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SyreN

SyreN System – Acidification of slurry

In modern agriculture, loss of nutrients (emissions) has become a problem. This happens when nitrogen in slurry is evaporates as ammonia from animal manure / slurry or is leached as nitrate to the groundwater.

Loss of ammonia has a negative impact on nitrogen sensitive nature and is a serious contributes to air pollution through the formation of particulate matter PM 2.5. The ammonia emission is estimated to cause 140.000 premature death in EU pr. year. Leaching of nitrate to groundwater is creating difficulties in relation to use of groundwater as drinking water. An efficient solution to both of these problems is presented in the following as utilization of two different technologies through the use of SyreN System.

SyreN Acidification

Ammonia (gas) and ammonium (salt) are in a chemical equilibrium when dissolved in a liquid as slurry. By lowering the pH value, the equilibrium is displaced and a larger part of the ammonia is to be found as ammonium that cannot evaporate from the slurry.

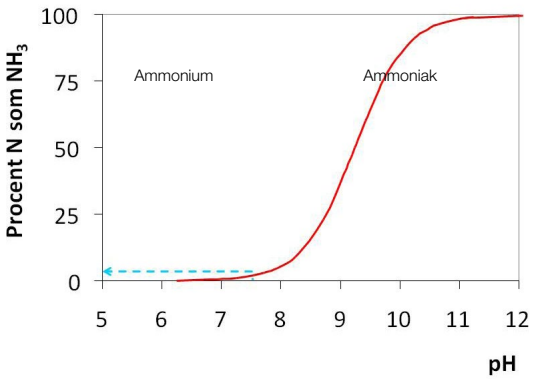
The SyreN system automatically defines and lowers the pH of the slurry. It uses sulphuric acid to lower the pH, as this is 100% environmentally balanced product and the most concentrated and effective acid to lower the pH. The ammonia is thus transformed to ammonium and readily available to the plants after application, when the slurry penetrates into the soil. Ammonium is the optimal N fertilizer available to plants and has a minimal loss to the environment as it has a positive charge and binds itself to soils and does leach out.

A VERA verification done by Århus University, has documented a 49 % ammonia emission reduction. In that trail, 2.5 liter sulphuric acid was used at a pH value of 7.8 and a lowering of the pH to 6.4

The volume of acid used, is depending on the slurry pH value and its buffer capacity (Buffer = other chemical reactions than ammonia that consumes acid).

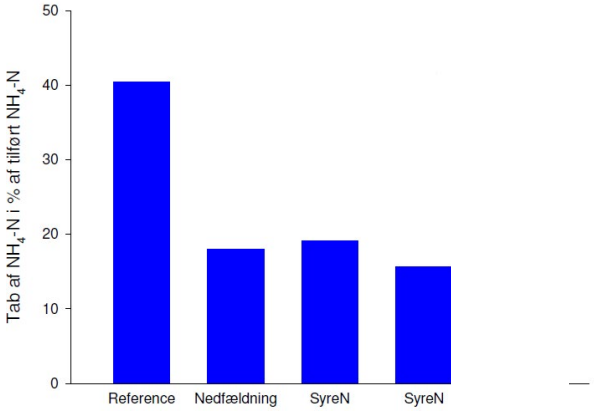
In praxis, a very large variation of acid consumption is to be expected, but on average, about 1 liter of acid is used with cow slurry and 1.5 liter with swine slurry. This represents a very good correlation between acid consumption and crop need for Sulphur as fertilizer. There are examples of very high pH values (especially digested slurry) where the acid consumption is +4 liter.

pH value deciding NH3 or NH4+ (ammonium – ammonia)



pH value of slurry

Kvæggylle tilført til sletgræs d. 15. juni 2010



Different income opportunities with SyreN

There are more ways to optimize the use of SyreN system. The chemical process and thus the Fertilizer effect can be used differently and thus the system is not just part of a better nitrogen utilization Objective.

Effects are:

- Better nitrogen utilization – up to 85 %
- Fertilization with ammonium sulphate – especially in grass and rape
- Addition of nitrogen inhibitor
- 40% increased plant availability of phosphorus
- Reduction in manganese deficiency
- Use of bandspreading instead of open slot injection
- Legislative compliance (EU directives)
- Odour reduction

Extra ammonium nitrogen

By means of the acidification process, ammonia gas is fixed as ammonium salt that cannot evaporate. That means that the volume of ammonium is increased and there is a larger amount of plant available nitrogen. Ammonium is also the best nitrogen fertilizer we know of. This is because the plants are not "force feed" as with water soluble nitrate, but that they absorb what they need when they need it. When the plants absorb ammonium, the shed a H+ ion, that may help make more phosphorus plant available.

All this leads to increased yield that can be measured in yield trails:

There are a long range of factors that have influence on emissions. This results in a variation between trails and years. Because of this, it is necessary to view yield increases over years.

The most influential factors are:

- Volume of slurry
- Amount of ammonia
- Dry matter
- pH value
- Wind speed
- Temperature
- Plant cover
- Soil- and air moisture contend
- Application technology

Udbytterespons i vinterhvede som følge af forsuring med SyreN system

År	Antal forsøg	Udbytte hkg pr. ha.	pH	Syreforbrug l gennemsnit. l/m³ gylle
2010	3	4.0	6,1	2
2011	4	5.0	5,9	2
2013	6	3,2	6,3	3,3
2014	4	0,3	6,3	2,6
2015	6	-0,4	6,1	1,9
2016	5	0,7	6,1	1,7
2017	2	6,3	5,8	
Gennemsnit		**2,2**	**6,1**	**2,1**

Martin Nørregaard Hansen, PlanteInnovation SEGES

A couple of average effects:

Grass / cow slurry: Emission 18.8% with application in April 30t/Ha = 15 kg ekstra N pr. Ha + 3% yield pr. Ha

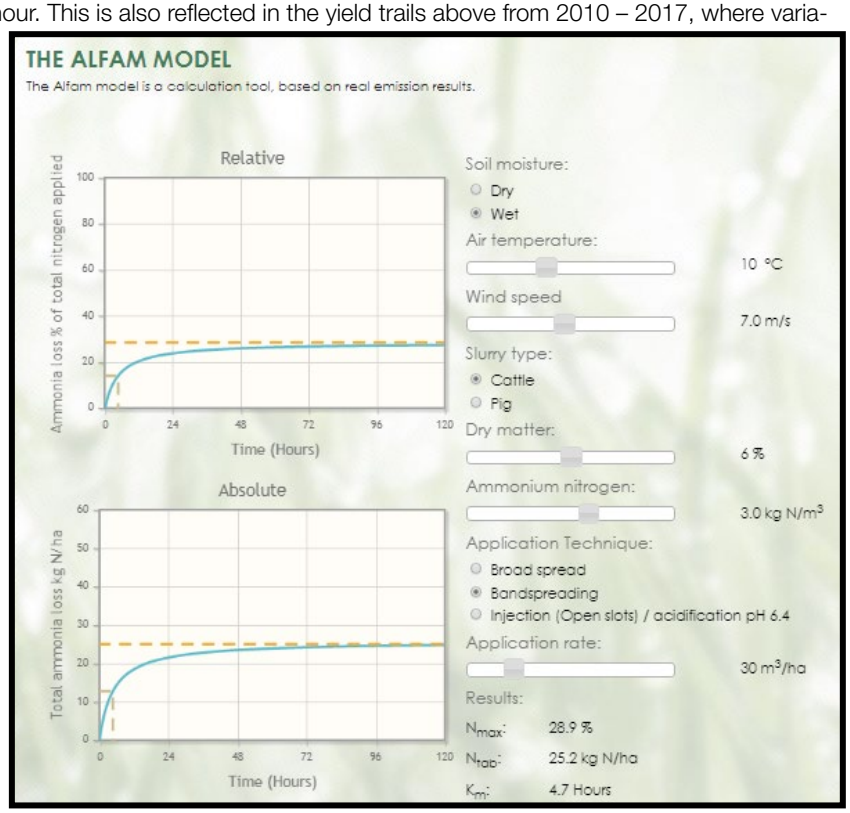
Winter wheat / swine slurry: Emission with application in April 24 t/Ha = 10 kg ekstra N pr. Ha + 2.1 Hkg yield pr. Ha

The normal variation can be from 5 kg to 50 kg N pr. Ha depending on climate and above mentioned conditions. It is possible to estimate the effect of SyreN technology but it is always important to remember, that it is the conditions on the day that decides. 60- to 80% of emissions happen within the first hour. This is also reflected in the yield trails above from 2010 – 2017, where variations from 0 to 26 % in increased yield were measured and with a yield variation from -0.4 to + 6.3 hkg

The ALFAM Model

A good help to estimate the ammonia emission on a given day is found in the ALPHAM model. It is a database of +2000 ammonia emission trails. it contains descriptions of which parameters are important and which weight they have in in the estimation and leaves a good overview of how much nitrogen is lost.

On days with god wind and high temperatures, emission may total as much as 30-50 % of the total volume of nitrogen. On such days, the economy of using SyreN System may increase a factor x2. On days with low temperatures and no wind, it may not be feasible to use the system, so there is a lot of good management praxis in optimizing when- and how much to use SyreN system



The ALFAM model may be found at www.biocover.dk - counseling

Fertilization with Sulphur

Sulphuric acid is very well suited to be used as a fertilizer. It contains 577 g Sulphur pr. liter and in the process of lowering the pH, it is converted from H2SO4 to SO4 – sulphate, which is direct plant available. It is thus an excellent fertilizer, inexpensive and easy to dose with the right timing. As there is hardly any plant available Sulphur in slurry, it may well make a mineral NS dosage redundant in grass and rape.
For winter wheat, 0.9 liter of sulphuric acid pr. m3 with an application of 30 ton / Ha is used and for rape 2.1 liter is used with 30 ton / Ha. In the SyreN system terminal, a series of charts identifies the need for different crops depending on crop type, dose rate and soil type. From this list, some typical recommendations can be seen here:

Crop need for Sulphur

	S-need, kg pr. ha	Typical amount of slurry, ton pr. ha	Needed kg S pr. ton	Liter H2SO4 pr. ton slurry
Winter wheat, clay soil	15	30	0,5	0,9
Spring barley, sandy soil	10	30	0,3	0,6
Winter rape, clay soil	35	30	1,2	2,1
Silage grass, irrigated sandy soil	30	40	0,8	1,3

In the period from 1960 to 2000, agriculture has benefited from a background deposit of Sulphur from coal burning of up to 300 kg S pr. Ha. This deposition is reduced to only 2-3 kg S / Ha today and as a result, Sulphur deficiency is common and may first be visually identified when a +20 % deficiency is a reality. There is a large difference in crop need for S. Both wheat and rape need Sulphur early in the season. To fertilize with Sulphate through slurry may save a passing of the field to compensate for the lack of Sulphur in slurry. Sulphur in slurry is also often exposed to emission through hydrogen sulfate (H2S – rotten eggs). A loss of 20 % is not uncommon and it leads to variable plant availability. Sulphur in digested slurry has been immobilized through the fermentation. What emits is later on cleaned out of the gas. Sulphate is water soluble and thus exposed to leaching along with nitrate and must be applied every year. The Sulphate in sulphuric acid is price competitive pr. kg compared to other mineral fertilizers and the spreading of it through slurry makes it quickly plant available.

A fertilization plan to replace ammonia sulphate could look like this:

Conventional fertilizer strategy:				
Slurry + 80 kg N / Ha - NitroStar (NS 28-5)		90 Euro/ Ha		
Slurry + 80 kg N / Ha – sulphur ammonia (NS 21-24)				109 Euro /Ha
Alternative SyreN acidification:				
Slurry + 80 kg N /Ha - N-34 Svovlsyre 30 m3 - ca. 1.5 liter x 2.50 Kr.	75 Euro / Ha 10 Euro / Ha	85 Euro / Ha	75 Euro / Ha 10 Euro / Ha	85 Euro / Ha
Difference in cost pr Ha.		+5 Euro / Ha		+24 Euro / Ha
Source: Torben Viuf, Sønderjysk landboforening				

In addition, the strategy of using sulphuric acid as an S fertilizer in slurry has the potential of reducing ammonia emission with 50%, at the same time as being an extremely cost beneficial system and the only known sustainable alternative to injection of slurry into the soil.

Manganese deficiency treatment

Rape is of the species brassica that is known to smell like cabbage or Sulphur. Not surprisingly, it is a crop that needs a lot of Sulphur. Also for rape, sulphuric acid in slurry may substitute price heavy ammonium sulphate, which is often needed to supply the rape with enough sulphate. Since the amount of sulphate is variable with addition of sulphuric acid, it is easy to dose individually. Test have shown that rape often responds with significant yield increases up to 6 liter of sulphuric acid or app. 100 kg S/Ha.

Sulphate for rape

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Sulphate for grass

Grass is the crop that responds most favorably to acidification. This is due to a combination of factors, where climate is the main cause. Slurry for grass is often applied after cut in the summertime, where it is warm, dry and without any plant cover. This leads to a significant higher emission in grass than with fertilization of small grains in spring time and thus a higher effect. In addition, grass may consume a larger amount of nitrogen than grains. Grass has a very tight netted and deep root net, so the risqué of leaching of nitrogen is less. Like rape, it has an appetite for sulphate where a dose rate of 40-50 kg S/Ha ensures maximum yield. Acidification has also proven to be very valuable in decomposition of the organic matter following rotation of a field.

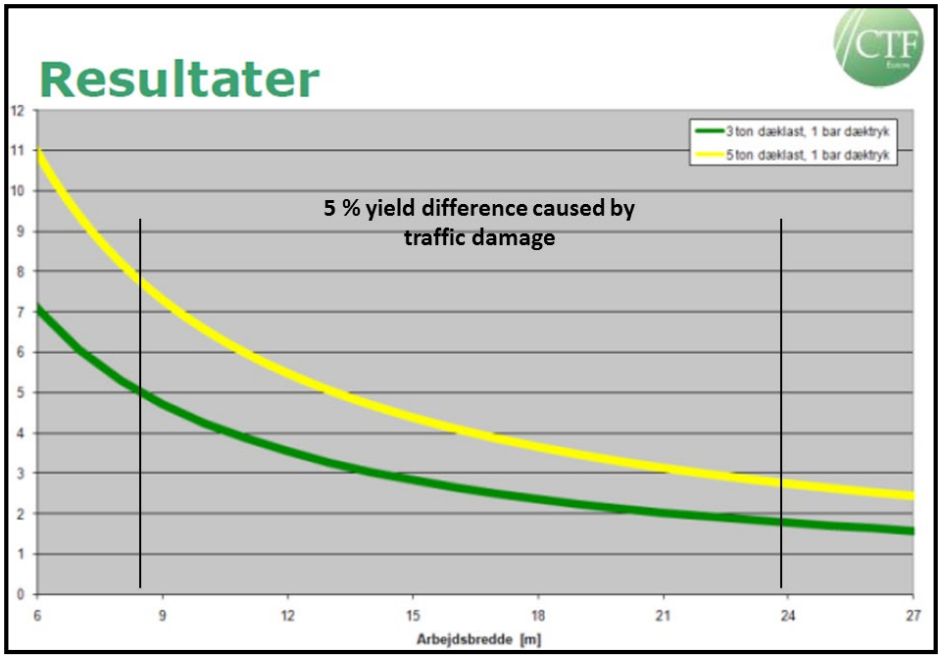
Use of bandspreading in lieu of injection

Economic incentives and user advantages are huge when comparing acidification with band spreading to grass open slot injection. Both systems reduce ammonia emission on about the same level but that is where the comparison stops. In general, it can be said that acidification always works, where grass injection does not when the slurry placement is too shallow as a result of dry soils.

Advantage band spreading with SyreN	Advantage grass injection
• Wider work with gives 50 – 66 % reduction in traffic damage from slurry tanker • 100 % reduction in tine damage in grass • 24 – 36m working with – app. 25 % increased capacity for slurry application • Certain and good operational economy with acidification • Unchanged need for HP power / diesel • Less structural damage because of heavy traffic • Less structural damage because of heavy traffic • No risqué for drought damage with exposed grass roots • No wear parts with soil exposure • Longer life time for grass fields • Increased window for slurry application (independent of emissions) • Climate gas reduction (no N2O emission)	• No transport- or storage of sulphuric acid • Reduced risqué of slurry dry matter transport back to barn.

Difference between the two technologies

The most significant economic difference is in yield reduction caused by traffic damage. This effect is caused by bandspreading having 24-36m working with and grass injection with 6-12m



Below is an estimate of the cost between the two technologies:

Band spreading of acidified slurry compared to grass injection, before 1 cut, 25 to slurry pr. Ha			
	Band spreading 24 m SyreN	Injection 12 m	SyreN-injektion Euro pr. Ha.
Increased cost	2,0 l sulphuric acid pr. m3 cow slurry 25 cent pr. l	0	-21.00
	Application cost 0 cent pr. m3	0	0
S fertilization value	25 kg / 0.33 cent pr. kg	0	+ 8.25
Traffic damage	175 Fe pr. Ha 0.14 cent	350 Fe pr. Ha 0.14 cent	+ 25.70
Crop damage	0 Fe pr. Ha	480 Fe pr. Ha	+ 70.40
Difference			+ 83.35

(Flemming Hedegård, Byggeri og teknik)

More plant available phosphorus – use of slurry to replace start fertilizer for maize.

Slurry analysis has showed up to 40% more plant available phosphorus with acidification. Maize is a crop that requires a lot of phosphorus. Normally, there is plenty of phosphorus in slurry, but it is not immediately plant available and therefore mineral phosphorus is added as a starting fertilizer during sowing. Because of the higher plant availability, the starter fertilizer can now be replaced by acidified slurry. A number of studies have shown that acidification of slurry to PH 6.5 is releasing bonding between Calcium and phosphorus and transforms up to 40% more phosphorus in slurry to plant available phosphorus. The slurry application must be guided with RTK GPS and the maize seeds sown at a distance of 5 cm from the slurry approximately one week later. This makes sure that the large quantity of liquid in the slurry does not inhibit the germination of the seed.

Use of Lime with acidification

The use of acid can affect the Soil's pH buffer. Studies have not been able to measure a change in the soil pH buffer when using sulphuric acid, but theoretically 1 liter of sulphuric acid will consume about 1 kg of lime. The Soil´s natural pH must be below 7 for lime use to be relevant and acidification can also be used to purposely lower the soil pH in the event of a high soil pH.

SyreN additive System:

Several different additives may be used together with slurry for different purposes.

Nitrogen inhibitor

Nitrogen inhibitor is a group of active substances intended to inhibit degradation of ammonium to nitrate. This process is also called denitrification. The degradation is caused by a group of bacteria that are active soon after application and already after 1-2 weeks, depending on temperature, have transformed the ammonium to nitrate. This is not a desirable process as it destroys the advantage of using ammonium as a fertilizer. The nitrogen inhibitor may delay this process 6-10 weeks. This delay gives the plants better time to absorb the ammonium and minimizes leaching and thus increases the utilization rate of the nitrogen. This also reduces greenhouse gas emission, as denitrification also produces laughter gas (N2O) which is x300 stronger than CO2

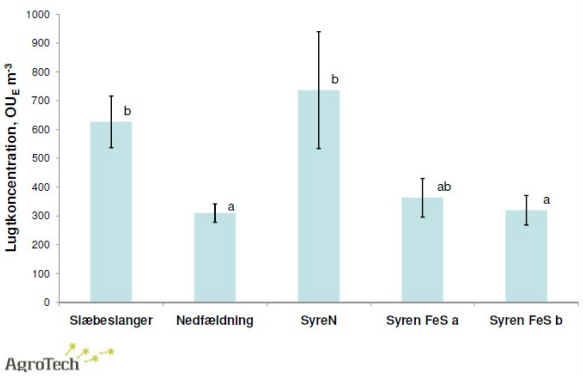
Iron Sulphate Fe3 +

The acid system has two different means of reducing the odour From slurry.
Iron Sulphate is a known means of eliminating odor from hydrogen sulphide, known for a very characteristic odor of the rotten eggs. It is used as standard in sewage treatment plants with good effect.
Iron sulphate is added to the slurry during filling of the slurry tanker. This is important since the volumes of iron sulphate is small – typically 0.5 - to 1 liter pr. m3. – and because it takes about 10 minutes from the addition to the optimum effect.

Iron sulphate works by splitting hydrogen sulphide:

$$FeSO_4 + H_2S \leftrightharpoons FeS + SO_4^{2-} + 2H^+ = No\ odor$$

The addition of sulphuric acid also means that a number of odors change in character and thus may have an altered odor. The effect of odor reduction is very variable. In some slurry types, outstanding results can be achieved, while in others, it may only achieve a modest reduction. This is caused by a different content of hydrogen sulphide and the chemical composition of the slurry origin (pig, dairy, digested). A good advice is to ask neighbors to participate in an odor assessment, since it is often because of the neighboring interest that we want an odor reduction. In relation to neighbors, wind direction



AgroTech test: Effekt af tilsætning af ½ liter jernsulfat pr. m3 - kvæggylle

Tabel 6.1 Estimated use of lime for different types of slurry and acidification. Data from Hansen og Knudsen 2017

	Ton slurry pr. ha[1]	Stable-acidifica-tion	Tractor acidifi-cation	Field-acidifi-cation	Stable-acidification		Tank acidification		Field-acidification	
					Kg. lime pr. liters of sulfuric acid					
		I svovlsyre pr. ton			1,0	1,8	1,0	1,8	1,0	1,8
					Kg. lime pr. ha pr. years due to acidification					
Pig manure	30	7,2	7,2	2,9	217	390	217	390	87	156
Cattle manure	43	4,4	3,7	3,1	190	342	159	286	131	235
Degraded manure	35	0,0	0,0	8,3					292	525

1The amount of slurry is calculated on the basis of the standard number and the supply of 140 kg nitrogen per liter. ha. pig manure, 170 in cattle manure and 155 in degraded manure.

and distance to slurry odor is very important. It is known that it is not possible to smell against the wind, but there are fewer who think about the effect of odor reduction due to dilution over the distance to the neighbor. That means that an odor reduction effect will be increasing the further away you are positioned from the Odor source. Neighbors can therefore experience a very significant odor reduction with the use of iron sulphate during slurry application, without this necessarily applying to those who are involved with the slurry application.

Manganese Nitrate

Manganese Nitrate is well known as a remedy for Manganese deficiency. In areas – fields – where manganese deficiency occurs, manganese nitrate is often added together with pesticides when treatment during the early growing season has not delivered sufficient effect. Thus, Manganese nitrate can advantageously be added together with slurry, as the effect is prompt when dissolved in a large amount of liquid that has immediate soil/root contact.

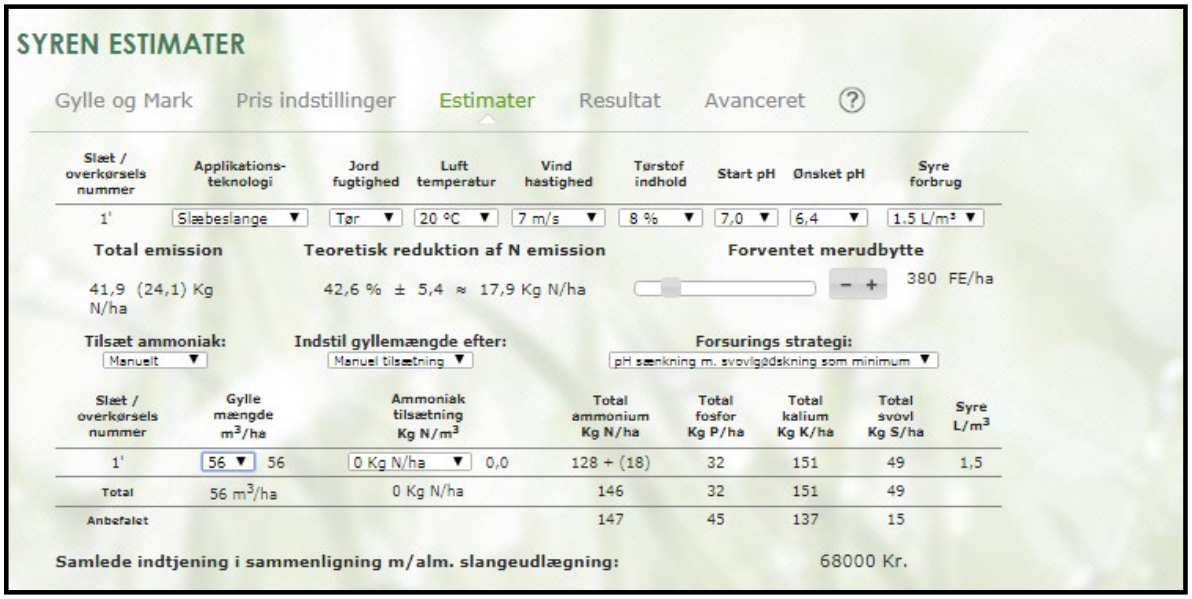
Summary Economy:

Much of the above is difficult to summarize in an economy calculation. There are a great many variable parameters that needs to be identified to know before it is possible to create an overview for each individual farm. Biocover has therefore made an economy calculator based on the above ALFAM model and the financial parameters to be added / estimated before a statement of earnings. In the internet based program, default values have been inserted, meaning that standard values have been entered that can be used if no budget figure / knowledge is at hand.

An example thereof is the amount of nitrogen in the slurry. If there is no slurry analysis available, the norm for each barn type/livestock can be used by clicking on the type of barn at hand.

Part of the SyreN Systems impact does not relate directly to the farm but to society as a whole. Therefore, specific legal framework conditions for the use of the SyreN System implemented in many countries. In Denmark for instance, injection or acidification has been made mandatory on grass and black soils and it is expected to be mandatory on all winter seed crops from 2020.

It is difficult to estimate a value on biodiversity loss or increased leaching of nitrate, less CO2 emission or environmental planning permit. The Estimater program is therefore based on the factors that apply to all farms – added yield and value of Sulphur as fertilizer. The framework conditions may be the factor that creates a decision on the use of the system, but the scope of use should always be the subject of an analysis of costs vs. earnings.



Example of earnings of 200 Ha of silo maize by lowering PH to 6.4 and using 1.5 liters of sulphuric acid Estimater can be found at http://www.biocover.dk/radgivning/syren-estimater)

Environmental legislation

All EU member states are required to reduce ammonium emissions through the NEC (National Emission Ceiling)

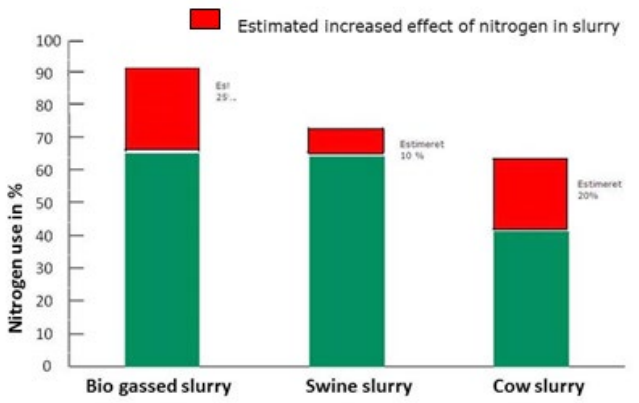
The NEC directive aims at reducing air pollution. When ammonia escapes into the atmosphere as gas, it is part of forming Particulate Matter (PM 2.5 and PM 10). Those particles are allergy- and cancer forming and the cause of a range of respiratory illness.

The EU estimates that air pollution is causing 460.000 premature death pr. year and PM pollution is responsible for +40 % of the health-related costs of particulate pollutants, which make a negative contribution to the Danish economy of 170 million DKK pr. year.

Nitrat direktivet limits the amount of nitrate leaching to groundwater, lakes and rivers.

One of the important limits is a max dosage rate of 170 kg nitrogen per ha / year from organic fertilizer.

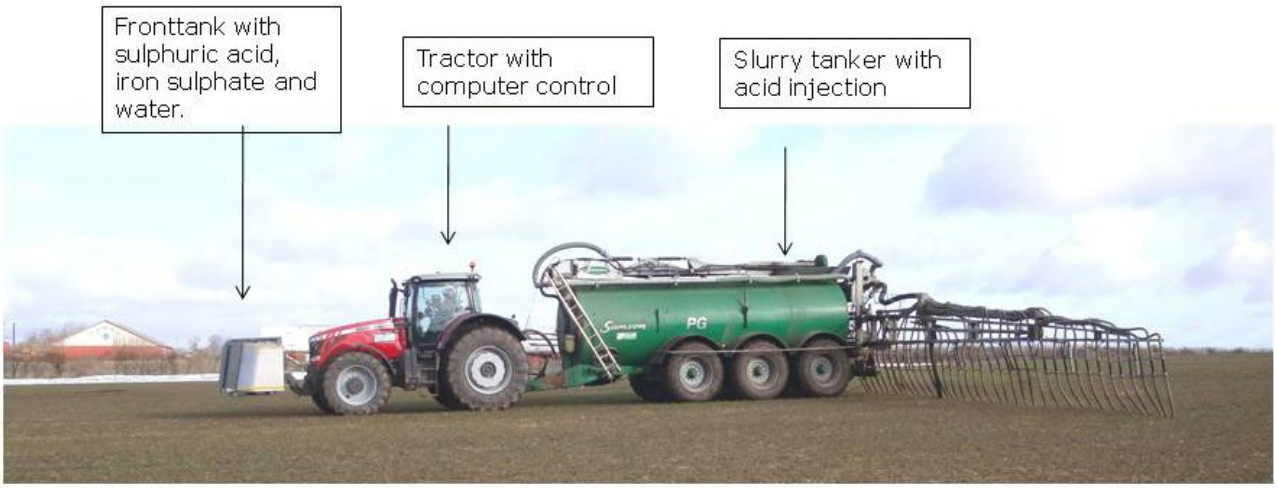
A higher utilization rate of nitrogen in slurry is therefore a necessity for many farm / biogas digesters in need of finding farms / fields for application of slurry. This is caused by the receiver of the slurry needs to be certain of the effect when it is recorded into the farm fertilizer accounting. In addition to the acidification effect, SyreN System enables the use of nitrogen inhibitor that creates an average less leaching into the groundwater of app. 3 kg N/ha pr. Year.



There is a difference between the slurry volume emission. A high pH in degassed slurry creates a high emission and a high solids content combined with high temperatures at application increases the emission from cattle manure in comparison to pig manure

SyreN Product:

The SyreN System is constructed for mounting on all types of new or existing slurry tankers. The system is designed with the highest safety standards in mind and that the operation of the process does not encompass a risk from its use and while the function and effect can be documented to authorities.
Installation and use of the components does not interfere with the operation of existing products, nor does it add much in terms of operation of the slurry tanker.



The SyreN System in front of the tractor contains tanks for sulphuric acid, additive and water. The System has a hydraulic drive for the acid pump and electric drive for the additive system. I tis constructed around the use of an IBC tank for transport of sulphuric acid. This ”cassette system” ’ insures that there is no overfilling of acid from a storage system – which can be a dangerous and time consuming operation. Instead, the operator placed inside the cab of the tractor, operates the tractor with the SyreN front unit and pick up the IBC tank and thus avoid any danger with filling of the IBC tank. In addition, this is a very quick way to refill the system for continued operation. It should take no more than 4 minutes to change the tank. The coupling of the IBC tank to the SyreN System is made via a dry coupler with no exposure to contact with acid. When the IBC tanks needs to be refilled, the sulphuric acid is ordered from distribution tankers

with IBC tank filling equipment. That means the IBC tanks becomes a storage facility where there are no residues as any remains in a tank are simply part of the replenishment of the tank.
When detaching the system from the tractor, the system is fitted with dry couplers and operators are instructed to use water from the water tank with the last load before detachment so that the system is filled with water when it is detached and left for storage.

Transport legislation

Sulphuric acid is registered as dangerous goods. That means it must be transported according to the international ADR convention. However, agriculture has a number of exemptions to the ADR regulation. In general, when a tractor is operated in combination with an implement - like a slurry tanker - it is considered to be a work operation and that is exempt from ADR, so in principal anybody with a driver's license may operate the SyreN System. They may not transport the IBC containers on a trailer as this is considered to be a transport operation which is subject to ADR regulation. A complete set of ADR safety equipment is available as an accessory for countries where ADR is an issue.

The transport legislation has different restrictions to be observed in each country as well as safety precautions for storage of the IBC tanks. This is a comprehensive list and it must be observed in the user manuals which list the individual requirements or each country.

BioCover organizes training in use of the SyreN System and the agronomics behind the effects of using the system. This is normally a 2 day course with one part specific to health and safety of using sulphuric acid and the other part with focus on fertilization, use of sulphuric acid as a fertilizer and the effect of the system in relation to different climate conditions.

Fitting a system to a slurry tanker

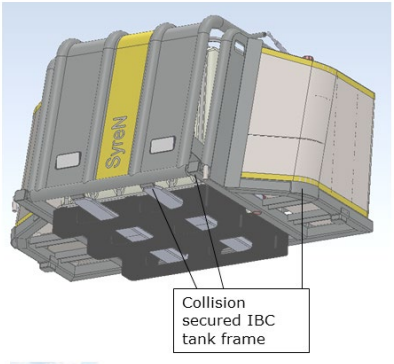
The delivery and fitting of the SyreN System to a slurry tanker does require some minor modification to the slurry tanker, which can be undertaken by 2 fitters in a two day operation. The hoses or the slurry tanker must be ordered when the slurry tanker has been identified, as the individual length of the hoses for acids and additives may differ considerably. Depending on tractor model, trays for protection of the hoses under the tractor may have to be constructed individually.

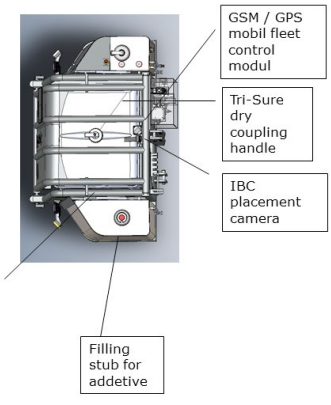
Research and plot trail work

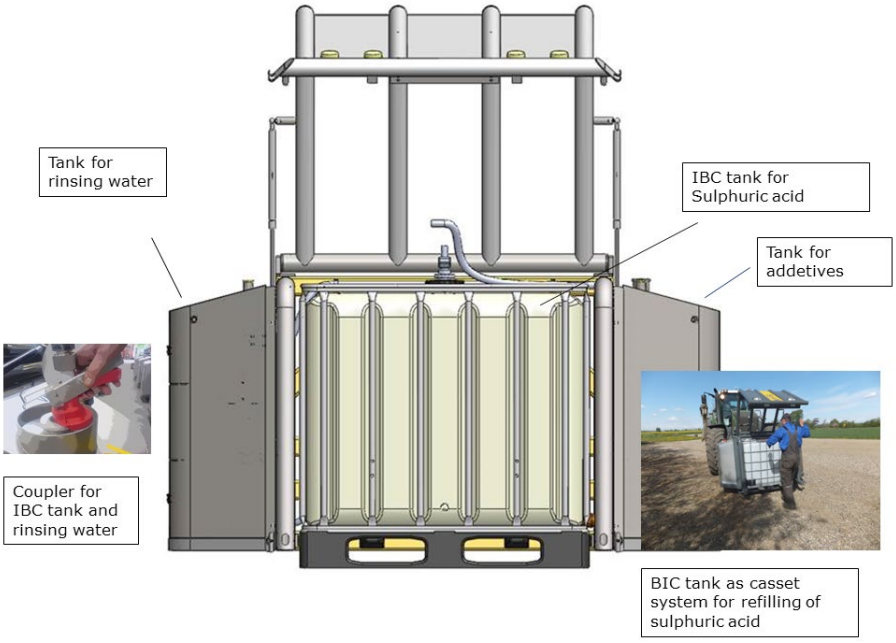
SyreN System has a number of safety measures build into the operating system. It cannot add acid unless it has 1. Speed 2. There are min 2 m3 volumes in the flow sensor 3. The three way valve is set to empty tank. This makes it difficult to use as a plot trail system. There is however, a special version of SyreN system available for research- and trail work. Please see separate brochure.

Front Tank

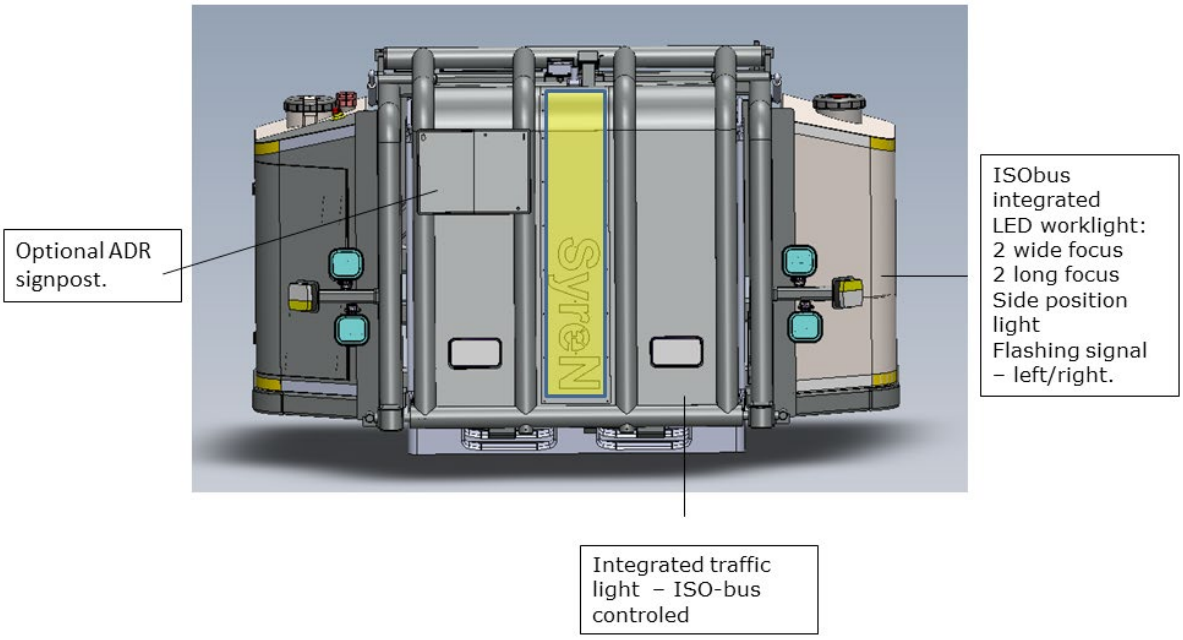
Strong gas pressure cylinders hold the door in place when changing the Pallet tank and a fixed extra coupler shoe, eliminates the possibility of acid spillage- or contact.

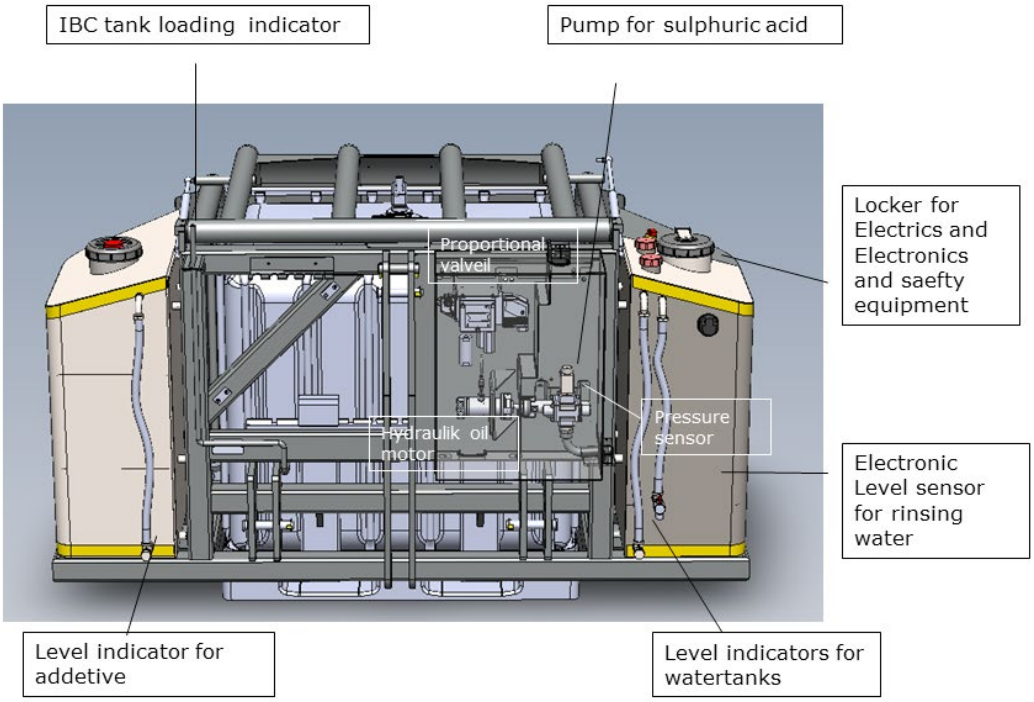






The Front linkage system is constructed with extra safety dimensions and thus is collision-proof. The operating system is an Isobus system and the operation is therefore integrated into the Tractor's own functions such as turn signals, traffic lights and working light. The control is operated through the Tractor's integrated terminal. Alternatively, the SyreN system can use a separate Isobus terminal.





Sulphuric acid Pump

Pump is a displacement pump in Stainless Steel 316 L with internal components of special sulphuric acid suitable alloys and plastics. The displacement pump is selected because of a wide range of Variable Flow and good self priming ability. It is powered by a Danfoss hydraulic oil motor with PVG valve and has a capacity of 25 liter oil pr. minute.

Addition of sulphuric acid

Two strategies for adding sulfur are used:

- Sulphuric acid as Fertilizer
- Sulphuric acid for lowering PH value

When sulphuric acid is used as fertilizer, the liter/m3 must be entered into the control Program. The SyreN System management program contains tables where it is possible to determine the quantity of acid needed in relation to the crop, number of m3 and soil type. The amount is automatically translated into rotational speed of the oil engine, thus allows the pump to dose the required amount of acid per cubic meters. The system continuously measures the amount of slurry through the flow meter or the slurry pump of the slurry tank and automatically adjusts the acid volume after m3 slurry pr. minute.

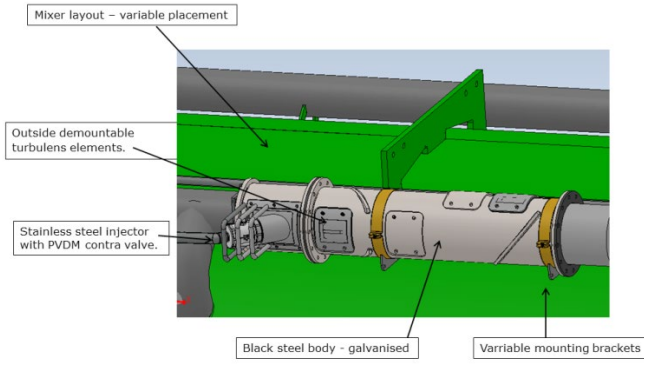
Sulfuric acid can foam very strongly by the addition of sulphuric acid – especially biogas slurry

Sulphuric acid can also be added according to pH value of the liquid. A dose rate, like VERA recommended pH 6.4 must be entered into the program. By start of a new job, the system will apply a variable rate from1-5 m3 without adding acid. During this process, it reads the current pH in the liquid and locks this into the memory. Following, acid is added gradually until the target value has been reached. The equivalent amount of acid to the pH, is then added as long as the job is active.

The automatic determination of dose rate according to pH is ideal for reducing ammonia emission, thereby adding an extra amount of ammonia nitrogen to the crop. This is also the ultimate method of reducing eutrophication of nitrogen sensitive nature. The lower the pH, the less emission. The pH level 6.4 is an economical optimum with app. 50% reduction. The reduction increases all the way down to pH 5.5, where emissions are almost nonexistent.

Sulphuric acid Injector

The Sulphuric acid injector is placed at the rear of the slurry tanker. It is made of heavy dimensions because of the powerful reaction caused by the dissolution of the acid with the liquid. It is very important to get the acid mixed into the full amount of slurry very quickly, because the liquid is split into two directions only milliseconds after injection and because the acidity of the acid must be eliminated before the liquid reaches the ground. After injection, turbulence in the liquid slurry and the slurry distributers make sure the acid is evenly mixed between the band hoses/ applicators. Injecting acid into the slurry tanker is not possible because the many chemical reactions that takes place, produces foaming and pressure. This makes control of volume of slurry impossible as well as pumping a foaming liquid is not possible.



Addition of Additivs

The use of the additive tank takes place while the slurry tanker is being filled. This gives a very good mixing of the additives with the slurry. The needed amount of additive pr. ha is entered into the system, and it is automatically transferred into time needed for injection. When the additive button is activated, the pump will dose additive for the set time.

PH sensor

The PH Sensor is an important part of the system. This provider assurance of the effect of the addition of acid and provides the documentation often requested by authorities. When using the program part to target a PH value, it is a key part of the process to identify the right amount of sulphuric acid. The PH sensor is located after the distributors to measures the slurry after addition of acid and shortly before application to the field.

It is important that the PH sensor is always immersed in a liquid. Otherwise, there is a risks of drying out, thereby losing its precision. For this reason, The pH sensor is therefore located in a specially designed box that allows the sensor to measure in the slurry flow during application and at the same time be immersed in liquid when no slurry flows through the system. The PH sensor head lifetime is limited to 1 year and is replaced via a service subscription each year.

Slurry Sump with PH sensor

Safety

Every imaginable precaution has been taken to create a 100% safe system. An important element of safety is good operating routines, starting with a 2 day course for users.
There are 3 step requirements to activate any injection of acid

- A job and name must be entered and activated
  indtastet og aktiveret
- There must be speed on the tractor
- A min. flow of 2 M3 must be measured in the flow sensor
- PTO sensor shall display revolutions (Isobus systems)

This safety combination for injection of slurry has made sure that we have never seen any damage from acid. To prevent anyone from coming into contact with acid while changing an IBC tank, a dry coupler handle together with a coupler shoe welded to the IBC tank has been chosen. A second coupler shoe is situated on the side of the IBC tank with direct access to the water tank. When the IBC tank is removed from the SyreN system, the coupler handle is simply parked at the second dry coupler shoe and the IBC tank can be safely removed from the SyreN system. If the SyreN system itself is being detached, the coupler handle must be attached to the parking shoe. A Flushing Program is then activated on the terminal in the tractor cab during the last load of slurry application. The acid pump will then be activated at the highest speed for 1 minute, injecting water from the water tank.

This insures that the system is completely emptied of acid and any residual amount is neutralized with water. Thus, the system can be safely detached from the tractor using the stainless steel dry couplers between SyreN system and the tractor.
In addition, protective gloves, glasses and safety aprons are mandatory to use in all interaction with the system and the equipment are located in the safety locker on the side of the front tank.

Terminal Control Unit/Software

SyreN styringssystemet er opbygget efter den nye standard for kommunikation mellem traktor og redskab – ISObus.

The SyreN control system is developed according to the standard of communication between tractor and implement – Isobus. Isobus enables SyreN System to utilize a lot of the existing electronic equipment on the tractor, like the tractor terminal and several of the tractor sensors. This means a very good integration of the controls into the tractor cabin and less wiring. If the tractor does not use the Isobus standard, a second terminal is then installed to operate the SyreN system.

John Deere touch screen with SyreN software uploaded

Data acquisition-GPS/GSM

A perpetual source of problems is the collection of data for documentation. This function is optimally solved with SyreN System. The system has an integrated mobile phone with a built-in GSM transmitter. This includes a GPS and it is connected to all information via the Isobus. It logs a large number of data every 10 seconds and send them online to a server. This is a large amount of data, among others:

- Name of Customer and field
- Quantity of slurry delivered per job
- PH value before application and during application
- Amount of sulphuric acid consumed
- Hour

Map with slurry tanker tracks easily identified

The position of the slurry spreader can also be monitored online on the internet while it is spreading slurry in the field. With the included log-in, data such as the position of the slurry tank and various operational information can be monitored continuous.
When a job is reported as finished on the slurry tanker terminal, the job data are available as a data file or a report for download on the server. The data acquisition system is an optional extra on most markets.

Summary

Acidification technology is undergoing rapid development. The technology still finds new and exciting applications. It is only a part of the benefits of the system which can be quantified under average operational considerations as a lot of the benefits relates to individual conditions and to societal value.
Acidification technology will continue to be tried and tested and it will become a standard as it has the unique position of being the only technology with a significant ammonia emission reduction with surface application of slurry.