DIGESTATE FROM MANURE RECYCLING TECHNOLOGIES

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Project website: www.digesmart.eu
Under the Eco-Innovation project DIGESMART, a consortium of European partners from Spain, Italy and Belgium has set out a digestate processing train in which ammonia stripping plays a key role. Manure and co-substrates are digested in an anaerobic digestion unit to produce biogas. This biogas is used as fuel for a CHP-engine to generate electricity and heat. The digested material is separated into a liquid and solid fraction. Phosphorus is mostly withheld in the solid fraction, whereas nitrogen (N) and potassium (K) are found in the liquid fraction which is subsequently treated by passing through the stripping and scrubbing system. After scrubbing, the remaining liquid can be further treated by drying. An innovative approach within the project is the use of solar assisted drying to reduce the energy consumption for the production of concentrate with high potassium content.

The first step in the recovery process is releasing the ammonia from the digestate (i.e. stripping). Releasing of gaseous ammonia from a liquid phase is function of the acidity (pH) and temperature. A caustic substance is therefore added to the substrate (to increase the pH) and residual heat can be used to heat up the input material. An acid like hydrogen nitrate (nitric acid) is used in the second step (i.e. scrubbing) to chemically bind the ammonia present in the air coming from the stripping. The resulting product is ammonium nitrate (52%), which is a chemical product mainly used as mineral fertiliser.

After the stripping/scrubbing process a liquid fraction remains for a second treatment step. The DIGESMART project foresees in a solar drying step as add-on to the first process step. Heat from solar radiation is captured by inclined panels. An air-heat system is implemented next to a high efficiency solar module (glycol system). Heat is transferred to the air circulating in the system and passes over an evaporating unit containing the liquid fraction which is consequently dried as the warm air passes over it. Using solar systems is deemed possible in those situations where solar radiation is abundant, and it can be implemented as a “heat booster” in combination with heat coming from the CHP-module.

The ammonium nitrate obtained, DIGESMART fertiliser, is tested in agricultural practise by the consortium partners in Italy and Belgium. As expected, the tests give promising results, as the product provides a yield comparable to regular chemical fertilisers. Its use in industry also shows a promising outlook to further elaborate different business models.
INTRODUCTION

Although biogas production is efficient at reducing agricultural emission by converting the biomass into electricity and thermal energy or biomethane, its major issue is the production of large volumes of digestate with high concentration of nutrients. This means that large agricultural areas are required for the application of the fermentation residues (because of nitrates regulation).

The DIGESMART solution aims to reduce the environmental impact of European farms or biogas plants by facilitating the market uptake of innovative solutions for the treatment, recycling and valorisation of digestate. In this project the partners set out to bring together all the stakeholders for the installation of a new process to minimize spreading digestate flows and to economically valorise the minerals (N, P, K, among others). By using recovered nutrients instead of synthetic fertilizers, it is possible to save energy, limit consumption of fossil fuels and reduce carbon footprint.

The schematic overview in Figure 1 depicts the different steps in the process. Digestate coming from anaerobic digestion is separated (preferably by centrifuge) into a solid and liquid fraction. The solid part is of value for further composting or similar and retains most of the phosphorus (P). The liquid fraction containing most nitrogen (N) and potassium (K) is further treated in a stripping and scrubbing unit. The products of this step are technical pure ammonium nitrate and a remaining liquid that is treated in a next drying or evaporation step. The drying process uses heat from the CHP, being an important innovation the fact that this project tested the possibility to use solar radiation as an add-on to the system.
INSTALLATION SITE

The final set-up location for the first DIGESMART implementation is the pig farm IVACO located in Belgium. In the South East of the farm and next to the silos for solid substrate storage there was an open part left of the concrete flooring. This was considered a proper location to set up the stripping silos and auxiliaries. Also, there is a grass field in front of this space on which the solar drying could be installed. The installation spot is visualised by the yellow cross in Figure 2.

The IVACO site is mainly a pig farm with a theoretic capacity of over 11000 pigs. A manure treatment system is in place with a capacity of 60000 tons per year. As for now all the ammonia is treated in a classical aerobic biology, with further processing in a constructed wetland.

Since May 2013 a biogas installation is in operation on the farm site (see Figure 3). At first a permit was obtained to process 5000 tons of input material per year, but currently this is extended to 12500 tons on an annual base. The produced biogas is fed to a CHP (MAN E2876 LE302) of 190 kWe, and on a yearly basis the installation produces maximally 1170 MWh of electricity and 1530 MWh of heat.

Digestate storage is located in the west of the pilot area and the biogas installation can be seen at the far western part of the farm site. The composting is located in the large hall and the aerobic biological after treatment can be seen just under the biogas reactor. A full constructed wetland is located behind the large stable.

DIGESMART PILOT SYSTEM

The core of the system is the large stripping&scrubbing tank. Here the chemical process to recover the ammonium takes places. This tank was installed during the month of October in 2015. The auxiliary equipment was added during the following weeks. The container contains all the pumping and technical steering. The other tanks are for product storage.

How to recover ammonium?

1. Push ammonia out of the liquid digestate by adding caustic solution and heat
2. Spray acid on the ammonia rich air
3. Acid - ammonia react to form ammonium nitrate
4. Purify the product
What makes the system stand out next to other ammonia recovery systems is that a technical pure product is obtained. An innovative purification system made by DETRICON is in place in the container. Another feature is that heat produced by the chemical reaction is recovered by using a heat exchanging system. In this way, the outside addition of energy is considerably minimised.

The pilot system was not complete without the solar drying test rig, which was installed during the course of May 2016 by the Italian specialists from the University of Turin. In Figure 4 two different types of solar panels in place can be seen, together with the evaporator. The blue panel (left) is an air-heating panel that successfully works in direct sunlight, as where the other (middle) high efficiency module works also with diffuse radiation.

From left to right in Figure 4, the parts of the DIGESMART pilot plant are: ammonium nitrate storage, stripping&scrubbing tank (green), auxiliary equipment container, double walled acid storage (black silo), treated digestate settling tank, solar panels and evaporator.

FIELD TRIAL ASSESSMENTS

Field trials are the most important way to assess the agronomical potential of any (mineral) fertilisers. In order to validate the use of the mineral fertiliser produced by the DIGESMART technology, the consortium set up two clusters of trials in two different crop systems in Italy and Belgium. The goal was to identify the most suitable crops and utilisation ways according to the characteristics of the DIGESMART fertiliser.

Firstly, DIGESMART fertiliser was tested by using lettuce as crop. Trials were conducted in pots, in a greenhouse spring cycle (Figure 5) and autumn cycle. The results showed similar yield and performance among the specimens conventionally fertilised and with the recovered ammonium nitrate. Phytotoxicity assessment and decease parameters were not significantly different. Also, visual inspection gave no noticeable differences among the ammonium nitrate and synthetic fertilisers (Figure 6).
The liquid formulation of the DIGESMART fertiliser makes it an excellent product for use in fertigation systems in greenhouses. It can be accurately dosed via the irrigation tubes.

Maize was selected as the second crop were the DIGESMART fertiliser was to be tested. A field experiment was conducted on grain maize in Italy and on silage maize in Belgium. Yet again no significant differences were detected between regular practice and the use of the recovered ammonium product.

Nitrate leaching is for open field crops a very important issue. Too much nitrate in the soil after harvest will lead to a higher nitrate load in ground and surface water. A nitrate residue measurement was done after harvest and showed no values above the legal limit.

A final experiment was done in Italy to see if the DIGESMART product could be used as a foliar fertiliser. A wheat crop was divided into blocks of which some were treated with a commercial foliar fertiliser, the DIGESMART fertiliser or not treated. Also here the results obtained by applying the recovered product were similar to the conventional treatment.

**MARKET**

Marketing and business of the DIGESMART solution depend on the availability of ammonia rich side streams on the one hand. In this sense, the need for biological processing of this nitrogen, because of surplus, makes it possible for the DIGESMART solution to offer a cheaper and more durable alternative.

Business can also be made in those niches where concentrated products are more desirable than either raw digestate or manure. The latter is linked to the farm size and possible logistical benefits. For the solar drying, the costs of land area and solar radiation are the key factors.

Digestate is considered a problem from a logistical point of view. Farmers are interested in the application of nutrients to crops but, when using raw digestate they have to transport huge amounts in order to attain the...
satisfactory N-P-K supply conditions due to the high content of water in digestate. Furthermore, when a surplus of nutrients in soils occurs in a specific area, farmers need to transport to regions further from their own land which might be considerably costly; they would drive as far as there is still business margin possible on the biogas production (livestock production in the case of manure). These areas of high nutrient surplus are correlated with livestock production. For the pig sector specifically, some high density areas are identified in Figure 8.

![Figure 8. Livestock density at Regional level (pig farms in EU countries in 2014)](image)

It is deemed possible by the consortium that the DIGESMART solution can offer a profitable business in case of being able to offset these digestate transports at an agreeable level. By stripping and drying, the product loses water content and more concentrated nutrients can be applied with less volume to transport. This is applicable to on farm and off farm situations. Logistical benefits can thus even be important if there is no N-surplus.

**BUSINESS REPLICATION**

A business model was elaborated for the different plausible scenarios identified in the market. Options like avoided digestate spreading or treatment, selling or own use of the DIGESMART fertiliser are included. The model calculated different techno-economical parameters such as: net profit, payback period, net present value, return-on-investment, cash flow, etc. Also an indication is given on how much fertiliser there is to be produced to run break-even.

For this, a front sheet, which contains the most important results, was prepared to be filled by the user as single requirement to run the model.

By marketing and business elaboration the project was able to have a preliminary, but significant, outreach in the targeted countries. Multiple offers were send to interested companies. This resulted in an overall commitment of 4 partners to install one or more DIGESMART solutions.
STAKEHOLDER VISITS

To outreach the stakeholders, a full program of visits to the installation in Belgium was established. Firstly, the visits were advertised through newsletters, website and press releases, among others. Secondly, a selection of participants for the visit tour was made among the interested people from each country according to the main target group of the project. In particular, the selection of participants was focused on biogas plant owners, regional and national policy makers, journalist of technical press, scientists, consultants and providers of related environmental technologies such as biogas plants. Thirdly, specific information and a program of workshops/visits were developed in each of the involved countries.

On the 15th of April 2016 the Belgian audience was invited to see the DIGESMART pilot. Around 41 people attended the visit (Figure 9) and also came to an introduction workshop on the same day. Another small excursion was done for Walloon stakeholders on the 29th of August 2016.

At the end of May 2016, the workshop and visit (Figure 10) were elaborated for the Spanish stakeholders. During the workshop the most important issues on the stripping & scrubbing, the solar drying, logistics and field performances were addressed. Positive aspects of the installation were highlighted in the discussion with the audience, such as the value of the product and the innovation of the solution. Remarks were given on the permit procedure and legal status.

The last large stakeholder visit organised within the project was targeted towards the Italian biogas sector. The participants were all member of the “Consorzio Monviso Agroenergia”, a biogas consortium in the region of Piemonte (Figure 11). The Italian biogas sector has known high incentives, but since 2012 there has been a steep decrease. Current business owners are very interested in innovation to make their installation more durable and profitable.
OUTREACH AND KNOWLEDGE SHARING

The project is brought to a larger audience and interested parties by the project website (Figure 12). Critical project information can be found on www.digesmart.eu in 4 different languages.

On the website, this report can be found next to other public documents and reports from the project activities. Also other information, presentations, past newsletters and press releases are available on the website.

The website attracted over 6500 people during the project duration and will serve as a prolonged information source after the project has ended.

Next to the website, newsletters were send to interested subscribers on a regular basis. All in all 6 newsletters were elaborated on the status and results of the project. An example is given in Figure 13. The original versions can be found through the project website. The newsletters received 426 reads.

Social media activity was incorporated in the partners general social media strategy. This resulted in #DIGESMART being mentioned 29 times by partners and participants during project workshops, press releases, pilot plant visits and others. LinkedIn was especially targeted by AINIA.

Outreach of the project and project results was also done on numerous occasions by the different parties. The project was represented in fairs and conferences, as well as during workshops and educational sessions. Interaction with policy makers was done on regional, national and European level.
-TO CONCLUDE-

**digesM**art project

6559
Website visitors

429
Newsletter readers

209
People reached in workshops

117
People visited the pilot plant

32
Business plans elaborated

4+1

DIGESMART Market Replications
The DIGESMART project was made possible by the collaboration of the following partners

**BIOGAS-E** ([www.biogas-e.be](http://www.biogas-e.be)) is a non-profit organization and the platform for anaerobic digestion in Flanders. As main activities, Biogas-E works on knowledge transfer, policy support, education, advice centre, networking and sector development.

**DETRICON** ([www.detricon.eu](http://www.detricon.eu)) is a Belgian SME constructing environmental technologies for the valorisation of organic waste streams. The focus lies on the nutrient recovery out of manure and digestate, producing biobased or green fertilizers for local use.

**AINIA** ([www.ainia.es](http://www.ainia.es)) is a Spanish non-profit technological centre formed by companies in the food manufacturing sector and related industries, whose objective is the promotion of innovation and technological development.

**SATA** ([www.satasrl.it](http://www.satasrl.it)) was established in 1986 as Studio Agronomico Tecnico Associato then went on to become a company of agronomists, whose mission is to meet the growing demand for services in the vegetable supply chain, from production in the countryside to distribution right through to the consumer.

**UNITO**, Universita degli Studio di Torino. University of Turin (Dept. DISAFA) ([www.disafa.unito.it](http://www.disafa.unito.it)) is organized in four sections: Economy, Hydraulics, Mechanics and Topography and Rural Buildings. Sixty people work in the department that is among the two leading agricultural engineering institutions in Italy.