Minute	Knowledge Centre for Agriculture Plant Production						
Economic and logistic	Responsible	IKJ					
-	Made	06-01-2014					
Project: 2525 - Biochain	Page	1 af 13					

## **1** Introduction

The management of a biomass can be done in various ways prior gasification in a biogas plant. The design of the supply chain will depend on factors such as harvest time, biomass composition, and biomass stability during storage and also time of use in the biogas plant. There are many supply chain opportunities but only few are optimal based on economic and environmental aspects. The aim of this project named Biochain is to develop a dynamic value chain model which will work as a decision support tool for consultants and biogas producers when assessing establishment of biogas plant. The overall result is an advanced mathematical model. The research activities are organized in six closely linked work packages which are shown in figure 1.



Figure 1: The interactions between the work packages in the Biochain project

In work package 0, all coordination and dissemination will be carried out whereas work package 3-5 focus on providing information and models needed to assess biogas production, environmental benefits and costs associated with each unit of the supply chain. The information from these work packages will be integrated and validated on existing biogas plants in work package 2. Work package 1 integrates the different information and sub-models gained from the other work packages into an advanced dynamic value chain model. The Knowledge Centre for Agriculture (KCA) is responsible for work package 5. The aim of this WP is to provide submodels to optimize the logistics of harvest, storage and transportation of biomasses for biogas plants. This will be economically evaluated by estimating the costs associated to each unit operation and the income based on the expected biogas potential of the biomass by using some specific biomasses as substrate in biogas plants. Based on that, the supply chain can be optimized.

# 2 System boundary

An excel model is developed which can optimize the logistic of harvest, storage and transport of large amounts of biomasses and also evaluate the economy. The model which KCA are developing, focus on the economy in each unit operation from field to plant based on seven different biomasses as listed below:

- Manure
- Deep litter
- Wheat straw
- Rapeseed straw
- Meadow grass
- Beets
- Whole crop corn

The supply chain of the biomasses is very diverse. Among others can be mentioned the harvest method, the management of the biomass and the stability of the biomass during storage. The boundary of the supply chain for the biomasses is similar to each other. The supply chain of the biomass initiates with the production and harvest and ends with storage of the biomass at the biogas plant site. An exception is the supply chain of straw where production and harvest of the straw is not included as those operations are allocated to the grain. Hence, the supply chain is initiated with collection of the straw. In appendix 1, some scenarios of the value chain for straw is presented.

Manure and deep litter are residual products from the animal production. The supply chain of manure initiates from collection of the manure from the manure pre-tank at the animal house and finish off by delivering the manure to the biogas plant in the pre-tank. As concerns deep litter, the supply chain initiates by collection of the deep litter at a site near the animal house and ends by storing the deep litter in stack at the biogas plant.

### **3 Model structure**

The contribution to the model work by KCA is made in Excel.

#### 3.1 Transport and logistical model

The model is organized so that it consists of 7 sub-models – one for each biomass. Each sub model consists of an assumption sheet where all assumptions are listed. It includes dry matter %, hourly rate of different machines and vehicles, capacities, time consumption, transport distance, efficiency in gas engine and price for electricity and heat. All these values are variable and can be changed. If the user changes the values, the model sheet will automatically recalculate new results. The model sheet where the results are presented is categorised in the following categories:

- Biomass (e.g. yield in field, field size, dry matter %)
- Production and harvest (unit costs and machine- and work costs)
- Transport (time consumption loading, on road and unloading)
- Storage (storage methods)
- Potential pre-treatment (briquetting and extrusion)
- Gas yield and gas engine efficiency

The costs are stated in kr. per ton of biomass, so that the costs are comparable to each other. The model is corrected so that limited capacities of vehicles and storages are taken into account. For instance, the costs (kr. /ton) for storage will vary depending on the utilisation of the capacity of the storage facility. The lowest cost level is gained when the capacity is fully utilised. It is not taken into account that other biomass may utilise free capacity which will reduce the storage costs if the capacity is not utilised.

The costs of using the machines and vehicles are given in an hourly rate based on price levels from a contractor. In these prices, the manpower, insurance and depreciation of the machinery are included. The time consumption of each operation is likewise based on experiences gained from contractors. The model also estimates the expected biogas potential for each biomass, treated and untreated prior gasification. Biomasses which will require some kind of pretreatment is straw, deep litter and meadow grass. The pretreatments are limited to extrusion and briquetting. It is possible to pre-treat the straw by briquetting or extrusion. Meadow grass and deep litter can only be extruded to this point. The intension is to try to pre-treat meadow grass by briquetting.

The biogas potential is based on experiments performed at Foulum Research Centre, Aarhus University. The biogas yield is converted into an income in form of sold electricity and heat by conversion in a CHP. Another option is to upgrade the biogas for the purpose of selling the gas to the gas grid. However, this is not modelled to this point. In appendix 2, an example of a sub model is shown. In figure 2, the conclusions of total costs or transport costs for the supply chain for straw (untreated and briquetted) is shown in relation to the driven kilometres. The model is still being in the process of modification.



Figure 2: Total- and transport costs for the supply chain of straw, untreated or briquetted in relation to number of driven kilometres. It is presumed that 60.000 tons of straw can be collected in a radius of 25 km from origin. Within this circle, one briquette station is placed. In the calculation behind the curves it is assumed that there is a distance of 10 km in average from each supplier to the briquette station.

The model will be integrated in the larger dynamic model made by DTU which can calculate different parameters in a given case such as greenhouse gas emissions when using wheat straw as substrate in a biogas plant

#### 3.2 Storage model

The input of biomass to a biogas plant requires optimization of which biomasses that is available and when the biomasses are going to be used in the biogas plant, so the plant can adapt the production of biogas and avoid different kind of inhibitions such as substrate inhibition and ammonia inhibition. The biomasses are only available few months every year and the quality of the biomasses may be impaired since harvest. For that reason, KCA are working on a model

called an *annual wheel* for the chosen biomasses. The annual wheel will function as stock management model from where the biogas plant can adjust the input of biomass to the plant and hence optimize the gas production and the utilisation of each biomass. In a longer run, the model will be developed so it can correct for a quality change in the biomass during storage as a function of time. At present, the model is organized in weeks so each week has a sheet. In each sheet the storage stock is given for the stock left the week before, the input this week, the output this week and the stock left at the end of the this week. This amount corresponds to the initiated amount the week after. There are cells where the input and output can be entered each week. The stock is given in wet weight, dry weight, volatile solids, total nitrogen, phosphor, potassium and methane. This is showed in appendix 3.

Hence, the model provides an overview of which biomass and how much biomass in total, that is fed to and taken out of the storage on weekly and yearly basis and also a graphical presentation of the gas production and biomass composition, so that an undesirable substrate composition can be observed quickly by a predicted decreasing gas production. The decrease in gas production can then be traced back to the composition and substances in the biomass.

## 4 Storage and quality

There are many different ways to store biomass depending on the composition of the biomass. Some storage methods are ensiling in plan silo, wrapping of bales, storage in building or outside and also storage in tank. The choice of storage method depends among others of the dry matter content of the biomass.

#### 4.1 Ensiling

Biomasses with a low DM content corresponding to 20-45 % is most efficiency stored by ensiling in order to avoid growth of fungus or another impairment of the biomass. Ensiling is normally done in plan silo where the biomass is compacted to a degree where anaerobic conditions are achieved. The process of ensiling takes at least 4 weeks. The time span of ensiling depends on the buffer capacity of the biomass. During ensiling pH drops during formation of acetic acid and lactic acid. A high level of lactic acid ensures a good preserving. The relation between lactic acid and acetic acid should be at least 3:1 and preferably 5:1 (Attermann *et al* 2003).



Figure 3: To the left: ensiling of corn silage in plan silo. To the right: Ensiling of grass.

Whole crop corn has a dry matter content of 30 %, and thus ensiling is required. During ensiling, pH drops to below 4.3 in order to achieve a good quality of the ensiled corn silage. Corn has to be stored quickly after harvest in order to avoid any loss and preferable within 2-3 hours. If aerobic conditions occur a lot of the energy in the biomass is lost as CO<sub>2</sub>.

Beets have lower dry matter content than corn silage (20 %). For that reason, beets also need to be ensiled if stored in a longer period. Beets can be stored as whole beets in plan silo or as pulp in a tank or lagoon.

In some cases, it is also necessary to ensile meadow grass. However, it depends on the dry mater content of the grass which varies a lot. The critical pH value depends on the dry matter content. If the dry matter content of the grass is 20 %, pH has to drop to below 4.2 in order to achieve a good quality of the ensiled biomass whereas pH only has to drop to below 4.8 if the dry matter content is 45 % (Attermann *et al* 2003). Figure 3 shows a plan silo with corn silage and with grass silage.

#### 4.2 Wrapping

It is necessary to wrap biomasses with a dry matter content of 45-85 %. A biomass is not storage stabile before the dry matter content reaches 85 %. It is not suited to ensile biomasses with a DM content of 45-85 % in plan silo because it is not possible to maintain the degree of compaction needed to maintain anaerobic conditions and oxygen will sink in between the biomass and initiate degradation to  $CO_2$ . The microbial processes happening after wrapping is similar to those when ensiling in plan silo. Anaerobic conditions are made and the biomass gets preserved after some time.



Figure 4: Grass wrapped in roundbales and stored on the flat surface

Wrapping will only be relevant in relation to meadow grass as the DM content of meadow grass can be within this range. Wrapped round bales have to be stored on the flat surface because a thicker layer of plastic is present there, see figure 4 (Attermann *et al* 2003).

#### 4.3 Storage in hall or outside

Storage in hall or likewise is especially suited for dry biomasses such as wheat straw in order to keep the stability of the biomass during storage. Straw has a DM content of 85-95 %. There are nearly no loss of energy during storage of dry biomasses in a hall. Straw is often pressed into big bales. However, big bales are not suited to be stored outside in a longer period of time because the way big bales are pressed allows water to penetrate into the big bale.



Figure 5: To the left: straw in big bales stored under roof. To the right; Grass in round bales stored outside on the round side.

The DM content of meadow grass varies a lot and depends on the area where it is harvested. In some meadow areas, the grass has DM content close to 85 %. In such a case, the meadow grass will be left on the field after harvest to dry until the grass is storage stabile and pressed in bales afterwards. Meadow grass will be pressed in round bales due to the vulnerability of meadow areas against heavy traffic (Bertelsen *et al* 2012). Experiments made with meadow grass from Nørreådalen showed an average weight of round bales of 280 kg (Høy, 2010), whereas big bales have a weight of approximately 550 kg. It will not be necessary to store round bales inside as straw in big bales because water cannot penetrate into round bales to a degree seen in big bales if round bales are stored on the round side as seen in figure 5.

#### 4.4 Storage in pre-tank

Liquid biomass such as manure is stored in the pre-tank on the biogas plant. In some cases, deep litter is mixed with manure in the pre-tank. However, it depends on how systematic the deep litter arrived to the biogas plant and also how the relation between manure and deep litter is. If deep litter arrives steady during time and in small amounts, the deep litter are stored mixed with manure. If the amount of deep litter is higher than what is pumpable, the deep litter will be stores on a site with drain outlets to the pre-tank with manure. A small number of biogas plants have a mixing- and shredding tank to deep litter with the purpose to get the deep litter more liquid so it can be pumped directly to the pre-tank or digestor. Den average retention time in a pre-tank is 4-7 days.

#### 4.5 Quality change during storage

During storage qualitative and quantitative changes will happen in the biomass. There are small losses of energy in spite of the preservation of ensiled biomass. There is a loss of app. 7% DM during storage of whole crop corn silage (Farmtal Online 2013a). Laursen (2011) from KCA has made an experiment on 4 farms where the loss of DM from corn silage during ensiling was found to vary from 0.7-6.4 % with average 3.1 % loss of DM.

The storage loss is 7 % of DM from grass silage (Farmtal Online 2013b). Laursen (2011) made similar experiments with storage of grass as for corn silage and he found losses from 0.5-6.7 % DM on the 4 farms with an average loss of 3.7 % DM in the grass silage.

The loss from wrapped bales will be even higher than from biomass ensiled in plan silo due to higher surface area in proportion to the volume. For that reason, a larger amount of the biomass will be exposed to oxygen.

The loss during storage of beets is not investigated yet but experiments for this purpose are planned in 2014. There is a loss of 9 % of DM during storage of fresh beets in clamp (Farmtal Online 2013c).

During ensiling the biomass is depolymerized leading to formation of lactic acid and small amounts of  $CO_2$ . In the anaerobic digestor, lactic acid will be degraded in a fermentation process and create  $CO_2$  and reduced compounds. The biogas potential after storage will decrease because a part of the biogas evaporates in the form of CO2 during storage. However, the methane potential of the biomass will change insignificant after storage and the biogas will have a higher methane %. However, the overall production of methane will not be higher due to the loss of DM.

During storage of deep litter, the biomass will compost and thus loose some of its energy when oxygen is present. According to Sommer (2001), there is a loss of 48.5 % carbon during storage of untreated deep litter from dairy cattle stored in 132 days. It corresponds to app. 55 % loss of the volatile solids after storage. However, deep litter used for biogas will only be stored up to 14 days on the biogas plant before used in the digestor which is why a smaller loss is expected. In general, the size of the loss depends on where the deep litter originates from (cattle, calves or pigs). The loss is lower in deep litter from cattle than from calves because the deep litter from cattle is much more compacted and oxygen will not penetrate into the deep litter. More straw is used to the calves and the deep litter, the biomass should be moved as little as possible because every time deep litter is moved the biomass is oxidized (Møller & Jørgensen 2003).

Manure is stored in 4-7 days prior used in the digestor. The pre-tank, where the manure is stored, is not temperate. For that reason the temperature varies from app. 5-20 degrees depending on the season. Møller *et al* (2004) have investigated the loss of carbon from manure during storage and they found an accumulated loss of 1.8-3.8 % carbon after 5 days of storage at 15 degrees. The loss is calculated based on the degradable volatile solids which are present in cattle and pig manure. The highest loss was observed from storage of cattle manure and the lowest from pig manure. The losses are modest after short-term storage which also will be the case in the model. The content of volatile fatty acids increases within 5 days of storage but the actual distribution between the different volatile fatty acids is constant within the same period of time (Møller *et al* 2004). Hence, there is a modest substance and energy loss.

## **5** References

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## Appendix 1

The figure below presents possible supply chains for straw from field to storage at biogas plant.



# Appendix 2

This appendix shows some print screens of the model from Excel.

A	В	ι.	U		E	F	G		н	1	1	ĸ	L
1 Wheat straw													
2													
3 Biomass							Økonomidata						
4 Yield of wheat straw, tons/ha	3,5						Bjærgning, kr/ton		-308				
5 Dry matter, %	85%						Lager, kr/ton		-93				
6 Yield in dry matter, tons DM/ha	3,0						Forbehandling, kr/ton		-140				
7 Density of wheat straw, ton/m3	0,14						Lager til briketter, kr/ton		-60				
8 Weight, big bales, ton/bale	0,55						Traktor med frontlæsser, kr/time		-625				
9 Density of briquettes (bulk), ton/m3	0,45						Lastbil med lad, kr/time		-525				
10 Field, ha	17142						Lastbil med tipvogn, kr/time		-600				
11													
	Just after harvest of												
	grain.												
12 Time of harvest:	August/September												
13													
14													
15 Collecting at field													
16													
17 Straw turning and collecting													
18 Turning/collecting, kr/kg	-0,07												
19 Turning/collecting, kr/ha	-245												
20 Capacity, ha/hour	4												
21 Turning/collecting, kr/ton	-70												
22													
23 Straw baling in field													
24 Baler, big bales, kr/kg	-0,15												
25 Capacity, bales/hour	24												
26 Baler, big bales, kr/ton	-149												
27 28 Londing with transformation from London													
29 Number of bales, bales /ba	5.4												
30 Tractor cost kr/bour	-625												
31 Loading and unloading of hales hours/ha	05												
32 Loading and unloading of bales, kr/ha	-313												
33 Loading, kr/ton	-89												
34													
35 Total costs for field work, kr/ton	-308												
36													
37													
38													
39 Storage													
40													
41 Barn with fixed floor		Barn with gra	vel ground				Barn "Staklade"			Barn for briquettes y	with fived floor		
42 Price/loan kr	1 816 500	Price/loan k		•	1 391 500		Price/loan kr		1 001 500	Price/loan_kr	and the theory	1 816 500	
43 Canacity m3	5 000	Canacity m3			5 000		Canacity m3		5 000	Canacity m3		5 000	
44 Utilisation of barn. %	90%	Utilisation of	barn, %		90%		Utilisation of barn. %		90%	Utilisation of barn 9	6	80%	6
45 Storage capacity, m3	4,500	Storage cana	city, m3		4,500		Storage capacity, m3		4,500	Storage capacity, m	3	4.000	
46 Number of big bales, stk	1.145	Number of bi	g bales, stk		1.145		Number of big bales, stk		1.145	Service life, years		30	,
47 Service life, years	30	Service life. v	ears		30		Service life, years		30	Interest, %		4%	<u>i</u>
48 Interest, %	4%	Interest, %			4%		Interest, %		4%	Fee, kr/year		kr105.048	3
49 Fee, kr/year	-105.048	Fee, kr/vear			-80.471		Fee, kr/year		-57.917	Fee, kr/ton		-60	
50 Fee, kr/ton/year	-168	Fee, kr/ton/w	ear		-129		Fee, kr/ton/year		-93				
51													
₩ ◀ ▶ Ħ 📕 Wheat straw model 🦯	Assumptions, straw	Straw model in graphs	Beet model	Assumptions - beets	Background	d mode	el data - beets Meadow grass m	nodel /	Assumpti	ons - meadow grass	Background dat	a - meadow grass	s Deep

8 Pelletising in field, mobile		Brigget plant		Extruder		Chain crusher		
7 Cost price kr	5 063 400	Cormall hammer mill straw conveyer, straw hale breaker	411 000	Extruder mixer conveyer kr	5 500 000	Pricelloan kr	2 319 314	
8 Seruice life uper	20		7 455	Service life year	10	Service life veers	10	
9 Interest 1/	5.5%	Correntoy Corrent og vicement kr	3 064 005	Interest 1/	55%	lotorost "/	5.5%	
0 Vasilu fas Iriluser	-424 204	Brievet else tille	1.250.000	Fee kilveer	La -729.673	Foo kriveer	Le _207.699	
1 Vasily fee, kilyear	-424.204	Concernant, Kr	10.000	Fee, kiiyear Fee, kiiyear	KI, F123,013	Fee, kilyear E July	KI301.030	
T Yearly ree, kriton	-7	Lapacity of briquetter, tonryear	10.000	ree, kriton	-73	Fee, kriton	 	
Uperation costs, l/ton	-48	Number of plants, stk	ь	Uperation costs, kWh/ton	-123	Equipment, intensive treatment, kriton	-1,19	
Curency, kr/l	7,5	Briquet plants, kr	7.500.000	Capacity, ton/year	10.000	Uperation, kr/ton	-3,08	
4 Operation costs, kr/ton	-358	Other things (installation etc.), I	50.000	Maintenance costs, kr/ton	-25	Capacity, ton/year	27.900	
5 Capacity, ton/hour	2,5	Total price for plant, kr	10.936.755	Energy price, kr/kWh	0,4	Costs at max capacity, kr/ton	-15	
6 Capacity, ton/year	4.650	Interest, X	5,5%	Operation costs, kr/ton	-49	Casts, kntan	-20	
7 Costs at max capacity, kr/ton	-449	Service life, year	10	Depreciation, %	10%			
8 Total costs, kilton	-450	Yearly fee, kr/year	-1.450.955	Depreciation, kr/ton	-55			
3		Fee, kr/ton	-24	Costs at max capacity,kr/ton	-147			
0		Maintenance costs, kr/ton	-40	Casts, knltan	-202			
'1		Energy price, kr/kWh	-0,4					
2		Energy use, kWh/ton	60					
3		Operation costs. kr/ton	-24					
4		A bire building kr/uear	-120,000					
5			-50.000					
о '6		Staff kr/ugar	-1.860.000					
7		Depreciation 1/	101/					
'9		Depreciation, //	-1.093.676					
9		Casha dahar	-1.000.010					
0		Losis, knon	-140					
0								
i2								
3 Transport								
:4								
Townset opened at a				Transaction and a				
is Iransport scenario 1				Transport scenario 2				
		• · · · · · · · · ·				• ··· · · ·		
I ransport of bales from field to biogas	plant	I ransport of bales from field to briquet station	10	Loading of briquettes to tipper		I ransport of briquettes from briquet	station to biogas	s plant
Distance to biogas plant (and back), km	50	Listance to biogas plant (and back), km	10	Hourly rate for tractor with frontloader, kr/hou	ur -625	Distance to biogas plant, km	40	
3 Truck vehicle, kr/hour	-525	Truck vehicle, kr/hour	-525	lime consumption for loading, hours/load	0,33	I ruck with tipper, kr/hour	-600	
0 Speed, km/hour	45	Speed, km/hour	45	Capacity of tipper, m3/load	60	Speed, km/hour	50	
1 Capacity, big bales/load	24	Capacity, big bales/load	24	Capacity of tipper, ton/load	27	Capacity, m3/load	60	
12 Number of loads, ha-1	0,27	Number of loads, ha-1	0,27	Costs, kr/load	-208	Capacity, ton/load	27	
🛽 Time consumption, loading, hours/load 🎴	0,25	Time consumption, loading, hours/load	0,25	Casts, kritan	-8	Number of loads, ha-1	0,13	
14 Time consumption on road, hours/load	1,11	Time consumption on road, hours/load	0,22			Time consumption, loading, hours/load 🍡	0,3	
5 Time consumption, unloading, hours/load	0,25	Time consumption, unloading, hours/load	0,25			Time consumption on road, hours/load	0,8	
6 Time consumption, total, hours/load	1,61	Time consumption, total, hours/load	0,72			Time consumption, unloading, hours/load	0,08	
17 Costs, kr/load	-845,8	Costs, kr/load	-379			Time consumption, total, hours/load	1,18	
18 Costs, kr/ha	-224	Costs, kr/ha	-101			Costs, kr/load	-708	
9 Casts, kritan	-64	Casts, kritan	-29			Costs, kr/ha	-92	
0						Casts, kaltan	-26	

- 4	A	В	C	D	E	F	
103							
104	Biogas potential and income						
105							
106		Untreated straw	Briquetted straw	Extruded straw			
107	Potential, m3 CH4/ton VS	197	221	229			
108	VS% af DM	95%	80%	87%			
109	CH4 m3/ba	556	526	593			
110	CH4 m3/ton	159	150	169			
111	Energy in CH4_kWh/m3	10	10	10			
112	Fnergy kWb/ton	1589	1503	1693			
113	cherby, and con	1909	1909	1000			
114	Gasmotor						
115	Electricity %	40%	40%	40%			
116	Heat %	50%	50%	50%			
117	Electricity kWh/ten	626	501	577			
110	Heat Whitee	795	751	0/7			
110	Price of electricity, be/W/b	0.79	0.79	0.79			
119	Price of electricity, kr/kwn	0,75	0,75	0,75			
120	Ince of feet, kr/kwn	0,25	0,25	0,25			
121	Income from electricity, kr/ton	100	4/3	335			
122	income from neat, kr./ton	199	100	212			
125	In some in a set of the face	701		747			
124	income in total, kr/ton	701	003	747			
125							
126							
127							
128	Total costs						
129		Untreated straw	Briquetted straw	Extruded straw			
130	Costs, Kr/ton:						
131	Scenario 1, barn with fixed floor	-541					
132	Scenario 1, barn with gravel floor	-501					
133	Scenario 1, Staklade	-465					
134	Scenario 2, barn with fixed floor		-431				
135	Scenario 3, barn with fixed floor			-743			
136	Scenario 3, Barn with gravel floor			-703			
137	Scenario 3, Staklade			-667			
138	Scenario 4, barn with fixed floor		-541				
139	Scenario 4, barn with gravel floor		-501				
140	Scenario 4, staklade		-465				
141							
142							
143	Profit						
144		Untreated straw	Briquetted straw	Extruded straw			
145	Profit kr/ton:		bilderice bildi				
145	Scenario 1 harn with fixed floor	160					
147	Scenario 1, barn with gravel floor	200					
149	Scenario 1 Staklade	226					
149	Scenario 2, barn with fived floor	250	222				
150	Scenario 2, barn with fixed floor		2.52	4			
151	Scenario 3, Barn with growal floor			42			
152	Scenario 3, Staklada			79			
152	Scanario A harn with fixed floor		122	73			
155	Scenario 4, barn with record floor		161				
154	Scenario 4, stabilado		101				
155	Scenario 4, stakiade		150				
120							

## **Appendix 3**

Annual cycle of biomasses Wook Stuck, start Output Input 
 Pharpharur
 Gar pase...

 kg/tan/
 tan/

 ,16
 0,9

 0,9
 1,64

 330
 19

 4 al 2,55
 330
 Type of biam tilezelidar Nitragen Pharpharuar Garpatentia tare kaftens tenar kaftens tenar möften VSm3 321 (19,6 3,51 2,46 0,85 0,60 330,0 322 42,0 4,00 5,26 0,90 1,18 330,0 
 Descrip
 Drymetter
 Velatilizatildz
 Fitragen
 Pharpharuz
 Gur peterteil, CH

 10
 1,00
 3,5%
 7,00
 2,3%
 5,60
 3,51
 0,70
 0,85
 0,17
 330,0
 1,848

 00
 1,00
 3,5%
 7,00
 2,3%
 5,60
 3,51
 0,70
 0,85
 0,17
 330,0
 1,848

 00
 1,00
 4,5%
 13,77
 11,26
 4,20
 1,29
 1,00
 0,31
 330,0
 3.714

 50
 1,02
 5,5%
 3,14
 4,20
 1,29
 1,00
 0,31
 330,0
 3.714

 50
 1,02
 5,5%
 5,14,81
 4,02
 1,29
 1,00
 0,31
 330,0
 5.718

 50
 1,03
 5,5%
 5,14,81
 4,02
 1,29
 1,00
 0,31
 330,0
 5.118

 50
 1,03
 5,5%
 5,14,84
 4,27
 1,28
 1,00
 0,32
 330,0
 1,118

 50
 1,05
 Inr/m3 % tenr 1,00 3,5% 7 1,01 4,0% 9 1,02 4,5% 1 narfm3 2 tanar 2 tanar kq/tanar kar/ 1,00 3,5% 31,5 2,8% 25,2 3,5 3,16 1,01 4,0% 72,7 3,2% 58,2 4,0 7,27 1,02 4,5% 114,8 3,7% 93,7 4,2 10,71 tonr/m3 tanrfm3 ) tors 5td. pigslurry, mixed, 3,5 % D 701 1.314 330 83 330 19198 52,6 Std. pigslurry, mixed, 4,0×TS 101.0 4% 82.5 4.20 9.43 Std. pigslurry, mixed, 4,5×DM 2.245 2.201 330,0 272 330 30925, 8.396 8,151 5,0% 4% 335,8 4,30 36,10 5.0% 442.9 4.0% 354.3 4,3 38,0 1,1 9,30 
 103
 5,02
 23,13
 4,02
 1,79
 1,05
 0,47
 330,0
 15,84

 1,04
 5,54
 5,46
 4,424
 41,18
 4,10
 1,03
 1,10
 1,03
 330,0
 15,841

 1,05
 6,02
 54,81
 4,824
 41,88
 4,25
 3,88
 0,90
 0,82
 330,0
 15,841

 1,05
 6,02
 54,81
 4,824
 41,88
 4,25
 3,88
 0,90
 0,82
 330,0
 15,841

 1,10
 7,02
 50,84
 4,02
 3,20
 2,374
 0,60
 0,82
 250,0
 10,472

 1,15
 3,24
 3,30
 5,284
 2,113
 3,50
 1,44
 0,60
 0,32
 250,0
 10,472

 1,15
 3,24
 3,30
 7,272
 12,98
 3,70
 0,67
 0,80
 0,22
 250,0
 10,32

 1,20
 9,02
 15,20
 7,272
 12,98
 3,70
 0,67
 0,30
 0,14
 210,0
 2,722 1.1 4,46 3.121 3.00 1.04 5.5% 5.5% 23 304, d. piqslurry, mixod, 6,0×D 6.0 10030 Sluri 1,10 7,0% 446,6 5,6% 357,3 1,15 8,2% 452,6 5,3% 289,8 Std. Cattleslurry, mixed, 7×DM 5.662 5.147 Std. Cattleslurry, mixed, 8,2×C 5.119 4.451 1,10 7,0× 396,3 1,15 8,2× 419,7 3,3 21,0 3,5 19,3 0,8 5,10 250 8932 0,8 4,42 250 7245 5% 268,7 3,50 17,92 0,80 4,09 250,0 671 5.520 4.80 Std. Cattleslurry, mixed, 9×DM 9.061 1,20 9,0% \$15,5 7% 652,4 3,70 33,53 210,0 1370 9.240 7.70 9,0% \$31,6 7,2% 665,3 3.7 34.1 210 139708. 5,761 1,10 7,5% 475,3 6% 380,2 15,00 95,06 2,00 12,67 280,0 10646 1,10 7,5% 495,0 6,0% 396,0 15,0 99,00 2,0 13,20 280 1108 1,10 7,5% 19,80 6,0% 15,84 15,00 3,96 2,00 0,53 280,0 4.43 6.600 6.000 )oop littor, cattle 0,90 30,0% 24,2 8,50 55 0,90 30,0% 150,0 24,0% 120,0 8,5 4,2 0,8 0,40 230 2760 0,90 30,0% 6,00 24,0% 4,80 8,50 0,17 0,80 0,02 230,0 1.10 30.3 24% 0,86 0,80 0,08 230,0 0,00 25,0% 62,8 20% 50,8 11,00 2,76 1,70 0,04 250,0 0,90 25,0% 205,1 35% 222,6 20,77 13,31 7,20 4,62 280,0 0,90 44,3% 232,0 22% 112,2 20,77 10,40 7,20 3,61 280,0 
 0,90
 25,02
 75,0
 20,22
 60,7
 11,0
 3,20

 0,90
 25,02
 75,0
 20,22
 60,7
 11,0
 3,20

 0,90
 22,02
 24,12
 243,1
 20,8
 14,54

 0,80
 45,32
 43,9
 22,42
 212,8
 20,8
 19,73

 0,90
 26,02
 28,0
 21,02
 21,0
 3,5
 0,85

 E
 0,00
 25/02
 20,22
 10,12
 11,00
 0,55
 1,70
 0,00
 25/02
 20,22
 10,12
 10,00
 25,02
 20,22
 10,12
 10,00
 25,02
 20,22
 20,21
 10,00
 25,02
 20,22
 20,24
 20,37
 12,25
 7,20
 0,43
 28,00
 55,33

 50
 0,60
 45,872
 0,232
 22,424
 10,00
 20,77
 1,25
 7,20
 3,24
 28,00
 5,334

 22
 0,90
 28,002
 5,50
 21,002
 4,20
 3,50
 0,17
 1,75
 0,044
 28,202
 17,00
 7,12
 1,75
 0,044
 170,0
 714
 Dopp littor, piq Poultry manuro 1.7 0.51 1518 7,2 5,04 6806 5958 ickon manura 314 arso manuro 0,90 28,0% 21% 289) 357 0,14 86,0% 4120,3 77% 3708,2 5,00 23,96 0,70 20,0% 560,2 18% 515,4 5,00 14,01 0,70 18,0% 126,2 15% 102,2 5,00 3,51 0,14 85,0% 816,9 81% 776,0 5,00 4,81 4.791 34.22 260 100620 360 1987 2.801 4.001 701 1.001 1,00 2,80 360,0 1855 .000,0 4.285 0,70 20,0% 600,0 18,4% 552,0 5,0 15,00 1,0 3,00 200,0 285,7 Top of be-1,00 420,0 429) 0,70 18,0% 180,0 14,6% 145,8 5,0 5,00 420 612 1.0 1.00 0,14 85,0× 1275,0 80,8× 1211,3 5,0 7,50 0,15 19,0× 190,0 17,1× 171,0 5,0 5,00 6.26 0.60 0.58 00.0 10.71 0.6 0.90 260 3149 540.0 3.857.1 5,0 5,00 5472 47965 Clover areas Plan 8,160 412.957 E F G H I J K L M N O P Q R S T U V W X Y Z AA AB AC AD AE AF AG C D nual cycle of biom Wook Stuck, start Input Output Type of biam 
 tans
 kq/tans
 tans

 2,8x
 25,2
 3,5
 3,1

 1,2x
 58,2
 4,0
 7,2

 1,7x
 93,7
 4,2
 10,1
 9/tonr 1 3,51 4,00 0.9 0.77 tanır r 200 505 
 X
 tanr
 x
 tanr
 kq/tanr
 tanr
 kq/tanr
 tanr
 m3/tan.V
 m3

 3,5%
 7,00
 2,8%
 5,60
 3,51
 0,70
 0,85
 0,17
 330,0
 1.840

 4,0%
 20,20
 3,2%
 15,60
 2,6%
 2,02
 0,90
 0,45
 330,0
 5.333

 4,5%
 13,77
 3,7%
 11,25
 4,20
 1,29
 1,00
 0,31
 330,0
 3.711
 tonr/m3 1.40% d. piqslurry, mix: 1.818 2.550 8.858 d. piqslurry, mixed, 4,0: 2774 4,0% 72,7 3,2% 4,5% 114,8 3,7% td. pigslurry, mixed, 4,5× 330 30925, 4,0% 18,54 4,30 Std. pigslurry, mixed, 5,0: 16.301 4% 671,6 4,30 72,2 22162 330 116925, 1,99 1,05 0,49 330,0 6.11 8.600 Std. pigslurry, mixed, 5,5% 6.001 1,04 5,5% 343.3 4% 274,6 4,10 25,5 1.10 6.87 330,0 4.056 3.900 7.245 6.900 1,04 5,5% 223,1 4,4% 178,5 4,1 16,63 1,1 4,46 330 58893.1 1,04 5,5% 51,48 4,4% 41,18 4,10 3,84 1,10 1,03 330,0 13.591 1,06 6,02 434,7 4,42 178,5 4,1 19,53 1,05 6,02 434,7 4,42 43,43 4,4 3,30,79 1,10 7,02 446,6 5,62 357,3 2,3 2,405 1,15 3,22 446,6 5,62 357,3 2,3 2,405 1,20 9,02 331,6 7,22 665,3 7,1 34,19 1,10 7,52 495,0 6,02 396,0 15,0 99,00 1,04 5,52 51,48 4,42 41,18 4,10 5,84 1,10 1,10 5,291 1,05 6,07 54,34 4,37 43,25 4,25 3,88 0,90 0,82 330,0 14,270 1,10 7,02 50,36 5,52 40,29 3,30 2,27 0,80 0,58 250,0 10.072 1,15 6,22 33,0 5,32 21,13 3,50 1,41 0,30 0,32 250,0 5,283 1,20 9,07 16,20 7,22 12,66 3,70 0,67 0,60 0,14 210,0 2,722 1,10 7,57 19,80 6,02 15,84 15,00 2,96 2,00 0,53 280,0 4,435 12.061 1,05 6,0% 759,8 5% 607,9 4,25 53,82 0,90 11,40 330,0 0,9 6,52 td. pigslurry, mixed, 6,0 % 330 11476 914 719 0,80 9,06 250,0 158 
 100
 702.6
 6.52
 6.54
 1.20
 1.01
 7.02
 1.01
 7.02
 1.01
 7.02
 1.01
 7.02
 1.01
 7.02
 1.01
 7.02
 1.01
 7.02
 1.01
 7.02
 1.01
 7.02
 1.02
 9.02
 1.23
 3.70
 6.70
 0.20
 9.04
 2.26
 0.01
 1.01
 7.52
 950.5
 6.27
 760.4
 15.00
 190.10
 2.00
 2.23.9
 2.26.0
 123.41

 1.10
 7.52
 950.5
 6.27
 760.4
 15.00
 190.10
 2.00
 2.5.35
 2.26.0
 2.12.91
 Slurry Std. Cattle slurry 11.3 10.293 6.380 5.800 5.520 4.800 0.8 5.10 654 10.236 9.240 7.700
6.600 6.000 210,0 273993 280,0 212908 18,121 11.521 280 11088 0% 150,0 24,0% 120,0 Doop littor, cattl. 0,90 30,0% 174,3 24% 139,4 8,50 4,94 0,80 0,46 230,0 320 8,5 4,25 0,8 0,40 230 2760 opp littor, piq aultry manuro 0,90 25,0% 125,3 20% 101,4 11,00 5,51 1,70 0,85 250,0 253 1518 1,7 0,51 250 7,2 5,04 280 
 409,6
 357
 444,8
 20,17
 26,60
 7,20
 9,22

 463,5
 22%
 224,2
 20,77
 20,79
 7,20
 7,21

 451,1
 21%
 33,8
 8,50
 1,37
 1,75
 0,28
 0.90 32.0% 280.0 12459 6806 6278. 5958 3576 950,0 1.187,5 100,0 111,1 0,80 46,3% 0,90 28,0% con manur Dooplite rso manuro 9.581 68.436 0.14 86.0% 8239.7 77% 7415.7 5.00 47.9 260, 0,14 86,0% 4300,0 77,4% 3870, 260 100620 360 19872 0,14 86,0% 180,60 77,4% 162,54 5,00 1,05 0,70 0,15 260,0 42,26 6,71 5.000.0 35.714 5.0 25.00 210.0 1.500.0 
 8%,022
 18%,040
 77,422
 182,54
 5,000
 1,05

 20,02x
 40,000
 18,442
 58,40
 5,000
 1,00

 18,022
 54,000
 14,652
 423,74
 5,000
 1,50

 88,002
 456,000
 8,08,22
 426,05
 5,000
 2,70

 19,022
 115,000
 17,142
 104,31
 5,000
 3,052

 33,022
 267,300
 31,442
 253,94
 7,000
 5,67
 5.60 0,70 20,0% 600,0 18,4% 552, 1,00 0,20 0,70 18,0% 180,0 0,14 85,0% 1275,0 0,15 19,0% 190,0 0,90 33,0% 1485,0 6123 31492 5472 47965 1,00 0,30 420,0 18.31 0,60 0,32 260,0 113.37 0,60 0,37 220,0 33.37 420,0 0 14.6% 145.8 5,00 42736 786741 or an arr 0,37 320,0 33.379 0,81 340,0 86.338 38 39 40 41 Plan binma 126.756 198.205 21.559 5.255.913 71.717 115.675 10.784 3.050.829 8.440 16.692 428.413 724 12.492 1.742 1.472

The structure of the storage model is shown below for two weeks – week number 2 and week number 3. The end-stock from week 2 is equivalent to the initial stock in week number 3. The pattern continues until week 52.



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