
Hydropower	~0	
-Wave	~0	
Geothermal	~0	
Fossil fuels	650	200
Total consumption	**800-850**	**600**

Source; JBHN – Centre for Bioenergy, AAUE/SDU, Esbjerg 2007

Future society needs & demands!

- Minimizing the fossil fuel dependencies
- Making the food production more sustainable
  - Increasing the nutrient recirculation
  - Minimizing the odour from animal production
  - Increased rural employment, new jobs
- Balanced resource utilization
  - Energy, nutrients/fertilizers, land use, money/finanzing
- Developing new knowledge based industries
- Minimizing greenhouse gas release
  - **Too big focus on the energy sector / single sectors**
  - **New focus on more diversified areas of the society**
    - farming and rural development,
    - transportation sectors,
    - consumers and living conditions
    - Biogas and renewables will be increasing tools

Biogas for a sustainable clean environment and renewable energy production



Source: JBHN/TAS

Manure based co-digestion biogas plant - the basic joint biogas concept

Animal manure and slurry from local farms

- Dairy and cattle slurry
- Pig slurry
- Poultry manure

INPUTS

Organic wastes

- Waste from food processing industries
- Vegetable and catering waste
- Household waste, source separated

- Homogenisation
- Pasteurisation
- Digestion and gas production

- Odour reduction
- Fibre and liquid separation
- Nutritionally defined product

Agricultural biofertiliser

OUTPUTS

* Improved utilisation of plant nutrients

Reduced consumption of mineral fertilisers

Reduced water pollution

Disease and weed seed free biofertiliser

Separated fibre/soil improver

Biogas for combined heat and power generation

- Renewable energy source
- Displacement of fossil fuel
- CO2 - neutral
- Reduced air pollution
- Effective energy utilisation

Ribe Biogas; 15 years of production, 18.000 m3 biogas/day.
Source J. B. Holm-Nielsen, Bioenergy Dept., SDU, Denmark.

Estimated amounts of animal manure in EU-27 (based on Faostat, 2003)

Country	Cattle	Pigs	Cattle	Pigs	Cattle manure	Pig manure	Total manure
	[1000Heads]	[1000Heads]	1000livestock units	1000livestock units	[10^6 tons]	[10^6 tons]	[10^6 tons]
Austria	2051	3125	1310	261	29	6	35
Belgium	2695	6332	1721	529	38	12	49
Bulgaria	672	931	429	78	9	2	11
Cyprus	57	498	36	42	1	1	2
Czech R.	1397	2877	892	240	20	5	25
Denmark	1544	13466	986	1124	22	25	46
Estonia	250	340	160	28	4	1	4
Finland	950	1365	607	114	13	3	16
France	19383	15020	12379	1254	272	28	300
Germany	**13035**	**26858**	**8324**	**2242**	**183**	**49**	**232**
Greece	600	1000	383	83	8	2	10
Hungary	723	4059	462	339	10	7	18
Ireland	7000	1758	4470	147	98	3	102
Italy	6314	9272	4032	774	89	17	106
Latvia	371	436	237	36	5	1	6
Lithuania	792	1073	506	90	11	2	13
Luxembourg	184	85	118	7	3	0	3
Malta	18	73	11	6	0	0	0
Netherlands	3862	11153	2466	931	54	20	75
Poland	5483	18112	3502	1512	77	33	110
Portugal	1443	2348	922	196	20	4	25
Romania	2812	6589	1796	550	40	12	52
Slovakia	580	1300	370	109	8	2	11
Slovenia	451	534	288	45	6	1	7
Spain	6700	25250	4279	2107	94	46	140
Sweden	1619	1823	1034	152	23	3	26
U.K.	10378	4851	6628	405	146	9	155
EU-27	**91364**	**160530**	**58348**	**13399**	**1284**	**295**	**1578**

Energy potential of pig and cattle manure in EU-27

Total manure	Biogas	Methane	Potential	Potential
[10^6 tons]	[10^6 m^3]	[10^6 m^3]	[PJ]	[Mtoe]
1,578	31,568	20,519	827	**18.5**

Methane heat of combustion: 40.3 MJ/m^3; 1 Mtoe = 44.8 PJ
Assumed methane content in biogas: 65%

Biogas Production & Forecast:

Actual 2008 production of biogas in EU 27:	7 Mtoe
2012-2015 EU forecast	15 Mtoe
Manure potentials	18.5-20 Mtoe
Organic waste and byproducts	15-20 Mtoe
Crops and crop residuals	20-30 Mtoe
Total long term forcast Biogas	**60 Mtoe**

Biogas can cover 1/3 of EU's total RES 20% demands year 2020

AD Co-digestion - heterogeneous feedstock's

- Manure
- Food waste
- Organic by-products
- Crops

Biogas and biogas + separation, upgrading facilities

Animal manure

– from farming problems to society resources!

Biogas in Denmark 2009

- Joint biogas and farmbased biogas

Amounts of manure and organic waste 2008:

Animal manure t/y	1.742.156
Organic waste t/y	450.708
Total t/y - 2008	2.192.864

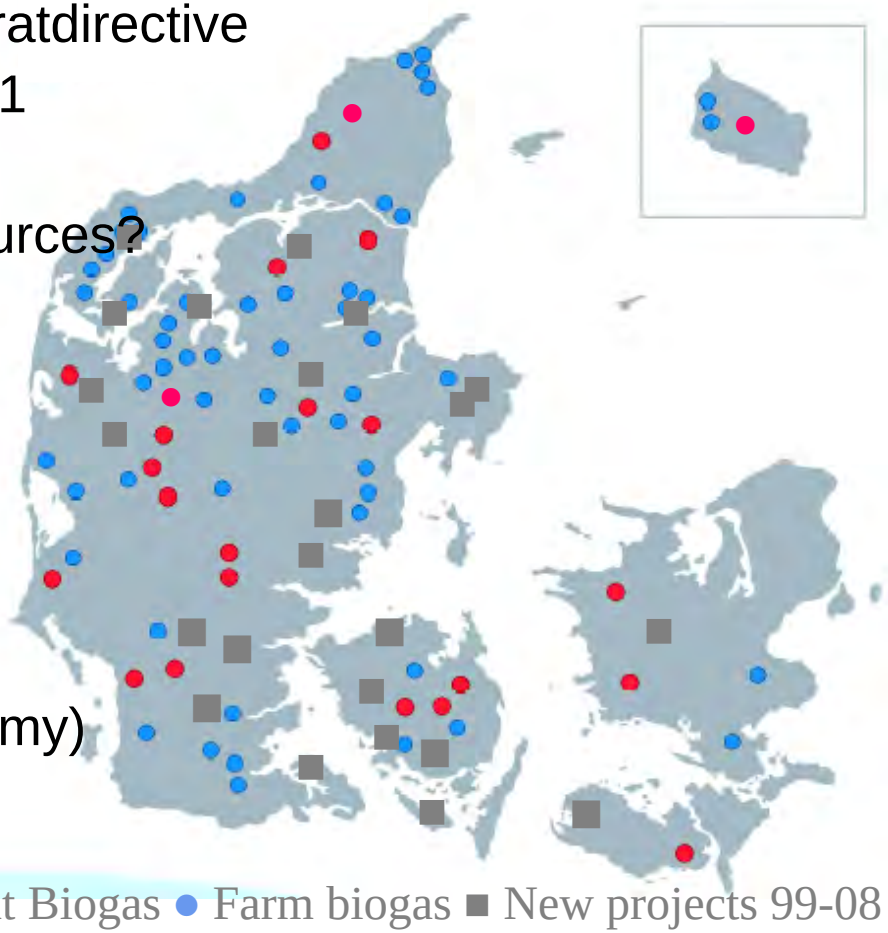
Big biogas interests from the farming society

New environmental demands – nutrients and green house gasses

- Freshwater planning-, Habitat- and nitratdirective
- Water environmental actionplan-4 2011
- Manure treatment before application?
- Methan release, N2O, Soil-Carbon sources?

Needs/demands?

- Reduction of Odour
- Redistribution of Manure
- Reduction of surplus (N/P)
- Recovering and recyc. of P (resource)
- Optimal utilization of N (enviro., economy)
- Carbon source sustainability



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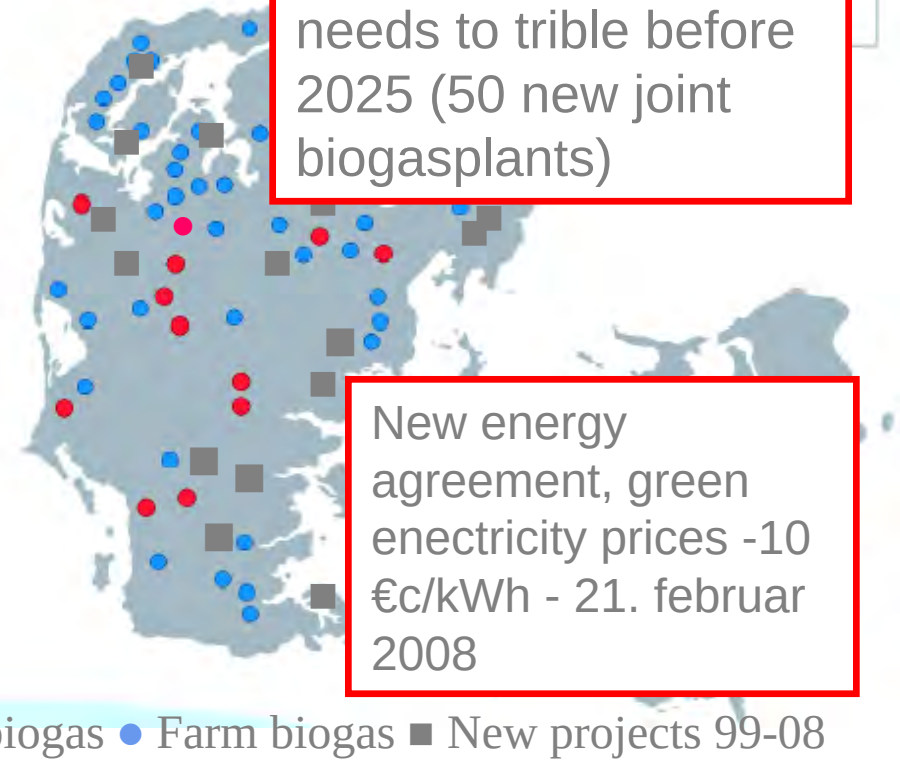
DK government 19. januar 2007:

Biogas production needs to trible before 2025 (50 new joint biogasplants)



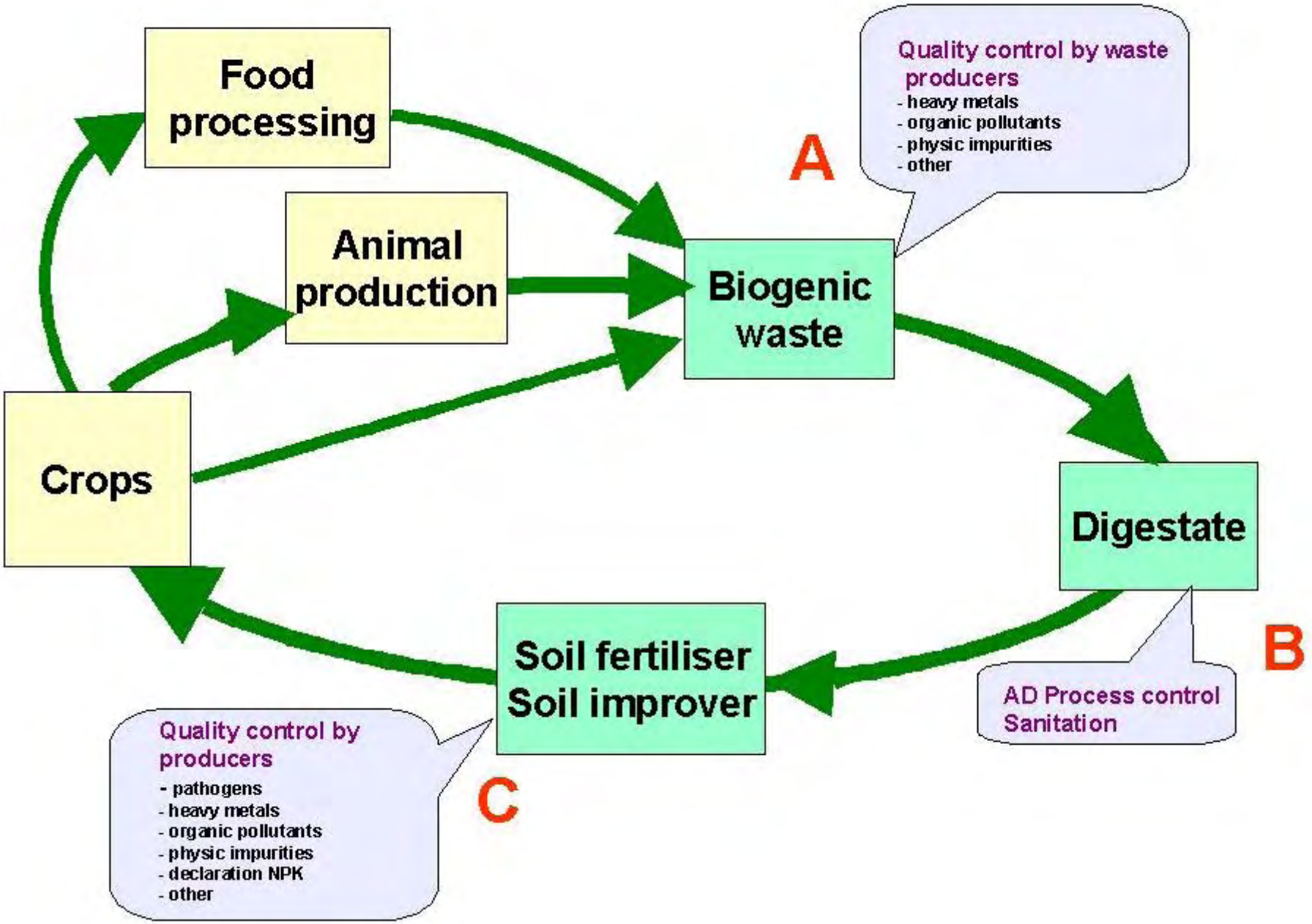
New energy agreement, green enectricity prices -10 €c/kWh - 21. februar 2008

Advantages of biogas plants

- Greenhouse gas reduction
- Utilisation of organic waste
  - co-digestion
  - increased gas production
  - gate fee
  - reduced costs for industry
  - new types of biomass:
    - energy crops
    - animal by-products

Type of waste	Tonnes
Gut and stomach content	110000
Fat / flotation sludge	71000
Feeding factories	10000
Fish industry	50000
Fruit and vegetables	3600
Breweries	800
Bakeries	1900
Dairies	29000
Pectin industry	7000
Bleech earth	17000
Tanneries	2300
Pharmaceutical industry	20500
Concentrated fat waste	2600
Waste from water supply	1600
Other industrial waste	10000
Sewage sludge	20000
Household and catering waste	17000
Total	374300

Source: DK-Joint biogas plants 2002


Food processing
Animal production
Crops
Biogenic waste
Digestate
Soil fertiliser
Soil improver
A
Quality control by waste producers
- heavy metals
- organic pollutants
- physic impurities
- other
B
AD Process control
Sanitation
C
Quality control by producers
- pathogens
- heavy metals
- organic pollutants
- physic impurities
- declaration NPK
- other

Pre-Treatment

- Hygienic step if recycling nutrients
- Separate unit to guarantee of retention time
- Elimination of pathogens and weeds

Main measures contributing to veterinary safe recycling of co-digested animal manure

- Livestock health control: No animal manure and slurries will be supplied from any livestock with health problems

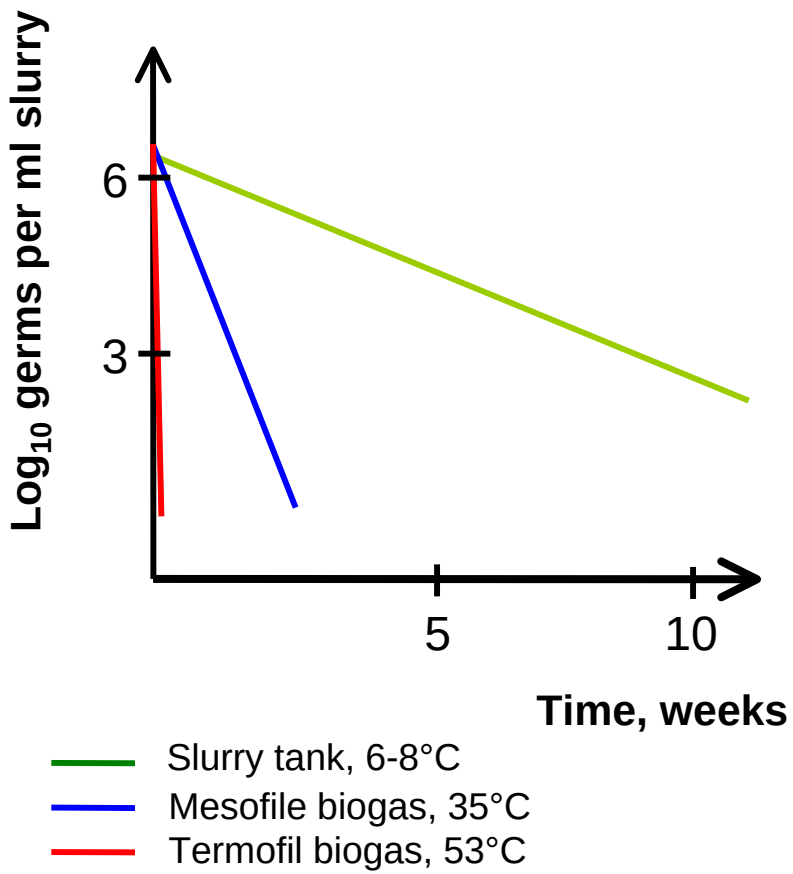
- Feedstock selection and control. Hazardous biomass types are excluded from anaerobic digestion and canalised towards suitable, safe treatment and disposal methods

- Pre-treatment/sanitation of feedstock
  - Pressure sterilisation: 133 ^{0}C, 3 bar, for 20 minutes for category 2, except for manure

- Pasteurization: 70 ^{0}C, for 1 hour for category 3

- Regularly control of the efficiency of pathogen reduction

Digested slurry is low on germs



Test results from Ribe Biogas, bacteria per ml. slurry (1998)

Date	Before	After
Mar. 18	1,300,000	<5
May 13	140,000	<5
July 15	690,000	<5
Sept. 9	9,000,000	<5
Nov. 11	62,000	<5

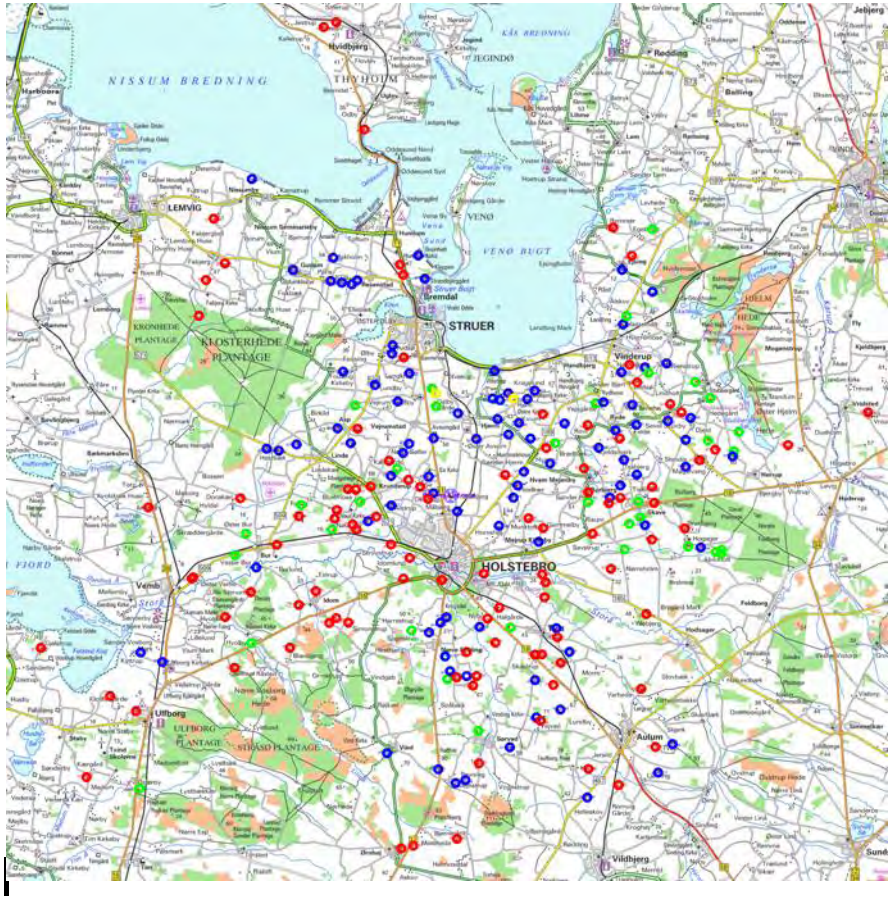
Source: Danish Agricultural Advisory Centre, Aarhus, DK

Four contributions to better fertilizer value

1. Lower ammonia volatilization due to faster absorption in the soil
2. Increased availability of nitrogen due to mineralization of organic bound nitrogen
3. Better balance between requirement of P and K and the application of P and K
4. Organic waste is added to the manure

Society benefits from biogas

- Joint biogas and farm biogas
- Cheap Kyototool 40 kr/ton CO2
- Recycling of organic waste
- Efficient redistribution of manure
  - From animal farms to crop farmers
  - From stables to decentralized slurry tanks in the fields
  - Trucking througout the year
  - Environmental technology to all kinds of farms



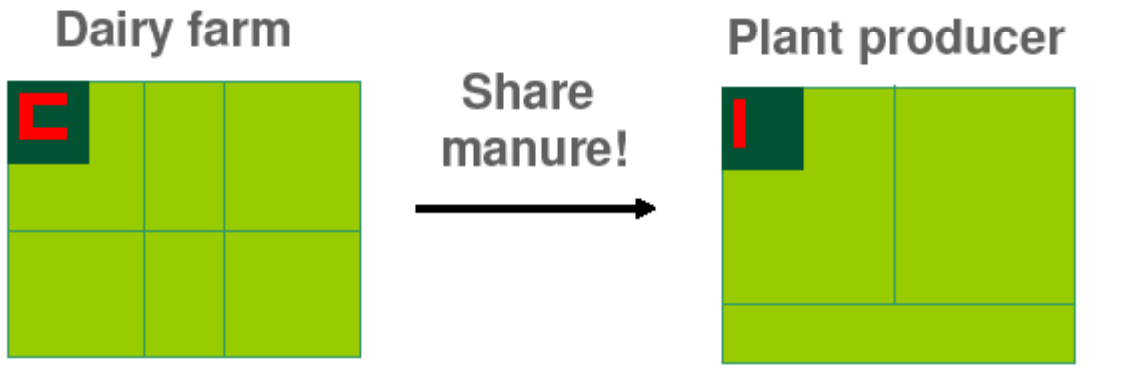
P and K-utilization – an example

P-requirement: 20 kg P/ha
P-application: 40 kg P/ha
P-utilization: 50 percent
P i mineral fertilizer: 0 €/ha

P-requirement: 20 kg P/ha
P in manure: 0 kg P/ha
P-utilization: -
P i mineral fertilizer: 22 €/ha

Danish Agricultural Advisory Service
National Centre

P and K-utilization – an example



P-requirement: 20 kg P/ha
P-application: 20 kg P/ha
P-utilization: 100 percent
P i mineral fertilizer: 0 €/ha

P-requirement: 20 kg P/ha
P in manure: 20 kg P/ha
P-utilization: 100 percent
P i mineral fertilizer: 0 €/ha

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Advantages of biogas plants

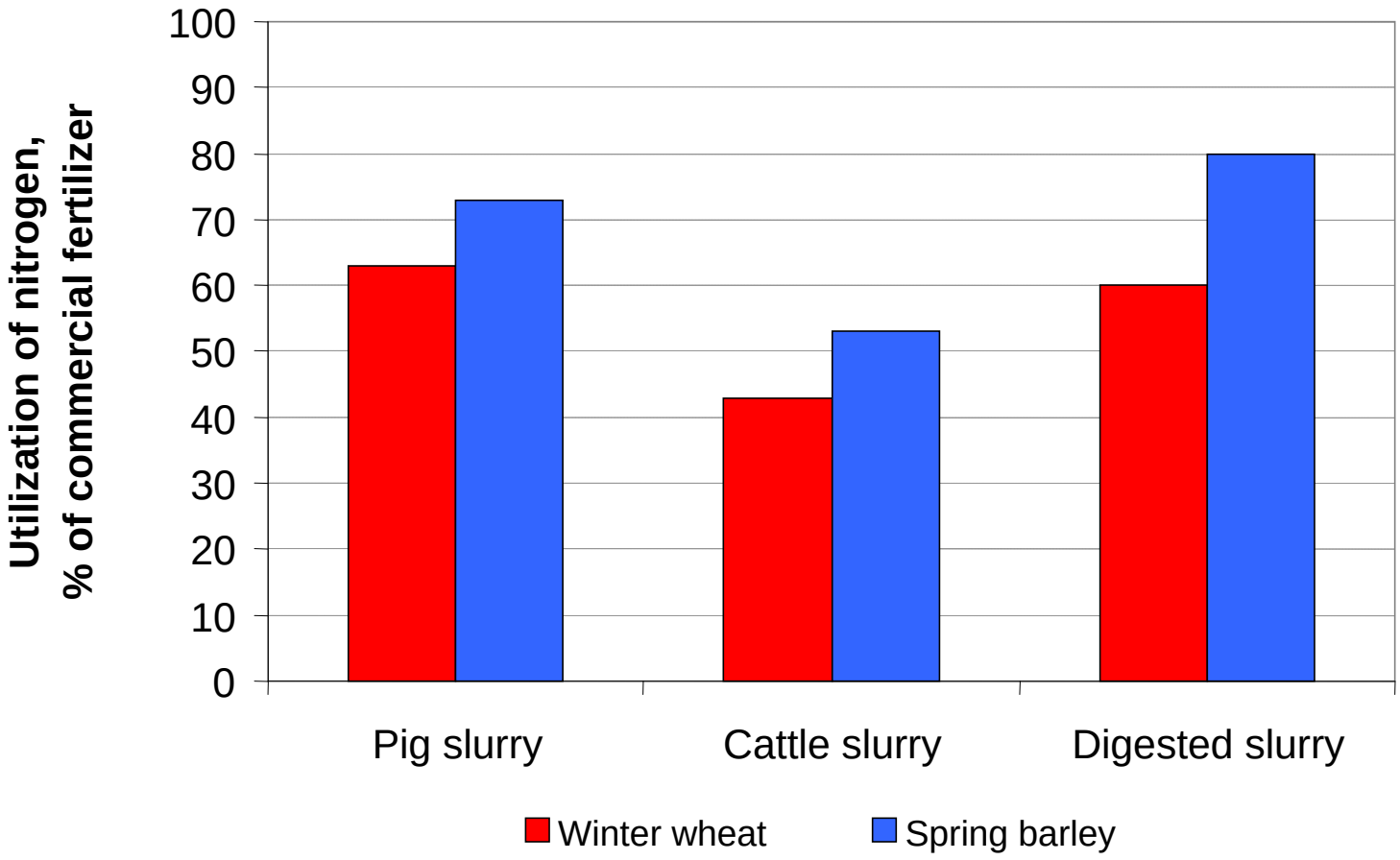
- Greenhouse gas reduction
- Utilisation of organic waste
- Redistribution of manure
- Organic fertiliser
  - declarated nutrient content
  - free of pathogens and weed seeds

Kg/ton	
Total N:	5,0
NH4-N:	4,0
P:	0,9
K:	2,8

Mixing and digesting slurry change the characteristic of the slurry

	DM, %	N-tot, kg/t	NH_4-N, kg/t	P, kg/t	K, kg/t	pH	NH_4-N, %
Digested slurry	4.8	4.4	3.5	1.0	2.3	7.6	81
Pig slurry	5.0	4.8	2.9	1.1	2.3	7.1	74
Cattle slurry	7.5	3.9	2.4	0.9	3.5	6.9	61

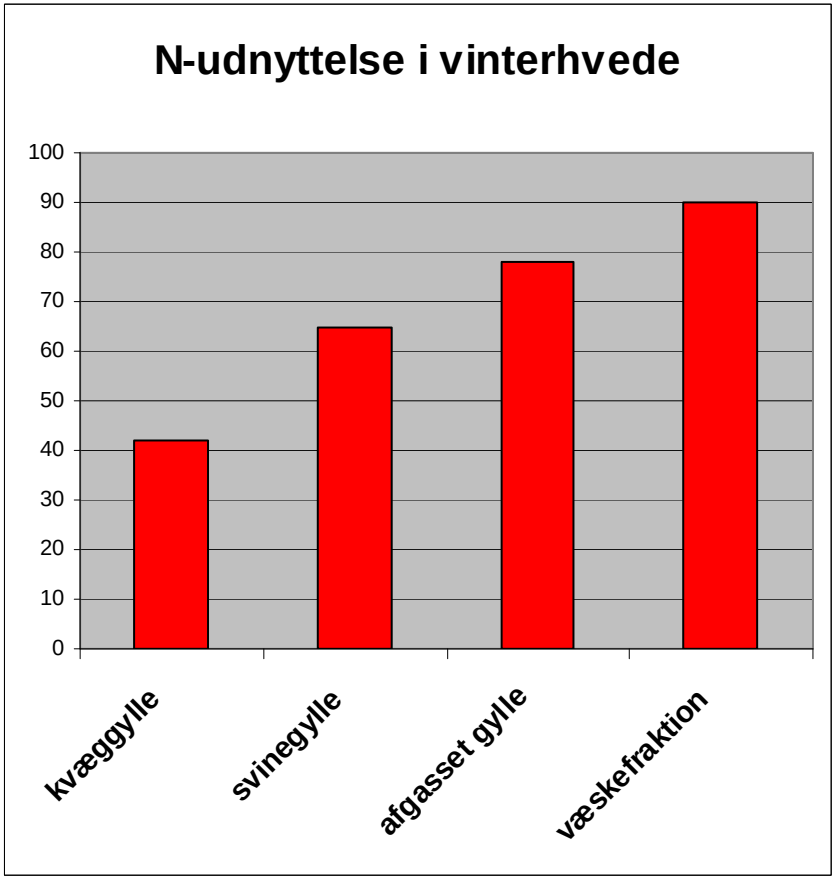
Fertilizer value



Source: Danish Agricultural National Advisory Centre, Aarhus, DK

Samfundsmæssige fordele ved biogas

- Fællesanlæg og gårdanlæg
- Billigt Kyotoredskab 40 kr/ton
- Genanvendelse af affald
- Effektiv omfordeling af gylle
- Deklareret gødningsindhold
- Fri for ukrudt og patogener
- Mindre lugt ved udbringning
- Lettere at få afsat gyllen
- Højere kvælstofudnyttelse
- Lavere udvaskningsrisiko
- Mulighed for separation



Advantages of biogas plants

- Greenhouse gas reduction
- Utilisation of organic waste
- Redistribution of manure
- Organic fertiliser
- Smell from slurry reduced
  - thinner liquid
  - disperses quicker into soil
  - less complaints from neighbours
  - easier to find fields for spreading digested than raw slurry

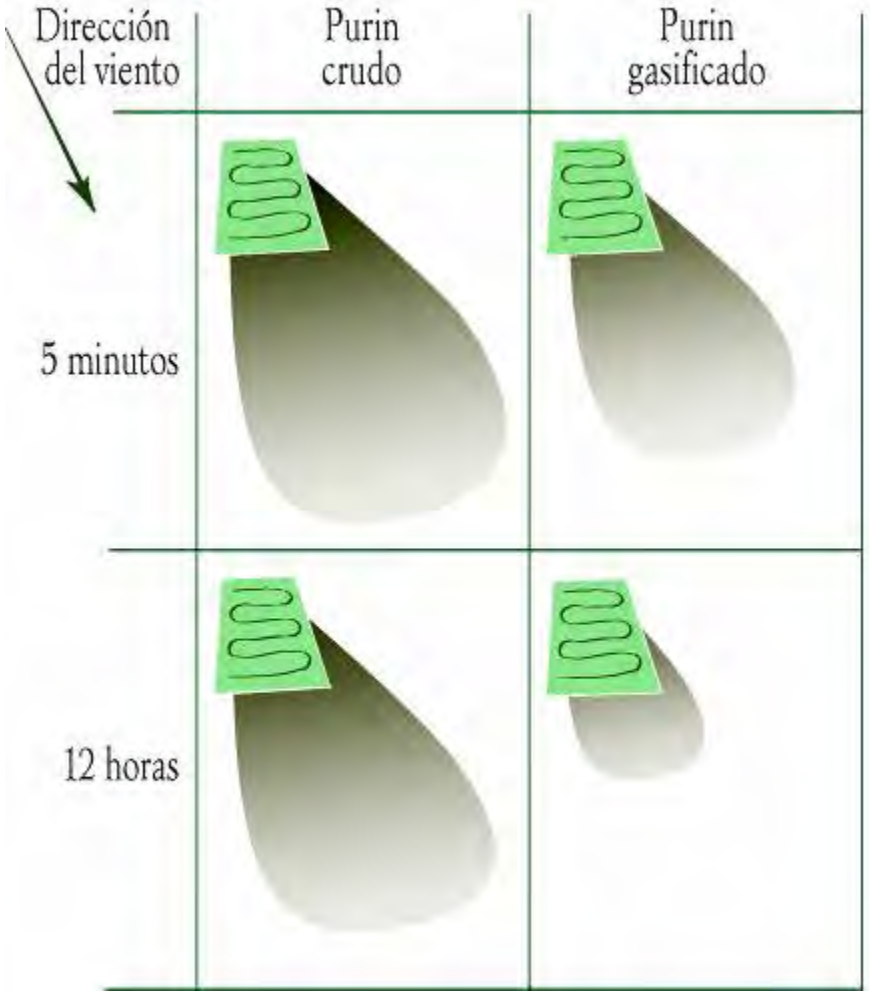


Foto: Torben Skøtt, BioPress

Biogas and separation

Combination of slurry-separation with biogas-production

- Large scale and joint benefits
- As well a tool for small producers
- No extra transport
- Better energy yields
- In husbandry dense areas
- Hyginize the slurry (Animal byproduct doc. 1774!)
- Industrtial upgrading and sales of fertilizer products!

Biogas and separation

Digested slurry

Fiberfraction ← Decanter → Liquid fraction

70 pct. P

15 pct. af volume

Objectives:

- sustainability
- relations to neighbours
- further development of farm

80 pct. N

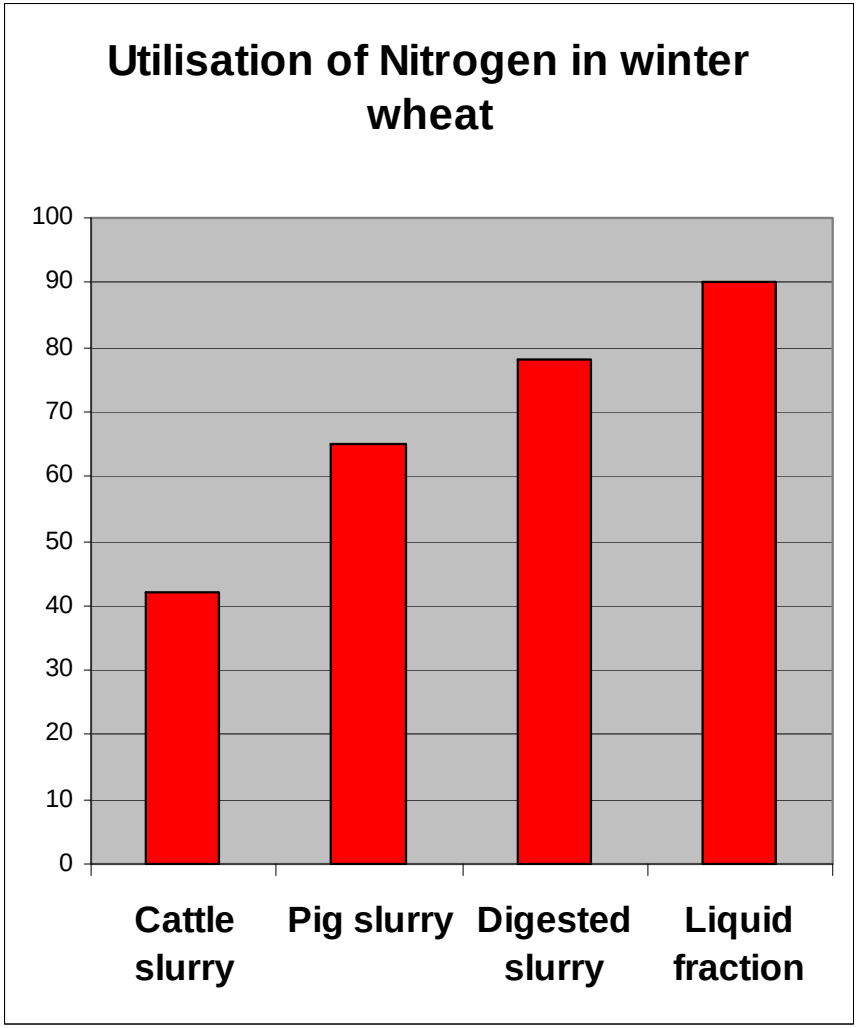
Almost all ammonium

5 field trials: N i fibres, fiberpillets and liquid fraction for spring barley, 2003

		Grain yields & surplus yld.
1	0 N	**34,2**
2	40 N	8,9
3	80 N	14,6
4	120 N	18,8
6	120 total-N i fiber	11,2
7	40 N + 120 total-N i fiber	15,6
8	40 N + 120 total-N i fiberpiller	9,9
9	80 NH_4-N i væskefraktion, slangeudl.	16,3
10	80 NH_4-N i væskefraktion, nedfældet	17,7

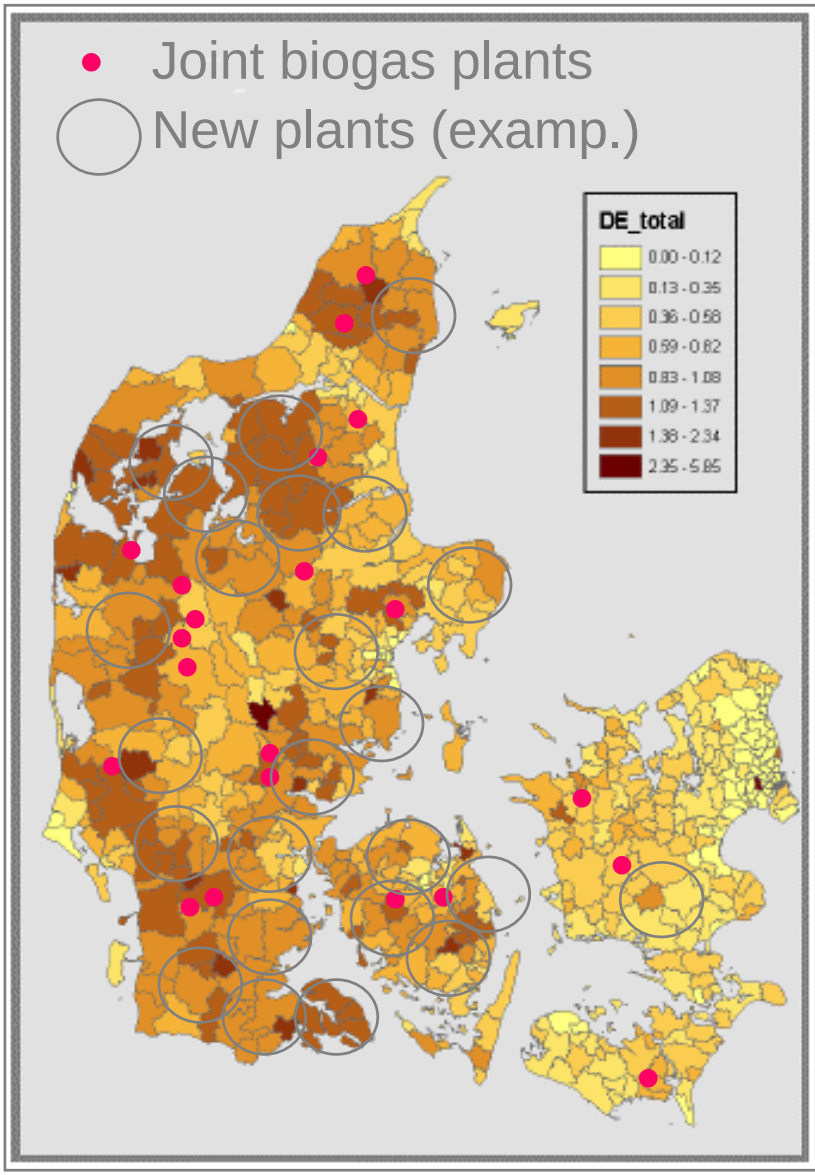
Source: Danish Agricultural Advisory Centre, Aarhus, Dk.

Biogas and separation



Biogas

- **Redistribution and treatment facilities,**
- **Organic fertilizer plants**
  - Bioslurry, biofibres and other biomasses.
  - Redistribution and surplus treatment as organic fertilizer sale products
  - Electricity, heat and transportation fuels
  - Water environment, Climate tool and odour reduction
  - Further treatment of fibres
  - Digested fibre incineration /gasification
- **Increased utilisation of biogas**
  - Local and further distances from the biogas plants – gas grid injection.
  - CHP utilisation and the transport sector



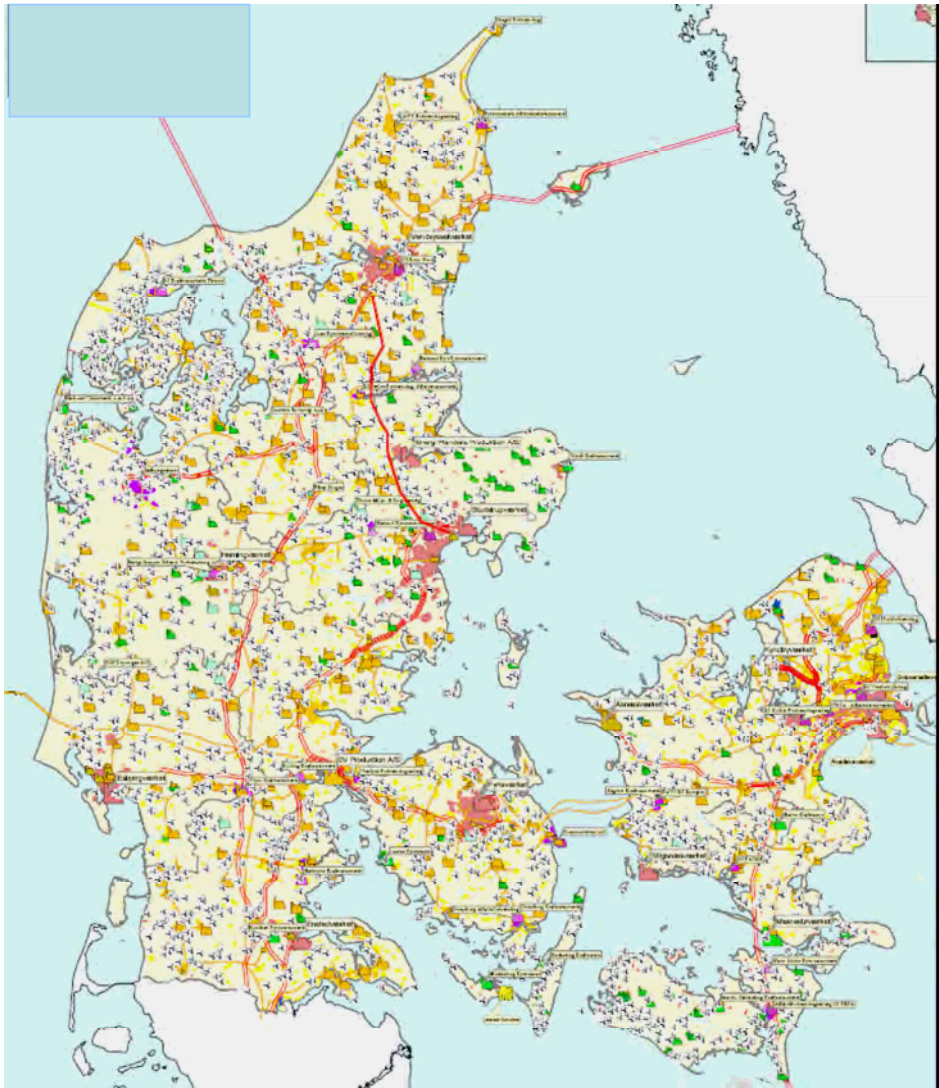
Where to utilize the biogas?

Decentralized CHP

- Direct transmission
  - Cheap and simple
  - Local integration?
- Naturgas grid trans.?
  - Possibilities of storing
  - Better heat utilisation?
  - Expensive upgrading
  - Downgrading of N-gas

Transportfuels

  - Most efficient biofuels, low carbon footprint!



Conclusion

Biogas is an efficient conversiontechnology, converting biomass to high value products as electricity, heat and/or transportation fuel and organic fertilizer

- Converting heterogeniously biomass to values
- Flexible and stable supply of – power, heat, fuels
- Energy sector bridge from demands of today to future needs of:
  - CHP solutions and transport
  - CHP applications and fuel cells
  - Stationary or mobile
- Society trouble-shooter regarding solutions:
  - Climate, water-environment, agriculture and rural development

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Biogas from co-digestion of animal manure

Thank you for your attention!

Further information via
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