Anaerobic digestion plants as upstream treatment before composting - technology, costs and profitability -

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BUNDESMINISTERIUM FÜR UMWELT, NATURSCHUTZ UND REAKTORSICHERHEIT (FKZ 0327544)

Optimierungen für einen nachhaltigen Ausbau der Biogaserzeugung und –nutzung in Deutschland (FKZ 0327544).

AUFTRAGNEHMER UND PROJEKTLEITUNG:

TEIL-BERICHT

Wirtschaftliche Bewertung von Kompostierungsanlagen hinsichtlich der Integration einer Anaerob-Stufe als Vorschaltanlage

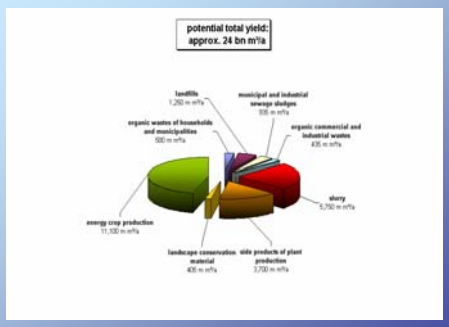
BEARBEITUNG DURCH DIE ARBEITSGEMEINSCHAFT:

Juli 2007

Research study on behalf of the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety:
„Improvements for a sustainable development of biogas production and use in Germany“

Report on project part:
„Economic assessment of composting plants regarding the integration of an anaerobic treatment unit as upstream plant“

Biogas potential in Germany



Source: IE at http//www.bio-energie.de

Approach

- **Assessment of the existing composting plants**
- **Estimate of the operational expenses of biowaste composting**
- **Inquiry of manufacturers regarding the investment and operational expenses of anaerobic digestion plants**
- **Estimate of the operational expenses of an anaerobic pretreatment unit for**
  - three different technical designs
  - three different plant sizes
- **Estimate of biogas utilization revenues**
- **Overall economic assessment with regard to applied technology and plant size**

Plant Inventory

size range	number	capacity [Mg]	capacity [%]
up 10,000	410	2,409,870	25.1%
10,001 - 20,000	119	1,826,370	18.9%
20,001 - 30,000	69	1,796,925	18.6%
30,001 - 50,000	42	1,654,856	17.1%
more than 50,000	28	1,962,940	20.3%
sum	**668**	**9,650,961**	**100.0%**

Assessed plant sizes:

- **10,000 Mg/a**
- **20,000 Mg/a**
- **40,000 Mg/a**

Basic conditions

- **Treatment of coarse fraction of biowaste exists**
- **Plant meets requirements of TA-Luft (technical regulation „Air“)**
  (enclosed reception area and composting hall; exhaust air collection and cleaning)
- **Treatment of digestion residues is realized in the existing aerobic treament facility of the composting plant**
- **Structural conditions of the site can be called „normal“**
  (building ground conditions, emission and immission situation etc.)
- **Integration of an upstream plant can be realized without purchase of site**
  (complete integration in existing plant area is possible)
- **Disposal and marketing conditions for digestion residues are comparable to those for compost**

Anaerobic treatment strategies

- **Type 1: Partial flow digestion**
  - 50 to 80 % of biowaste into digestion unit
  - high gas yield of 150 Nm³ based on fermenter input
  - high technical complexity and automation level
  - high specific investment costs (350 – 700 €/Mg)
- **Type 2: Complete flow digestion with hig gas yield**
  - 100 % of the biowaste into the digestion unit
  - gas yield of 100 - 130 Nm³ based on the plant-/fermenter input
  - high technical complexity and automation level
  - high specific investment costs (300 – 600 €/Mg)
- **Type 3: Complete flow digestion with low mechanization level**
  - 100 % of the biowaste into the digestion unit
  - low gas yield of 80 Nm³ based on the plant-/fermenter input
  - low technical complexity and automation level
  - low spezific investment costs (200 – 300 €/Mg)

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Cost structure for integrating an AD plant connected upstream of a composting plant (all costs without VAT) dated June 07

Type 1: Partial flow digestion

INPUT biowaste digestion (treatment) Mg/a	10.000	20.000	40.000
dry matter DM (%):	average 45	average 45	average 45
organic dry matter oDM (%):	average 60	average 60	average 60
of which INPUT biology digestion (%)	50 to 80	50 to 80	50 to 80
INVESTMENT			
investment for integrating the digestion (i.e. no general dry processing, e.g. separation of unwanted materials, coarse crushing, without composting, without post-maturation, without storage, but incl. additional required digestion-specific up- and downstream processing technology) in €/Mg Input (1)	400 to 700; average 600	350 to 650; average 550	350 to 550; average 450
MATERIAL-/ENERGY BALANCE			
expected gas yield (Nm³ biogas/Mg input fermenter)	average 150	average 150	average 150
expected methane content (%)	average 55	average 55	average 55
power demand of plant (kWh/Mg input)	average 85	average 75	average 65
heat demand of plant (kWh/Mg input)	50 to 180; average 130	50 to 180; average 130	50 to 180; average 130
quantity of AD residue dewatered (Mg AD residue/Mg input fer	0,20 to 0,40	0,20 to 0,40	0,20 to 0,40
sewage water quantity to be disposed (l/Mg input fermenter)	500 to 700	500 to 700	500 to 700
OPERATIONAL EXPENSES			
full load hours CHP plant (h/a)	7.000 to 7.500	7.200 - 7.800	7.500 - 8.000
labour demand (AK/a)	1 to 2	1 to 2	1 to 2
other equipment (€/Mg Input)	< 10	< 10	< 10
maintenance, repair, support (% of invest)	2 to 5; average 3,5	2 to 5; average 3,5	2 to 5; average 3,5
operational expenses digestion incl. debt service without EEG support (€/Mg input), dated 2007	45 to 55	42 to 50	40 to 45
cost reduction aerobic treatment (lower troughput required, lower organic input, lower aeration rates) specific to asset (€/Mg input)	5 to 10	5 to 10	5 to 10
MISCALLANEOUS			
area demand (m²/Mg input)	0,15 to 0,25	0,12 to 0,18	0,07 to 0,12
number of fermenters	> 2	> 2	> 2
possible capacity increase aerobic treatment (% of 1)	25 to 45	25 to 45	25 to 45

size
fermenter input
investment
biogas yield
capacity increase

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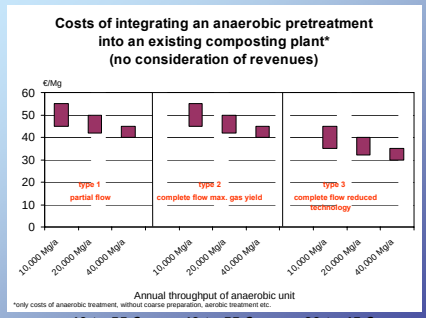
Cost structure for the integration of an AD plant connected upstream of a composting plant (all costs without VAT) dated June 07

Type 3: Complete flow digestion with low mechanization level

INPUT biowaste digestion (treatment) Mg/a	10	20	40
dry matter DM (%):	average 45	average 45	average 45
organic dry matter oDM (%):	average 60	average 60	average 60
of which INPUT biology digestion (%)	100	100	100
INVESTMENT			
investment for integrating the digestion (i.e. no general dry processing, e.g. separation of unwanted materials, coarse crushing, without composting, without post-maturation, without storage, but incl. additional required digestion-specific up- and downstream processing technology) in €/Mg Input (1)	250 to 300; average 275	225 to 275; average 250	200 to 250; average 225
MATERIAL-/ENERGY BALANCE			
expected gas yield (Nm³ biogas/Mg input fermenter)	average 80	average 80	average 80
expected methane content (%)	average 55	average 55	average 55
power demand of plant (kWh/Mg input)	average 25	average 25	average 25
heat demand of plant (kWh/Mg input)	average 30	average 30	average 30
quantity of AD residue dewatered (Mg AD residue/Mg input fer	0,90 to 0,95	0,90 to 0,95	0,90 to 0,95
sewage water quantity to be disposed (l/Mg input fermenter)	50 to 100	50 to 100	50 to 100
OPERATIONAL EXPENSES			
full load hours CHP plant (h/a)	7.000 to 7.500	7.200 - 7.800	7.500 - 8.000
labour demand (AK/a)	1 to 2	1 to 2	1 to 2
other equipment (€/Mg Input)	< 10	< 10	< 10
maintenance, repair, support (% of invest)	2 to 5; average 3,0	2 to 5; average 3,0	2 to 5; average 3,0
operational expenses digestion incl. debt service without EEG support (€/Mg input), dated 2007	35 to 45	32 to 40	30 to 35
cost reduction aerobic treatment (lower troughput required, lower organic input, lower aeration rates) specific to asset (€/Mg input)	< 5	< 5	< 5
MISCALLANEOUS			
area demand (m²/Mg input)	0,30 to 0,50	0,25 to 0,35	0,15 to 0,25
number of fermenters	> 2	> 2	> 2
possible capacity increase aerobic treatment (% of 1)	5 to 10	5 to 10	5 to 10

size
fermenter input
investment
biogas yield
capacity increase

Operational expenses



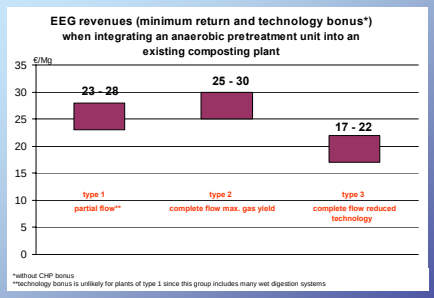
+ 40 to 55 € **+ 40 to 55 €** **+ 30 to 45 €**

Payment of biogas utilization

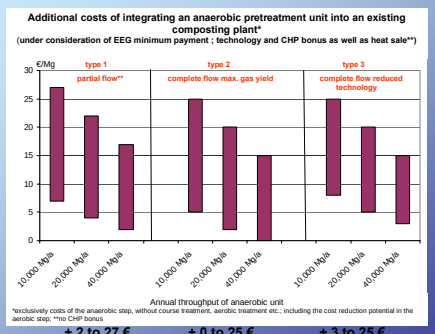
plant size	biomass minimum payment*	CHP bonus	innovative technology bonus**
	Cent/kWh	Cent/kWh	Cent/kWh
≤ 150 kW	10.83	2.00	2.00
≤ 500 kW	9.32	2.00	2.00
≤ 5 MW	8.38	2.00	2.00
≤ 20 MW	7.91	2.00	2.00

* minimum payment of previous year minus 1,5%
** only in connection with CHP

Revenues of biogas use



Remaining additional costs



+ 2 to 27 € + 0 to 25 € + 3 to 25 €

average of + 10 to 20 € additional costs

Options for cost optimization

Increase of throughput of the existing composting facility

Green waste treatment

Synergies in compost production

- Pretreament reduces the retention time in the aerobic treatment unit

⇨ Additional revenue/cost reduction approx. 5 to 10 €/Mg

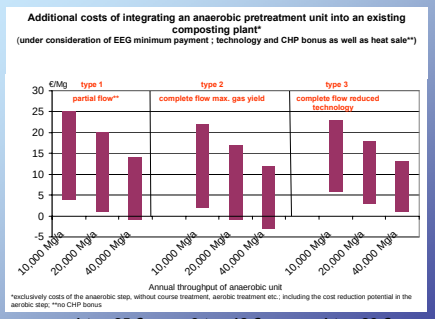
Heat utilization and CHP bonus

- Heat utilization depends on location and market
- Heat revenue (tentative estimate) = 20 €/MWh
- Assumption: 40 % of excess heat is used

⇨ Additional revenue/cost reduction approx. 3 €/Mg

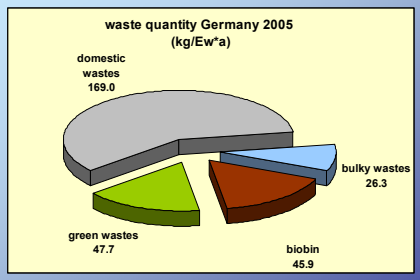
CO_2 trade

Additional costs under favorable conditions



-1 to +25 € -3 to +12 € +1 to +23 €

Cost optimization green waste treatment



Green waste treatment

Cost reduction through new recovery ways for green waste

„Golden section“

Fraction of high calorific value for thermal recovery
Inert materials and plant nutrients for compost

Treatment

With simple, usually existing technology

Cost savings – green waste treamtent

- Starting point for composting and compost marketing 30 to 60 € per ton green waste
- Separation rate for fuel = one third
- Treatment costs for fuel = revenue incl. local transport
- Cost savings = 10 to 20 € per ton green waste
- Additional costs for anaerobic biowaste treatment can be counterbalanced
- Ecological energy and CO_2 savings without additional costs by using existing resources

CO_2 savings

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- Energy from biowaste (η = 38 %) ⇨ 228 kWh/Mg $_{untreated}$
- Energy from green waste (η = 25 %) ⇨ 800 kWh/Mg $_{untretaed}$
- CO_2 savings ⇨ 345 g/kWh power $_{energy\ mix}$
- from 40,000 Mg biowaste ⇨ 3,150 Mg CO_2 savings per year
- from 40,000 Mg green waste ⇨ 11,040 Mg CO_2 savings per year
- Costs for CO_2 certificate ⇨ 22 to 23 € per ton CO_2
- Value of CO_2 savings ⇨ 312,180 to 326.370 € per year

ECN Workshop Nürnberg, January 16th to 17th 2008

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Thank you very much for your attention!

ECN Workshop Nürnberg, January 16th to 17th 2008

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