Conference on Biomass and Energy for the Great Lake Bio-Economy
Queens University, Ontario, Canada
8.th and 9.th of June 2008

Europe's Progress Toward Energy Security and Greenhouse Gas Reductions Through Intelligent Renewable Energy Strategies

Bioenergy – cases of large scale CHP co-generation plants and Biogas plant developments

Integration between **agriculture - forestry - energy & environmental sectors**!!!

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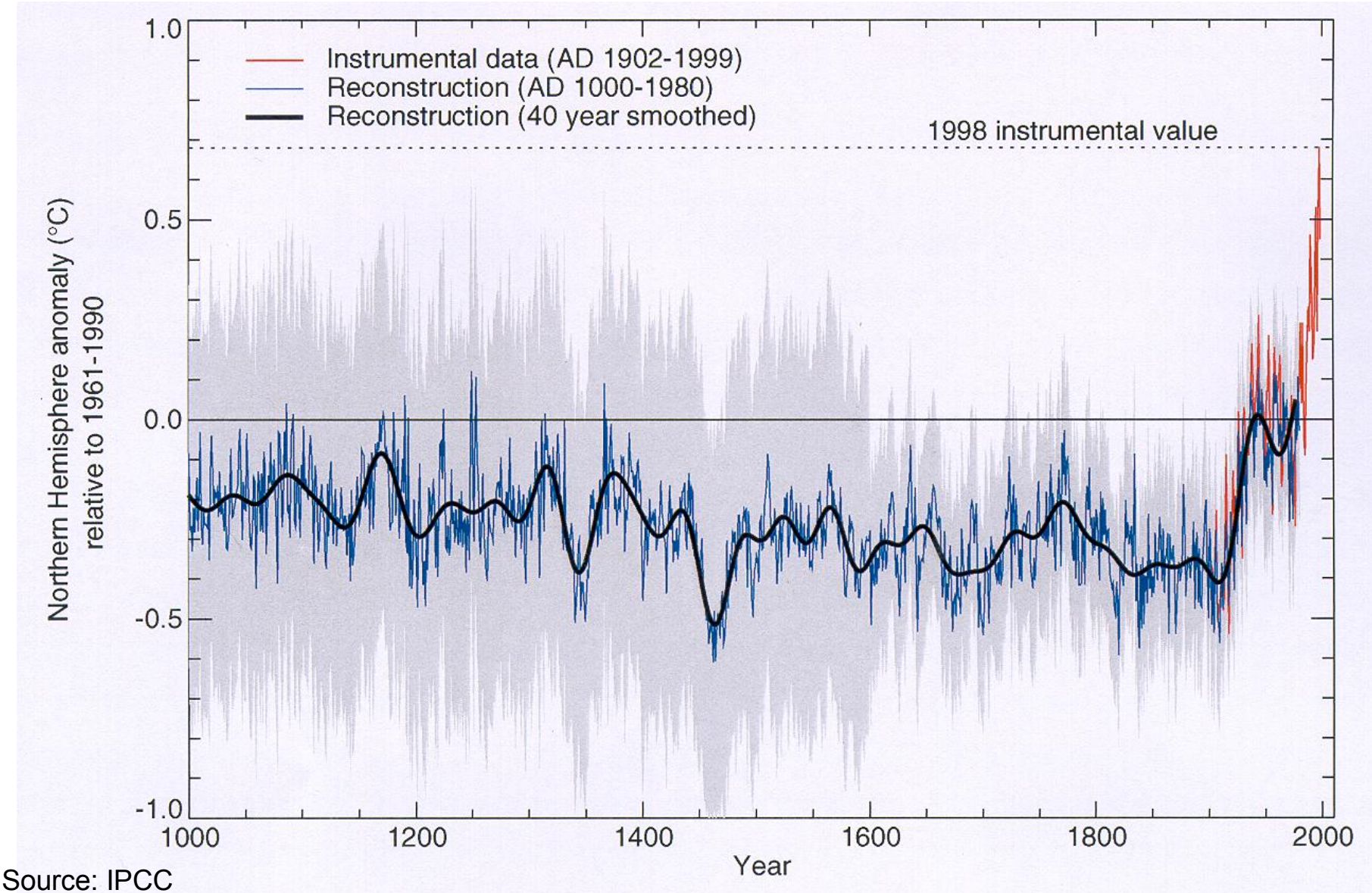
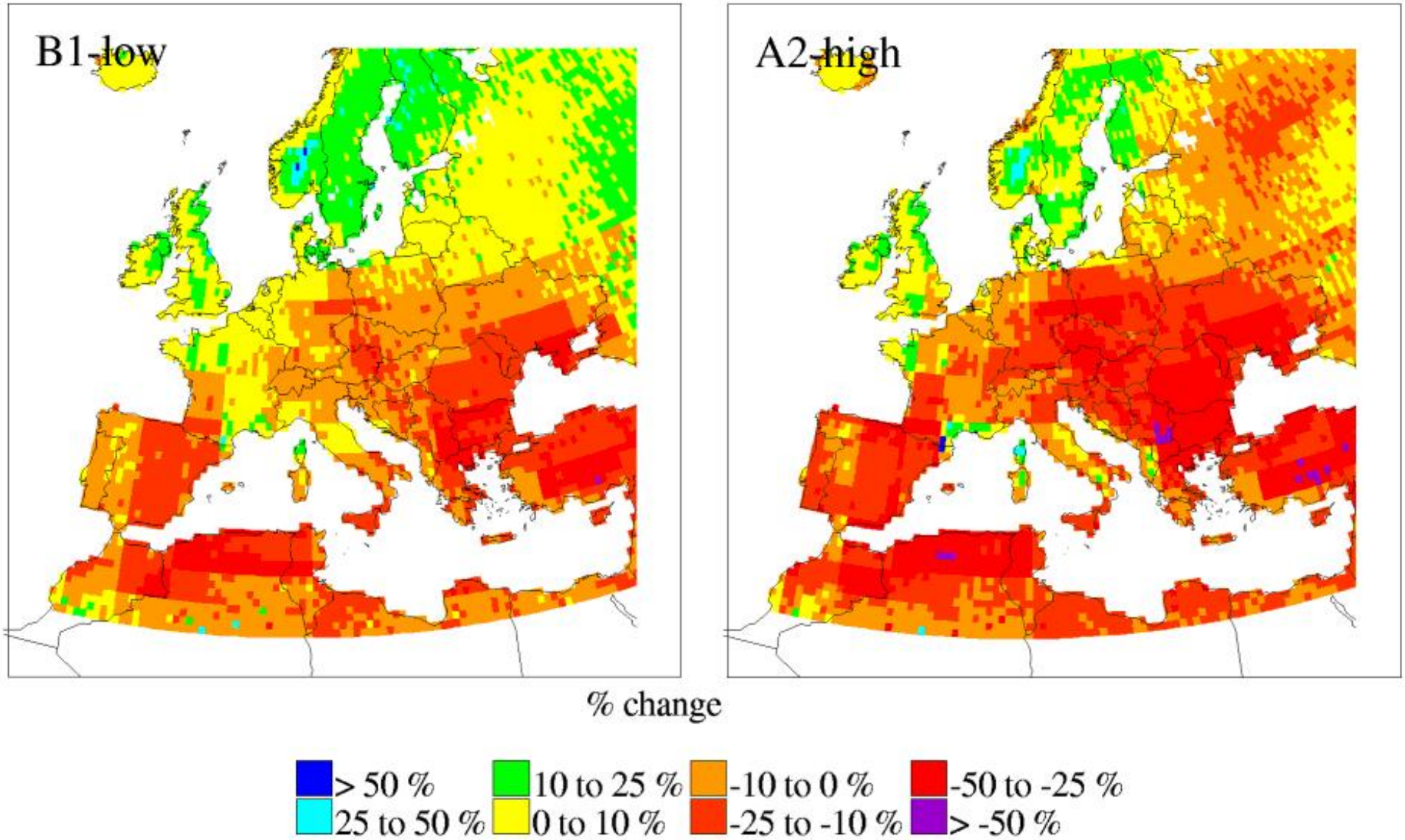
Development in global mean temperature



Source: IPCC

Changes in the water balance in the 2050'ties



Energy crop potential in EU-27, depending on percentage of utilized arable land and achieved crop yield

Yield	10% arable land in EU-27		20% arable land in EU-27		30% arable land in EU-27	
10 t TS/ha	2,042 PJ	46 Mtoe	4,084 PJ	91 Mtoe	6,127 PJ	137 Mtoe
20 t TS/ha	4,084 PJ	91 Mtoe	8,169 PJ	**182 Mtoe**	12,253 PJ	274 Mtoe
30 t TS/ha	6,127 PJ	137 Mtoe	12,253 PJ	274 Mtoe	18,380 PJ	410 Mtoe

New EU energy plan include a cut in CO_2 emissions by at least **20%** by **2020**. The EU-Commission demands increasing the use of renewable energy sources to **20%** of the total demand, to limit global temperature changes to no more than 2°C above pre-industrial levels. It also wants to improve the EU's energy efficiency by **20%.** This would make Europe the most energy-efficient region in the world.

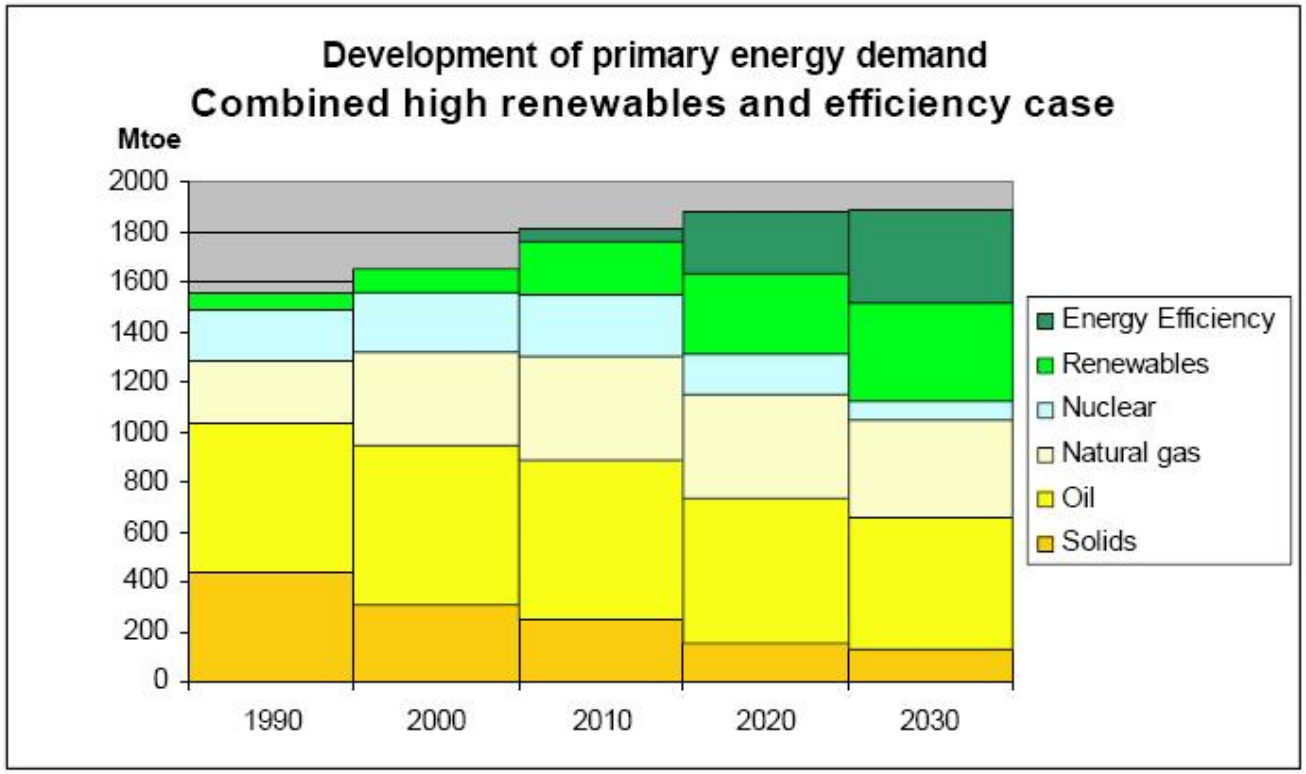


Figure 9: Impact of the strong renewable energy and energy efficiency penetration on the EU's primary energy demand (PRIMES modelling results)

Source: European Commission

182 Mtoe can be achieved from biomass cultivated on 20% of arable land in EU-27.

This corresponds to more than 10% of primary energy demand in 2020, equals 50-60% of the RES share.

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%

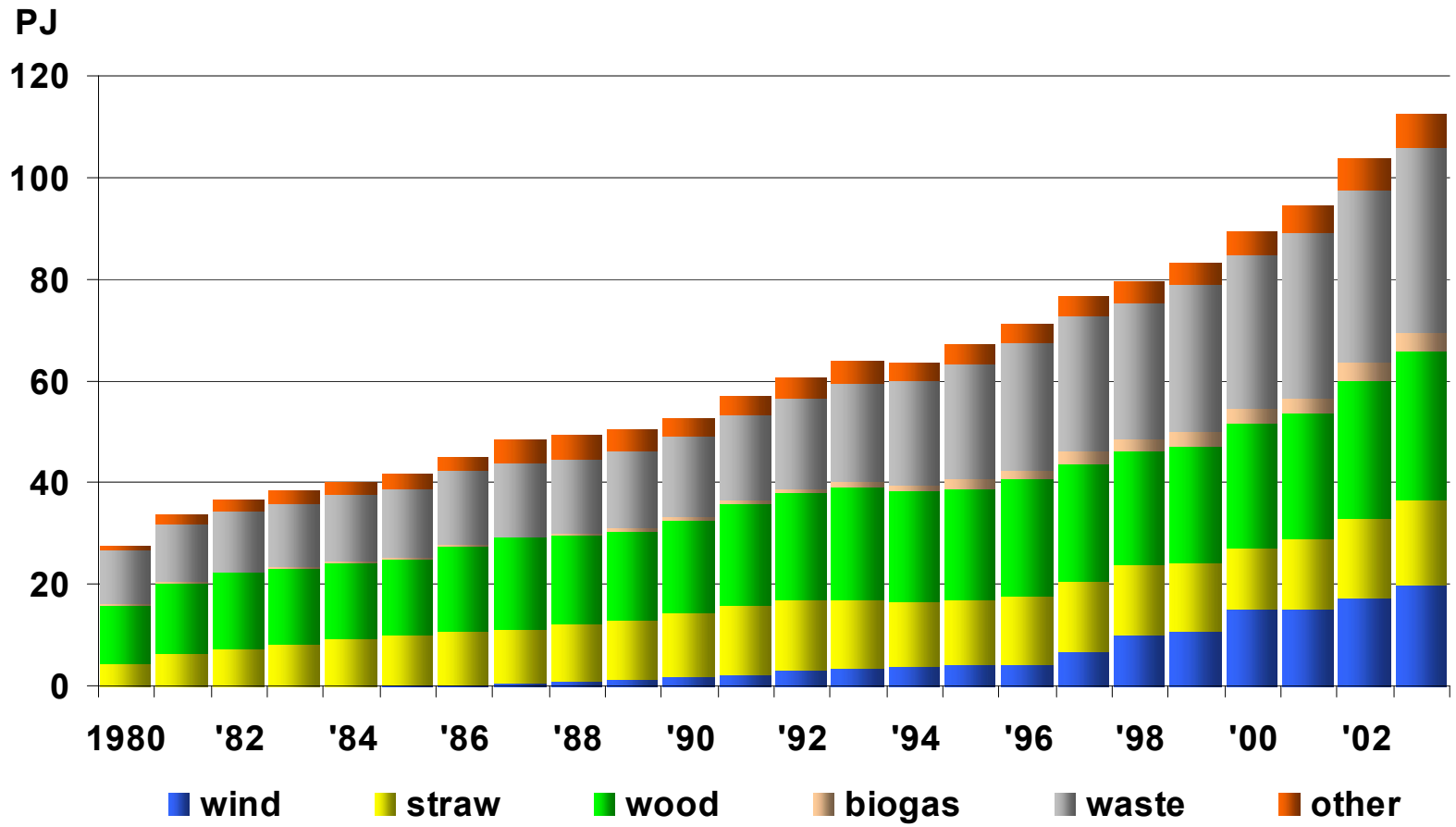
Cultivation of non-food crops in Germany in 2006

Raw materials	Surface area in ha			Total
	Base areas*		Set aside	
	without energy crop premium	with energy crop premium		
Rapeseed	610,000	172,000	318,000	1,100,000
Oilseed lin	3,000			3,000
Sunflower	4,000		1,000	5,000
Other energy crops(incl.maize)	30,000	188,000	77,000	295,000
Starch	128,000			128,000
Sugar	18,000			18,000
Fibres	2,000			2,000
Pharmaceutical crops	10,000			10,000
Total	805,000	360,000	396,000	**1,561,000***

***1,561,000 ha is 13.2% of the German arable land**

Source: Shusseler P. Fachagentur Nachwachsende Rohstoffe e.V. (FNR - Agency of Renewable Resources). Personal communication, 2006.

Renewable energy production in Denmark



Biomass & waste accounts for more than 75% of the total renewable energy production. Total gross energy consumption equals 836 PJ (2004). 16% of all Energy consumption 2007. Goals 30% year 2020.

Source: The Danish - DOE, http://www.ens.dk

Scenario for sustainable bioenergy from agriculture (today ca. 24 PJ)

		Area in 1000 ha
• 80% of grain straw	27 PJ	
• 80% of rape seed straw	4 PJ	
• 75% of animal manure biogas	20 PJ	
• Fiberfraction for CHP	3 PJ	
• 100% rape oil for fuel	5 PJ	125
• 50% of set aside energy crops	9 PJ	57
• 15% of grainarea energy crops	43 PJ	224
• 75% of lowland grasslands	5 PJ	115
• 40% nature concervation	5 PJ	138
• Total	121 PJ	659

Source: Aarhus University & Ministry of Food and Agriculture, 2007 & 2008

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

Environmental and Nature Conservation considerations; Permanent grassland and pastures – at such areas the nature has the highest priority.

-Ruman grasing or small amounts of biomass harvesting from extensive grassland areas can take place if its in a strategy to support the management of species-rich grassland, to maintain a high biodiversity.

Source: J.B. Holm-Nielsen, Department of Bioenergy, SDU, Denmark

Suggestions for international cooperation in the frame of EU, UN, FAO or other organisations, for implementing regulatory mechanisms and framework conditions.

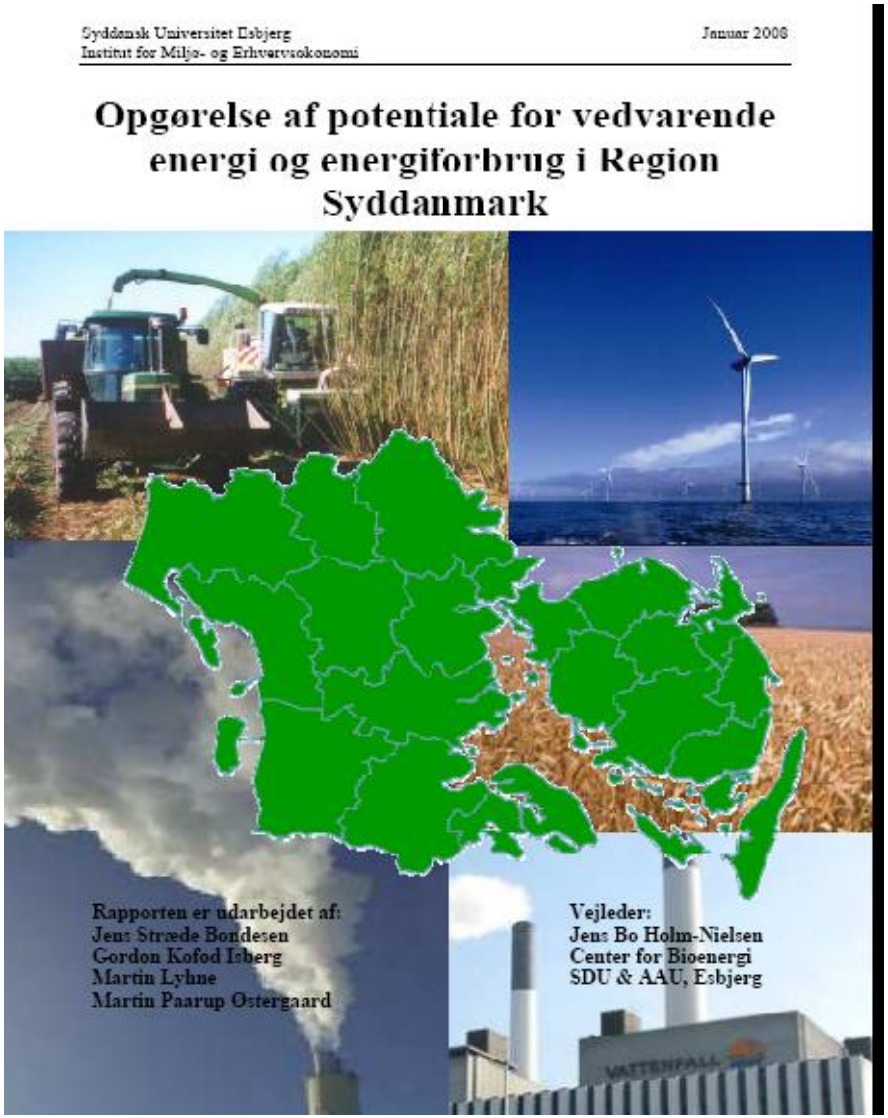
	International CODEX of Biomass production for FOOD – FEED – FUELS
a.	Environmentally and economically sustainable biomass production conditions at commercial farming and forestry areas.
b.	Sustainable rural development, paradigm change, new ways of rural economy.
c.	Acting as a tool for restoring climate and preventing further climate change.
d.	Prohibit any involvement of the nature resource areas in commercial biomass production activities.

Renewable Energy Systems (RES)

- Region of Southern Denmark & Schleswig-Holstein (D); combining goals of quality of living, high employment rate and sustainable energy supply in the cross boarder regions. Target:

  > 50% RES supply of the demand, 2025!

- Nature and ressource utilisation have to find a sustainable balance. Agriculture and Environment goes hand in hand in a balanced manner.



Den udleverede rapport er kun tænkt som en appetitvækker til selv at sam-tænke videre ud fra. Efter workshoppen får deltagerne et lille regneark til at lade sig inspirere af.

A Bioenergy Cluster have been founded to full-fill the goals in the Region of Southern Denmark

Claus Schmidt, UdviklingsRåd Sønderjylland
Charles Nielsen, DONG ENERGY A/S
Conny Stjernholm, SYDENERGI
Rasmus Banke, Danfoss A/S
Per Balslev, Danfoss A/S
Jens Bo Holm-Nielsen, AAUE & Syddansk Universitet/SDU
Peter B. Nissen, Tønder Bioenergi Park
Erling Sørensen, Fyns Erhvervscenter
Erik Dam, Sydvestjysk Udviklingsforum, SVUF
Ole Bang, Aabenraa Fjernvarme

Activities: Coordination, Activation of SMV's, New projects; Biorefineries, Biomass based Fuels Cells

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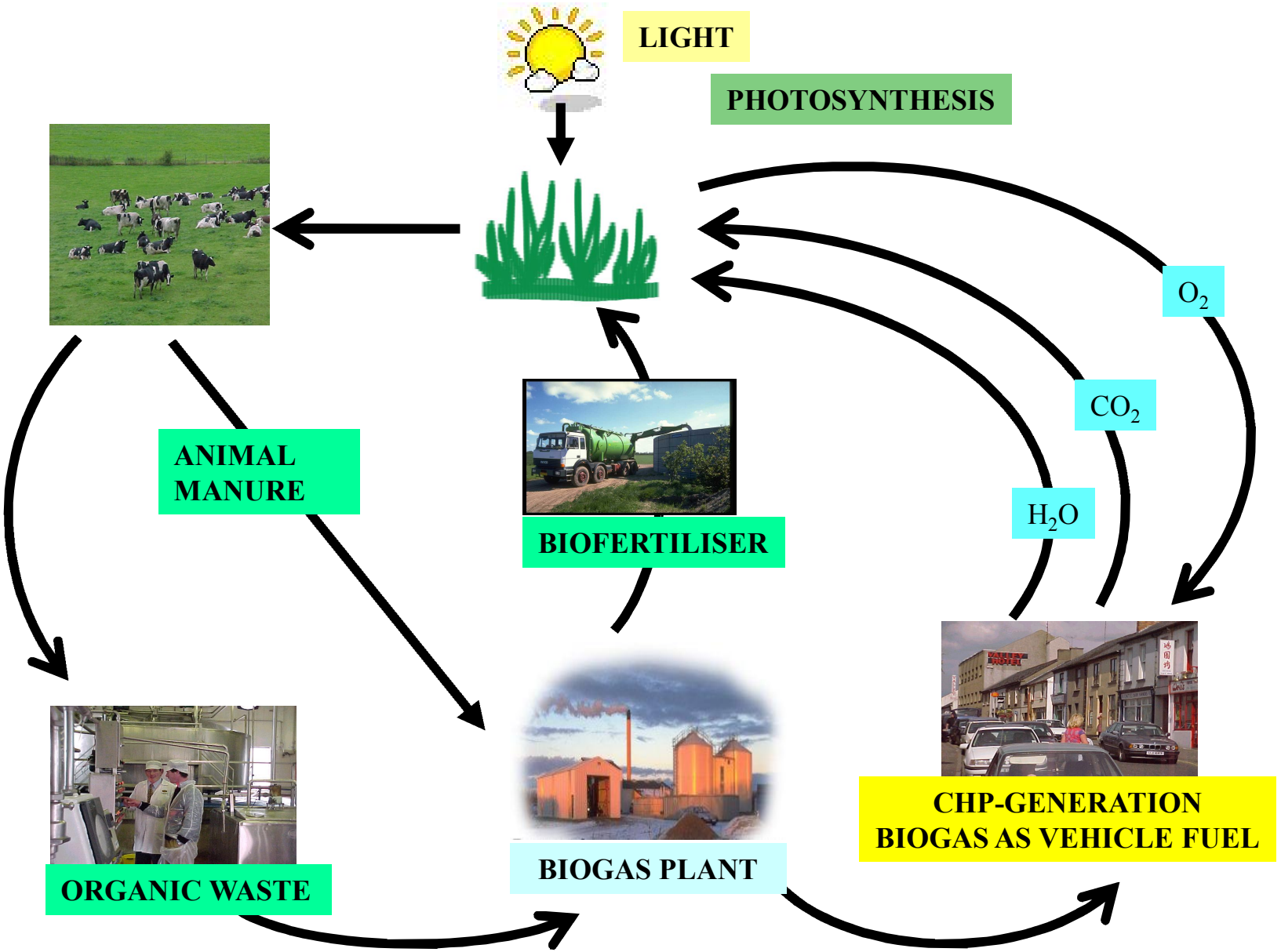
Bioenergy – cases of large scale CHP co-generation plants and Case1:Biogas plant developments

Integration between **agriculture - forestry - energy & environmental sectors**!!!

Biogas cases for a sustainable clean environment



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 production from biogas in Denmark

Unit: PJ per year	Potential	Production 2001	Production 2002	Production 2003	Production 2004
Animal manure	26.0	0.61	0.70	0.85	0.91
Sewage sludge	4.0	0.86	0.87	0.87	0.83
Industrial waste	2.5	0.59	0.67	0.80	0.86
Industrial waste, imported	-	0.40	0.45	0.55	0.65
Meat and bone meal	2.0	0.00	0.00	0.00	0.00
Household waste	2.5	0.03	0.05	0.07	0.03
Green waste/garden waste	1.0	0.00	0.00	0.00	0.00
Landfill gas	1.0	0.56	0.62	0.44	0.46
Total	**39**	**3.05**	**3.58**	**3.58**	**3.74**

Source: Tafdrup, S. (2006). DOE.

Animal manure and slurry from local farms

- Dairy and cattle slurry
- Pig slurry
- Poultry manure

Organic wastes

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

INPUTS

Biogas Plant

- **Homogenisation**
- **Pasteurisation**
- **Digestion and gas production**

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

OUTPUTS

Agricultural biofertiliser

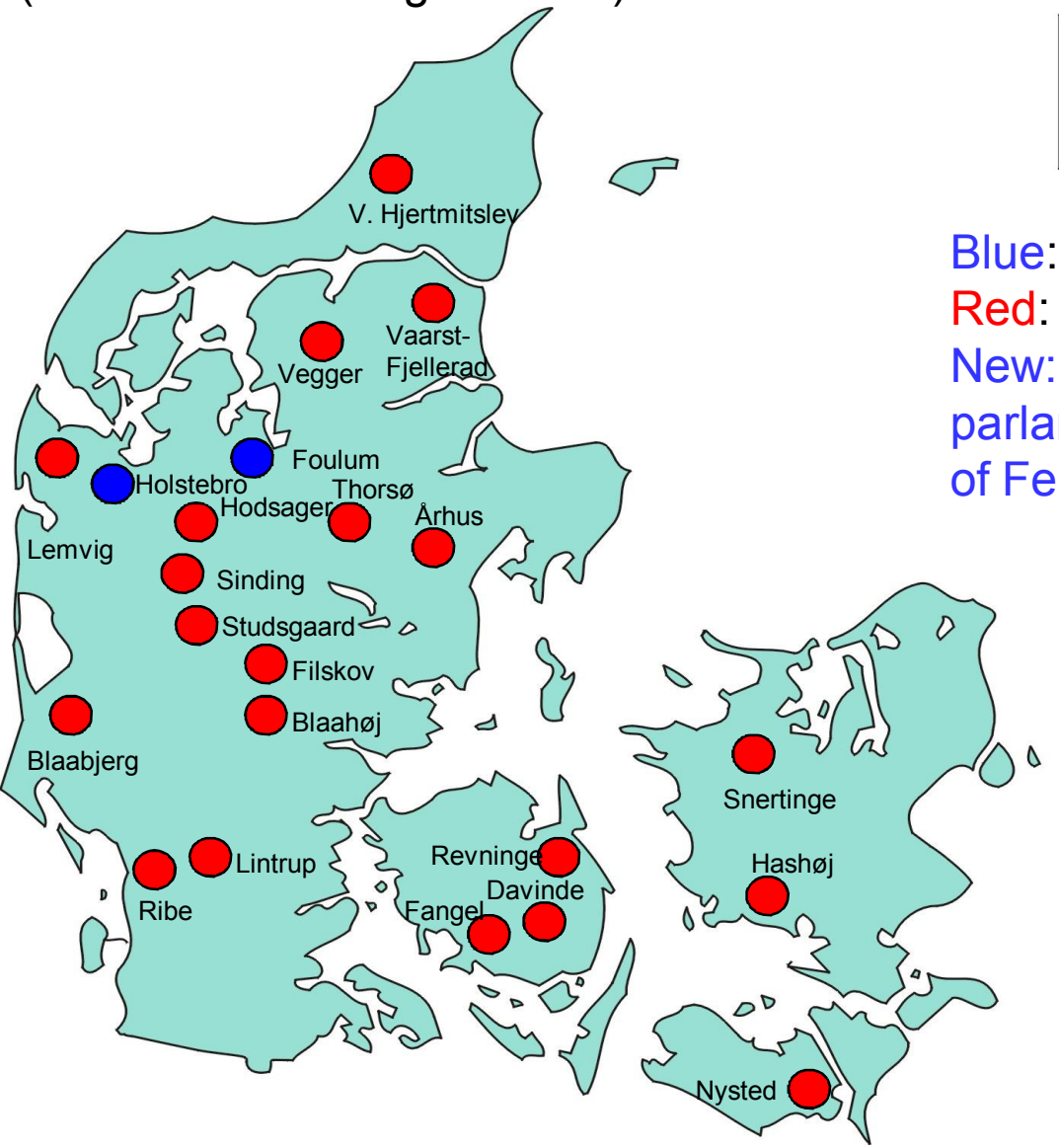
- Improved utilisation of plant nutrients
- Reduced consumption of mineral fertilisers
- Reduced water pollution
- Disease and weed seed free biofertiliser
- Separated fibre/soil improver

Biogas for combined heat and power generation

- Renewable energy source
- Displacement of fossil fuel
- CO_2 - neutral
- Reduced air pollution
- Effective energy utilisation

Location of centralised co-digestion biogas plants in Denmark

(As of the 1st of august 2006)

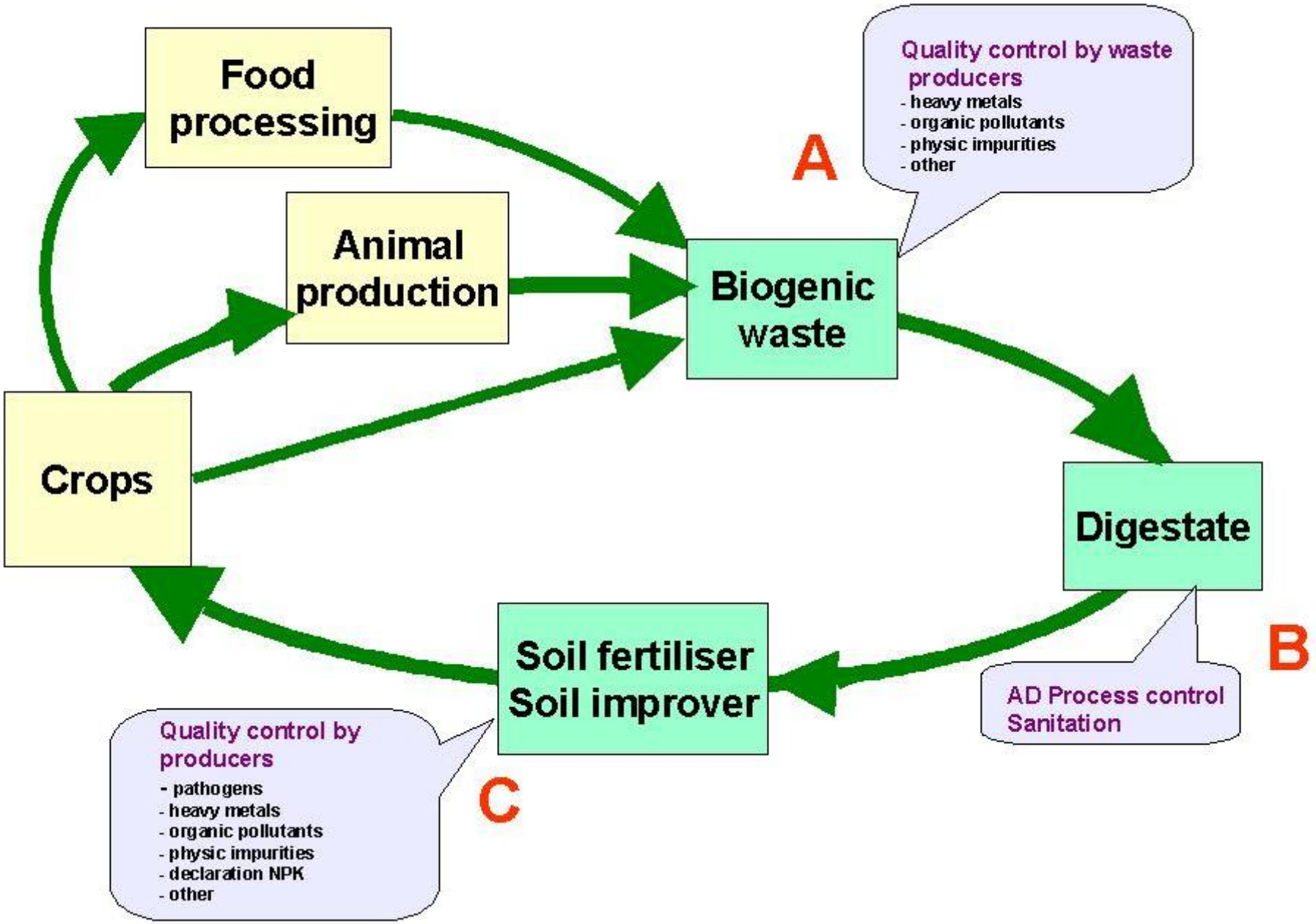


Blue: plants under construction / planning
Red: existing co-digestion plants
New: 15 projects in the pipeline, after parlamentary green electricity agreement of Febr. 2008

Waste Collection

- Tankers
  - 20 m^3
  - 30 m^3
- Tippers
- Pipeline
- Average distance to plant
- Emptying cycle

NIRAS


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 gurantee of retention time
- Elimination of pathogens and weeds

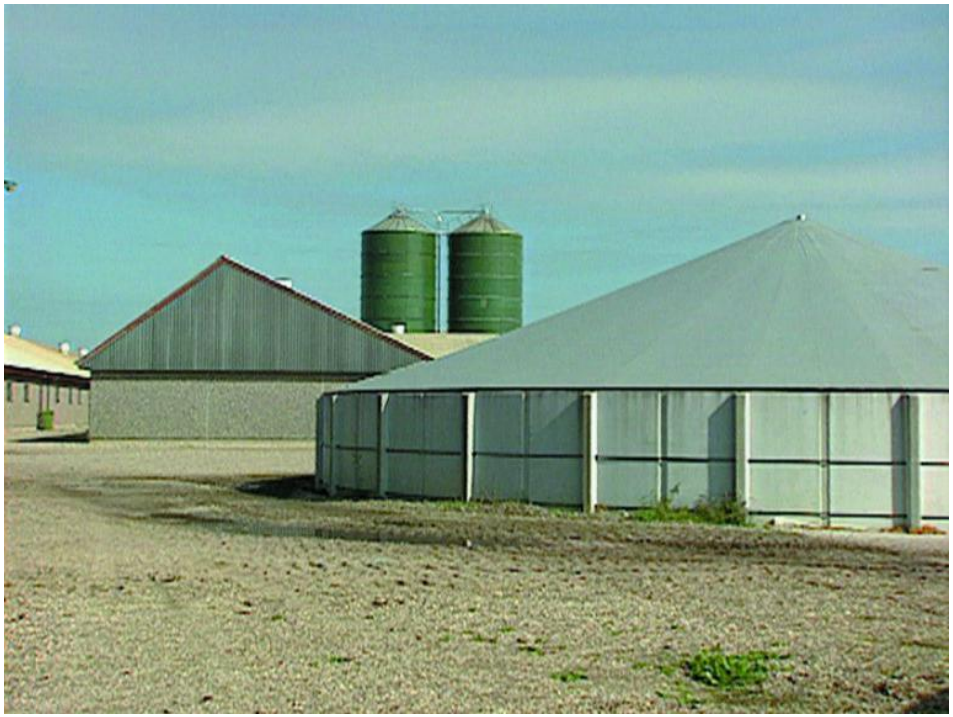
NIRAS

Digesters

- Steel or concrete tanks
- Insulated
- Processes
  - mesophilic
  - thermophilic

After Storage

- Second digester
- Buffer for return of digestate or
- Buffer before after treatment



Digested slurry

Fiberfraction ← Decanter → Liquid fraction

80 pct. P

15 pct. af volume

Objectives:

- sustainability
- relations to neighbours
- further development of farm

80 pct. N

Almost all ammonium

Sill no market fibre fraction. Costs of drying (50 eur/T) exceed nutrient value of fibres.
Heavy metals content could be a problem; removal expensive
Incineration seen like the only alternative; Documentation and approvals needed.

Fluid Fraction – post treatment

- Various technologies can separate the liquid fraction in
  - concentrated N & K nutrients
  - clean reject water for industrial utilisation.

NIRAS

Gas Storage

- Equalize gas production
- Max. for 24 hours storage
- Size depends on utilization of gas

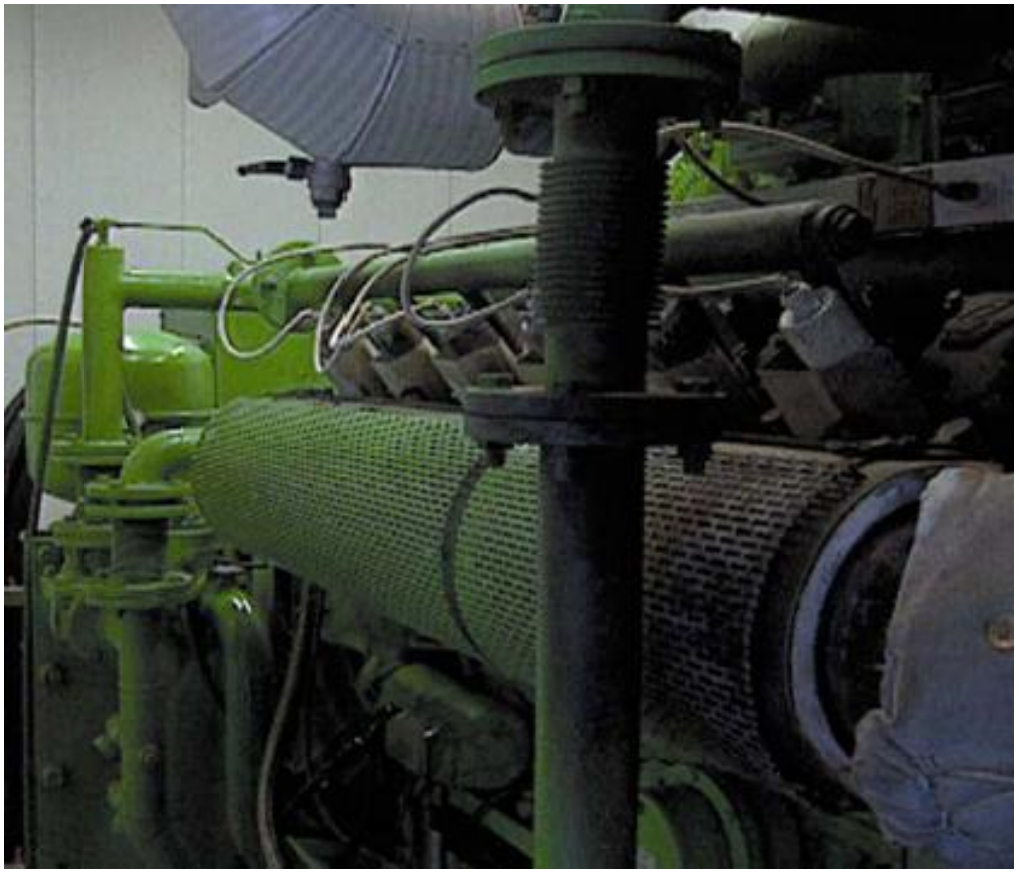
Gas Treatment

- Gas contains H_2S
- Can be removed biologically in
  - after storage
  - gas cleaning unit
  - a must to do!!!

NIRAS

Gas Utilization

- Boilers
- Internal combustion engines
- Gas turbines
- **CHP applications**
- **Fuel cells**



NIRAS

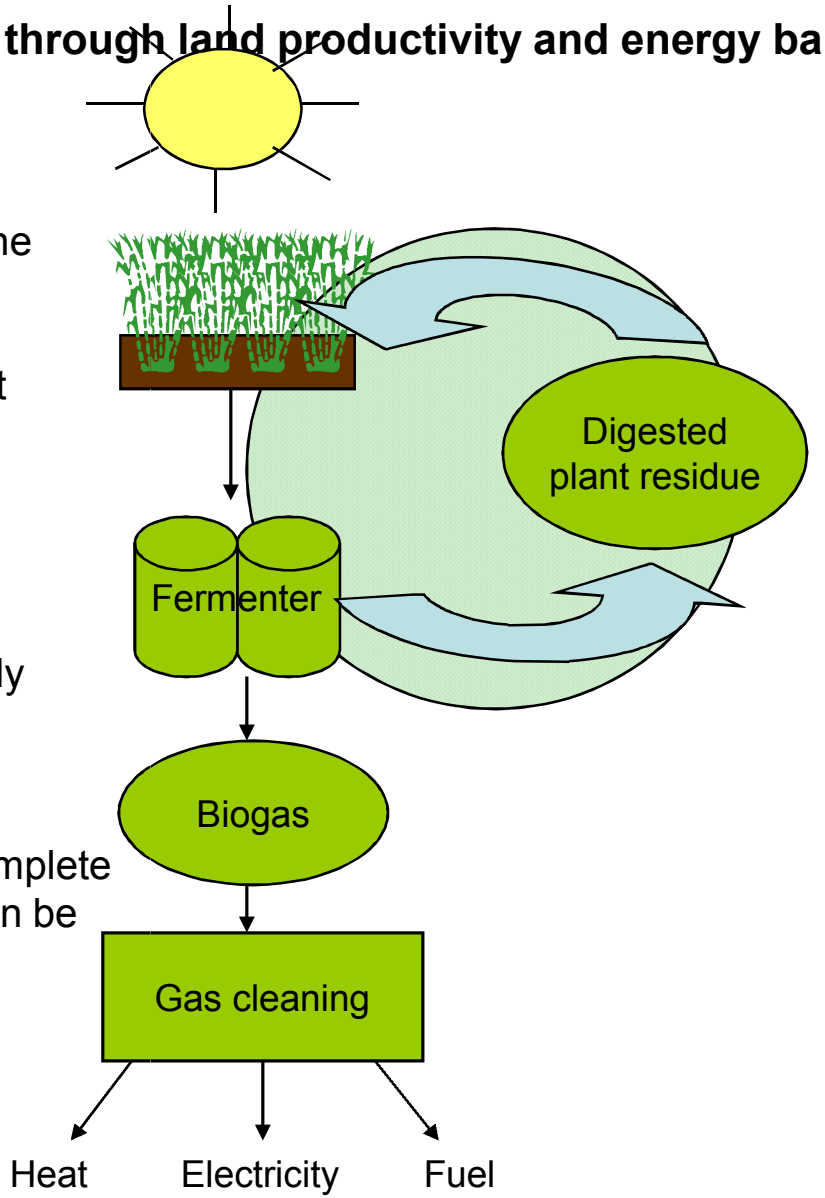
Land application of digested manure recycling of N, P & K for crops!

- Direct application to field
- After treatment – separation
- After treatment - upgrading

NIRAS

Energy crops Paradigm shift through land productivity and energy balance

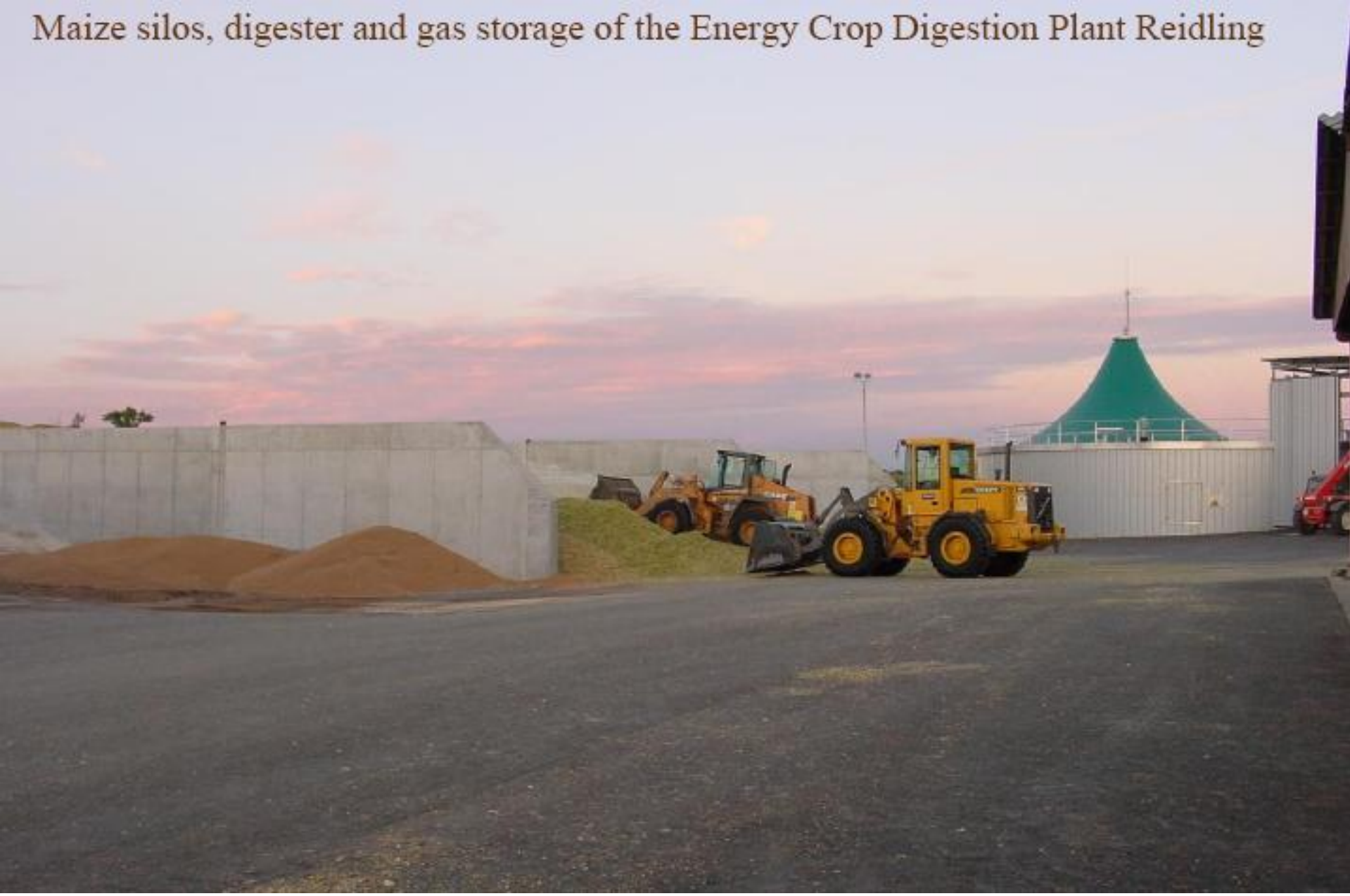
- The Sun as energy source
- Special energy crops that use the entire vegetation period
- Total digestion of the whole plant
- Nutrient cycle possible
  Low Input High Output
- Large installations work efficiently and are friendly towards the environment
- Upgrading of biogas enables complete utilisation of the crop (the gas can be stored)
- Biorefineries;biothanol/biogas/ biodiesel



Source: KWS

Harvest of energy maize

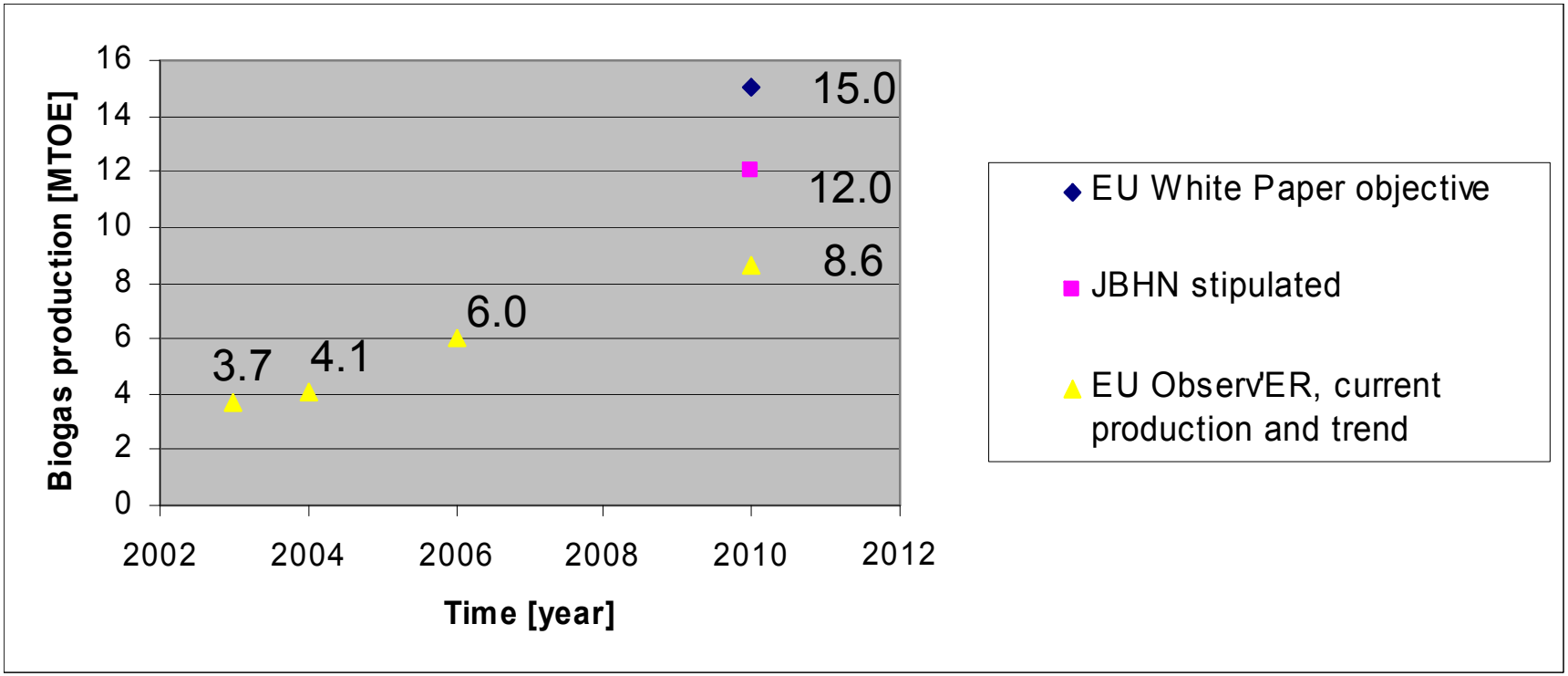
Source: KWS, Germany.



Source: R. Braun, IFA, Austria

Västerås Biogas Plant, Sweden, Start up - 2005;
Source: T. Al Seadi, Department of Bioenergy, SDU, Denmark

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


Biogas production [MTOE]
16
14
12
10
8
6
4
2
0
2002
2004
2006
2008
2010
2012
Time [year]
3.7
4.1
6.0
8.6
12.0
15.0
EU White Paper objective
JBHN stipulated
EU Observ'ER, current production and trend

The future of biogas in Europe. How to make a real movement!

- Biogas upgrading & utilisation for:
  * Biogas for combined heat and power production.
  * Biogas & Natural gas; integration in the European gas grid
  * Biogas as transportation fuel
  * Biogas as fuel for micro CHP, - gas grid
  * Biogas as fuel in fuel cells, - gas grid
  * Biogas for multible purposes …

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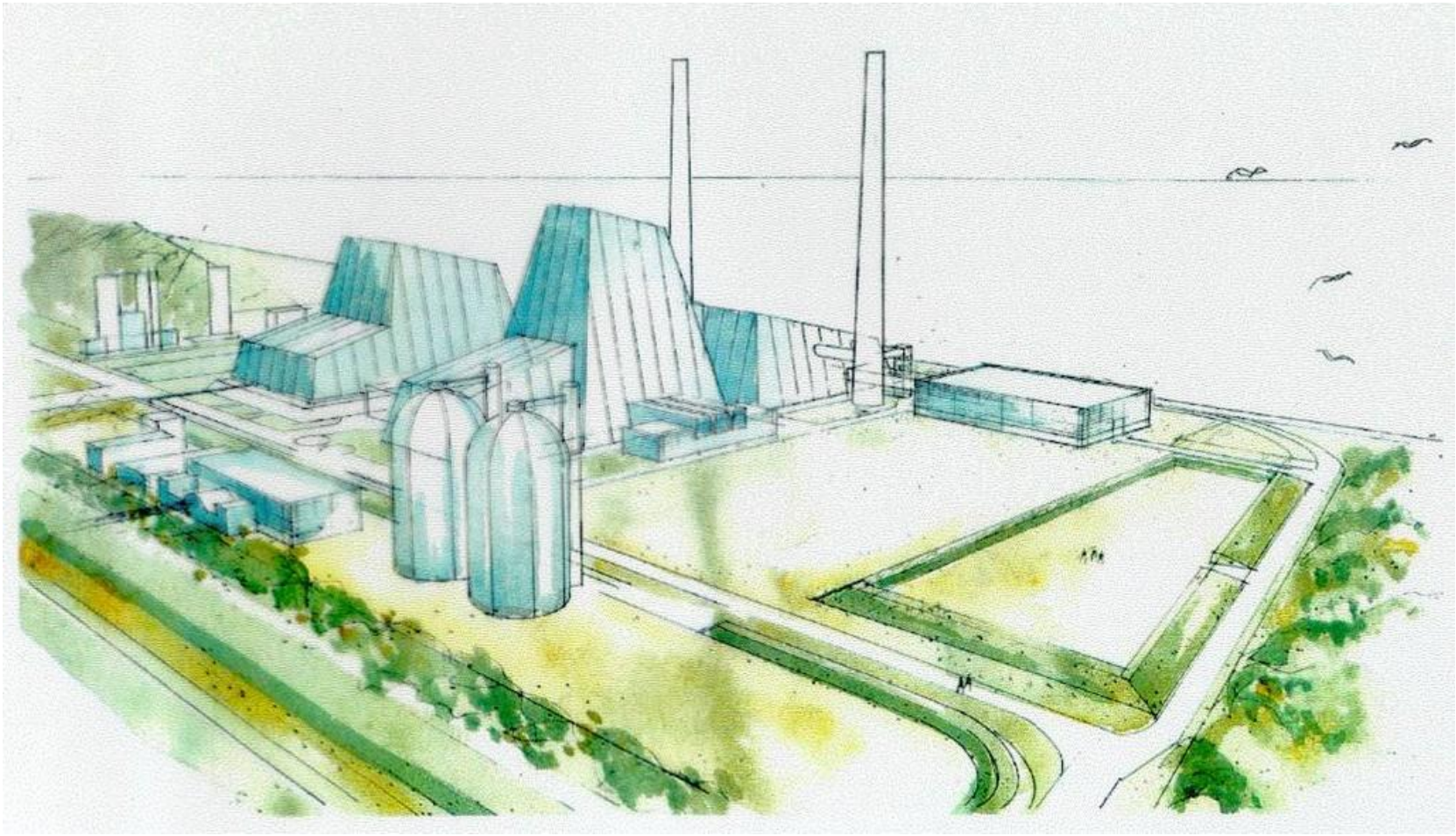
Bioenergy – case 2 of large scale CHP co-generation plants and Biogas plant developments

Integration between **agriculture - forestry - energy & environmental sectors**!!!

Avedøre Power Plant 550 MW, Copenhagen, Biomass & N-gas.



Strawbarn Unit 2 –150.000 tons of straw per year

Biomass boiler at Avedøre 2

a Feedinglines

b

c Furnace

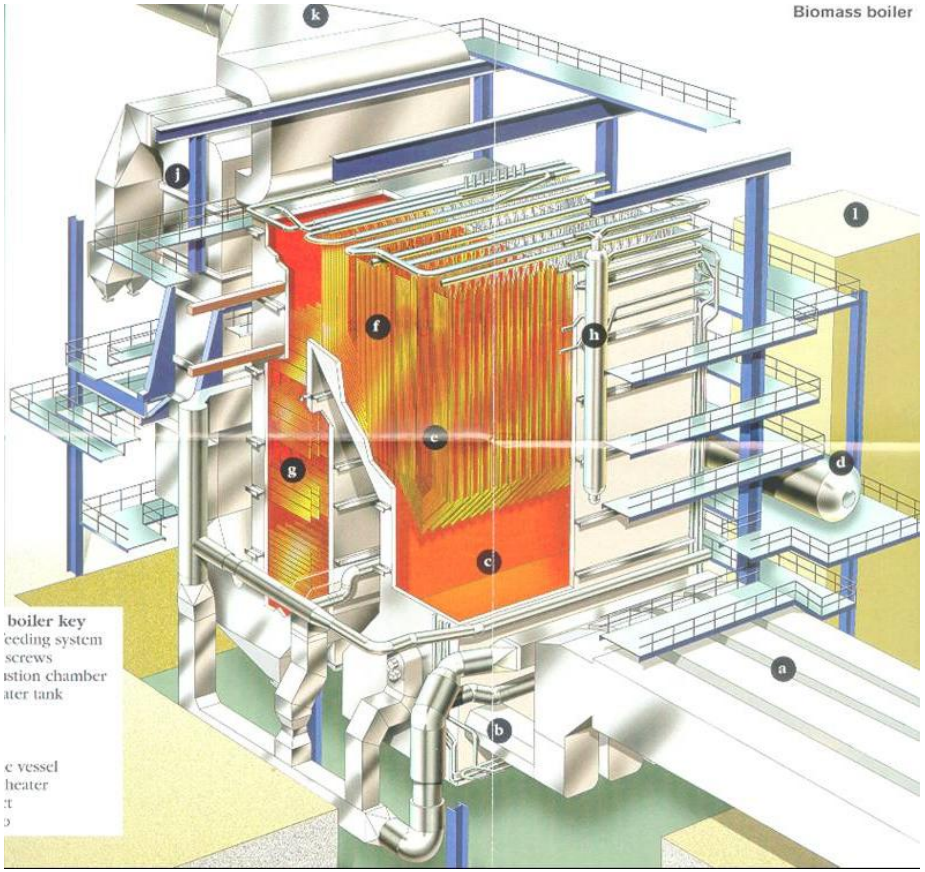
d Feedwatertank

e Superheater 2

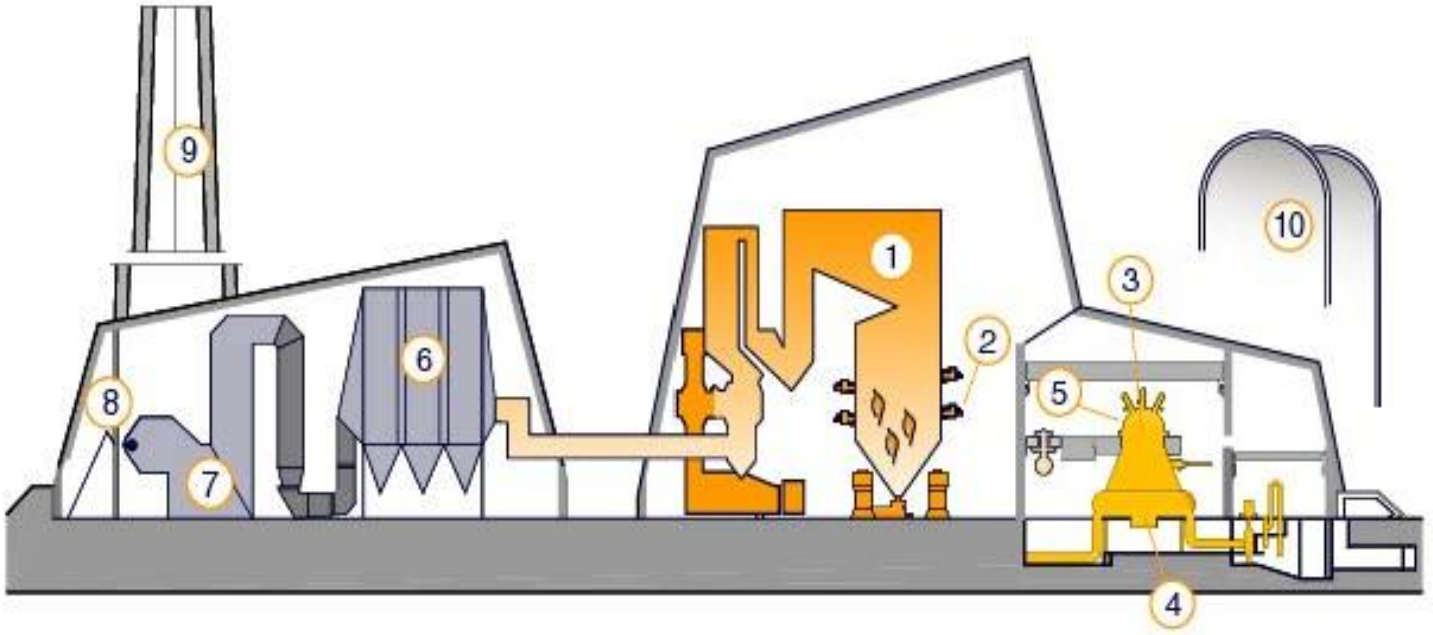
f Superheater 3

g Superheater 1

Max capacity: 20 tons/hour

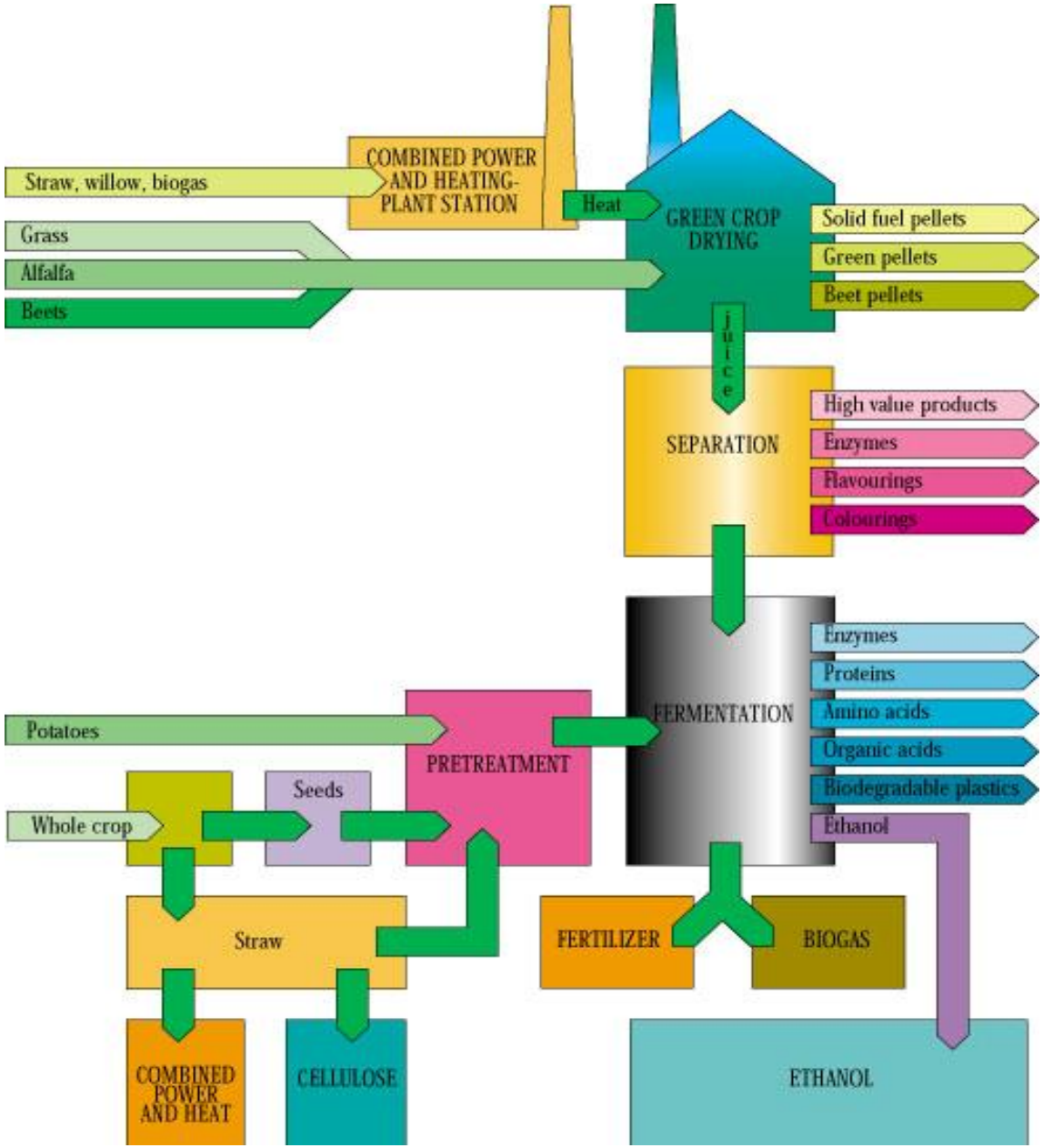


Process in Avedøre Power Station Smokecleaning



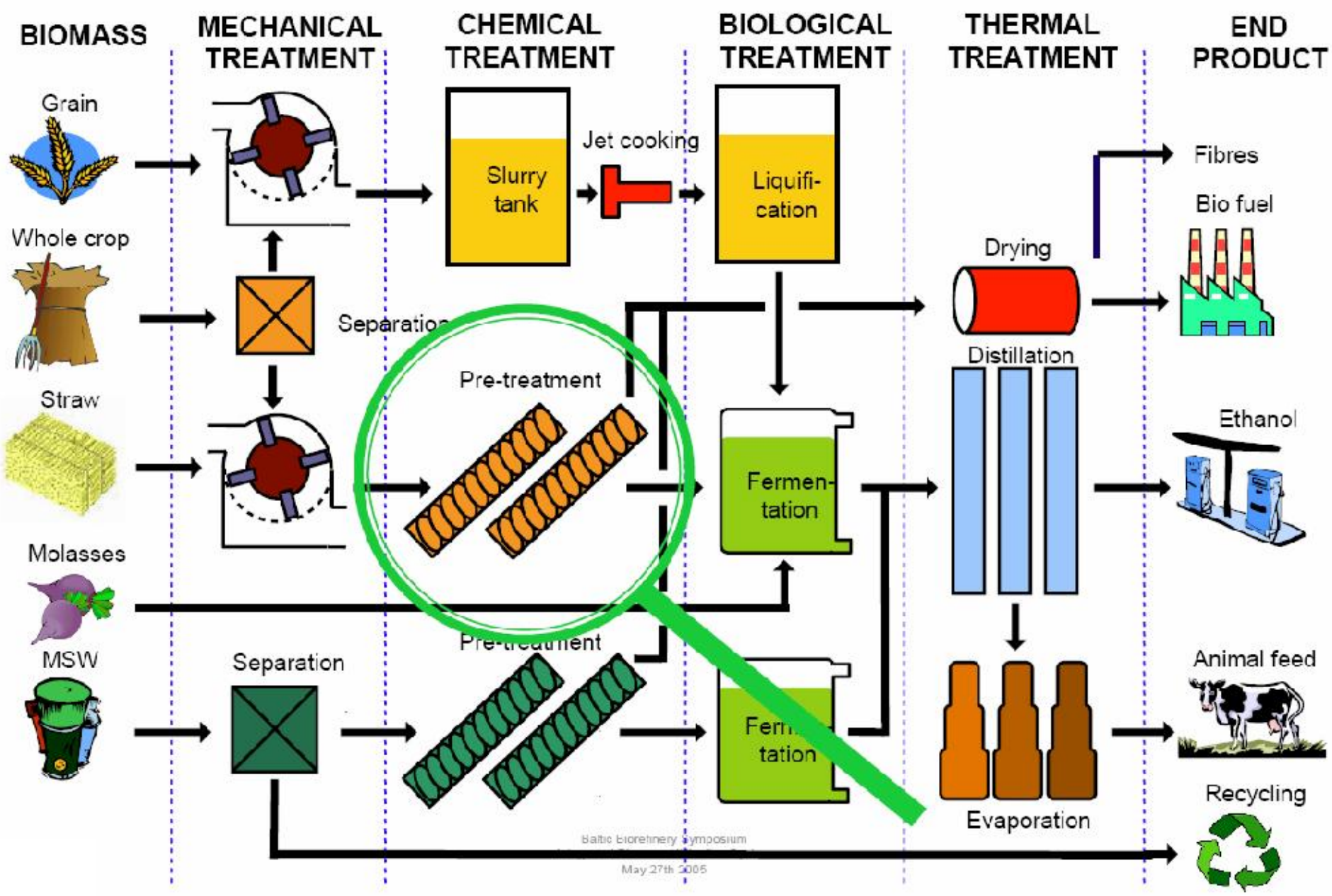
1. Boiler
2. Burner
3. Turbine
4. Heat exchangers
5. Generator
6. Ash precipitator
7. Desulphurisation plant
8. Gypsum store
9. Stack
10. Heat accumulator tank

The Green Biorefinery

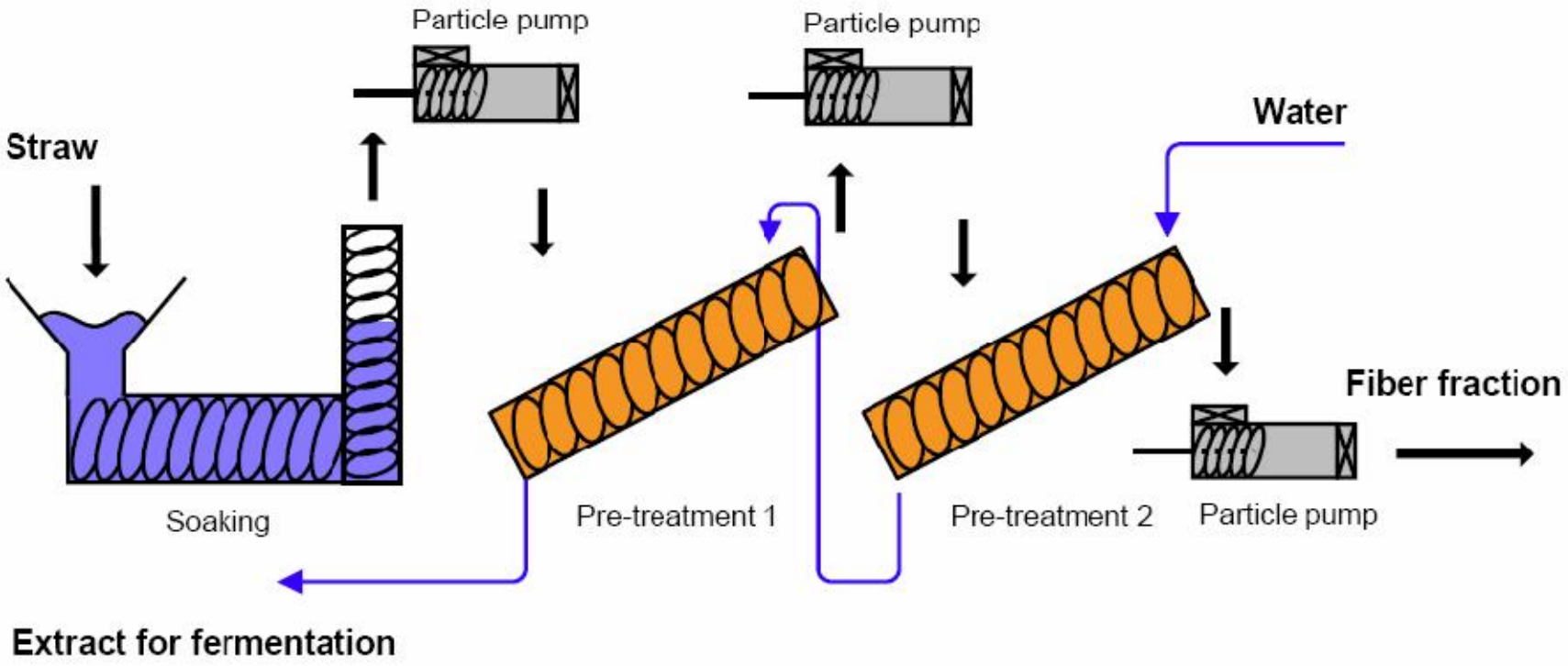


Source:

P. Kiel & J.B. Holm-Nielsen
University of Southern Denmark
1994


BIOMASS
MECHANICAL TREATMENT
CHEMICAL TREATMENT
BIOLOGICAL TREATMENT
THERMAL TREATMENT
END PRODUCT
Grain
Whole crop
Straw
Molasses
MSW
Separation
Slurry tank
Jet cooking
Liquifi-cation
Pre-treatment
Fermen-tation
Drying
Distillation
Evaporation
Fibres
Bio fuel
Ethanol
Animal feed
Recycling
Baltic Biorefinery Symposium
May 27th 2005

CHEMICAL TREATMENT 1000 kg/h
of lignocellulosic raw materials



Liquefaction and saccharification of cellulose

0 hour

High dry matter content

2 hour

5 hour

20 hour

Summary and Conclusion

Biorefineries are thoroughly integrated thinking and conversion of biomasses of any kind for new products for industrial and energy use

Technologies for conversion of biomass for food, feed, fuels, fibers and fertilisers is going to be realized and implemented at increasingly speed in this and the next decade.

A full paradigm shift is well under way from fossil fuel dependencies towards biomass and accompanying renewable energy resource based economies.

The world is getting greener and more sustainable by peoples will, urgent needs of new energy sources and environmental commitment.

Thank you for your attention

Further contact: Jens Bo Holm-Nielsen; jhn@aaue.dk,
E-mail; jhn@bio.sdu.dk; www@sdu.dk/bio

World energy scenarios – Future goals

No.			Source
1.	Non collected straw (50%)	**75 000 PJ/year**	Sanders J.: *Biorefinery, the bridge between Agriculture and Chemistry*. Wageningen University and Researchcenter. Workshop: Energy crops & Bioenergy.
2.	Collected waste processing (50%)	**45 000 PJ/year**	
3.	Forest/pastures (50%)	**150 000 PJ/year**	
4.	10% of arable land – World Wide (20tTS/ha)	50 500 PJ	Holm-Nielsen J.B., Madsen M., Popiel P.O.: *Predicted energy crop potentials for biogas/bioenergy. Worldwide – regions – EU25*. AAUE/SDU. Workshop: Energy crops & Bioenergy.
5.	20% of arable land – World Wide (20tTS/ha)	**101 000 PJ**	
6.	30% of arable land – World Wide (20tTS/ha)	151 500 PJ	
Sum: 1+2+3+5		**371 000 PJ**	

	Predicted value	Source
Total energy required year 2050	**1 000 000 PJ/year**	Sanders J.: *Biorefinery, the bridge between Agriculture and Chemistry*. Workshop: Energy crops & Bioenergy.
Total energy demand year 2050	**1 300 000 PJ/year**	Shell's World Energy Scenario