Introductory guide to SYSTEMIC

For outreach locations, associated plants and interested biogas plants

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Inventory

Introduction

SYSTEMIC is a 4-year H2020 demonstration project running from June 2017 until 2021 and is funded by the European Commission under call CIRC-01-2016 'Eco-innovative approaches for the circular economy: large-scale demonstration projects' of its H2020 framework (projectnr. 730400).

SYSTEMIC aims to give a boost to the implementation of circular economy solutions for manure, sewage sludge and food waste through nutrient recycling and recovery (NRR) technologies.

SYSTEMIC has partnered up with five **demonstration plants**: large scale anaerobic digestion plants located all over Europe, which have already invested in nutrient recovery technologies.

The project also selected twelve so-called '**outreach locations**' which are biogas plants interested in opportunities to improve their current practice in a sustainable way. Other interested biogas plants could still join the project as an '**associated plant'**.

The demo plants will facilitate the outreach plants in their process of business case development by sharing knowledge on nutrient recovery technologies and related financial and legislative issues. The project consortium will have a coordinating role and will evaluate the envisaged business cases in terms of technological feasibility, economic viability and sustainability.

The project will be

- demonstrating the technical, economic- and environmental performance of the recovery and reuse of nutrients (NRR) technologies from the demo plants running on manure, sewage sludge and/or bio-waste
- Developing an online tool to explore the possibilities of different nutrient recovery techniques and setting up a business case with NRR
- reinforcing the cooperation and experience exchange between practitioners, research entities and companies
- Translating this information into opportunities for circular economy business cases/opportunities at twelve outreach locations.
- -Fact sheets on end products and techniques & roadmap that gives an overview of barriers and bottlenecks of innovations and ways to overcome these
- Field trials and analyses on recovered products
- formulating policy recommendations and to derive a roadmap to support the roll out of Circular Economy Solutions for bio-waste over Europe

Concept of Living Labs: benefits & expectations of outreach locations and associated plants

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Introduction

In the process of innovation (in nutrient recovery from digestate) the scale up from lab scale and pilot scale tot full scale techniques is seen as a valley of death. There are a lot of factors stopping innovation in this stage:

- The impact of translating small volumes (lab scale) to large volumes (full scale) is not to be underestimated
- A market value has to be created for new products
- The economic feasibility of a full scale technique (CAPEX, OPEX, business plan,…)
- Regional and EU legislation: for example: anaerobic digestion is supported on a regional level while the recognition of recovered products is part of European Legislation

In the project SYSTEMIC we will try to overcome these barriers for innovation and find solutions by joining forces between scientists, business and practitioners and policymakers.

Demonstration plants

SYSTEMIC includes five large-scale **Demonstration Plants** which will advance their current treatment process through the implementation of novel nutrient recycling and recovery (NNR) technologies. Thereby, these plants will demonstrate the practical feasibility and commercial viability of NRR from organic waste streams. Throughout the project, the demonstration plants will be closely monitored hereby generating data on mass- and energy balances, technical performance, product quality, product prices and feed tariffs and premiums etc. These data will be used to evaluate the technical, economic and environmental performance of the AD plants and the implemented NRR technologies. During the project they will supply information for mass-& energy balances, business case, market, grants/subsidies, costs, etc (Read more about the Demo Plants)

Outreach locations

Spread over Europe, eleven large-sized anaerobic digester plants have been selected as **outreach locations**. All outreach locations have a strong interest in opportunities for NRR and want to find out if this could be a sustainable and profitable way to prepare their business for the future. All outreach locations offer excellent opportunities for implementation of NRR technologies, enhancement of existing NRR technologies and/or optimization of their business case.

The set of outreach locations covers all relevant feedstocks; manure, mostly combined with digestion of various other agro-industrial and municipal organic waste streams, sewage sludge and slaughterhouse waste. Outreach location Atria (Finland), being part of the project consortium, is a forerunner among the outreach locations.

Associated plants

The eleven outreach locations were selected from a larger group of interested plants. The non-selected AD plants were offered the possibility to remain connected to SYSTEMIC as a '**Associated plant**' meaning that they can, on their own costs, join the workshops and meetings organised with the outreach locations and will be asked to bring in their experiences regarding nutrient recovery of biomass streams.

"Business Development Package"

One of the outcomes of SYSTEMIC will be the **"Business Development Package" , which includes a Web based tool, fact sheets and roadmap.**

Web based tool

The web based tool will be based on a database with information from literature, real-life data from the Demo Plants, Outreach Locations and Associated plants.

The web based tool will contain information on:

- Mass -& energy balances
- Nutrient recovery & separation efficiency
- Economic aspects:

  CAPEX, OPEX, maintenance cost, wearing cost
- Energy requirement
- Chemicals
- Environmental impact

Fact sheets

For each demo plant a fact sheet was made and can be downloaded at the SYSTEMIC website.

The contain basic information about the plant, the basic process steps, their drivers and benefits for and from nutrient recovery.

- end products, techniques, grants and subsidies
- Regional market for recovered end products
- Success stories
- Barriers and bottlenecks
- Drivers for NRR

Such fact sheets will also be made for each outreach location and for interested associated plants and published on the website.

To do this, all outreach locations and associated plants will be invited in March -April 2018, to complete an online questionnaire.

Confidentiality

The fact sheets will be revised by each outreach locations/associated plant and they will have to approve their factsheet before it is published on the website.

All other information will be used to build up the database for the Business Development Package and will not be published or visible.

- Mass- and energy balances will be published in factsheets and reports but **only after written permission of the plant owner**
- Economic data **will remain confidential**

Living Labs

One of the outcomes the project aims for are partnerships, cooperation, good advice and experience exchange between practitioners, business and scientists.

To facilitate this, the project aims to set up Living Labs.

A living lab would be a regional collaboration between biogas plants, farmers and industry to form a sustainable (environment, economic, social) circular chain (recovery, recycling and re-use).

A good example of a Living Lab in the Netherlands is "An Achterhoek without artificial fertilizer".

This region (de Achterhoek) in the Netherlands has received a special pilot status from the Dutch Government by means of a "Green Deal". With Green Deals the government helps to overcome bottlenecks encountered by sustainable innovations. Demo Plant Groot Zevert, located in de Achterhoek, is also participating in this project. More information

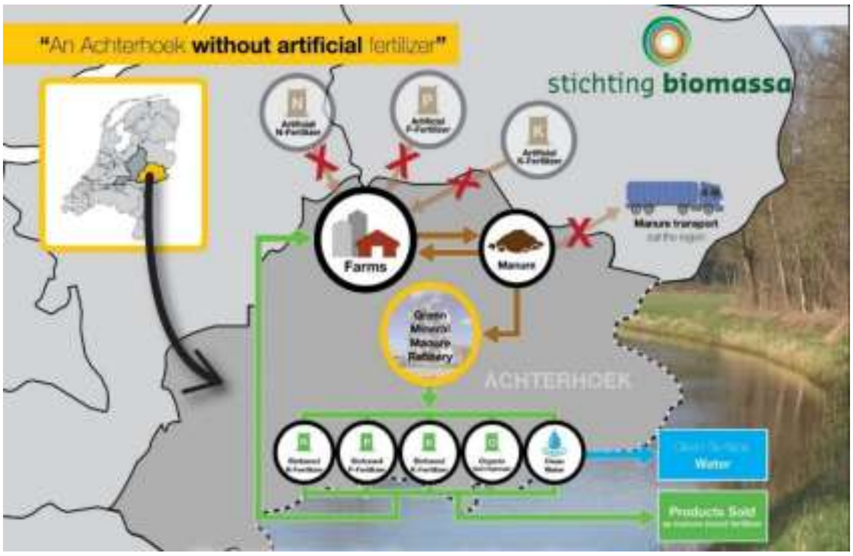


Figure 1: Scheme of the concept of "An Achterhoek free from mineral fertilizer"

Another example of a Living Labs is the outreach location "NDM Naturwertstoffe GmbH", where 90 farmers in the district of Borken and Naturdünger Münsterland GmbH & Co. KG have made a joint venture to build the natural resources plant (NDM) would be built at the Nordvelen site in accordance with the principles of the bio economy. The aim of the planned biogas-nutrient recycling plant is to make an important contribution to reducing the manure surplus in the district of Borken by the practical development of environmental technologies for the treatment of manure.

A fact sheet of this plant can be found on the Systemic website in June 2018. More information can already be found on the NDM website (German only).

Living Lab meetings

SYSTEMIC will try to stimulate the development of more of these Living Labs by **bringing together practitioners, industry and researchers**, to exchange ideas on innovation and research and collaborate to find joint ventures and concrete solutions for implementation of NRR.

In the framework of this, **3 meetings** will be organized during the project where to each outreach locations, associated plant and demo plant is invited.
Each meeting will be an interactive networking moment with updates about the project including a visit demo plant or an outreach location. At the final meeting the web based tool for nutrient recovery will be exhibited in première before it goes public and different stakeholders will be brought together.

Identification of regional market for recovered end products

Since most of the recovered end products are new to possible end users, this will be an important parameter in the development of the business cases with NRR and will need to be investigated.

To identify potential regional markets, a questionnaire will be send to the outreach locations and associated plants in the summer of 2018.

If no market opportunities are imaginable by the outreach locations in their region, the SYSTEMIC consortium will try to supply tips and tricks and information gained in the project.

Follow up, support and guidance in this market study will be provided to the outreach locations via one on one interviews, telephone contact or skype.

Benefits for Outreach Locations and Associated plants

All outreach locations and associated plants:

1. will – as mentioned before- be invited to the Living Lab meetings where an intensive interactive exchange of knowledge & experiences is facilitated.
2. Their logo & fact sheet will appear on the Systemic website
3. Will receive exclusive newsletters & reports on:
    - the progress of the outreach locations and associated towards nutrient recovery
    - Intermediate project results
        - Development web tool
        - Progress on demo plants development to large scale NRR
        - Analyses on end products + pot & field trials
        - Progress in business plan development Atria & 1 outreach location

The 12 outreach locations:

- Will assess/develop together with the consortium a business case with NRR
- Get analysis results of a limited amount of their digestate and/or recovered products
- Get reimbursement for their travel and hotel costs for attending the Living Lab meetings

Planning

February 2018

Kick off meeting Living Labs in Amsterdam

March 2018

- Outreach locations and associated plants receive and elaborated summary on the Kick off meeting.
- A questionnaire will be send to the outreach locations as background for their plant fact sheet.

May 2018

- The fact sheets of the outreach locations will be finished and put on the website after approval by the plant owners.

June-July 2018

A second questionnaire will be send out to the outreach locations and associated plants.

When things are not clear about the answers in the questionnaire, consortium will organize a skype or telephone call or group meeting at a plant to discuss this.

The second questionnaire will include more in depth questions and data.

- To identify potential regional markets
- To get information for the database behind the web based tool.
- To characterize the regional legislation including legislative barriers and economic landscape.

Reminder: economic data will remain confidential.

August-September 2018

- Consortium and outreach locations will start the business case development by using the web based tool

January 2019

- The first draft of business cases should be ready and will be discussed with consortium and plant owners.
- The outreach locations for business plan development will be selected by the consortium. (This action can also start earlier in the project)

June 2019

The second Living Lab workshop will take place at a demo plant, outreach location or associated plant. The business cases developed for the outreach locations and problems encountered will be discussed.

2019-2020

- business plan development of Atria and one outreach location will start
- Further development and finetuning of the business cases

2020-2021

Final workshop of the Living Labs where experiences will be shared, business cases shown, future plans discussed and the web tool presented. This meeting will attempt to bring together all different stakeholders.

ANNEX

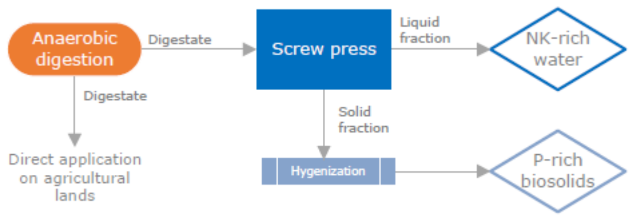
Annex I: Introduction to the five demonstration plants

A short summary of the five demonstration plants is given. Factsheets with more information on feedstock, biogas production, digestate treatment and end products of the demo plants can be found on the SYSTEMIC website.

Groot Zevert Vergisting, Beltrum, The Netherlands

Current process

Groot Zevert has a state-of-the-art mesophilic digester and treats yearly about 100 000 ton of manure (80%) and agro-industrial waste (20%) which translates to 5m^3/h.



Current process

Because manure is difficult to spread in the region, due to P-rich soils with stringent P application rates, the P-rich biosolids (solid fraction after separation) are exported to Germany together with a part of the liquid fraction of the digestate.

Drivers for nutrient recovery

In February 2018, the cost for transport on long distance and spreading the pig slurry from fattening pigs and (manurecode 50; 4 kg P2O5/tonne, 7 kg N/tonne) or digestate inclusive sampling, weighing and analysis is estimated between 21,50 and 27.50 EUR/tonne (excl VAT).

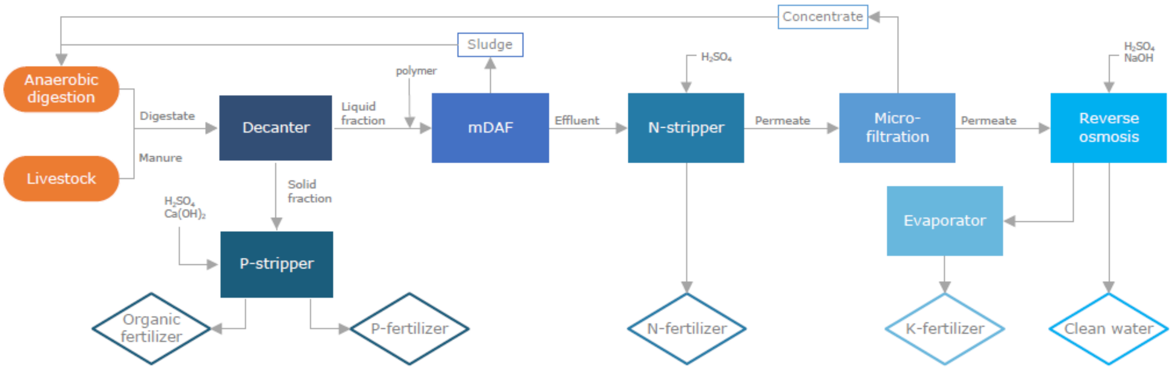
For cattle manure (manurecode 14; 1,8 - 2 kg P2O5/tonne, 4-4,5 kg N/tonne) this cost is estimated between 16,5 and 21 EUR per tonne (exl VAT)(*Boerenbusiness Mestmarkt Inside*, 2018).

Also, the Nitrates Directive limits N application rate from animal manure is up to 170 kg N ha/y (exception: derogation up to 250 kg N ha/y) and digestate from animal manure is regarded as manure.

Separation of nutrient streams could generate cost savings by local spreading (e.g. less transport, more certainty to get rid of nutrient surplus).

Envisaged process

During the SYSTEMIC project, Groot Zevert will implement NK recovery technology from the liquid fraction (GENIUS) and P recovery from solid fraction (Re-P-eat).



Envisaged process in phase 2 of GENIUS-Total

The GENIUS process from Nijhuis Industries, includes a N-stripper/scrubber of the liquid fraction which give ammonium sulphate as end product. The permeate is further purified by reverse osmosis and the concentrate is concentrated even further to a K-rich liquid.
Depending on the market, Groot Zevert will produce N and K as separate products or a blend whereas a NK-concentrate if the N-stripper/scrubber would be eliminated from the process.
The goal is to process 400 m^3 of liquid fraction/day and the full scale installation is planned to be working in December 2018.

Ammonium sulphate is free of organic matter, while K-fertilizer contains dissolved organics. The recovered water from the RO (50-60% up to 80%) meets stringent criteria for discharging to surface water.

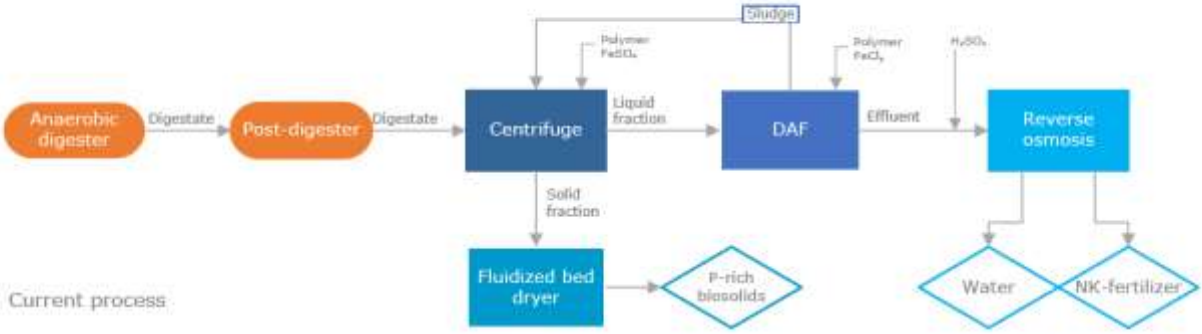
The Re-P-eat system will be built in the framework of the SYSTEMIC project. After separation of the digestate, the solid fraction is acidified (±pH 5) and the phosphorus from the solid fraction (>80% of total P) will become available in the liquid fraction. Afterwards P-precipitation can be induced by adding $Ca(OH)_2$. $Ca_3(PO_4)_2$ crystals with a small percentage of organics can be recovered(12% P, 25% OM). This could be exported to regions with a demand for P-fertilizers (e.g. France) or used as a feedstock for the production of triple-superphosphate at ICL Fertilizers.
The P-poor organic solid fraction (< 1g P/kg) remains after filtering off the phosphate crystals, is ideal as soil conditioner to increase carbon contents.

The full scale Re-P-eat system is estimated to be built in October-December of 2018.

AM-Power, Pittem, Belgium

Current process

AM-Power has the largest anaerobic thermophilic digester in Belgium, which treats about 180 kt of feedstock every year out of which almost 90% is organic biological waste (i.e. food waste) and 20% animal manure and energy maize.



The current process separates the digestate by means of a centrifuge (while adding water based polymer and $FeSO_4$). The P-rich solid fraction cannot be put on already P-rich Flemish soil and is dried and exported to France, a region with high P demand (fe for grape cultivation).

The liquid fraction is treated by a DAF (dissolved air flotation) unit (while adding water based polymer and $FeCl_3$). Separating the suspended solid and fats from the liquid fraction. The latter goes to the RO installation after acidification (H_2SO_4) to ensure a good efficiency from the RO membranes. The membranes need to be cleaned and treated with antiscalant regularly.

The end products are water (permeate from the RO) and NK – concentrate. The water is not clean enough to discharge and is therefore currently used on site to clean trucks and make polymer solution for the separation steps. The NK-concentrate which is regarded as "other fertilizer"(Dutch: "andere meststof") when no manure has entered the digester. This is currently used as fertilizers in the greenhouses owned by AM-Power or has to be transported to grasslands to be spread (which includes a transport and spreading cost).

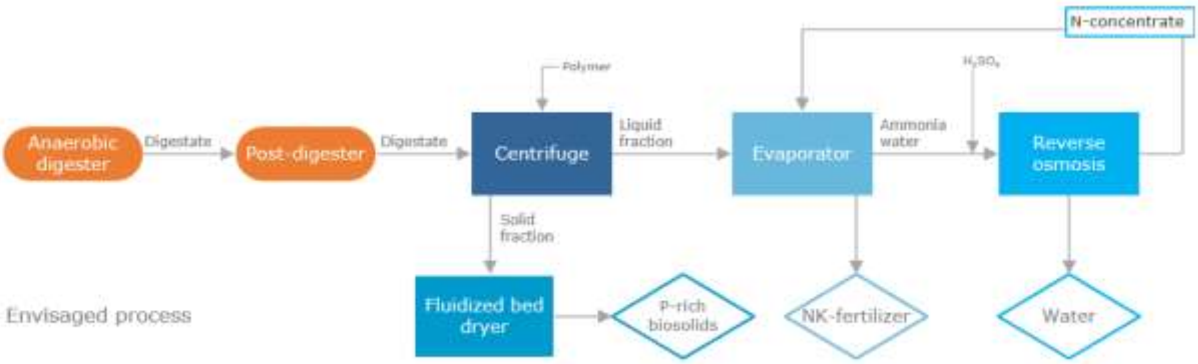
Drivers for nutrient recovery

AM-Power recognizes the importance and benefits of moving towards circular economy and realized that transport of products with 90% water is a big cost which could be reduced by lowering the water content.

There is also a high competition between biogas plants for agro-waste as feedstock in Flanders. A gate fee is charged to the biogas plant owner for intake of such bio-waste. Nutrient recovery could increase their competitiveness on this market.

Envisaged process

During the SYSTEMIC project, AM-Power will built an evaporator custom made to get the end products they imagined.



The evaporator will replace the DAF unit and therefore less polymer and acid will be used.

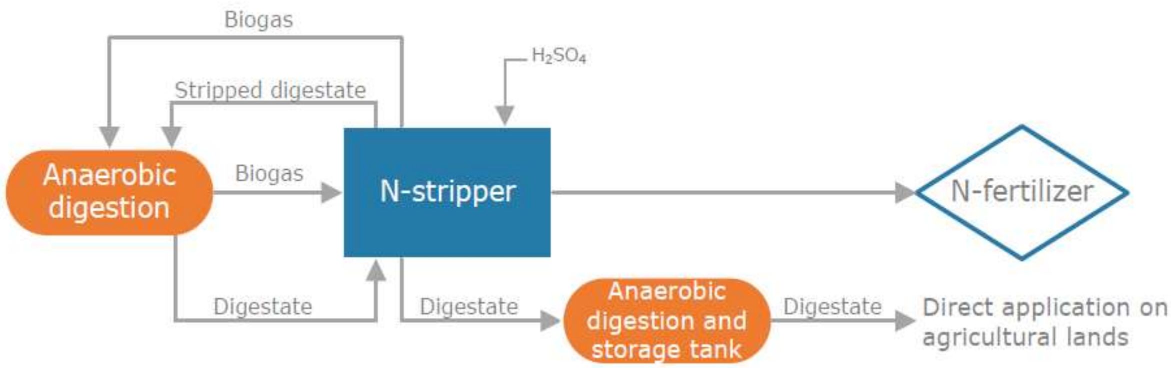
This elaborate pre-treatment of the liquid fraction should also improve the robustness of the RO. Permeate from the RO can be polished with active carbon and discharged or reused, which reduces the amounts of city water used.

The mineral concentrate also has more potential to be spread on the land in comparison to liquid fraction of digestate, which also generates lower transport costs if it could be used in the region.

Acqua & Sole, Vellezzo Bellini, Italy

Current process

The experimental phase on anaerobic digestion process and ammonia removal started in 2010. The idea was born in farms where the need to restore organic matter in soil was increasing yearly. Many inputs and methods were tested in those first years: looking for the most advantageous in terms of quality of digestate produced and efficiency of removing ammonia. From these results a large-scale plant was developed: Acqua & Sole.



The plant treated in 2017 72 kt of municipal waste water treatment sludge (85%) and food-waste(15%)the city. Acqua & Sole gets a gate fee for processing the wastewater treatment sludge. At the moment the plant is only economically viable because of rate of input.

Feedstocks (DM 14,5%) are being thermophilically digested in the first digestor and the ammonia in a part of the digestate (DM 11%) is stripped with a part of the produced biogas. After addition of H_2SO_4

an ammonium sulphate solution (7,2%) is recovered. The ammonia removal efficiency from the digestate is currently 20%.

The high temperatures of thermophilic digestion ensures the obliged hygenisation step required for waste water treatment sludge. Also, the risk for ammonia toxicity of the bacteria in the second digester is lowered (nitrogen content in the first digester is 60 mg/l N).

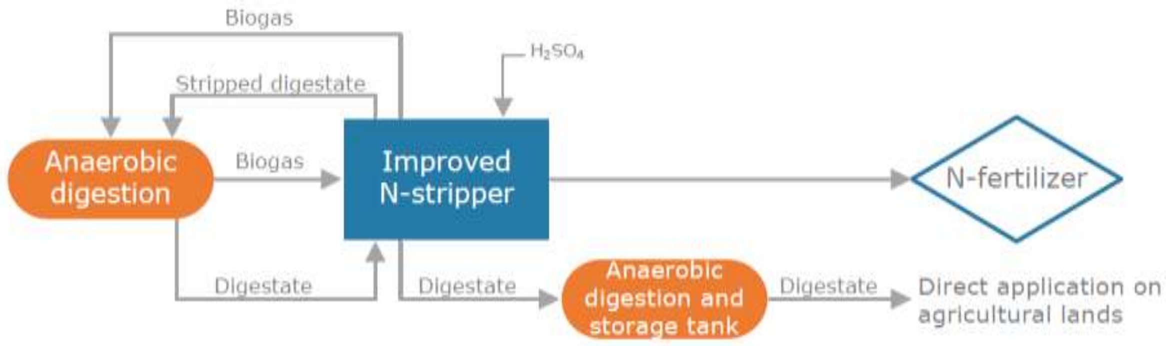
Digestate (low N content) and ammonium sulphate are both used as fertilizers in precision agriculture on 1500ha of land owned by the owner of Acqua & Sole.

Drivers of nutrient recovery

Acqua & Sole believes in their current system and hopes to has the ambition of improving soil fertility without any use of synthetic fertilizer over an area of 5000 hectares, and ensuring the nutrient requirements of the surrounding farms for their annual crop production.

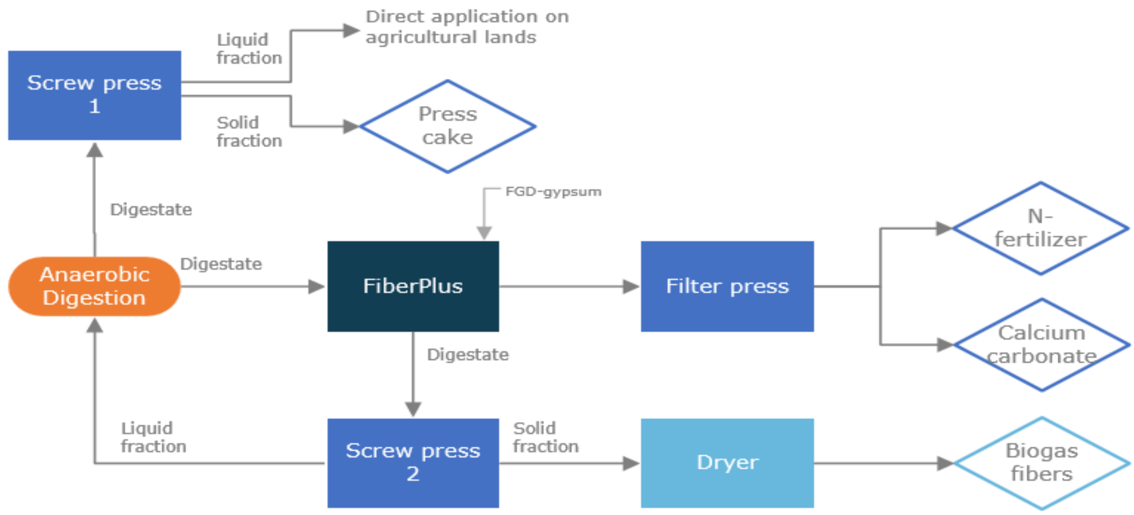
Evisaged process

Acqua & Sole hopes to improve the ammonia removal efficiency of the stripper to 80-85% by stripping at a higher temperature. Technologies to reach this high temperatures need to be found and tests need to be performed that the bacteria in the second digester are not affected by these higher temperatures.



Benas, Ottersberg, Germany

Current process



Benas uses thermophilic digestion (12% DM input) to process about 100 kton of corn silage (55%), chicken maure (25%) and other agricultural material (20%). Benas is planning to decrease every year the amount of corn silage fed to the digester, because chicken manure is readily available as feedstock at a low gate fee for the plant owner.

The digestate can be directed to one of the two post treatment lines according. The first line is a separation by means of a screw press, after which both fractions are used as fertilizers on the arable land of the plant owner surrounding the biogas plant (1000 ha) or some 100 km away from the plant (2500 ha). Benas has his own truck fleet to minimize the transport costs, but sees their current nutrient recovery technologies as a way to reduce the transported volume and to be able to spread end products within the stringent N application rates.

The second post treatment line contains a Modified Stripping Process System and FiberPlus technology developed and patented by GNS.

The Stripping Process System strips up to 80% of the ammonia in the digestate.

According to the need for a certain end product, the digestate can be send to another 2 different treatment lines.

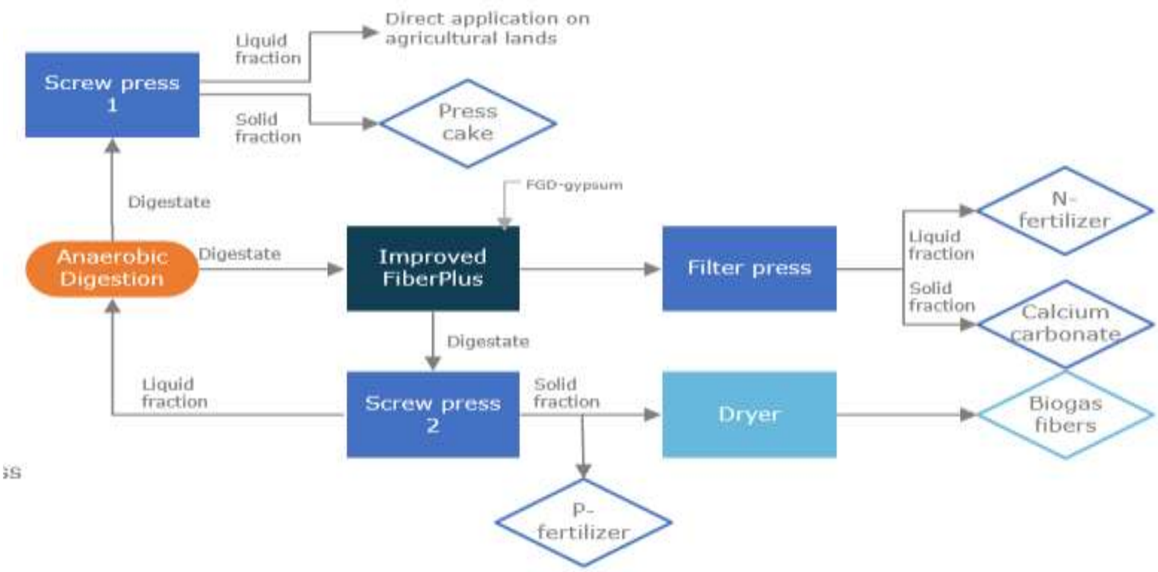
The first line separates the stripped digestate and the liquid fraction is recycled to the digester to dilute the N-rich chicken manure and means of this lowering the ammonia toxicity.

The solid fraction of the stripped digestate is dried and the fibres are recovered with the FiberPlus system and can be used for producing fibre boards. The amount of recovered fibres is highly dependent on the feedstock of the digester.

The second treatment line, adds Gypsum from Flue Gas Desulphurisation of coal power plants to the stripped digestate and the solution is mixed in a large vessel. Solid lime ($Ca(CO_3)_2$ 70% DM) is separated from an ammonia sulphate solution (75% water) by means of a filter press. Ammonia recovery reduces the cost of mineral fertilizer use and an income is generated from selling the recovered biogas fibres.

Envisaged process

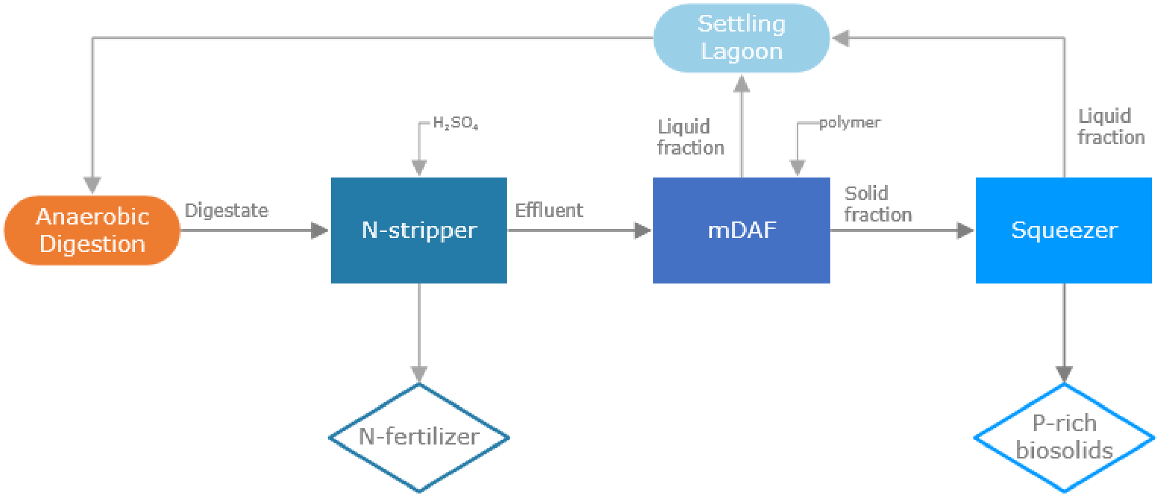
Benas wants to expand the market for their recovered products and optimize their system further. Phosphorus recovery is one of the options to be looked at.



Fridays Eggs, Kent, UK

Envisaged process

Fridays is planning to build a mesophilic digester to process the 40kt chicken manure they produce each year. Rika Biofuels supplies them guidance and support and provides the technology. A DVO plug flow digester.



In a first step the feedstocks undergo a hydrolysis step in an acidification chamber (without adding any chemicals). After that the feedstock/digestate passes to a very large U-shaped methanogenic chamber, where the pH is no as low and methanogenic bacteria are favoured. Biogas circulation moves the input through the system with a retention time of around 20 days. The gradual increase

of pH in the methanogenic chamber to 8.5 provides optimal conditions for subsequent ammonia

stripping. N is recovered as a valuable ammonium sulphate solution (40% AS) after scrubbing the ammonia rich air with H_2SO_4.

From the N poor scrubberwater, organic matter and P-rich suspended solids are recovered with a through a modified Dissolved Air Flotation step (mDAF). 90% of the phosphorus is recovered in P-rich biosolids which provides a valuable storable end product which could also be blended with N-rich end products.

The N-poor liquid fraction after the mDAF is recycled to the digester to reduce the requirement for water to dilute high nitrogen containing feedstocks (e.g. poultry manure)

Rika Biofuels is also exploring the option of crystallising AS solution.

Annex II: Business case development: Green Mineral Manure Refinery

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member of Work Package 5, Wageningen University & Research

The Demo Plant Groot Zevert Vergisting (NL) is very active in looking for innovative opportunities to recovery of nutrients and re-use in the region. The call themselves a " Green Mineral Mining Centre".

Groene Mineralen Centrale

Incentives for manure treatment

As mentioned before, with the current P-limits for soil application in the Netherlands, more than 25% of P in manure cannot be applied on land within the Netherlands and is obliged to undergo manure treatment and/or export.

The current business case of Groot Zevert Vergisting is a problem- driven one:

- Valuable organic matter, N,K are lost from the region
- High costs: fragile balance intake fee vs processing cost + export cost
- High CO2 emissions associated with transport
- Strong dependance on subsidies

Groot Zevert found a way to turn problem-driven business case into a market-driven business case by using manure as a feedstock for the production of NK- fertilizers, nutrient-poor soil improvers, clean water and biogas. Hereby closing nutrient cycles within the region, reducing GHG emissions and reducing costs.

Market-driven business case

One of the biggest obstacle for implementing this business case with nutrient recovery is finding a market for products that cannot be used as fertilizers according to EU and regional legislation.

The good news is, that a potential market is present in the region. 27% of the N,P,K currently used to fertilize the soil in the Achterhoek are mineral fertilizers, while 73% comes from mainly cow manure.

The N-limits for nitrogen from manure is 170 kg N/ha per year. This can be added with mineral fertilizer up to 350kg N/ha per year (crop uptake). If the mineral concentrate (recovered N from manure) could obtain and end-of-manure status and be used on top of170 kg N/ha per year, this could replace a part of the synthetic fertilizer market.

Unfortunately, this end-of-manure status cannot be achieved in short notice and therefore several parties in the Achterhoek have joint forces and have applied for a Green Deal. In the framework of a Green Deal, the government allows a pilot status to a region. In the case of the Achterhoek, this means a 2-year exemption on the use of N-concentrates as mineral N-fertilizer on 200 farms.

The objective is to collect and report data that can be used in descion-making according this end-of-manure status. Data that will be collected are:

- Emissions of ammonia with a low-emission-injector
- Nitrogen-use-efficiency
- leaching of nitrate to groundwater
- Yield
- Farmers acceptance towards blended products: NKS products with specific ratio's according to crop demands

Re-P-eat

The Re-P-eat technology (developed by Wageningen University & Research) produces Calciumphoshates and soil improver from manure/ digestate.

Depending on market demands the calciumphosphate will be sold as slurry or dried product. The P-fertilizer can be a sold to area's with a P-shortage but proof of plant-availability in field trials will be needed to convince farmers.

In a first phase the low-P organic matter (33%DM, 93% OM, <2g P_2O_5/kg) will be sold as a soil improver in the region (<25km).

In a second phase the possibilities of upgrading it to potting soil/substrate will be researched. The difficulties here are to get a coarse product with stable fibres, but this high valuable product would make the business case of Groot Zevert favourable.

Annex III: Development of Business Development Tool with nutrient recovery

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Projectcoordinator and member of WP5, Wageningen University & Research

Within SYSTEMIC, a Business Development Package is developed, containing a quantitative tool will be developed for supporting cost-benefit analysis (CBA) and the selection of technology combinations.

The objective of the tool is to forecast the

- costs and performances (CAPEX, OPEX, maintenance cost, wearing cost)
- composition and amounts of different end products
- Nutrient recovery & separation efficiency
- Energy requirement
- Chemicals requirement
- Environmental impact

for technology combinations selected by the user.

For now the techniques that will be included in the tool are:

- Separation:
    - Screw press
    - Centrifuge
    - Dissolved Air Flotation (DAF)
- Ammonia stripping/scrubbing
- Membrane processes: Reversed Osmosis (with possible pre-treatments: MF, UF)
- Chemically induced P precipitation
- Evaporation
- Drying
- Biological treatment (nitrification and denitrification) as polishing step

The tool will be based on a database, which will be constructed by the SYSTEMIC consortium.

The goal is to incorporate preferably real life, practical data on different brands and concepts of these techniques. In a later stage, it could be considered to add more techniques in the tool. Requests done by the outreach locations and associated plants will be looked into.

This data on the performance & costs of the the different techniques will be gathered from:

- Literature
- Demonstration plants
- Outreach locations & Associated Plants
- Expert knowledge

The tool should be web-based, simple and transparent and user friendly. The outreach locations will be the first test cases of the tool: with support of the consortium, they will use it to develop their business case with nutrient recovery during the project.
The tool will be calibrated on data of AM-Power and validated on data of Atria and at the end of the project will become publically available.

Using the tool

To start with working with the tool, you'll need to input which feedstock is fed to the digester and which subsidies and gate fee you currently receive.

	Select max 5 inputs	code	kg
1	Digestate pig slurry	2	1000
2	Type of input	1	
3	Type of input	1	
4	Type of input	1	
5	Type of input	1	

Also, the composition of your biomass source (digestate etc) is needed. Obliged parameters are DM%, OS%, tot-N, NH4-N, tP, K. This is preferably based on recent analyses. If these are not available, assumptions will be made based on values from the database.

Characteristics	Variable	Unit	Digestate pig slurry	Assumptions		
content of liquid material in digestate (Water & Solubles)	W	kg/ton	940			
content of DM suspended	DMsus	kg/ton	60			
content of DM in solution	DMsol	kg/ton	13			
content of OM in digestate (completely suspended)	OM	kg/ton	42	70%	of DM	
content of total P in digestate	tP	kg P/ton	1.747	4	kg P2O5/m3	
content of P-PO4 in organic matter structures	OrgP	kg P/ton	0.175	10%	of TP	
content of P-PO4 solid mineral fraction in digestate	MinP	kg P/ton	1.534			
content of P soluble in liquid fraction	oP	kg P/ton	0.038	40	mg P/l	
content of total N in digestate	tN	kg N/ton	6			
content of N-NH4 in organic matter structures	OrgN	kg N/ton	3.3	55%	of TN	
content of N-NH4 solid mineral fraction in digestate	NH4_s	kg N/ton	0.54	20%	of min N	
content of NH4 soluble in liquid fraction	NH4_l	kg N/ton	2.16		2298	mg N/l
content of total K in digestate	K	kg K/ton	3.32	4	K2O	kg/ton
solid	K_s	kg K/ton	1.00	30%		
liquid	K_l	kg K/ton	2.32	70%	2472	mg K/l
content of total SO4 in digestate	S-SO4	kg S/ton	1.66	2	SO4	kg/ton
solid	S-SO4_s	kg S/ton	1.41	85%		
liquid	S_SO4_l	kg S/ton	0.25	15%	265	mg S/l
content of total Cl in digestate	Cl	kg Cl/ton	5.81	7	Cl	kg/ton
solid	Cl_s	kg Cl/ton	0.29	5%		
liquid	Cl_l	kg Cl/ton	5.52	95%	5870	mg Cl/l
content of total Ca in digestate	Ca	kg Ca/ton	6.64	8	Ca	kg Ca/ton
solid	Ca_s	kg Ca/ton	5.31	80%		
liquid	Ca_l	kg Ca/ton	1.33	20%	1412	mg Ca/l
content of total Mg in digestate	Mg	kg Mg/ton	4.98	6	Mg	kg/ton
solid	Mg_s	kg Mg/ton	4.23	85%		
liquid	Mg_l	kg Mg/ton	0.75	15%	794	mg Mg/l

Figure 2: Draft of the input page with examples of input values needed (green fields are assumptions, orange fields are calculations)

The tool would make it possible to virually experiment with different techniques by selecting techniques (Figure 3).

One of the outcomes of the tool would be scheme of a technology cascades including recovery and separtion effieciencies (Figure 4).

It will also give an estimation of the costs, energy and chemical requirement and environmental impact.

Finally, a list of the different end products is shown, with an estimation of the produced amounts and composition (Figure 5).

Unit	Name	Code		
1	Separator A	2		
2	DAF B	7		
3	Membrane Filtr. A	14		
4	Concentrator C	20		
5	P-Stripper A	22	pH	5
6	DAF D	9		
7	Process unit	1		
8	Process unit	1		
9	Process unit	1		
10	Process unit	1		
11				
12				

Figure 3: Dropdown menu to select techniques.

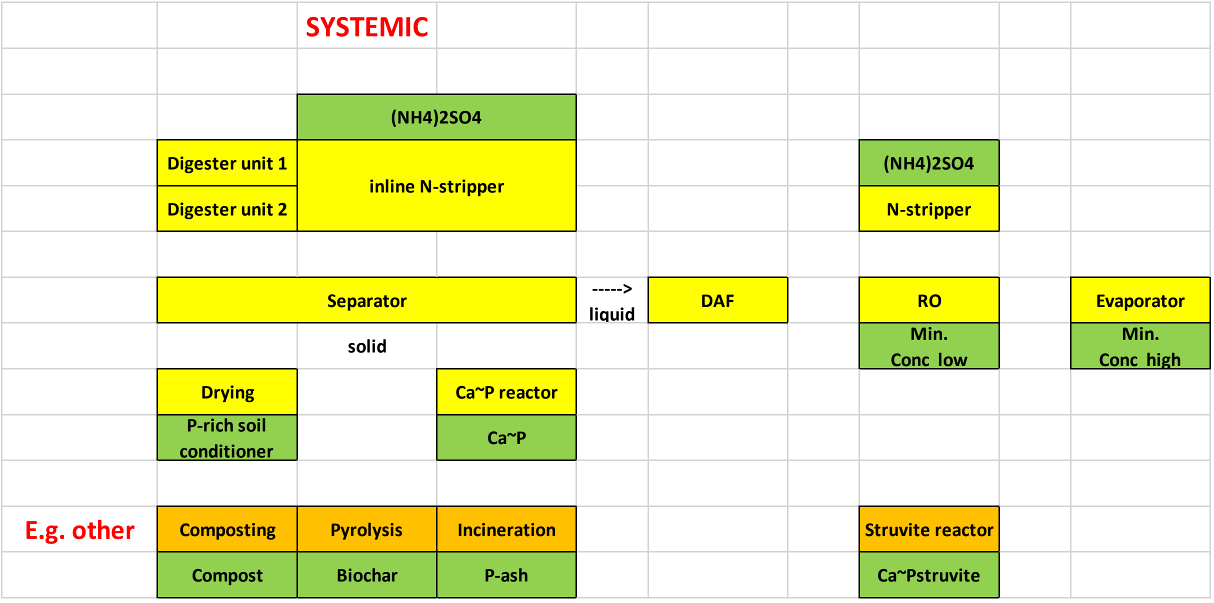

Figure 4: Draft of a cascade of technologies as outcome of the tool.

		OUT						
	IN	Perm	CONC1	Air	SF1	CaP	Total	diff
Mass	1000.00	641.13	112.79	48.08	195.67	2.33	1000.00	0.00
W	940.00	641.12	112.20	48.08	138.13	0.47	940.00	0.00
DMsus	60.00	0.01	0.59	0.00	57.54	1.86	60.00	0.00
OM	42.00	0.00	0.42	0.00	41.21	0.37	42.00	0.00
tP	1.75	0.00	0.05	0.00	0.21	1.49	1.75	0.00
tN	6.00	0.09	1.79	0.00	4.12	0.00	6.00	0.00
K	3.32	0.10	1.89	0.00	1.33	0.00	3.32	0.00
S-SO4	1.66	0.01	0.22	0.00	1.43	0.00	1.66	0.00
Cl	5.81	0.24	4.47	0.00	1.10	0.00	5.81	0.00
Ca	6.64	0.06	1.13	0.00	5.45	0.00	6.64	0.00
Mg	4.98	0.03	0.65	0.00	4.30	0.00	4.98	0.00

Figure 5: Example of an output of the tool: estimated amount and composition of different end products

One of the outreach locations remarked that visocosity of the digestate is a very important parameter which can influence the separation step and hereby has an effect on every subsequent step. This will from now on be taken into account when developing the tool.

The next steps in the development of the tool are:

1. Collect information of the demo plants, outreach locations and associated plants
2. Collect information of the NRR units (literature, suppliers, constructors, consultant experience)
3. Improvement of the tool: testing it with the outreach locations, calibration and validation
4. Set up guidelines on how to use the tool
5. Look for market possibilities & required products & composition
6. Assessments of the expected products (quantity and quality)
7. Collect data on costs – benefits or make reliable assumptions

Annex IV: Economic aspects, legislation & business case assessment in outreach locations

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leader of Work Package 2, Proman Management GmbH

Within SYSTEMIC Work Package 2, will be studying different economic, legislative and ecological aspects influencing the feasibility of a business case with nutrient recovery from digestate.

Regulatory framework evaluation

Since EU has its own legislation, translated in the national legislation of the different member states, there is a need to characterise and categorise these standards and statutory regulations regarding anaerobic digestion, digestate and derived products.

Moreover, we believe that this diverse regulatory framework is an important setscrew to foster anaerobic digestion with nutrient recovery and recycling.

In a first step we will be exhibiting the impact of determined subsidy and regulatory systems of the 5 demonstration countries (Belgium, Germany, Italy, Netherlands, UK).

The information collected from the Demo-Countries would include:

- Feed-in tariffs: electricity, SNG, LNG
- Feed-in premiums: electricity, SNG, LNG
- Subsidies: GreenCertificates, OPEX, CAPEX
- Nutrient framework/regulations
- Substrate related regulations
- Waste management
- Other

Results from the achieved work up till now have shown that there is a large diversity in economic conditions (Feed in tariffs/ Feed in premiums / GreenCertificates from € 0 to € 150/MWh-el) and agricultural practices in the 5 demo countries.

This results in a very uneven distribution of AD plants with different business cases, societal awareness and challenges and would lead to a different NRR approach.

This would be supplemented with data from

- EBA Statistical Report
- National Biogas Associations
- VCM
- Plant Owners
- Atria (A-Farmers)
- RISE
- Outreach locations

From the outreach locations we will collect and record basic information with a focus on characterizing drivers and barriers for setting up a business cases with nutrient recovery.

These factors will be compared to other relevant EU member states to accentuate key factors.

A final report assess and report legal and commercial framework conditions directing the investment decisions of farmers and agricultural businesses in Europe and will therefore include recommendations for political decision makers.

These recommendations are intended to foster anaerobic digestion plants and nutrient recovery and recycling and are specifically targeting:

- the limits based on Nitrates Directive and national nutrient use limitations (e.g. P in NL).
- Less attractive and highly fragmented incentive schemes
- Different definitions for the same words in different EU countries (fe "biomass")
- Generally complicated regulations, including hundreds of pages in every country

Therefore SYSTEMIC will be

- Promoting new EU Fertiliser Regulation expected to bring EU-wide free, harmonised market for EU-fertilisers
- Promoting "end-of-waste" status for mineral products produced from digestate by amendment of "manure" definition in Nitrates Directive

An EU-wide **harmonized definitions and free market** would already be a **great achievement!**

Business case evaluation

Within SYSTEMIC we would like to demonstrate commercially viable and to some extend transferable business cases with nutrient recovery from digestate. To get to this, the 5 demo plant business cases will be studied in detail from the start of the project and after successful implementation of peripheral nutrient recovery and recycling (NRR) technologies.

The business case of the outreach locations will also be evaluated (in less detail) and business cases with NRR will be developed by using the web based tool.

For outreach locations a business plan with NRR will be set up, which includes a closing financial plan.

The ultimate goal of SYSTEMIC is not to get all 11 outreach locations to implement NRR techniques, but to show them the possibilities and stimulate innovation and sustainability.

Key Performance Indicator (KPI) identification

Work Package 2 will focus on identifying Key Performance Indicators (KPI's). These KPI's are are measurable values (technical or economic) that demonstrate how effectively a company is achieving key business objectives. KPI's have a large impact on the success of the business case but can also be controlled in a way.

Examples are:

- Conversion rate feedstock-to-biogas
- Optimized energy mix – power / methane / heat
- Recovery rate for nutrient-to-fertilizer
- Feedstock gate-fee / cost
- Revenues from digester based products

Life Cycle Assessment (LCA)

Work Package 2 aims to deliver comparative LCAs, which shows the environmental impact of each chain of (process) steps of NRR treatment of the digestate.

The starting point will be to exhibit the whole environmental footprint of the five demonstration cases which includes the environmental performance of the plant, its substrates, processes and outputs.

This will be benchmarked against the scenario of a biogas plant without NRR and the production of mineral fertilizers by conventional processes and from conventional raw materials.

Business model development

In a final summary of all previous tasks, work package to will come to commercially viable and transferable business models under the prevailing framework conditions and which are sustainable according to LCA.

The transferability of these models to the outreach plants / other regions will be assessed with a focus identifying legislative barriers and attempting to minimize their dependency on subsidies.

Annex V: Atria (Finland) key outreach location testimonial on participating in SYSTEMIC

Teija Paavola, Project Manager A-farmers Ltd, teija.paavola@atria.com

Key Outreach Location, Finland

Atria is one of the leading food companies in the Nordic countries, Russia and the Baltic region. The Group is divided into four business areas: Atria Finland, Atria Scandinavia, Atria Russia and Atria Baltic.

Atria Finland develops, manufactures and markets 100% Finnish fresh meat and other foodstuffs and provides services related to them. It is the market leader in Finland's slaughterhouse industry and has significant export operations.

Atria is planning to build a large biogas and NRR Plant in Seinäjoki (Finland), a region (in a radius of 50 km) characterized by intensive primary production, slaughterhouses from the Atria group and some lands where digestate (derivates) can be spread.

Drivers for nutrient recovery

Atria wants to enhance competition capability of Finnish meat in global market and the environmental sustainability of primary production and the whole food production cycle.

When manure can be valorised to recovered products, this would enhance the development of primary production of A-farmers in the neighbourhood of slaughterhouses.

It will also prepare Atria for stricter rules for spreading manure/digestate yet to come in the future.

In Finland, growing season is quite short. There are only <2 months per year when the digestate spreading makes sense, since spreading into frozen land is not allowed nor useful. The rest of the year, the produced digestate has to be stored, which requires a very large storing capacity.

Atria realized that digestate spreading as such is not going far enough in nutrient recycling, nor from the environmental or economic point of view and therefore nutrient recovery will be a central aspect in the new plant.

Planned feedstocks

The plant will be built in 2019 and will have an estimated treatment capacity of 164,000 tonnes/year in the beginning (the environmental permit will be for 240 000 tons/year).

Table 1: Atria feedstocks estimated in the business plan

Type	Mass per year
Pig slurry	50 kt
Solid fraction of pig slurry	20 kt
Cow manure	10 kt
Chicken manure	10 kt
By-products slaughterhouse	22 kt
Food industry waste	10 kt
Plant biomass	20 kt
Potato fluid	20 kt
Total	**164 kt**

Nutrient recovery technologies

The envisaged process works as follows:

- Feedstocks are received into a continuously mixed tank and diluted to 12% dry matter, DM) with recycled water if needed.
- After the receiving tank, mixed feedstock are directed into a pre-digester/hydrolysation tank before pumping through hygenisation into the mesophilic digesters.
- Digestate (8% DM) is sent to a centrifuge for solid/liquid separation. Coagulation and flocculation are enhanced by the addition of polymer which is prepared with recovered water from the RO.
- The solid fraction, containing ~70% of the initial total phosphorous (P) of the feedstock, is stored in the plant for 1 – 2 months before transport to end-users which use it as such in agriculture as a fertilising soil conditioner. The liquid fraction from which DM content will be <2% DM is directed through a screening unit. The screen will purify rests of animal hairs, straw, fouling particles etc. before the evaporation unit. Acid (H_2SO_4) is used to maintain nitrogen in a NPK-concentrate produced by evaporation unit.
- To the produced condensate a small amount of base (NaOH) may be added to adjust the pH before going to the RO. This will ensure the required recovery of nitrogen and soluble organic

compounds (biological oxygen demand (BOD)) before discharging on waters. The concentrate from the RO has low nutrient levels and it is used for polymer manufacturing or feedstock dilution.

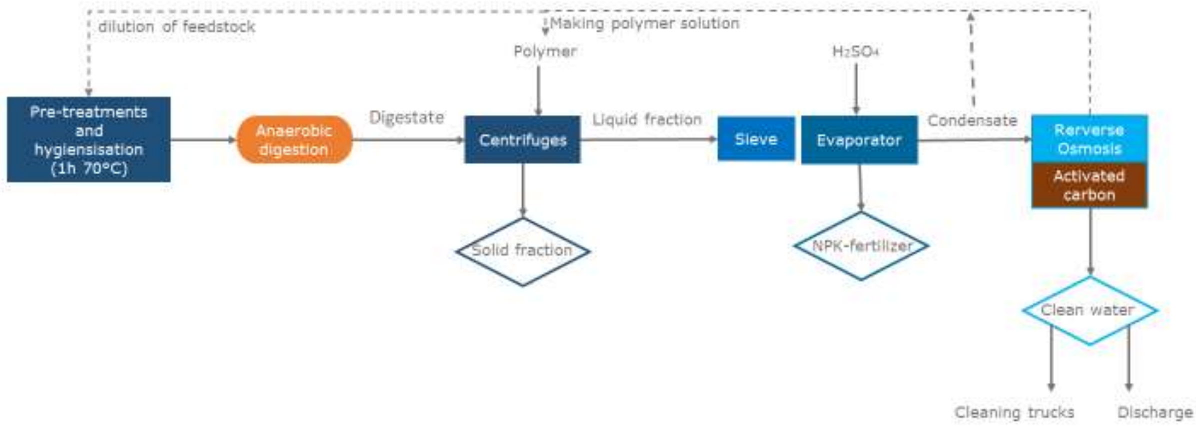

Figure 6: Scheme of the envisaged process to be built in 2019-2020

State of the project

- Environmental assessments have been made for 360 00 tons/year
- Pre-agreements exist for the land of the plant
- An environmental permit has been applicated for 240 000 tons/year. The objective is to submit it in the end of February 2018 and the permit should be ready by the end of 2018.
- The zoning process started at November 2017 and will be completed in autumn 2018.
- At the moment detailed planning is ongoing about technical issues, invitations to tender etc., detailed economic calculations and negotiations about feedstocks and energy. For example, Atria is looking into the feasibility of producing liquified biogas to run their trucks on.
- The investment aid application will be submitted in the spring 2018 and a decision from the Ministry is expected in autumn 2018. After this, a final investment decision will be made.
- The building permit application will be submitted in the autumn 2018 and the processing and approval will take time 2 – 3 months.
- After the zoning and permits are ready, building can start.
- It is estimated that the plant would be operational in December 2019 – January 2020.

Benefits from being part of the project SYSTEMIC

We look forward to exchanging knowledge with specialists and other plant operators.

We have experience with evaporators and membrane technology and have conducted field tests and analyses on digestate and recovered products including organic harmful compounds.

We would like to hear everyone's experience with feedstocks that could cause technical problems.

We would like to learn more about the different nutrient recovery technologies, especially technical issues regarding operation and maintenance and the maturity of the technologies now and in the future.