KNOWLEDGE CENTRE FOR AGRICULTURE

Organic Biogas in Denmark

Master Thesis
Morten Brix Jensen

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PARTNER IN DLBR

Naturerhverv.dk
Ministeriet for Fødevarer, Landbrug og Fiskeri
Den Europæiske Landbrugsfond for Udvikling af Landdistrikterne
Danmark og Europa investerer i landdistrikterne

Se 'European Agricultural Fund for Rural Development' (EAFRD)

Agenda

- VFLs project and this master thesis
- The Sjællandcase
- The symbiosis
- Business case
  - Best case
  - Realistic case
- Theoretical profit from the biomasses
- Recommendations and use of knowledge

VFLs project

- Organic fertilizer based on solid organic material treated in biogas plants

- Hypothesis:

"There are low degree of profitable economy in an organic biogas plant, especially if the primarily biomass is plant material"

This master thesis

- Based on the goals for 2020
  - More biogas
  - More organic argriculture
  - Out phasing of conventional manure
- Defining the symbiosis between biogas and organic farming
- Defining the synergy towards the national policies

Research methods

- Case study
- Organic biogas workshop
- Mapping and visualization
- Literature study
- Retroductive synthesis
- Business case
- Analysis of the symbiosis
- National political analysis

Sjællandcase

- Only crop production – Dependent on conventional animal manure
- Sale of electricity and heat
- Extra yield at the three farmers
- 2300 ha – Larger organic farmers

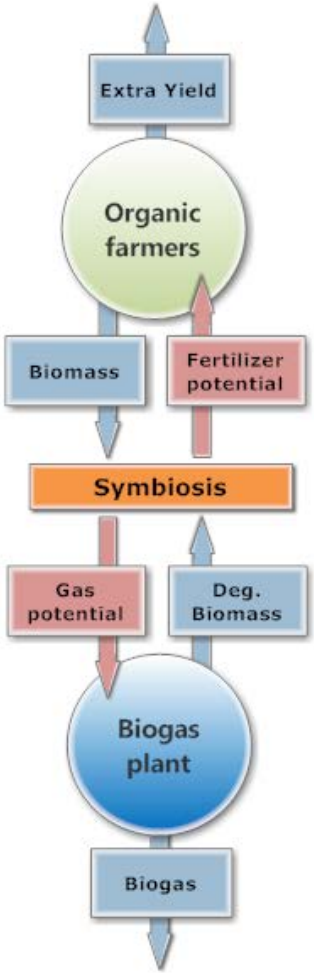
Available biomasses

Biomass	DM %	DM ton	ton
Organic crop biomass			
Clover grass silage	37,9	752	1.985
Straw + Clover grass silage	42,3	621	1.470
Seed grass straw	85,0	1.088	1.280
Straw	85,0	1.020	1.200
Permanent grass silage	37,1	152	410
Carrots + tops	17,6	52	300
Regrown seed grass silage	34,7	76	220
Separated grains	85,0	170	200
Yellow mustard silage	15,5	23	150
Organic animal manure			
Cattle deep straw	27,5	715	2.600
Cattle slurry	8,0	160	2.000
Cattle manure (Solid)	27,5	275	1.000
Total	-	**5.107**	**12.815**
Conventional animal manure			
Pig slurry	4,0	1.280	32.000
Cattle deep straw	27,5	852	3.100
Pig deep straw	25,3	165	600
Poultry manure (solid)	45,0	225	500
Cattle manure (solid)	8,0	32	400
Total	-	**2.555**	**36.600**

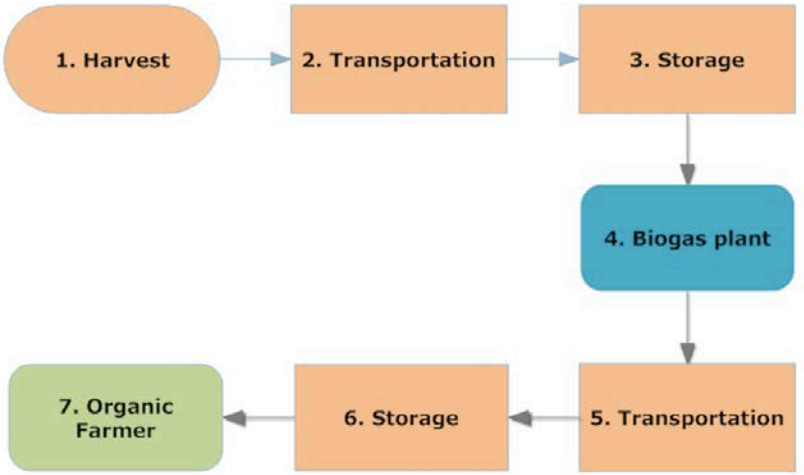
Preconditions and objectives

- Availability of more organic fertilizer
  - Higher yield
  - Higher protein content
- External investor is needed for the biogas plant
- Utilization of the current crop
- Calculations on different scenarios

The Symbiosis



Proces flow in the symbiosen



Scenarios

- Best case
  - Sale of heat
  - No loss of fertilizer ability
- Realistic case
  - No sale of heat
  - Loss of 20 percent fertilizer ability

Investment

Plant	Dranco	Sauter	Agrikomp	Combigas	Aikan
Total investment	**45.046.501 kr.**	**12.429.869 kr.**	**18.004.001 kr.**	**17.195.941 kr.**	**64.629.001 kr.**
Ton	40.630	10.400	12.535	47.715	20.500
Ton DM	10.813	3.386	4.712	6.614	7.507
Investment per. ton input	1.108 kr.	1.195 kr.	1.436 kr.	360 kr.	3.152 kr.
Investment per. Ton DM input	4.166 kr.	3.671 kr.	3.821 kr.	2.600 kr.	8.609 kr.
Technical solution	Garage/slurry based	None-slurry based	None-slurry based	Slurry based	Garage based

- Simple offers
- Dranco and Aikan using expensive methods
- Combigas using well known method
- Sauter and Agrikomp specialize in solid biomasses

Production

Plant	Dranco	Sauter	Agrikomp	Combigas	Aikan
Biogas production	**4.228.302 Nm3**	**1.633.956 Nm3**	**1.705.717 Nm3**	**2.499.042 Nm3**	**1.253.681 Nm3**
Biogas production per ton input	104,07 Nm3	157,11 Nm3	136,08 Nm3	52,37 Nm3	61,16 Nm3
Biogas produktion pert ton DM input	391,03 Nm3	482,62 Nm3	362,01 Nm3	377,86 Nm3	167,00 Nm3
NH4-N per ton input	1,40 kg	0,31 kg	0,99 kg	1,84 kg	1,04 kg
NH4-N production	156 ton	40 ton	58 ton	157 ton	89 ton
NH4-N production per ton output	4,44 kg	4,86 kg	5,64 kg	3,52 kg	5,44 kg

- Aikan is specialized for a different biomass
- Combigas can only handle a low dry matter

Profitability (Best case)

Plant	Dranco	Sauter	Agrikomp	Combigas	Aikan
The biogas plant					
Earning	12.140.292 kr.	4.130.967 kr.	4.477.904 kr.	7.502.220 kr.	3.631.095 kr.
Cost	11.273.887 kr.	3.484.889 kr.	3.894.901 kr.	3.758.431 kr.	15.380.800 kr.
Profit	**866.405 kr.**	**646.078 kr.**	**589.003 kr.**	**3.743.789 kr.**	**-11.749.705 kr.**
The organic farmers					
Earning	5.921.425 kr.	2.904.324 kr.	3.502.753 kr.	6.089.364 kr.	4.208.262 kr.
Cost	1.226.470 kr.	266.245 kr.	345.975 kr.	1.116.775 kr.	227.500 kr.
Profit	**4.694.956 kr.**	**2.638.079 kr.**	**3.156.778 kr.**	**4.972.589 kr.**	**3.980.762 kr.**
The symbiosis					
Joint profit	5.561.361 kr.	3.284.157 kr.	3.739.781 kr.	8.716.378 kr.	-7.768.942 kr.
Cost	7.615.689 kr.	3.131.891 kr.	2.976.277 kr.	5.350.745 kr.	3.710.095 kr.
Profit in the symbiosis	**-2.054.327 kr.**	**152.267 kr.**	**763.504 kr.**	**3.365.633 kr.**	**-11.479.038 kr.**
Profit per ton	-50,56 kr.	14,64 kr.	60,91 kr.	70,54 kr.	-559,95 kr.
Profit per ton DM	-189,89 kr.	44,97 kr.	162,04 kr.	524,35 kr.	-1.529,07 kr.

Profitability (Realistic case)

Plant	Dranco	Sauter	Agrikomp	Combigas	Aikan
The biogas plant					
Earning	11.169.858 kr.	3.685.068 kr.	4.207.357 kr.	6.686.156 kr.	3.092.566 kr.
Cost	11.273.887 kr.	3.484.889 kr.	3.894.901 kr.	3.758.431 kr.	15.380.800 kr.
Profit	**-104.029 kr.**	**200.178 kr.**	**312.455 kr.**	**2.927.724 kr.**	**-12.288.234 kr.**
The organic farmers					
Earning	5.183.943 kr.	2.419.800 kr.	2.971.080 kr.	5.346.107 kr.	3.619.731 kr.
Cost	1.226.470 kr.	266.245 kr.	345.975 kr.	1.116.775 kr.	227.500 kr.
Profit	**3.957.473 kr.**	**2.153.556 kr.**	**2.625.105 kr.**	**4.229.331 kr.**	**3.392.231 kr.**
The symbiosis					
Joint profit	3.853.444 kr.	2.353.734 kr.	2.937.560 kr.	7.157.056 kr.	-8.896.003 kr.
Cost	7.615.689 kr.	3.131.891 kr.	2.976.277 kr.	5.350.745 kr.	3.710.095 kr.
Profit in the symbiosis	**-3.762.244 kr.**	**-778.156 kr.**	**-38.717 kr.**	**1.806.311 kr.**	**-12.606.098 kr.**
Profit per ton	-92,60 kr.	-74,82 kr.	-3,09 kr.	37,86 kr.	-614,93 kr.
Profit per ton DM	-347,93 kr.	-229,84 kr.	-8,22 kr.	281,42 kr.	-1.679,20 kr.

What are the earnings for the farmers?

Fertilizer use	All fertilizer	Only organic
Earning	4.841.031 kr.	704.466 kr.
Cost	1.133.000 kr.	176.000 kr.
Profit	**3.708.031 kr.**	**528.466 kr.**
Acquisition cost	?	?

- How large are the acquisition costs?
- Better profit in the current situation

Theoretical output from the biogas plant

Biomasses	Yield	Dry matter	Biogas		NH4-N	
Unit	Ton/ha	%	Nm3/ton	Nm3/ha	Kg/ton	Kg/ha
Clover grass	6	37,9	197,40	**1.184**	7,06	**42,38**
Straw + Clover grass	7	42,3	233,22	**1.632**	5,87	**41,11**
Seed grass straw	4	85,0	297,49	**1.190**	7,44	**29,77**
Straw	3	85,0	318,99	**957**	4,49	**13,47**
Permanent grass	4	37,1	190,24	**761**	6,49	**25,96**
Carrots + tops	-	17,6	70,65	**-**	2,77	**-**
Regrown seed grass	1	34,7	150,83	**150**	6,38	**6,38**
Separated grains	-	85,0	380,57	**-**	9,35	**-**
Yellow mustard	5	15,5	58,99	**295**	2,21	**11,06**

- High dry matter content and N content
- Inhibition of the process

Theoretical earnings from the biomasses

Biomasses	Earnings Biogas		Earnings Farmer		Total earnings	
Unit	Kr./ton	Kr./ha	Kr./ton	Kr./ha	**Kr./ton**	**Kr./ha**
Clover grass	650	3.902	684	3.706	**1.334**	**7.608**
Straw + Clover grass	750	5.253	570	3.608	**1.320**	**8.861**
Seed grass straw	946	3.785	720	2.703	**1.666**	**6.488**
Straw	1.008	3.024	437	1.282	**1.445**	**4.305**
Permanent grass	624	2.497	629	2.383	**1.253**	**4.880**
Carrots + tops	225	-	271	-	**496**	**-**
Regrown seed grass	503	503	619	619	**1.122**	**1.122**
Separated grains	1.235	-	899	-	**2.134**	**-**
Yellow mustard	180	900	217	1.059	**397**	**1.959**

- Best case used in the calculations – Heat sale
- Fertilizer on seed grass – Generating the highest yield

Cost related to the biomasses

Biomasses	Symbiosis		Degasification		Spreading		Total cost	
Unit	Kr./ton	Kr./ha	Kr./ton	Kr./ha	Kr./ton	Kr./ha	**Kr./ton**	**Kr./ha**
Clover grass	272	1.633	310	1.860	26	155	**608**	**3.647**
Straw + Clover grass	246	1.725	310	2.170	25	175	**581**	**4.070**
Seed grass straw	285	1.141	310	1.240	21	86	**617**	**2.467**
Straw	285	855	310	930	21	63	**616**	**1.849**
Permanent grass	358	1.432	310	1.240	26	105	**694**	**2.777**
Carrots + tops	109	-	310	-	31	-	**450**	**-**
Regrown seed grass	1.127	1.127	310	310	26	26	**1.463**	**1.463**
Separated grains	91	-	310	-	18	-	**419**	**-**
Yellow mustard	315	1.578	310	1.550	32	160	**658**	**3.288**

- Agrikomp plant
- Average distance of 17 km

Profit from the biomasses?

Biomasses	Cost		Earning		Profit	
Unit	Kr./ton	Kr./ha	Kr./ton	Kr./ha	**Kr./ton**	**Kr./ha**
Clover grass	608	3.647	1.334	7.608	**726**	**3.960**
Straw + Clover grass	581	4.070	1.320	8.861	**739**	**4.791**
Seed grass straw	617	2.467	1.666	6.488	**1.049**	**4.021**
Straw	616	1.849	1.445	4.305	**829**	**2.457**
Permanent grass	694	2.777	1.253	4.880	**559**	**2.103**
Carrots + tops	450	-	496	-	**46**	**-**
Regrown seed grass	1.463	1.463	1.122	1.122	**-340**	**-340**
Separated grains	419	-	2.134	-	**1.715**	**-**
Yellow mustard	658	3.288	397	1.959	**-260**	**-1.328**

- Clover grass and straw is making the best profit
- Carrots, yellow mustard and regrown seed gas is not profitable

Profit from the biomasses?

Biomasses	Cost		Earning		Profit	
Unit	Kr./ton	Kr./ha	Kr./ton	Kr./ha	**Kr./ton**	**Kr./ha**
Clover grass	807	4.847	848	4.947	**40**	**100**
Straw + Clover grass	781	5.470	863	5.908	**82**	**438**
Seed grass straw	817	3.267	1.090	4.297	**273**	**1.029**
Straw	816	2.449	987	2.951	**171**	**503**
Permanent grass	894	3.577	799	3.151	**-94**	**-425**
Carrots + tops	650	-	311	-	**-339**	**-**
Regrown seed grass	1.663	1.663	703	703	**-959**	**-959**
Separated grains	619	-	1.402	-	**783**	**-**
Yellow mustard	858	4.288	249	1.235	**-609**	**-3.053**

- Realistic case – No heat sale and 20 percent NH4-N loss
- Very low profit generated

How can VFL use the knowledge?

- Calculations of similar cases
  - Development of a case calculator
  - Investigations in cooperation with NorFor
- Confirmation of the hypothesis
- Knowledge is created regarding the symbiosis and synergy
- Development of business area

How can the knowledge be used by other stakeholders?

- Government:
  - No profitability in organic biogas production
  - Need for more organic fertilizer
  - Setup of a trail plant
  - Knowledge creation is needed
- Farmers:
  - Optimization of the crop rotation
  - Optimization of the symbiosis
  - Pressure on the national policies

How can the knowledge be used by other stakeholders?

- Plant manufactures:
  - Optimization of the plant
  - New methods for organic biogas
  - More focus on the output biomass

- Universities:
  - Optimization of the symbiosis
  - AU research project regarding optimization of the crop rotation

Recommendations from the thesis

- Yes, the symbiosis can make more organic fertilizer available

- Optimization of all areas of the symbiosis
- Governmental support to a trail plant
- Knowledge creation within the area
- Optimization of the crop rotation in the symbiosis
- A support scheme is necessary, if the use of conventional animal fertilizer is phased out