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Strategic panel Other fuels - biogas

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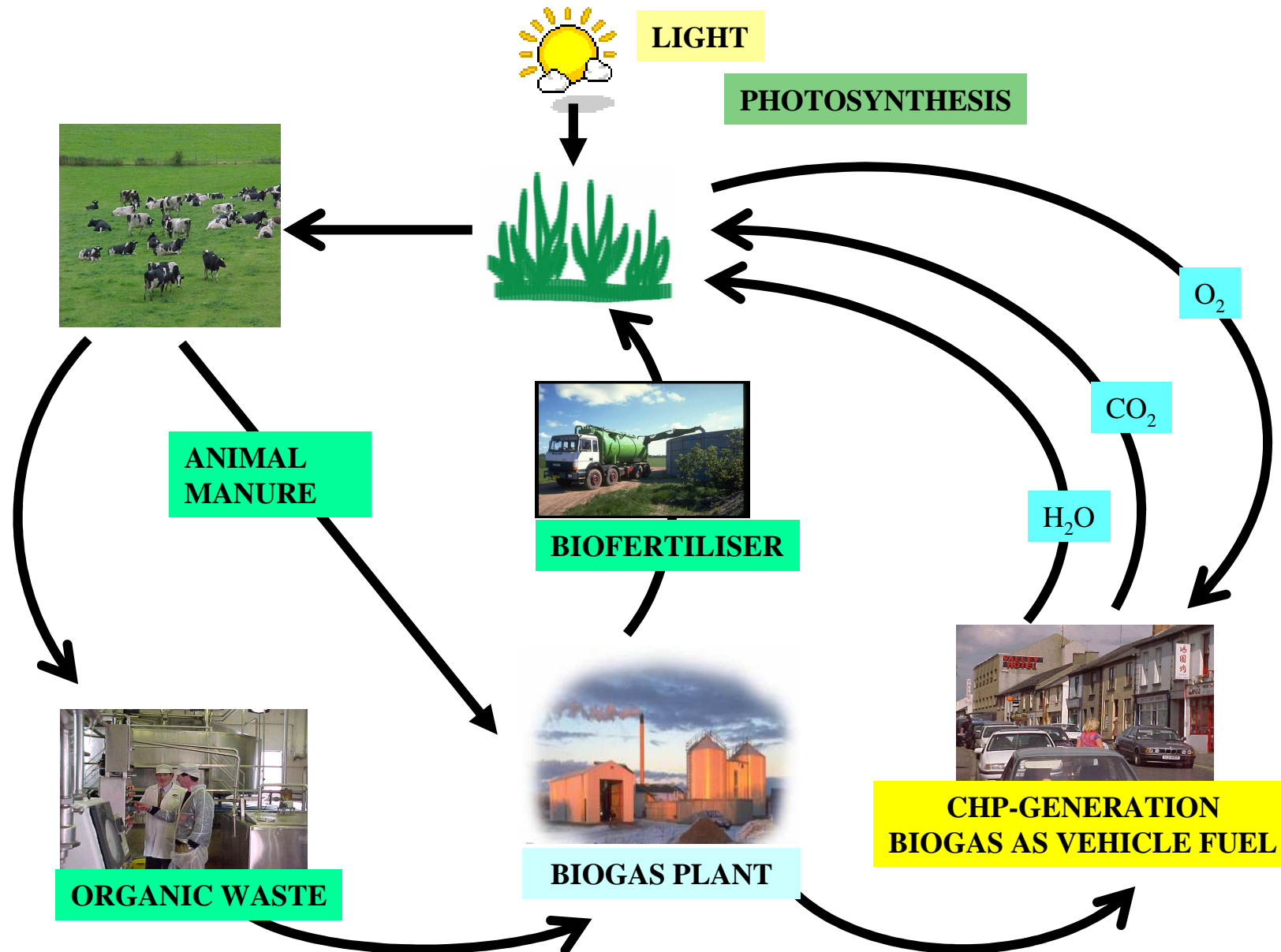
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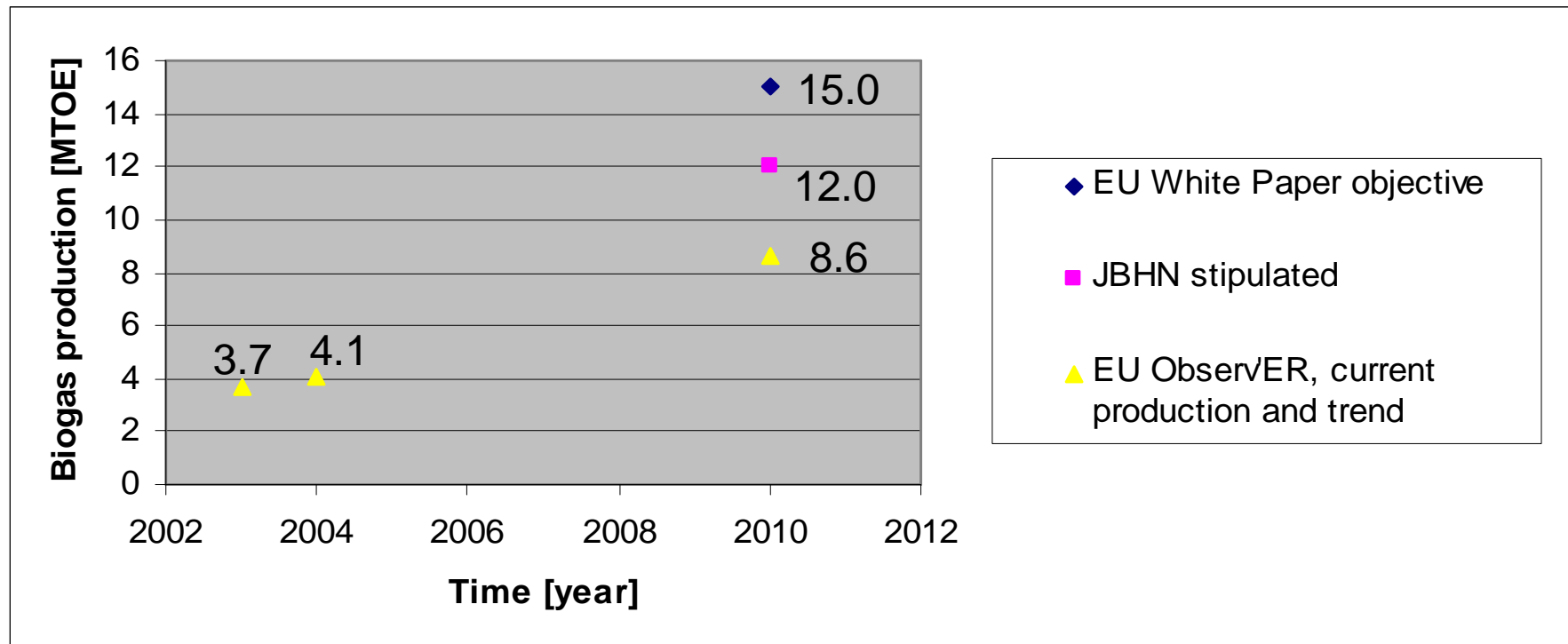
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Biogas for a sustainable clean environment



Comparison between current trend and White Paper objectives (in millions of TOE)



Status of digestible biomass in the 15 EU-countries

	Cattle manure	Pig manure	Total manure	Population (humans)	Municipal waste generation		Sewage sludge	Industrial org. waste
	(1993)	(1993)	(1993)	(1993)	Total waste (450kg/capita)	Org. waste (30% of total)	(1990)	Digestible <35%DM (100 kg/cap)*
	mill. t	mill. t	mill. t	mill.	mill. t	mill. t	mill. t	mill. t
Austria	25	8	32	7,7	3,5	1,0	**2,3	0,8
Belgium	35	14	49	9,9	4,5	1,3	0,7	1,0
Denmark	22	22	44	5,1	2,3	0,7	1,3	0,5
Finland	14	3	17	***5,1	***3,1	0,7	0,1	0,5
France	211	26	238	56,5	25,5	7,6	0,6	5,7
Germany	167	51	218	62,7	28,2	8,5	1,8	6,3
Greece	6	3	9	10,0	4,7	1,4	-	1,0
Ireland	66	3	69	3,5	1,6	0,5	0,6	0,4
Italy	80	15	95	57,6	25,9	7,8	**3,4	5,8
Luxembourg	2	0,2	2	0,4	0,2	0,02	0,02	0,04
Netherlands	48	28	77	14,9	6,7	2,0	0,3	1,5
Portugal	14	6	20	10,3	***3,4	1,0	-	1,0
Spain	53	37	89	38,9	17,5	5,3	10,0	3,9
Sweden	19	5	24	8,6	3,9	1,2	0,2	0,9
U. Kingdom	125	16	141	57,3	25,8	7,7	1,0	5,7
Total EU	887	237	1124	348,5	156,8	46,9	22,32	35,04

* Estimated figures, based on fixed data from Denmark, Finland and the Netherlands, ** 1994 data, *** 1996 data

Source: Holm-Nilsen, J.B. & Al Seadi, T. (1997): The Future of Biogas in Europe. Altener Programme, Final Report Phase II

Area usage in the EU-25

Unit: 1 000 ha	Total area	Agriculture area	Arable land		Forest		Permanent grass		Fallow
Country			(% of total area)		(% of total area)		(% of total area)		
Austria	8 387	3 374	1 379	16	3 260	39	1 917	23	106
Belgium	3 053	1 393	833	27	607	20	536	18	28
Cyprus	925	137	87	9	N/A	N/A	1	<1	7
Czech Republic	7 887	3 652	2 767	35	2 643	34	839	11	83
Denmark	4 310	2 676	2 479	58	473	11	186	4	205
Estonia	4 523	698	613	14	2 251	50	67	1	25
Finland	33 815	2 236	2 204	7	22 487	66	27	<1	211
France	54 909	29 556	18 275	33	15 403	28	9 972	18	1 280
Germany	35 703	16 974	11 791	33	10 531	29	4 970	14	835
Greece	13 196	3 897	2 211	17	N/A	N/A	146	1	441
Hungary	9 303	5 867	4 516	49	1 772	19	1 063	11	195
Ireland	7 027	4 372	1 177	17	N/A	N/A	3 193	45	18
Italy	30 134	15 546	8 384	28	6 856	23	4 379	15	617
Latvia	6 459	1 596	973	15	2 862	44	610	9	94
Lithuania	6 530	2 903	1 639	25	1 997	31	1 203	18	193
Luxembourg	259	128	62	24	89	34	65	25	2
Malta	32	10	9	27	N/A	N/A	N/A	N/A	0
Netherlands	4 153	1 949	1 011	24	353	9	892	21	30
Poland	31 269	16 899	13 067	42	9 090	29	3 562	11	2 302
Portugal	9 191	3 846	1 589	17	3 465	38	1 468	16	539
Slovakia	4 903	2 236	1 377	28	2 002	41	799	16	4
Slovenia	2 027	505	168	8	1 283	63	307	15	1
Spain	50 532	25 289	13 081	26	16 493	33	7 125	14	3 195
Sweden	41 034	3 140	2 680	7	22 323	54	482	1	269
United Kingdom	24 291	16 352	6 397	26	N/A	N/A	9 906	41	33
Summary EU-25	393 849	165 229	98 765	25	126 239	32	53 715	14	10 710

J.B. Holm-Nielsen, P.O. Popiel & M. Madsen, Department of Bioenergy, SDU, Denmark (2005)

Energy potential in biomass in the EU-25

Table 3a. Scenarios of area utilization of arable land for EU-25 in PJ

Area used for energy prod.	10 % of arable land in EU-25	20 % of arable land in EU-25	30 % of arable land in EU-25
Yield pr. ha			
10 t TS pr. ha	1 778 PJ	3 556 PJ	5 333 PJ
20 t TS pr. ha	3 556 PJ	7 111 PJ	10 667 PJ
30 t TS pr. ha	5 333 PJ	10 667 PJ	16 000 PJ

* 1 PJ equals 10^{15} J

Note: The total area of the arable land in the EU-25 is assumed to be in the order of 98.765.000 ha (according to Eurostat figures 2002)

Table 3b. Scenarios of area utilization of arable land for EU-25 in MTOE

Area used for energy prod.	10 % of arable land in EU-25	20 % of arable land in EU-25	30 % of arable land in EU-25
Yield pr. ha			
10 t TS pr. ha	40 MTOE	79 MTOE	119 MTOE
20 t TS pr. ha	79 MTOE	159 MTOE	238 MTOE
30 t TS pr. ha	119 MTOE	238 MTOE	357 MTOE

* MTOE: Million Ton Oil Equivalent. 1 MTOE equals 44.8 PJ

J.B. Holm-Nielsen, P.O. Popiel & M. Madsen, Department of Bioenergy, SDU, 2005

World energy scenarios – Future goals

No.		2040-2050	Source
1.	Non collected straw (50%)	75 000 PJ/year	Sanders J.: <i>Biorefinery, the bridge between Agriculture and Chemistry</i> . 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)	50 549 PJ	Holm-Nielsen J.B., Madsen M., Popiel P.O.: <i>Predicted energy crop potentials for biogas/bioenergy. Worldwide – regions – EU25</i> . AAUE/SDU. Workshop: Energy crops & Bioenergy.
5.	20% of arable land – World Wide (20tTS/ha)	101 097 PJ	
6.	30% of arable land – World Wide (20tTS/ha)	151 646 PJ	
Sum: 1+2+3+5		371 097 PJ	

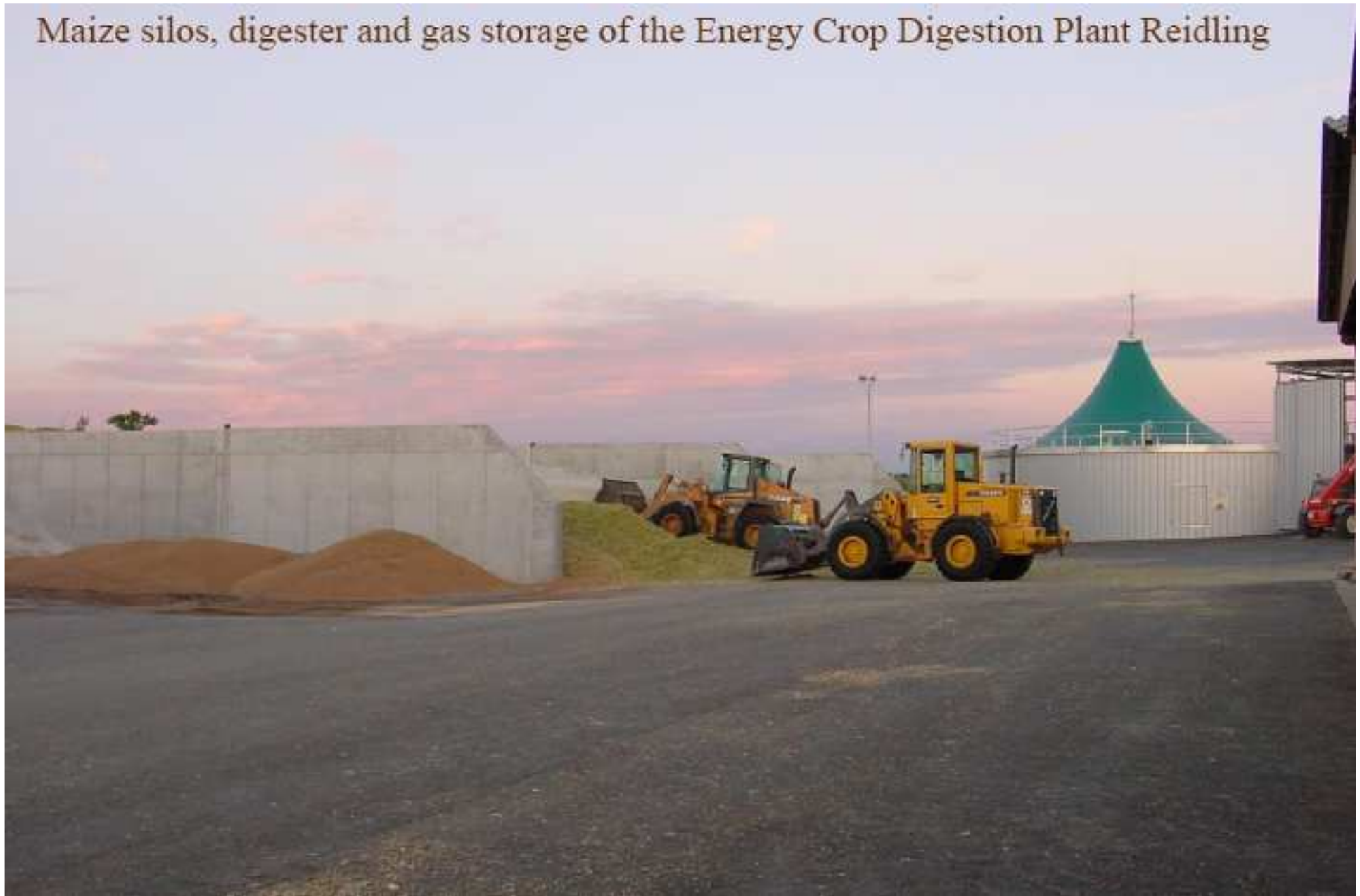
	Predicted value	Source
Total energy required year 2050	1 000 000 PJ/year	Sanders J.: <i>Biorefinery, the bridge between Agriculture and Chemistry</i> . Workshop: Energy crops & Bioenergy.
Total energy demand year 2050	1 300 000 PJ/year	Shell's World Energy Scenario

Harvest of energy maize



Source: KWS, Germany.

Maize silos, digester and gas storage of the Energy Crop Digestion Plant Reidling



Source: R. Braun, IFA, Austria



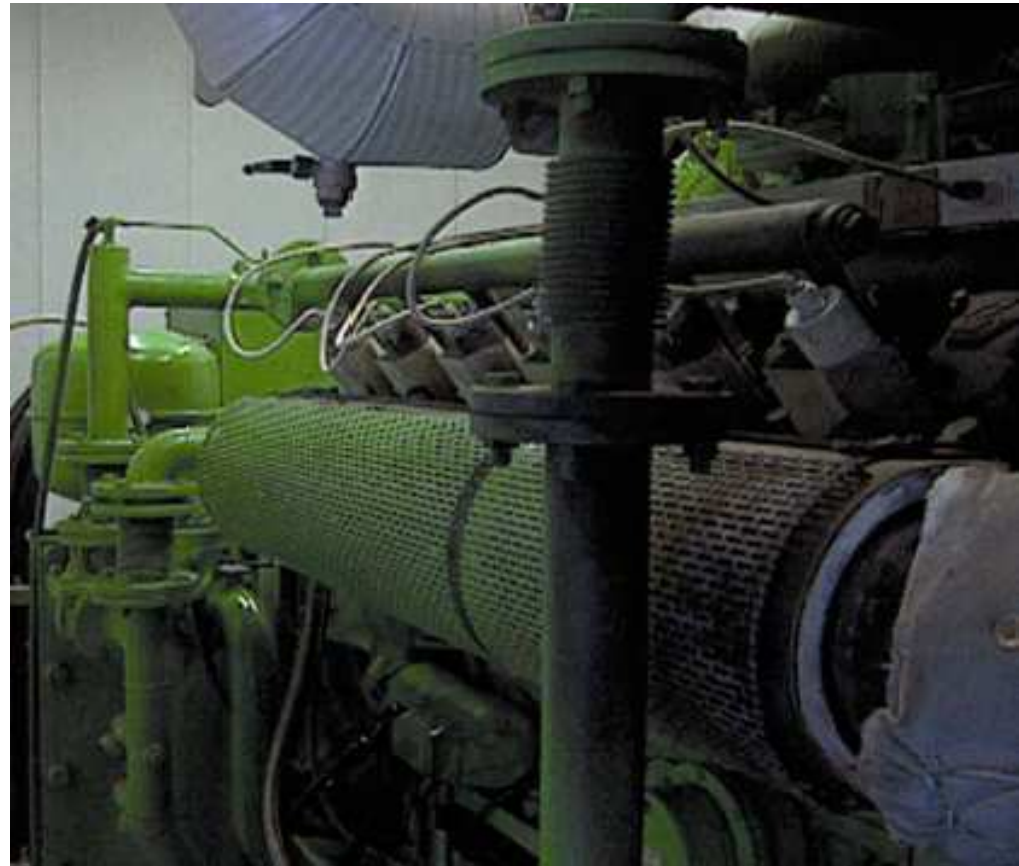
Västerås Biogas Plant, Sweden, Start up - 2005;
Source: T. Al Seadi, Department of Bioenergy, SDU, Denmark



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

Biogas Utilization

- Boilers
- Internal combustion engines
- Gas turbines
- CHP applications
- Industrial utilisation
- Fuel cells



Biogas in the natural gas grid

- Dynamic and flexible utilisation
- Supplementary supply to N-gas
- Multi purpose utilisation
- Combining and synergies

Demands for integration:

1. Cooling, draining and drying
2. Cleaning for H_2S – biological and/or chemical
3. Separation of CO_2 and upgrading into natural gas quality

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 (Combining and synergies of Renewable gas and fossil gas)
 - * Biogas as transportation fuel
 - * Biogas for high performing gas combi power plants
 - * Biogas as fuel for micro CHP, - gas grid
 - * Biogas as fuel in fuel cells, - gas grid
 - * Biogas for multiple purposes ...