Socio-economic aspects of centralized co-digestion.

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PROBIOGAS:
Promotion of Biogas for Electricity and Heat Production in EU Countries - Economic and Environmental Benefits of Biogas from Centralized Co-digestion,
An IEEA - ALTENER project.

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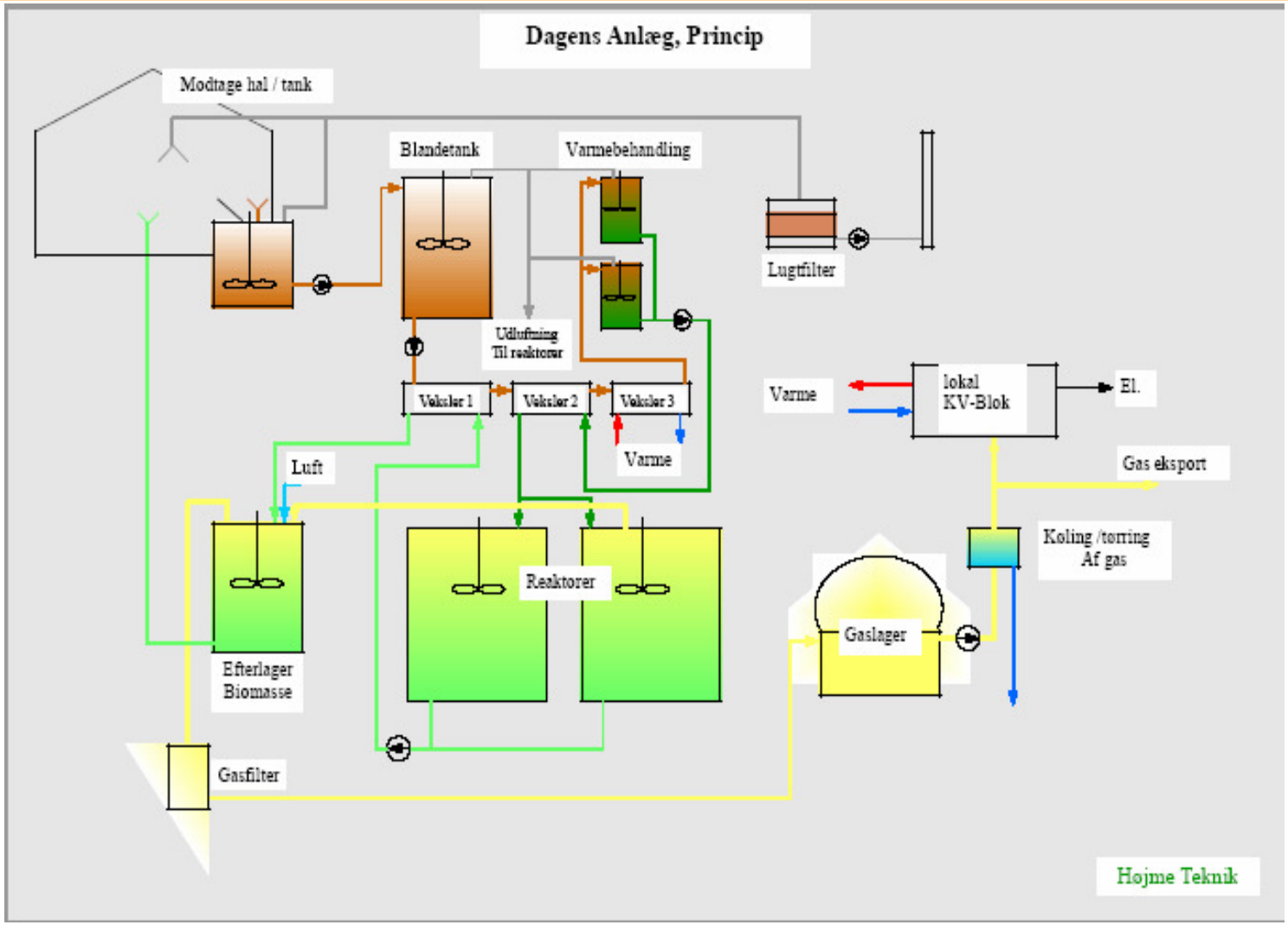
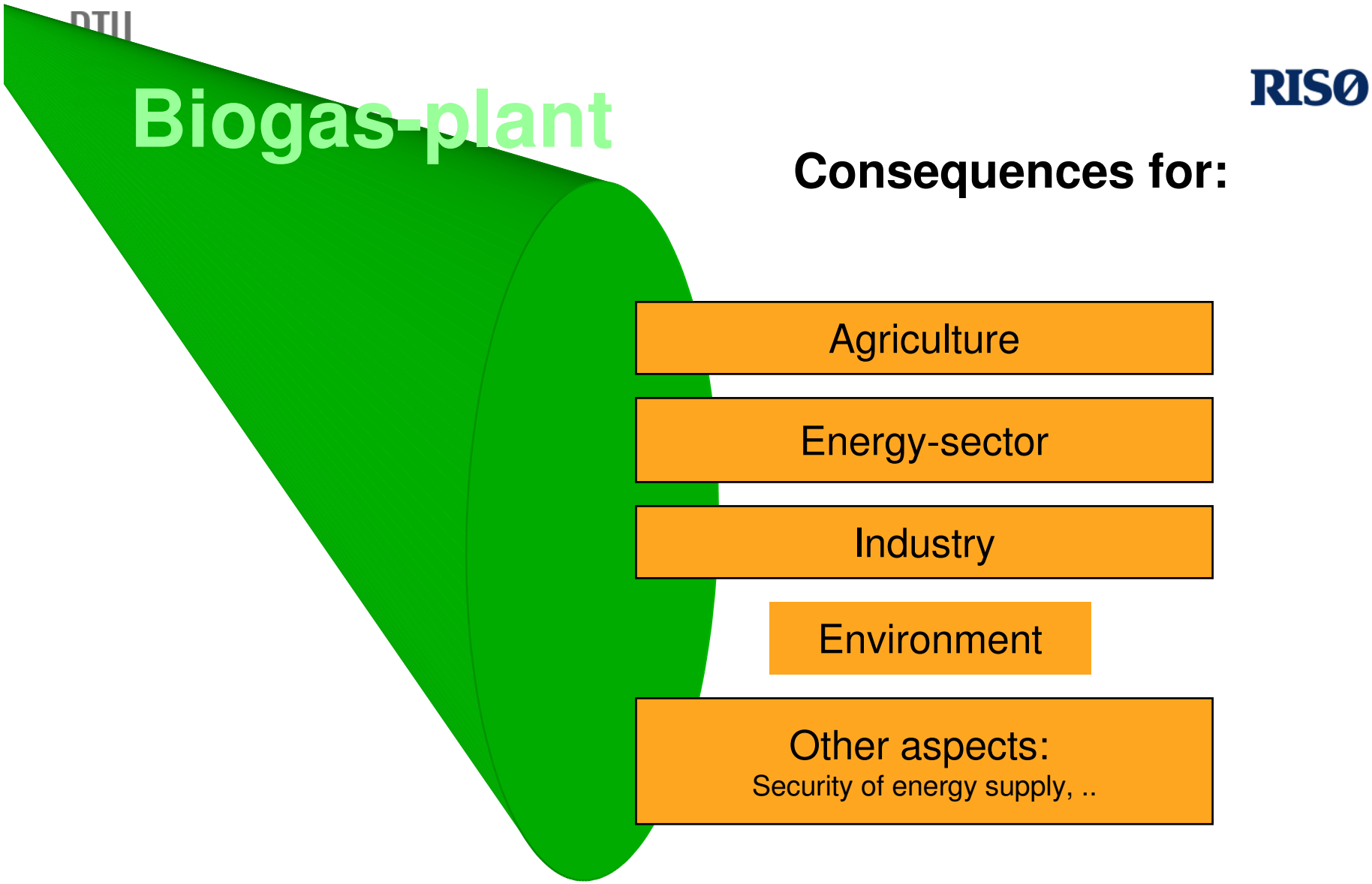
Centralized biogas plant concept analysed (Dagens Biogas-anlæg)




Biogas-plant
Consequences for:
Agriculture
Energy-sector
Industry
Environment
Other aspects:
Security of energy supply, ..
Alternative
Reference

Socio-economic aspects

Split on levels termed: Result 0,1,2,3

Level of analysis:	Result 0	Result 1	Result 2	Result 3
Aspects included:				
Energy and resources:				
Value of energy production (biogas, electricity, heat)	R0	R0	R0	R0
Capacity savings related to grids	R0	R0	R0	R0
Security of energy supplies and political stability issues				(R3)
Resource savings (energy and nutrients)				
Global balance of trades				
Infrastructure costs / roads, ..				
..				
Environment				
Value of GHG reduction (CO_2, CH_4 and N_2O)			R2	R2
Other emissions (SO_2, NO_x,..)				
Savings related to organic waste treatment and recycling		R1	R1	R1
Value of reduced N-eutrophication of ground water:			R2*	R2*
Value of reduced obnoxious smells				R3
..				
Agriculture				
Storage, handling and distribution of liquid manure:		R1	R1	R1
Flexibility gains at associated farms				
Value of improved manurial value (NPK)		R1	R1	R1
Veterinary aspects				
..				
Investments and O&M-costs:				
Investments. Biogas Plant & CHP	R0	R0	R0	R0
O&M of Biogas Plant , incl. CHP unit for process heat	R0	R0	R0	R0
Investments and O&M for liquid manure transport	R0	R0	R0	R0
..				
Other aspects				
Employment effects				
Working environment aspects, helth and comfort				
..				

Market prices and externalities

Externalities: **Socio-economic costs and benefits**

not reflected in market prices

"Socio-economic price" = Market price + External costs/benefits

Methods for monetising external effects:

- Preference-based methods

  E.g. via virtual markets that reveal market-preferences
  (Interview investigations: How much will people pay to avoid an external effect.)
  Theoretical preferable. However, data often not available.

- Cost-based methods

  Focus on damage costs due to the external effect.
  (Repair of damage, loss of production value, medical costs et.c.)
  May not reveal all external costs.

Monetising via: Costs for avoiding / removing the negative external effect

Treatment capacity and estimated energy production.

	F	IRL	SP	GR	B	NL
Treatment capacity:						
1000 ton /year	44	53	168	34	75	220
Treatment capacity:						
ton /day	**120**	**144**	**460**	**93**	**200**	**600**
Biogas yield:						
mil m3 CH4/y	1,6	1,1	4,4	1	1,5	6,4
Biogas yield:						
m3 CH4/t	**37**	**21**	**26**	**30**	**20**	**29**
Electricity:						
1000 MWh/y	**5,9**	**4**	**16**	**3,7**	**7,9**	**23**
Heat:						
1000 MWh/y	**7,5**	**4,6**	**23**	**5,2**	**7,9**	**34**

Basic socio-economic assumptions

- **Rate of interest:** **6% p.a.** Sensitivity on 4% p.a. and 10% p.a.
- Base year: Year 2005
- Period analysed: Year 2005-2025
  Time horizon year 2025
- Terminal values: Via annuity until time horizon.
- Re-investments: Identical re-investments at life times below time horizon.
- **Price level:** **Fixed year 2005 price level.**

(NB: factor-prices Ex. tax, subsidies et.c.)

- **Fuel prices:** **Based on IEA-forecasts covering the period**

  (Adjusted according to the oil price rise seen, - but IEA data from 2010)

- **Electricity prices:** **Nordpool ex. estimated CO2-price element**

Annual socio-economic costs and benefits for the CAD alternatives, levelised annuities.

	F	IRL	SP	GR	B	NL
Per day treatment capacity, tons	**120**	**144**	**460**	**93**	**200**	**600**
Methane yields, m3 CH4/ton biomass	37	21	26	30	20	29
Costs:			**1,000,000 Euro /Year**			
Investments:						
-Biogas plant	0.389	0.388	0.493	0.249	0.359	0.574
-CHP plant	0.049	0.038	0.109	0.025	0.044	0.185
Operation and maintenance						
-Biogas production	0.284	0.285	0.413	0.180	0.278	0.566
-Vehicle fuel	0.013	0.004	0.061	0.006	0.027	0.071
-Transport costs (excl. fuel)	0.104	0.137	0.456	0.036	0.132	1.374
Sum	**0.839**	**0.852**	**1.532**	**0.496**	**0.840**	**2.770**
Benefits:			**1,000,000 Euro /Year**			
Energy production						
-Electricity sales	0.190	0.136	0.479	0.126	0.355	0.785
-Heat sales	0.188	0.093	0.000	0.000	0.088	0.000
Agriculture						
-Storage and handling of manure	-0.014	-0.036	0.000	0.000	-0.025	-0.037
-Improved fertilizer value (NPK)	0.016	0.021	0.160	0.076	0.087	0.308
-Transport savings at farms	0.000	-0.027	0.000	0.004	-0.006	1.066
-Veterinary aspects (not quantified)						
Industry						
-Savings in organic waste treatment	0.182	0.235	0.104	0.278	0.062	0.000
Environment						
-Value of green house gas reduction	0.165	0.096	0.399	0.114	0.078	0.631
-Value of reduced Nitrogen losses	0.051	0.038	0.166	0.037	0.061	0.347
-Value of reduced obnoxious odours	0.017	0.017	0.083	0.008	0.026	0.108
Sum	**0.795**	**0.573**	**1.391**	**0.643**	**0.726**	**3.208**
Socioeconomic surplus:	**-0.044**	**-0.279**	**-0.140**	**0.147**	**-0.114**	**0.438**

Reduced N leakage to ground water / Danish data !

	F	IRL	SP	GR	B	NL
Per day treatment capacity: tons/day	**120**	**144**	**460**	**93**	**200**	**600**
Reduced leakage: ton N / year	**15.3**	**11.1**	**49.4**	**11.2**	**18.2**	**103.3**
Monetised value of reduced leakage: €/year	**51500**	**38000**	**166000**	**37611**	**61000**	**347000**

Reduced leakage: 25 % of saved chemical N fertilizer.
Monetised value 3,4 €/kg N reduced leakage (ref. Brian Jacobsen, Økonomisk midtvejsevaluering, Vandmiljøplan II, dec.2000)

Green House Gasses included

IPCC-defined GHGs and GWP cf. 2. Assessment Report (SAR) :

- **CO_2, GWP_{100}= 1 (weight based)**
- **CH_4, GWP_{100}= 21**
- **N_2O, GWP_{100}= 310**

GWP_{100}: Global Warming Potential covering 100 years

Other GHGs are not important in relation to biogas plants

Quantify changed emission of:

Carbon dioxide, methane and laughing gas due to the biogas alternatives

Value of GHG emission reduction:

National Quotas and a market for CO2 emission allowances

EU-project ExternE (damage costs): 3.8-139 €/ton CO_2

EU aim for 'CO_2 capture and sequestration': 30 / 20 €/ton CO_2

PCF(JI,CDM)/ World Bank. **GHG** Price 2006 about: ~ 10 $/ton CO_2

NordPool (CO_2 emission allowance). Market price: ~ 0.5 $/ton CO_2 (2007) ~ 20-21$/ton CO_2 (2008-12)

The present analysis (cf. Danish Energy Authority. 2007): 20 €/ton CO_2

(150DKK/ton CO2)

Estimated annual Green House Gas reduction in the case studies.

	F	IRL	SP	GR	B	NL
Per day treatment capacity, tons	**120**	**144**	**460**	**93**	**200**	**600**
Ton CO2 or CO2 eqv.						
Electricity sales	**3575**	**1856**	**10823**	**2320**	**1762**	**15386**
Heat sales	2637	1217	0	0	920	0
NPK substitution	622	299	1909	453	742	3932
Transport fuel	-99	-32	-454	-44	-201	-531
Total from energy substitution	**6735**	**3340**	**12278**	**2729**	**3223**	**18787**
CH4, Ton CO2 eqv						
Animal manure	336	6	2163	840	219	7308
Organic waste	630	183	105	1848	122	0
CHP plant, unburnt	-378	-273	-1134	-252	-226	-1575
Total from reduced CH4 emissions	**582**	**-78**	**1124**	**2436**	**115**	**5726**
N2O, Ton CO2 eqv.						
Manure and waste	**839**	**446**	**6365**	**465**	**507**	**6737**
Total reduction in ton CO2 eqv	**8155**	**3709**	**19767**	**5630**	**3845**	**31250**
CO2 reduction, ton CO2 eqv/ton biomass	**0.186**	**0.071**	**0.118**	**0.166**	**0.051**	**0.142**

For Break-Even Green House Gas (GHG) reduction costs

	F	IRL	SP	GR	B	NL
Per day treatment capacity, tons/day	120	144	460	93	200	600
Euro / ton CO2 eqv.						
GHG reduction costs, €/ton CO_2	26	79	27	-6	50	6

NordPool (CO2 emission allowance)

Market price: ~ 0.5 $/ton CO2 (2007)

~ 20-21 $/ton CO2 (2008-12)

Electricity production costs for Break-Even of the CAD system

	F	IRL	SP	GR	B	NL
Per day treatment capacity, tons/day	**120**	**144**	**460**	**93**	**200**	**600**
Euro / kWh						
Electricity production costs, €/kWh	**0,042**	**0,104**	**0,044**	**-0,006**	**0,071**	**0,015**

Electricity price 2006-2025 ?

Average Nordpool market price assumed (inclusive CO2 cost element): 0.0417 EUR/kWh
Nordpool market price assumed (exclusive CO2 cost element): 0.0341 EUR/kWh
(Levellized for 2006-2025)

Transmission cost compensation not included ?

Main socio-economic conclusions

- Two out of six cases are found to be socio-economically profitable when all quantified externalities are taken into account.
- Another three plants are close to Break-Even, and would certainly be profitable if they were given more favourable conditions, i. e. if existing barriers were removed.

- Lack of heat markets in some cases reduce the potential benefits (from energy substitution, CO2-emission reduction and economy)

- In general organic waste contributes largely to the socio-economic benefits, and several cases would benefit greatly from additional waste input.

  Admixture of organic waste important:

  Combined benefits on e.g. biogas production, savings on organic waste treatment, improved manurial value (NPK) and increased CO_2 reduction.

- Due to the lack of case-specific data some environmental benefits are based on Danish data. Therefore some of these estimates are relatively uncertain.

(A number of externalities have not been quantified for the analysis. Most expected in favour for Biogas)