Nutri2Cycle

D.2.1 Longlist of innovations & compilation of factsheets

Deliverable:	Longlist of innovations & compilation of factsheets
Author(s):	Nutri2Cycle consortium Editors: Hongzhen Luo, Evi Michels, Erik Meers (Ghent University)
Quality review:	Final version
Date:	28/02/2019 (revision 29/01/2021)

Grant Agreement N°:	773682
Starting Date:	01/10/2018
Duration:	48 months
Co-ordinator:	Prof. Erik Meers, Ghent University
Contact details:	Erik.meers@ugent.be

This project has received funding from the European Union's Horizon 2020 research and innovation programme under gran agreement No 773682.

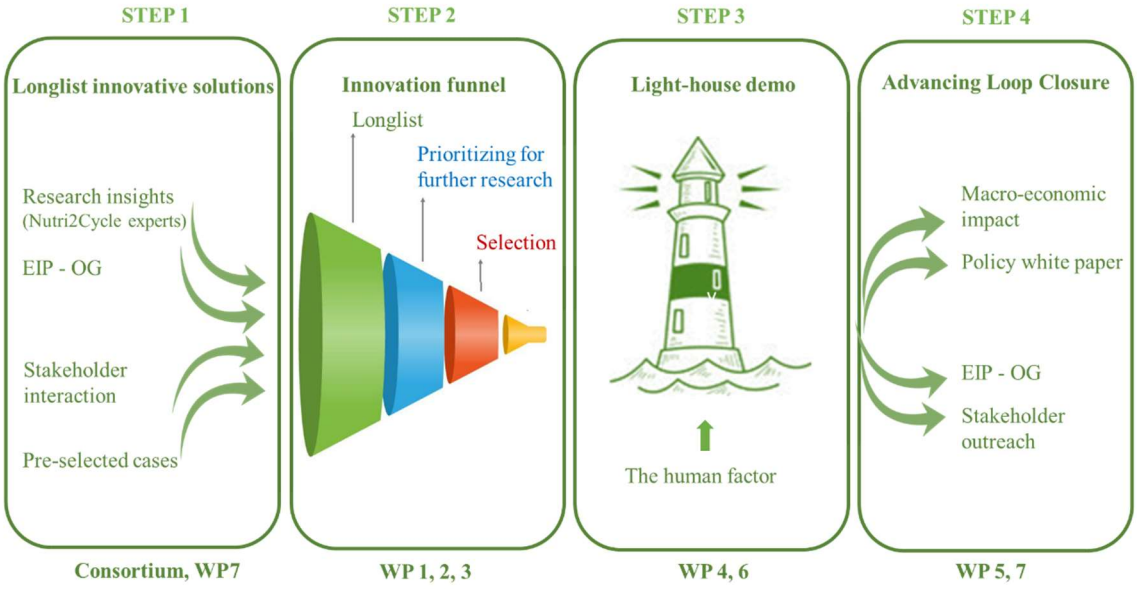
1. Table of Contents

This project has received funding from the European Union's Horizon 2020 research and innovation programme under gran agreement No 773682.

2. Introduction

The NUTRI2CYCLE methodology is an integrated approach designed to generate more efficient nutrient loops by identifying the factors and mechanisms that govern these cycles and through benchmarking, investigation and introduction of effective combinations of existing technologies and high-potential innovations in nutrient management. The focus is to induce effective implementations where NUTRI2CYCLE serves as a catalyst. We strive towards increased market uptake and geographic replication of agronomic success stories, and move beyond theoretical reflections.

The NUTRI2CYCLE methodology follows a logical flow which is represented in the figure below. The current deliverable represents step 1 in which we aim to longlist minimal 60 proposed technical and management solutions for farming systems aimed at closing nutrient loops and efficient mitigation measures. These solutions were acquired through partner and stakeholder collaboration, with particular attention for end user driven practices/strategies and multi-actor whole chain approaches (bottom-up approach).



The NUTRI2CYCLE methodology for more efficient nutrient loops at the local, regional & European scale

This project has received funding from the European Union's Horizon 2020 research and innovation programme under gran agreement No 773682.

3. Methods and organization

In this collection step of the project the consortium deemed it crucial to be as open as possible towards potential solutions. Therefore a factsheet was designed to have an uniform base to compare the collected solutions for further use in the project. The factsheet requested information on the following questions:

- the potential to address effective closing of NPC loops and the capacity to address specific local environmental constrains (nitrate vulnerable zone, excess nutrients, organic matter scarcity and soil quality).
- the solutions need to address selected agro-typologies investigated within NUTRI2CYCLE.
- solutions should be widely adoptable, covering a wide geographical areas in the EU.
- the potential innovation beyond the current state-of-play (innovation in technology, management and business model).
- the environmental potential of the solutions.
- the research capacity and competence of partners and data availability.
- the availability (now or in the future) of economic data.
- the willingness to share samples and/or agro-technical insights, working together with the consortium on the proposed solution.

To identify potential solutions three sources of information were used:

- Innovative solutions provided via Operational Groups (OGs).

To reach the operational groups (task leader= ZLTO) the project partners actively scanned the national inventories for potentially relevant operational groups. Also operational groups that already indicated a clear interest during the grant preparation phase were contacted again.

- Innovations proposed by pioneering farmers & agri-businesses

To reach this target group the partners (lead= TEAGASC) reconnected with the pioneers that already were identified during the application phase to evaluate their interest and status.

- New (Pilot) solutions (TRL 3-5) acquired from progressive research.

The consortium research partners have been selected for their frontrunning research. The insights from their progressive research with pilot potential was collected and compiled by the task leader (UGent).

After initial contact by a Nutri2Cycle partner 104 solutions were collected. In a subsequent stage, the contacts for each proposed solution were asked to fill the factsheet template.

In total 104 solutions were collected with variability in the amounts of detailed information provided. In an iterative process with respondents, the quality, level of information and uniformity between solutions was improved. During the revision, reviewing & optimization process also 28 solutions were finally discarded on one or more of the following grounds: insufficient available data provided, no further responsiveness or willingness to complete the factsheet, solution not yet sufficiently developed for providing required information (e.g. some Operational Groups or projects at the start

This project has received funding from the European Union's Horizon 2020 research and innovation programme under gran agreement No 773682.

of their activities indicated they had not gathered detailed information yet that would be relevant for NUTRI2CYCLE at that stage). An overview of the 104 solutions can be found in Table 1.

Table 1. List of factsheets (source: 1= pioneering farmers & agri-businesses; 2= operational groups ; 3= consortium)

No.	Title	Source
1	Ammonium stripping / scrubbing and NH4NO3 as substitute for synthetic N fertilizers	1
2	Ammonium stripping / scrubbing and NH4SO4 as substitute for synthetic N fertilizers	1
3	Mineral concentrate from reverse osmosis	1
4	Liquid fraction of pressed grass from roadside clippings as a substitute for mineral fertilizer	3
5	Biochar production from manure	3
6	Concentrate from vacuum evaporation/ stripping as nutrient-rich organic fertilizer	1
7	Acidification as a tool to reduce ammonia emission from manure (storage)	1
8	Acid leaching of P from organic agro-residues in order to produce OM-rich soil enhancers and P-fertilizers	1
9	Liquid fraction of digestate as a substitute for mineral N & K fertilizer	1
10	Small / Farm scale anaerobic digestion	2
11	Recycling fibres of manure as organic bedding material for dairy cows	3
12	Using the compost tea in plant production	3
13	Sensor technology to assess crop N status	3
14	Substituting mineral inputs with organic inputs in organic viticulture	3
15	Closing the loops at the scale of farm : using the livestock manure to fertilize the feeding crop on agroforestry plots	3
16	Farm using digestate, precision agriculture and no-tillage focusing on OM stocking in an area characterized by the lack of OM	3
17	Crop farmer using a variety of manure and dairy processing residues to recycle and build soil C, N, P fertility	3
18	Slurry acidification with industrial acids to reduce NH3 volatilisation from animal husbandry	3
19	Slurry bioacidification using org. waste products to reduce NH3 volatilisation and increase fertiliser value	3
20	Low temperature ammonium-stripping using vacuum	3
21	Catch crops to reduce N losses in soil and increase biogas production by anaerobic co-digestion	3
22	BIO-PHOSPHATE: high temperature reductive thermal process recovery of concentrated Phosphorus from food grade animal bones	3
23	Pig manure refinery into energy (biogas) and fertiliser using a combination of techniques applicable at industrial pig farms	3
24	Adapted stable construction for separated collection of solid manure and urine in pig housing (followed by separate post-processing)	3
25	Soybeans in Poland - innovative solutions in the cultivation, plant protection and feeding on farms	2
26	Integration of the farming and breeding system with a distillery and a biogas plant	3
27	Use of an inoculate of microbiota and enzymatic precursors to reduce ammonia emmisions and opytimize nutrients use efficiency	3
28	Precision farming and optimized application: under-root application of liquid manure for maize and other row crops	3
29	The role of leguminous N fixation and biogas processing in organic farming	3
30	Precision farming coping with heterogeneous qualities of organic fertilizers in the whole chain	3
31	Certification systems for precision application technologies	3
32	Annual Nutrient Cycling Assessment (ANCA)	3
33	Anaerobic digestion and microbial electrolysis cell integrate system for biogas upgrading and ammonia recovery	3
34	Secondary harvest: additional valorisation of crop harvest and processing residues	3
35	Aquaponics on nutrients recovered from aquaculture	3
36	Biological processes to produce bio-hydroponic nutritive solution	3
37	Manure aeration techniques to reduce emissions	3
38	Smart fertilization: using (tele)sensing and IT-tools to optimize within field fertilization regimes	3

This project has received funding from the European Union's Horizon 2020 research and innovation programme under gran agreement No 773682.

No.	Title	Source
39	Plasma Manure Processing Technology	3
40	Insect breeding as an alternative protein source on solid agro-residues (manure and plant wastes)	3
41	Floating wetland plants grown on liquid agro-residues as a new source of proteins	3
42	Fertile Cycle Overijssel - Vruchtbare Kringloop Overrijsel (VKO)	2
43	Pig manure evaporation plant	2
44	Tools to minimize the impact of pig slurry applications on the natural environment	2
45	INPULSE: Innovating towards the use of Spanish legumes in animal feed	3
46	Operational Group: INNOVATIVE FERTILIZERS	2
47	Production of growing substrates for horticulture application from poultry manure, solid state digestate and biochar through composti	1
48	Recovery of energy from poultry manure and organic waste through anaerobic digestion	1
49	Nitrogen and phosphorus recovery from pig manure via struvite crystallization and design of struvite based tailor-made fertilizers	1
50	Utilization of NIR sensors on fertilization machine	1
51	Utilization of NIR sensors on storage	1
52	Pilot-scale crystallizer for P recovery	1
53	ALG-AD : Integrating algal and anaerobic digestion technology for sustainable animal feed production	3
54	Tailor made production of soil enhancers (OC) and NPK fertilising products	3
55	Manure processing and replacing mineral fertilizers – The Netherlands	3
56	Application of ammonia water from digestate treatment	1
57	Recovered organic materials and composts for precision fertilization of orchards and vineyards	3
58	Electro Coagulation for separation of manure or digestate	1
59	Impact of (and on) viscosity on manure and digestate treatment	1
60	IRRIGATION / FERTIGATION: use of effluent on arable land	1
61	Tailor made digestate products (tool development)	1
62	Blending of raw and treated organic materials to produce organic fertilisers (NPC)	3
63	Precision fertilization of Maize using organic materials	3
64	Combining Conservation Agriculture and organic fertilization to close the NPC loop	3
65	Struvite as a substitute of synthetic P fertilizer	1
66	Application of digestate in large orchards	3
67	Treatment of liquid fraction of digestate from digestion of food wastes for production of ammonia water and mineral concentrate	3
68	Integration of UAV/Drone and optical sensing technology into pasture systems	3
69	Drying poultry manure and converting it to standardized product	3
70	Agroforestry: smart combination of orchards and animal production	3
71	Practices for increasing soil organic matter content in Dutch soils	3
72	Composting its own cattle manure monitoring the temperature	3
73	Precision arable farming using bio-based fertilizers in potato growing	3
74	Pig manure processing into separated N and K fertilisers and water re-usable for agro-application	3
75	Ammonification & De-ammonification as a pretreatment for N-recovery	1
76	N-measures in soil for optimal grassland management (grazing and mowing)	2

This project has received funding from the European Union's Horizon 2020 research and innovation programme under gran agreement No 773682.

No.	Title	Source
77	Hydrothermal and enzymatic processing of poultry animal waste (feathers) into amino-acids for animal feed and foliar fertilisation	1
78	Pig manure processing into separated N and K fertilisers and water re-usable for agro-application	1
79	Biochar production from pig manure	1
80	Amino acids produced from enzymatic/ hydrothermal cracking of poultry feather waste	1
81	Ammonia water for industrial use instead of urea	3
82	Solutions to change viscosity of waste streams	3
83	Odour treatment at Biogastur	3
84	Design of tools to minimize the impact of the natural enviroment in slurry applications of pig farms	1
85	Can single cell proteins play any significant role in closing nutrient loops in agriculture?	1
86	Drying grass with residual heat to optimize N-efficiency of soil and (dairy) cattle	1
87	Anaerobic digestion and microbial electrolysis cell integrate system for biogas upgrading and ammonia recovery	1
88	Successful implementation of membrane RO for producing mineral (NK) concentrates from digestate	1
89	Reuse fish waste water to irrigate hydroponic crops (focus on plant biostimulating effect of fish water)	1
90	Manure aeration techniques to reduce emissions	1
91	Drainwater as a replacement for fertilizers	1
92	Smart fertilization	1
93	Fibers from solid manure fraction as a source for paper	1
94	Feed efficiency	1
95	Biostimulation and biopesticides	1
96	Trees as a buffer for nutrient loss on a pig farm	1
97	INOSOLTEC : Integrating micro-organism providing strategies to improve fertility and soil health in agroecological culture systems	2
98	ULTIBIOMASS : Exploratory approaches for sustainable agronomic improvement of coastal soils	2
99	EST HORTICOLE : Use of products derived from the methanization for the production of certified organic pot aromatic plants	2
100	QUALIPRAT: To reduce farmers ' dependence on nitrogenous fertilization and improve grassy surfaces	2
101	GASCON'INNOV : a tool for diagnosing the biological condition of winegrowers soil	2
102	Agro-ecology Northern-Netherlands. Various projects on closing nutrient cycles	2
103	Energy efficient processing of manure at farm scale. Innovative processes for drying thick fraction and de-watering fluid fraction of manure	2
104	Processing manure residues to algae. Development of farm scale productionof algae from manure residues and use the algae as feed	1

Of the 104 collected proposed solutions, 28 solutions (nr77-104 in Table 1) were not withheld during the reviewing and revision phase for a number of reasons : lack of information available, no / limited willingness to share economic or agro-technical insights of the solution, solution not sufficiently in scope of NUTRI2CYCLE, lack of responsiveness…

The final longlist therefore contains 76 solutions (104 collected minus 28 discarded), of which 8 originating from operational groups, 19 from pioneering farms and agri-businesses and 49 from progressive research. An overview and compilation of the factsheets can be found below, including an extensive description of the potential of the innovation to close C,N,P loops according to the providers. Table 2 gives a comprehensive overview of the other information as taken up in the factsheets. In point 4 a compilation of factsheets can be found.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under gran agreement No 773682.

Table 2. Comprehensive summary of the collected information on the 76 collected solutions

No.	TRL	Agro-typology								Research line					€ data	Samples & collab	Country										
		1	2	3	4	5	6	7	8	1	2	3	4	5			BE	IT	PL	ESP	GE	HU	NL	PT	DK	FR	IR	HR
1	7							√	√	√			√		√	√	√											
2	9							√	√	√			√		√	√	√											
3	5								√				√		√	√	√											
4	2				√	√	√				√		√			√	√											
5	6	√			√	√	√	√	√	√	√	√	√		√	√	√											
6	4								√				√		√	√	√											
7	9								√	√			√		√	√	√											
8	7								√	√			√		√	√	√											
9	7				√	√	√						√		√	√	√											
10	8	√	√	√		√		√	√	√			√		√	√	√											
11	9			√					√				√		√	√	√											
12	9				√	√	√				√	√	√									√						
13	6				√						√	√										√						
14	6						√				√	√	√		√	√									√			
15	7		√								√				√	√									√			
16	9				√			√			√	√	√		√	√		√										
17	6		√	√	√				√		√		√		√	√										√		
18	9	√		√	√				√	√	√	√	√		√	√								√				
19	5	√		√	√				√	√	√	√	√		√	√								√				
20	4								√	√						√				√								
21	6				√			√	√	√	√				√	√				√								
22	8					√	√	√	√		√	√	√		√	√						√						
23	9	√			√			√			√		√		√	√		√										
24	9	√							√	√					√	√	√											
25	4	√	√	√	√						√								√									
26	8			√	√			√	√	√	√		√						√									
27	7	√	√	√	√	√	√		√	√	√		√		√	√				√								
28	8	√		√	√				√		√	√			√	√					√							
29	9				√			√			√		√		√	√					√							
30	8-9	√		√	√			√	√	√	√	√			√	√					√							
31	8	√	√	√	√						√	√									√							
32	8-9			√	√					√	√	√			√	√							√					
33	3-5							√	√	√						√					√							
34	4-5			√	√	√		√		√			√	√	√	√	√											
35	5										√				√	√	√											
36	2	√	√	√	√	√	√	√	√	√	√		√			√	√											
37	5-9	√		√				√	√	√					√	√	√											
38	5-9				√	√	√				√	√			√	√	√											

This project has received funding from the European Union's Horizon 2020 research and innovation programme under gran agreement No 773682.

No.	TRL	Agro-typology								Research line					€ data	Samples & collab	Country										
		1	2	3	4	5	6	7	8	1	2	3	4	5			BE	IT	PL	ESP	GE	HU	NL	PT	DK	FR	IR	HR
39	7	√		√	√	√				√	√		√		√	√	√											
40	7	√	√			√	√		√	√			√	√	√	√	√											
41	6	√		√					√	√				√	√	√	√											
42	9			√	√					√	√	√											√					
43	5	√			√	√		√	√			√	√		√	√							√					
44	/	√			√	√	√		√	√	√	√	√			√				√								
45	/	√	√	√							√				√					√								
46	7-8					√	√	√	√		√	√	√		√	√						√						
47	3								√		√		√		√	√			√									
48	3							√	√					√	√	√			√									
49	6				√	√	√	√	√		√		√		√	√				√								
50	7	√		√	√	√					√	√					√											
51	7				√						√	√					√											
52	4-5	√		√				√	√				√			√		√										
53	7	√	√					√	√	√				√	√	√	√											
54	9				√	√	√					√	√				√											
55	7	√		√	√				√		√		√		√	√							√					
56	7							√	√				√		√	√	√											
57	5	√	√	√			√		√		√	√			√	√								√				
58	4-5							√	√				√		√	√	√											
59	9							√	√				√			√	√											
60	4	√	√	√	√	√	√	√	√				√		√	√	√											
61	4								√				√		√	√	√											
62	3-4	√	√	√	√	√	√		√		√		√			√								√				
63	6	√	√	√	√						√				√	√								√				
64	6-7				√						√	√			√	√								√				
65	6				√	√	√	√	√	√	√	√	√		√	√	√											
66	8-9						√				√				√	√												√
67	9								√				√			√	√											
68	4			√						√	√	√			√	√											√	
69	8		√						√	√						√									√			
70	9	√		√			√			√					√	√	√											
71	9			√	√						√		√		√	√							√					
72	8			√					√		√					√									√			
73	5-6				√	√					√	√			√	√							√					
74	5-9	√							√	√			√		√	√	√											
75	4-8	√	√	√				√	√	√			√		√	√	√											
76	5			√	√						√	√											√					

This project has received funding from the European Union's Horizon 2020 research and innovation programme under gran agreement No 773682.

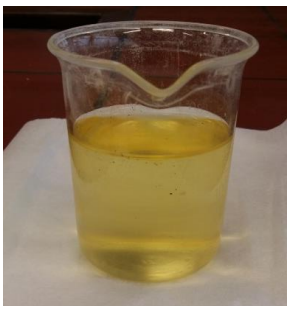
This longlist will now form the base of the innovation funnels as depicted in the figure. In this funnel approach the listed solutions will be further evaluated and prioritised. They will be scrutinised for their ability and potential to close N, P and C loops and their technological, environmental and economical validity. Using a uniform NUTRI2CYCLE framework of indicators reflecting agro-economics & environmental impact at farm system level (micro-economics) a priority shortlist will be generated with scenario's/technologies which have the highest potential for improving nutrient use efficiency, carbon recycling (and soil stock enhancement), energy cycling and/or greenhouse gas emission mitigation and score better than the benchmark situation.

4. Compilation of factsheets

This project has received funding from the European Union's Horizon 2020 research and innovation programme under gran agreement No 773682.

1 Ammonium stripping / scrubbing and NH_4NO_3 as substitute for synthetic N fertilizers

AIM OF THE TECHNOLOGY



Ammonium nitrate recovered from stripping-(scrubbing) of liquid fraction of digestate

Provide a brief description of the proposed management solution or technique

- *What is the purpose/aim of the innovative solution/technique?*
  The aim of ammonia (stripping-)scrubbing is to produce ammonium nitrate (AN) solution. AN contains total nitrogen (N) entirely in mineral form, as ammonium nitrogen (NH_4-N) and nitrate nitrogen (NO_3-N). Total N concentration is reported to vary in range of 13-20% N[1]. The high N concentration gives a potential for recovered AN to be used as a replacement for synthetic N fertilizers.

- *What is the underlying working principle?*
  AN is an end-product of (stripping-)scrubbing technology. This technology is currently applied in livestock operations to recover N from waste streams such as animal manure, digestate and their respective liquid fractions. The operating principle of (stripping-)scrubbing is that ammonia (NH_3) can be stripped by air, steam or vacuum through the N rich waste stream in an NH_3 stripping reactor, resulting in NH_3 transfer from the aqueous phase to a gas phase. The released NH_3 is removed in a chemical air scrubber by washing it with a strong acidic solution such as nitric acid (HNO_3), resulting in AN. The efficiency of process can be increased by adjusting the pH and/or temperature as main process parameters. By increasing pH and/or temperature in the stripping reactor, more of water soluble NH_4-N ion will be converted into the gaseous ammonia. Currently, the use of HNO_3 is not so common in (stripping-)scrubbing installations due to the higher handling risks and purchase costs as compare to, for example, sulphuric acid.

- *What is the current and foreseen scale of operations (e.g. kg, tonnes/year)?*
  The available scale of operations in livestock sector is still on pilot scale with capacity to treat around 30 000 tonnes – 40 000 tonnes of N rich waste stream per year (case study in Flanders, Belgium)[2]. The wastewater treatment plant VEAS (Oslo, Norway) produces about 3 000 tonnes

[1] Systemic, 2018. Ammonium nitrate – factsheet. Available from: https://systemicproject.eu/wp-content/uploads/2018/06/Factsheet-product-Ammonium-Nitrate-FINAL-22052018.pdf
[2] Digesmart, 2016. D3.3 Final report on the trials – technologies for nutrient recovery from digestate. Available from: http://www.digesmart.eu/documentos/D3.3%20Final%20report%20on%20the%20trials%20-%20technologies%20for%20nutrient%20recovery%20from%20digestate_(public)_EN.pdf

of AN (dry weight) per year[3]. The use of AN is not common and currently it is not recognized as mineral fertilizer in the EU.

- *Why is it innovative when compared to existing (farming) practices?*
  The use of AN as a replacement of synthetic N fertilizer can be considered innovative since it represents recovery of N and re-use in agriculture. As it contains high N and no phosphorus (P) and carbon (C), AN shares similar traits as synthetic N fertilizers. The European Commission has recognized this by listing ammonium nitrate as a high priority product with potential to replace synthetic N fertilizers. The current issue in its recognition is the lack of scientific-based knowledge on the product quality and fertilizer performance.

- *How does it improve the Nitrogen-Phosphorus and/or Carbon cycles in agriculture?*
  In most of the EU nutrient surplus regions the nitrogen from waste streams is currently still being eliminated by aerobic treatment which involves N conversion from waste streams into N_2. This loss of N into environment is non-sustainable and recovery of AN via (stripping-)scrubbing technology would help in closing N cycle on farm by recovering N and re-using it in the form of AN.

- *Add a separate line on the location of your management solution: "Currently this technology / technique / management solution is applied in ……. (city, region, country))."*
  Currently, this product is produced in Belgium (Gistel, Flanders) by treating agricultural waste (i.e. animal manure and food waste) and in Norway from VEAS municipal waste water.

[3] Evans, T., 2007. Recovering ammonium and struvite fertilisers from digested sludge dewatering liquors. Proc. IWA Specialist Conference: Moving Forward–Wastewater biosolids sustainability.

1 Ammonium stripping / scrubbing and NH_4NO_3 as substitute for synthetic N fertilizers

TRL (Technology Readiness Level) – how close is your solution to the market?

Use the slider above to position the current TRL* of your proposed solution

* TRLs are a type of measurement system used to assess the maturity level of a particular technology. Where a topic description refers to a TRL, the following definitions apply, unless otherwise specified:

• TRL 1 – basic principles observed • TRL 2 – technology concept formulated • TRL 3 – experimental proof of concept • TRL 4 – technology validated in lab • TRL 5 – technology validated in relevant environment (industrially relevant environment in the case of key enabling technologies) • TRL 6 – technology demonstrated in relevant environment (industrially relevant environment in the case of key enabling technologies) • TRL 7 – system prototype demonstration in operational environment • TRL 8 – system complete and qualified • TRL 9 – actual system proven & running in operational environment

Please provide some sentences explaining your Technology Readiness Level

In Flanders a pilot plant is running on nitrogen recovery from agricultural waste.

If the proposed solution/ technique is currently at low TRL (≤5), is upscaling foreseen within the next year(s)?

If the proposed solution/ technique is currently at high TRL (≥7), is there any product already being produced from the proposed solution/ technique?

- *If yes, what is the name of the product:*
  Ammonium nitrate

- *Short description of the product*
  Ammonium nitrate is a liquid end-product that can contain 13-20% of total N completely present in mineral form. The product does not contain P or C and as such has some similar traits as synthetic N fertilizers.

- *Are there any EC/MS Authority permits already for use of the product (title or link if available)?*
  NO.

1 Ammonium stripping / scrubbing and NH_4NO_3 as substitute for synthetic N fertilizers

POTENTIAL LINKAGE TO THE PROJECT

Indicate to which agro-typology under study and which potential research line of the project, your proposed solution/technique contributes:

	Pig Production
	Poultry Production
	Cattle Farming
	Open field cultivation of cereals or maize
	Open air cultivation of vegetables
	Orchards
X	Agro-energy systems (e.g. biogas)
X	Animal Byproduct processing (e.g. manure processing)

Innovative solutions for optimized nutrient & GHG in animal husbandry	X
Innovative soil, fertilisation & crop management systems & practices	
Tools, techniques & systems for higher-precision fertilization	
Biobased fertilisers (N, P) and soil enhancers (OC) from agro-residues	X
Novel animal feeds produced from agro-residues	
Other, please specify :	

2 Ammonium stripping / scrubbing and $(NH_4)_2SO_4$ as substitute for synthetic N fertilizers

AIM OF THE TECHNOLPGY

Ammonium sulphate recovered from scrubbing ammonia rich air from animal stables

Provide a brief description of the proposed management solution or technique.

- *What is the purpose/aim of the innovative solution/technique?*
  The aim of ammonia (stripping-)scrubbing is to produce ammonium sulphate (AS) solution. AS contains total nitrogen (N) entirely in mineral form, as ammonium nitrogen (NH_4-N). The total N concentration is reported to vary in range of 3-9% N. The high N concentration gives a potential for recovered AS to be used as a replacement for synthetic N fertilizers. Additionally, given the high sulphur content (3-11%), AS is also a valuable source of S[1].

- *What is the underlying working principle?*
  AS is an end-product of (stripping-)scrubbing technology. It can be obtained from scrubbing ammonia (NH_3) rich air from livestock operational units (i.e. stables, drying and composting) or from stripping and scrubbing NH_3 from nitrogen (N) rich waste streams. In the case of air cleaning, the air from animal stables is blown into the system either horizontally (cross-current) or upwards (counter-current), and scrubbed in a scrubbing reactor by means of sulphuric acid (H_2SO_4). The second option is to first strip NH_3 from N rich waste streams, by adjusting pH and/or temperature levels, to achieve NH_3 transfer from liquid to gaseous phase. Once stripped, the NH_3 in gaseous form is transferred to a scrubbing column where it gets scrubbed with H_2SO_4. The most common way of obtaining AS in livestock operations is air scrubbing as it presents a viable economic option to reduce NH_3 emissions from operational units. In certain EU regions, for example Flanders (Belgium), farmers are obliged to reach 70% of NH_3 reduction during the whole year and they accomplish this by using the air scrubber.

- *What is the current and foreseen scale of operations (e.g. kg, tonnes/year)?*
  Currently this product is produced at large number of livestock farms in Flanders by treating air from livestock operational units. On average 1.5 L of H_2SO_4 is applied to remove 1 kg of NH_3 which results in approximately 30 L of AS, depending on the amount of NH_3 to be removed and the amount of NH_3 that can be in scrubbing water before it is saturated[2].

[1] Systemic, 2018. Ammonium sulphate – factsheets. Available from: https://systemicproject.eu/wp-content/uploads/2018/06/Factsheet-product-Ammonium-Sulphate-FINAL-22052018.pdf

[2] Leirs, H., Degroote, T., Bossin, S., Canniere, E., 2017. Een luchtwasser, wat nu? Chemische luchtwassers. Vemis, consortium kennisopbouw luchtemissies veehouderij. Belgium, pp.18.

2 Ammonium stripping / scrubbing and $(NH_4)_2SO_4$ as substitute for synthetic N fertilizers

At Acqua & Sole biogas plant (Italy), around 1 000 tonnes (t) of AS are produced every year (y). The plant estimated to reach a production of 4 000 t/y, when it will operate at full capacity. At Benas (Germany), the production of AS ranges between 1 800 and 14 000 t/y.

- *Why is it innovative when compared to existing (farming) practices?*
  This replacement can be considered innovative since it represents recovery of N and re-use in agriculture. In most of the EU nutrient surplus regions the N from waste streams is currently still being eliminated by aerobic treatment which involves N conversion from waste streams into N_2. The European Commission has recognized this by listing AS as a high priority product with potential to replace synthetic N fertilizers. The current issue in its recognition is the lack of scientific-based knowledge on the product quality and fertilizer performance.

- *How does it improve the Nitrogen-Phosphorus and/or Carbon cycles in agriculture?*
  In most of the EU nutrient surplus regions the nitrogen from waste streams is currently still being eliminated by aerobic treatment which involves N conversion from waste streams into N_2. The loss of N into environment is non-sustainable and recovery of N via (stripping-)scrubbing technology would help in closing N cycle on farm by recovering N and re-using it in the form of AS.

- *Add a separate line on the location of your management solution: "Currently this technology / technique / management solution is applied in ……. (city, region, country))."*
  Currently this management solution is applied in several farms and biogas plants across Europe including Belgium, the Netherlands, Italy, Germany.

2 Ammonium stripping / scrubbing and $(NH_4)_2SO_4$ as substitute for synthetic N fertilizers

TRL (Technology Readiness Level) – how close is your solution to the market?

Use the slider above to position the current TRL* of your proposed solution

* TRLs are a type of measurement system used to assess the maturity level of a particular technology. Where a topic description refers to a TRL, the following definitions apply, unless otherwise specified:

• TRL 1 – basic principles observed • TRL 2 – technology concept formulated • TRL 3 – experimental proof of concept • TRL 4 – technology validated in lab • TRL 5 – technology validated in relevant environment (industrially relevant environment in the case of key enabling technologies) • TRL 6 – technology demonstrated in relevant environment (industrially relevant environment in the case of key enabling technologies) • TRL 7 – system prototype demonstration in operational environment • TRL 8 – system complete and qualified • TRL 9 – actual system proven & running in operational environment

Please provide some sentences explaining your Technology Readiness Level

Stripping and scrubbing installations operating at farm/full scale level.

If the proposed solution/ technique is currently at low TRL (≤5), is upscaling foreseen within the next year(s)?

If the proposed solution/ technique is currently at high TRL (≥7), is there any product already being produced from the proposed solution/ technique?

- *If yes, what is the name of the product:*
  Ammonium sulphate

- *Short description of the product*
  Ammonium sulphate is a liquid end-product that can contain 3-9% of total N completely present in mineral form. The product does not contain P or C and as such has some similar traits as synthetic N fertilizers.

- *Are there any EC/MS Authority permits already for use of the product (title or link if available)?*
  YES, MS authority permit in Flanders, but not on European level.

2 Ammonium stripping / scrubbing and $(NH_4)_2SO_4$ as substitute for synthetic N fertilizers

POTENTIAL LINKAGE TO THE PROJECT

Indicate to which agro-typology under study and which potential research line of the project, your proposed solution/technique contributes:

	Pig Production
	Poultry Production
	Cattle Farming
	Open field cultivation of cereals or maize
	Open air cultivation of vegetables
	Orchards
X	Agro-energy systems (e.g. biogas)
X	Animal Byproduct processing (e.g. manure processing)

Innovative solutions for optimized nutrient & GHG in animal husbandry	X
Innovative soil, fertilisation & crop management systems & practices	
Tools, techniques & systems for higher-precision fertilization	
Biobased fertilisers (N, P) and soil enhancers (OC) from agro-residues	X
Novel animal feeds produced from agro-residues	
Other, please specify :	

3 Mineral concentrate from reverse osmosis

AIM OF THE TECHNOLOGY

Reverse osmosis installation (source: VCM).

Provide a brief description of the proposed management solution or technique.

- *What is the purpose/aim of the innovative solution/technique?*
  The aim of reverse osmosis (RO) is to produce a mineral concentrate rich in nitrogen (N) and potassium (K) from digestate or manure. The concentrations of total nitrogen and potassium in mineral centrate are about 7 g/kg each. Most of N is present in the form of NH_4-N (about 90% of total N). Compared to pig slurry, the ratio NH_4-N/N_{total} increases from 66% to 90%. Furthermore, the product contains around 13 g/kg of organic matter. The permeate water removed by reverse osmosis has low concentrations of nutrients and can be discharged[1].

- *What is the underlying working principle?*
  Membrane separation is one promising candidate for producing nutrient-rich fertilizing products from animal slurry and digestate, in which RO stands out as an efficient separation and concentration technique at macro and micro levels[2-3] RO applicability is limited by conductivity, organics, and scaling inorganic elements[4]. Thus, pretreatments like physical separation and low pressure membrane filtration are needed to reduce fouling/ scaling and improve RO performance. Coagulants and flocculants are often added to favor particles removal. A first solid-liquid separation is achieved by means of a decanter centrifuge, auger press or belt press. The resulting liquid fraction is further processed to remove bigger particles and reduce membrane fouling. For this purpose, systems like dissolved air flotation, ultrafiltration, nanofiltration, and paper filters are used. Finally, the resulting liquid fraction is pushed under pressure through semipermeable membranes (RO), producing a nitrogen and potassium rich concentrate (NK-concentrate) and permeate water. Before discharge, the permeate may require additional treatment such as ion exchange. Multiple RO steps are often used. Mineral

[1] Systemic, 2018. Mineral concentrate – factsheets. Available from: https://systemicproject.eu/wp-content/uploads/2018/06/Factsheet-product-Mineral-Concentrate-FINAL-22052018.pdf
[2] Lebuf, V., et al. Nutrient recovery from digestates: techniques and end-products. in 4th International symposium on Energy from Biomass and Waste. 2012.
[3] Ledda, C., et al., Nitrogen and water recovery from animal slurries by a new integrated ultrafiltration, reverse osmosis and cold stripping process: a case study. Water research, 2013. 47(16): p. 6157-6166.
[4] Masse, L., et al., Fouling of reverse osmosis membranes processing swine wastewater pretreated by mechanical separation and aerobic biofiltration. Separation Science and Technology, 2014. 49(9): p. 1298-1308.

concentrate has also proven to be a suitable substrate for ammonia (stripping-)scrubbing technology to produce ammonium sulphate and a K-rich fertilizer solution.

- *What is the current and foreseen scale of operations (e.g. kg, tonnes/year)?*
  The biogas plant of Am Power (Belgium) produces 60 000 tonnes per year of mineral concentrate.

- *Why is it innovative when compared to existing (farming) practices?*
  The mineral concentrate obtained from RO process can be seen as nitrogen-potassium fertilizers. The average variations depend on the composition of the influent (manure slurry) and on the pretreatment technique. It was reported that the Nitrogen Fertiliser Replacement Value (NFRV) of injected mineral concentrate was similar to that of injected liquid ammonium nitrate and 72-84% compared to that of calcium ammonium nitrate[5]. NK-concentrate from RO process also priority in terms of lower transportation cost by reduced volume.

- *How does it improve the Nitrogen-Phosphorus and/or Carbon cycles in agriculture?*
  In most of the EU nutrient surplus regions carbon (C) and N from waste streams are currently still being eliminated by aerobic treatment. RO represents an interesting alternative for the recovery and reuse in agriculture of both C and N in the form of organic matter and NH_4-N.

- *Add a separate line on the location of your management solution: "Currently this technology / technique / management solution is applied in ……. (city, region, country))."*
  Currently this management solution is applied at the biogas plant of Am Power, located in Pittem, Belgium.

[5] Velthof, G.L., Mineral concentrate from processed manure as fertiliser. 2015, Alterra, Wageningen-UR.

3 Mineral concentrate from reverse osmosis

TRL (Technology Readiness Level) – how close is your solution to the market?

Use the slider above to position the current TRL* of your proposed solution

* TRLs are a type of measurement system used to assess the maturity level of a particular technology. Where a topic description refers to a TRL, the following definitions apply, unless otherwise specified:

• TRL 1 – basic principles observed • TRL 2 – technology concept formulated • TRL 3 – experimental proof of concept • TRL 4 – technology validated in lab • TRL 5 – technology validated in relevant environment (industrially relevant environment in the case of key enabling technologies) • TRL 6 – technology demonstrated in relevant environment (industrially relevant environment in the case of key enabling technologies) • TRL 7 – system prototype demonstration in operational environment • TRL 8 – system complete and qualified • TRL 9 – actual system proven & running in operational environment

Please provide some sentences explaining your Technology Readiness Level

Reverse Osmosis is mostly used in wastewater treatment and small demonstration scale in agricultural systems

If the proposed solution/ technique is currently at low TRL (≤5), is upscaling foreseen within the next year(s)?

YES.

If the proposed solution/ technique is currently at high TRL (≥7), is there any product already being produced from the proposed solution/ technique?

- *If yes, what is the name of the product:*
- *Short description of the product:*
- *Are there any EC/MS Authority permits already for use of the product (title or link if available)?*

3 Mineral concentrate from reverse osmosis

POTENTIAL LINKAGE TO THE PROJECT

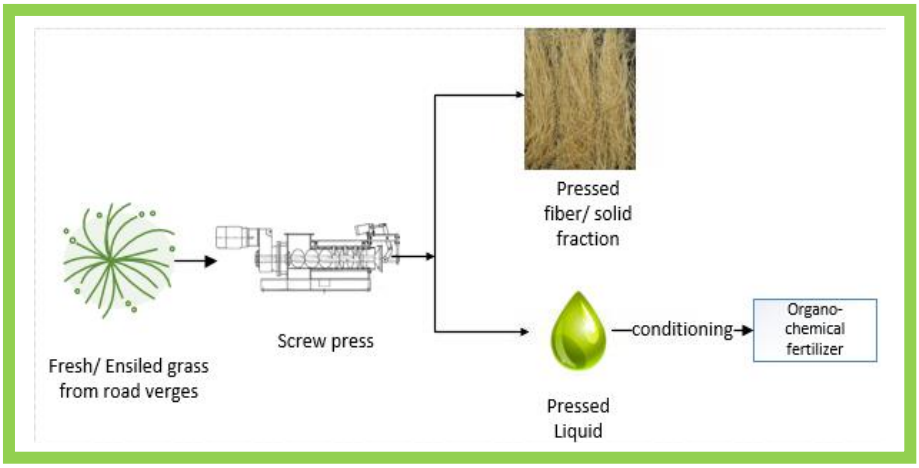
Indicate to which agro-typology under study and which potential research line of the project, your proposed solution/technique contributes:

	Pig Production
	Poultry Production
	Cattle Farming
	Open field cultivation of cereals or maize
	Open air cultivation of vegetables
	Orchards
X	Agro-energy systems (e.g. biogas)
X	Animal Byproduct processing (e.g. manure processing)

Innovative solutions for optimized nutrient & GHG in animal husbandry	
Innovative soil, fertilisation & crop management systems & practices	
Tools, techniques & systems for higher-precision fertilization	
Biobased fertilisers (N, P) and soil enhancers (OC) from agro-residues	X
Novel animal feeds produced from agro-residues	
Other, please specify :	

4 Liquid fraction of pressed grass from roadside clippings as a substitute for mineral fertilizer- GRASSIFICATION

AIM OF THE TECHNOLOGY



Provide a brief description of the proposed management solution or technique.

- *What is the purpose/aim of the innovative solution/technique?*
  The GRASSIFICATION project aims at analysing different value chains for roadside grass clippings to identify the ideal pathways and help to develop a more bio-based and circular economy. One of the value chains being evaluated under GRASSIFICATION is the use of the liquid fraction from road side clippings for the production of bio-based fertilizers. The liquid fraction of grass is a nutrient-rich juice containing proteins, minerals, lactic and amino acids[1] and can potentially be used as a fertilizer, either in pure form or further conditioned into a product.

- *What is the underlying working principle?*
  The processing of grass is carried out in two steps, namely primary and secondary processing. Primary processing involves the use of a high-volume screw press to isolate the juice from the fiber, and secondary processing is done to further refine the fiber and extract the residual juice. The liquid fractions may subsequently be utilised for fertilizer production.

- *What is the current and foreseen scale of operations (e.g. kg, tonnes/year)?*
  The technology is still being tested in laboratory scale; therefore, there are no current large-scale operations and the possibility of up-scaling will depend on the results obtained in the lab-scale experiments.

- *Why is it innovative when compared to existing (farming) practices?*
  Roadside grass is currently considered as a waste product. With growing emphasis on circular economy to include recycled and organic materials[2], press liquids from roadside grass, either in pure form or as a refined product, can be used as a possible substitute for mineral fertilizers. Also, with the Nitrates Directive[3] limiting the use of bio-based fertilizers from manure, the liquid fraction of grass may potentially be seen as a suitable alternative.

[1] Mandl, M (2010). Status of green biorefining in Europe. Biofuels, Bioprod. Bioref. 4:268–274
[2] European Union (2018). Regulation laying down rules on the making available on the market of EU fertilizing products and amending regulations (EC) No 1069/2009 and (EC) No 1107/2009
[3] European Commission (2018). Report on the implementation of Council Directive 91/676/EEC concerning the protection of waters against pollution caused by nitrates from agricultural sources based on Member reports for the period 2012-2015

4 Liquid fraction of pressed grass from roadside clippings as a substitute for mineral fertilizer- GRASSIFICATION

TRL (Technology Readiness Level) – how close is your solution to the market?

* TRLs are a type of measurement system used to assess the maturity level of a particular technology. Where a topic description refers to a TRL, the following definitions apply, unless otherwise specified:

• TRL 1 – basic principles observed • TRL 2 – technology concept formulated • TRL 3 – experimental proof of concept • TRL 4 – technology validated in lab • TRL 5 – technology validated in relevant environment (industrially relevant environment in the case of key enabling technologies) • TRL 6 – technology demonstrated in relevant environment (industrially relevant environment in the case of key enabling technologies) • TRL 7 – system prototype demonstration in operational environment • TRL 8 – system complete and qualified • TRL 9 – actual system proven & running in operational environment

Please provide some sentences explaining your Technology Readiness Level

The readiness of this technology is still in the nascent stages. There are a few pilot scale biorefineries[4] in Europe which focus on valorising grass, but the use of the liquid fraction is currently limited to the production of amino acid mixtures, feed grade proteins and lysine. The GRASSIFICATION project therefore will perform a feasibility assessment for the use of the liquid fraction of grass in fertilizer production.

If the proposed solution/ technique is currently at low TRL (≤5), is upscaling foreseen within the next year(s)?

Yes, if the current tests yield positive results.

If the proposed solution/ technique is currently at high TRL (≥7), is there any product already being produced from the proposed solution/ technique?

- *If yes, what is the name of the product:*
- *Short description of the product*
- *Are there any EC/MS Authority permits already for use of the product (title or link if available)?*

[4] Shekhar Sharma, H.S., Mandl, M (2014) Green Biorefinery, Sustainable Bioenergy Production-chapter 25

4 Liquid fraction of pressed grass from roadside clippings as a substitute for mineral fertilizer- GRASSIFICATION

POTENTIAL LINKAGE TO THE PROJECT

Indicate to which agro-typology under study and which potential research line of the project, your proposed solution/technique contributes:

	Pig Production
	Poultry Production
	Cattle Farming
X	Open field cultivation of cereals or maize
X	Open air cultivation of vegetables
X	Orchards
	Agro-energy systems (e.g. biogas)
	Animal Byproduct processing (e.g. manure processing)

Innovative solutions for optimized nutrient & GHG in animal husbandry	
Innovative soil, fertilisation & crop management systems & practices	X
Tools, techniques & systems for higher-precision fertilization	
Biobased fertilisers (N, P) and soil enhancers (OC) from agro-residues	X
Novel animal feeds produced from agro-residues	
Other, please specify :	

5 Biochar production from pig manure

AIM OF THE TECHNOLOGY

Provide a brief description of the proposed management solution or technique.

- *What is the purpose/aim of the innovative solution/technique ?*
  The purpose of this technique is to recover value from waste streams (solid fraction of pig manure) and upcycle the nutrients into biochar. Biochar contains high levels of nitrogen, phosphorous, magnesium and potassium in addition to its water retention properties, carbon fixation, high mineral composition, and porous structure that supports soil microorganisms. It is easily managed and can be transported to nutrient deficient farm lands to be used as a soil amendment. Because biochar is more stable and dryer then the raw material, its decomposition is slower.

- *What is the underlying working principle ?*
  Liquid pig slurry (approx. 8% dry matter) is passed through a solid-liquid separation process, usually using a screw press. The resulting solid fraction has a dry matter content of approx. 30%. Slurry separation results in approx. 20% solid fraction ('manure cake') and 80% liquid fraction by weight. The solid manure cake is further dried from approx. 30% dry matter to 75% dry matter in an indirectly heated drier[1].
  The solid fraction is pyrolyzed for 10 to 30 minutes under low oxygen conditions in a pyrolysis reactor, at a temperature range of 250 - 550˚C, producing a solid, grainy-powdery material, called biochar with approx. 95 % dry matter and a combustible syngas[1].

- *What is the current and foreseen scale of operations (e.g. kg, tonnes/year) ?*
  There is a paucity of data on the current scale of operations of this technology.
  This primarily because under the European regulations, biochar is considered as a by-product of the energy industry and, as such, is classified as a waste. For this reason, it is subjected to the European Directive on Waste[2] which limits its possible agricultural use[3].

[1] Gollenbeek Luuk, Ehlert Phillip, de Buisonjé Fridtjof (2018). Perspectives of Ecochar in Europe: Uses and regulatory requirements. Wageningen Livestock Research.
[2] EU. 2008. Council Directive 2008/98/EC of 19 November 2008 on waste and repealing certain Directives. Off. J. Eur. Communities. L312:3. http://eur-lex.europa.eu/legal-content/EN/ALL/?uri=CELEX:32008L0098 (accessed 2 May 2015).
[3] Conte Pellegrino, Schmidt Hans-Peter, Cimò Giulia (2015). Research and Application of Biochar in Europe. In: Agricultural and Environmental Applications of Biochar: Advances and Barriers. SSSA Special Publication 63. M. Guo, Z. He, and M. Uchimiya, editors

5 Biochar production from pig manure

- *Why is it innovative when compared to existing (farming) practices ?*
  Pig slurry is produced in massive quantities – more than 930 million cubic metres in the EU alone in 200[4]. Traditionally, farmers disposed of this mix of urine, faeces and waste water by simply spreading it on the ground as fertiliser. But an increase in intensive farms has left farmers with more manure than they can handle. As a result, most farms move waste to a treatment plant, where volume is reduced. But transportation is not cheap (it accounts for 60% of processing costs), and the treatment process is cumbersome[4].
  Furthermore, the storage of pig manure has an impact on the quality of air, groundwater and surface water. Manure also results in the release of NH_3, N_2O and volatile organic compounds and has an odour nuisance[5]. Environmental restrictions also limit the direct use of pig manure for agriculture due to the high P and heavy metal contents.
  Therefore, pyrolysis of dried pig manure can be considered as an economically viable approach for converting this agricultural waste into value added products in regions with large manure excesses and related problems.

- *How does it improve the Nitrogen-Phosphorus and/or Carbon cycles in agriculture ?*
  The organic carbon present in biochar is recalcitrant meaning that it is subjected to a very slow biological degradation and can thus serve as a stable carbon source for soil microorganisms. The recalcitrance of carbon in biochar is acknowledged by some as a form of carbon sequestration (CO_2 storage).
  The production temperature of biochar is a critical factor for determining its nutrient content as a certain fraction of elements in the feedstock can be excessively lost by volatilization[6] Nonetheless, manure-based biochar has been shown to have high levels of nitrogen, phosphorous and potassium compared to plant-based biochar[7]. Thus, pig manure biochar can be used as a slow release fertilizer with high concentration of N, K and P and has beneficial effects as a carbon sequesterer and improver of soil quality and crop productivity.

- *Add a separate line on the location of your management solution: "Currently this technology / technique / management solution is applied in ……. (city, region, country))."*
  This technology is not yet applied on a significant scale due to legislation limitations.

[4] Making the most of pig manure (2014). https://ec.europa.eu/programmes/horizon2020/en/news/making-most-pig-manure
[5] EEA (European Environment Agency). (2009). Part B: sectoral guidance chapters, 4b. Manure management EMEP/EEA air pollutant emission inventory guidebook, EEA
[6] Peiris Chathuri, Gunatilake R. Sameera. Wewalwela J. Jayani, Vithanage Meththika (2018) Biochar for Sustainable Agriculture: Nutrient Dynamics, Soil Enzymes, and Crop Growth In: Biochar from biomass and waste: fundamentals and applications, Y.S. Ok, D. Tsang, N. Bolan, J.M. Novak, editors.
[7] Maggen Jens, Carleer Robert, Yperman Jan, De Vocht Alain, Schreurs Sonja, Reggers Guy, Thijsen Elsy (2017). Biochar Derived from the Dry, Solid Fraction of Pig Manure as Potential Fertilizer for Poor and Contaminated Soils. Sustainable Agriculture Research; Vol. 6, No. 2

5 Biochar production from pig manure

TRL (Technology Readiness Level) – how close is your solution to the market?

Use the slider above to position the current TRL* of your proposed solution

* TRLs are a type of measurement system used to assess the maturity level of a particular technology. Where a topic description refers to a TRL, the following definitions apply, unless otherwise specified:

• TRL 1 – basic principles observed • TRL 2 – technology concept formulated • TRL 3 – experimental proof of concept • TRL 4 – technology validated in lab • TRL 5 – technology validated in relevant environment (industrially relevant environment in the case of key enabling technologies) • TRL 6 – technology demonstrated in relevant environment (industrially relevant environment in the case of key enabling technologies) • TRL 7 – system prototype demonstration in operational environment • TRL 8 – system complete and qualified • TRL 9 – actual system proven & running in operational environment

Please provide some sentences explaining your Technology Readiness Level

The readiness of the technology is limited by legislation. Regulations regarding biochar at the European level are not yet implemented, but proposals are currently developed and expected to be implemented in 2-3 years. National regulations are in force in Germany, Austria, Switzerland and Italy, and limited to biochars from vegetable origin only[1].

If the proposed solution/ technique is currently at low TRL (≤5), is upscaling foreseen within the next year(s)?

If the proposed solution/ technique is currently at high TRL (≥7), is there any product already being produced from the proposed solution/ technique?

- *If yes, what is the name of the product :*
  Biochar.

- *Short description of the product*
  Biochar is a solid, carbon-rich material obtained from the thermochemical decomposition of biomass (pig manure) in an oxygen-limited environment.

- *Are there any EC/MS Authority permits already for use of the product (title or link if available)?*
  NO

5 Biochar production from pig manure

POTENTIAL LINKAGE TO THE PROJECT

Indicate to which agro-typology under study and which potential research line of the project, your proposed solution/technique contributes :

X	Pig Production
	Poultry Production
	Cattle Farming
X	Open field cultivation of cereals or maize
X	Open air cultivation of vegetables
X	Orchards
X	Agro-energy systems (e.g. biogas)
X	Animal Byproduct processing (e.g. manure processing)

Innovative solutions for optimized nutrient & GHG in animal husbandry	X
Innovative soil, fertilisation & crop management systems & practices	X
Tools, techniques & systems for higher-precision fertilization	X
Biobased fertilisers (N, P) and soil enhancers (OC) from agro-residues	X
Novel animal feeds produced from agro-residues	
Other, please specify :	

6 Concentrate from vacuum evaporation/ stripping as nutrient-rich organic fertilizer

AIM OF THE TECHNOLOGY

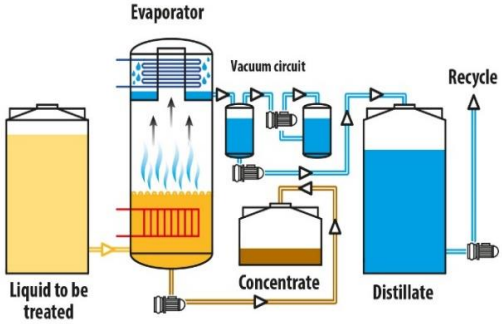


Fig.1 a common unit of vacuum evaporation process (source: www.pf10.it)

Provide a brief description of the proposed management solution or technique.

- *What is the purpose/aim of the innovative solution/technique?*
  The purpose of vacuum evaporation is to optimize nutrient recovery from waste stream and produce organic fertilizer with high content of nutrients in small volume.

- *What is the underlying working principle?*
  Vacuum evaporation consists in the boiling of a liquid substrate at negative pressure, at a temperature lower than typical boiling temperature at atmospheric conditions. Figure 1 shows a common unit of vacuum evaporation process, consisting of an input tank and an evaporator followed by a vacuum circuit. It transforms waste effluent into highly concentrated substances and yields a high quality distillate that can be recycled or used as discharge water. The functioning of the system can be automatic and managed by a programmable logic controller.

- *What is the current and foreseen scale of operations (e.g. kg, tonnes/year)?*
  Vacuum evaporation is currently applied in various industrial and agro-industrial domains but it is still on trial for livestock effluents[1].

- *Why is it innovative when compared to existing (farming) practices?*
  Vacuum evaporation is one of the most competitive and efficient techniques for treating aqueous effluents when conventional techniques are not effective or feasible. Since the boiling temperature of the liquid effluent is lower, this technique saves energy and improves efficiency. Moreover, as it occurs in a closed system, the exhaust gases can be easily treated, and the low treatment temperatures reduce the emission of volatile compounds.

- *How does it improve the Nitrogen-Phosphorus and/or Carbon cycles in agriculture?*
  Waste streams, like manure and digestate, can be processed through vacuum evaporation in order to obtain a final product with a high nutrient concentration and a reduced volume, standing

[1] Guercini, S., Castelli, G., & Rumor, C. (2014). Vacuum evaporation treatment of digestate: Full exploitation of cogeneration heat to process the whole digestate production. Water Science and Technology, 70(3), 479-485.

6 Concentrate from vacuum evaporation/ stripping as nutrient-rich organic fertilizer

out as a good fertilizer in terms of easier transportation, lower management costs as well as higher content of nutrient and organic matter[2].

- *Add a separate line on the location of your management solution: "Currently this technology / technique / management solution is applied in ……. (city, region, country))."*
  This technology is derived from other sectors and is mainly dedicated to the recovery of chemicals from industrial by-products, while it has not been widely implemented in the field of agricultural waste processing.

TRL (Technology Readiness Level) – how close is your solution to the market?

Use the slider above to position the current TRL* of your proposed solution

* TRLs are a type of measurement system used to assess the maturity level of a particular technology. Where a topic description refers to a TRL, the following definitions apply, unless otherwise specified:

• TRL 1 – basic principles observed • TRL 2 – technology concept formulated • TRL 3 – experimental proof of concept • TRL 4 – technology validated in lab • TRL 5 – technology validated in relevant environment (industrially relevant environment in the case of key enabling technologies) • TRL 6 – technology demonstrated in relevant environment (industrially relevant environment in the case of key enabling technologies) • TRL 7 – system prototype demonstration in operational environment • TRL 8 – system complete and qualified • TRL 9 – actual system proven & running in operational environment

Please provide some sentences explaining your Technology Readiness Level

Vacuum concentration process has been applied in lab and industrially relevant environment, but rare in actual practice in manure processing due to the relatively high operation expense and complicated characteristics of manure.

If the proposed solution/ technique is currently at low TRL (≤5), is upscaling foreseen within the next year(s)?

YES.

If the proposed solution/ technique is currently at high TRL (≥7), is there any product already being produced from the proposed solution/ technique?

- *If yes, what is the name of the product:*
- *Short description of the product*
- *Are there any EC/MS Authority permits already for use of the product (title or link if available)?*

[2] Chiumenti, A., Da Borso, F., Chiumenti, R., Teri, F., & Segantin, P. (2013). Treatment of digestate from a co-digestion biogas plant by means of vacuum evaporation: tests for process optimization and environmental sustainability. Waste management, 33(6), 1339-1344.

6 Concentrate from vacuum evaporation/ stripping as nutrient-rich organic fertilizer

POTENTIAL LINKAGE TO THE PROJECT

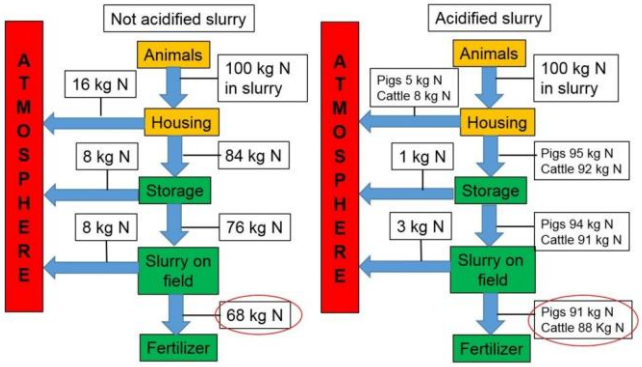
Indicate to which agro-typology under study and which potential research line of the project, your proposed solution/technique contributes:

	Pig Production
	Poultry Production
	Cattle Farming
	Open field cultivation of cereals or maize
	Open air cultivation of vegetables
	Orchards
	Agro-energy systems (e.g. biogas)
X	Animal Byproduct processing (e.g. manure processing)

Innovative solutions for optimized nutrient & GHG in animal husbandry	
Innovative soil, fertilisation & crop management systems & practices	
Tools, techniques & systems for higher-precision fertilization	
Biobased fertilisers (N, P) and soil enhancers (OC) from agro-residues	X
Novel animal feeds produced from agro-residues	
Other, please specify :	

7 Acidification as a tool to reduce ammonia emission from manure (storage)

AIM OF THE TECHNOLOGY



Acidification reduced ammonia emission from slurry storage (Source: JH Agro)

Provide a brief description of the proposed management solution or technique.

- *What is the purpose/aim of the innovative solution/technique?*
  Emissions of NH_3 from livestock housing and slurry storage represent up to 80% of the total NH_3 emissions from agricultural activities[1].The aim of acidification is to reduce the NH_3 emissions from waste streams and also their global warming potential (GWP).

- *What is the underlying working principle?*
  Ammonium (NH_4^+) and ammonia (NH_3) are two common forms of nitrogen existing in waste streams, which are in dynamic equilibrium at different pH and temperature conditions. Acidification is a simple way to avoid NH_3 emissions by minimizing the concentration of NH_3 relative to NH_4^+ under lower pH, which can be adjusted with natural or chemical additives. By lowering the slurry pH to 5.5, the ratio NH_4^+/NH_3 is strongly modified, with about 98.00-99.98% going towards NH_4^+ form[2].

- *What is the current and foreseen scale of operations (e.g. kg, tonnes/year)?*
  In Denmark, 20% of annually produced manure was acidified, over 75% of this as an alternative to soil injection of manure on grasses and autumn crops[3]. Application in many other countries is on-going and foreseen.

- *Why is it innovative when compared to existing (farming) practices?*
  During and after slurry application to soil, more than 50% of the applied N can be lost by NH_3 emissions[4], which strongly reduces the fertilizer values of slurry while negatively impact the environment and humans and animal welfare. Acidification is a simple way to avoid NH_3 emissions in manure/slurry processing and field application. Moreover, acidification has been

[1] Anderson, N., Strader, R., Davidson, C., 2003. Airborne reduced nitrogen: ammonia emissions from agriculture and other sources. Environ. Int. 29, 277e286.
[2] Fangueiro, D., Hjorth, M., Gioelli, F., 2015a. Acidification of animal slurry e a review. J. Environ. Manage. 149, 46-56.
[3] Joubin, M. Animal slurry acidification: effects of slurry characteristics, use of different acids, slurry pH buffering. RISE (Research Institutes of Sweden) report, 2018.
[4] Sommer, S.G., Genermont, S., Cellier, P., Hutchings, N.J., Olesen, J.E., Morvan, T., 2003. Processes controlling ammonia emission from livestock slurry in the field. Eur. J. Agron. 19, 465-486.

proved to improve the N availability by increasing the mineralization of organic N during field application[5,6,7].

- *How does it improve the Nitrogen-Phosphorus and/or Carbon cycles in agriculture?*
  In agricultural processing, acidification is mainly applied in three management steps: in-house acidification (long term), storage tank acidification (short or long term) and acidification at field application (short term). Combined with other techniques such as membrane filtration or stripping and scrubbing, acidification can help to achieve a better recovery of nitrogen and thus produce fertilizers like mineral concentrate and ammonium sulphate. Sulphuric acid (H_2SO_4) is commonly used for acidification due to economic reasons, and during the processing, extra S is added, which benefit the fertilizer value of the final product.

- *Add a separate line on the location of your management solution: "Currently this technology / technique / management solution is applied in ……. (city, region, country)).”*
  Currently Denmark is leading the way in application of this solution to minimize nitrogen losses from livestock production.

[5] Fangueiro, D., Ribeiro, H., Coutinho, J., Cardenas, L., Trindade, H., Cunha-Queda, C., Vasconcelos, E., Cabral, F., 2010. Nitrogen mineralization and CO2 and N2O emissions in a sandy soil amended with original or acidified pig slurries or with the relative fractions. Biol. Fert. Soil 46 (4), 383-391.
[6] Fangueiro, D., Pereira, J., Bichana, A., Surgy, S., Cabral, F., & Coutinho, J. 2015b. Effects of cattle-slurry treatment by acidification and separation on nitrogen dynamics and global warming potential after surface application to an acidic soil. Journal of environmental management, 162, 1-8.
[7] Kai, P., Pedersen, P., Jensen, J.E., Hansen, M.N., Sommer, S.G., 2008. A whole-farm assessment of the efficacy of slurry acidification in reducing ammonia emissions. Eur. J. Agron. 28, 148-154.

7 Acidification as a tool to reduce ammonia emission from manure (storage)

TRL (Technology Readiness Level) – how close is your solution to the market?

Use the slider above to position the current TRL* of your proposed solution

* TRLs are a type of measurement system used to assess the maturity level of a particular technology. Where a topic description refers to a TRL, the following definitions apply, unless otherwise specified:

• TRL 1 – basic principles observed • TRL 2 – technology concept formulated • TRL 3 – experimental proof of concept • TRL 4 – technology validated in lab • TRL 5 – technology validated in relevant environment (industrially relevant environment in the case of key enabling technologies) • TRL 6 – technology demonstrated in relevant environment (industrially relevant environment in the case of key enabling technologies) • TRL 7 – system prototype demonstration in operational environment • TRL 8 – system complete and qualified • TRL 9 – actual system proven & running in operational environment

Please provide some sentences explaining your Technology Readiness Level

Acidification has been proved to significantly reduce ammonia emission and applied in manure processing plants to produce N-rich fertilizer.

If the proposed solution/ technique is currently at low TRL (≤5), is upscaling foreseen within the next year(s)?

If the proposed solution/ technique is currently at high TRL (≥7), is there any product already being produced from the proposed solution/ technique?

- *If yes, what is the name of the product:*
  Ammonium Sulphate, Ammonium Nitrate or ammonium water.

- *Short description of the product*
  The characteristics of acidification product depend on many parameters, such as slurry composition, acidification process or acid used, as well as the technique for recovery.

- *Are there any EC/MS Authority permits already for use of the product (title or link if available)?*
  YES.
  Title 1: VERA Verification Statement for manure acidification JH Forsuring NH_4^+
  http://www.vera-verification.eu/fileadmin/download/VERA_Statements/VERA-Statement006_JH-Forsuring-NH4.pdf
  Title 2: VERA Verification Statement for Manure application SyreN
  http://www.vera-verification.eu/fileadmin/download/VERA_Statements/VERA-Statement001_SyreN.pdf

7 Acidification as a tool to reduce ammonia emission from manure (storage)

POTENTIAL LINKAGE TO THE PROJECT

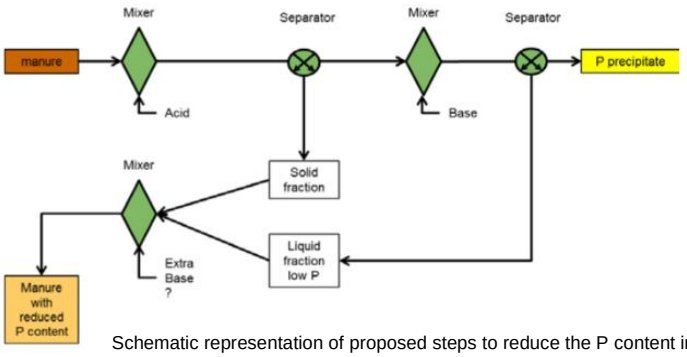
Indicate to which agro-typology under study and which potential research line of the project, your proposed solution/technique contributes:

	Pig Production
	Poultry Production
	Cattle Farming
	Open field cultivation of cereals or maize
	Open air cultivation of vegetables
	Orchards
	Agro-energy systems (e.g. biogas)
X	Animal Byproduct processing (e.g. manure processing)

Innovative solutions for optimized nutrient & GHG in animal husbandry	X
Innovative soil, fertilisation & crop management systems & practices	
Tools, techniques & systems for higher-precision fertilization	
Biobased fertilisers (N, P) and soil enhancers (OC) from agro-residues	X
Novel animal feeds produced from agro-residues	
Other, please specify :	

8 Acid leaching of P from organic agro-residues in order to produce OM-rich soil enhancers and P-fertilizers

AIM OF THE TECHNOLOGY



Schematic representation of proposed steps to reduce the P content in pig slurry by treatment of the pig slurry as a whole (Schoumans et al., 2014)

Provide a brief description of the proposed management solution or technique.

- *What is the purpose/aim of the innovative solution/technique?*
  The aim of this solution is to decouple C and P from waste streams and recover P as fertilizer while produce soil amendment which is poor in plant available-P but rich in organic matter (C).

- *What is the underlying working principle?*
  By lowering pH in waste streams, acidification can modify characteristics like composition, particle size and nutrient distribution between particles, thus increases separation efficiency[1] of manure or digestate. Moreover, it tends to increase the soluble P, which might be due to the solubilisation of compounds such as Ca and Mg carbonates, phosphates, or hydroxides, and their transfer to the liquid phase at low pH[2]. The acidified slurry thus has higher concentrations of plant available P compared to untreated slurry, with positive impacts on its fertilizer value, and potential for P recovery as high-purity struvite, Ca/Mg–P precipitates, or a concentrated P-solution[3]. This is interesting for potential decoupling of P from C in manure and digestate where most P is associated to particles and only about 20% of total P is soluble[4].

- *What is the current and foreseen scale of operations (e.g. kg, tonnes/year)?*
  Currently a pilot test is on-going in the Netherlands and up-scale application is foreseen in the near future due to the stricter limits for phosphate application in agricultural land.

- *Why is it innovative when compared to existing (farming) practices?*
  The P/C decoupling has been reported in studies by Dutch researchers where P recovery and production of P poor solid fraction from animal manure is currently being tested only on pilot

[1] Hjorth, M., Cocolo, G., Jonassen, K., Abildgaard, L., & Sommer, S. G. 2015. Continuous in-house acidification affecting animal slurry composition. Biosystems Engineering, 132, 56-620.
[2] Fangueiro D, Ribeiro H, Vasconcelos E, Coutinho J, Cabral F. 2009. Treatment by acidification followed by solid–liquid separation affects slurry and slurry fractions composition and their potential of N mineralization. Bioresource Technol. 100:4914–4917.
[3] Vaneeckhaute, C., Zeleke, A. T., Tack, F. M., & Meers, E. 2017. Comparative evaluation of pre-treatment methods to enhance phosphorus release from digestate. Waste and Biomass Valorization, 8(3), 659-667.
[4] Masse, L., Masse, D. I., Beaudette, V., & Muir, M. 2005. Size distribution and composition of particles in raw and anaerobically digested swine manure. Transactions of the ASAE, 48(5), 1943-1949.

scale. This technique can be considered innovative as it gives potential to nutrient surplus regions to use C in their region and only export P, if needed. As such it can contribute in closing local C cycle and regional P cycle.

- *How does it improve the Nitrogen-Phosphorus and/or Carbon cycles in agriculture?*
  In nutrient surplus regions, animal manure and digestate are often mechanically separated. The mechanical separation of livestock manure and digestate results in a P-rich solid fraction and a P-poor, NK nutrient-rich liquid fraction. The P-rich solid fraction is usually exported to P-deficient regions due to low P application rates. By exporting P, the valuable organic matter is also exported. In order to keep organic matter in nutrient surplus regions the P concentration in the solid fraction of livestock manure and/or digestate should be reduced. One of the strategies could be to acidify manure or digestate prior to mechanical separation. The pH reduction to c 5.5 would increase the P availability in manure or digestate, resulting after separation in P rich liquid fraction and P poor solid fraction. The solid fraction would still contain valuable C that can be used in nutrient surplus regions. The P in liquid fraction could be precipitated by different base solutions (eg. CaOH, MgOH), allowing P recovery in a solid from.

- *Add a separate line on the location of your management solution: "Currently this technology / technique / management solution is applied in ……. (city, region, country))."*
  At the moment, it is a quite popular technique in Denmark, while being less applied in other European regions.

8 Acid leaching of P from organic agro-residues in order to produce OM-rich soil enhancers and P-fertilizers

TRL (Technology Readiness Level) – how close is your solution to the market?

Use the slider above to position the current TRL* of your proposed solution

* TRLs are a type of measurement system used to assess the maturity level of a particular technology. Where a topic description refers to a TRL, the following definitions apply, unless otherwise specified:

• TRL 1 – basic principles observed • TRL 2 – technology concept formulated • TRL 3 – experimental proof of concept • TRL 4 – technology validated in lab • TRL 5 – technology validated in relevant environment (industrially relevant environment in the case of key enabling technologies) • TRL 6 – technology demonstrated in relevant environment (industrially relevant environment in the case of key enabling technologies) • TRL 7 – system prototype demonstration in operational environment • TRL 8 – system complete and qualified • TRL 9 – actual system proven & running in operational environment

Please provide some sentences explaining your Technology Readiness Level

Pilot scale testing is currently on-going in the Netherlands.

If the proposed solution/ technique is currently at low TRL (≤5), is upscaling foreseen within the next year(s)?

If the proposed solution/ technique is currently at high TRL (≥7), is there any product already being produced from the proposed solution/ technique?

- *If yes, what is the name of the product:*
  Recovered P in solid form and P-poor solid fraction.

- *Short description of the product*
  In the pilot plant in the Netherlands, P from waste stream is recovered as calcium phosphate.

- *Are there any EC/MS Authority permits already for use of the product (title or link if available)?*
  NO.

8 Acid leaching of P from organic agro-residues in order to produce OM-rich soil enhancers and P-fertilizers

POTENTIAL LINKAGE TO THE PROJECT

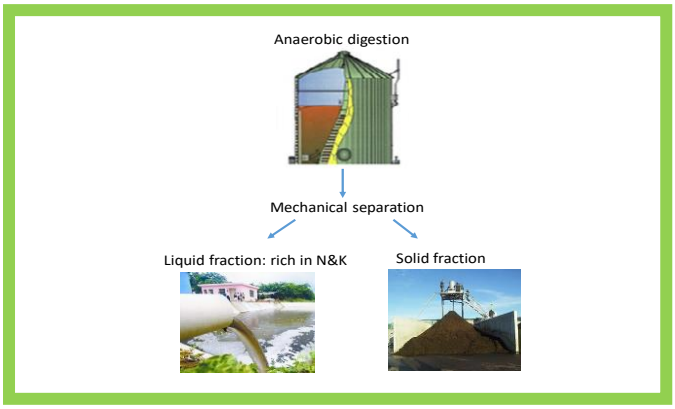
Indicate to which agro-typology under study and which potential research line of the project, your proposed solution/technique contributes:

	Pig Production
	Poultry Production
	Cattle Farming
	Open field cultivation of cereals or maize
	Open air cultivation of vegetables
	Orchards
	Agro-energy systems (e.g. biogas)
X	Animal Byproduct processing (e.g. manure processing)

Innovative solutions for optimized nutrient & GHG in animal husbandry	X
Innovative soil, fertilisation & crop management systems & practices	
Tools, techniques & systems for higher-precision fertilization	
Biobased fertilisers (N, P) and soil enhancers (OC) from agro-residues	X
Novel animal feeds produced from agro-residues	
Other, please specify :	

9 Liquid fraction of digestate as a substitute for mineral N & K fertilizer

AIM OF THE TECHNOLOGY



Provide a brief description of the proposed management solution or technique.

- *What is the purpose/aim of the innovative solution/technique?*
  Solid-Liquid separation is the most frequent first step in digestate processing and is usually carried out on-site to reduce transportation costs for disposal, to free up storage space or for further upgrading (such as nutrient extraction). The phase separation leads to a P-rich solid fraction (SF) and a N and K-rich liquid fraction (LF). The SF contains high phosphorous and organic fractions, which is interesting for soil properties and humus formation. It can be further dried, composted, granulated or directly applied to the field as soil amendment. The LF, with high contents of plant-available N and K, is more suitable as a fertiliser applied via soil mixing (slurry cultivator), mechanical injection, drag hoses or surface dressing.

- *What is the underlying working principle?*
  To mechanically separate the raw digestate into its liquid and solid forms. The most commonly used techniques are the screw-press, the centrifuge (decanter) and the belt filter press.
  Characteristics of LF digestates are variable as they depend on the type(s) of feedstock, the operating parameters used in the digester and the type of solid-liquid separation. Generally, LF digestate is alkaline at pH 7.5-8.5, with 5.0-9.0% DM of total N, in which 40-80% is in the form of NH_4^+ and is directly available for crop uptake[1, 2, 3].

- *What is the current and foreseen scale of operations (e.g. kg, tonnes/year)?*
  For the year 2016, in Flanders alone, the total processing capacity of liquid digestate was reported to be 71,979 tonnes (and 55,782 tonnes of solid digestate)[4].
  In Flanders, in 2017, the quantity of processed input material for separation into SF and LF ranged from 23,500 (low end) to 225,000 tonnes (highest). 31 biogas plants are reported to separate digestate into LF and SF totalling 2,214,000 tonnes of fresh input material in 2017[5].

[1] Akhiar, A., Battimelli, A., Torrijos, M., & Carrere, H. 2017. Comprehensive characterization of the liquid fraction of digestates from full-scale anaerobic co-digestion. *Waste management*, *59*, 118-128.
[2] Guercini, S., Castelli, G., & Rumor, C. 2014. Vacuum evaporation treatment of digestate: full exploitation of cogeneration heat to process the whole digestate production. Water Science and Technology, 70(3), 479-485.
[3] Möller, K., & Müller, T. (2012). Effects of anaerobic digestion on digestate nutrient availability and crop growth: a review. Engineering in Life Sciences, 12(3), 242-257.
[4] Snauwaert, E., & Vannecke, T. (2017). VCM-Enquete. Operationele Stand van Zaken. Mestverwerking in Vlaanderen. https://cdn.digisecure.be/vcm/2018911135026326_20180809-enquete-finaal.pdf
[5] Biogas-E, De Vlaamse Bioagssector in 2017'.

9 Liquid fraction of digestate as a substitute for mineral N & K fertilizer

- *Why is it innovative when compared to existing (farming) practices?*
  In line with a circular economy frame of mind, this solution provides a low-tech and affordable way of recycling the nutrients present in the digestate. Additionally, the dependency of farmers' on imported chemical fertilisers is reduced while their resiliency in the face of fertiliser price volatility is bettered.
  Due to its high water content, the applied LF of digestate in agriculture not only returns nutrients to the field but also reduces water use for irrigation purposes. Moreover, LF digestate can also provide plants with various water-soluble trace metals as well as anomic acids and plant hormones, which puts stock in liquid digestate as an organic fertiliser.
  Field trials of LF digestate as a N-K source have shown similar effects on biomass yields and soil properties as the conventional fertilisation regime which uses animal manure and synthetic N-K fertilisers[6, 7, 8]. However, from a sustainability point of view, the ecological benefits of using LF digestate were considerably higher, indicating that LF digestate might be of interest to substitute mineral fertiliser in P saturated areas.
  Currently the fertiliser potential of LF digestate is not fully evaluated. Up-scaled and long-term investigations are needed to provide recommendation for further implementation.

- *How does it improve the Nitrogen-Phosphorus and/or Carbon cycles in agriculture?*
  The valorisation of the solid and liquid fractions of digestate is a worthwhile contribution to closing the nutrient cycles, as digestate contains most of the macronutrients (N, P, K, Ca, S and Mg) and micronutrients (B, Cl, Mn, Fe, Zn, Cu, Mo and Ni) needed by plants. This solution proposes to recycle and reuse nutrients that are readily available in the local feedstocks and reduce imported volumes of synthetic fertilisers.
  The separated solid fraction of the digestate contains stable carbon compounds (humic precursors), which generally have a higher humus formation capacity than undigested manure. The restitution to soils of quality organic matter compounds is of key importance for soil health, soil conservation, biological activity and soil structure. The SF also contains phosphorous, a non-renewable resource of which rock reserves are declining and of which Europe has only very limited resources (the European Commission has added P to the list of 20 Critical Raw Materials). The separated liquid fraction, which contains most of the N and K present in the digested feedstock, can serve as a partial or complete substitute to chemical fertilisers, whose production is heavily dependent on the use of fossil fuels.

- *Add a separate line on the location of your management solution: "Currently this technology / technique / management solution is applied in ……. (city, region, country))."*

[6] Sigurnjak, I., Michels, E., Crappé, S., Buysens, S., Tack, F. M., & Meers, E. 2016. Utilization of derivatives from nutrient recovery processes as alternatives for fossil-based mineral fertilizers in commercial greenhouse production of Lactuca sativa L. Scientia horticulturae, 198, 267-276.
[7] Sigurnjak, I., Vaneeckhaute, C., Michels, E., Ryckaert, B., Ghekiere, G., Tack, F. M. G., & Meers, E. 2017. Fertilizer performance of liquid fraction of digestate as synthetic nitrogen substitute in silage maize cultivation for three consecutive years. Science of The Total Environment, 599, 1885-1894.
[8] Vaneeckhaute, C., Meers, E., Michels, E., Buysse, J., & Tack, F. M. G. 2013. Ecological and economic benefits of the application of bio-based mineral fertilizers in modern agriculture. Biomass and Bioenergy, 49, 239-248.

9 Liquid fraction of digestate as a substitute for mineral N & K fertilizer

TRL (Technology Readiness Level) – how close is your solution to the market?

Use the slider above to position the current TRL* of your proposed solution

* TRLs are a type of measurement system used to assess the maturity level of a particular technology. Where a topic description refers to a TRL, the following definitions apply, unless otherwise specified:

• TRL 1 – basic principles observed • TRL 2 – technology concept formulated • TRL 3 – experimental proof of concept • TRL 4 – technology validated in lab • TRL 5 – technology validated in relevant environment (industrially relevant environment in the case of key enabling technologies) • TRL 6 – technology demonstrated in relevant environment (industrially relevant environment in the case of key enabling technologies) • TRL 7 – system prototype demonstration in operational environment • TRL 8 – system complete and qualified • TRL 9 – actual system proven & running in operational environment

Please provide some sentences explaining your Technology Readiness Level

Liquid fraction of digestate has been used as fertilizer in field trail and demonstration, while large-scale utilization is under promotion.

If the proposed solution/ technique is currently at low TRL (≤5), is upscaling foreseen within the next year(s)?

If the proposed solution/ technique is currently at high TRL (≥7), is there any product already being produced from the proposed solution/ technique?

- *If yes, what is the name of the product:*
- *Short description of the product*
- *Are there any EC/MS Authority permits already for use of the product (title or link if available)?*

POTENTIAL LINKAGE TO THE PROJECT

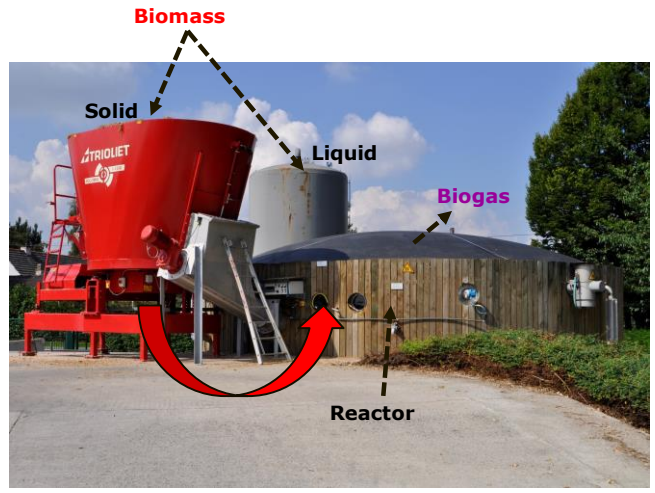
Indicate to which agro-typology under study and which potential research line of the project, your proposed solution/technique contributes:

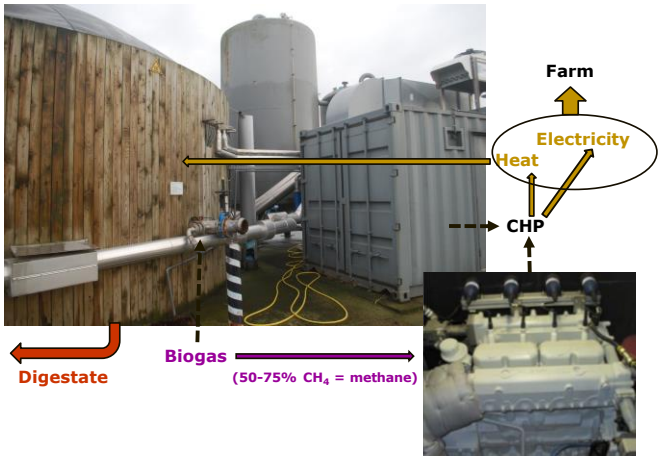
	Pig Production
	Poultry Production
	Cattle Farming
X	Open field cultivation of cereals or maize
X	Open air cultivation of vegetables
X	Orchards
	Agro-energy systems (e.g. biogas)
	Animal Byproduct processing (e.g. manure processing)

Innovative solutions for optimized nutrient & GHG in animal husbandry	
Innovative soil, fertilisation & crop management systems & practices	
Tools, techniques & systems for higher-precision fertilization	
Biobased fertilisers (N, P) and soil enhancers (OC) from agro-residues	X
Novel animal feeds produced from agro-residues	
Other, please specify :	

10 Small / Farm scale anaerobic digestion

AIM OF THE TECHNOLOGY





Research & demo biogas installation of Inagro vzw, research & advice centre in agri- & horticulture (31 kWel, located in Beitem, Belgium)

Provide a brief description of the proposed management solution or technique.

- *What is the purpose/aim of the innovative solution/technique?*
  Residues from agriculture may lead to odour and greenhouse gases. The purpose of this technique is to digest those on-farm residues to produce on-site renewable energy. Furthermore greenhouse gases from manure storage may be reduced by the application of this technique while there is less need for fossil fuels.
  'Pocket' or small scale anaerobic digestion is a tool for agricultural companies to increase self-sufficiency in terms of energy demand and thus to be less dependent on fluctuating energy market prices.
  The biggest difference with large-scale anaerobic digestion is the proprietary nature of small-scale anaerobic digestion. Although there is no internationally accepted legal definition for pocket digestion, there is a consensus that the term "pocket digestion" is applicable to installations with a proprietary biomass supply that produce energy in function of the proprietary

energy demand. “Mono-digestion” is applicable for installations that use only one type of biomass input. The smallest installations are also called micro digesters[1].
There is an operational group in Flanders about this subject, consisting of Inagro, Boerenbond, Biogas-E, Innovatiesteunpunt, Hooibeekhoeve, Innolab and 40 farmers who have a pocket digester on farm[2].

- *What is the underlying working principle?*
  Micro-organisms break down complex biomass components to smaller, less complex molecules in the absence of oxygen. This takes place in a reactor, where biogas and digestate are produced. Digestate can be used as an organic fertilizer, while the biogas consists mainly of CH_4 and CO_2. CH_4 is mostly combusted in a combined heat and power installation (CHP), driving the generator that produces electricity. Next to electricity the farmer can also use the heat provided by the CHP[1].

- *What is the current and foreseen scale of operations (e.g. kg, tonnes/year)?*
  Most small-scale digesters in Belgium have a power of 10 kW and digest 5-10 m^3 manure on a daily basis. In Belgium there are approximately 50 operative units (mostly on cattle farms).

- *Why is it innovative when compared to existing (farming) practices?*
  Small scale anaerobic digestion is not yet implemented everywhere. In Belgium it is for the moment mostly implemented on dairy farms. Therefore the gap of knowledge between dairy farms and other sectors should be closed. Furthermore it is a renewable energy production from on-farm biomass, improving the carbon footprint on farm by reduction of greenhouse gas emissions during manure storage and by saving fossil energy through production of renewable energy. Critical factors for greenhouse gas emission reduction are that the controlled digestion must take place in a properly managed, sufficiently robust and correctly dimensioned and equipped reactor as high digester methane losses and low digester retention times increase the carbon footprint significantly[3] .The implementation of first installations over the past few years has demanded quite a learning curve of both constructors and farmers, making new installations recently better performing. It can be expected that by the recent coming of a second constructor on the Flemish market, quality of installations will further improve.

- *How does it improve the Nitrogen-Phosphorus and/or Carbon cycles in agriculture ?*
  Considering these three nutrient cycles, small scale anaerobic digestion has the largest impact on the carbon cycle. Carbon present in the manure in all kinds of compounds is under controlled conditions converted into CO_2 and CH_4 (methane). The methane is then mostly combusted to produce renewable energy, which can be used on the farm. Also we can expect that less methane emissions will originate from the digestate compared to the manure, since a significant part of the carbon is already converted. The nitrogen in the digestate is made better available

[1] De Dobbelaere, A., De Keulenaere, B., De Mey, J., Lebuf, V., Meers, E., Ryckaert, B., Schollier, C. & Van Driessche, J. (2015). Small-scale anaerobic digestion: case studies in Western Europe. Rumbeke, Belgium: Inagro. Accessed on 07/01/2019 https://leden.inagro.be/DNN_DropZone/Publicaties/2509/Smallscale_Anaerobic_Digestion_Brochure_ENG.pdf

[2] EIP AGRI (2018). Operational Groups taking innovation to the field. Agrinnovation magazine issue 5. Accessed on 21/02/2019 via: https://ec.europa.eu/eip/agriculture/sites/agri-eip/files/eip-agri_agrinnovation_magazine_5_2018_en_web_update.pdf

[3] Vergote, T., Vanrolleghem, W., Van der Heyden, C., De Dobbelaere, A., Buysse, J., Meers, E. & Volcke, E. (2019). Model-based analysis of greenhouse gas emission reduction potential through farm-scale digestion. Biosystems Engineering. <accepted, soon to be published>

by an increase in the share of NH_4-N. Anaerobic digestion can be an intermediate step in a cascade combing it with further manure processing.

- *Add a separate line on the location of your management solution: "Currently this technology / technique / management solution is applied in ……. (city, region, country))."*
  Flanders (installations are running on approximately 49 companies), e.g. Inagro, Akivar, etc.

TRL (Technology Readiness Level) – how close is your solution to the market?

Use the slider above to position the current TRL* of your proposed solution

* TRLs are a type of measurement system used to assess the maturity level of a particular technology. Where a topic description refers to a TRL, the following definitions apply, unless otherwise specified:

• TRL 1 – basic principles observed • TRL 2 – technology concept formulated • TRL 3 – experimental proof of concept • TRL 4 – technology validated in lab • TRL 5 – technology validated in relevant environment (industrially relevant environment in the case of key enabling technologies) • TRL 6 – technology demonstrated in relevant environment (industrially relevant environment in the case of key enabling technologies) • TRL 7 – system prototype demonstration in operational environment • TRL 8 – system complete and qualified • TRL 9 – actual system proven & running in operational environment

Please provide some sentences explaining your Technology Readiness Level

The TRL is dependent on the farm, construction and type of biomass available. Not all small-scale digesters work on their full capacity because of some technical issues.

If the proposed solution/ technique is currently at low TRL (≤5), is upscaling foreseen within the next year(s)? YES / NO

If the proposed solution/ technique is currently at high TRL (≥7), is there any product already being produced from the proposed solution/ technique?

- *If yes, what is the name of the product :*
  Biolectric, BioTechnics

- *Short description of the product:*
  Both are companies that produce small-scale digesters (≥9,7 kW_{el}). Biolectric produces digesters in which the manure is digested between a liner. Biotechnics offers digesters constructed in concrete, but manure bags also belong to the assortment. Also relating to control infrastructure, there are differences in execution.

- *Are there any EC/MS Authority permits already for use of the product (title or link if available)?*

10 Small / Farm scale anaerobic digestion

POTENTIAL LINKAGE TO THE PROJECT

Indicate to which agro-typology under study and which potential research line of the project, your proposed solution/technique contributes :

X	Pig Production
X	Poultry Production
X	Cattle Farming
	Open field cultivation of cereals or maize
X	Open air cultivation of vegetables
	Orchards
X	Agro-energy systems (e.g. biogas)
X	Animal Byproduct processing (e.g. manure processing)

Innovative solutions for optimized nutrient & GHG in animal husbandry	X
Innovative soil, fertilisation & crop management systems & practices	
Tools, techniques & systems for higher-precision fertilization	
Biobased fertilisers (N, P) and soil enhancers (OC) from agro-residues	X
Novel animal feeds produced from agro-residues	
Other, please specify :	

11 Recycling fibres of manure as organic bedding material for dairy cows

AIM OF THE TECHNOLOGY

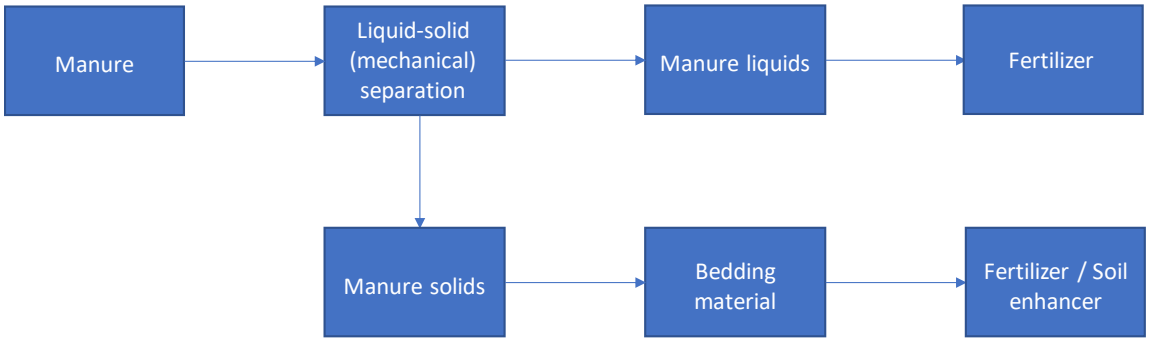


Figure 1: Manure solids after separation (2015)

Provide a brief description of the proposed management solution or technique.

- *What is the purpose/aim of the innovative solution/technique ?*
  Manure solids are rich in organic material and phosphate, while manure liquids consist mainly of nitrogen and potassium. Separating the manure into a solid and a liquid fraction can improve post processing techniques, recycling the manure and thus improving circular economy. Dried manure solids can first be used as a bedding for dairy cows, while the manure liquids is a convenient fertilizer for pasture and other crops[1].

[1] Gorissen, A. & Snauwaert, E. (2018) Oplossingen voor het mestoverschot in de melkveehouderij. Uitgegeven door het Vlaams Coördinatiecentrum Mestverwerking vzw te Brugge. Accessed via https://cdn.digisecure.be/vcm/2018121314837396_boekje-lowres.pdf

11 Recycling fibres of manure as organic bedding material for dairy cows

- *What is the underlying working principle ?*
  A screw press can be used for manure separation. The working principle of this technique is that a screw is turning into a circular perforated tube with perforations of 0.1-1 mm. The manure liquids are being separated from the manure solids via those perforations. The screw is responsible for a gradual increasing pressure throughout the tube. It is a good technique to obtain a high dry matter (DM) fraction. When the manure has a low DM-content (<4% DM), a centrifuge is a better option. Nutrients are being separated in a good way by using this technique[1].

- *What is the current and foreseen scale of operations (e.g. kg, tonnes/year) ?*
  In Flanders 50-100 cattle farms are using this technique. It is believed that this is going to expand to several hundreds of farms within a few years.

- *Why is it innovative when compared to existing (farming) practices ?*
  In many cases we produce more manure than our crops need which can overload soils with nutrients. By separation and processing the manure is being 'recycled', having no longer an impact on the environment[2]. This technique makes it possible to use the thick and the thin fraction of manure in a complete different way, which is innovative compared to current techniques because the manure liquids are a better fertilizer and the manure solids could be used to e.g. produce biogas or as a bedding for dairy cows. The manure liquids are better spread out on the field than raw manure and moreover the nitrogen is better available, making it a convenient fertilizer. The use of the manure solids as a bedding is only permitted when proprietary manure is used and if the company has its own separator.
  Farmers no longer need to pay for manure processing.

- *How does it improve the Nitrogen-Phosphorus and/or Carbon cycles in agriculture ?*
  The manure liquids after separation are clearly richer in nitrogen and potassium than non-separated manure and can be used as a fertilizer. Therefore there could be a mineral fertilizer use decrease of 40%, which means less depletion of natural resources. The low phosphorus content in the manure liquids is no longer causing phosphorus limitation.
  The manure solids can be used as a bedding for dairy cows. Afterwards, it can be used as a soil enhancer because it is carbon rich material[1]. Manure solids normally don't give hygienical problems when used as bedding material (for the animals as well as for the milk production), if it is being exploited in a correct way[3]. Also, because of the separation in liquids and solids, there should not be an increase of emissions. The main advantage of using this technique is that nutrients stay in their cycle.

- *Add a separate line on the location of your management solution: "Currently this technology / technique / management solution is applied in ……. (city, region, country))."*
  Currently this solution is applied in Flanders.

[2] Shwarz, M. & Bonhotal, J. (2010) Use of Dried Manure Solids as Bedding For Dairy Cows and "How frequently should stalls be refreshed with new bedding" case study, Cornell Waste Management Institute. Accessed via http://cwmi.css.cornell.edu/useofDMS.pdf

[3] Driehuis, F., Lucas-van den Bos, E., Feiken, M. & Wells-Bennik, M. H. J., (2013). Risico's van het gebruik van gescheiden mest als beddingmateriaal voor de melkkwaliteit: sporen van Bacillus cereus en boterzuurbacteriën. Rapport, Zoetermeer, Nederlandse zuivel organisatie, 14 pages.

11 Recycling fibres of manure as organic bedding material for dairy cows

TRL (Technology Readiness Level) – how close is your solution to the market?

Use the slider above to position the current TRL* of your proposed solution

* TRLs are a type of measurement system used to assess the maturity level of a particular technology. Where a topic description refers to a TRL, the following definitions apply, unless otherwise specified:

• TRL 1 – basic principles observed • TRL 2 – technology concept formulated • TRL 3 – experimental proof of concept • TRL 4 – technology validated in lab • TRL 5 – technology validated in relevant environment (industrially relevant environment in the case of key enabling technologies) • TRL 6 – technology demonstrated in relevant environment (industrially relevant environment in the case of key enabling technologies) • TRL 7 – system prototype demonstration in operational environment • TRL 8 – system complete and qualified • TRL 9 – actual system proven & running in operational environment

Please provide some sentences explaining your Technology Readiness Level

The technique is already used on some farms of different scale, so therefore there is already a high TRL.

If the proposed solution/ technique is currently at low TRL (≤5), is upscaling foreseen within the next year(s)?

If the proposed solution/ technique is currently at high TRL (≥7), is there any product already being produced from the proposed solution/ technique?

- *If yes, what is the name of the product :*
- *Short description of the product:*
- *Are there any EC/MS Authority permits already for use of the product (title or link if available)?*

POTENTIAL LINKAGE TO THE PROJECT

Indicate to which agro-typology under study and which potential research line of the project, your proposed solution/technique contributes :

	Pig Production
	Poultry Production
X	Cattle Farming
	Open field cultivation of cereals or maize
	Open air cultivation of vegetables
	Orchards
	Agro-energy systems (e.g. biogas)
X	Animal Byproduct processing (e.g. manure processing)

Innovative solutions for optimized nutrient & GHG in animal husbandry	
Innovative soil, fertilisation & crop management systems & practices	
Tools, techniques & systems for higher-precision fertilization	
Biobased fertilisers (N, P) and soil enhancers (OC) from agro-residues	X
Novel animal feeds produced from agro-residues	
Other, please specify :	

12 Using the compost tea in plant production

AIM OF THE TECHNOLOGY

Provide a brief description of the proposed management solution or technique.

- *What is the purpose/aim of the innovative solution/technique?*
  The aim of this technique is to produce a liquid microbiological compost tea that is suitable for the boost of the soil microbiom and provide plant supporting (protection, growth, nutrient uptake, etc.) microbes in an easy way.

- *What is the underlying working principle?*
  A high biological quality humuscompost is made, which compost is than used to propagate microbes using air, water and foodstuff in the compost tea unit in 24 hours.

- *What is the current and foreseen scale of operations (e.g. kg, tonnes/year)?*
  The applied ammount is 100l/ha. The units can make 30l, 100l, 200l, 1000l, 2000l and 6000 liter/day.

- *Why is it innovative when compared to existing (farming) practices?*
  Farmers can propagate their own native microbiology in a price efficient, easy way. Both preparation and application is easy.

- *How does it improve the Nitrogen-Phosphorus and/or Carbon cycles in agriculture?*
  The microbes organically mineralize and bond the nutrients according to the needs of the plant instead of wash off or immobilization.

12 Using the compost tea in plant production

- *Add a separate line on the location of your management solution: "Currently this technology / technique / management solution is applied in ……. (city, region, country)).*
  Currently this technique is applied in Hungary and other countries.

TRL (Technology Readiness Level) – how close is your solution to the market ?

Use the slider above to position the current TRL* of your proposed solution

* TRLs are a type of measurement system used to assess the maturity level of a particular technology. Where a topic description refers to a TRL, the following definitions apply, unless otherwise specified:

• TRL 1 – basic principles observed • TRL 2 – technology concept formulated • TRL 3 – experimental proof of concept • TRL 4 – technology validated in lab • TRL 5 – technology validated in relevant environment (industrially relevant environment in the case of key enabling technologies) • TRL 6 – technology demonstrated in relevant environment (industrially relevant environment in the case of key enabling technologies) • TRL 7 – system prototype demonstration in operational environment • TRL 8 – system complete and qualified • TRL 9 – actual system proven & running in operational environment

Please provide some sentences explaining your Technology Readiness Level

TRL 9

If the proposed solution/ technique is currently at low TRL (≤5), is upscaling foreseen within the next year(s)?

If the proposed solution/ technique is currently at high TRL (≥7), is there any product already being produced from the proposed solution/ technique?

- *If yes, what is the name of the product:*
  AF-alko series.

- *Short description of the product*
  A series of compost tea maker units with different tank sizes (30 l, 100l, 200l, 1000l, 2000l, 6000l).

- *Are there any EC/MS Authority permits already for use of the product (title or link if available)?*
  YES.

12 Using the compost tea in plant production

POTENTIAL LINKAGE TO THE PROJECT

Indicate to which agro-typology under study and which potential research line of the project, your proposed solution/technique contributes :

	Pig Production
	Poultry Production
	Cattle Farming
X	Open field cultivation of cereals or maize
X	Open air cultivation of vegetables
X	Orchards
	Agro-energy systems (e.g. biogas)
	Animal Byproduct processing (e.g. manure processing)

Innovative solutions for optimized nutrient & GHG in animal husbandry	
Innovative soil, fertilisation & crop management systems & practices	X
Tools, techniques & systems for higher-precision fertilization	X
Biobased fertilisers (N, P) and soil enhancers (OC) from agro-residues	X
Novel animal feeds produced from agro-residues	
Other, please specify :	

13 Sensor technology to assess crop N status

AIM OF THE TECHNOLOGY

Provide a brief description of the proposed management solution or technique.

- *What is the purpose/aim of the innovative solution/technique?*

  To fulfill the site-specific fertilization which is one of the main objectives in precision agriculture. Variable rate application requires accurate and efficient tools to determine the actual nutrient demand. Remote sensing techniques offer the opportunity to deliver this information quickly, precisely and cost-efficiently. The N-Sensor™ has been developed to determine the crop N status by measuring the light reflectance properties of crop canopies and to enable variable rate fertilization "on-the-go". N-Sensor™ is a tractor-mounted tool that allows farmers to measure a crop's nitrogen requirement as the tractor passes across the field and to vary the fertilizer application rate accordingly. N-Sensor™ ensures that the right and optimal rate of fertilizer is applied at each individual part of the field. It has become the benchmark technology for precision agriculture.

- *What is the underlying working principle?*

  The tractor mounted N-Sensor™ determines a nitrogen demand by measuring the crop's light reflectance covering a total area of approximately 50m^2. Measurements are taken every second with the system designed to operate at normal working speeds and all bout widths. Sensing technology applied to agriculture is based on the typical light reflectance curve for vegetation. N-Sensor™ measures light reflectance at specific wave bands related to the crop's chlorophyll content and biomass. It calculates the actual N-uptake of the crop. Optimum application rates are derived from the N-uptake data and sent to the controller of the variable rate spreader or sprayer, which will adjust fertilizer rates accordingly. The whole process of determining the crop's nitrogen requirement and application of the correct fertilizer rate happens instantaneously, with no time delay. This enables "real time agronomy" to be possible.

- *What is the current and foreseen scale of operations (e.g. kg, tonnes/year)?*

  The technology is used in several European countries, in Hungary in more than 10 agricultural sites where Yara products are used.

  Why is it innovative when compared to existing (farming) practices?

  By using a real time N application without precedent space informatics the N sensor provide several advantages as bring the optimal fertilizer rate in every part of the field, increase fertilizer use efficiency, decrease nitrogen residues in soils, the harvested product quality is more homogeneous, reduce harvesting time and cost, reduce risk of N losses to the environment.

- *How does it improve the Nitrogen-Phosphorus and/or Carbon cycles in agriculture?*

13 Sensor technology to assess crop N status

By using a precision fertilisation technology reduce the N losses to the environment, so assure a more balanced N-P-C cycle. According to the open field plants need, the specific N amount is distributed , that is usefull from economic and ecological point of view.

- *Add a separate line on the location of your management solution: "Currently this technology / technique / management solution is applied in ……. (city, region, country))."*
  Currently this technology is applied in Almost in every European country, in Hungary over 10 tool.

TRL (Technology Readiness Level) – how close is your solution to the market?

Use the slider above to position the current TRL* of your proposed solution

* TRLs are a type of measurement system used to assess the maturity level of a particular technology. Where a topic description refers to a TRL, the following definitions apply, unless otherwise specified:

• TRL 1 – basic principles observed • TRL 2 – technology concept formulated • TRL 3 – experimental proof of concept • TRL 4 – technology validated in lab • TRL 5 – technology validated in relevant environment (industrially relevant environment in the case of key enabling technologies) • TRL 6 – technology demonstrated in relevant environment (industrially relevant environment in the case of key enabling technologies) • TRL 7 – system prototype demonstration in operational environment • TRL 8 – system complete and qualified • TRL 9 – actual system proven & running in operational environment

Please provide some sentences explaining your Technology Readiness Level

TRL 9 actual system proven & running in operational environment.

If the proposed solution/ technique is currently at low TRL (≤5), is upscaling foreseen within the next year(s)?

If the proposed solution/ technique is currently at high TRL (≥7), is there any product already being produced from the proposed solution/ technique?

- *If yes, what is the name of the product:*
  ALS Sensor.

- *Short description of the product*
  Following development coordinated by Yara's Research and Development Centre, Hanninghof in Germany, the first N-Sensor (Classic) was introduced in 1999 for use on cereals. Work to develop the N-Sensor to keep up with changes in cereal production as well as for use on a wider range of crops and has been a continuous part of Yara's R&D Programme. More than 250 trials have been carried out between 1997 and 2010 to refine its performance and add new programs such as the Absolute-N calibrations for oilseed rape.
  In 2006, Yara launched the new N-Sensor™ ALS (Active Light Source), which works in a similar way to the classic N-Sensor™ to determine a crop's Nitrogen demand by measuring the crop's light reflectance. Both systems make use of the same field trial based agronomic algorithms for optimum site-specific fertilization and both are connected to a vehicle terminal where crop and GPS data is stored for processing.
  The major difference between the two N-Sensors™ is that the ALS Sensor has its own built in light source. Instead of using daylight for the measurement the N-Sensor™ ALS is constantly beaming its own source of light at the crop, using Xenon flash lamps, and recording the reflectance. This enables N-Sensor™ ALS operation independent from ambient light conditions, even at night.

13 Sensor technology to assess crop N status

- *Are there any EC/MS Authority permits already for use of the product (title or link if available)?*
  No permit is required to use the tool.

POTENTIAL LINKAGE TO THE PROJECT

Indicate to which agro-typology under study and which potential research line of the project, your proposed solution/technique contributes :

	Pig Production
	Poultry Production
	Cattle Farming
X	Open field cultivation of cereals or maize
	Open air cultivation of vegetables
	Orchards
	Agro-energy systems (e.g. biogas)
	Animal Byproduct processing (e.g. manure processing)

Innovative solutions for optimized nutrient & GHG in animal husbandry	
Innovative soil, fertilisation & crop management systems & practices	X
Tools, techniques & systems for higher-precision fertilization	X
Biobased fertilisers (N, P) and soil enhancers (OC) from agro-residues	
Novel animal feeds produced from agro-residues	
Other, please specify :	

14 Closing the loops at the scale of farm : using the livestock manure to fertilize the feeding crop on agroforestry plots

AIM OF THE TECHNOLOGY

Provide a brief description of the proposed management solution or technique.

- *What is the purpose/aim of the innovative solution/technique?*

EARL “Le Petit Bois” – district of Charente-Maritime, region of New Aquitania, in France - associates arable crops – 105 ha - and viticulture for cognac production – 25 ha - since the nineties. The farm began organic viticulture seven years ago and organic crops three years ago and had to change its fertilization practices.

Organic viticulture is a practice of viticulture according to the principles of organic farming. Organic viticulture is compelled not to use synthetic organic molecules, promotes the natural struggle between species, the life of soils, the sustainability of animal and plant species and their natural ecosystems.

It is governed by the European regulation CE 2092/911, and since 2012 regulations regulate specifically the production of organic wine. This regulation follows the one that governed the production of grapes from organic viticulture.

14 Closing the loops at the scale of farm : using the livestock manure to fertilize the feeding crop on agroforestry plots

The purpose of this cultural system is to keep the ability of fertilization with bio-based fertilizers, matched with the organic standards.

A problem to avoid indeed in organic agriculture is to lose too much efficiency in NP inputs, because of behaviour of the organic fertilizers

- which are more difficult to know without the appropriate characterization;
- whose mixing with soil involves microbiological reactions more complex to be assessed.

- *What is the underlying working principle?*

The question of crop nutrition in organic farming is usually dealt with taking account of the soil fertility which can be improved thanks to organic soil improvers.

Depending on the soil analyzes, the amount of organic amendments in variable quantity can be made:

- on the plots normally provided with organic materials (and not having undergone too deep recess): from 2 to 5 tons of humus, ie 20 at 50 tonnes of farmyard stock or 8 to 20 tonnes of industrial stock,
- on plots with low organic matter or having been deep-shattered: 5 to 15 tonnes / ha of humus, ie 50 to 150 tonnes of farm compost or 20 to 60 tonnes of industrial compost.

The inputs must be made with well decomposed products, low in nitrogen, rich in waste of plant origin, ligneous, buried superficially (maximum 15 cm deep) at least 3 to 6 months before planting (It is possible to spread them one year before, and to cultivate a cereal or other annual crop in the meantime). Soils should be regularly worked superficially (covercrop) between the crop and the plantation to facilitate the decomposition of organic matter. The ideal is to divide the inputs into 2 or 3 annual spreads, interspersed with cereals-type annual crops. Placing cereals with burying straws is a good way to correct the humus rate of a soil (1 ha cereals produces 1 ton of humus, more if the straws are incorporated; moreover, the aceramic system favours the maintenance of the soil structure).

But the transition from mainstream farming to organic farming needs to rely on bio-based fertilizers whose efficiency is close to synthetic ones to avoid to decrease the yield in a too heavy way. The encountered problem then is to find bio-based products authorized by organic standards at an acceptable price.

So the solution for this kind of farming is to build a fertilization pathway mixing the recycling of the own crop residues of the farm with others external sources of organic fertilizers.

14 Closing the loops at the scale of farm : using the livestock manure to fertilize the feeding crop on agroforestry plots

In the present case, the farmers have to choose to use their main farm residue, the oil cakes issue from the production of seed oil, as a livestock food or as bio-based fertilizer.
It will be necessary

- to rely on tools to assess the good synchronization between NP inputs from organic fertilizers, soil participation and needs of grape vine in nutrients.
- To select the practices to optimize the balance between carbon storage and organic fertility in soil of grapevine plots.

- *What is the current and foreseen scale of operations (e.g. kg, tonnes/year)?*
  The fertilizer needs of the farm is:
  - For the vineyard, about 14 tons;
  - For the crop, 175 tons.

  The cost of fertilizers for a vineyard farm with alcohol distillation (cognac) is higher than 10 000 € (source : Regional Department for Food, Agriculture and the Forest of New-Aquitania, 2018). the increase of accessibility of bio-based is a condition to develop organic farming at the region scale.

- *Why is it innovative when compared to existing (farming) practices?*
  The farm of EARL “Le Petit Bois” is able to link the management of organic crop residues to organic viticulture**.**
  To be sure, to succeed their evolution in organic farming, the farmers participate with the Chamber of agriculture to the test of precision farming tools.

- *How does it improve the Nitrogen-Phosphorus and/or Carbon cycles in agriculture?*
  The fertilisation system of the farm involves two kinds of loop in the element cycles :
  - The recovery of the oil cakes to bring to the vine plots is a loop at the closer scale of the farm;
  - The use of bio-based fertilizers is a loop at the the scale depending on the fertilizer origin : district, region, country...

- *Add a separate line on the location of your management solution: “Currently this technology / technique / management solution is applied in ……. (city, region, country)).”*
  The fertilisation management is actually farm-specific.

14 Closing the loops at the scale of farm : using the livestock manure to fertilize the feeding crop on agroforestry plots

TRL (Technology Readiness Level) – how close is your solution to the market?

Use the slider above to position the current TRL* of your proposed solution

* TRLs are a type of measurement system used to assess the maturity level of a particular technology. Where a topic description refers to a TRL, the following definitions apply, unless otherwise specified:

• TRL 1 – basic principles observed • TRL 2 – technology concept formulated • TRL 3 – experimental proof of concept • TRL 4 – technology validated in lab • TRL 5 – technology validated in relevant environment (industrially relevant environment in the case of key enabling technologies) • TRL 6 – technology demonstrated in relevant environment (industrially relevant environment in the case of key enabling technologies) • TRL 7 – system prototype demonstration in operational environment • TRL 8 – system complete and qualified • TRL 9 – actual system proven & running in operational environment

Please provide some sentences explaining your Technology Readiness Level

The system is actually farm-specific and works are necessary to make the knowledge and practices useful for others cases of organic perennial crops :

- about the disponibility of nutrients from the bio-based fertilizer,
- about the assessment of the nutrients needs of the crop

That's the motivation of the field demonstration proposed by the Chamber of agriculture whose device is presented at the end of this sheet

If the proposed solution/ technique is currently at low TRL (≤5), is upscaling foreseen within the next year(s)?

If the proposed solution/ technique is currently at high TRL (≥7), is there any product already being produced from the proposed solution/ technique ?

- *If yes, what is the name of the product :*
- *Short description of the product*
- *Are there any EC/MS Authority permits already for use of the product (title or link if available)?*

14 Closing the loops at the scale of farm : using the livestock manure to fertilize the feeding crop on agroforestry plots

POTENTIAL LINKAGE TO THE PROJECT

Indicate to which agro-typology under study and which potential research line of the project, your proposed solution/technique contributes :

	Pig Production
	Poultry Production
	Cattle Farming
	Open field cultivation of cereals or maize
	Open air cultivation of vegetables
X	Orchards
	Agro-energy systems (e.g. biogas)
	Animal Byproduct processing (e.g. manure processing)

Innovative solutions for optimized nutrient & GHG in animal husbandry	
Innovative soil, fertilisation & crop management systems & practices	X
Tools, techniques & systems for higher-precision fertilization	X
Biobased fertilisers (N, P) and soil enhancers (OC) from agro-residues	X
Novel animal feeds produced from agro-residues	
Other, please specify :	

14 Closing the loops at the scale of farm : using the livestock manure to fertilize the feeding crop on agroforestry plots

If you have any other information you want to share with us, please insert in the box below

We propose for 2019 to start the monitoring of a plot proposed by the EARL “Le Petit Bois” with organic vine, to show the first level of circular fertilization with recovery of nutrients from the oil cake as own farm’s wastes compared to a market organic fertilizer, with this experimental device :

- the A area with the farm’s oil cake spreading (the real surface will be adapted according to the available stock of oil cake);

- the B strip with the organic fertilizer spreading.

We will make samples for analysis :

- One sample of oil cake for characterization (1 analysis)
- One soil sample from the entire plot for chemical and trace-elements analysis (1 analysis)
- One soil sample from the entire plot for biological analysis (1 analysis)
- One soil sample from the entire plot for N mineralization kinetics (1 analysis)
- One soil sample for each A and B areas after spreading for N mineralization kinetics (2 analysis)

We will organize drone's flights to follow the vine’s development with remote sensing to assess biomass activity with vegetation indexes.

We expect the results:

- Soil’s initial characteristics whose potential N supply of soil and situation of organic matter in soil;
- Balance of NP fertilization for the vine with efficiency of oil cake as fertilizer or soil improver;
- Test of monitoring method with vegetation index.

15 Substituting mineral inputs with organic inputs in organic viticulture

AIM OF THE TECHNOLOGY

Provide a brief description of the proposed management solution or technique.

- *What is the purpose/aim of the innovative solution/technique?*

The farm EARL Manicot – district of Charente-Maritime, region New Aquitania, in France - associates arable crops – wheat, triticale, pea, corn, and rapeseed – and goose breeding. For a 93 ha agricultural area, 7 ha are used are as pasture and exercise area and 86 ha are used for arable crops. 5 ha of the pasture area and 7 ha of the crop area have trees plantation for agroforestry (dual band planting).

The purpose of this cultural system is the recycling livestock manure to fertilize the feeding crops production with the increase of carbon storage and biological fertility in soil.
To provide a part of feeding and energy by self-production and with short loops, manure and slurry are recycled for crops production which is firstly used for feeding then for sale, the wood is used for energy production on the farm.

15 Substituting mineral inputs with organic inputs in organic viticulture

- *What is the underlying working principle?*

  The farmers needs are to be able to prove and to assess the carbon storage and the increase of soil fertility thanks to agroforestry.

  Agroforestry increases the overall productivity of the land. Indeed, the trees planted in a plot, by soliciting a negligible surface on the ground, constitute an investment which allows a capitalization. A harvest of wood will be possible eventually. Because of the tree / crop association, the growth of the latter is faster than in the forest, but with a very different architecture.

  Judicious associations (ex50 walnuts / ha in wheat) allowed to increase the productivity and the "carbon sink" effect: if, instead of sharing a two-part plot, one planted with fifty walnut trees, the other winter wheat, we practice a combination of the two species on the same plot, the productivity of the plot, in biomass, increases from 20 to 40%. Indeed, the energy of the sun which is no longer used by wheat once the harvest is made in early summer will be profitable for the farmer as it will allow the development of walnut; conversely, when in winter and early spring, walnut trees do not yet have leaves, the light energy, which would be lost if the walnut trees were planted alone on the plot, is used by the wheat at the time of its growth. Agroforestry trees constitute a sizeable stock of carbon, both in their wood but also in the soil which is enriched in depth in organic matter by the continuous decomposition of their fine roots, year after year.

  From an agronomic point of view, trees and their roots and associated fungi help fight erosion and recharge the soil with organic matter.

15 Substituting mineral inputs with organic inputs in organic viticulture

This system permits to the farmers:

- to ensure gooses comfort;
- to monitor the N and P outputs and the risk of leaching in water by optimizing the balance between mineral and organic fertilization with a better knowledge of their effluents;
- to produce green energy with the wood biomass

- *What is the current and foreseen scale of operations (e.g. kg, tonnes/year)?*
  It's a small production : 50 tons of solid manure and 80 m^3 of liquid manure. Production is completely recycled on the farm without the need for effluent export.

- *Why is it innovative when compared to existing (farming) practices?*
  The use of agroforestry to boost the C loop and to ensure the N loop.
  a) To boost the C loop : the storage of carbon by agroforestry plant strips si reflected in two ways,
     - Increase of soil organic matter and its fertility,
     - Circular production of green energy by wood cutting and use directly on the farm.
  b) To ensure the N loop by combining perennial and annual cultures to reduce the stock of mineral N. In fact the perennial crop uses the mineral N excess of soil after harvesting arable crops.

- *How does it improve the Nitrogen-Phosphorus and/or Carbon cycles in agriculture?*
  There is a complete recycling of the NP elements from manure by the local crops and a recovery of a part of NP stocks in soil to store C with wood of agroforestry.

- *Add a separate line on the location of your management solution: "Currently this technology / technique / management solution is applied in ……. (city, region, country)."*
  Currently this management solution is applied in Saint Martial sur le Né, Charente-Maritime, France.
  There are others cases of agroforestry in the district but not in association with breeding practices.

15 Substituting mineral inputs with organic inputs in organic viticulture

TRL (Technology Readiness Level) – how close is your solution to the market?

Use the slider above to position the current TRL* of your proposed solution

* TRLs are a type of measurement system used to assess the maturity level of a particular technology. Where a topic description refers to a TRL, the following definitions apply, unless otherwise specified:

• TRL 1 – basic principles observed • TRL 2 – technology concept formulated • TRL 3 – experimental proof of concept • TRL 4 – technology validated in lab • TRL 5 – technology validated in relevant environment (industrially relevant environment in the case of key enabling technologies) • TRL 6 – technology demonstrated in relevant environment (industrially relevant environment in the case of key enabling technologies) • TRL 7 – system prototype demonstration in operational environment • TRL 8 – system complete and qualified • TRL 9 – actual system proven & running in operational environment

Please provide some sentences explaining your Technology Readiness Level

This solution is used and allows to manage livestock effluents but some results are needed to qualify elements balance and C storage efficiency. We have no information about similar case in the region of New Aquitania and we have no operational group of this kind.

To develop our knowledge about the efficiency of this farming system, we propose to lead an experiment starting in 2019 and described at the end of this sheet.

If the proposed solution/ technique is currently at low TRL (≤5), is upscaling foreseen within the next year(s)?

If the proposed solution/ technique is currently at high TRL (≥7), is there any product already being produced from the proposed solution/ technique?

- *If yes, what is the name of the product :*
  Gooses' manure and slurry

- *Short description of the product*
  There are manure and slurry storages on the farm but not enough to be exported or to be sold.

- *Are there any EC/MS Authority permits already for use of the product (title or link if available)?*
  YES, a spreading plan which is matched to the french ICPE regulation - Classified Installations for Environmental Protection (French Environment Code).

15 Substituting mineral inputs with organic inputs in organic viticulture

POTENTIAL LINKAGE TO THE PROJECT

Indicate to which agro-typology under study and which potential research line of the project, your proposed solution/technique contributes :

	Pig Production
X	Poultry Production
	Cattle Farming
	Open field cultivation of cereals or maize
	Open air cultivation of vegetables
	Orchards
	Agro-energy systems (e.g. biogas)
	Animal Byproduct processing (e.g. manure processing)

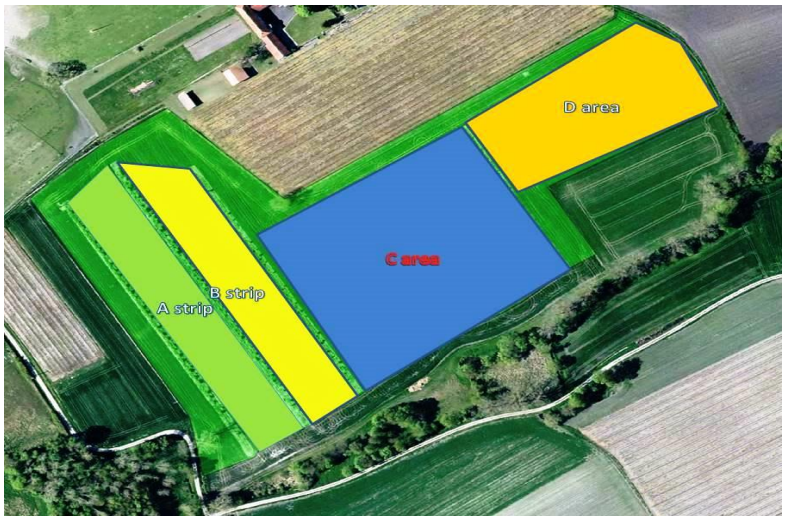
Innovative solutions for optimized nutrient & GHG in animal husbandry	
Innovative soil, fertilisation & crop management systems & practices	X
Tools, techniques & systems for higher-precision fertilization	
Biobased fertilisers (N, P) and soil enhancers (OC) from agro-residues	
Novel animal feeds produced from agro-residues	
Other, please specify :	

15 Substituting mineral inputs with organic inputs in organic viticulture

If you have any other information you want to share with us, please insert in the box below

We propose for 2019 to start the monitoring of the plot with agroforestry - winter wheat in 2019 - with this experimental device :

- the A strip as agroforestry area with a slurry spreading
- the B strip as agroforestry area with a manure spreading
- the C area as agroforestry area with conventional fertilization
- the D area as the "conventional" witness



We will make samples for analysis :

- One sample from goose slurry for characterization (one analysis)
- One sample from goose manure for characterization (one analysis)
- One soil sample from each area and strip for chemical and trace-elements analysis (4 analysis)
- One soil sample from each area and strip for biological analysis (4 analysis)
- One soil sample from each C and D areas for N mineralization kinetics (4 analysis)
- One soil sample from each A and B strips after spreading for N mineralization kinetics (2 analyses)

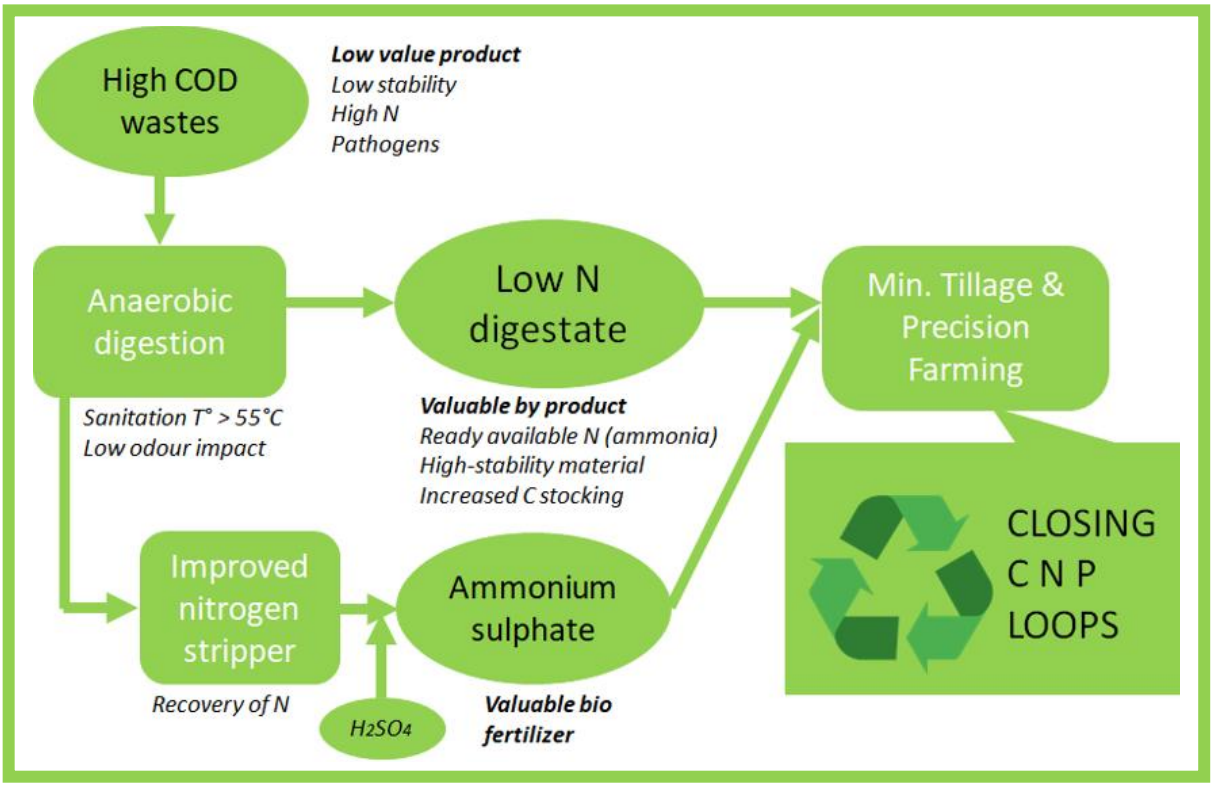
We will organize drone's flights to follow the crop's growth with remote sensing to assess biomass situation with vegetalization indexes

Expected results

- Soil's characteristics whose potential N supply of soil,
- Balance of NP fertilization for the crop with efficiency of slurry and manure as fertilizer or soil improver,
- Test of monitoring method with vegetalization index.

16 Farm using digestate, precision agriculture and no-tillage focusing on OM stocking in an area characterized by the lack of OM

AIM OF THE TECHNOLOGY



This technique is a complex synergy of technologies to process wastewaters, OFMSW, and agro/food industrial wastes. It includes AD, ammonia stripping system, bio-fertilizer and soils enhancers production, nutrients recycling, precision farming and minimum tillage tools to run effectively rice-culture.

Provide a brief description of the proposed management solution or technique.

- *What is the purpose/aim of the innovative solution/technique?*
  This solution couples a high efficiency N stripping system with precision farming and minimum tillage tools in order to maximize the efficiency of digestate as a fertilizer and soil enhancer.

- *What is the underlying working principle?*
  Ammonia is stripped by contact of digestate with biogas whereby the latter acts as stripping agent of ammonia. The ammonia enriched biogas is then purified from ammonia reacting with sulphuric acid producing inorganic ammonium sulphate, a valuable bio-fertilizer.
  Low N digestion residues can be used in field in a more effective way than the untreated ones. The decreased level of nitrogen allows a higher dose of digestate per hectare without exceeding the legal limit for this element, increasing the quantity of OM and the enhancer effect in field.
  The possibility to use more effluent per hectare is very useful to increase the P and K dose, saving valuable chemical fertilizers, without outrange the N provision.
  High quantity and quality of OM in soil is important for crops growth (physical features and bio-stimulation), carbon stocking and nutrients and water retention.

16 Farm using digestate, precision agriculture and no-tillage focusing on OM stocking in an area characterized by the lack of OM

In Italy, especially in southern regions, OM is easily depleted by high temperature and low precipitation rate. This problem, common to all Mediterranean regions, can be mitigated by the application of great quantity of OM at high recalcitrance level.

The digestion phase take place at 55°C for at least 20 days, through three reactor tanks in sequence, so that the effluent is hygienically safe and with a low odour impact. Furthermore, in digestate nitrogen is found mainly in ammonia form, which is the most easily absorbed by plants. NH4-N is more effective compared to organic nitrogen due to the immediate availability. The use of digestate allows a better development of the culture and the N stripping lead to a precise regulation of nutrient set for the culture that is grown at the moment. Furthermore, ammonia is a well-known inhibitor of anaerobic digestion; the stripping system allow a higher yield of bio-methane.
The efficiency of this high valuable effluent is increased by the precision farming and minimum tillage tools. These techniques can reduce the waste of nutrient and the loss of organic matter, so to increase the stocking of carbon and, together with the production of biogas, close the carbon cycle.
The precision farming system couple a minimum tillage approach with a GPS geolocation to accurate-dosing fertilization.
The minimum tillage is based on injection system 5-10 cm deep, directly in the soil, two times per year, pre-sowing and after the harvest. High precision geolocation allow to relate the sowing position with the fertilization. The minimum tillage (or no tillage) has many advantages, it reduces the loss of ammonia from fertilizer (i.e. digestate) injecting directly it in the soil, it allows a better management of OM in the soil due to the important loss of it during ploughing (or other tillage) and, finally, it is more energetically and economically efficient due to the less power needed by the agricultural machinery and doing tillage and fertilization in one passage. This practise can actively help to close the C cycle saving fuel for agricultural machinery and stocking OM in soil.
The cultivated surface of the plant and jointed farmers (total of 5.000 ha) is subdivided in a grid of one hectare per cell. The soil in each cell is tested every year for N and P content, cation exchange capacity and OM content. The amount of digestate (low N content) given is precisely calculated at every treatment. The growth is monitored continuously; bio-fertilizer ammonium sulphate is given to the culture in case of stress or nutrient deficit.
This system is run since 2013, this give a valuable amount of historical data on the cultural management.
An important device is the presence of wildlife corridor, that increase the biodiversity and the sustainability in the area. Especially in rice culture where periods of flood are followed by periods of dryness is important to have areas presenting water channels and ponds to consent small wild fauna to find shelter during the dry season.

- *What is the current and foreseen scale of operations (e.g. kg, tonnes/year)?*
At the moment this plant treats more than 120 000 tons of wastes per year, feedstock is so composed: 45% sewage sludge, 25% agro-food industries waste, 25% OF-MSW and 5% of manure. The digester works at 12-17% of total solids, the addition of water makes a quantity of effluents of 192.000 ton/year. Methane average yield is of 2300 kNm^3 of CH_4, and the specific production is 245 l CH_4/kg VS fed.
Digestate features are: dry matter 10.5%, organic carbon 31.2% of DM, total N 77.0 g/kg DM, total P_2O_5 57.6 g/kg DM and last total K_2O g/kg DM.
Results from the material balances show that the ammonia stripping system can remove up to 22% of the total NH_4-N.

16 Farm using digestate, precision agriculture and no-tillage focusing on OM stocking in an area characterized by the lack of OM

Bio fertilizer (ammonia sulphate) and soil enhancer (digestate) are actively used on a surface of 5000 hectares, mostly rice culture, belonging to different surrounding farms, besides is applied on an experimental field focused on research and development.

- *Why is it innovative when compared to existing (farming) practices?*
  The innovative solution consists in a full scale plant with high efficiency in nutrient recovery associated with precision farming on extended surfaces in different crops (mainly rice and, secondly corn).

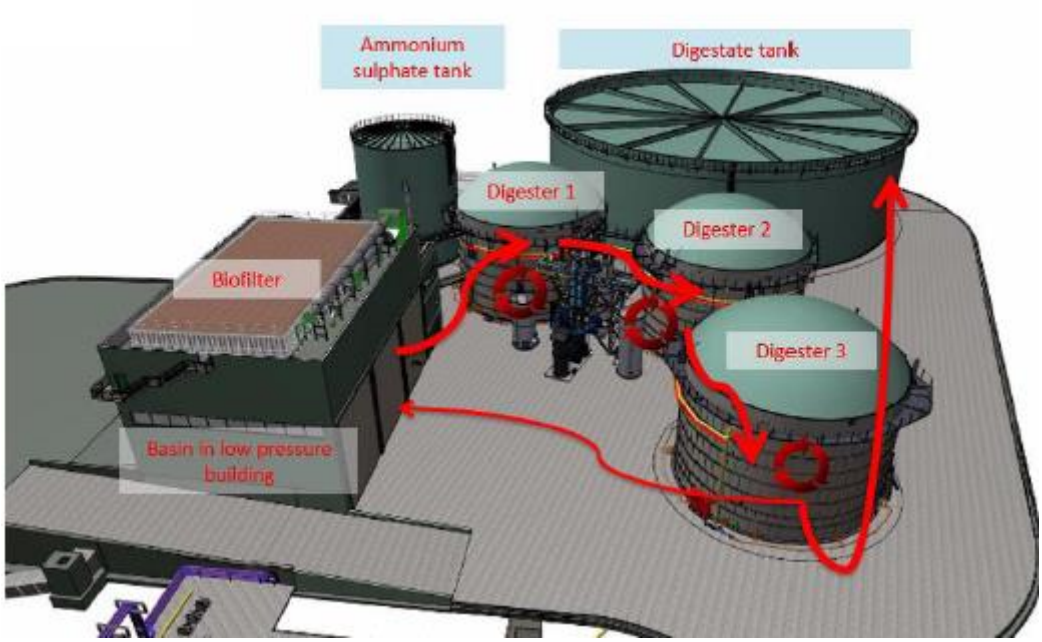
- *How does it improve the Nitrogen-Phosphorus and/or Carbon cycles in agriculture?*
  The use of AD can greatly help to close the C cycle, producing valuable methane and using digestate to increase soil OM quantity and stability. At the same time the stripping system can lead to a precise and effective exploitation of N in wastes. In fact, is possible to use more digestate per hectare avoiding the N limit, and producing concentrate bio-fertilizer.

- *Add a separate line on the location of your management solution: "Currently this technology / technique / management solution is applied in ……. (city, region, country)).”*
  Currently this technique is applied in Acqua & Sole organization, sited in Vellezzo Bellini, PV, Italy.

Picture 1 Satellite image of the plant

16 Farm using digestate, precision agriculture and no-tillage focusing on OM stocking in an area characterized by the lack of OM

Picture 2 Anaerobic Digestion tanks



Picture 3 Scheme of the plant

16 Farm using digestate, precision agriculture and no-tillage focusing on OM stocking in an area characterized by the lack of OM

TRL (Technology Readiness Level) – how close is your solution to the market ?

Use the slider above to position the current TRL* of your proposed solution

* TRLs are a type of measurement system used to assess the maturity level of a particular technology. Where a topic description refers to a TRL, the following definitions apply, unless otherwise specified:

• TRL 1 – basic principles observed • TRL 2 – technology concept formulated • TRL 3 – experimental proof of concept • TRL 4 – technology validated in lab • TRL 5 – technology validated in relevant environment (industrially relevant environment in the case of key enabling technologies) • TRL 6 – technology demonstrated in relevant environment (industrially relevant environment in the case of key enabling technologies) • TRL 7 – system prototype demonstration in operational environment • TRL 8 – system complete and qualified • TRL 9 – actual system proven & running in operational environment

Please provide some sentences explaining your Technology Readiness Level

The described technique is already successfully applied to the disposal of wastes, the obtained by-product has already been applied in field as fertilizer and soil enhancer. Still agronomical aspects have to be further investigated in on-field trials.

If the proposed solution/ technique is currently at low TRL (≤5), is upscaling foreseen within the next year(s)?

If the proposed solution/ technique is currently at high TRL (≥7), is there any product already being produced from the proposed solution/ technique ?

- *If yes, what is the name of the product:*
  1) Service/product of precision farming and minimum tillage using low N-content digestate.
  2) Ammonium sulphate bio-fertilizer

- *Short description of the product:*
  Acqua&Sole is jointed with many farmers in the area and provide them the service of minimum tillage and precision farming (above mentioned) and the low N-content digestate in field. The service can be considered a full management of innovative rice-culture.
  Ammonium sulphate produced by the ammonia-stripping system is also sold.

- *Are there any EC/MS Authority permits already for use of the product (title or link if available) ?*

16 Farm using digestate, precision agriculture and no-tillage focusing on OM stocking in an area characterized by the lack of OM

POTENTIAL LINKAGE TO THE PROJECT

Indicate to which agro-typology under study and which potential research line of the project, your proposed solution/technique contributes :

	Pig Production
	Poultry Production
	Cattle Farming
X	Open field cultivation of cereals or maize
	Open air cultivation of vegetables
	Orchards
X	Agro-energy systems (e.g. biogas)
	Animal Byproduct processing (e.g. manure processing)

Innovative solutions for optimized nutrient & GHG in animal husbandry		
Innovative soil, fertilisation & crop management systems & practices		X
Tools, techniques & systems for higher-precision fertilization		X
Biobased fertilisers (N, P) and soil enhancers (OC) from agro-residues		X
Novel animal feeds produced from agro-residues		
Other, please specify :	Waste disposal (e.g. wastewaters, OFSMW)	X

17 Crop farmer using a variety of manure and dairy processing residues to recycle and build soil C, N, P fertility

AIM OF THE TECHNOLOGY

To build soil C, N, P fertility and demonstrate the benefits of loop closure management practices and technologies

Cropping systems provide the grains which underpin the nutritional requirements of many animal production systems. In particular, poultry and pig systems but also pasture based cattle systems including beef and dairy which often feed supplemental feed which originates on crop farms. These grains carry nutrients from the croplands, concentrating them on animal farms. The dairy systems are large users of supplemental grain based feeds and the European dairy-industry is the largest in the world accounting for 22% of global milk production. This industry through processing of milk and dairy products generates large volumes of nutrient rich sludge. For example in Ireland the dairy processing industry generates circa 126,718 tonnes of this sludge annually. Recent work by Ashekuzzaman *et al*., (in review) shows that these dairy residues contain substantial levels of crop nutrients. For example N ranged from 20 – 57, P ranged from 15 - 70 and K ranged from 2.9 – 7.2, g/kg dry weight respectively. To close loops in C, N and P cycling it is important to return these nutrients to the croplands. Crop farmers are very sensitive to the nutrient feed out profile and available nutrients in bio-based materials as overestimation of nutrients can lead to reduced yields. Under estimation can lead to crop lodging. The present project will engage with a crop farmer to use these materials and to research and demonstrate the opportunities for C, N and P loop closure by integration of a suite of organic manures/ residues into an arable crop rotation. The arable farm grows crops including maize, winter barley, beans and oilseed rape. The organic sources of manure include cattle slurry, poultry manure, dairy processing based sludge and manure/sludge combinations with or without mineral fertiliser input to meet crop nutrient requirements. The footprint of the study site will be used to monitor longer-term effects of manure incorporation into this system on C, N and P cycling. The case has potential to be used as a lighthouse demo as it will involve a farmer, his advisor and the research element.

Provide a brief description of the proposed management solution or technique.

- *What is the purpose/aim of the innovative solution/technique?*
  Recycling of nutrients from animal farmers and intensive grain users such as poultry to cropping land. Additionally us of dairy processing residues in a crop system

- *What is the underlying working principle?*

17 Crop farmer using a variety of manure and dairy processing residues to recycle and build soil C, N, P fertility

Nutrient recycling and efficiency measures. Cropping systems are the source of the grains that frequently lead to the production of manures from animal systems or residues/sludge from the processing of animal products such as milk. To closing C, N and P loops recycling of this material back to the croplands is important. However, for arable/cropping farmers to switch away from the use of mineral fertilisers information and demonstration of the nutrient value and reliability of the other sources is needed.

- *What is the current and foreseen scale of operations (e.g. kg, tonnes/year)?*
  The research and demonstration will be conducted at a plot scale of 3 x 12 m plots in a replicated setting. The farm chosen already uses organic manures across approximately 80 ha so the plot scale demo will link to the farmer experiences and questions at the farm scale

- *Why is it innovative when compared to existing (farming) practices?*
  Current practices on tillage farms rely mainly on mineral fertiliser with farmers noting that land is becoming "worn" and a need for organic additions is recognised

- *How does it improve the Nitrogen-Phosphorus and/or Carbon cycles in agriculture?*
  C, N and P in residues is being redirected to land and the C, N, P in grain fed to poultry and ruminants is being returned to the crop land

- *Add a separate line on the location of your management solution: "Currently this technology / technique / management solution is applied in ……. (city, region, country)."*
  Currently this technology is applied in Wicklow, Ireland.

17 Crop farmer using a variety of manure and dairy processing residues to recycle and build soil C, N, P fertility

TRL (Technology Readiness Level) – how close is your solution to the market?

Use the slider above to position the current TRL* of your proposed solution

* TRLs are a type of measurement system used to assess the maturity level of a particular technology. Where a topic description refers to a TRL, the following definitions apply, unless otherwise specified:

• TRL 1 – basic principles observed • TRL 2 – technology concept formulated • TRL 3 – experimental proof of concept • TRL 4 – technology validated in lab • TRL 5 – technology validated in relevant environment (industrially relevant environment in the case of key enabling technologies) • TRL 6 – technology demonstrated in relevant environment (industrially relevant environment in the case of key enabling technologies) • TRL 7 – system prototype demonstration in operational environment • TRL 8 – system complete and qualified • TRL 9 – actual system proven & running in operational environment

Please provide some sentences explaining your Technology Readiness Level

The farmer is using ruminant and poultry manure but the dairy processing residue will be new.

If the proposed solution/ technique is currently at low TRL (≤5), is upscaling foreseen within the next year(s)?

If the proposed solution/ technique is currently at high TRL (≥7), is there any product already being produced from the proposed solution/ technique ?

- *If yes, what is the name of the product :*
- *Short description of the product*
- *Are there any EC/MS Authority permits already for use of the product (title or link if available)?*

POTENTIAL LINKAGE TO THE PROJECT

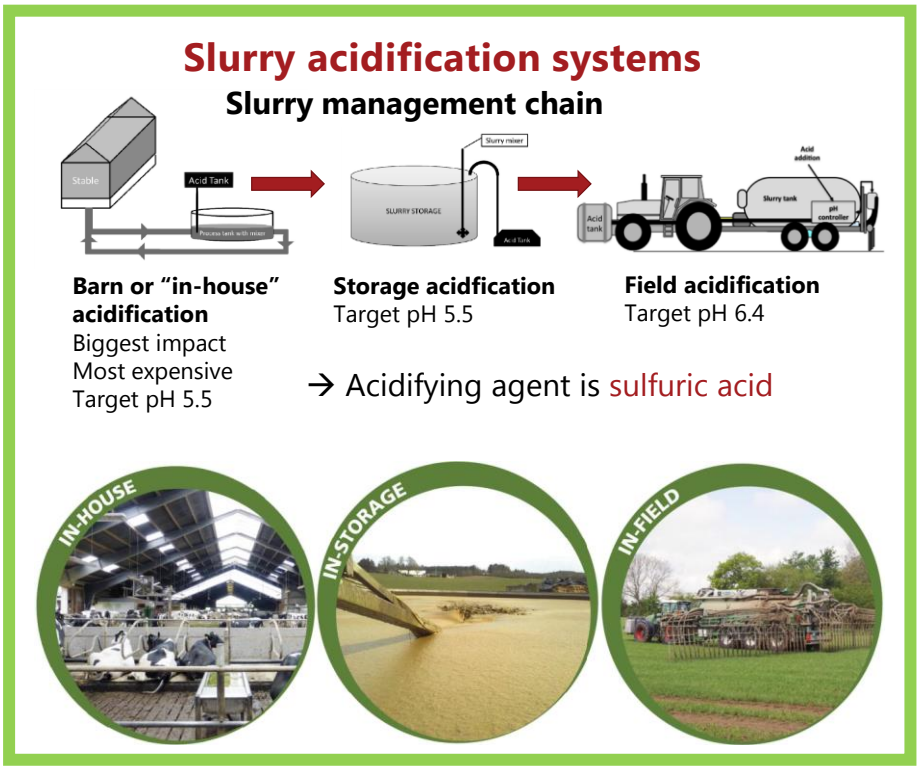
Indicate to which agro-typology under study and which potential research line of the project, your proposed solution/technique contributes :

	Pig Production
X	Poultry Production
X	Cattle Farming
X	Open field cultivation of cereals or maize
	Open air cultivation of vegetables
	Orchards
	Agro-energy systems (e.g. biogas)
X	Animal Byproduct processing (e.g. manure processing)

Innovative solutions for optimized nutrient & GHG in animal husbandry	
Innovative soil, fertilisation & crop management systems & practices	X
Tools, techniques & systems for higher-precision fertilization	
Biobased fertilisers (N, P) and soil enhancers (OC) from agro-residues	X
Novel animal feeds produced from agro-residues	
Other, please specify :	

18 Slurry acidification with industrial acids to reduce NH_3 volatilisation from animal husbandry

AIM OF THE TECHNOLOGY



Provide a brief description of the proposed management solution or technique.

- *What is the purpose/aim of the innovative solution/technique?*
  To reduce ammonia emissions to the atmosphere from the entire animal slurry management chain, i.e. the animal house, the storage tank and/or during the field application of slurries. As a co-benefit, acidification also reduces emissions of methane (CH_4) and nitrous oxide (N_2O), both potent greenhouse gases, from animal houses and slurry storage facilities.

- *What is the underlying working principle?*
  By lowering the pH of the slurry with sulfuric acid the equilibrium betwenn NH3 and NH4+ shift towards ammonium (NH4+). Ammonium is the dissolved form of inorganic N in the slurry and does not volatilise to the atmosphere, but stays in the slurry.

- *What is the current and foreseen scale of operations (e.g. kg, tonnes/year)?*
  Around 6-8 kg sulfuric acid per m3 of slurry needs to be added to lower pH to 5.5 – but it depends on the amount of dry matter content in the slurry. The more solids in the slurry, the more sulfuric acid is needed. 1 L sulfuric acid = 1.8 kg. Acidification during the field application requires less acid (target pH 6.4) to be effective.
  The technology can be scaled for any sized farm or field application situation (see below for more details on implementation)

18 Slurry acidification with industrial acids to reduce NH_3 volatilisation from animal husbandry

- *Why is it innovative when compared to existing (farming) practices?*
  This technology enables both reduced environmental impacts and at the same time increased crop fertiliser nitrogen efficiency and may potentially enhance availability of several other nutrients (fertiliser, manure or soil derived).
  Acidification can potentially reduce ammonia volatilisation by more than 90% and may thus eliminate the need for slurry injection into the soil during field application. Slurry injection is energy demanding, has low capacity and may damage a growing crop, and hence substituting it with slurry acidification may have multiple benefits, balancing the cost for sulfuric acid and technology for acid dosage.
  Furthermore, manure acidification in the animal house improves animal welfare, since ammonia emissions are reduced directly from the source inside the stable from slurry pits below drained floors, reducing the concentration of ammonia in the stable air significantly. Ammonia in gas form is especially aggressive to mucous membranes and respiratory organs and the reduction therefore improves animal health and productivity. Less ammonia in the stable air is also a great advantage to the human working environment, especially for respiratory diseases.

  How does it improve the Nitrogen-Phosphorus and/or Carbon cycles in agriculture ?
  The ammonia (NH3) that would volatilise and pollute the atmosphere is retained in the acidified slurry as additional plant-available nitrogen and will result in an increase in agricultural mineral fertiliser equivalent value of the acidified slurry of up to 15-20% units (i.e. the ability to replace mineral fertiliser N will increases from e.g. 50 to 65-70 kg N per 100 kg total N in the untreated and acidified slurry, respectively). Sulfuric acid furthermore provides full plant available sulphur supply to the crops and applying acidified slurry will also minimise the risk of crop manganese deficiency.

- *Add a separate line on the location of your management solution: "Currently this technology / technique / management solution is applied in ……. (city, region, country))."*
  Currently acidification technology is applied mainly in the Scandinavian countries, especially Denmark, where up to 20% of all slurry is acidified in either the animal house, the storage or during field application (see also below).

18 Slurry acidification with industrial acids to reduce NH_3 volatilisation from animal husbandry

TRL (Technology Readiness Level) – how close is your solution to the market?

Use the slider above to position the current TRL* of your proposed solution

* TRLs are a type of measurement system used to assess the maturity level of a particular technology. Where a topic description refers to a TRL, the following definitions apply, unless otherwise specified:

• TRL 1 – basic principles observed • TRL 2 – technology concept formulated • TRL 3 – experimental proof of concept • TRL 4 – technology validated in lab • TRL 5 – technology validated in relevant environment (industrially relevant environment in the case of key enabling technologies) • TRL 6 – technology demonstrated in relevant environment (industrially relevant environment in the case of key enabling technologies) • TRL 7 – system prototype demonstration in operational environment • TRL 8 – system complete and qualified • TRL 9 – actual system proven & running in operational environment

Please provide some sentences explaining your Technology Readiness Level

This technology is already on the market, mainly in the Scandinavian countries, and produced in particular by some technology providers from Denmark (see below)

There is also a joint EU funded project on slurry acidification which disseminates information, demonstrates technologies and provides enhanced data on the technology, which can be found at: http://balticslurry.eu.

If the proposed solution/ technique is currently at low TRL (≤5), is upscaling foreseen within the next year(s)?

If the proposed solution/ technique is currently at high TRL (≥7), is there any product already being produced from the proposed solution/ technique?

- *If yes, what is the name of the product :*
  JH Agro www.jhagro.com
  BioCover A/S www.biocover.dk
  Ørum www.oerum-smeden.dk

- *Short description of the product*
  See the websites above.

- *Are there any EC/MS Authority permits already for use of the product (title or link if available)?*
  YES - there are VERA certifications for several of the products.

18 Slurry acidification with industrial acids to reduce NH_3 volatilisation from animal husbandry

POTENTIAL LINKAGE TO THE PROJECT

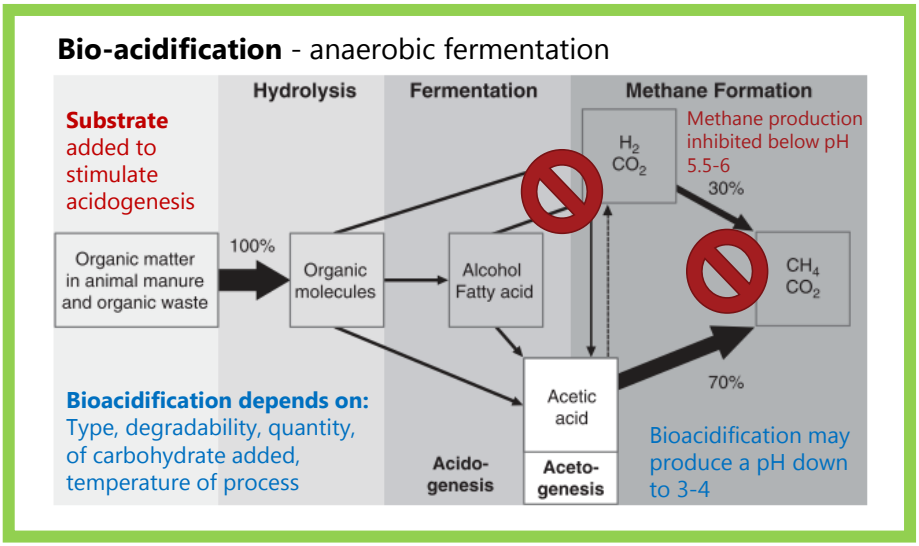
Indicate to which agro-typology under study and which potential research line of the project, your proposed solution/technique contributes :

X	Pig Production
	Poultry Production
X	Cattle Farming
X	Open field cultivation of cereals or maize
	Open air cultivation of vegetables
	Orchards
	Agro-energy systems (e.g. biogas)
X	Animal Byproduct processing (e.g. manure processing)

Innovative solutions for optimized nutrient & GHG in animal husbandry	X
Innovative soil, fertilisation & crop management systems & practices	X
Tools, techniques & systems for higher-precision fertilization	X
Biobased fertilisers (N, P) and soil enhancers (OC) from agro-residues	X
Novel animal feeds produced from agro-residues	
Other, please specify :	

19 Slurry bio-acidification using organic waste products to reduce NH_3 volatilisation and increase fertiliser value

AIM OF THE TECHNOLOGY



Provide a brief description of the proposed management solution or technique.

- *What is the purpose/aim of the innovative solution/technique?*
  Bioacidification aims to reduce ammonia emissions to the atmosphere from the animal slurry management, similar to slurry acidification using sulfuric acid, but without using industrial, synthetic acids. Bioacification is based on decreasing the pH through natural fermentation in the manure. This alternative is relevant because:
  - Although sulfuric acid is one of the cheapest industrial acids, it is still a cost
  - Organic farms under current EU and national organic certification schemes are not allowed to use synthetic acids, and these farms also need to reduce their ammonia emissions and increase manure fertiliser value and
  - Acidification with sulfuric acid increases the sulphur content to a level, which prohibits extensive use of acidified slurry in anaerobic digestion biogas plants, due to the inhibition of the biogas process.
  - Concentrated sulfuric acid is a hazardous and corrosive chemical and may cause excessive foaming when added to slurry.

- *What is the underlying working principle?*
  By lowering the pH of the slurry through bioacidification the equilibrium betwenn NH_3 and NH_4^+ shift towards ammonium (NH_4^+). Ammonium is the dissolved form of inorganic N in the slurry and does not volatilise to the atmosphere, but stays in the slurry.
  Bioacidification is based on stimulating the formation of organic acids (especially lactic and acetic acid) in the manure by fermentation. This can be done by adding simple sugars or other carbohydrates that easily hydrolyse into sugars, which promote lactic acid fermentation and a rapid pH drop, preventing methane formation (see figure).

- *What is the current and foreseen scale of operations (e.g. kg, tonnes/year)?*
  Sugar concentrations of around 1% are sufficient to drop slurry pH below 6.5, while sugar concentrations of around 3% are sufficient to drop slurry pH below 5, lasting for up to 2 weeks. However, larger additions are required to maintain the pH decline for longer periods.

19 Slurry bio-acidification using organic waste products to reduce NH_3 volatilisation and increase fertiliser value

Pure sugars are costly, but other residual or waste carbohydrates like molasses, soy-molasses (from soybean processing), maltose syrup, paper pulp sludge may also be useful substrates for stimulating fermentation.

- *Why is it innovative when compared to existing (farming) practices?*
  This technology enables both reduced environmental impacts from ammonia emissions and utilisation of residual biomasses of little economic value.
  Furthermore, manure bioacidification can be applied both by organic farms and on farms using manure for anaerobic digestion (residual carbohydrates will furthermore enhance biomethane formation)
  Similar to slurry acidification using industrial acids (see separate factsheet) the reduction in ammonia emission inside the animal house improves animal welfare and productivity as well the human working environment, due to lowering concentrations of ammonia in the stable air which is harmful to mammal respiratory organs.

- *How does it improve the Nitrogen-Phosphorus and/or Carbon cycles in agriculture?*
  The ammonia (NH3) that would volatilise and pollute the atmosphere is retained in the bioacidified slurry as additional nitrogen and will potentially result in an increase in agricultural mineral fertiliser equivalent value of the acidified manure. However, very few studies have yet been conducted on the fertiliser value of bioacidified manure, so this still needs to be verified.

- *Add a separate line on the location of your management solution: "Currently this technology / technique / management solution is applied in ……. (city, region, country))."*
  Currently bioacidification technology is not yet applied commercially, but several research studies have been conducted, and one demonstration project (pilot scale, on-farm) has been conducted inI Denmark in 2018.

19 Slurry bio-acidification using organic waste products to reduce NH_3 volatilisation and increase fertiliser value

TRL (Technology Readiness Level) – how close is your solution to the market?

Use the slider above to position the current TRL* of your proposed solution

* TRLs are a type of measurement system used to assess the maturity level of a particular technology. Where a topic description refers to a TRL, the following definitions apply, unless otherwise specified:

• TRL 1 – basic principles observed • TRL 2 – technology concept formulated • TRL 3 – experimental proof of concept • TRL 4 – technology validated in lab • TRL 5 – technology validated in relevant environment (industrially relevant environment in the case of key enabling technologies) • TRL 6 – technology demonstrated in relevant environment (industrially relevant environment in the case of key enabling technologies) • TRL 7 – system prototype demonstration in operational environment • TRL 8 – system complete and qualified • TRL 9 – actual system proven & running in operational environment

Please provide some sentences explaining your Technology Readiness Level

This technology is not yet on the market, but there is great interest in the Scandinavian countries, and one pilot project has been conducted. Provided current interest is continued, it is likely that more pilot or full-scale demonstrations may be carried out.

There is also a joint EU funded project on slurry acidification which disseminates information, demonstrates technologies and provides enhanced data on the technology, which can be found at: http://balticslurry.eu.

If the proposed solution/ technique is currently at low TRL (≤5), is upscaling foreseen within the next year(s)?

YES definitively, see above and below. JH Agro www.jhagro.com has made one pilot demonstration plant.

If the proposed solution/ technique is currently at high TRL (≥7), is there any product already being produced from the proposed solution/ technique?

- *If yes, what is the name of the product :*
- *Short description of the product*
- *Are there any EC/MS Authority permits already for use of the product (title or link if available)?* NO.

19 Slurry bio-acidification using organic waste products to reduce NH_3 volatilisation and increase fertiliser value

POTENTIAL LINKAGE TO THE PROJECT

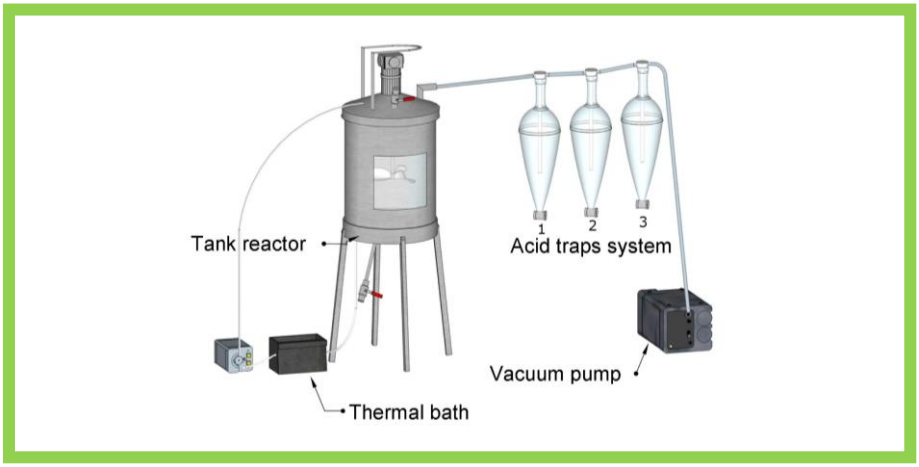
Indicate to which agro-typology under study and which potential research line of the project, your proposed solution/technique contributes :

X	Pig Production
	Poultry Production
X	Cattle Farming
X	Open field cultivation of cereals or maize
	Open air cultivation of vegetables
	Orchards
	Agro-energy systems (e.g. biogas)
X	Animal Byproduct processing (e.g. manure processing)

Innovative solutions for optimized nutrient & GHG in animal husbandry	X
Innovative soil, fertilisation & crop management systems & practices	X
Tools, techniques & systems for higher-precision fertilization	X
Biobased fertilisers (N, P) and soil enhancers (OC) from agro-residues	X
Novel animal feeds produced from agro-residues	
Other, please specify :	

20 Low temperature ammonium-stripping using vacuum

AIM OF THE TECHNOLOGY



Provide a brief description of the proposed management solution or technique.

- *What is the purpose/aim of the innovative solution/technique?*
  The aim of the low temperature vacuum ammonium-stripping solution is the recovery of ammonia from livestock slurry and obtaining an ammonia salt that can be reused as a fertiliser. The recovered ammonia can be in the form of an ammonium sulphate or nitrate salt solution

- *What is the underlying working principle?*
  This technology is based on the evaporation of ammonia in vacuum conditions. When vacuum is applied to an enclosed reactor, boiling point temperature decreases below normal boiling point, thus reducing energy cost as a result of lower heating requirement. In addition, gas-phase ammonia mass transfer is boosted by suction effect of the applied vacuum.
  A stainless steel reactor equipped with a serpentine for the circulation of hot water is needed. A thermal bath will maintain the reactor temperature at a range of 40-45º C. A mixing system is also required to improve the ammonia transference from the liquid to the gas phase. A vacuum pump is connected to the reactor in order to provide an operation pressure between 20-40 kPa. Finally, a system of acid traps will allow to absorb the evaporated ammonia.
  To improve the ammonia recovering efficiency, the liquid fraction of raw or digested livestock manure should be used, since solid particles content interferes with ammonia evaporation. An increase of the pH to a value of 9-10 also boost ammonia evaporation.

- *What is the current and foreseen scale of operations (e.g. kg, tonnes/year)?*
  Currently, at pilot plant scale, around 15 tonnes/year of raw or digested livestock manure can be treated with a 30 L reactor operated in discontinuous mode (6 hours per batch). Further improvement of the area-volume relation of the system and scale-up will allow for a higher capacity of treatment.

- *Why is it innovative when compared to existing (farming) practices?*
  This technology favours ammonia recovery by evaporation without lower heating requirements, differently from conventional ammonia stripping and absorption systems. This technology can be applied directly to the liquid fraction of raw livestock manure, in order to avoid ammonia gas emissions to the atmosphere, or as a subsequent step of an anaerobic digestion process.

20 Low temperature ammonium-stripping using vacuum

- *How does it improve the Nitrogen-Phosphorus and/or Carbon cycles in agriculture?*
  Nitrogen cycle in agriculture is improved because ammonia content of the liquid fraction of raw or digested livestock manure can be recovered and be reused as a fertiliser, closing nutrient cycle. Furthermore, ammonia emissions to atmosphere due to livestock manure storage are reduced.
  The processed livestock manure with lower nitrogen content, should be managed as fertilizer accordingly its composition (e.g. new N/P ratio) or further processed (e.g. to recover phosphorus)

- *Add a separate line on the location of your management solution: "Currently this technology / technique / management solution is applied in ……. (city, region, country))."*
  Currently this technology has been tested at pilot scale in the IRTA facilities (Caldes de Montbui, Barcelona, Spain).

TRL (Technology Readiness Level) – how close is your solution to the market?

Use the slider above to position the current TRL* of your proposed solution

* TRLs are a type of measurement system used to assess the maturity level of a particular technology. Where a topic description refers to a TRL, the following definitions apply, unless otherwise specified:

• TRL 1 – basic principles observed • TRL 2 – technology concept formulated • TRL 3 – experimental proof of concept • TRL 4 – technology validated in lab • TRL 5 – technology validated in relevant environment (industrially relevant environment in the case of key enabling technologies) • TRL 6 – technology demonstrated in relevant environment (industrially relevant environment in the case of key enabling technologies) • TRL 7 – system prototype demonstration in operational environment • TRL 8 – system complete and qualified • TRL 9 – actual system proven & running in operational environment

Please provide some sentences explaining your Technology Readiness Level

The recovery of ammonia through low temperature ammonium-stripping using vacuum has been assessed at lab scale and at pilot scale (30 L evaporator tank). The obtained results make feasible to apply this technology at farm.

If the proposed solution/ technique is currently at low TRL (≤5), is upscaling foreseen within the next year(s)?

YES.

If the proposed solution/ technique is currently at high TRL (≥7), is there any product already being produced from the proposed solution/ technique ?

- *If yes, what is the name of the product :*
- *Short description of the product*
- *Are there any EC/MS Authority permits already for use of the product (title or link if available)?*

20 Low temperature ammonium-stripping using vacuum

POTENTIAL LINKAGE TO THE PROJECT

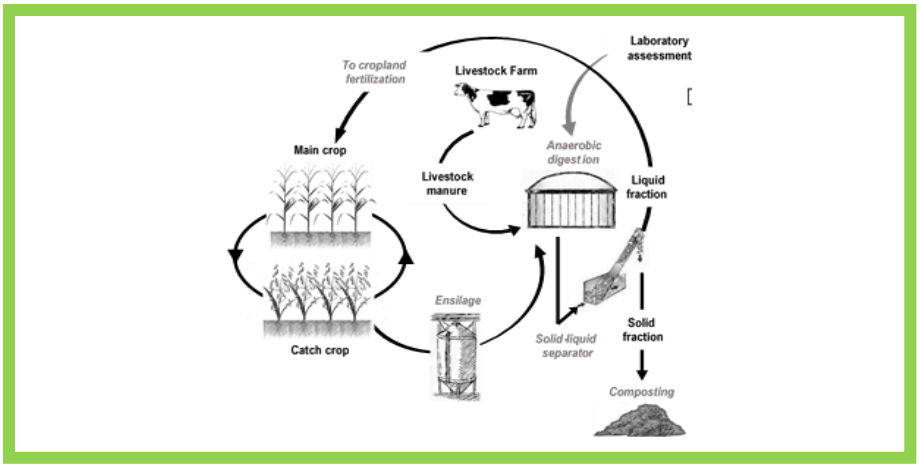
Indicate to which agro-typology under study and which potential research line of the project, your proposed solution/technique contributes :

	Pig Production
	Poultry Production
	Cattle Farming
	Open field cultivation of cereals or maize
	Open air cultivation of vegetables
	Orchards
	Agro-energy systems (e.g. biogas)
X	Animal Byproduct processing (e.g. manure processing)

Innovative solutions for optimized nutrient & GHG in animal husbandry	X
Innovative soil, fertilisation & crop management systems & practices	
Tools, techniques & systems for higher-precision fertilization	
Biobased fertilisers (N, P) and soil enhancers (OC) from agro-residues	
Novel animal feeds produced from agro-residues	
Other, please specify :	

21 Catch crops to reduce N losses in soil and increase biogas production by anaerobic co-digestion

AIM OF THE TECHNOLOGY



Provide a brief description of the proposed management solution or technique.

- *What is the purpose/aim of the innovative solution/technique?*
  The aim of the introduction of catch crops in crop rotation is to optimise nitrogen management in agriculture, by the reduction of nitrate content of the soil after harvesting the main crop and thus nitrogen losses. On the other hand, the use of catch crops as a co-substrate in anaerobic digestion of livestock manure aims to increase biogas production in comparison with conventional anaerobic mono-digestion of manure. Finally, the use of digestate as fertilizer enable to close the nutrient lop

- *What is the underlying working principle?*
  Catch crops are fast growing crops that are grown between two main crops, which allow retaining part of the remaining nitrogen into soil since the catch crop absorbs part of the remaining nutrients to grow up. Furthermore, the catch crop protects the soil from erosive phenomena and against the formation of the soil crust, improves the habitat of the micro-wildlife and increases the landscape diversity. Subsequently, this catch crop can be incorporated into the soil in the form of green fertiliser, or be destined to other uses, such as co-digestion with livestock manure.
  Catch crops must present the following characteristics: fast growth, low water requirements, few or no requirements for agronomic practices, must be well adapted to the climatology of the area, and must present high rates of nutrient withdrawals. The species that are evaluated as possible anaerobic digestion co-substrates catch crops are Ryegrass (*Lolium multiflorum)*, Oilseed Rape (*Brassica napus*) and Black Oat (*Avena strigosa*). Furthermore, other proposed species are Lacy phacelia (*Phacelia tanacetifolia*), Flax (*Linum usitatissimum*), White mustard (*Sinapis alba*).
  Production of catch crops have been reported to be between 3 - 6 t/ha (dry matter), and the amount of nitrogen and phosphorus that catch crops have been able to absorb varies between 70 -150 kg/ha and 10 - 20 kg/ha, respectively.
  Anaerobic digestion plants that treat livestock manure usually use co-substrates to increase biogas production, due to the low carbon to nitrogen (C/N) ratio of livestock manure. The use of a carbon-rich co-substrate improves substrate characteristics and compensate its carbon

deficiency. Thus, the co-digestion of catch crops with livestock manure improves C/N relation of the anaerobic digestion substrate and the subsequent biogas production.

- *What is the current and foreseen scale of operations (e.g. kg, tonnes/year)?*
  It could be foreseen an essay for the use of catch crops as anaerobic digestion co-substrate in a full-scale biogas plant with a treatment capacity of 36500 tonnes/year.

- *Why is it innovative when compared to existing (farming) practices?*
  The use of catch crops between two main crops avoids nitrogen leaching from soil to groundwater and soil erosion. Biologic activity of the soil and fertility are also favoured.
  The anaerobic digestion of livestock manure is characterised by low biogas yields. Lab-scale assays have shown that the co-digestion of livestock manure with catch crops (10% w/w) such as Ryegrass (*Lolium multiflorum)*, Oilseed Rape (*Brassica napus*) and Black Oat (*Avena strigosa*) can increase biogas yield between 35-48%, in comparison with a conventional anaerobic mono-digestion of manure.

- *How does it improve the Nitrogen-Phosphorus and/or Carbon cycles in agriculture?*
  The nitrogen cycle in agriculture is improved using catch crops because nitrogen leaching after harvesting the main crop is avoided. The catch crop will absorb nitrogen that is not used by the main crop. After the co-digestion of the catch crop with livestock manure, the liquid fraction of the digestate can be used for cropland fertilisation, while the solid fraction can be exported as organic fertiliser, closing nutrient cycle.

- *Add a separate line on the location of your management solution: "Currently this technology / technique / management solution is applied in ……. (city, region, country))."*
  Currently a pilot test of this technology has been performed at the anaerobic digestion plant in Sant Esteve de Guialbes (Catalonia, Spain), and fields placed at Bàscara and Vilademuls (Catalonia, Spain).
  The technical and economic viability of this strategy is strongly dependent on climate conditions and catch crop species used. Tests in different climate regions and with different catch crops species is the advisable to have a European picture of its viability.

21 Catch crops to reduce N losses in soil and increase biogas production by anaerobic co-digestion

TRL (Technology Readiness Level) – how close is your solution to the market?

Use the slider above to position the current TRL* of your proposed solution

* TRLs are a type of measurement system used to assess the maturity level of a particular technology. Where a topic description refers to a TRL, the following definitions apply, unless otherwise specified:

• TRL 1 – basic principles observed • TRL 2 – technology concept formulated • TRL 3 – experimental proof of concept • TRL 4 – technology validated in lab • TRL 5 – technology validated in relevant environment (industrially relevant environment in the case of key enabling technologies) • TRL 6 – technology demonstrated in relevant environment (industrially relevant environment in the case of key enabling technologies) • TRL 7 – system prototype demonstration in operational environment • TRL 8 – system complete and qualified • TRL 9 – actual system proven & running in operational environment

Please provide some sentences explaining your Technology Readiness Level

The co-digestion of catch crops has been evaluated at a anaerobic digestion plant in Sant Esteve de Guialbes (Catalonia, Spain), and 23 Ha of fields have been planted with catch crops at Bàscara and Vilademuls (Catalonia, Spain) as a pilot test.

If the proposed solution/ technique is currently at low TRL (≤5), is upscaling foreseen within the next year(s)?

If the proposed solution/ technique is currently at high TRL (≥7), is there any product already being produced from the proposed solution/ technique?

- *If yes, what is the name of the product :*
- *Short description of the product*
- *Are there any EC/MS Authority permits already for use of the product (title or link if available)?*

21 Catch crops to reduce N losses in soil and increase biogas production by anaerobic co-digestion

-

POTENTIAL LINKAGE TO THE PROJECT

Indicate to which agro-typology under study and which potential research line of the project, your proposed solution/technique contributes :

	Pig Production
	Poultry Production
	Cattle Farming
X	Open field cultivation of cereals or maize
	Open air cultivation of vegetables
	Orchards
X	Agro-energy systems (e.g. biogas)
X	Animal Byproduct processing (e.g. manure processing)

Innovative solutions for optimized nutrient & GHG in animal husbandry	X
Innovative soil, fertilisation & crop management systems & practices	X
Tools, techniques & systems for higher-precision fertilization	
Biobased fertilisers (N, P) and soil enhancers (OC) from agro-residues	
Novel animal feeds produced from agro-residues	
Other, please specify :	

22 BIO-PHOSPHATE: high temperature reductive thermal process recovery of concentrated Phosphorus from food grade animal bones

AIM OF THE TECHNOLOGY

Provide a brief description of the proposed management solution or technique.

- *What is the purpose/aim of the innovative solution/technique?*
  The purpose/aim of the Bio-Phosphate system is to substitute and replace the high Cadmium and Uranium content non-renewable and imported rock phosphates (different types) based mineral fertilizers with a natural, fully safe, renewable and high efficient organic innovative fertilizer in economical high nutrient concentration for less cost, while mitigating environmental contamination and GHG emissions. The high added value recovered and safe Phosphorus innovative Bio-Phosphate organic fertilizer is produced food grade animal bone grist, which is an unexploited biomass. Food grade animal bone grist is a food industrial rendering by-product that is available in economical industrial scale. The Bio-Phosphate production of market competitive BIO-NPK-C formulated compound organic fertilizer aiming an economical and efficient reuse of recovered Phosphorus at regional scale with coherent integration and closing loops approaches. The break-through technology is focusing on phosphorus, nitrogen and carbon cycling in agro-ecosystems while providing wide range of integrated solutions in European dimensional economical scale for the interests and benefits of the SME farmers in the fields of organic and low input cultivation applications.

- *What is the underlying working principle?*
  Phosphorus is key essential for all life and all efficient agricultural food production. No Phosphorus availability results no food production. The only phosphate mineral natural resource with high Phosphorus concentration on this Planet Earth in industrially and economically available scale is the apatite mineral, which is having two major natural forms, mineral phosphates and bio-origin animal bones. However, mineral phosphates having naturally occurring contaminations, including potential toxic elements such as Cadmium, Uranium and Thorium, in most cases in rather high concentration. As the EU is importing and using over 6 million tons of mineral phosphates (over 90% of the total agri applications) for agricultural applications, the import substitution and economical replacement with recovered and safe material Phosphorus streams that can be produced in European dimension is an key important objective of the EU. This is why titled the EC Commission the mineral phosphates and Phosphorus products as critical raw material (COM(2017) 490 final).

22 BIO-PHOSPHATE: high temperature reductive thermal process recovery of concentrated Phosphorus from food grade animal bones

The bio-origin animal bone is of apatite origin, therefore containing same high concentrated Phosphorus content than its mineral version. There are no any other naturally high Phosphorus concentrated materials than animal bones, but it does not containing potential toxic elements. After specific carbonization/formulation processes of the animal bones, unique character product made (ABC Animal Bone Char – Bio-Phosphate) with high environmental, ecological and human safety. This carbon refinery process makes the Bio-Phosphate highly optimal for innovative organic fertilizer for commercial market competitive price and in European market dimension industrial scale.

The animal by-product rendering industry processing large amount of animal bones for production of gelatine, pet-food, China Bone and bone grist. While poultry bones used for pet-food, the cattle bones and part of pig bones are the input materials for the 3R zero emission technology based Bio-Phosphate carbon refinery. However, carbonization of animal bone requires highly advanced and specifically designed high thermal processing technology at 850°C material core temperature for production of safe Bio-Phosphate products that meet the new and strict safety and environmental regulations. The Bio-Phosphate phosphorus recovery and carbon refinery is a purposely designed and specific carbonization system with zero emission performance with interlinked wide range of BIO-NPK-C formulations, incl. biotechnological formulations as well.

- *What is the current and foreseen scale of operations (e.g. kg, tonnes/year) ?*

Current scale: 2,000 t/y throughput capacity with 1,200 t/y Bio-Phosphate production with 30% P_2O_5 concentration. BIO-NPK-C formulation as of user need.

Foreseen scale 2019/2020: 20,800 t/y throughput capacity/unit with 12,500 t/y Bio-Phosphate production with 30% P_2O_5 concentration. BIO-NPK-C formulation made as of specific organic and low input farming user need.

Foreseen scale 2020-2025: ten projects targeted in the EU, USA and Australia with 125,000 t/y Bio-Phosphate production with >30% P_2O_5 concentration. BIO-NPK-C formulation made as of specific organic and low input farming user need.

Foreseen scale 2025-2030: at least additional 20-25 projects targeted in the EU, USA and Australia with additional 250,000 t/y Bio-Phosphate production with 30% P_2O_5 concentration. BIO-NPK-C formulation made as of specific organic and low input farming user need. Estimated total production volume by 2030 is ≈+400,000 t/y Bio-Phosphate/year.

Phosphate import substitution and EU27 replacement value of the Bio-Phosphate technology and product system <2030 as of conservative calculation and plans = at least >**7%/year continous P fertilizer substitution potential in all the EU27 for long term.**

- The EU agriculture is importing ≈6 million t/y mineral phosphate rock, while the EU production is ≈900k/y only (Finland) for chemosynthetic processing of different types of phosphate fertilizers at ≈13% P or ≈30% P2O5 concentrations or higher. Phosphate rock is used predominantly to produce phosphate fertilizers (mainly, via phosphoric acid)
- All mineral phosphate rock naturally containing high levels of Cadmium and Uranium. This is why the P-rock processing industry is the world largest producer of the enriched Uranium fuels. In Germany the use of the phosphate fertilizers from 1951-2011 has resulted in a cumulative application of approx. 14,000 tons of Uranium in agri land.
    - "Fertilizer derived Uranium and its threats to human health" dx.doi.org/10.1021/es4002357 | Environ. Sci. Technol. 2013, 47, 2433−2434.
    - "Mobility of fertiliser-derived uranium in arable soils and its contribution to uranium concentrations in groundwater and tap water" Jacobs University 2011.

  - The Uranium concentration from different types of P rocks and P containing fertilisers is up to 200 mg/kg (Kratz et al., 2008) (mean concentration of Uranium 61.3 mg/kg), while maximum Cadmium concentration 56 mg/kg (mean concentration of Cd 12 mg/kg). The low Cd/U contaminated P-rock resources already exhausted, while the overall reserves of mineral phosphorous last little more than one hundred years.
  - Official EU reference for P import substitution: European Commission - press release December 12, 2018 (IP/18/6161 Circular Economy: Agreement on Commission proposal to boost the use of organic and waste-based fertilisers) and December 2, 2015 (IP/15/6203).
- The EC titled phosphate rock and Phosphorus as Critical Raw Materials (COM/2017/490), where P-rock import reliance rate is 88% and P is100% both as non-substitutable substances with high economic importance and high supply risk parameters.
- The Fertilizers Regulation revision aiming to significantly decrease the Cadmium in fertilizers form the presently used 90 mg/kg and introduce an initial limit of 1.5 mg/kg for organic farming and 60 mg cadmium/kg phosphorus for mineral fertilizers, that is to be tightened to 40 mg/kg after 6 years, and to 20 mg/kg after 16 years. Several Member States using 1.5 mg/kg Cadmium limit since long time.

- *Why is it innovative when compared to existing (farming) practices ?*

The new Fertilizers Regulation revision opening the Single Market for organic fertilisers and providing common rules on safety, quality and labelling requirements for all fertilisers to be traded freely across the EU. The innovative EC fertilizers, (that so far regulated by MS regulations only but that resulted differences in the 27 MS), will open new and EU wide user opportunities when compared to existing (farming) practices.

The Regulation for the first time introduces limits for toxic contaminants, including a new 60 mg/kg limit for Cadmium, which will be further reviewed 4 years after the date of application. This will guarantee a high level of soil protection and reduce health and environmental risks, while allowing producers to adapt their manufacturing process to comply with the new limits. To encourage the use of even safer fertilisers, producers will also be able to use a low-Cadmium label applicable to products with less than 20mg/kg cadmium content. These rules will affect those fertilisers that choose to affix CE marking.

Additionally the Regulation also offers the possibility to opt for optional harmonisation. A manufacturer who does not wish to CE-mark the product can choose to comply with national standards and sell the product to other EU countries based on the principle of mutual recognition.

Organic farmers using soft rock phosphate with up to 90 mg/kg Cadmium levels and unknown Uranium contaminations, that is often higher load than the Cadmium itself. So far the Cadmium, Uranium and other contamination in phosphorus fertilizers was not regulated properly, as these potential toxic elements (metals and metalloids) not measured at all and not regulated on EU level, but MS only.

The new EC Fertilizer Regulation revision identifying Cadmium as priority toxic element. For the organic farming use 1/60 decreasing the Cadmium level from 90 mg/kg to 1.5 mg/kg maximum level negotiated, that lower level have already been applied in some Member States since log time.

In the intensive farming user cases the Cadmium level is decreased provisionally to 60 mg/kg as of November 20, 2018 European Parliament and Council agreement and further timeline consider for 40 mg/kg and finally 20 mg/kg targeted decrease. Notice: while several MS having

stricter regulation for Cadmium content in fertilizers and soils, (such as in The Netherlands, Finland and Sweden requested the introduction of a stricter Cd limit as well), other MS opposed any limits below 60 mg/kg. Further debates expected in the future; also regulation's relevance for the organic sector, voluntary labelling and continued accumulation of Cadmium/Uranium in soils.

The Cadmium and Uranium contaminated, unsafe and non-renewable mineral P-rock based fertilizers with economical high nutrient concentration have been large scale applied in the European agriculture since long time. However, to maintain sustainability for long term, there is a need for substitution of P-rock mineral fertilizers with same high nutrient concentrated recovered and renewable innovative Phosphorus fertilizer substance, which is safe, does not containing unwanted toxic substances, efficient and economical while available in European industrial scale. The challenge is, the only high nutrient concentrated, recovered, natural and fully safe Phosphorus organic fertilizer substance available is the ABC Animal Bone Char Bio-Phosphate.

Only the apatite minerals containing high P on this Planet Earth, which is having two natural forms, mined mineral rock phosphate and all bones. This is the reason for high P concentration in the Bio-Phosphate.

The Bio-Phosphate is a new generation Phosphorus recovery technology and product system for organic and low input horticultural applications, that has been expressively developed to meet the new EC Circular Economy Fertilizers Regulation revision (COM (2016) 157) standards and norms and other strict MS regulations as well for the rapidly increasing market demands for safe and economical bio-fertilizers. The 3R technology for Bio-Phosphate recovery is vital part and strategy of the EC Circular Economy Fertilizers Regulation revision.

- *How does it improve the Nitrogen-Phosphorus and/or Carbon cycles in agriculture?*

  The Bio-Phosphate is a renewable and high sustainability recovered natural substance that produced with zero emission performance and interlinked wide range of BIO-NPK-C formulations, incl. biotechnological formulations as well. All formulations materials used are also renewable and high sustainability recovered natural substance.

- *Add a separate line on the location of your management solution: "Currently this technology / technique / management solution is applied in ……. (city, region, country))."*

  The advanced and new generation high material core temperature pyrolysis 3R technology has been specifically developed for Bio-Phosphate recovery under the EC Commission RTD programmes 2002-2018 (FP5, FP6, FP7, H2020, CIP-Eco-innovation and other industrial research programmes) from TRL5 to TRL8/IRL8. The 3R technology for Bio-Phosphate recovery development invented and mainly large scale financed by the original inventor and S&T senior engineer Edward Someus (Terra Humana Ltd.) and co-financed by the EC Commission since 2002. The central location of the management solution has been in Sweden and Hungary, while large number of specialized and high-qualified partners cooperated from ten countries actively participated in the applied RTD including application tests in different climatic and soil conditions (Italy, The Netherlands, Germany, Spain, Hungary, Slovenia, Israel, UK, USA and Australia).

  The European central location for solution is at the Biofarm Agri Research Station (West Budapest area) in Hungary https://goo.gl/maps/wHxmZ7J1ChJ2 with several application schedules at Producer Organizations.

22 BIO-PHOSPHATE: high temperature reductive thermal process recovery of concentrated Phosphorus from food grade animal bones

EC Circular Economy Fertilizers Regulation revision for recovered Phosphorus organic based fertilisers on the EU Single Market from 2022 - related to the CE-mark fertilizers and MS optional harmonisations to comply with MS national standards.

Preliminary comparison of major characters of 3 pre-selected high and low concentrated recovered Phosphorus product steams:

	ABC Bio-Phosphate mg/kg	**Struvite mg/kg**	**Digested manure pellet mg/kg**	EC threshold mg/kg	MS threshold mg/kg
Farm applications	Organic Low input	Intensive inorganic	Intensive		
Average dose kg/ha	300	500	1500		
Authority permit	Y	N	Y		
Cadmium mg/kg	0.3	0.4	1 (as of high dose main Cd source)	60-40-20 1.5 organic	1.5 organic
Zn mg/kg	198	139	1133	600	600
Cu mg/kg	2	3	402	200	200
Al mg/kg	n/d	n/a	1073		
Fe mg/kg	87	n/a	2480		
Pharmaceuticals	Not relevant	High risk	High risk		
Illicit drugs	Not relevant	High risk	Not relevant		
Microbial contamination	Not relevant	High risk	High risk		
PAH16	0.07	0.12	n/a	4	1
PAH19		n/a	n/a	n/a	1
P2O5 % Phosphorus mg/kg	P_2O_5: 31.9% 139000	P_2O_5: 23.5%	P_2O_5: 5.9%		
Calcium mg/kg	297000 CaO: 41.5%	n/a	500		
Output production scale tons/year/unit Input in K-tons/y	>12500 t/y Input: 21 K-tons/y bone yield= 60%	9 to 100 t/y	<9000 t/y Input: 150 K-tons/y manure yield= 6%		

22 BIO-PHOSPHATE: high temperature reductive thermal process recovery of concentrated Phosphorus from food grade animal bones

The blank ABC Bio-Phosphate product is further on BIO-NPK-C formulated for organic/low input farming applications in any configuration.

Reminder: Producers accept their responsibility when they design their products to minimize the lifecycle environmental impacts and when they accept legal, physical or economic responsibility for the environmental impacts that cannot be eliminated by design" [Davis, Gary 1994].

Notice: the JRC STRUBIAS mentioned MBM meat and bone meal is incorrect terminology. Meat meal does not containing any Phosphorus at all with economic importance. If high protein content MBM or processed bone meal is utilized in open ecological environmental, than there is a very high risk for cross and recontamination during applications. Animal rendering by-products (MBM, bone meal, PAP) are sterile products at the point of production only. As because animal rendering by-products are mammal protein based, the following human and animal pathogens are prime risk potential: salmonella, anthrax, TBC and mouth and foot disease, and others as well. Producers having full responsibility for animal by-product disease cross and recontamination cases (manufacturers of products bear responsibility for the environmental impacts of their products throughout the products life-cycles, including upstream impacts inherent in the selection of materials for the products, impacts from manufacturers, production process itself, and downstream impacts form the use and disposal of the products as well).

22 BIO-PHOSPHATE: high temperature reductive thermal process recovery of concentrated Phosphorus from food grade animal bones

TRL (Technology Readiness Level) – how close is your solution to the market?

Use the slider above to position the current TRL* of your proposed solution

* TRLs are a type of measurement system used to assess the maturity level of a particular technology. Where a topic description refers to a TRL, the following definitions apply, unless otherwise specified:

• TRL 1 – basic principles observed • TRL 2 – technology concept formulated • TRL 3 – experimental proof of concept • TRL 4 – technology validated in lab • TRL 5 – technology validated in relevant environment (industrially relevant environment in the case of key enabling technologies) • TRL 6 – technology demonstrated in relevant environment (industrially relevant environment in the case of key enabling technologies) • TRL 7 – system prototype demonstration in operational environment • TRL 8 – system complete and qualified • TRL 9 – actual system proven & running in operational environment

Please provide some sentences explaining your Technology Readiness Level

The Bio-Phosphate is a TRL8/IRL8 – system field demonstrated, qualified and validated metrics in operational environment towards TRL 9 – actual system proven & running in operational environment. where TRL9 is a full industrial, market and commercial replication model, economical full production scale under international market competitive conditions (20,800 t/y throughputs) in the EU, USA and Australia.

If the proposed solution/ technique is currently at high TRL (≥7), is there any product already being produced from the proposed solution/ technique?

- *If yes, what is the name of the product :*
  PROTECTOR, biotechnologically formulated organic Bio-Phosphate fertilizer.

- *Short description of the product:*
  ABC Animal Bone Char Bio-Phosphate granulate is a high concentrated over 30% P2O5 phosphate content specific material with macroporous surface characteristics. For agricultural applications the material is BIO-NPK-C formulated, incl. biotechnologically formulations with Phosphorus mobilization selected fungus strains and adapted by product specific solid-state fermentation and formulation technology. There are wide ranges of formulations available as well, in any BIO-NPK-C innovative bio-compound fertilizer configurations.

- *Are there any EC/MS Authority permits already for use of the product (title or link if available)?*
  YES, Government Authority permitted product, permit number: 04.2/102-2/2015 (issued in 2015 by the National Food-chain Safety Office: Plant, Soil and Agricultural Environmental Protection Directorate- EC Mutual Recognition regulation applied). The Authority permit approval is based on four years accredited and comprehensive safety and agronomical efficiency tests in two climatic and soil conditions with several tests plants.

22 BIO-PHOSPHATE: high temperature reductive thermal process recovery of concentrated Phosphorus from food grade animal bones

POTENTIAL LINKAGE TO THE PROJECT

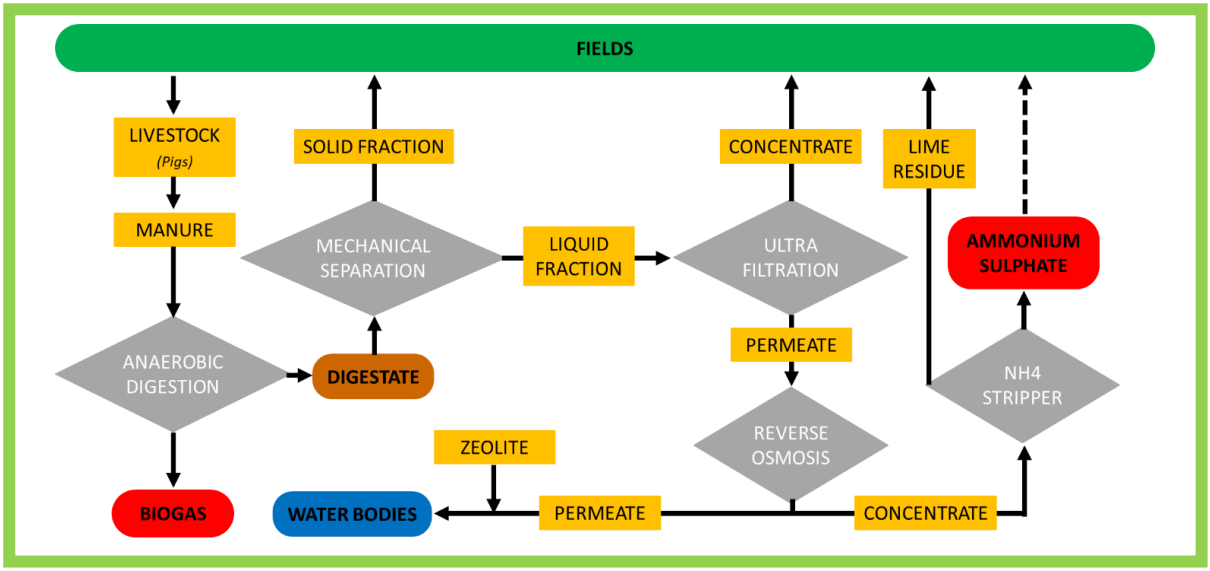
Indicate to which agro-typology under study and which potential research line of the project, your proposed solution/technique contributes :

	Pig Production
	Poultry Production
	Cattle Farming
	Open field cultivation of cereals or maize
X	Open air cultivation of vegetables
X	Orchards
X	Agro-energy systems (green electricity)
X	Animal Byproduct processing (e.g. manure processing)

Innovative solutions for optimized nutrient & GHG in animal husbandry	
Innovative soil, fertilisation & crop management systems & practices	X
Tools, techniques & systems for higher-precision fertilization	X
Biobased fertilisers (N, P) and soil enhancers (OC) from agro-residues	X
Novel animal feeds produced from agro-residues	
Other, please specify :	

23 Pig manure refinery into energy (biogas) and fertiliser using a combination of techniques applicable at industrial pig farms

AIM OF THE TECHNOLOGY



Provide a brief description of the proposed management solution or technique.

- *What is the purpose/aim of the innovative solution/technique?*
  The proposed innovative solution combines physical and chemical treatments in order to obtain a sustainable process of valorisation of livestock manure. The whole process aims to close Carbon, Nitrogen and Phosphorus loops, since the obtained by-products can be reused in agriculture as fertilizers and soil quality enhancers.

- *What is the underlying working principle?*
  Manure from pig farms is treated by a process of Anaerobic Digestion, which recovers energy in form of biogas. The obtained product of anaerobic digestion process, or digestate, can serve as substrate for a series of physical and chemical processes that permit the separation and concentration of the liquid part, and the production of ammonium sulphate as a fertilizer for N nutrient recovery, and as well P and K recovery from a concentrated stream.
  The process starts with solid/liquid separation achieved by a screw press separator, complemented with a centrifuge separation; this step allows the reducing of volumes to be treated in the following steps and the removal of the thick fraction.
  The liquid fraction pass through Ultrafiltration Unit, equipped with organic-based membranes with high permeation capacity. The permeate enters the Reverse Osmosis Unit for the final step of separation, which consists of a cascade of two passages for the removal of all the ammonia nitrogen. After this process two phases are obtained: the permeate is refined in a zeolites bed before the discharge in surface water bodies. On the other hand, the concentrate enters into a stripping unit, where the addition of sludge of lime increases the pH up to 12; the shifted outcome of NH_3 is stripped as gaseous ammonium by a controlled air flow. Air plus ammonia is cleaned with sulfuric acid producing liquid ammonium sulfate (8% on a wet weight basis as N).

- *What is the current and foreseen scale of operations (e.g. kg, tonnes/year)?*
  The process operates in batch mode, and can manage up to 100 m^3/day of raw anaerobic digestate, about 14 m^3 of digestate per cycle. The number of cycles per day, depending on total

23 Pig manure refinery into energy (biogas) and fertiliser using a combination of techniques applicable at industrial pig farms

daily treated volume, normally ranges from 4 to 7.The production of concentrated ammonium sulfate $(NH_4)_2SO_4$ can be up to 1.8 m^3 per each 100 m3 of digestate treated by the plant, with a 8% of N on a wet weight basis.
From the digestate of swine manure, the N captured as ammonium sulfate plus the residual N in the Reverse Osmosis permeate can be exportable from the farm.
The reduction on N can be up to 45% on Total Kjeldhal Nitrogen (TKN), and 71% on ammonia nitrogen ($N\text{-}NH_4^+$), compared to the values of the digestate.
For P and K, these elements are retained in the solids and concentrated streams in 100% and 86% respectively, compared to the Total Phosphorus and Total Nitrogen values of the digestate.

- *Why is it innovative when compared to existing (farming) practices?*
  The described process is innovative for the completely closed circuit of ammonia stripping, which avoids any emission in the air. The stripping is operative at environmental temperature, by so reducing energy costs.
  Also the two-step Reverse Osmosis, and its combination with Ultrafiltration, allows a reduction up to 50% in the initial digestate volume as a clean water, and a high $N\text{-}NH_4^+$ removal, and with a production of concentrated ammonium sulfate.

- *How does it improve the Nitrogen-Phosphorus and/or Carbon cycles in agriculture?*
  Digestate is a stable product that can be used as fertiliser and soil quality enhancer, but the actual use of this product is limited by regulations on nutrients load limits.
  The proposed technology can overcome this problem; the combination of solid / liquid separation of digestate, with the recovery of concentrated streams and also the production of chemical fertilisers such as Ammonium Sulphate allows to obtain by-products with different characteristics; these products can be so used in a more efficient way and also be exported from the farm.

- *Add a separate line on the location of your management solution: "Currently this technology / technique / management solution is applied in ……. (city, region, country))."*
  This process is currently applied in some farm companies in Northern Italy.

TRL (Technology Readiness Level) – how close is your solution to the market?

Use the slider above to position the current TRL* of your proposed solution

* TRLs are a type of measurement system used to assess the maturity level of a particular technology. Where a topic description refers to a TRL, the following definitions apply, unless otherwise specified:

• TRL 1 – basic principles observed • TRL 2 – technology concept formulated • TRL 3 – experimental proof of concept • TRL 4 – technology validated in lab • TRL 5 – technology validated in relevant environment (industrially relevant environment in the case of key enabling technologies) • TRL 6 – technology demonstrated in relevant environment (industrially relevant environment in the case of key enabling technologies) • TRL 7 – system prototype demonstration in operational environment • TRL 8 – system complete and qualified • TRL 9 – actual system proven & running in operational environment

Please provide some sentences explaining your Technology Readiness Level

This technique is already successfully tested and applied at large scale in areas in Northern Italy indicated as Nitrate Vulnerable Zones. Obtained by-products are already commercialized and applied as fertilizers and soil enhancers.

23 Pig manure refinery into energy (biogas) and fertiliser using a combination of techniques applicable at industrial pig farms

If the proposed solution/ technique is currently at low TRL (≤5), is upscaling foreseen within the next year(s)?

If the proposed solution/ technique is currently at high TRL (≥7), is there any product already being produced from the proposed solution/ technique?

- *If yes, what is the name of the product :*
  Ammonium sulfate at 6-8% as N, market value of about 0,5 €/m^3.

- *Short description of the products:*
  N solution containing 100 % ammonia (N title 8% w/w) and solid fraction (TS of 20 % or 90-95 % after drying) containing > 4 % N+P+K.

- *Are there any EC/MS Authority permits already for use of the product (title or link if available) ?*
  YES (national regulation allow using this product on farm basis).

POTENTIAL LINKAGE TO THE PROJECT

Indicate to which agro-typology under study and which potential research line of the project, your proposed solution/technique contributes :

X	Pig Production
	Poultry Production
	Cattle Farming
X	Open field cultivation of cereals or maize
	Open air cultivation of vegetables
	Orchards
X	Agro-energy systems (e.g. biogas)
	Animal Byproduct processing (e.g. manure processing)

Innovative solutions for optimized nutrient & GHG in animal husbandry		
Innovative soil, fertilisation & crop management systems & practices		X
Tools, techniques & systems for higher-precision fertilization		
Biobased fertilisers (N, P) and soil enhancers (OC) from agro-residues		X
Novel animal feeds produced from agro-residues		
Other, please specify :	Biobased fertilisers from pig slurry	X

24 Adapted stable construction for separated collection of solid manure and urine in pig housing (followed by separate post-processing)

AIM OF THE TECHNOLOGY

(https://www.beton-dobbelaere.be/nl/producten/c/57/agrarische-sector/varkensmateriaal/vedows-mest-en-giergoten/, no date)

Provide a brief description of the proposed management solution or technique.

- *What is the purpose/aim of the innovative solution/technique?*
  Underneath the slatted floor of a stable system a shallow cellar is constructed which enables the separation of urine and solid manure. Using a scraper, the solid manure is removed from the manure gutter daily. This primary separation of manure in the cellar is the basis of lower ammonia emissions. Post-processing is also easier because P is particularly being found in the thick fraction, while N is being particularly found in the urea.

- *What is the underlying working principle?*
  Ammonia is formed when urine comes into contact with urease, which can be found in solid manure. Therefore when solid manure and urine are collected separately there is less ammonia (NH3) emission because urine is less in contact with urease, Manure is being removed on a daily basis, which makes it more interesting to be digested because fresh manure has a better biogas potential.

- *What is the current and foreseen scale of operations (e.g. kg, tonnes/year)?*
  The technique is independent of scale. Right now there are approximately 15000 places where this technique is being used. It is believed that in the future 5000 more will follow.

- *Why is it innovative when compared to existing (farming) practices?*
  A separation of solid manure and urine makes it easier to post-process the manure. There is less emission of greenhouse gases. The technique is officially recognised as a stable system with a low ammonia emission.

- *How does it improve the Nitrogen-Phosphorus and/or Carbon cycles in agriculture?*
  Post-processing is easier because of the separated manure. Carbon-rich solid manure could be digested. Urine is nitrogen- and potassium-rich and can be used as a fertilizer.

- *Add a separate line on the location of your management solution: "Currently this technology / technique / management solution is applied in ……. (city, region, country))."*

24 Adapted stable construction for separated collection of solid manure and urine in pig housing (followed by separate post-processing)

Currently this technology is applied in Pittem / Hooglede / Westrozebeke → West-Flanders (Belgium)

TRL (Technology Readiness Level) – how close is your solution to the market?

Use the slider above to position the current TRL* of your proposed solution

* TRLs are a type of measurement system used to assess the maturity level of a particular technology. Where a topic description refers to a TRL, the following definitions apply, unless otherwise specified:

• TRL 1 – basic principles observed • TRL 2 – technology concept formulated • TRL 3 – experimental proof of concept • TRL 4 – technology validated in lab • TRL 5 – technology validated in relevant environment (industrially relevant environment in the case of key enabling technologies) • TRL 6 – technology demonstrated in relevant environment (industrially relevant environment in the case of key enabling technologies) • TRL 7 – system prototype demonstration in operational environment • TRL 8 – system complete and qualified • TRL 9 – actual system proven & running in operational environment

Please provide some sentences explaining your Technology Readiness Level

The system is already implemented in some companies.

If the proposed solution/ technique is currently at low TRL (≤5), is upscaling foreseen within the next year(s)?

If the proposed solution/ technique is currently at high TRL (≥7), is there any product already being produced from the proposed solution/ technique?

- *If yes, what is the name of the product:*
  VeDoWS (Vermeulen Dobbelaere Welfare System).

- *Short description of the product*
  A VeDoWS system separates solid manure and urine in pig houses.

- *Are there any EC/MS Authority permits already for use of the product (title or link if available)?*

24 Adapted stable construction for separated collection of solid manure and urine in pig housing (followed by separate post-processing)

POTENTIAL LINKAGE TO THE PROJECT

Indicate to which agro-typology under study and which potential research line of the project, your proposed solution/technique contributes :

X	Pig Production
	Poultry Production
	Cattle Farming
	Open field cultivation of cereals or maize
	Open air cultivation of vegetables
	Orchards
	Agro-energy systems (e.g. biogas)
X	Animal Byproduct processing (e.g. manure processing)

Innovative solutions for optimized nutrient & GHG in animal husbandry	X
Innovative soil, fertilisation & crop management systems & practices	
Tools, techniques & systems for higher-precision fertilization	
Biobased fertilisers (N, P) and soil enhancers (OC) from agro-residues	
Novel animal feeds produced from agro-residues	
Other, please specify :	

25 Soybeans in Kujawsko-Pomorskie and Wielkopolskie voivodships in Poland - innovative solutions in the cultivation, plant protection and feeding on farms

AIM OF THE TECHNOLOGY

Provide a brief description of the proposed management solution or technique.

- *What is the purpose/aim of the innovative solution/technique?*
  The main goal of the operation is to increase income in agricultural farms by providing the farmer with a comprehensive methodology for cultivating, fertilizing and protecting conventional varieties of soybeans. The purpose is also showing the highest efficiency and adaptation to nutrition through extrusion of seeds and their use in optimally balanced feeds used in livestock nutrition.

- *What is the underlying working principle?*
  One of the activities of this operation will be the economic analysis of the profitability of soybean cultivation, its extrusion and use for feeding in its own farm on the example of swine and dairy cattle. As part of the operation, field tests and tests on suitable soybean varieties, seed inoculants and improvement of weed control will be carried out, leading to maximization of yields and minimization of conventional soybean cultivation costs. In addition, five farms from the Kujawsko-Pomorskie and Wielkopolskie voivodeships will run 5 ha of soybean development for two years. Soybean seeds from own production will be used for feeding swine and dairy cattle on their own farms. Farmers will buy extruders and use the extrusion service, for the production of soy meal ready for feeding in their own livestock production.

- *What is the current and foreseen scale of operations (e.g. kg, tonnes/year)?*
  Currently five farms in crops of 5 hectares of soybeans- 20 tonnes/per year.

- *Why is it innovative when compared to existing (farming) practices?*
  The final result of the operation is an increase in farmers' incomes of the consortium participants, which is planned to be achieved as a result of taking action, having in mind changing market needs, while applying innovative elements. The innovations applied, on the one hand, enable the implementation of pro-market changes, and on the other hand, they reinforce their beneficial economic effect for the farmer. Due to the fact that conventional soybean as a cultivated plant responds to environmental conditions in a special way, those relating to the climate, and the operation will be carried out on farms located in the Kujawsko-Pomorskie and Wielkopolskie Voivodships, the obtained results will refer to farms located in the belt of latitude from the parallel of 52 N to 54 N. Scope of the operations related to the use of soybean seeds for feeding during swine feeding, beef cattle and dairy cows is universal and can be used throughout the

country. Also, the needs for food products obtained from the implementation of GMO-free plants have a national and European scale of importance, which is confirmed by analyzes of consumer expectations and preferences in the use of GMO-free feeds in the European Union countries. The implementation system for cultivating, extruding and feeding livestock with soybeans, developed as part of the project, will be disseminated among farmers through information activities, scientific publications, training and field demonstrations and conferences for farmers and entrepreneurs from the agri-food sector with the participation of advisers.

- *How does it improve the Nitrogen-Phosphorus and/or Carbon cycles in agriculture?*
  The innovative solution presented (implementing methods of growing and sowing leguminous plants in Poland) increases the nitrogen cycle and its uptake from the air, and reduces the consumption of fertilizers.
  - *Currently this technology /technique / management solution is applied in Szubin, Poland*

  http://www.mojasoja.eu/
  https://ec.europa.eu/eip/agriculture/en/find-connect/projects/soja-w-wojew%C3%B3dztwach-kujawsko-pomorskim-i-0

25 Soybeans in Kujawsko-Pomorskie and Wielkopolskie voivodships in Poland - innovative solutions in the cultivation, plant protection and feeding on farms

TRL (Technology Readiness Level) – how close is your solution to the market?

Use the slider above to position the current TRL* of your proposed solution

* TRLs are a type of measurement system used to assess the maturity level of a particular technology. Where a topic description refers to a TRL, the following definitions apply, unless otherwise specified:

• TRL 1 – basic principles observed • TRL 2 – technology concept formulated • TRL 3 – experimental proof of concept • TRL 4 – technology validated in lab • TRL 5 – technology validated in relevant environment (industrially relevant environment in the case of key enabling technologies) • TRL 6 – technology demonstrated in relevant environment (industrially relevant environment in the case of key enabling technologies) • TRL 7 – system prototype demonstration in operational environment • TRL 8 – system complete and qualified • TRL 9 – actual system proven & running in operational environment

Please provide some sentences explaining your Technology Readiness Level

Currently the technology is validated in lab and is ready to be validated in farming systems.

If the proposed solution/ technique is currently at low TRL (≤5), is upscaling foreseen within the next year(s)?

YES.

If the proposed solution/ technique is currently at high TRL (≥7), is there any product already being produced from the proposed solution/ technique?

- *If yes, what is the name of the product :*
- *Short description of the product*
- *Are there any EC/MS Authority permits already for use of the product (title or link if available)?*

POTENTIAL LINKAGE TO THE PROJECT

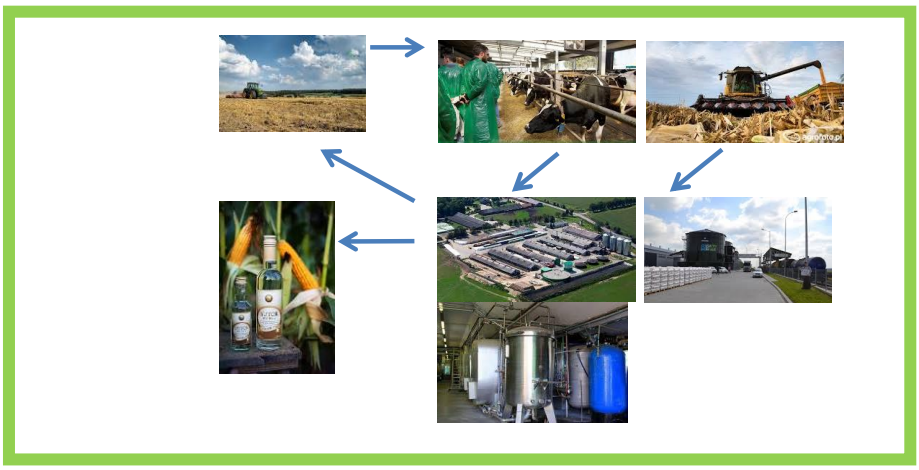
Indicate to which agro-typology under study and which potential research line of the project, your proposed solution/technique contributes :

X	Pig Production
X	Poultry Production
X	Cattle Farming
X	Open field cultivation of cereals or maize
	Open air cultivation of vegetables
	Orchards
	Agro-energy systems (e.g. biogas)
	Animal Byproduct processing (e.g. manure processing)

Innovative solutions for optimized nutrient & GHG in animal husbandry	
Innovative soil, fertilisation & crop management systems & practices	X
Tools, techniques & systems for higher-precision fertilization	
Biobased fertilisers (N, P) and soil enhancers (OC) from agro-residues	
Novel animal feeds produced from agro-residues	
Other, please specify :	

26 Integration of the farming and breeding system with a distillery and a biogas plant

AIM OF THE TECHNOLOGY



Provide a brief description of the proposed management solution or technique.

- *What is the purpose/aim of the innovative solution/technique?*
  The innovative solution carried out in a farm (Łany Wielkie, Poland) is an example of the perfect use of by-products in agricultural production and for the production of biogas. The innovative solution is unique combination of two separate technological processes into one unit- distillery along with a biogas plant. The biogas plant, producing 0.5 MW of electricity, consumes waste from the distillery, mainly the decoction and manure and other organic residues from farms. In addition, the product derived from biogas is an excellent organic fertilizer used in fields (ecological and odourless). Most of the generated energy is consumed for the company's own needs. This innovative solution is a unique combination of two separate technological processes into one unit- distillery along with a biogas plant. Moreover, intensive crop and animal production is also carried out in the Farm. Close cooperation between farms and the biogas distillery is a system that fully fits the idea of using renewable energy sources.

- *What is the underlying working principle?*
  This innovative solution is a unique combination of two separate technological processes into one unit- distillery along with a biogas plant. Moreover, intensive crop and animal production also carried out in the Farm. The farm also specializes in milk production. Manure and liquid manure are used for the production of biogas, which are by-products of animal breeding, as well as decoction of the refinery is used as input for biogas plant. This raw material allows to produce electricity and heat that fully secure the production of the distillery. The biogas plant uses manure from 800 cattle. As a result of whole farm operation, 40 tonnes of substrate per day are delivered to the biogas plant. The feed then goes to the fermenter, which is heated by the energy (heat) generated in the biogas plant, then biogas is produced. Afterward the biogas is feeding the steam generator powering the distillery. In the distillery, corn grown on farms of the producer group is processed raw alcohol is obtained, while the refinery decoction is intended for biogas plants. On the other hand, organic fermentation products produced during the technological process are used as a fertilizer for soil fertilization. The biogas plant has a capacity of 0.5MW and this value is enough to fully supply the distillery with technological steam.

26 Integration of the farming and breeding system with a distillery and a biogas plant

- *What is the current and foreseen scale of operations (e.g. kg, tonnes/year)?*
  The distillery has annual production capacity of 1,600,000 liters of agricultural distillate from cereals with an average alcohol content of 94%, which can be directly allocated to the production of alcohol. In crop production maize is grown for 700 ha of arable land and rape grown for 300 ha, cereals in the area of 400 ha, also for the purpose of certified seed. The biogas plant uses manure from 800 cattle. As a result of whole farm operation, 40 tonnes of substrate per day are delivered to the biogas plant.
- *Why is it innovative when compared to existing (farming) practices?*
  This investment is a unique combination of two separate technological processes into one unit. The pioneering farmer's solution is combination of cow breeding, milk production, agricultural crop production, distillery along with a biogas plant. The pioneering farmer's solution is combining simple agricultural activities of soil cultivation and plant breeding as well as advanced activities with running biorefinery and biogas plant in one farm, covering all technologically available cycles of energy and matter.

- *How does it improve the Nitrogen-Phosphorus and/or Carbon cycles in agriculture?*
  The solution proposed on the farm closes the C, N, P and energy cycles quite tightly. Plants grown in the fields are consumed in cattle breeding. The by-products of cattle breading; manure and liquid manure, are processed with the addition of straw in biogas plants for safe fertilizers. The biorefinery produces alcohols from corn and by-products (decoction) goes to the biogas plant as an input. The digestate from the biogas plant is used for soil fertilizing (enriches the soil in N, P and C) or goes as a bedding for farm animals.
  Ecological agriculture is preferred, every year the amount of artificial fertilizers used in the cultivation of plants is reduced by introducing organic fertilizers obtained from biogas plant into the field.

- *Add a separate line on the location of your management solution: "Currently this technology / technique / management solution is applied in ……. (city, region, country))."*
  Butor Group
  Łany Wielkie , Łabędzka 54
  44-153 Sośnicowice, Poland

  Tel./fax. 032 238-71-78; 032 238-76-73; 032 238-74-00
  E-mail: biuro@butor.pl
  WWW: www.butor.pl

26 Integration of the farming and breeding system with a distillery and a biogas plant

TRL (Technology Readiness Level) – how close is your solution to the market?

Use the slider above to position the current TRL* of your proposed solution

* TRLs are a type of measurement system used to assess the maturity level of a particular technology. Where a topic description refers to a TRL, the following definitions apply, unless otherwise specified:

• TRL 1 – basic principles observed • TRL 2 – technology concept formulated • TRL 3 – experimental proof of concept • TRL 4 – technology validated in lab • TRL 5 – technology validated in relevant environment (industrially relevant environment in the case of key enabling technologies) • TRL 6 – technology demonstrated in relevant environment (industrially relevant environment in the case of key enabling technologies) • TRL 7 – system prototype demonstration in operational environment • TRL 8 – system complete and qualified • TRL 9 – actual system proven & running in operational environment

Please provide some sentences explaining your Technology Readiness Level

The proposed solution is a complete and qualified system.

If the proposed solution/ technique is currently at low TRL (≤5), is upscaling foreseen within the next year(s)?

If the proposed solution/ technique is currently at high TRL (≥7), is there any product already being produced from the proposed solution/ technique?

- *If yes, what is the name of the product :*
  biogas and refinery products

- *Short description of the product*

- *Are there any EC/MS Authority permits already for use of the product (title or link if available)?*

26 Integration of the farming and breeding system with a distillery and a biogas plant

POTENTIAL LINKAGE TO THE PROJECT

Indicate to which agro-typology under study and which potential research line of the project, your proposed solution/technique contributes :

	Pig Production
	Poultry Production
X	Cattle Farming
X	Open field cultivation of cereals or maize
	Open air cultivation of vegetables
	Orchards
X	Agro-energy systems (e.g. biogas)
X	Animal Byproduct processing (e.g. manure processing)

Innovative solutions for optimized nutrient & GHG in animal husbandry	X
Innovative soil, fertilisation & crop management systems & practices	X
Tools, techniques & systems for higher-precision fertilization	
Biobased fertilisers (N, P) and soil enhancers (OC) from agro-residues	X
Novel animal feeds produced from agro-residues	
Other, please specify :	

27 Use of an inoculate of microbiota and enzymatic precursors to reduce ammonia emissions and optimize nutrients use efficiency

AIM OF THE TECHNOLOGY

Provide a brief description of the proposed management solution or technique.

- *What is the purpose/aim of the innovative solution/technique?*
  Additives for manure and soil based on a concentrated blend of microorganisms and yeasts that are designed to liquify, metabolize, deodorize and balance the nutritive value of manure.
  Target products under study have been specially balanced for the carbon:nitrogen ratio of manure to produce more usable fertilizer that will be better utilized by plants, resulting in reduced runoff. These additives, when added to the manure, are expected to improve hygienic conditions in facilities (barns, coops, pens…) reducing ammonia emissions and also moving carbon sources and nutrients in manure to forms easily assimilable by plants (ammonium to nitrate in the case of nitrogen, solubilization of solids and phosphorous and residual proteins converted into aminoacids).

- *What is the underlying working principle?*
  The manure is innoculated with microbes that were selected to perform specific functions. They act directly on the slurry first, and on the soil later, reducing nitrogen losses by enhancing the biodegradation of manure.
  More specifically, the product under study is a liquid suspension of microorganisms based on phototropic and lactic acid bacteria and yeast in a natural environment of sugarcane molasses. The lactic bacteria transform part of the carbohydrates into lactic acid with a resulting effect that is the lowering of the pH with great power of control of pathogenic microorganisms. The phototropic bacteria carry out an incomplete anaerobic photosynthesis, being very useful because they are able to detoxify the soil of substances toxic to the plant that are formed during fermentation. They are also able to conserve soil nitrogen during the transformation of decomposition substances.
  This product contains the aerobic and anaerobic microorganisms that produce the decomposition of organic matter. Fermentation is an anaerobic process in which microorganisms and complex organic molecules are broken down into simpler organic parts that can often be absorbed directly by plants. During the fermentation, little energy is generated compared to the aerobic decomposition of the same substrate through the same group of

microorganisms. Aerobic decomposition causes complete oxidation of a substrate and releases a large amount of energy, gas and heat, producing carbon dioxide and water.
The microflora of the soil and the environment of the root (rhizosphere) enhances the growth of plants and increases their ability to resist diseases and parasites through the production of bioactive substances.
The microorganisms contained in this additive constitute the growth environment of the plants with a great rooting and biostimulating effect, directly affecting the quality of the crops and the soil. This product it is supposed to progressively inhibits the attack of other bacteria and microorganisms that cause pathologies by having a colonizing effect on the soil due to the displacement produced by the space they occupy and by reducing the source of food.

- *What is the current and foreseen scale of operations (e.g. kg, tonnes/year)?*
  Nowadays, two demo greenhouses in Almeria are working with preconditioned poultry manure as fertilizer (manure proceeding from a farm where the above-mentioned liquid suspension of microorganism was used). During Nutri2Cycle project, a maximum of 3000 t of product would be available for trials covering up to 300 ha of arable land (according to the information provided by the farmers who will collaborate in the study).

- *Why is it innovative when compared to existing (farming) practices?*
  Currently, in the study area (Castilla y Leon, Spain), manure is added directly to the land (soil injection) or is composted for later application (by dispersion). Nitrogen losses during the process are high. Conditioned manure is not commonly used although it can lead to an improved nutrients valorization (less losses to the environment, better assimilation by the plant) using the same application techniques.

- *How does it improve the Nitrogen-Phosphorus and/or Carbon cycles in agriculture?*
  (NH_3) volatilization decreases the N-nutrient value of livestock manure slurries and can lead to soil acidification and eutrophication problems. Nutrient losses to the atmosphere can be avoided (or very reduced) adding some key bacteria directly to the manure, so these nutrients will be available for the crop. Conditioned manure can also allow to improve and vitalize the properties of the soil while increasing the root system of plants.

- *Add a separate line on the location of your management solution: "Currently this technology / technique / management solution is applied in ……. (city, region, country))."*
  The product has been tested in poultry farms in Burgos (Spain) and the conditioned manure is being used in orchards (greenhouses) in Almería (Spain). Also, some assays have been developed in maize crops.
  New tests are foreseen in the following facilities:
  - Farm Santa Rosalía (Burgos) – cattle farming; https://www.fincasantarosalia.com/
  - Avícola de Burgos– poultry production; http://cobur.es/
  - Farm COPISO (Burgos) – pig production; http://www.copiso.com/
  - Farm La COLAGA (Valladolid) – horses; https://lacolaga.com/
  - Sheep farm in the Valladolid region (to be defined)

  These farms have also arable soil that will be available for project fertilization tests. Potential assays:
  - conditioned poultry manure for maize crops fertilization
  - conditioned cattle manure for fodder crops fertilization
  - conditioned pig manure for general uses

27 Use of an inoculate of microbiota and enzymatic precursors to reduce ammonia emissions and optimize nutrients use efficiency

TRL (Technology Readiness Level) – how close is your solution to the market?

Use the slider above to position the current TRL* of your proposed solution

* TRLs are a type of measurement system used to assess the maturity level of a particular technology. Where a topic description refers to a TRL, the following definitions apply, unless otherwise specified:

• TRL 1 – basic principles observed • TRL 2 – technology concept formulated • TRL 3 – experimental proof of concept • TRL 4 – technology validated in lab • TRL 5 – technology validated in relevant environment (industrially relevant environment in the case of key enabling technologies) • TRL 6 – technology demonstrated in relevant environment (industrially relevant environment in the case of key enabling technologies) • TRL 7 – system prototype demonstration in operational environment • TRL 8 – system complete and qualified • TRL 9 – actual system proven & running in operational environment

Please provide some sentences explaining your Technology Readiness Level

The product has been tested in poultry farms and the conditioned manure is being used in orchards in Almeria (greenhouses). Also, some assays have been developed in maize crops.

If the proposed solution/ technique is currently at low TRL (≤5), is upscaling foreseen within the next year(s)?

If the proposed solution/ technique is currently at high TRL (≥7), is there any product already being produced from the proposed solution/ technique?

- *If yes, what is the name of the product :*
  Polizymes.

- *Short description of the product*
  Additive (mixture of microorganisms that act as enzyme precursors) to be added to the manure or directly to the soil. With this action the farm avoid nutrients losses to the environment and, furthermore, nutrients move to forms more assimilable by plants.

- *Are there any EC/MS Authority permits already for use of the product (title or link if available)?*
  YES, Council Regulation (EC) No 834/2007 of 28 June 2007 on organic production and labelling of organic products.

27 Use of an inoculate of microbiota and enzymatic precursors to reduce ammonia emissions and optimize nutrients use efficiency

POTENTIAL LINKAGE TO THE PROJECT

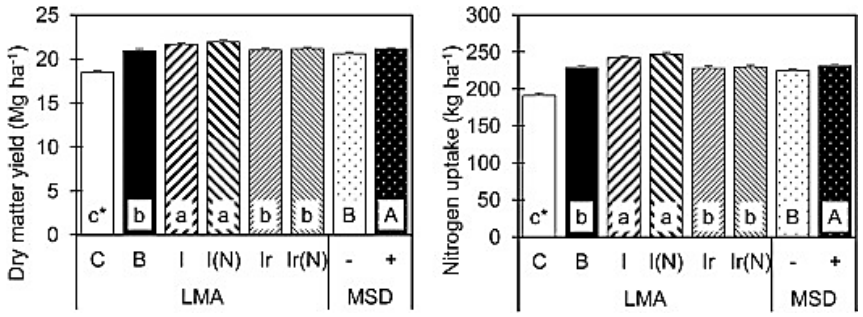
Indicate to which agro-typology under study and which potential research line of the project, your proposed solution/technique contributes :

X	Pig Production
X	Poultry Production
X	Cattle Farming
X	Open field cultivation of cereals or maize
X	Open air cultivation of vegetables
X	Orchards
	Agro-energy systems (e.g. biogas)
X	Animal Byproduct processing (e.g. manure processing)

Innovative solutions for optimized nutrient & GHG in animal husbandry	X
Innovative soil, fertilisation & crop management systems & practices	X
Tools, techniques & systems for higher-precision fertilization	
Biobased fertilisers (N, P) and soil enhancers (OC) from agro-residues	X
Novel animal feeds produced from agro-residues	
Other, please specify :	

28 Precision farming and optimized application: under-root application of liquid manure for maize and other row crops

AIM OF THE TECHNOLOGY



Fertilization with liquid manure (LMA): C = no manure, B = manure broadcast, I = manure injection, I(N) = manure injection with nitrification inhibitor, Ir = I treatment with reduced manure rate, Ir(N) = I(N) treatment with reduced manure rate
Mineral side dress (MSD) without (-) and with (+) mineral side dress of 23 kg N ha^{-1} and 10 kg P ha^{-1}

*Different letters for treatments within LMA and MSD factors indicate significant differences (Tukey $P < 0.05$).

Source: Federolf et al. (2016), p. 134, Fig. 1
Enhanced nutrient use efficiencies from liquid manure by positioned injection in maize cropping in northwest Germany. European Journal of Agronomy, 75, 130-138.

Provide a brief description of the proposed management solution or technique.

- *What is the purpose/aim of the innovative solution/technique?*
  In oversupplied soils of intensive livestock production areas, this solution can contribute to replace mineral N and P fertilizers for under-root application around maize seeds (or similar row crops) by liquid manure to increase nutrient efficiency and, thus, to contribute closing the nutrient loops.
  In poor soils, particularly deficient of P, under-root application ensures that nutrients are available below the soil surface near roots, so roots can grow better towards them, especially in dry periods of the growing season.

- *What is the underlying working principle?*
  Maize is cultivated commonly in regions with high livestock density mainly because of two benefits: firstly, maize is a suitable arable feed crop with a high yield potential; secondly, manure obtained from livestock husbandry can be applied to maize fields (ideally) closing the nutrient loops, especially of nitrogen.
  In the early root development, maize crops require high concentration of nitrogen and especially of phosphorus close to the seeds. In this context, under-root fertilization can be of advantage by applying fertilizers below the seeds in order to stimulate a steady early plant growth.
  By this solution, air pollution from slurry can also be reduced.
  Application of under-root fertilization can be carried out before or after sowing, or simultaneously.

- *What is the current and foreseen scale of operations (e.g. kg, tonnes/year)?*
  Under-root fertilization with liquid manure instead of mineral fertilizer has been tested in various experiments and showed promising results for potential replacement (e.g., see the figure above).
  If applied by contractors of agricultural machinery and farm machinery cooperatives, large parts of

Precision farming and optimized application: under-root application of liquid manure for maize and other row crops

total slurry application to maize in spring could be improved substituting mineral fertilizer applications.

- *Why is it innovative when compared to existing (farming) practices?*
  Up to now, under-root fertilizer application has been conducted to a great extent using mineral N and P fertilizers. This is due to missing applications techniques, to habitual practice of farmers, and to a lack of advice on the side of farmers' extension services.

- *How does it improve the Nitrogen-Phosphorus and/or Carbon cycles in agriculture?*
  Under-root application of liquid manure improves N and P cycles, since maize is commonly used as a feed crop in animal husbandry, and manure obtained from animal husbandry can be applied more efficiently with this technique to maize fields and would, thus, reduce the demand for mineral fertilizer application and mitigate nutrient loss via volatilization in the field.

- *Add a separate line on the location of your management solution:*
  Currently this technique is being applied in many regions in Germany, such as Lower Saxony, North-Rhine Westphalia, and Schleswig-Holstein, but it is still not a widely used practice.

TRL (Technology Readiness Level) – how close is your solution to the market?

Use the slider above to position the current TRL* of your proposed solution

* TRLs are a type of measurement system used to assess the maturity level of a particular technology. Where a topic description refers to a TRL, the following definitions apply, unless otherwise specified:

• TRL 1 – basic principles observed • TRL 2 – technology concept formulated • TRL 3 – experimental proof of concept • TRL 4 – technology validated in lab • TRL 5 – technology validated in relevant environment (industrially relevant environment in the case of key enabling technologies) • TRL 6 – technology demonstrated in relevant environment (industrially relevant environment in the case of key enabling technologies) • TRL 7 – system prototype demonstration in operational environment • TRL 8 – system complete and qualified • TRL 9 – actual system proven & running in operational environment

Please provide some sentences explaining your Technology Readiness Level

Technical transformation not completely satisfied.

If the proposed solution/ technique is currently at low TRL (≤5), is upscaling foreseen within the next year(s)?

If the proposed solution/ technique is currently at high TRL (≥7), is there any product already being produced from the proposed solution/ technique?

- *If yes, what is the name of the product :*
- *Short description of the product*
- *Are there any EC/MS Authority permits already for use of the product (title or link if available)?*

28 Precision farming and optimized application: under-root application of liquid manure for maize and other row crops

POTENTIAL LINKAGE TO THE PROJECT

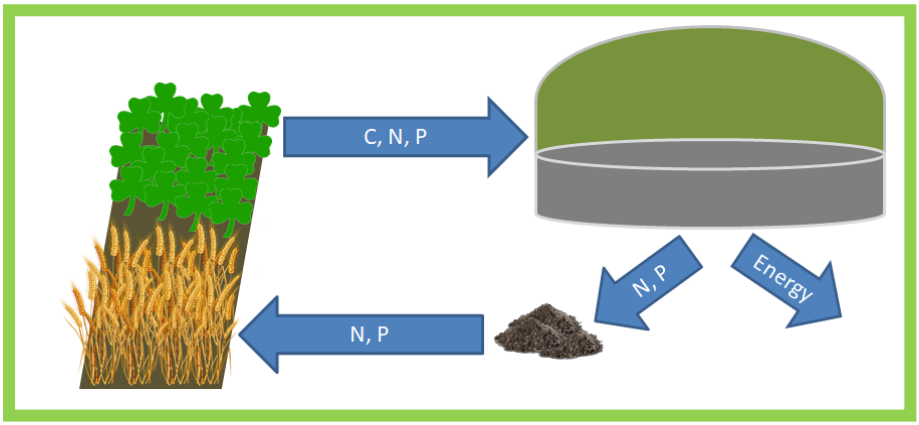
Indicate to which agro-typology under study and which potential research line of the project, your proposed solution/technique contributes :

X	Pig Production
	Poultry Production
X	Cattle Farming
X	Open field cultivation of cereals or maize
	Open air cultivation of vegetables
	Orchards
	Agro-energy systems (e.g. biogas)
X	Animal Byproduct processing (e.g. manure processing)

Innovative solutions for optimized nutrient & GHG in animal husbandry	
Innovative soil, fertilisation & crop management systems & practices	X
Tools, techniques & systems for higher-precision fertilization	X
Biobased fertilisers (N, P) and soil enhancers (OC) from agro-residues	
Novel animal feeds produced from agro-residues	
Other, please specify :	

29 The role of leguminous N fixation and biogas processing in organic farming

AIM OF THE TECHNOLOGY



Provide a brief description of the proposed management solution or technique.

- *What is the purpose/aim of the innovative solution/technique?*
  The main purpose of this innovative solution is to increase nutrient use efficiency in organic farming systems, while generating energy.

- *What is the underlying working principle?*
  Organic farming systems require continuous and sufficient organic fertilizer supply, since application of certain (synthetic/processed) mineral fertilizers, such as mineral nitrogen fertilisers, is not allowed. Especially, organic farm types specialised in field crop production mostly lack on-farm organic manure which is the major source of nutrient supply in organic farming. Cultivation of legumes in these systems is common to increase – above all – nitrogen availability in soil pool via symbiotic fixation. Additionally, plant biomass can be mulched in the field, or composted and accordingly applied as organic fertilizer to the field. Nevertheless, a considerable amount of nitrogen is lost to the surrounding environment during composting or when plant biomass is left in the field. An alternative use of legume biomass or grass-clover mix is its utilization as biogas substrate to generate energy, whereas the digestate is returned as organic fertilizer to the field for the succeeding cultivation, e.g. cash crops.
  - By this means, the nitrogen fixed in the biomass is used more efficiently, since losses during composting/mulching are avoided.
  - Additionally, plant-availability of nitrogen in digestates is far higher than of nitrogen in composted biomass, so an application can be effectuated much more targeted.
  - Furthermore, nutrients are stored in the manure tanks and can be applied timely and according to plant needs.
  - Finally, application techniques are developed to incorporate/inject the liquid digestate into soil and, thus, prevent aerial losses of N.

- *What is the current and foreseen scale of operations (e.g. kg, tonnes/year)?*
  This depends on the future role of organic agriculture. One of the main disadvantages and challenges of organic production systems is the low N use efficiency, even though nitrogen is the most needed nutritional element. It might be a necessity to promote the use of digestate in order to prevent high N-losses. Once developed under conditions of organic farming, this innovation could also be applied for N supply and management in conventional farming.

29 The role of leguminous N fixation and biogas processing in organic farming

- *Why is it innovative when compared to existing (farming) practices?*
  In organic farming systems, mulching or composting of legumes is prevalent, resulting in low N use efficiency.
  In conventional farming, energy crops such as silage maize, are used as biogas substrate due to their high yields. Including N fixation in the biogas production system could improve sustainability of nutrient management.

- *How does it improve the Nitrogen-Phosphorus and/or Carbon cycles in agriculture?*
  This management solution improves the nitrogen cycle in agriculture by utilizing the legume crop biomass in biogas production and applying the digestate as organic fertilizer in the field, which avoids nitrogen losses of legume crop biomass during composting or mulching in the field, which are the current common practices in organic farming systems, and allowing for timely and more precise applications. High leguminous N-fixation rates (> 250 kg/ha, KTBL-Datensammlung Ökolandbau) may exceed the plant need of the succeeding crop, with the result of leaching and low N use efficiency.

- *Add a separate line on the location of your management solution: "Currently this technology / technique / management solution is applied in ……. (city, region, country))."*
  Currently this management solution is being applied e.g. in north-western Germany.

TRL (Technology Readiness Level) – how close is your solution to the market?

Use the slider above to position the current TRL* of your proposed solution

* TRLs are a type of measurement system used to assess the maturity level of a particular technology. Where a topic description refers to a TRL, the following definitions apply, unless otherwise specified:

• TRL 1 – basic principles observed • TRL 2 – technology concept formulated • TRL 3 – experimental proof of concept • TRL 4 – technology validated in lab • TRL 5 – technology validated in relevant environment (industrially relevant environment in the case of key enabling technologies) • TRL 6 – technology demonstrated in relevant environment (industrially relevant environment in the case of key enabling technologies) • TRL 7 – system prototype demonstration in operational environment • TRL 8 – system complete and qualified • TRL 9 – actual system proven & running in operational environment

Please provide some sentences explaining your Technology Readiness Level

Since the innovation proposed here is rather a management system than a technology, the indications in this section of TRL are not applicable.

If the proposed solution/ technique is currently at low TRL (≤5), is upscaling foreseen within the next year(s)?

If the proposed solution/ technique is currently at high TRL (≥7), is there any product already being produced from the proposed solution/ technique?

- *If yes, what is the name of the product*
- *Short description of the product*
- *Are there any EC/MS Authority permits already for use of the product (title or link if available)?*

29 The role of leguminous N fixation and biogas processing in organic farming

POTENTIAL LINKAGE TO THE PROJECT

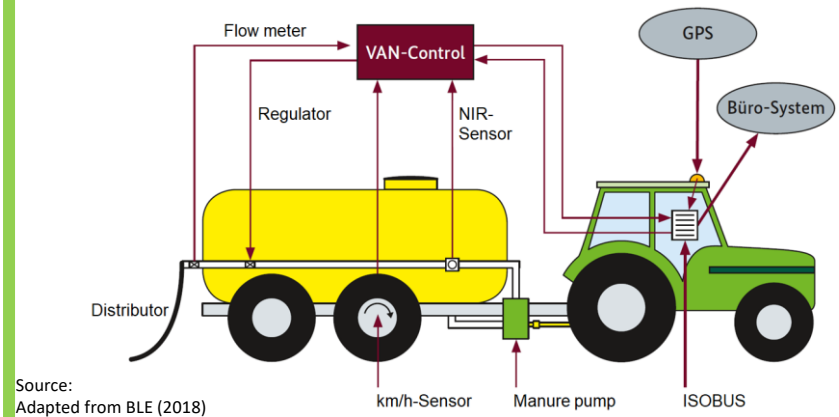
Indicate to which agro-typology under study and which potential research line of the project, your proposed solution/technique contributes :

	Pig Production
	Poultry Production
	Cattle Farming
X	Open field cultivation of cereals or maize
	Open air cultivation of vegetables
	Orchards
X	Agro-energy systems (e.g. biogas)
	Animal Byproduct processing (e.g. manure processing)

Innovative solutions for optimized nutrient & GHG in animal husbandry	
Innovative soil, fertilisation & crop management systems & practices	X
Tools, techniques & systems for higher-precision fertilization	
Biobased fertilisers (N, P) and soil enhancers (OC) from agro-residues	X
Novel animal feeds produced from agro-residues	
Other, please specify :	

30 Precision farming coping with heterogeneous qualities of organic fertilizers in the whole chain

AIM OF THE TECHNOLOGY



Source:
Adapted from BLE (2018) "Effizient düngen", p. 23

Provide a brief description of the proposed management solution or technique.

- *What is the purpose/aim of the innovative solution/technique?*
  The main purpose of this innovative solution is to cope with heterogeneous nutrient contents of liquid manure, in order to optimise nutrient supply according to plant needs and site-specific conditions.
  Manure processing can provide homogenous amounts of manure, and on-the-fly detection of nutrient contents of liquid manure based on a near-infrared (NIR) sensing technology allows for precise application rates.
  Furthermore, tracking of manure transport and documentation of application rates help to improve nutrient management at farm level and to comply with legal frameworks.

- *What is the underlying working principle?*
  Tracking of manure transport (farm towards field) is possible by using GIS (Geographical Information Systems) and GPS (Global Positioning System) data of transport vehicles.
  NIR sensing techniques have been developed to identify nutrients in liquid manure. NIR-sensors operate with the principle of reflection and absorption of matters in liquid manure within certain wavelengths.
  NIR-sensors for nutrient detection are commonly employed in three ways: a) during manure filling from storage into application tank; b) during mixing of manure in the application tank or c) during application via NIR-sensor mounted on distributor.
  Precision sensing equipment can be utilized for liquid manure of cattle and pig, and liquid digestate.
  Sensors can detect dry matter, total nitrogen, ammonium nitrogen (NH4-N), potassium oxide (K2O), and phosphorus pentoxide (P_2O_5).
  The accuracy of nutrient sensing in liquid manure was tested for various techniques and certified by the German Agricultural Society "DLG" (Deutsche Landwirtschafts-Gesellschaft).
  The abovementioned implements can be combined with each other and/or other elements of precision agriculture, i.e., different maps (soil, climate, yield potential), precision application techniques for manure (incorporation into soil) and mineral fertiliser, determination of actual plant needs (different methods of plant sensing/analysis).

30 Precision farming coping with heterogeneous qualities of organic fertilizers in the whole chain

- *What is the current and foreseen scale of operations (e.g. kg, tonnes/year)?*
  If applied by contractors of agricultural machinery and farm machinery cooperatives, large parts of total liquid manure (in Germany and other EU countries) could be applied more precisely. In this way manure application can substitute mineral fertilizer to a greater extent, in case the N-fertilization strategy is adapted accordingly (i.e., determination of N-plant need with plant analysis, split fertilizer application, and/or use of N-inhibitors). However, the application upper-limits of organic and total fertilizer depend with regard to N on the rules of the EU Nitrates Directive and national regulations of the member states.

- *Why is it innovative when compared to existing (farming) practices?*
  Tracking of fertilizer transport and application is an appropriate method to prevent mismanagement of organic fertilizer, especially in regions with intensive livestock production.
  The analytical determination of plant nutrients in organic fertilizers is unprecise: both, sampling error and analytical error accepted in fertilizer legislation are extremely high. In order to obtain a representative sample, liquid manure or digestate has to be mixed up thoroughly. When mixed in the manure storage, this provokes climate-relevant aerial emissions. The result of classical chemical analysis takes time, additionally, the analysis refers to a bulk sample.
  The combination of all described elements of precision agriculture with manure use is a step forward to higher nutrient and especially N use efficiency.

- *How does it improve the Nitrogen-Phosphorus and/or Carbon cycles in agriculture?*
  NIR-sensors for nutrient detection in liquid manure are often combined with other techniques, such as cultivator, so that losses via volatilization of nutrients, above all nitrogen, is minimized.

- *Add a separate line on the location of your management solution: "Currently this technology / technique / management solution is applied in ……. (city, region, country))."*
  There are different locations of this management solution, determined by innovative contractors of agricultural machinery and farm machinery cooperatives.
  This solution has already been applied by contractors and large farmers in Germany.

30 Precision farming coping with heterogeneous qualities of organic fertilizers in the whole chain

TRL (Technology Readiness Level) – how close is your solution to the market?

Use the slider above to position the current TRL* of your proposed solution

* TRLs are a type of measurement system used to assess the maturity level of a particular technology. Where a topic description refers to a TRL, the following definitions apply, unless otherwise specified:

• TRL 1 – basic principles observed • TRL 2 – technology concept formulated • TRL 3 – experimental proof of concept • TRL 4 – technology validated in lab • TRL 5 – technology validated in relevant environment (industrially relevant environment in the case of key enabling technologies) • TRL 6 – technology demonstrated in relevant environment (industrially relevant environment in the case of key enabling technologies) • TRL 7 – system prototype demonstration in operational environment • TRL 8 – system complete and qualified • TRL 9 – actual system proven & running in operational environment

Please provide some sentences explaining your Technology Readiness Level

For some types of organic fertilizers, calibration of NIRS technology is not yet satisfying. The link of all precision farming techniques to achieve optimal performance is in development.

If the proposed solution/ technique is currently at low TRL (≤5), is upscaling foreseen within the next year(s)? YES / NO

If the proposed solution/ technique is currently at high TRL (≥7), is there any product already being produced from the proposed solution/ technique?

- *If yes, what is the name of the product :*
  HarvestLab 3000 by John Deere
  VAN-CONTROL 2.0 by Zunhammer

- *Short description of the product*
  NIRS-Sensors to detect nutrient contents in liquid manure and digestate.

- *Are there any EC/MS Authority permits already for use of the product (title or link if available)?*

30 Precision farming coping with heterogeneous qualities of organic fertilizers in the whole chain

POTENTIAL LINKAGE TO THE PROJECT

Indicate to which agro-typology under study and which potential research line of the project, your proposed solution/technique contributes :

X	Pig Production
	Poultry Production
X	Cattle Farming
X	Open field cultivation of cereals or maize
	Open air cultivation of vegetables
	Orchards
X	Agro-energy systems (e.g. biogas)
X	Animal Byproduct processing (e.g. manure processing)

Innovative solutions for optimized nutrient & GHG in animal husbandry	X
Innovative soil, fertilisation & crop management systems & practices	X
Tools, techniques & systems for higher-precision fertilization	X
Biobased fertilisers (N, P) and soil enhancers (OC) from agro-residues	
Novel animal feeds produced from agro-residues	
Other, please specify :	

31 Certification systems for precision application technologies

AIM OF THE TECHNOLOGY

Provide a brief description of the proposed management solution or technique.

- *What is the purpose/aim of the innovative solution/technique?*
  The main purpose of this solution is to define relevant and essential indicators to assess and further develop certification schemes for precision application technologies that are consistent at the EU level.

- *What is the underlying working principle?*
  Fertilizer application techniques should have a minimum of distribution accuracy and dosage accuracy. Certain variation coefficients from these values (i.e., width and overlap) should be determined in order to reveal to what extent deviations from requirements can be tolerated.
  Accuracy of application technologies is normally not part of mandatory legal requirements. For the farm sector and contractors, information on application accuracy as well as proper management is crucial.
  There is a need to have a uniform system for certification requirements and respective information at the EU level, so that in future precision application techniques can be produced, traded, and employed in all EU member states, when they are consistent with common requirements.
  Compliance with the requirements needs to be proven by certain certifying institutions, such as the German Agricultural Society “DLG” (Deutsche Landwirtschafts-Gesellschaft), whether the equipment is certified according to a recognized test protocol.

- *What is the current and foreseen scale of operations (e.g. kg, tonnes/year)?*
  Precise application is relevant to the total of organic fertiliser application, and is to be regarded as a widely ignored key element of improved nutrient management.

- *Why is it innovative when compared to existing (farming) practices?*
  Distribution and dosage accuracy can improve N and P fertilizer use efficiency with potentially positive effects on yields.
  Lower fertilizer application for higher or unchanged yield levels can lead to higher economic returns and lower negative environmental impacts.

- *How does it improve the Nitrogen-Phosphorus and/or Carbon cycles in agriculture?*
  Apart from satisfying regulatory requirements, the increase in distribution and dosage accuracy improves nutrient use efficiency by a better targeted supply of fertilizers, and reduced losses.

- *Add a separate line on the location of your management solution: “Currently this technology / technique / management solution is applied in ……. (city, region, country)).”*
  Applied to specific farm machinery, the geographical coverage exceeds the EU member state level.

31 Certification systems for precision application technologies

TRL (Technology Readiness Level) – how close is your solution to the market?

Use the slider above to position the current TRL* of your proposed solution

* TRLs are a type of measurement system used to assess the maturity level of a particular technology. Where a topic description refers to a TRL, the following definitions apply, unless otherwise specified:

• TRL 1 – basic principles observed • TRL 2 – technology concept formulated • TRL 3 – experimental proof of concept • TRL 4 – technology validated in lab • TRL 5 – technology validated in relevant environment (industrially relevant environment in the case of key enabling technologies) • TRL 6 – technology demonstrated in relevant environment (industrially relevant environment in the case of key enabling technologies) • TRL 7 – system prototype demonstration in operational environment • TRL 8 – system complete and qualified • TRL 9 – actual system proven & running in operational environment

Please provide some sentences explaining your Technology Readiness Level

If the proposed solution/ technique is currently at low TRL (≤5), is upscaling foreseen within the next year(s)?

If the proposed solution/ technique is currently at high TRL (≥7), is there any product already being produced from the proposed solution/ technique?

- *If yes, what is the name of the product :*
- *Short description of the product*
- *Are there any EC/MS Authority permits already for use of the product (title or link if available)?*

POTENTIAL LINKAGE TO THE PROJECT

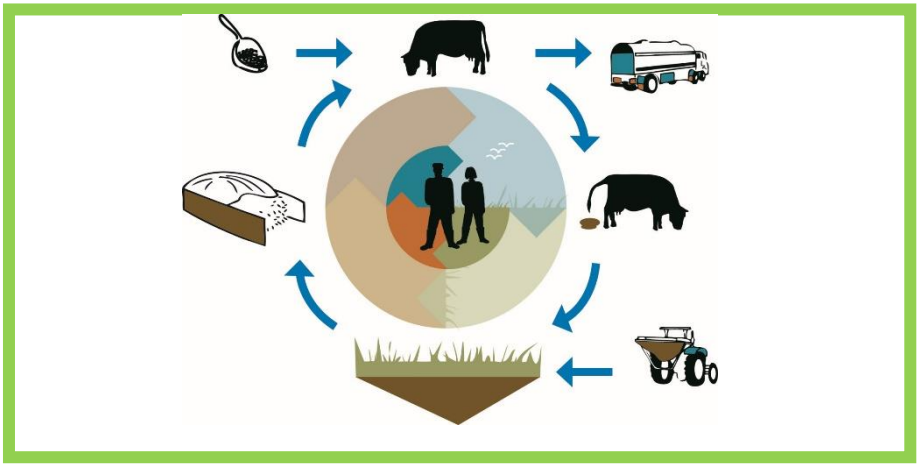
Indicate to which agro-typology under study and which potential research line of the project, your proposed solution/technique contributes :

X	Pig Production
X	Poultry Production
X	Cattle Farming
X	Open field cultivation of cereals or maize
	Open air cultivation of vegetables
	Orchards
	Agro-energy systems (e.g. biogas)
	Animal Byproduct processing (e.g. manure processing)

Innovative solutions for optimized nutrient & GHG in animal husbandry	
Innovative soil, fertilisation & crop management systems & practices	X
Tools, techniques & systems for higher-precision fertilization	X
Biobased fertilisers (N, P) and soil enhancers (OC) from agro-residues	
Novel animal feeds produced from agro-residues	
Other, please specify :	

32 Annual Nutrient Cycling Assessment (ANCA)

AIM OF THE TECHNOLOGY



Provide a brief description of the proposed management solution or technique.

- *What is the purpose/aim of the innovative solution/technique?*
  The ANCA is a management tool that visualises the total mineral efficiency on a dairy farm. To obtain more insight into the mineral cycle of animal, feed, soil and manure, the use of minerals can be better controlled. For example, this could lead to higher grass yield, less manure removal and savings on roughage purchase or fertilizer purchase.

- *What is the underlying working principle?*
  The dairy sector continue wants to develop in a sustainable way. The Dutch Dairy Association (NZO) and LTO presented a report for longterm goals. The basis for sustainable dairy products is efficient mineral utilization. The ANCA, gives insight in the nutrient cycle on a dairy farm. It shows, that when you change something in the nutrient cycle, it has many consequences in the rest of the cycle (positive and negative). The calculations used in the ANCA are scientific proven and distracted from the project Cows and Opportunities a public-private cooperation by practical and trail farms with high information density.

  What is the current and foreseen scale of operations (e.g. kg, tonnes/year)?
  In The Netherlands, for almost 95% of the dairy farmers (18.000 dairy farmers) the ANCA is obligated since 2017. The obligation is by the quality schemes of the Dutch dairy compagnies.

- *Why is it innovative when compared to existing (farming) practices?*
  In the tool, all the elements of dairy farming come together and gives a good insight in a whole farm. It makes it more clear that all the different parts of the cycle (animal, manure, soil and feed) are linked to each other. Approximately 90% of the data enters the digital database directly automatic. For example the purchased feed and fertilizers, grass and mais silage feeding values and amount, the delivered quantity of milk and urea, the number of livestock, manure transport off farm. The data of all dairy farmers come together in the central data base of ANCA. Farmers can give a permission to other persons or advisory compagnies to withdraw the data freely.

- *How does it improve the Nitrogen-Phosphorus and/or Carbon cycles in agriculture?*
  The tool gives more insight in the performance of the N-P-C cycles of the farm. The tool gives a lot of specific output of the cycles. The open database makes it possible for advisors to support

the farmer to help interpret the outcome and is a basis for advice for more efficient use of minerals, improve productivity of the grass and maisland, better use of the soil, more efficient use of livestock feed, CO2-foodprint. Due to the high enrolment of dairy farmers and standardizing of inputdata (groups) of farmers is a sound basic for comparison and working in farmgroups. Farmers tend to change/improve more easily in comparison with valued colleague-farmers.

- *Add a separate line on the location of your management solution: "Currently this technology / technique / management solution is applied in ……. (city, region, country))."*
  This tool is applied in the Netherlands by 95% of the dairy farmers

TRL (Technology Readiness Level) – how close is your solution to the market?

Use the slider above to position the current TRL* of your proposed solution

* TRLs are a type of measurement system used to assess the maturity level of a particular technology. Where a topic description refers to a TRL, the following definitions apply, unless otherwise specified:

• TRL 1 – basic principles observed • TRL 2 – technology concept formulated • TRL 3 – experimental proof of concept • TRL 4 – technology validated in lab • TRL 5 – technology validated in relevant environment (industrially relevant environment in the case of key enabling technologies) • TRL 6 – technology demonstrated in relevant environment (industrially relevant environment in the case of key enabling technologies) • TRL 7 – system prototype demonstration in operational environment • TRL 8 – system complete and qualified • TRL 9 – actual system proven & running in operational environment

Please provide some sentences explaining your Technology Readiness Level

The TRL level is almost 9. It is in between 8 and 9 because the ANCA don't have enough assurance in the Dutch Policy. The support of the ANCA have to grow.

If the proposed solution/ technique is currently at low TRL (≤5), is upscaling foreseen within the next year(s)?

If the proposed solution/ technique is currently at high TRL (≥7), is there any product already being produced from the proposed solution/ technique?

- *If yes, what is the name of the product :*
  The ANCA is a management tool and obligated for almost all the Dutch dairy farmers. (License to deliver).

- *Short description of the product*

- *Are there any EC/MS Authority permits already for use of the product (title or link if available)?*

32 Annual Nutrient Cycling Assessment (ANCA)

POTENTIAL LINKAGE TO THE PROJECT

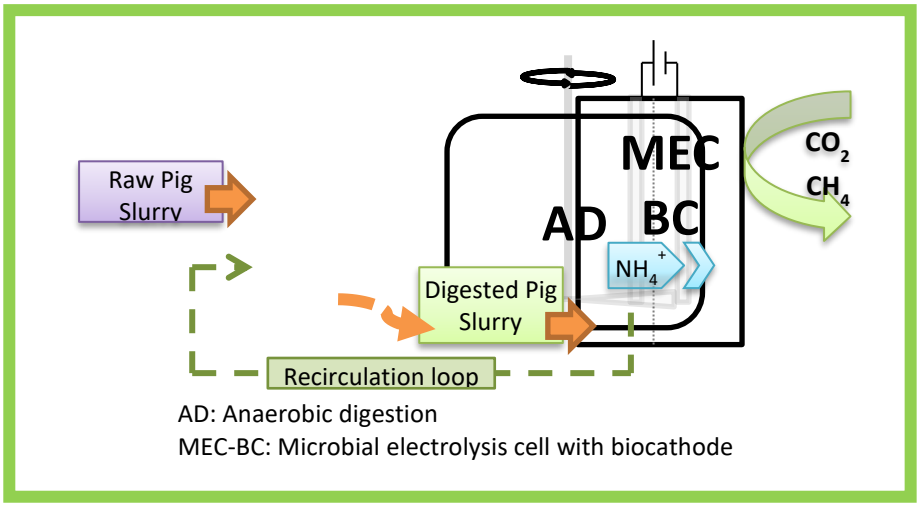
Indicate to which agro-typology under study and which potential research line of the project, your proposed solution/technique contributes :

	Pig Production
	Poultry Production
X	Cattle Farming
X	Open field cultivation of cereals or maize
	Open air cultivation of vegetables
	Orchards
	Agro-energy systems (e.g. biogas)
	Animal Byproduct processing (e.g. manure processing)

Innovative solutions for optimized nutrient & GHG in animal husbandry	X
Innovative soil, fertilisation & crop management systems & practices	X
Tools, techniques & systems for higher-precision fertilization	X
Biobased fertilisers (N, P) and soil enhancers (OC) from agro-residues	
Novel animal feeds produced from agro-residues	
Other, please specify :	

33 Anaerobic digestion and microbial electrolysis cell integrate system for biogas upgrading and ammonia recovery

AIM OF THE TECHNOLOGY



Provide a brief description of the proposed management solution or technique.

- *What is the purpose/aim of the innovative solution/technique?*
  The aim of this technology is to recover ammonia from digestates, reduce ammonia inhibition in anaerobic digestion process and upgrade the produced biogas.

- *What is the underlying working principle?*
  Bioelectrochemical systems (BES) are bioreactors in which the oxidation and/or reduction reactions are catalysed by microorganisms on the surface of an electrode and generally produced in two compartments separated by an ion exchange membrane. Among the different types of BES, in a microbial electrolysis cells (MEC) the chemical energy of biodegradable organic matter is converted into electricity through metabolic activity. An external supply of electricity is required in order to promote a thermodynamically non-spontaneous reaction at the cathode, generating a target product, such as molecular hydrogen.
  In dual chamber microbial fuel cells, ammonia in the influent of the anode chamber (digested livestock manure, for example) migrates through a cation exchange membrane to the cathode compartment. The effluent of the anode chamber, with a lower nitrogen content, can be recirculated to the anaerobic digester to reduce ammonia inhibition phenomena. The ammonia content of the cathode chamber effluent can be recovered in a subsequent stripping and absorption step and be reused as a fertiliser.
  On the other hand, a biofilm can be promoted on the cathode able to produce methane from carbon dioxide (electromethanogenesis). This way, the biogas produced in anaerobic digestion can be upgraded, reducing its carbon dioxide content.

- *What is the current and foreseen scale of operations (e.g. kg, tonnes/year)?*
  Currently this technology is operated at lab scale, treating around 20 mL/h (200 kg/year) of digested pig slurry.

- *Why is it innovative when compared to existing (farming) practices?*
  The combination of anaerobic digestion with microbial fuel cell increases the stability of the anaerobic digestion process against organic or nitrogen overloads. Furthermore, the coupling of

anaerobic digestion with MECs allows for the recovery of this nitrogen and the reuse as a fertilizer.
Regarding biogas upgrading, in a MEC with electromethanogenic biocathode CO_2 is transformed into methane, differently from existing upgrading techniques focused on CO_2 removing.

- *How does it improve the Nitrogen-Phosphorus and/or Carbon cycles in agriculture?*
  The Nitrogen cycle in agriculture is improved, since nitrogen content in livestock manure is recovered in the cathode compartment of the MEC and can be reused as a fertilizer, closing the cycle. Carbon (CO_2) as a source of energy is also used.

- *Add a separate line on the location of your management solution: "Currently this technology / technique / management solution is applied in ……. (city, region, country))."*
  Currently this technology is being tested at lab scale in the IRTA facilities (Caldes de Montbui, Barcelona, Spain).

TRL (Technology Readiness Level) – how close is your solution to the market?

Use the slider above to position the current TRL* of your proposed solution

* TRLs are a type of measurement system used to assess the maturity level of a particular technology. Where a topic description refers to a TRL, the following definitions apply, unless otherwise specified:

• TRL 1 – basic principles observed • TRL 2 – technology concept formulated • TRL 3 – experimental proof of concept • TRL 4 – technology validated in lab • TRL 5 – technology validated in relevant environment (industrially relevant environment in the case of key enabling technologies) • TRL 6 – technology demonstrated in relevant environment (industrially relevant environment in the case of key enabling technologies) • TRL 7 – system prototype demonstration in operational environment • TRL 8 – system complete and qualified • TRL 9 – actual system proven & running in operational environment

Please provide some sentences explaining your Technology Readiness Level

The combination of anaerobic digestion and microbial electrolysis cell has been assessed at lab scale for the treatment of pig slurry (TRL3-TR. The results obtained make feasible to scale up the technology to a pilot scale in the next years (TRL5).

If the proposed solution/ technique is currently at low TRL (≤5), is upscaling foreseen within the next year(s)?

YES.

If the proposed solution/ technique is currently at high TRL (≥7), is there any product already being produced from the proposed solution/ technique?

- *If yes, what is the name of the product :*
- *Short description of the product*
- *Are there any EC/MS Authority permits already for use of the product (title or link if available)?*

33 Anaerobic digestion and microbial electrolysis cell integrate system for biogas upgrading and ammonia recovery

POTENTIAL LINKAGE TO THE PROJECT

Indicate to which agro-typology under study and which potential research line of the project, your proposed solution/technique contributes :

	Pig Production
	Poultry Production
	Cattle Farming
	Open field cultivation of cereals or maize
	Open air cultivation of vegetables
	Orchards
X	Agro-energy systems (e.g. biogas)
X	Animal Byproduct processing (e.g. manure processing)

Innovative solutions for optimized nutrient & GHG in animal husbandry	X
Innovative soil, fertilisation & crop management systems & practices	
Tools, techniques & systems for higher-precision fertilization	
Biobased fertilisers (N, P) and soil enhancers (OC) from agro-residues	
Novel animal feeds produced from agro-residues	
Other, please specify :	

34 Secondary harvest: additional valorisation of crop harvest and processing residues

AIM OF THE TECHNOLOGY

Valorisation of the stem of Brussels sprouts

Provide a brief description of the proposed management solution or technique.

- *What is the purpose/aim of the innovative solution/technique?*
  Crop residues and manure may lead to nutrient leaching. The purpose of this technique is to valorize those unwanted biomass into something useful, e.g. feed of the stem of Brussels sprouts, creating paper of crop residues, etc.

- *What is the underlying working principle?*
  A machine cuts the stems of Brussels sprouts in pieces of approximately 7 cm. These are stocked in bunkers and afterwards transported separately.

- *What is the current and foreseen scale of operations (e.g. kg, tonnes/year)?*
  Stems of Brussels sprouts: 230.000 tonnes/year in Belgium, the Netherlands and the UK
  Leaves of Brussels sprouts: 190.000 tonnes/year in Belgium, the Netherlands and the UK
  Fiber-rich material of tomatoes: 100.000 tonnes/year for Belgium, the Netherlands and the UK

- *Why is it innovative when compared to existing (farming) practices?*
  Today most of these streams remain behind on the field to rot, or they have to be deposited as waste. Research is still ongoing to extend this technique to other crop residues like cauliflower, beans, peas, etc.

- *How does it improve the Nitrogen-Phosphorus and/or Carbon cycles in agriculture?*
  Through the rotting of the plant remains, nutrients are released during the winter period when no other crops grow on the field to use them useful resulting in nitrate leaching. However, farmers are asking what the impact on their land is because if everything is removed how will you continue feeding the soil with organic material? There is research needed to discuss the impact on the carbon cycle.

- *Add a separate line on the location of your management solution: "Currently this technology / technique / management solution is applied in ……. (city, region, country))."*
  Currently this management solution is mainly applied in Belgium and The Netherlands.

34 Secondary harvest: additional valorisation of crop harvest and processing residues

TRL (Technology Readiness Level) – how close is your solution to the market?

Use the slider above to position the current TRL* of your proposed solution

* TRLs are a type of measurement system used to assess the maturity level of a particular technology. Where a topic description refers to a TRL, the following definitions apply, unless otherwise specified:

• TRL 1 – basic principles observed • TRL 2 – technology concept formulated • TRL 3 – experimental proof of concept • TRL 4 – technology validated in lab • TRL 5 – technology validated in relevant environment (industrially relevant environment in the case of key enabling technologies) • TRL 6 – technology demonstrated in relevant environment (industrially relevant environment in the case of key enabling technologies) • TRL 7 – system prototype demonstration in operational environment • TRL 8 – system complete and qualified • TRL 9 – actual system proven & running in operational environment

Please provide some sentences explaining your Technology Readiness Level

Brussels sprouts: 4-5

Tomato foliage: 7

An important note is that ensiling is very important (research still ongoing) because crop residues are season dependent.

If the proposed solution/ technique is currently at low TRL (≤5), is upscaling foreseen within the next year(s)?

If the proposed solution/ technique is currently at high TRL (≥7), is there any product already being produced from the proposed solution/ technique ?

- *If yes, what is the name of the product :*
- *Short description of the product:*
- *Are there any EC/MS Authority permits already for use of the product (title or link if available)?*

34 Secondary harvest: additional valorisation of crop harvest and processing residues

POTENTIAL LINKAGE TO THE PROJECT

Indicate to which agro-typology under study and which potential research line of the project, your proposed solution/technique contributes :

	Pig Production
	Poultry Production
X	Cattle Farming
X	Open field cultivation of cereals or maize
X	Open air cultivation of vegetables
	Orchards
X	Agro-energy systems (e.g. biogas)
	Animal Byproduct processing (e.g. manure processing)

Innovative solutions for optimized nutrient & GHG in animal husbandry	X
Innovative soil, fertilisation & crop management systems & practices	
Tools, techniques & systems for higher-precision fertilization	
Biobased fertilisers (N, P) and soil enhancers (OC) from agro-residues	X
Novel animal feeds produced from agro-residues	X
Other, please specify :	

35 Aquaponics on nutrients recovered from aquaculture

AIM OF THE TECHNOLOGY

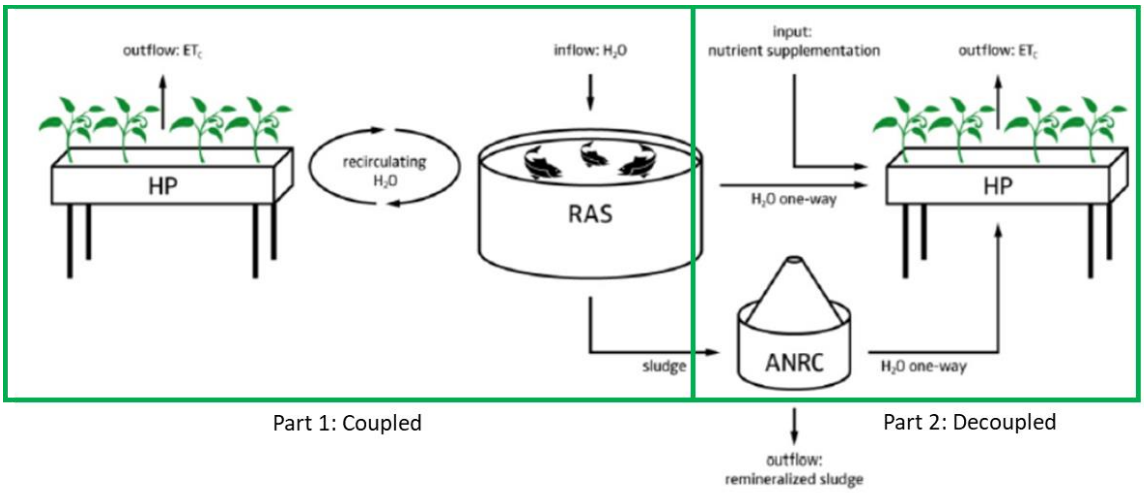


Fig 1. Hybrid coupled-decoupled aquaponic system (Goddek et al. 2016). RAS: recirculating aquaculture system, HP: hydroponic culture, ANRC: sludge digestion bioreactor system.

Provide a brief description of the proposed management solution or technique.

- *What is the purpose/aim of the innovative solution/technique?*
  The main aim is to reuse aquaculture waste water to irrigate hydroponic crops. Aquaponics is the integration of aquaculture and hydroponic systems where, in general terms, the waste produced by aquatic organisms becomes nutrients through bacterial action for plant growth.

- *What is the underlying working principle?*
  Aquaponics combines hydroponics and recirculating aquaculture elements and different combinations can be designed. Conventional hydroponics requires mineral fertilizers in order to supply the plants with necessary nutrients, while the aquaponic systems use the available fish waste water that is rich in nutrients as fertilizer. The system results in a closed water loop between fish, microorganisms and plants, and encourages sustainable use of water and nutrients. This combination substantially minimizes the need for input of nutrients and output of waste, unlike when run as separate systems. Figure 1 outlines, in our opinion, the optimal aquaponics system design. This consists in two parts: Part 1 is a recirculating aquaculture systems (RAS) and hydroponics coupled part, where water recirculates in a closed water loop from fish to plant. In this part, leafy vegetables and microgreens can be grown. Part 2 is a decoupled part; some fish waste water and fish sludge leave the RAS to go in another hydroponic culture part but do not come back to the fish. There, the water leaves only through plant transpiration. In this part the fish waste water can be complemented with nutrients in order to grow heavy feeder plants as fruity vegetables. The water can be complemented with standard fertilizer but also with nutrient recovered from the sludge thanks to a digestion system using bioreactors.

- *What is the current and foreseen scale of operations (e.g. kg, tonnes/year)?*
  The most common scale worldwide is lab or demo scale in research centres. A lot of backyard systems are used also for hobby.

35 Aquaponics on nutrients recovered from aquaculture

Some higher scale decoupled aquaponic systems have been recently build in Germany (Berlin), Belgium (Brussels), Switzerland (Bale), UK, South Africa, Australia and USA. These systems can produce no more than a few tons of fish (mostly tilapia) and plant per year. Different new small companies have been founded to run it, all are in a testing phase at industrial and economic scale.

- *Why is it innovative when compared to existing (farming) practices?*
  Aquaponics is a circular economy approach for aquaculture and hydroponics. Aquaculture waste water is not spilled into the environment but used for hydroponic irrigation and fertilization. Hydroponic crop production can rely on organic fertilizer instead of chemical fertilizers.
  The fish waste water is loaded with microorganisms and dissolved organic matter, both can have a plant biostimulating effect leading to plant yields increase and/or better plant health (e.g. higher resistance to biotic and abiotic stress). This aspect can be a strong advantage of growing plant in aquaponic systems.

- *How does it improve the Nitrogen-Phosphorus and/or Carbon cycles in agriculture?*
  The proposed management solution assures the use of the soluble Nitrogen and Phosphorus excreted by fish to fertilize hydroponic plants instead of releasing it into the environment. Some part of N, P and C are excreted as solids and, after appropriate mechanical filtration in the RAS, end up in sludge. With our proposed design, this sludge is treated into bioreactor in order to recover N and P into soluble forms and used in the decoupled part to fertilize hydroponic crops. This assure a maximal use of the nutrients onsite and a minimal runoff. The C-organic contained in sludge is converted in CO2 and CH4 during the sludge treatment process. CH4 can be burned into CO2 and produce a part of the energy (Heat, electricity) required onsite.

- *Add a separate line on the location of your management solution: "Currently this technology / technique / management solution is applied in ……. (city, region, country))."*
  We can currently run experiments on aquaponics in INAGRO facilities until a semi-practice scale. We have a large pikeperch RAS and a large area of hydroponic greenhouses. A pipe network was installed to connect the RAS and the hydroponic greenhouses.

35 Aquaponics on nutrients recovered from aquaculture

TRL (Technology Readiness Level) – how close is your solution to the market?

Use the slider above to position the current TRL* of your proposed solution

* TRLs are a type of measurement system used to assess the maturity level of a particular technology. Where a topic description refers to a TRL, the following definitions apply, unless otherwise specified:

• TRL 1 – basic principles observed • TRL 2 – technology concept formulated • TRL 3 – experimental proof of concept • TRL 4 – technology validated in lab • TRL 5 – technology validated in relevant environment (industrially relevant environment in the case of key enabling technologies) • TRL 6 – technology demonstrated in relevant environment (industrially relevant environment in the case of key enabling technologies) • TRL 7 – system prototype demonstration in operational environment • TRL 8 – system complete and qualified • TRL 9 – actual system proven & running in operational environment

Please provide some sentences explaining your Technology Readiness Level

Aquaponics is actually up scaled up to relevant industrial environment by several small companies worldwide. Different designs are used. Our proposed design is not yet used on a large scale. For each type of design, it is important to establish the mass balances of nutrients and validate if the maximal reuse of fish wasted nutrient by hydroponic crops occurs. The bio-stimulating effect of fish water and its impact on yields and plant health is not yet clearly established.

If the proposed solution/ technique is currently at low TRL (≤5), is upscaling foreseen within the next year(s)?

YES for the reasons exposed above.

If the proposed solution/ technique is currently at low TRL (≤5), is upscaling foreseen within the next year(s)?

If the proposed solution/ technique is currently at high TRL (≥7), is there any product already being produced from the proposed solution/ technique?

- *If yes, what is the name of the product :*
- *Short description of the product:*
- *Are there any EC/MS Authority permits already for use of the product (title or link if available)?*

35 Aquaponics on nutrients recovered from aquaculture

POTENTIAL LINKAGE TO THE PROJECT

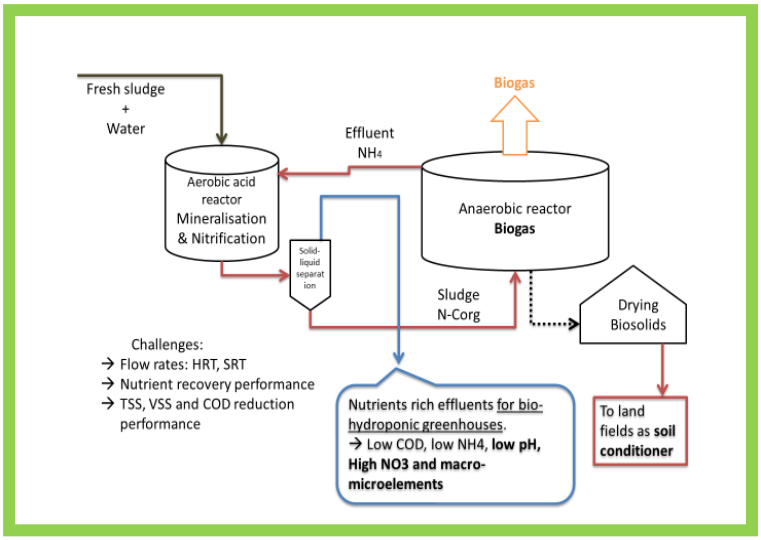
Indicate to which agro-typology under study and which potential research line of the project, your proposed solution/technique contributes :

	Pig Production
	Poultry Production
	Cattle Farming
	Open field cultivation of cereals or maize
	Open air cultivation of vegetables
	Orchards
	Agro-energy systems (e.g. biogas)
	Animal Byproduct processing (e.g. manure processing)

Innovative solutions for optimized nutrient & GHG in animal husbandry		
Innovative soil, fertilisation & crop management systems & practices		X
Tools, techniques & systems for higher-precision fertilization		
Biobased fertilisers (N, P) and soil enhancers (OC) from agro-residues		
Novel animal feeds produced from agro-residues		
Other, please specify :	RAS and greenhouse hydroponics	X

36 Biological processes to produce bio-hydroponic nutritive solution

AIM OF THE TECHNOLOGY



Provide a brief description of the proposed management solution or technique.

- *What is the purpose/aim of the innovative solution/technique?*
  The aim is to recover nutrients (macro- and micronutrients) from organic waste streams as animal manure to produce a nutritive solution to use in circular bio-hydroponic greenhouses while using a combination of biological processes such as aerobic/anaerobic digestion, acidification and nitrification.

- *What is the underlying working principle?*
  The innovative treatment to recover nutrients while producing biogas and soil conditioner could be tested in the configuration proposed in the figure above. A first step would consist in macro and micronutrients recovery, except organic N, from the solid organic waste part via natural mineralisation occurring in low pH conditions (i.e. pH < 6). Acidic and aerobic conditions should be maintained in the bioreactor to avoid the presence of plant toxic dissolved organic molecules as monocarboxylic acids (or other volatile fatty acids (VFA)) in its effluents and assuring the recovery of nutrients as soluble ions or chelates. After a solid-liquid separation step of this aerobic reactor effluent, a nutrient rich solution can be recovered that would make a BF perfectly suitable for BHP.
  To further treat the solids resulting from this first step, anaerobic digestion can be used to degrade the organic matter and further release soluble N (i.e. proteins are degraded and N is released as soluble NH_3) and other nutrients trapped in the organic matter. This organic matter degradation process results in the production of methane (CH_4) and digestate. The liquid and the solid phase of this digestate will be separated. The liquid phase rich in NH_3 and other nutrients will be returned to the aerobic bioreactor for nitrification and removal of toxic VFA to then be used as BHP. This insertion of NH_3 is supposed to decrease the pH because of the nitrification process (i.e. for each mol of NH_3 converted to NO_3, 3 moles of H^+ is released) occurring in aerobic conditions. This nitrification process will be a natural way to maintain acidic conditions into the reactor. It remains to be established if the mineralisation and the nitrification processes can be achieved in the same aerobic bioreactor or should be achieved in two separated ones.

36 Biological processes to produce bio-hydroponic nutritive solution

- *What is the current and foreseen scale of operations (e.g. kg, tonnes/year) ?*
  Currently this management solution is not applied in big scale. But all the currently used hydroponic greenhouses in Netherlands and Flanders could be converted into circular bio-hydroponic greenhouses. This practice could be spread worldwide as soon as organic waste stream exist nearby the greenhouse.

- *Why is it innovative when compared to existing (farming) practices? How does it improve the Nitrogen-Phosphorus and/or Carbon cycles in agriculture?*
  This proposed circular bio-hydroponics (BHP) approach consist in the production of biofertilizer (BF) and its use on-site as nutritive solution in recirculated hydroponic horticultural systems. Actual recirculating hydroponic practices (in greenhouses or outside) can be considered as the most productive way for production of horticultural plants, i.e. in term of yields (kg biomass/m²/year). The recirculation is a great technology as it increases the fertilizer use efficiency while avoiding the infiltration of nutrients (N, P, K, …) in the soil and pollution of surface water. However, two major drawbacks that are making this practice not sustainable are:
  (1) its high demand in fossil energy for electricity and heat (for cold climate) and,
  (2) the intensive use of chemical fertilizers based on finite resources as P and K. Namely, the formulation and transport of the chemical fertilisers requires also substantial amount of fossil energy. BHP could mitigate these drawbacks by processing local biowaste streams (e.g. animal manure) in biodigesters in order to produce at the same times soluble biofertilizers and biogas (i.e. CH_4). The biogas could cover the all energy needs required by the biofertilizer production process itself and for the hydroponic production. Making then the BHP neutral in term of greenhouse gas emission. CO_2 can also be recovered to increase yields in BHP greenhouses. The biofertilizer produced should be used as only fertilizer in BHP avoiding reliability on finite mined resources as P and K. Stabilized biosolids constituted only with recalcitrant carbon molecules (e.g. humic acids-like molecules) plus macro- and micronutrients with a low solubility (e.g. precipitated minerals) will be also produced and can be used as land field conditioner.

36 Biological processes to produce bio-hydroponic nutritive solution

TRL (Technology Readiness Level) – how close is your solution to the market?

Use the slider above to position the current TRL* of your proposed solution

* TRLs are a type of measurement system used to assess the maturity level of a particular technology. Where a topic description refers to a TRL, the following definitions apply, unless otherwise specified:

• TRL 1 – basic principles observed • TRL 2 – technology concept formulated • TRL 3 – experimental proof of concept • TRL 4 – technology validated in lab • TRL 5 – technology validated in relevant environment (industrially relevant environment in the case of key enabling technologies) • TRL 6 – technology demonstrated in relevant environment (industrially relevant environment in the case of key enabling technologies) • TRL 7 – system prototype demonstration in operational environment • TRL 8 – system complete and qualified • TRL 9 – actual system proven & running in operational environment

Please provide some sentences explaining your Technology Readiness Level

The management solution proposed combines technologies already existing with a TRL of 7 to 9. The innovation is in the way these technologies are combined. A proper sizing of the components is required, and the optimal hydraulic and sludge retention times need to be determined. Also, mass balances studies must be carried to assess the nutrient recovery efficiency of the overall system. The combination of technology of high TRL will lead to a rapid increase in TRL of the proposed management solution.

If the proposed solution/ technique is currently at low TRL (≤5), is upscaling foreseen within the next year(s)?

YES, possible rapidly as combining technology of TRL 7-9.

If the proposed solution/ technique is currently at high TRL (≥7), is there any product already being produced from the proposed solution/ technique?

- *If yes, what is the name of the product :*
- *Short description of the product:*
- *Are there any EC/MS Authority permits already for use of the product (title or link if available)?*

36 Biological processes to produce bio-hydroponic nutritive solution

POTENTIAL LINKAGE TO THE PROJECT

Indicate to which agro-typology under study and which potential research line of the project, your proposed solution/technique contributes:

X	Pig Production
X	Poultry Production
X	Cattle Farming
X	Open field cultivation of cereals or maize
X	Open air cultivation of vegetables
X	Orchards
X	Agro-energy systems (e.g. biogas)
X	Animal Byproduct processing (e.g. manure processing)

Innovative solutions for optimized nutrient & GHG in animal husbandry		X
Innovative soil, fertilisation & crop management systems & practices		X
Tools, techniques & systems for higher-precision fertilization		
Biobased fertilisers (N, P) and soil enhancers (OC) from agro-residues		X
Novel animal feeds produced from agro-residues		
Other, please specify :	Bio hydroponic nutrient solution	X

37 Manure aeration techniques to reduce emissions

AIM OF THE TECHNOLOGY

(Bos Aeromix te Stassen Mestrecycling in Born, no date).

Provide a brief description of the proposed management solution or technique.

- *What is the purpose/aim of the innovative solution/technique?*
  The purpose of this technique is to reduce manure ammonia emission. Air bubbles are blown into the liquid manure. By doing this the manure is mixed and could possibly reduce ammonia emissions by 50%. Also other toxic gasses like CH_4 and H_2S could be reduced, as well as bad odour.

- *What is the underlying working principle?*
  Tylene pipelines are used with two or four outlet openings, which are all controlled separately. The liquid manure is only mixed for a couple of minutes per day. This is not enough to bind oxygen to nitrogen. The mixing prevents the formation of a floating layer, so that the manure cannot reach anaerobic conditions. By mixing on a daily basis the manure remains “fresh” and the fermentation of liquid manure is being influenced in a positive way.
  A minimum depth of 0.5 m of manure is required.

- *What is the current and foreseen scale of operations (e.g. kg, tonnes/year)?*
  The technique is being used by approximately 60 cattle farmers in the Netherlands. In Ireland and England this system is being used for 20 years now.

- *Why is it innovative when compared to existing (farming) practices?*
  Less ammonia emissions lead to a better climate. Anaerobic digestion is influenced in a positive way by pre-processing the manure in this way.

- *How does it improve the Nitrogen-Phosphorus and/or Carbon cycles in agriculture?*
  Less ammonia is being released. By using this technique the manure is possibly also more suitable as fertilizer.

37 Manure aeration techniques to reduce emissions

- *Add a separate line on the location of your management solution: "Currently this technology / technique / management solution is applied in ……. (city, region, country)).*
  Lokeren (Belgium), the Netherlands, UK, Ireland.

TRL (Technology Readiness Level) – how close is your solution to the market?

Use the slider above to position the current TRL* of your proposed solution

* TRLs are a type of measurement system used to assess the maturity level of a particular technology. Where a topic description refers to a TRL, the following definitions apply, unless otherwise specified:

• TRL 1 – basic principles observed • TRL 2 – technology concept formulated • TRL 3 – experimental proof of concept • TRL 4 – technology validated in lab • TRL 5 – technology validated in relevant environment (industrially relevant environment in the case of key enabling technologies) • TRL 6 – technology demonstrated in relevant environment (industrially relevant environment in the case of key enabling technologies) • TRL 7 – system prototype demonstration in operational environment • TRL 8 – system complete and qualified • TRL 9 – actual system proven & running in operational environment

Please provide some sentences explaining your Technology Readiness Level

TRL 9 for cattle farming
TRL 7 for pig housing

If the proposed solution/ technique is currently at low TRL (≤5), is upscaling foreseen within the next year(s)?

If the proposed solution/ technique is currently at high TRL (≥7), is there any product already being produced from the proposed solution/ technique?

- *If yes, what is the name of the product :*
  Bos Aeromix.

- *Short description of the product*
  The original air mixing system is developed by Ameram Ltd from the UK as a slurry mixing system for manure canals in barns and for manure storages. It is being sold as the Bos Aeromix by Bos Ecosystems BV from the Netherlands. The mixing takes place by large air bubbles produced by a compressor and distributed by an air distribution system with hoses over the whole floor surface of the manure storage. In this way every spot in the storage can be mixed regularly with a restricted amount of air and electrical power.

- *Are there any EC/MS Authority permits already for use of the product (title or link if available)?*
  No.

37 Manure aeration techniques to reduce emissions

POTENTIAL LINKAGE TO THE PROJECT

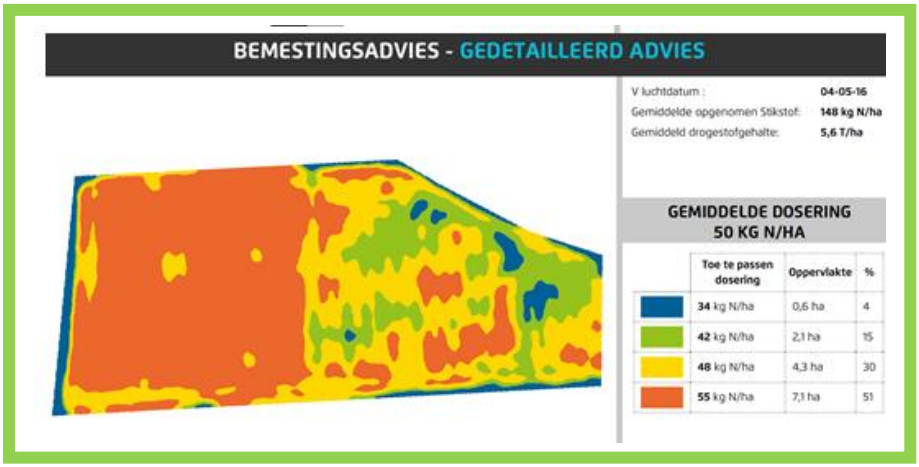
Indicate to which agro-typology under study and which potential research line of the project, your proposed solution/technique contributes :

X	Pig Production
	Poultry Production
X	Cattle Farming
	Open field cultivation of cereals or maize
	Open air cultivation of vegetables
	Orchards
X	Agro-energy systems (e.g. biogas)
X	Animal Byproduct processing (e.g. manure processing)

Innovative solutions for optimized nutrient & GHG in animal husbandry	X
Innovative soil, fertilisation & crop management systems & practices	
Tools, techniques & systems for higher-precision fertilization	
Biobased fertilisers (N, P) and soil enhancers (OC) from agro-residues	
Novel animal feeds produced from agro-residues	
Other, please specify :	

38 Smart fertilization: using (tele)sensing and IT-tools to optimize within field fertilization regimes

AIM OF THE TECHNOLOGY



Provide a brief description of the proposed management solution or technique.

- *What is the purpose/aim of the innovative solution/technique?*
  The purpose of smart fertilization is to use nutrients in a more efficient way than it is done nowadays. Only those places where additional nutrients are required should be fertilized.

- *What is the underlying working principle?*
  Tools used for smart fertilization are drones, cropsensors, satellite sensors and soil scans to get an idea on the available and required nutrients. Knowledge about what nutrients are available, what quantities of nutrients are already taken up by plants and what they require, give an idea about the exact quantities of nutrients still need to be dispensed.

- *What is the current and foreseen scale of operations (e.g. kg, tonnes/year)?*
  It varies between 10 until 60 kg/ha nutrients less utilized. For the moment it is already implemented for cereals, rapeseed and some *Poaceae*.
  Smart fertilization for potatoes will be possible within the next year. For fruits and vegetables the research is still ongoing.

- *Why is it innovative when compared to existing (farming) practices?*
  It is innovative because smart fertilization makes it possible to vary fertilization throughout a parcel. This is very useful in order to prevent over- or underfertilization. It will be possible to optimize fertilizing each plant individually.

- *How does it improve the Nitrogen-Phosphorus and/or Carbon cycles in agriculture?*
  The use of those nutrients will become much more effective and therefore less nutrients will be leached to the environment.

- *Add a separate line on the location of your management solution: "Currently this technology / technique / management solution is applied in ……. (city, region, country))."*
  Currently this technology is applied in Europe (Belgium, the Netherlands, France, Germany, United Kingdom).

38 Smart fertilization: using (tele)sensing and IT-tools to optimize within field fertilization regimes

TRL (Technology Readiness Level) – how close is your solution to the market?

Use the slider above to position the current TRL* of your proposed solution

* TRLs are a type of measurement system used to assess the maturity level of a particular technology. Where a topic description refers to a TRL, the following definitions apply, unless otherwise specified:

• TRL 1 – basic principles observed • TRL 2 – technology concept formulated • TRL 3 – experimental proof of concept • TRL 4 – technology validated in lab • TRL 5 – technology validated in relevant environment (industrially relevant environment in the case of key enabling technologies) • TRL 6 – technology demonstrated in relevant environment (industrially relevant environment in the case of key enabling technologies) • TRL 7 – system prototype demonstration in operational environment • TRL 8 – system complete and qualified • TRL 9 – actual system proven & running in operational environment

Please provide some sentences explaining your Technology Readiness Level

The TRL is different according to what crops are being produced.

- Cereals: TRL 9
- Rapeseed: TRL 9
- Poaceae: TRL 7-8
- Potatoes: TRL 6
- Vegetables: TRL 5

If the proposed solution/ technique is currently at low TRL (≤5), is upscaling foreseen within the next year(s)?

YES.

If the proposed solution/ technique is currently at high TRL (≥7), is there any product already being produced from the proposed solution/ technique?

- *If yes, what is the name of the product :*
  Farmstar / Airinov.

- *Short description of the product*
  Farmstar uses satellite images to apply variable rate fertilizer, while Airinov uses drones for the same purpose.

- *Are there any EC/MS Authority permits already for use of the product (title or link if available)?*
  NO.

38 Smart fertilization: using (tele)sensing and IT-tools to optimize within field fertilization regimes

POTENTIAL LINKAGE TO THE PROJECT

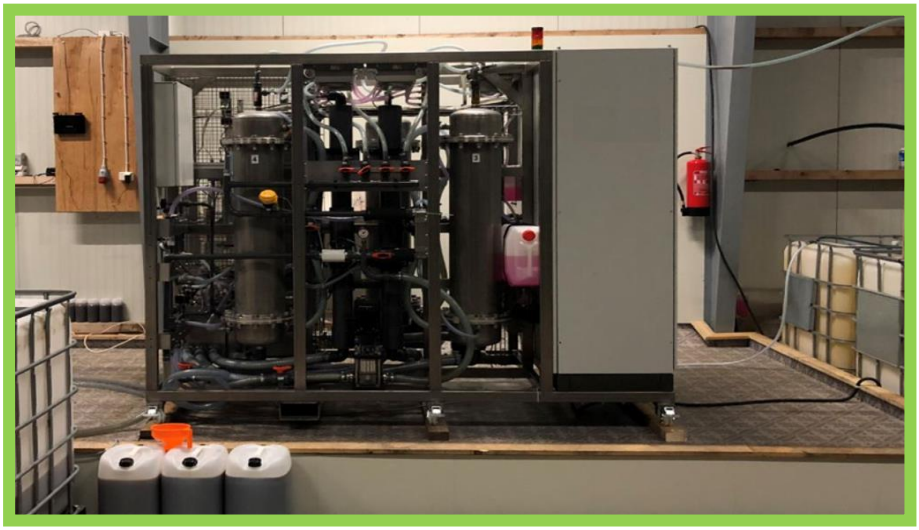
Indicate to which agro-typology under study and which potential research line of the project, your proposed solution/technique contributes :

	Pig Production
	Poultry Production
	Cattle Farming
X	Open field cultivation of cereals or maize
X	Open air cultivation of vegetables
X	Orchards
	Agro-energy systems (e.g. biogas)
	Animal Byproduct processing (e.g. manure processing)

Innovative solutions for optimized nutrient & GHG in animal husbandry	
Innovative soil, fertilisation & crop management systems & practices	X
Tools, techniques & systems for higher-precision fertilization	X
Biobased fertilisers (N, P) and soil enhancers (OC) from agro-residues	
Novel animal feeds produced from agro-residues	
Other, please specify :	

39 Plasma Manure Processing Technology

AIM OF THE TECHNOLOGY



Provide a brief description of the proposed management solution or technique.

- *What is the purpose/aim of the innovative solution/technique?*

  N2 Applied's technology produces nitrogen fertilizer on the farm, through fixing nitrogen from air and reaction with ammonia in manure or biogas digestate. The reaction stops the ammonia losses and increases the nitrogen content in the manure or digestate. It also removes the odour from the nitrogen enriched fertilizer product.

  The aim is to enable the livestock farmer to recycle nitrogen and produce his own fertilizer with lower greenhouse gas emissions, improved resource efficiency and reduced cost. The farmer will complement and may eventually substitute traditional fossil-fuel based industrial fertilizer.

- *What is the underlying working principle?*

  N2 Applied's plasma unit fixates nitrogen from air by splitting the N2 and O2 molecules in air into N and O atoms forming nitrogen oxides. The nitrogen oxides are absorbed into liquid manure or biogas digestate and combined with free ammonia to form ammonium nitrate. Nitrogen oxides are the basis for nitric acid, which neutralizes the liquid by lowering the pH to around 6 to 7, which stops ammonia loss in storage and during field application. This is the key component for converting ammonia to a stable ammonium nitrate fertilizer. The plasma unit absorption system can be adapted to various types of manure or digestate.

  The plasma unit only uses (preferably renewable) energy and air to operate and process the liquid part of manure or biogas digestate. Operation requires filtering as a pre-condition to reach a maximum of 5 to 7% dry matter and to remove large particles (3 to 5 mm filter). The optimal placing is close to the liquid stream, which could be on the farm or a central located biogas plant. The energy use is around 30 MWh/ton NOx gas produced and current focus of development is on increasing the energy efficiency further.

  N2 Applied is currently carrying out Life Cycle Assessments in cooperation with 2.-0 LCA Consultants from Denmark. The emphasis of the environmental effect lies in the reduction of ammonia emissions in storage (80% to 100%) and during field application (70% to 90%).

- *What is the current and foreseen scale of operations (e.g. kg, tonnes/year)?*

39 Plasma Manure Processing Technology

A 25 kW plasma unit with 20 MWh/ton N energy effiency produces around 10 ton NOx gas annually. Total energy consumption based on 8,000 hours operation is 200 MW per year. Assuming a free ammonia-N content of 3 kg per m3 of input material this setup can process around 3,333 m3 yearly. Assuming 25 m3 per cow per year (and capturing all manure), this setup can annually process manure of 133 cows. A 50 kW plasma unit would process twice as much and a 100 kW unit four times as much. Besides improvement of energy efficiency, energy price is important in the overall business case.

Output of the 25 kW plasma unit is 10 ton NOx gas annually and the potential to reduce emission of another 5 to 10 ton of ammonia-N. Phosphate in the liquid fraction is being mobilized by volatilization effect. The N/P balance is improved through the doubling of the nitrogen content. The nitrogen is directly available for plant uptake as ammonium nitrate. Assuming an input stream of 5 kg total-N per m^3 (0.5%) of which 3 kg as ammonia-N, the output stream generally contains 8 to 10 kg total-N (0.8% to 1.0%) of which 6 to 8 kg as ammonium nitrate.

- *Why is it innovative when compared to existing (farming) practices?*

  N2 Applied's technology is competitive through a unique technical breakthrough which increased the energy efficiency of the process for nitrogen production and the improved quality of the produced fertilizer in regard of plant up-take of nutrients. In contrast to the centralized and linear approach and value chain of the industrial fertilizer industry, we have developed a distributed and circular solution that enables the transition to a closed-on-farm-nitrogen-cycle by enabling livestock farmers to recycle and produce low cost nitrogen fertilizer on the farm. Our solution is an integrated farm solution for nitrogen and manure management, using only energy and air and aimed to keep the minerals in the existing farm supply chain.

  Other new developments in solving manure issues focus on techniques and solutions that either remove minerals and introduce transport activity and/or use chemicals (acids) to treat the manure. N2 technology provides low cost, scalable and distributed - on farm - fertilizer production. The main advantage compared to competing solutions is that we combine environmental sustainability with high crop yield and the ability to recycle nitrogen at farm level. Several incubation and pot trials as well as agronomic field trials have been carried out by independent academic research organisations. These show an increased crop yield – due to optimal availability of ammonium nitrate of the treated product - up to 25% and a higher nitrogen uptake up to 38%. Besides saving money on mineral fertilizer, this increased crop yield has a significant impact on the farmer's income. Besides these benefits, smell removal, emission reduction and a higher nitrogen content per m3 manure have positive effects on smell and health issues around application management and application flexibility.

- *How does it improve the Nitrogen-Phosphorus and/or Carbon cycles in agriculture?*

  Reducing ammonia emissions from manure or biogas digestate and adding nitrogen into the liquid stream directly from air, enables farmers to close the nitrogen cycle on the farm. The ammonium nitrate that is produces is directly available for plant uptake and leads to a significant higher nitrogen use efficiency.

- *Add a separate line on the location of your management solution: "Currently this technology / technique / management solution is applied in ……. (city, region, country))."*

  N2 Applied's solution can be installed on the farm or on a biogas plant. We have tested the system in 2018 on a dairy farm in Northern Ireland and a pig farm in Denmark. We are currently arranging more test installations in Northern Ireland, Scotland, Denmark, Sweden and South Africa.

39 Plasma Manure Processing Technology

TRL (Technology Readiness Level) – how close is your solution to the market?

Use the slider above to position the current TRL* of your proposed solution

* TRLs are a type of measurement system used to assess the maturity level of a particular technology. Where a topic description refers to a TRL, the following definitions apply, unless otherwise specified:

• TRL 1 – basic principles observed • TRL 2 – technology concept formulated • TRL 3 – experimental proof of concept • TRL 4 – technology validated in lab • TRL 5 – technology validated in relevant environment (industrially relevant environment in the case of key enabling technologies) • TRL 6 – technology demonstrated in relevant environment (industrially relevant environment in the case of key enabling technologies) • TRL 7 – system prototype demonstration in operational environment • TRL 8 – system complete and qualified • TRL 9 – actual system proven & running in operational environment

Please provide some sentences explaining your Technology Readiness Level

Current status: **TRL 7**

Technology demonstrated at farm with manure showing successful production and absorption. Scientific field tests showing increased yield and proving that the technology removes ammonia loss and increase nitrogen use efficiency. Prototype machines have been tested in Norway, Denmark, UK and Q1 2019 being installed in South Africa. Technology objectives 2019: Improved energy efficiency and increasing run time for stable production.

Technology development overview and background:

TRL 1-2

2010: N2 Applied AS founded. Basic proof of thermal equilibrium in arc and plasma as not limiting energy efficiency.

2011: N2 Applied teams up with production partner SBI GmbH (Austria).

TRL 3-4

2012: Gliding electric arc produced 0,3% NO at an outlet temperature of 130 ^{o}C. Verified at University in Vienna, Institute of Applied Physics.

2012: Patent No 1 (WO 2012/150865 A1) granted.

2013: Patent No 2 (WO 2013/085395 A1) granted.

2014: Produced NO gas on 24 kwh/kgN gross energy input.

TRL 5-6

2014: First prototype tested at biogas plant in Hamar (Norway)

2017: Two plasma reactors tested in relevant farm environment.

2017: Proved that nitrate and nitrite stabilize ammonia and stop biological activity in manure at pH 4-6. Fertilizer value from nutrient content proven. Storage stability of proven over 3 months.

TRL-7

2017: Pre-production units installed and production on a Danish pig farm and on a Norwegian biogas plant.

2018: Test of plasma unit under farm conditions and agronomic field trials on a Northern Ireland dairy farm and a Danish pig farm.

If the proposed solution/ technique is currently at low TRL (≤5), is upscaling foreseen within the next year(s)?

If the proposed solution/ technique is currently at high TRL (≥7), is there any product already being produced from the proposed solution/ technique?

- *If yes, what is the name of the product :*
- *Short description of the product*

39 Plasma Manure Processing Technology

The current test product is a 10 kW plasma unit.
A 25 kW unit will be produced in 2019.

- *Are there any EC/MS Authority permits already for use of the product (title or link if available)?* YES. The plasma unit complies with the requirements of the Ordinance on Machine Safety-MSV 2010, Federal Law Gazette No. II 282/2008 and accordingly implemented EC Machinery Directive 2006/42/EC.

POTENTIAL LINKAGE TO THE PROJECT

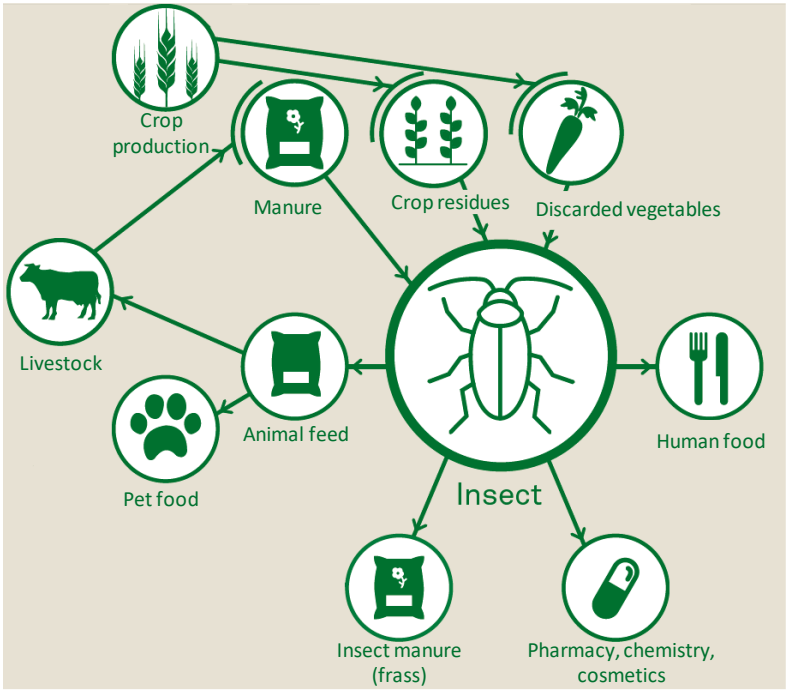
Indicate to which agro-typology under study and which potential research line of the project, your proposed solution/technique contributes :

X	Pig Production
	Poultry Production
X	Cattle Farming
X	Open field cultivation of cereals or maize
X	Open air cultivation of vegetables
X	Orchards
X	Agro-energy systems (e.g. biogas)
X	Animal Byproduct processing (e.g. manure processing)

Innovative solutions for optimized nutrient & GHG in animal husbandry	X
Innovative soil, fertilisation & crop management systems & practices	X
Tools, techniques & systems for higher-precision fertilization	
Biobased fertilisers (N, P) and soil enhancers (OC) from agro-residues	X
Novel animal feeds produced from agro-residues	
Other, please specify :	

40 Insect breeding as an alternative protein source on solid agro-residues (manure and plant wastes)

AIM OF THE TECHNOLOGY



Provide a brief description of the proposed management solution or technique.

- *What is the purpose/aim of the innovative solution/technique?*
  Driven by the worldwide demand for proteins, the production of black soldier fly (*Hermetia illucens*) and mealworm (*Tenebrio molitor*) is enjoying increasing interest & importance. Side streams and by-products from agriculture are an interesting rearing substrate for the growth of insects depending of its nutritional value and other properties.

- *What is the underlying working principle?*
  Bio-conversion of low value side-streams to high value insect biomass (consisting of protein, chitin and fat) with application as feedstock, pet food and human food.

- *What is the current and foreseen scale of operations (e.g. kg, tonnes/year)?*
  The expected production in Europe for 2019 is estimated to be around 50.000 tonnes live weight. 1 ton of insects requires approximately 3,3 tonnes of rearing substrate, resulting in the processing of 160.000 tonnes of side streams in 2019.

- *Why is it innovative when compared to existing (farming) practices?*
  Insects represent an innovative food and feed source rich in high quality protein as well as other beneficial nutritional ingredients such as fat, minerals and vitamins. Despite traditional knowledge about insects and their harvest in the wild, for the industrial mass production of safe insects and insect products for consumption and for processing into food and feed, the development of rearing, harvest as well as post-harvest technologies is required.

40 Insect breeding as an alternative protein source on solid agro-residues (manure and plant wastes)

- *How does it improve the Nitrogen-Phosphorus and/or Carbon cycles in agriculture?*
  Proteins and carbohydrates that are otherwise spread on the field and cause leaching of nutrients into the environment are converted into valuable biomass.

- *Add a separate line on the location of your management solution: "Currently this technology / technique / management solution is applied in ……. (city, region, country))."*
  Belgium (Roeselare), France (Évry), Spain (Madrid), Denmark (Copenhagen), Germany (Mark), Netherlands (Dongen), UK (Cambridge), …

TRL (Technology Readiness Level) – how close is your solution to the market?

Use the slider above to position the current TRL* of your proposed solution

* TRLs are a type of measurement system used to assess the maturity level of a particular technology. Where a topic description refers to a TRL, the following definitions apply, unless otherwise specified:

• TRL 1 – basic principles observed • TRL 2 – technology concept formulated • TRL 3 – experimental proof of concept • TRL 4 – technology validated in lab • TRL 5 – technology validated in relevant environment (industrially relevant environment in the case of key enabling technologies) • TRL 6 – technology demonstrated in relevant environment (industrially relevant environment in the case of key enabling technologies) • TRL 7 – system prototype demonstration in operational environment • TRL 8 – system complete and qualified • TRL 9 – actual system proven & running in operational environment

Please provide some sentences explaining your Technology Readiness Level

Several companies in Europe already have a production capacity of several 100 tonnes (between 100 and 500 tonnes) of live weight production with at least 3 companies with advanced plans for new infrastructure with a production capacity of 10.000 tonnes per year.

If the proposed solution/ technique is currently at low TRL (≤5), is upscaling foreseen within the next year(s)?

If the proposed solution/ technique is currently at high TRL (≥7), is there any product already being produced from the proposed solution/ technique?

- *If yes, what is the name of the product :*
  eg. ProteinX™ (Protix), ProtiNova™ (Innovafeed), MagMeal™ (AgriProtein).

- *Short description of the product*
  All three products are examples of an insect protein meal produced on by-products.

- *Are there any EC/MS Authority permits already for use of the product (title or link if available)?*
  YES.

40 Insect breeding as an alternative protein source on solid agro-residues (manure and plant wastes)

POTENTIAL LINKAGE TO THE PROJECT

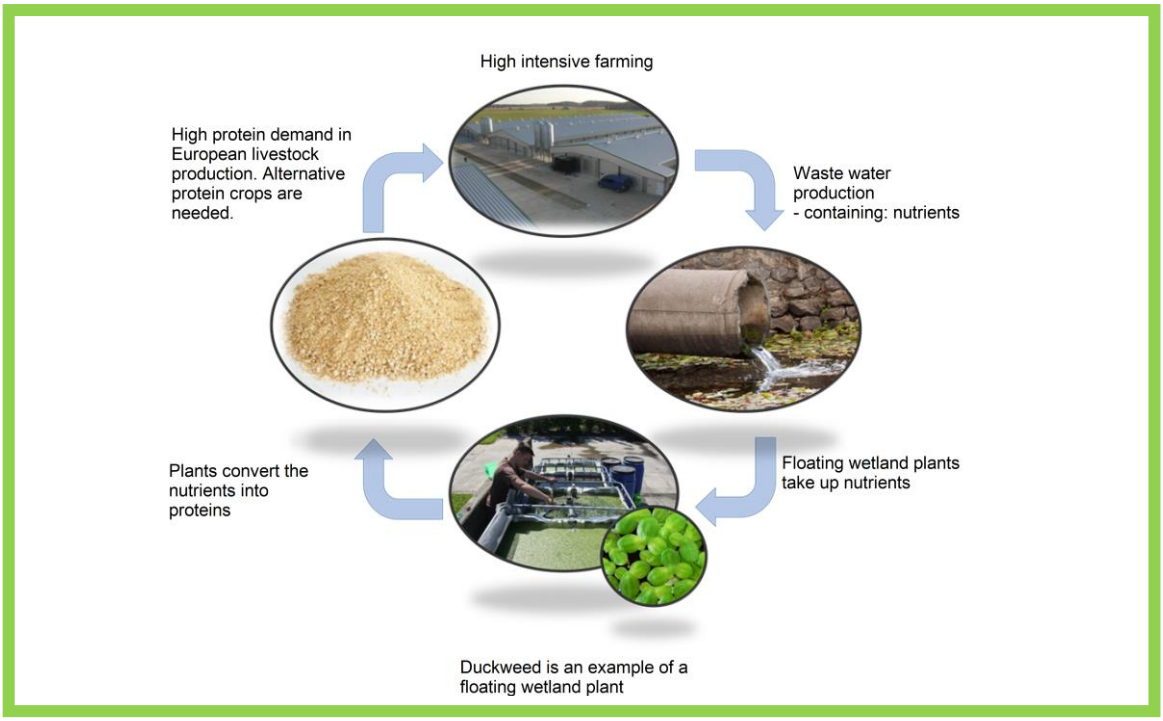
Indicate to which agro-typology under study and which potential research line of the project, your proposed solution/technique contributes :

X	Pig Production
X	Poultry Production
	Cattle Farming
	Open field cultivation of cereals or maize
X	Open air cultivation of vegetables
X	Orchards
	Agro-energy systems (e.g. biogas)
X	Animal Byproduct processing (e.g. manure processing)

Innovative solutions for optimized nutrient & GHG in animal husbandry	X
Innovative soil, fertilisation & crop management systems & practices	
Tools, techniques & systems for higher-precision fertilization	
Biobased fertilisers (N, P) and soil enhancers (OC) from agro-residues	X
Novel animal feeds produced from agro-residues	X
Other, please specify :	

41 Floating wetland plants grown on liquid agro-residues as a new source of proteins

AIM OF THE TECHNOLOGY



Provide a brief description of the proposed management solution or technique.

- *What is the purpose/aim of the innovative solution/technique?*
  Recuperation of nutrients from liquid agro-residues by growing protein-rich floating wetland plants.

- *What is the underlying working principle?*
  Plants take up nutrients like phosphate, ammonium and nitrate in order to grow. These nutrients are pollutants in liquid agro-residues. Therefore these nutrients are often removed or transformed in neutral forms during waste water treatment. However these are also essential nutrients for plant growth and can still be applied to some floating wetland plants. The plants take up the nutrients and converts these nutrients partly into proteins. Proteins are of high need in Europe due to an intensive livestock production, there is a higher demand for feed proteins than production.

- *What is the current and foreseen scale of operations (e.g. kg, tonnes/year)?*
  0,6 tonnes fresh weight/year (Ivaco) / 0,2 tonnes fresh weight/year (Inagro) / 160.000 tonnes fresh weight/year (Van Hall Larenstein)

- *Why is it innovative when compared to existing (farming) practices?*
  - A higher protein production per hectare than land based protein crops
  - A local, sustainable alternative for imported soybean meal
  - Valorisation of useful nutrients in liquid agro-residues with a high efficiency (kg N and P/ha)

41 Floating wetland plants grown on liquid agro-residues as a new source of proteins

- *How does it improve the Nitrogen-Phosphorus and/or Carbon cycles in agriculture?*
  Introducing floating wetlands in agriculture partly closes Nitrogen-Phosphorus cycles in agriculture. It increases the recirculation of nutrients and thus treats the excess of produced N and P in waste streams and reduces the need for imported protein rich crops and their derivates.

- *Add a separate line on the location of your management solution: "Currently this technology / technique / management solution is applied in applied in ……. (city, region, country))."*
  Currently this technology is applied in Eernegem, West Flanders, Belgium.

TRL (Technology Readiness Level) – how close is your solution to the market?

Use the slider above to position the current TRL* of your proposed solution

* TRLs are a type of measurement system used to assess the maturity level of a particular technology. Where a topic description refers to a TRL, the following definitions apply, unless otherwise specified:

• TRL 1 – basic principles observed • TRL 2 – technology concept formulated • TRL 3 – experimental proof of concept • TRL 4 – technology validated in lab • TRL 5 – technology validated in relevant environment (industrially relevant environment in the case of key enabling technologies) • TRL 6 – technology demonstrated in relevant environment (industrially relevant environment in the case of key enabling technologies) • TRL 7 – system prototype demonstration in operational environment • TRL 8 – system complete and qualified • TRL 9 – actual system proven & running in operational environment

Please provide some sentences explaining your Technology Readiness Level

The technology readiness level is very high for floating wetland plants that are grown in controlled conditions on synthetic media. For example, duckweed has been commercialised as a dried powder by the Japanese company Ajinomoto, and the European company Barents. Examples of professional Duckweed producers are Parabel, USA, and Hinoman, Israel.

The technology readiness level of floating wetland plants grown on liquid agro-residues is lower. Although the potential of waste water treatment and the use in feed of water hyacinth, water lettuce, water spinach and duckweed has been investigated and used all over the world, the implementation has been limited to low input systems in developing countries.

In the EU-28, there are several pilot scale productions of floating wetland plants on liquid agro-residues. However, the technology doesn't comply with European legislation yet, and no private companies are commercialising floating wetlands on liquid agro-residues in Europe.

The technology readiness level of Inagro's TRL is 5 in the research of floating wetland plants. The concept has been proven on cubicontainer level. A production area of 9 m² has been set up. In collaboration with Ivaco and UGent there is a pilot of 140 m². However, processing steps and proof of safety still have to be investigated in order to have a marketable product.

If the proposed solution/ technique is currently at low TRL (≤5), is upscaling foreseen within the next year(s)?

If the proposed solution/ technique is currently at high TRL (≥7), is there any product already being produced from the proposed solution/ technique?

- *If yes, what is the name of the product :*
- *Short description of the product*
- *Are there any EC/MS Authority permits already for use of the product (title or link if available)?*

41 Floating wetland plants grown on liquid agro-residues as a new source of proteins

POTENTIAL LINKAGE TO THE PROJECT

Indicate to which agro-typology under study and which potential research line of the project, your proposed solution/technique contributes :

X	Pig Production
	Poultry Production
X	Cattle Farming
	Open field cultivation of cereals or maize
	Open air cultivation of vegetables
	Orchards
	Agro-energy systems (e.g. biogas)
X	Animal Byproduct processing (e.g. manure processing)

Innovative solutions for optimized nutrient & GHG in animal husbandry	X
Innovative soil, fertilisation & crop management systems & practices	
Tools, techniques & systems for higher-precision fertilization	
Biobased fertilisers (N, P) and soil enhancers (OC) from agro-residues	
Novel animal feeds produced from agro-residues	X
Other, please specify :	

42 Vruchtbare Kringloop Overijssel (VKO) 'Fertile Cycle Overijssel'

AIM OF THE TECHNOLOGY

Provide a brief description of the proposed management solution or technique.

- *What is the purpose/aim of the innovative solution/technique?*
  'VKO' is an project in the province 'Overijssel'. VKO wants to inspire and facilitate dairy farmers to be more efficiently with the minerals at their farm and also to challenge farmers for future sustainable and societal goals. For example to improve of soil fertility, grassland based dairy farming and greenhouse gasses. Another aim is to introduce new technologies for better utilization of nutrients.

- *What is the underlying working principle?*
  The base is to work with regional dairy farm studygroups (operational group) in which the results of their nutrient cycle tool (ANCA) are compared. (See description in the factsheet of ANCA). Each studygroup has an own advisor and depending on the subject experts will be flown in. The initiators want to create awareness and carry through change amongst the enrolled dairy farmers. To improve on a practical way by learning from each other to improve the water quality, soil fertility, less input, tools to participate for future goals. This should lead to improved technical results and better income. Another part of VKO are field trials. The field trials are focussed on soil and crop quality, cultivation and fertilization techniques. The aim is to show the possible impact in soil and crop quality.

- *What is the current and foreseen scale of operations (e.g. kg, tonnes/year)?*
  At the moment around 420 farmers (next year 450) are enrolled in VKO. In VKO, the dairy farmers are part of different operational groups. An OG meets approximately 4 times a year. For example in the last 4 years the farmers have a better efficiency of available nutrients. The (nutrient)surplus in the soil has declined. The greenhouse gasses and ammonia have declined by keeping less youngstock and a higher milk production per cow.
  In Overijssel, also VKO consist of 4 field trials.

- *Why is it innovative when compared to existing (farming) practices?*
  A lot of projects only focus on smaller group, the fore-runners. A real innovation is when the innovation is implemented into the day to day operation. The innovative of this project is the high number of farmers participate in the project and therefor real implementation of innovation.

42 Vruchtbare Kringloop Overijssel (VKO) 'Fertile Cycle Overijssel'

In the OG, the dairy farmers are brought together in studygroups with an advisor about closing the cycles. Farmers learn from each other.

- *How does it improve the Nitrogen-Phosphorus and/or Carbon cycles in agriculture?*
  To create more insight in N-P-C cycles, the dairy farmers use the Annual Nutrient Cycling Assessment (ANCA). The ANCA is a management tool which give insight in all the different parts of a dairy farm (animal, manure, soil and feed). In the OG, the dairy farmers compare in studygroups their output with a specialist/advisor.

- *Add a separate line on the location of your management solution: "Currently this technology / technique / management solution is applied in ……. (city, region, country))."*
  Currently this project is applied in the province 'Overijssel'. There are more 'Fertile Nutrient Cycle' projects with large number of participants in The Netherlands. For example Achterhoek, Gelderland en Brabant.

TRL (Technology Readiness Level) – how close is your solution to the market?

Use the slider above to position the current TRL* of your proposed solution

* TRLs are a type of measurement system used to assess the maturity level of a particular technology. Where a topic description refers to a TRL, the following definitions apply, unless otherwise specified:

• TRL 1 – basic principles observed • TRL 2 – technology concept formulated • TRL 3 – experimental proof of concept • TRL 4 – technology validated in lab • TRL 5 – technology validated in relevant environment (industrially relevant environment in the case of key enabling technologies) • TRL 6 – technology demonstrated in relevant environment (industrially relevant environment in the case of key enabling technologies) • TRL 7 – system prototype demonstration in operational environment • TRL 8 – system complete and qualified • TRL 9 – actual system proven & running in operational environment

Please provide some sentences explaining your Technology Readiness Level

The TRL 9 because VKO is an proven, multi-year project and spread in other parts of the Netherlands.

If the proposed solution/ technique is currently at low TRL (≤5), is upscaling foreseen within the next year(s)?

If the proposed solution/ technique is currently at high TRL (≥7), is there any product already being produced from the proposed solution/ technique?

- *If yes, what is the name of the product :*
- *Short description of the product*
- *Are there any EC/MS Authority permits already for use of the product (title or link if available)?*

42 Vruchtbare Kringloop Overijssel (VKO) 'Fertile Cycle Overijssel'

POTENTIAL LINKAGE TO THE PROJECT

Indicate to which agro-typology under study and which potential research line of the project, your proposed solution/technique contributes :

	Pig Production
	Poultry Production
X	Cattle Farming
X	Open field cultivation of cereals or maize
	Open air cultivation of vegetables
	Orchards
	Agro-energy systems (e.g. biogas)
	Animal Byproduct processing (e.g. manure processing)

Innovative solutions for optimized nutrient & GHG in animal husbandry	X
Innovative soil, fertilisation & crop management systems & practices	X
Tools, techniques & systems for higher-precision fertilization	X
Biobased fertilisers (N, P) and soil enhancers (OC) from agro-residues	
Novel animal feeds produced from agro-residues	
Other, please specify :	

43 Pig manure evaporation plant

AIM OF THE TECHNOLOGY

Provide a brief description of the proposed management solution or technique.

- *What is the purpose/aim of the innovative solution/technique?*
  The aim is to process all fractions of the pig manure into separate fertilizer products for N, P and K. This to ensure optimal circular use of the different nutrients, suitable for precision fertilizing application techniques. These organic-based fertilizers will replace mineral fertilizers.

- *What is the underlying working principle?*
  The pig manure is first goes through the biogas production, the digestate is separated, the thick fraction is dried to 90% dry matter for further processing to organic fertilizer pellets, the fluid fraction is concentrated by the evaporation unit. N is recovered using N-stripping technology and the K-concentrate remains after evaporating water. The water is clean and can return to surface water. N, P and K can be used as separate fertilizing products.

- *What is the current and foreseen scale of operations (e.g. kg, tonnes/year)?*
  Input: 40.000 m3 fluid fraction /
  Output: 3000 ton K-concentrate, 2500 ton N concentrate and 33500 m^3 clean water

- *Why is it innovative when compared to existing (farming) practices?*
  The evaporation technique itself is innovative, plus the integration of the evaporation technique in the entire setting for processing all pig manure fractions and the production of green energy and organic fertilizer products is innovative.

- *How does it improve the Nitrogen-Phosphorus and/or Carbon cycles in agriculture?*
  Because the N, P and K nutrients are recovered in different fertilizing products they can be applied separately using precision fertilizing application techniques. This will lead to more nutrient efficiency and will reduce the need for mineral fertilizers.

- *Add a separate line on the location of your management solution: "Currently this technology / technique / management solution is applied in ……. (city, region, country))."*
  Currently this technology / technique / management solution is applied at pig farm / Eco-energy in Oirschot, the Netherlands

43 Pig manure evaporation plant

TRL (Technology Readiness Level) – how close is your solution to the market?

Use the slider above to position the current TRL* of your proposed solution

* TRLs are a type of measurement system used to assess the maturity level of a particular technology. Where a topic description refers to a TRL, the following definitions apply, unless otherwise specified:

• TRL 1 – basic principles observed • TRL 2 – technology concept formulated • TRL 3 – experimental proof of concept • TRL 4 – technology validated in lab • TRL 5 – technology validated in relevant environment (industrially relevant environment in the case of key enabling technologies) • TRL 6 – technology demonstrated in relevant environment (industrially relevant environment in the case of key enabling technologies) • TRL 7 – system prototype demonstration in operational environment • TRL 8 – system complete and qualified • TRL 9 – actual system proven & running in operational environment

Please provide some sentences explaining your Technology Readiness Level

TRL5: This is the first operational unit in the Netherlands.

If the proposed solution/ technique is currently at low TRL (≤5), is upscaling foreseen within the next year(s)?

YES.

If the proposed solution/ technique is currently at high TRL (≥7), is there any product already being produced from the proposed solution/ technique?

- *If yes, what is the name of the product :*
  N- and K- organic fertilizer concentrates.

- *Short description of the product*

- *Are there any EC/MS Authority permits already for use of the product (title or link if available)?*
  NO, but possible registration in the new Fertilizer Regulation and Safe manure will be explored.

43 Pig manure evaporation plant

POTENTIAL LINKAGE TO THE PROJECT

Indicate to which agro-typology under study and which potential research line of the project, your proposed solution/technique contributes :

X	Pig Production
	Poultry Production
	Cattle Farming
X	Open field cultivation of cereals or maize
X	Open air cultivation of vegetables
	Orchards
X	Agro-energy systems (e.g. biogas)
X	Animal Byproduct processing (e.g. manure processing)

Innovative solutions for optimized nutrient & GHG in animal husbandry	
Innovative soil, fertilisation & crop management systems & practices	
Tools, techniques & systems for higher-precision fertilization	X
Biobased fertilisers (N, P) and soil enhancers (OC) from agro-residues	X
Novel animal feeds produced from agro-residues	
Other, please specify :	

44 Tools to minimize the impact of pig slurry applications on the natural environment

AIM OF THE TECHNOLOGY

Provide a brief description of the proposed management solution or technique.

- *What is the purpose/aim of the innovative solution/technique?*

  This project/operational group [FEADER file 2016/55B] is defined by the problem of pig farms, in general at Galicia, derived from the need to manage the high amounts of manure they produce, in this rainy weather, and may in some cases lead to environmental problems arising from the use of very high doses repeatedly on farmland.

  Innovation is sought in the by-product management systems of pig farms, being more efficient in the use of the slurry generated in the operation. The study of different types of pig farms in the Mariñas-Betanzos area will serve to gain an in-depth knowledge of the problem and to design a SIX management tool, to provide livestock management information needed for storage and the subsequent application of slurry, on the lands dedicated to this purpose, in a correct way.

  Thanks to the tool designed the farmers can manage more efficiently the storage of slurry and will know the conditions of the application of optimum pig manure for each case, taking into account land uses and weather conditions, while allowing the monitoring of the process by the administrations with environmental competencies (Galician waters, town hall, Consellería de Medio Rural, etc…).

- *What is the underlying working principle?*

  The evolution of the pork sector in recent years has led to a significant intensification of production systems, which improved performance on pig farms,with an inseparable increase of the byproducts generated in the pig farms, which is revealed as the main limiting factor of the growth of this sector,as the use that was made of slurry in the extensive agricultural sector,mainly associated to the subscriber of crops and fodder for cattle feeding, is increasingly restricted due to the reduction of the agricultural area in the benefit of the forest area.

  The current problem in the management of these manure derives from its production in large quantities, at places not always suitable and generally in small superficial extension. Further, this has consequences for the economy of the companies of the sector by the high costs of later management, which in many cases, almost exclusively from the cost of transporting them to remote areas.

Tools to minimize the impact of pig slurry applications on the natural environment

However, sometimes the problem is that the closest areas where slurry can be applied can be dedicated to forestry. In this way, the application process is complicated because in these plots cannot be done efficiently and uniformly, said application being carried out at specific points in the plot, which can be considered as poured and not as application for subscriber.
One solution to this problem would be the promotion of collaboration between farms, so that by-products unusable in one farm can be used as fertilizer in other. It is also necessary to perform a good management of drinking water and cleaning and a correct approach of the outer pits to avoid dilutions by rainwater, thus reducing handling problems.
The objective of this project is the design of a SIX tool that allows to manage the slurry, connecting with farms with land that can use them as organic fertilizer, in addition to environmental monitoring of potential impacts.

- *What is the current and foreseen scale of operations (e.g. kg, tonnes/year)?*
  The actions of the OG include characterization and analysis of various slurry samples, characterization and georeferencing of farms and implementation of a database and a tool for optimal management of pig slurry. So, there are really no demonstrative actions in which to quantify the TRL or the annual production.

- *Why is it innovative when compared to existing (farming) practices? and How does it improve the Nitrogen-Phosphorus and/or Carbon cycles in agriculture?*
  The main objective of the project is the design of a SIX tool that allows:
  - Store all the information of farmers, livestock, analytical, incidents and historical management.
  - Plan slurry distribution operations.
  - Issue reports on the traceability of the purine movements, according to the requirements of the administration.
  - Interact with electronic control devices installed in vehicles, GPS type, to optimize and monitor the routes and times of application.

  With the information stored in the application you can establish the appropriate recommendations to try:
  - Reduce the volume of slurry in pig farms, developing protocols for a correct management of the water from its origin and that can be applied in other similar farms.
  - The definition of joint solutions for efficient and flexible storage of slurry, that allows an optimal use in the agricultural field. The possibility of applying slurry to abandoned land will also be analyzed, that can be recovered for cultivation and thus reduce the risk of fire.
  - Monitoring the management of slurry by public administrations (Galician waters, Health, Environment, Rural environment, Town Councils): permissions, incompatibilities, etc.

  The main actions that will be developed in the framework of the operational group are:
  - Bibliographic review on the subject related to the project.
  - Characterization, classification and georeferencing of 12 pig farms located in the area of influence of the Biosphere Reserve “Mariñas Coruñesas e Terras do Mandeo”,as well as of the parcels that make up the territorial base of each farm.
  - Collection of slurry samples in the different production cycles of the farms characterized
  - Execution of slurry analysis, previously collected according to the typologies of the holdings, with the objective of determining the fertilizer value of the same.
  - Sampling of soil in plots associated with each holding, and with permission for the application of slurry.
  - Determination of the fertility level of pig manure receiving land from selected pig farms.

44 Tools to minimize the impact of pig slurry applications on the natural environment

- Creation of a database where all the information necessary for the creation of the SIX tool is structured.
- Development of the tool for the management of pig slurry.
- Starting the SIX tool.
- Dissemination of project results in the rural and scientific fields.
- Project management.

- *Add a separate line on the location of your management solution: "Currently this technology / technique / management solution is applied in ……. (city, region, country))."*
  The project (operational group) is being developed in Galicia (Spain).

TRL (Technology Readiness Level) – how close is your solution to the market?

This section does not apply

Use the slider above to position the current TRL* of your proposed solution

* TRLs are a type of measurement system used to assess the maturity level of a particular technology. Where a topic description refers to a TRL, the following definitions apply, unless otherwise specified:

• TRL 1 – basic principles observed • TRL 2 – technology concept formulated • TRL 3 – experimental proof of concept • TRL 4 – technology validated in lab • TRL 5 – technology validated in relevant environment (industrially relevant environment in the case of key enabling technologies) • TRL 6 – technology demonstrated in relevant environment (industrially relevant environment in the case of key enabling technologies) • TRL 7 – system prototype demonstration in operational environment • TRL 8 – system complete and qualified • TRL 9 – actual system proven & running in operational environment

Please provide some sentences explaining your Technology Readiness Level

This section does not apply

If the proposed solution/ technique is currently at low TRL (≤5), is upscaling foreseen within the next year(s)?

If the proposed solution/ technique is currently at high TRL (≥7), is there any product already being produced from the proposed solution/ technique?

- *If yes, what is the name of the product :*
- *Short description of the product.*
- *Are there any EC/MS Authority permits already for use of the product (title or link if available)?*

44 Tools to minimize the impact of pig slurry applications on the natural environment

POTENTIAL LINKAGE TO THE PROJECT

Indicate to which agro-typology under study and which potential research line of the project, your proposed solution/technique contributes :

X	Pig Production
	Poultry Production
	Cattle Farming
X	Open field cultivation of cereals or maize
X	Open air cultivation of vegetables
X	Orchards
	Agro-energy systems (e.g. biogas)
X	Animal Byproduct processing (e.g. manure processing)

Innovative solutions for optimized nutrient & GHG in animal husbandry	X
Innovative soil, fertilisation & crop management systems & practices	X
Tools, techniques & systems for higher-precision fertilization	X
Biobased fertilisers (N, P) and soil enhancers (OC) from agro-residues	X
Novel animal feeds produced from agro-residues	
Other, please specify :	

45 Inpulse : innovating towards the use of Spanish legumes in animal feed

AIM OF THE TECHNOLOGY

Provide a brief description of the proposed management solution or technique.

- *What is the purpose/aim of the innovative solution/technique?*
  In this Project (operational group), barriers, needs and opportunities are identified for farmers, for seed traders, for cooperatives, for the feed industry.
  It identifies the conditions for the incorporation or substitution of protein sources in feed and the possible technological improvements that can be made for the extraction of proteins.
  The main objective of the INPULSE project (operational group) is twofold within the general framework of promoting the cultivation and use of legumes adapted to the needs of all actors in the animal feed chain.

- *What is the underlying working principle?*
  On the one hand, the design and evaluation of a common protocol for the testing of legume varieties (bean, soybean and pea) and, on the other hand, to constitute a mechanism or structure that allows the adequate application, continuous improvement and sustainability of this protocol.

- *What is the current and foreseen scale of operations (e.g. kg, tonnes/year)?*
  No technical actions have been implemented within the framework of the OG. The participants of the OG have taken the OG itself as a starting point to constitute project proposals that will serve to implement technical actions in the future.

- *Why is it innovative when compared to existing (farming) practices? and How does it improve the Nitrogen-Phosphorus and/or Carbon cycles in agriculture?*
  This main purpose is specified in a number of specific objectives, namely:
  - To analyse is the situation and availability of the seeds of the legumes under study and the companies that market them and their state of marketing.
  - To compile, inventory and standardize the tests and protocols for the evaluation of grain legumes for animal feed that are being carried out at the national level.
  - Identify, analyse and combine the needs of the links in the legume feed chain.
  - To determine the barriers and conditioning factors that determine the use and/or substitution of protein sources from legumes in animal feed.

- To define a common protocol for the testing of varieties adapted to the peculiarities of each crop and zone, as well as the optimisation of a network of trials in the main national agro-climatic zones.
- To identify and constitute a suitable and effective mechanism or figure for the correct application, continuous improvement and sustainability of the common protocol for variety trials.
- Disseminate and disseminate the activities of the INPULSE innovation project to facilitate decision making by professionals in the sector, maximizing the impact generated, through specific and specifically designed actions, and achieve optimum dissemination of the results of the project.

A series of expected results are derived from this:

- Promotion of the production and use of legumes in Spain, in order to reduce the external dependence on protein for animal feed.
- To contribute to the diversification of food systems in Spain, improving their sustainability, the incorporation of young people, favouring competitiveness and the economic development of the animal feed chain.
- Reducing greenhouse gas emissions and improving the environmental impacts of agricultural production and feed supply chains.
- Reconnect the animal feed chain, based on the needs of its different agents, and encourage the transfer of knowledge from and to research.

The generation of knowledge and science will be favored directly by the INPULSE operational group since in the process the entities in this field present among the members will detect the needs of different agents in the sector and may focus their future research and technological developments in these lines. On the other hand, the interrelationship between the actors involved in it and the attention to their demands means an improvement in the current state of the art that will allow a greater and better flow of information, transfer and acquisition of knowledge. Specifically, the aim is to provide the following elements:

- Typification and testing of varieties: varieties adapted to different agrosystems and agricultural practices, search for optimum yields in each area. Promotion of crops and use along the chain.
- Beneficial systems for the environment: reduction in the use of fertilizers through the use of legumes, reduction in the use of pesticides and water consumption, protection of the soil and improvement of storage processes.
- Protein quality requirements: analysis of protein value quality, collection of protein needs by sectors, application of technologies for the determination of nutritional values.

- *Add a separate line on the location of your management solution: "Currently this technology / technique / management solution is applied in ……. (city, region, country))."*

  The project (operational group) is being developed in different regions of Spain.

45 Inpulse : innovating towards the use of Spanish legumes in animal feed

TRL (Technology Readiness Level) – how close is your solution to the market?

No technical actions have been implemented within the framework of the OG.

Use the slider above to position the current TRL* of your proposed solution

* TRLs are a type of measurement system used to assess the maturity level of a particular technology. Where a topic description refers to a TRL, the following definitions apply, unless otherwise specified:

• TRL 1 – basic principles observed • TRL 2 – technology concept formulated • TRL 3 – experimental proof of concept • TRL 4 – technology validated in lab • TRL 5 – technology validated in relevant environment (industrially relevant environment in the case of key enabling technologies) • TRL 6 – technology demonstrated in relevant environment (industrially relevant environment in the case of key enabling technologies) • TRL 7 – system prototype demonstration in operational environment • TRL 8 – system complete and qualified • TRL 9 – actual system proven & running in operational environment

Please provide some sentences explaining your Technology Readiness Level

If the proposed solution/ technique is currently at low TRL (≤5), is upscaling foreseen within the next year(s)?

If the proposed solution/ technique is currently at high TRL (≥7), is there any product already being produced from the proposed solution/ technique?

- *If yes, what is the name of the product : …*
- *Short description of the product*.
- *Are there any EC/MS Authority permits already for use of the product (title or link if available)?*

POTENTIAL LINKAGE TO THE PROJECT

Indicate to which agro-typology under study and which potential research line of the project, your proposed solution/technique contributes :

X	Pig Production
X	Poultry Production
X	Cattle Farming
	Open field cultivation of cereals or maize
	Open air cultivation of vegetables
	Orchards
	Agro-energy systems (e.g. biogas)
	Animal Byproduct processing (e.g. manure processing)

Innovative solutions for optimized nutrient & GHG in animal husbandry	
Innovative soil, fertilisation & crop management systems & practices	X
Tools, techniques & systems for higher-precision fertilization	
Biobased fertilisers (N, P) and soil enhancers (OC) from agro-residues	
Novel animal feeds produced from agro-residues	
Other, please specify :	

46 Operational Group: INNOVATIVE FERTILIZERS

AIM OF THE TECHNOLOGY

Provide a brief description of the proposed management solution or technique.

- *What is the purpose/aim of the innovative solution/technique?*
  The purpose of the Operational Group "INNOVATIVE FERTILIZERS" is to bridge over the gap between the high research maturity results with "close to market" status and practical applications of the recycled innovative Nitrogen and Bio-Phosphate organic fertilizers. The goal is the organic production of fruits by application of specific innovative compound fertilizers, resulting high nutritious content functional food; such as sour cherry, beetroot, mulberry (and other deep red and claret colour fruits), elder and buckthorn, while improving food safety for less cost. The aim is the determination of the human physiological effects of these functionally and specifically cultivated human dietary supplement fruits, including follow up of its human medicinal, oncological, human disease prevention and health care impacts.

- *What is the underlying working principle?*
  Full cycle management of the innovative fertilizers for production of BIO-NPK-C natural substances and its applications at horticultural farmers for full production of the listed functional food specific fruits; quality/quantity determination and analytics of all materials/products; and human medical investigation of the effects and impacts of the functional human dietary supplement food with high concentrated nutritional content. The core technical element of the project is a Bio-Phosphate processing plant for production of concentrated organic phosphate innovative fertilizer and its organic compound fertilizer formulations. The results of the human medical investigations providing feedback retroactive effects with information for the composition/use of alternative innovative fertilizers and plant cultivation methods to obtain higher quality and functional food specific food crop production. The Operational Group "INNOVATIVE FERTILIZERS" is the flagship of the "Complex Ecological and Agricultural Development Plan ISBN978-963-12-6540-8 in the Transdanubian region.

- *What is the current and foreseen scale of operations (e.g. kg, tonnes/year)?*
  1200 t/y Bio-Phosphate and BIO-NPK-C compound organic fertilizers in different formulations.

- *Why is it innovative when compared to existing (farming) practices?*
  Organic farmers using soft rock phosphate with up to 90 mg/kg Cadmium natural levels and unknown Uranium contaminations, that Uranium is often higher load than the Cadmium itself. So far, the Cadmium and Uranium presence in fertilizers was not a highlighted problem, as these potential toxic elements not measured at all and not regulated on EU level either. The new EC

Fertilizer Regulation revision identifying Cadmium as priority toxic element and for the organic farming use 1/60 decreasing the Cadmium level from 90 mg/kg to 1.5 mg/kg maximum level with no derogation time, that lower level have already been applied in some Member States since log time. In the intensive farming user cases, the Cadmium level is decreased to 60 mg/kg, than to 40 mg/kg and finally to 20 mg/kg. The Bio-Phosphate is a new generation Phosphorus recovery technology and product system for organic and low input horticultural applications, that has been expressively developed to meet the new EC Circular Economy Fertilizers Regulation revision (COM (2016) 157) standards and norms and other strict MS regulations as well for the rapidly increasing market demands for safe and economical bio-fertilizers.

- *How does it improve the Nitrogen-Phosphorus and/or Carbon cycles in agriculture?*
  The Bio-Phosphate is a renewable and high sustainability recovered natural substance that produced with zero emission performance and interlinked wide range of BIO-NPK-C formulations, incl. biotechnological formulations as well. All formulations materials used are also renewable and high sustainability recovered natural substance.

- *Add a separate line on the location of your management solution: "Currently this technology / technique / management solution is applied in ……. (city, region, country))."*
  The European central location for the solution is at the Biofarm Agri Research Station (West Budapest area) in Hungary https://goo.gl/maps/wHxmZ7J1ChJ2 with several application schedules at Producer Organizations, in the EU, USA and Australia.

TRL (Technology Readiness Level) – how close is your solution to the market?

Use the slider above to position the current TRL* of your proposed solution

* TRLs are a type of measurement system used to assess the maturity level of a particular technology. Where a topic description refers to a TRL, the following definitions apply, unless otherwise specified:

• TRL 1 – basic principles observed • TRL 2 – technology concept formulated • TRL 3 – experimental proof of concept • TRL 4 – technology validated in lab • TRL 5 – technology validated in relevant environment (industrially relevant environment in the case of key enabling technologies) • TRL 6 – technology demonstrated in relevant environment (industrially relevant environment in the case of key enabling technologies) • TRL 7 – system prototype demonstration in operational environment • TRL 8 – system complete and qualified • TRL 9 – actual system proven & running in operational environment

Please provide some sentences explaining your Technology Readiness Level

The Bio-Phosphate is at TRL7 system prototype demonstration in operational environment and towards TRL 9 – actual system proven & running in operational environment, where TRL9 is a full industrial and market replication model, economical full production scale under international market competitive conditions (20,800 t/y throughput/unit) in the EU, USA and Australia.

If the proposed solution/ technique is currently at high TRL (≥7), is there any product already being produced from the proposed solution/ technique?

- *If yes, what is the name of the product:*
  PROTECTOR, biotechnologically formulated organic Bio-Phosphate fertilizer.

- *Short description of the product:*

46 Operational Group: INNOVATIVE FERTILIZERS

ABC Animal Bone Char Bio-Phosphate granulate with specific material and surface characteristics, which has been biotechnologically formulated with Phosphorus mobilization selected fungus strains and adapted by product specific solid state fermentation and formulation technology. There are wide ranges of formulations available, in any BIO-NPK-C innovative compound fertilizer configurations.

- *Are there any EC/MS Authority permits already for use of the product (title or link if available)?* YES, Government Authority permitted product, permit number: 04.2/102-2/2015 (issued in 2015 by the National Food-chain Safety Office: Plant, Soil and Agricultural Environmental Protection Directorate- EC Mutual Recognition regulation applied). The Authority permit approval is based on four years accredited and comprehensive safety and agronomical efficiency tests in two climatic and soil conditions with several tests plants.

POTENTIAL LINKAGE TO THE PROJECT

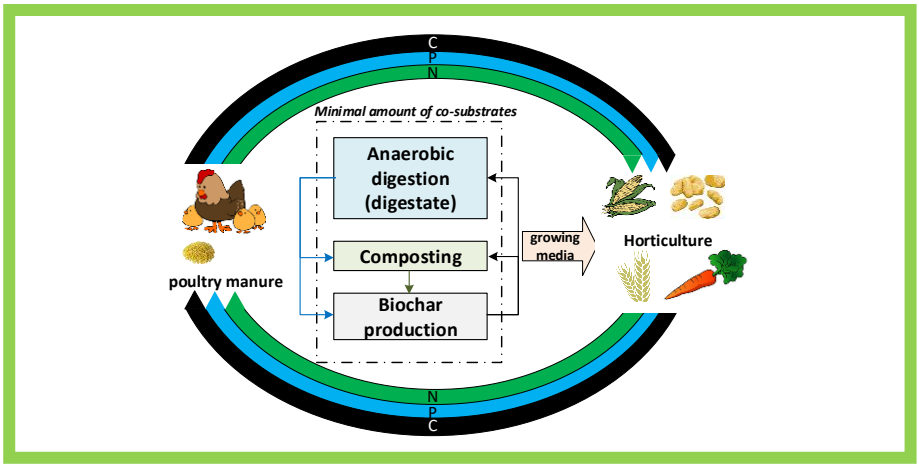
Indicate to which agro-typology under study and which potential research line of the project, your proposed solution/technique contributes :

	Pig Production
	Poultry Production
	Cattle Farming
	Open field cultivation of cereals or maize
X	Open air cultivation of vegetables
X	Orchards
X	Agro-energy systems (e.g. biogas)
X	Animal Byproduct processing (e.g. manure processing)

Innovative solutions for optimized nutrient & GHG in animal husbandry	
Innovative soil, fertilisation & crop management systems & practices	X
Tools, techniques & systems for higher-precision fertilization	X
Biobased fertilisers (N, P) and soil enhancers (OC) from agro-residues	X
Novel animal feeds produced from agro-residues	
Other, please specify :	

47 Production of growing substrates for horticulture application from poultry manure, solid state digestate and biochar through composting

AIM OF THE TECHNOLOGY



Provide a brief description of the proposed management solution or technique.

- *What is the purpose/aim of the innovative solution/technique?*
  The purpose of the innovative solution is the maximisation of closing C, N, P loops in poultry manure disposal in order to achieve valuable fertilizers for horticulture. The innovation in this solution is the application of advanced both biological and thermal methods in growing substrates production from poultry manure. The whole production system is based on the one main substrate- poultry manure. The process innovation is aimed at two biological methods (composting, anaerobic digestion) and one thermal method (biochar production) which are used for the treatment of the manure and are used compactly (as hybride system) in order to obtain one final product. The product of the poultry manure treatment from one process constitutes a cosubstrate for the next treatment process to run it properly. The addition of cosubstrate is constituting only a marginal addition, thus making the whole process (innovative solution) strongly autonomous of other external sources of substrates .
  This solution provides a pathogens and emerging contaminants free, valuable growing substrate. Innovative product as fertilizer is providing a minimized nutrients leaching, odourless properties, with prolonged release of micro and macronutrients. Availability of nutrients for plants is adjustable in accordance to plants nutrients demand. The whole system is very safe for environment.

- *What is the underlying working principle?*
  The whole production system is based on the one main substrate- poultry manure. The process innovation is aimed at two biological (composting, digestion) methods and one thermal method (biochar production) are used for the treatment of the manure and used compactly (as hybride system) in order to obtain one final product. The product of the poultry manure treatment from one process constitutes a cosubstrate for the next treatment process to run it properly. The addition of cosubstrate is constituting only a marginal addition, thus making the whole process (innovative solution) strongly autonomous of other external sources of substrates.

- *What is the current and foreseen scale of operations (e.g. kg, tonnes/year)?*
  At our lab scale we can produce 200 kg/year.

47 Production of growing substrates for horticulture application from poultry manure, solid state digestate and biochar through composting

- *Why is it innovative when compared to existing (farming) practices?*
  In this solution in the process of organic fertilizer production, the addition of external cosubstrate is constituting only a marginal part, thus making the whole process quite autonomous of other external sources of substrates.
  This solution provides a pathogens and emerging contaminants free, valuable growing substrate, what stands out the product from the unprocessed poultry manure. Innovative product as fertilizer is providing a minimized nutrients leaching, odourless properties, with prolonged release of micro and macronutrients, due to biochar share. Availability of nutrients for plants increases with plants growth. The whole system is very safe for environment and human.

- *How does it improve the Nitrogen-Phosphorus and/or Carbon cycles in agriculture?*
  This solution improves the N, P and C loops in agriculture. Poultry manure is a very rich medium in nutrients, especially in N and P as well as carbon. Unfortunately N can easily go into ammonia. The proposed solution is aimed at decreasing ammonia losses during fertilizer treatment. Moreover, the biochar production from poultry manure creates very stable carbon fraction, which for proposed solution is also a carrier for nutrients. In the results, the obtained product contains high amount of N, P, C. The basic nutrients as N and P are collected by agricultural plants biomass, while application of biochar (C) into soil is increasing the overall C stock, protecting soil against dissolved organic carbon (DOC) leaching and creates favourable conditions for effective plants photosynthesis. These processes result in plants biomass production, which is subsequently used as feedstock for agriculture purposes.

- *Add a separate line on the location of your management solution: "Currently this technology / technique / management solution is applied in ……. (city, region, country)."*
  Not applied in field scale

47 Production of growing substrates for horticulture application from poultry manure, solid state digestate and biochar through composting

TRL (Technology Readiness Level) – how close is your solution to the market?

Use the slider above to position the current TRL* of your proposed solution

* TRLs are a type of measurement system used to assess the maturity level of a particular technology. Where a topic description refers to a TRL, the following definitions apply, unless otherwise specified:

• TRL 1 – basic principles observed • TRL 2 – technology concept formulated • TRL 3 – experimental proof of concept • TRL 4 – technology validated in lab • TRL 5 – technology validated in relevant environment (industrially relevant environment in the case of key enabling technologies) • TRL 6 – technology demonstrated in relevant environment (industrially relevant environment in the case of key enabling technologies) • TRL 7 – system prototype demonstration in operational environment • TRL 8 – system complete and qualified • TRL 9 – actual system proven & running in operational environment

Please provide some sentences explaining your Technology Readiness Level

Proposed solution is currently at TRL-3. Proof of concept validation has been achieved at this level. The experimental research and development is initiated with analytical and laboratory studies.

If the proposed solution/ technique is currently at low TRL (≤5), is upscaling foreseen within the next year(s)?

YES. The proposed solution (technology) will be validated in laboratory conditions at Czestochowa university of Technology within the next 4 years of the project duration. In order to validate the technology, experiments will be carried out in bioreactors, composters, and devices for thermic processing of substrates and the biochar production. The obtained fertilizer substrates will be tested for fertilizer values in the growth chamber. All processes and products will be suitably tested to create the most closed balances of C, N and P flows. The technology will be prepared for the next 5th phase.

If the proposed solution/ technique is currently at high TRL (≥7), is there any product already being produced from the proposed solution/ technique?

- *If yes, what is the name of the product :*
- *Short description of the product*
- *Are there any EC/MS Authority permits already for use of the product (title or link if available)?*

47 Production of growing substrates for horticulture application from poultry manure, solid state digestate and biochar through composting

POTENTIAL LINKAGE TO THE PROJECT

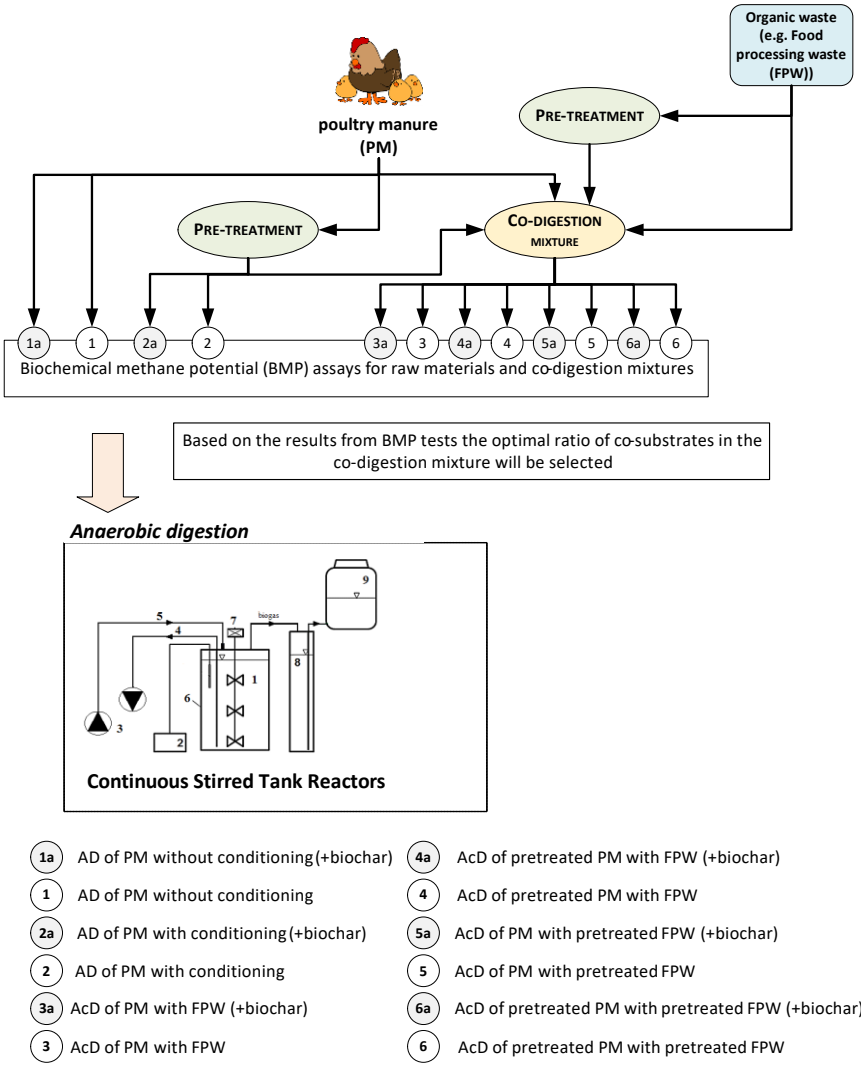
Indicate to which agro-typology under study and which potential research line of the project, your proposed solution/technique contributes :

	Pig Production
	Poultry Production
	Cattle Farming
	Open field cultivation of cereals or maize
	Open air cultivation of vegetables
	Orchards
	Agro-energy systems (e.g. biogas)
X	Animal Byproduct processing (e.g. manure processing)

Innovative solutions for optimized nutrient & GHG in animal husbandry	
Innovative soil, fertilisation & crop management systems & practices	X
Tools, techniques & systems for higher-precision fertilization	
Biobased fertilisers (N, P) and soil enhancers (OC) from agro-residues	X
Novel animal feeds produced from agro-residues	
Other, please specify :	

48 Recovery of energy from poultry manure and organic waste through anaerobic digestion

AIM OF THE TECHNOLOGY



Provide a brief description of the proposed management solution or technique.

- *What is the purpose/aim of the innovative solution/technique?*
  The purpose of the innovative solution is intensification of methane production from poultry manure as well as its mixtures with organic waste (e.g. food processing waste). Research focuses on the improvement of energy recovery from poultry manure and organic waste through anaerobic co-digestion and/or pre-treatment of feedstocks (see scheme). The process generates two potentially useful by-products - methane and digestate. The first one being a renewable fuel of potential use as fuel in cogeneration units for heat and electricity production, vehicle fuel after adequate purification and enchainment, natural gas substitute and resource for fuel cell production technologies. The second product, namely digestate, after proper post treatment may be applied in agriculture, forestry and used for reclamation purposes. For this reason, digestate may be play important role in the closing the circulation of elements (C, N, P) in poultry manure management. Furthermore, proposed solution allows to minimize GHG

emissions, reduce the use of fossil fuels and may play a large role in production renewable energy and energy self-sufficiency of plants.

- *What is the underlying working principle?*

  Anaerobic digestion (AD) is used technique for poultry manure stabilization. Nevertheless, application of process is limited by high nitrogen concentrations as well as low organic loads of the waste. For these reasons, in recent years, researches are focused on the enhancement of effectiveness of the process. From the available intensification options for anaerobic digestion (AD) of organic waste, two seem particularly interesting, namely co-digestion (AcD) with other organic wastes and pre-treatment of the feedstock prior to its introduction to the digester, methods combining both of the mentioned should also be taken into consideration.

  Generally, additions of another organic waste to the anaerobic digester causes: a) increase degradation degree of treated substances and improved biogas and methane yields, ii) support in establishing the required moisture content of the digester feed, b) improve nutrient balance and adjustment of C/N ratio in feedstock, c) increase load of biodegradable fraction as well as content of macro- and micronutrients, d) higher dilution of toxic compounds. Due to this strategy opens up new possibilities for disposal of organic waste– especially those wastes, which would be difficult to digestion separately (e.g. pig/cow waste slurry).

  In turn, pre-treatment of substrates prior to AD, accelerate hydrolysis of feedstock, which is the bottleneck stage of the process.

  Pre-treatment of feedstock (co-digestion mixture) seems to be an interesting approach. However, the available data is still pretty limited due to the fact that pre-treatment methods employed for co-digestion have become more widely described in literature starting from the year 2011.

- *What is the current and foreseen scale of operations (e.g. kg, tonnes/year)?*

  Anaerobic digestion is carried out in 3 reactors filled with at least 6 litres of working liquid. However, it's difficult to determine the current and foreseen scale of operations, because anaerobic digestion performance depends on the composition of the feedstocks as well as method its preparation.

- *Why is it innovative when compared to existing (farming) practices?*

  In recent years, the number of publications about the anaerobic co-digestion (AcD) of animal manure process has increased. However, these publications refer mainly to pig manure and cow manure, less attention has been paid to poultry manure. Therefore, more research needs to be carried out, for example in order to: 1) assess the feasibility and possible use of organic waste (e.g. food processing waste) as a co-substrate for improving biogas production in anaerobic digestion with poultry manure (due to the high nitrogen concentrations as well as low organic loads, animal manures are often associated with low biogas/methane production); 2) assess how pre-treatment affects the process performance; 3) asses impact of selected additives (e.g. biochar) on efficiency of the process. It is worth emphasising the pre-treatment methods employed for co-digestion have become more widely described in literature only starting from the year 2011.

- *How does it improve the Nitrogen-Phosphorus and/or Carbon cycles in agriculture?*

48 Recovery of energy from poultry manure and organic waste through anaerobic digestion

Stable digestate, after proper post treatment may be applied in agriculture, forestry and used for reclamation purposes. Furthermore, digestate may be play important role in the closing the circulation of elements (C, N, P) in poultry manure management.

- *Add a separate line on the location of your management solution: "Currently this technology / technique / management solution is applied in ……. (city, region, country))."*
  The co-digestion process has been implemented in following countries: Germany, Sweden, Denmark and Italy. However, in these countries, manure (lack of information about the origin) is mainly co-digested with organic waste made up of plant residue and agro-industrial waste.

TRL (Technology Readiness Level) – how close is your solution to the market?

Use the slider above to position the current TRL* of your proposed solution

* TRLs are a type of measurement system used to assess the maturity level of a particular technology. Where a topic description refers to a TRL, the following definitions apply, unless otherwise specified:

• TRL 1 – basic principles observed • TRL 2 – technology concept formulated • TRL 3 – experimental proof of concept • TRL 4 – technology validated in lab • TRL 5 – technology validated in relevant environment (industrially relevant environment in the case of key enabling technologies) • TRL 6 – technology demonstrated in relevant environment (industrially relevant environment in the case of key enabling technologies) • TRL 7 – system prototype demonstration in operational environment • TRL 8 – system complete and qualified • TRL 9 – actual system proven & running in operational environment

Please provide some sentences explaining your Technology Readiness Level

Proposed solution is currently at TRL-3. Proof of concept validation has been achieved at this level. The experimental research and development is initiated with analytical and laboratory studies.

If the proposed solution/ technique is currently at low TRL (≤5), is upscaling foreseen within the next year(s)?

YES. The proposed solution will be validated in laboratory conditions at Czestochowa University of Technology within the next 4 years of the project duration. The main objectives of this studies will be to determine the applicability of the selected methods as a means of intensification of methane production from poultry manure as well as its mixtures with organic waste (e.g. food processing waste). During experiment at least 12 solutions will be tested (see scheme). Methods will be based on a processes such as anaerobic co-digestion process and/or pre-treatment of substrates before AD/AcD and/or addition of biochar. During the experiment the following pretreatment methods will be tested: chemical, mechanical and thermal.

Selection of the best method to intensification of methane production from poultry manure will be determined based on results of two-stages experiment. During stage 1, biochemical methane potential (BMP) assay for raw materials and co-digestion mixtures (biochar and/or organic waste) (see scheme) will be conducted. Special attention will be paid to estimate the impact of the addition of co-substrate on the process performance. In the second stage, anaerobic co-digestion of selected mixtures will be carried out in three glass reactors (CSTR) filled with at least 6 litres of working liquid. Both phases will be performed at mesophilic conditions.

If the proposed solution/ technique is currently at high TRL (≥7), is there any product already being produced from the proposed solution/ technique?

48 Recovery of energy from poultry manure and organic waste through anaerobic digestion

- *If yes, what is the name of the product :*
- *Short description of the product*
- *Are there any EC/MS Authority permits already for use of the product (title or link if available)?*

POTENTIAL LINKAGE TO THE PROJECT

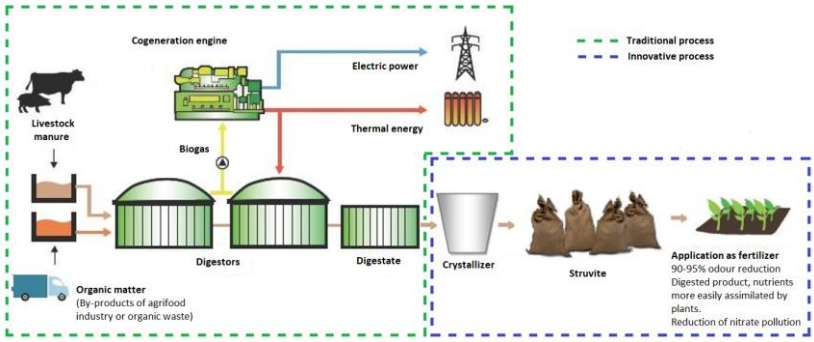
Indicate to which agro-typology under study and which potential research line of the project, your proposed solution/technique contributes :

	Pig Production
	Poultry Production
	Cattle Farming
	Open field cultivation of cereals or maize
	Open air cultivation of vegetables
	Orchards
X	Agro-energy systems (e.g. biogas)
X	Animal Byproduct processing (e.g. manure processing)

Innovative solutions for optimized nutrient & GHG in animal husbandry		
Innovative soil, fertilisation & crop management systems & practices		
Tools, techniques & systems for higher-precision fertilization		
Biobased fertilisers (N, P) and soil enhancers (OC) from agro-residues		
Novel animal feeds produced from agro-residues		
Other, please specify :	Enhancement of biogas production from poultry manure	X

49 Nitrogen and phosphorus recovery from pig manure via struvite crystallization and design of struvite based tailor-made fertilizers

AIM OF THE TECHNOLOGY



Provide a brief description of the proposed management solution or technique.

- *What is the purpose/aim of the innovative solution/technique?*

  Anaerobic digestion (AD) technology promotes the bioconversion of livestock waste, apart from other organic waste such as that of the agrifood industry, into methane and carbon dioxide, allowing its energetic valorization. This has led to the proliferation of AD plants in the EU in recent years. However, AD does not significantly reduce the concentration of nitrogen or phosphorus, and it is essential in all cases to carry out a nutrient balance before applying the digestate to farmland in order to minimize the environmental impact and, in many cases, it is essential to resort to techniques for reducing or recovering these nutrients.

  On the other hand, given these circumstances and the high number of AD plants currently operating in Europe, the recovery of nutrients from livestock waste and other anaerobically digested organic waste can become a source of income. The crystallization of nitrogen and phosphorus in the form of magnesium ammonium phosphate hexahydrate ($MgNH_4PO_4 \cdot 6H_2O$) also known as MAP or struvite, is one of the possible techniques used to eliminate and/or recover nutrients from the digestate, obtaining a product that can be applicable as a base in ecological fertilizers of high quality.

  In addition, the recovery of phosphate and ammonium in the form of struvite allows, in turn, the sustainable management of a non-renewable natural resource, phosphate, and the improvement of the quality of aquatic ecosystems.

- *What is the underlying working principle?*

  Struvite or MAP is a white crystalline substance formed by the combination of magnesium, phosphate and ammonium in equal molar amounts. The form of struvite according to the simplified reaction is as follows:

$$Mg^{+2} + NH_4^+ + PO_4^{-3} + 6H_2O \rightarrow MgNH_4PO_4 \cdot 6H_2O$$

  The morphology of struvite crystals is orthorhombic, however, it can also be found in spherical or dendritic form.

  Struvite precipitation can occur through two different mechanisms: crystal growth and nucleation. Nucleation is the first stage and occurs when ions combine to form crystal embryos. The second stage is the growth of the crystals and does not end until equilibrium is reached.

49 Nitrogen and phosphorus recovery from pig manure via struvite crystallization and design of struvite based tailor-made fertilizers

Several researchers have studied the rate of crystal formation, identifying that the growth kinetics of struvite crystals followed a first-order equation with velocity constants ranging from 3.7 to 12.3 h^{-1}, depending on the pH of the solution. However, in another study the reaction kinetics was identified as second order with a higher velocity constant.
Crystal formation (nucleation) usually occurs spontaneously (homogeneous nucleation) but can also be caused by the presence of solid impurities in suspension (heterogeneous nucleation). The time required for nucleation to occur is called induction time and has been investigated to identify what controls the formation of a precipitate. The pH and temperature influence the induction time: the increase in pH and temperature leads to a reduction in the induction time.
Several factors influence the precipitation of struvite: the chemical composition of the residual effluent (organic matter, presence of detergents, ionic strength), pH, molar ratio of Mg:N-NH_4:P-PO_4 (Mg:N:P), degree of supersaturation, temperature and the presence of foreign ions, such as calcium.

- *What is the current and foreseen scale of operations (e.g. kg, tonnes/year)?*
  Currently, Fundación CARTIF obtains struvite from livestock waste using a 50 L fluidized bed reactor. The reactor is made of borosilicate glass with a cylindrical shape. It has an internal diameter of 20 cm and a total height of 2 m, so that the L/D= 10 ratio recommended for fluidized-bed reactors is maintained. The reactor can work in continuous process as well as batch process.
  Depending on the regime used and the type of waste, a production of up to 300 g/batch of struvite or 100 g/h (by continuous operation) can be obtained.

- *Why is it innovative when compared to existing (farming) practices?*
  Struvite has been found to be a good slow release fertilizer and provides essential nutrients such as magnesium, nitrogen and phosphorus for agriculture and horticulture. Another factor that supports the use of struvite as a fertilizer is its low concentration in heavy metals compared to the phosphate rock usually used in the manufacture of synthetic fertilizers. Due to its slow release, the delivery of nutrients is carried out gradually and the plant consumes them according to its requirements, thus avoiding the leaching of these nutrients and their arrival to the water masses, as can occur when synthetic fertilizers are applied. It is therefore required less frequency of application and there is no burning of the plant, even at high rates of application.

- *How does it improve the Nitrogen-Phosphorus and/or Carbon cycles in agriculture?*
  Ammonia decreases the N nutrient value of manure slurry and can lead to problems of acidification and eutrophication of the soil. The loss of nutrients to the atmosphere can be avoided (or very reduced) by recovering them in a solid form and dosing them back into the soil, adding them so that they are available for cultivation.

- *Add a separate line on the location of your management solution: "Currently this technology / technique / management solution is applied in ……. (city, region, country))."*
  The product has been obtained within the framework of several regional, national and European projects (ADE_ECOCIR, CLAMBER, LIFE REVAWASTE, LIFE VALPORC), but no field tests have yet been carried out to demonstrate its benefits in the soil. Although, there are several scientific publications in which these benefits are confirmed.

49 Nitrogen and phosphorus recovery from pig manure via struvite crystallization and design of struvite based tailor-made fertilizers

TRL (Technology Readiness Level) – how close is your solution to the market?

Use the slider above to position the current TRL* of your proposed solution

* TRLs are a type of measurement system used to assess the maturity level of a particular technology. Where a topic description refers to a TRL, the following definitions apply, unless otherwise specified:

• TRL 1 – basic principles observed • TRL 2 – technology concept formulated • TRL 3 – experimental proof of concept • TRL 4 – technology validated in lab • TRL 5 – technology validated in relevant environment (industrially relevant environment in the case of key enabling technologies) • TRL 6 – technology demonstrated in relevant environment (industrially relevant environment in the case of key enabling technologies) • TRL 7 – system prototype demonstration in operational environment • TRL 8 – system complete and qualified • TRL 9 – actual system proven & running in operational environment

Please provide some sentences explaining your Technology Readiness Level

The technology has been demonstrated at a sufficiently relevant scale (crystallisation reactor with a capacity of 50 L), so that the results can be used for subsequent implementation on an industrial scale.

If the proposed solution/ technique is currently at low TRL (≤5), is upscaling foreseen within the next year(s)?

If the proposed solution/ technique is currently at high TRL (≥7), is there any product already being produced from the proposed solution/ technique?

- *If yes, what is the name of the product :*
- *Short description of the product*
- *Are there any EC/MS Authority permits already for use of the product (title or link if available)?* YES, Council Regulation (EC) No 834/2007 of 28 June 2007 on organic production and labelling of organic products.

49 Nitrogen and phosphorus recovery from pig manure via struvite crystallization and design of struvite based tailor-made fertilizers

POTENTIAL LINKAGE TO THE PROJECT

Indicate to which agro-typology under study and which potential research line of the project, your proposed solution/technique contributes :

	Pig Production
	Poultry Production
	Cattle Farming
X	Open field cultivation of cereals or maize
X	Open air cultivation of vegetables
X	Orchards
X	Agro-energy systems (e.g. biogas)
X	Animal Byproduct processing (e.g. manure processing)

Innovative solutions for optimized nutrient & GHG in animal husbandry	
Innovative soil, fertilisation & crop management systems & practices	X
Tools, techniques & systems for higher-precision fertilization	
Biobased fertilisers (N, P) and soil enhancers (OC) from agro-residues	X
Novel animal feeds produced from agro-residues	
Other, please specify :	

50 Utilization of NIR sensors on fertilization machine

AIM OF THE TECHNOLOGY

The N, P and K content is displayed in kg/m³, on the Greenstar display[1]

Provide a brief description of the proposed management solution or technique.

- *What is the purpose/aim of the innovative solution/technique?*
  By using NIR (near infrared) sensors on a fertilization machine the exact amount of nutrients present in fertilizer products can be known. Therefore a more precise fertilization is possible because the exact amount of applied nutrients is measured around the field. This technology will help ensure nutrients are applied to land as accurately as possible.

- *What is the underlying working principle?*
  A light beam within the NIR sensor housing is directed into the pipe. Some of the light is absorbed by the liquid, while the reflected part is captured by the sensor. This reflectance is measured continuously and compared with a database to calculate a calibration model for the N, P and K content in kg/m³. The tanker's slurry pump automatically adjusts the flow to deliver the pre-set required volumes of N, P or K or a maximum pre-set limit of each. The NIR sensor is installed inside the slurry tank filling pipe or where it is pumped to the distributor.[1] The detection process of a NIR sensor is non-destructive and non-polluting[2].

- *What is the current and foreseen scale of operations (e.g. kg, tonnes/year)?*

- *Why is it innovative when compared to existing (farming) practices?*
  Farmers will know exactly how many kilogrammes of nitrogen or phosphate have been applied to their land, which could help them to reduce artificial fertiliser inputs[1].

- *How does it improve the Nitrogen-Phosphorus and/or Carbon cycles in agriculture?*
  A reduction of artificial fertiliser inputs will help to decrease nutrient leaching.

- *Add a separate line on the location of your management solution: "Currently this technology / technique / management solution is applied in ……. (city, region, country))."*

[1] Future Farming, 2017. Smart sensors make slurry application more accurate. Accessed on 15/01/2019.
[2] Nie, P., Dong, T., He, Y. & Qu, F., 2017. Detection of Soil Nitrogen Using Near Infrared Sensors Based on Soil Pretreatment and Algorithms.

50 Utilization of NIR sensors on fertilization machine

Several slurry tanker makers, including Kaweco, Veenhuis, Vervaet, Slootsmid, Joskin, John Deere and Vredo, are working with the new technology. The difficulty of this system is that the sensor needs to be calibrated depending on the local circumstances, which can vary a lot.

TRL (Technology Readiness Level) – how close is your solution to the market?

Use the slider above to position the current TRL* of your proposed solution

* TRLs are a type of measurement system used to assess the maturity level of a particular technology. Where a topic description refers to a TRL, the following definitions apply, unless otherwise specified:

• TRL 1 – basic principles observed • TRL 2 – technology concept formulated • TRL 3 – experimental proof of concept • TRL 4 – technology validated in lab • TRL 5 – technology validated in relevant environment (industrially relevant environment in the case of key enabling technologies) • TRL 6 – technology demonstrated in relevant environment (industrially relevant environment in the case of key enabling technologies) • TRL 7 – system prototype demonstration in operational environment • TRL 8 – system complete and qualified • TRL 9 – actual system proven & running in operational environment

Please provide some sentences explaining your Technology Readiness Level

If the proposed solution/ technique is currently at low TRL (≤5), is upscaling foreseen within the next year(s)?

If the proposed solution/ technique is currently at high TRL (≥7), is there any product already being produced from the proposed solution/ technique?

- *If yes, what is the name of the product :*
  NUTRI-FLOW

- *Short description of the product*
  NUTRI-FLOW is the name of Veenhuis' NIR sensor system. Following nutrients can be measured while fertilizing: nitrogen, phosphate, ammonium and potassium. Also the dry matter content can be measured[3].
- *Are there any EC/MS Authority permits already for use of the product (title or link if available)?*

[3] Veenhuis, 2018. https://www.veenhuis.com/producten-2/mest-aanwenden/nutriflow-precisiebemesting/. Accessed on 16/01/2019.

50 Utilization of NIR sensors on fertilization machine

POTENTIAL LINKAGE TO THE PROJECT

Indicate to which agro-typology under study and which potential research line of the project, your proposed solution/technique contributes :

X	Pig Production
	Poultry Production
X	Cattle Farming
X	Open field cultivation of cereals or maize
X	Open air cultivation of vegetables
	Orchards
	Agro-energy systems (e.g. biogas)
	Animal Byproduct processing (e.g. manure processing)

Innovative solutions for optimized nutrient & GHG in animal husbandry	
Innovative soil, fertilisation & crop management systems & practices	X
Tools, techniques & systems for higher-precision fertilization	X
Biobased fertilisers (N, P) and soil enhancers (OC) from agro-residues	
Novel animal feeds produced from agro-residues	
Other, please specify :	

51 Utilization of NIR sensors on storage

AIM OF THE TECHNOLOGY

NIR technology on a Claas Jaguar 980[1]

Provide a brief description of the proposed management solution or technique.

- *What is the purpose/aim of the innovative solution/technique?*
  The purpose of this technique is to know the feed value of products already during harvesting. It could be applied to measure the feed value, dry matter, protein content, etc. of ensilaged maize or grass. A secondary advantage of this technique is that it is possible to know which fields or even parts of the fields have the best harvest. This technique makes it thus possible to make adjustments on fertilization because of the harvesting results[2, 3].

- *What is the underlying working principle?*
  A light beam within the NIR sensor housing is directed into the pipe. Some of the light is absorbed by the harvested matter, while the reflected part is captured by the sensor. This reflectance is measured continuously and compared with a database to calculate a calibration model for the protein and glucose content, dry matter, ADF and NDF. By measuring this on-site the feed value is already known while harvesting.
  By combining this with a weight measurement the exact harvest can be known[3].

- *What is the current and foreseen scale of operations (e.g. kg, tonnes/year)?*

- *Why is it innovative when compared to existing (farming) practices?*
  Feed value is known immediately and farmers will have more input about the harvest.

- *How does it improve the Nitrogen-Phosphorus and/or Carbon cycles in agriculture?*

[1] Claas, 2014. https://www.youtube.com/watch?v=RLmKYYh0Om8. Accessed on 18/01/2019
[2] Melkvee, 2015. https://www.melkvee.nl/artikel/56316-demo-schuitemaker-drogestofbepaling-in-combinatie-met-weging/. Accessed on 17/01/2019
[3] Kastelijn BV. https://kastelijnbv.nl/grasoogst/. Accessed on 17/01/2019

51 Utilization of NIR sensors on storage

By knowing which fields give a good or bad harvest, fertilization can be adapted in a more accurate way. This in turn will prevent too much fertilization on a certain field. Therefore there will be less nutrient leakage.

- *Add a separate line on the location of your management solution: "Currently this technology / technique / management solution is applied in ……. (city, region, country))."*
  The Netherlands (companies: Kastelijn BV, Schuitemaker) / Germany (company: Claas)

TRL (Technology Readiness Level) – how close is your solution to the market?

Use the slider above to position the current TRL* of your proposed solution

* TRLs are a type of measurement system used to assess the maturity level of a particular technology. Where a topic description refers to a TRL, the following definitions apply, unless otherwise specified:

• TRL 1 – basic principles observed • TRL 2 – technology concept formulated • TRL 3 – experimental proof of concept • TRL 4 – technology validated in lab • TRL 5 – technology validated in relevant environment (industrially relevant environment in the case of key enabling technologies) • TRL 6 – technology demonstrated in relevant environment (industrially relevant environment in the case of key enabling technologies) • TRL 7 – system prototype demonstration in operational environment • TRL 8 – system complete and qualified • TRL 9 – actual system proven & running in operational environment

Please provide some sentences explaining your Technology Readiness Level

If the proposed solution/ technique is currently at low TRL (≤5), is upscaling foreseen within the next year(s)?

If the proposed solution/ technique is currently at high TRL (≥7), is there any product already being produced from the proposed solution/ technique?

- *If yes, what is the name of the product:*
  Rapide (Schuitemaker) / John Deere 7480i (Kastelijn BV) / Jaguar 980 (Claas).

- *Short description of the product*
  These products are harvesting machines equipped with a NIR sensor to collect the necessary data during harvesting.
- *Are there any EC/MS Authority permits already for use of the product (title or link if available)?*

51 Utilization of NIR sensors on storage

POTENTIAL LINKAGE TO THE PROJECT

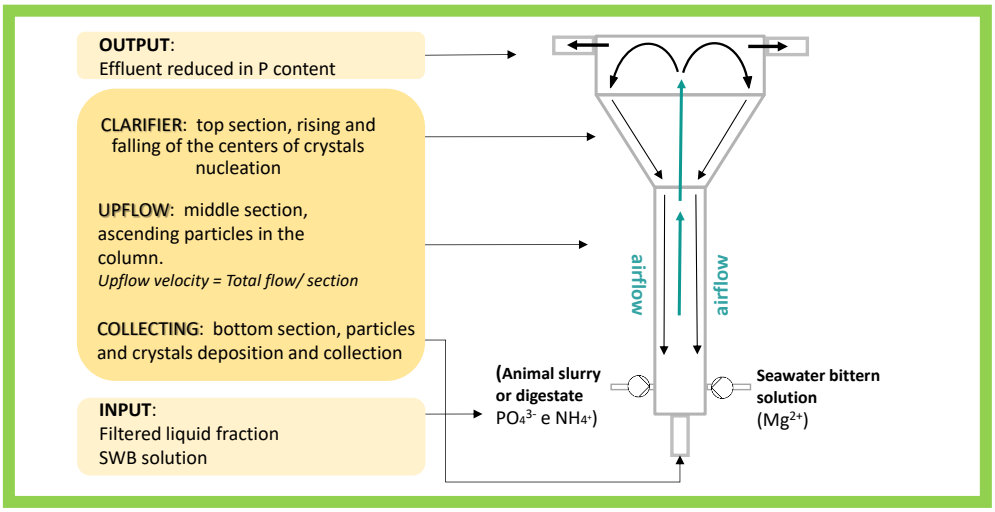
Indicate to which agro-typology under study and which potential research line of the project, your proposed solution/technique contributes :

	Pig Production
	Poultry Production
	Cattle Farming
X	Open field cultivation of cereals or maize
	Open air cultivation of vegetables
	Orchards
	Agro-energy systems (e.g. biogas)
	Animal Byproduct processing (e.g. manure processing)

Innovative solutions for optimized nutrient & GHG in animal husbandry	
Innovative soil, fertilisation & crop management systems & practices	X
Tools, techniques & systems for higher-precision fertilization	X
Biobased fertilisers (N, P) and soil enhancers (OC) from agro-residues	
Novel animal feeds produced from agro-residues	
Other, please specify :	

52 Pilot-scale crystallizer for p recovery

AIM OF THE TECHNOLOGY



Provide a brief description of the proposed management solution or technique.

- *What is the purpose/aim of the innovative solution/technique?*
  Since the second half of the 19th century the meat consumption has globally increased, and it is estimate by the scientists and the global organizations (e.g. FAO) that the trend will continue to increase. In the large retail sector, the growing demand of animal-by products is reflected in the increase of cereals production and the use of fertilizer, but also in the increment of livestock effluents and agricultural waste. Although the common purpose is to limit the nitrogen damages due to the livestock effluents pollution (Nitrates Directive), the attention is now focused on the phosphorus issues. Phosphorus is a non-renewable and scarce natural resource which is going to run out soon. The issues are related to both its concentration in the soil non-labile pool, which is unavailable for plants, and its soluble form which can be a pollutant and may cause the eutrophication of water bodies. This study focuses on one of the alternative methods for phosphorus recovery from the digested sludge. In the specific, phosphorus can be recovered from waste streams by the crystallization of struvite, which is an effective slow-release fertilizer and it offers many advantages versus conventional fertilizers, such as low leach rates and slowly release of nutrients. Many technological approaches are being developed to enhance struvite precipitation but few of them are suitable for livestock effluents, which are characterized by high solids concentration (3-4 % TS) that affect struvite crystallization rate. The struvite crystallizers technology had been developed in different prototypes and put into production successfully abroad. This study aims to elucidate the effect of solids (3-4 % TS) on struvite formation in a complex matrix, such as animal slurries and digestates. Special attention is given to identifying the role of solids in struvite nucleation and growth, and its impact on the quality of the product recovered.

- *What is the underlying working principle?*
  This is a prototype of airlift reactor, which shape and functioning are specifically designed to reproduce the best conditions for struvite precipitation.
  At the bottom there are the input flows: seawater bitter (SWB) on the left side, which represents the Mg source, and the liquid fraction of digestate on the right side, which is the ammonium and magnesium source. In the reactor a continuous air flux is used to create internal recycle flow,

allowing the struvite crystals to grow, under a monitored pH of 8.5. Three differentiated zones could be distinguished in the reactor after few days of sperimentation: riser (supersaturation conditions), clarifier (quiet zone with up-flow) and collector (particles settling). At the top of the reactor there are two output flows (see figure above).
Since seawater bitter is a waste brine remaining after salt (NaCl) extraction from seawater, it has no production costs. Thus, economical evaluations estimate that the total cost for a pilot-plant producing struvite with SWB as Mg source, is 0.01-0.22€ kg struvite^{-1} (about 0.6 € kg P^{-1}) including profit.

- *What is the current and foreseen scale of operations (e.g. kg, tonnes/year)?*
  The prototype is currently working at lab-scale level (processing 7 L/day for an equivalent of 1.5 ton/year).

- *Why is it innovative when compared to existing (farming) practices?*
  Struvite technology is nearing commercialization, but chemical input costs are very high when $MgCl_2$ or another Mg source (wood ashes, magnesite, magnesia or by-products of MgO production) are used in the process. Thus, the use of seawater bittern (SWB) instead of $MgCl_2$ salt is a promising strategy for P removal. Seawater bittern is a by-product of sea salt processing mainly composed by magnesium chloride (>95%) and a low-cost magnesium source.

- *How does it improve the Nitrogen-Phosphorus and/or Carbon cycles in agriculture?*
  Struvite is an effective slow-release fertilizer and it offers many advantages versus conventional fertilizers, such as low leach rates and slowly release of nutrients. It is suitable in grasslands and forests where fertilizers are applied once in several years; it does not damage growing plants when a single high dose is applied; represents an alternative for those crops that require magnesium, such as sugar beets; and, phosphorus uptake is higher in ryegrass when struvite is used as a fertilizer. Moreover, the nucleation of struvite crystals in animal slurries allows the recovery of organic carbon in the final fertiliser collected.

- *Add a separate line on the location of your management solution: "Currently this technology / technique / management solution is applied in ……. (city, region, country)"*
  Currently this technology is applied in Wageningen (The Netherlands).

52 Pilot-scale crystallizer for p recovery

TRL (Technology Readiness Level) – how close is your solution to the market?

Use the slider above to position the current TRL* of your proposed solution

* TRLs are a type of measurement system used to assess the maturity level of a particular technology. Where a topic description refers to a TRL, the following definitions apply, unless otherwise specified:

• TRL 1 – basic principles observed • TRL 2 – technology concept formulated • TRL 3 – experimental proof of concept • TRL 4 – technology validated in lab • TRL 5 – technology validated in relevant environment (industrially relevant environment in the case of key enabling technologies) • TRL 6 – technology demonstrated in relevant environment (industrially relevant environment in the case of key enabling technologies) • TRL 7 – system prototype demonstration in operational environment • TRL 8 – system complete and qualified • TRL 9 – actual system proven & running in operational environment

Please provide some sentences explaining your Technology Readiness Level

The total volume of the crystallizer is 7 L with an hydraulic retention time (HRT) of 1 d and the animal slurry/digestate is fed continuously (0.75 ± 0.04 L h^{-1}) into the crystallizer (riser zone). The SWB added to the slurry allows struvite precipitation at a ratio Mg^{2+}/PO_4^{3-} of 2.5. Aeration in the riser is controlled by means of a mass flow meter. pH is controlled in the riser at 8.5 using a control panel, dosing NaOH 1 M. Struvite particles settle in the bottom part of the crystallizer (collector) and are recovered at the end of the experiments, while the effluent wastewater is continuously discharged by overflow.

If the proposed solution/ technique is currently at low TRL (≤5), is upscaling foreseen within the next year(s)?

YES.

If the proposed solution/ technique is currently at high TRL (≥7), is there any product already being produced from the proposed solution/ technique?

- *If yes, what is the name of the product :*
- *Short description of the product*
- *Are there any EC/MS Authority permits already for use of the product (title or link if available)?*

52 Pilot-scale crystallizer for p recovery

POTENTIAL LINKAGE TO THE PROJECT

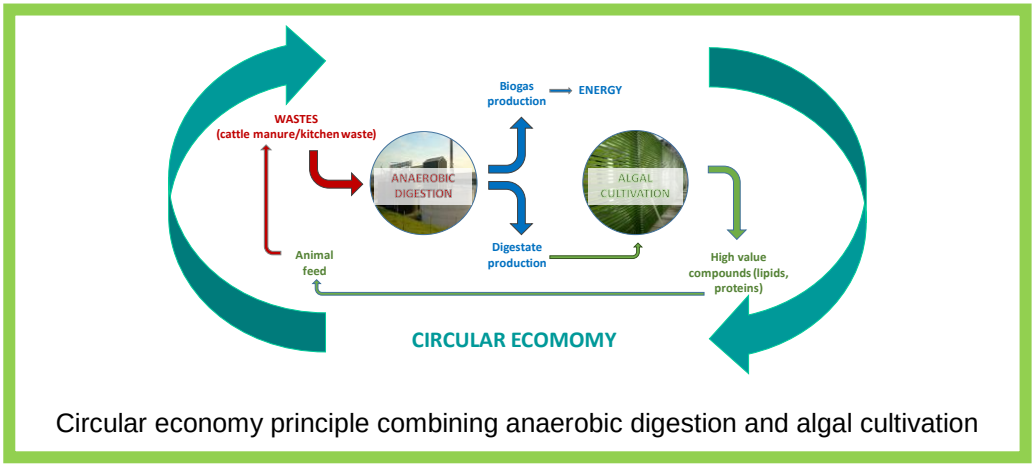
Indicate to which agro-typology under study and which potential research line of the project, your proposed solution/technique contributes :

X	Pig Production
	Poultry Production
X	Cattle Farming
	Open field cultivation of cereals or maize
	Open air cultivation of vegetables
	Orchards
X	Agro-energy systems (e.g. biogas)
X	Animal Byproduct processing (e.g. manure processing)

Innovative solutions for optimized nutrient & GHG in animal husbandry	
Innovative soil, fertilisation & crop management systems & practices	
Tools, techniques & systems for higher-precision fertilization	
Biobased fertilisers (N, P) and soil enhancers (OC) from agro-residues	X
Novel animal feeds produced from agro-residues	
Other, please specify :	

53 ALG-AD: Integrating algal and anaerobic digestion technology for sustainable animal feed production

AIM OF THE TECHNOLOGY



Circular economy principle combining anaerobic digestion and algal cultivation

Provide a brief description of the proposed management solution or technique.

- *What is the purpose/aim of the innovative solution/technique?*
  The main objective of the ALG-AD (INTERREG-NWE funded project) is to develop a new technology for recycling the excess waste nutrients produced from anaerobic digestion of food and farm waste within North West Europe (NWE) region and cultivate microalgal biomass for animal feed application.

- *What is the underlying working principle?*
  The working principle includes integrating algal (ALG) and anaerobic digestion (AD) for animal feed production. AD is a bioprocess which produces biogas as main product and nutrient rich digestate (NRD) as a co-product. NRD is composed of microalgal growth-promoting nutrients including nitrogen, phosphorus, potassium and trace metal elements. Microalgae are aquatic and autotrophic microorganisms which perform photosynthesis in the presence of photosynthetically active radiation (light), ambient temperature (heat) and nutrients available in the NRD. They absorb the light energy available in the form of photons and convert them into chemical energy. The chemical energy is later transformed into feed-applicable metabolites which are stored in the intracellular components of the microalgal cell. Metabolites such as proteins, high value lipids, essential amino acids, carbohydrates and mono/poly unsaturated fatty acids can be processed and be used as animal feed supplements.

- *Why is it innovative when compared to existing (farming) practices?*
  Integrating algal and anaerobic technology promotes complete recycling of excess waste nutrients like nitrogen and phosphorus to generate sustainable animal feed. The cultivation of algal biomass also promotes circular economy by mitigating pollution risk and reducing the dependence of European agricultural sector on imported corn or soya meal protein.

- *How does it improve the Nitrogen-Phosphorus and/or Carbon cycles in agriculture?*
  At the moment, major fraction of the NRD is returned to agricultural land as a (bio)fertilizer in NWE region. However, there are strict EU legislation limits imposed within Nitrate Vulnerable Zones on the amount of digestate which can be land applied. So, combining microalgal and anaerobic digestion technology improves the usage of excess Nitrogen-Phosphorus by accumulating

53 ALG-AD: Integrating algal and anaerobic digestion technology for sustainable animal feed production

intracellular feed-applicable metabolites like proteins, high value lipids, essential amino acids, carbohydrates and mono/poly unsaturated fatty acids.

- *What is the current and foreseen scale of operations (e.g. kg, tonnes/year)?*
  The ALG-AD project will be collaboratively implemented and tested in 4000 – 5000 litre bioreactors at three distinct 'real-life conditions' pilots facilities. Each facility will use local conditions to grow microalgae with expected annual output of 1 tonne biomass/year.

- *Add a separate line on the location of your management solution: "Currently this technology / technique / management solution is applied in ……. (city, region, country))."*
  Currently, this technology is being tested at pilots facilities in Devon (The United Kingdom), Brittany (France) and will be initiated in Flanders (Belgium) by mid-2019.

TRL (Technology Readiness Level) – how close is your solution to the market?

Use the slider above to position the current TRL* of your proposed solution

* TRLs are a type of measurement system used to assess the maturity level of a particular technology. Where a topic description refers to a TRL, the following definitions apply, unless otherwise specified:

• TRL 1 – basic principles observed • TRL 2 – technology concept formulated • TRL 3 – experimental proof of concept • TRL 4 – technology validated in lab • TRL 5 – technology validated in relevant environment (industrially relevant environment in the case of key enabling technologies) • TRL 6 – technology demonstrated in relevant environment (industrially relevant environment in the case of key enabling technologies) • TRL 7 – system prototype demonstration in operational environment • TRL 8 – system complete and qualified • TRL 9 – actual system proven & running in operational environment

Please provide some sentences explaining your Technology Readiness Level

Pilot scale investigations currently being performed in France and the United Kingdom.

If the proposed solution/ technique is currently at low TRL (≤5), is upscaling foreseen within the next year(s)?

If the proposed solution/ technique is currently at high TRL (≥7), is there any product already being produced from the proposed solution/ technique?

- *If yes, what is the name of the product:*
  Animal feed in the form of protein-rich microalgal biomass.

- *Short description of the product*
  Algal biomass in dried or paste form to be applicable as animal feed.

- *Are there any EC/MS Authority permits already for use of the product (title or link if available)?*
  NO.

53 ALG-AD: Integrating algal and anaerobic digestion technology for sustainable animal feed production

POTENTIAL LINKAGE TO THE PROJECT

Indicate to which agro-typology under study and which potential research line of the project, your proposed solution/technique contributes:

X	Pig Production
X	Poultry Production
	Cattle Farming
	Open field cultivation of cereals or maize
	Open air cultivation of vegetables
	Orchards
X	Agro-energy systems (e.g. biogas)
X	Animal Byproduct processing (e.g. manure processing)

Innovative solutions for optimized nutrient & GHG in animal husbandry	X
Innovative soil, fertilisation & crop management systems & practices	
Tools, techniques & systems for higher-precision fertilization	
Biobased fertilisers (N, P) and soil enhancers (OC) from agro-residues	
Novel animal feeds produced from agro-residues	X
Other, please specify :	

54 Tailor made production of soil enhancers (OC) and NPK fertilising products

AIM OF THE TECHNOLOGY

Tailor made organic fertilizer. Source: Fertikal

Provide a brief description of the proposed management solution or technique.

- *What is the purpose/aim of the innovative solution/technique?*
  Excess of waste (i.e. animal manure, food waste, sewage sludge) has stimulated the development of waste treatment technologies that nowadays generate significant amounts of end-derivatives. These derivatives contain valuable nutrients (eg. NPK and C) which might have potential for valorization as replacements of synthetic mineral fertilizers. The concentration of nutrients in these derivatives is highly variable, depending on the treated waste type and applied process.

- *What is the underlying working principle?*
  The issue of nutrient variability is perceived negatively by farmers as there is no assurance in the nutrient content that is used on arable fields. Potential solution could be to create tailor made blends that would result in recycled fertilizers with known nutrient concentration. The first step would be to examine nutrient demands for specific crops and accordingly create formula of tailor made fertilizers for respective crop types. This process would require machinery to blend homogenously different types of derivatives and to create a certain size and/or form of the fertilizer (eg; pellets), depending on demand for solid or liquid fertilizers.

- *What is the current and foreseen scale of operations (e.g. kg, tonnes/year)?*
  The current scale of operations can reach up to 180 000 tonnes per year, and it mostly involves the blends of chicken manure, compost and digestate.

- *Why is it innovative when compared to existing (farming) practices?*
  In general, blends are currently produced mostly from solid derivatives and less from liquid derivatives which are the biggest issue for disposal due to the high water content. Other derivatives such as liquid fraction of digestate, ammonia water, struvite, mineral concentrate, etc, might also have a potential for valorization as ingredients for blends.

- *How does it improve the Nitrogen-Phosphorus and/or Carbon cycles in agriculture?*
  The novel marketized blends, with wider range of used derivatives, would provide assurance for farmers as they would know exactly what is in the utilized fertilizer. This approach would not only

be focused on arable land, but also on greenhouses, gardens, parks, pot based cultivation and etc. Thereby increasing the market segments and utilization opportunities of recycled fertilizers.

- *Add a separate line on the location of your management solution: "Currently this technology / technique / management solution is applied in ……. (city, region, country)."*
  Currently this technology is applied in Ieper (Laviedor) and Antwerp (Fertikal), Belgium.

TRL (Technology Readiness Level) – how close is your solution to the market?

Use the slider above to position the current TRL* of your proposed solution

* TRLs are a type of measurement system used to assess the maturity level of a particular technology. Where a topic description refers to a TRL, the following definitions apply, unless otherwise specified:

• TRL 1 – basic principles observed • TRL 2 – technology concept formulated • TRL 3 – experimental proof of concept • TRL 4 – technology validated in lab • TRL 5 – technology validated in relevant environment (industrially relevant environment in the case of key enabling technologies) • TRL 6 – technology demonstrated in relevant environment (industrially relevant environment in the case of key enabling technologies) • TRL 7 – system prototype demonstration in operational environment • TRL 8 – system complete and qualified • TRL 9 – actual system proven & running in operational environment

Please provide some sentences explaining your Technology Readiness Level

There are companies that produce fertilizer blends, but not with all derivatives currently available in the sector of waste treatment.

If the proposed solution/ technique is currently at low TRL (≤5), is upscaling foreseen within the next year(s)?

If the proposed solution/ technique is currently at high TRL (≥7), is there any product already being produced from the proposed solution/ technique?

- *If yes, what is the name of the product:*
  Different types of organic fertilizers with specific in-house names.

- *Short description of the product*
- *Are there any EC/MS Authority permits already for use of the product (title or link if available)?*

POTENTIAL LINKAGE TO THE PROJECT

54 Tailor made production of soil enhancers (OC) and NPK fertilising products

Indicate to which agro-typology under study and which potential research line of the project, your proposed solution/technique contributes :

	Pig Production
	Poultry Production
	Cattle Farming
X	Open field cultivation of cereals or maize
X	Open air cultivation of vegetables
X	Orchards
	Agro-energy systems (e.g. biogas)
	Animal Byproduct processing (e.g. manure processing)

Innovative solutions for optimized nutrient & GHG in animal husbandry	
Innovative soil, fertilisation & crop management systems & practices	
Tools, techniques & systems for higher-precision fertilization	X
Biobased fertilisers (N, P) and soil enhancers (OC) from agro-residues	X
Novel animal feeds produced from agro-residues	
Other, please specify :	

55 Manure processing and replacing mineral fertilizers – The Netherlands

AIM OF THE TECHNOLOGY

Provide a brief description of the proposed management solution or technique.

In The Netherlands, more manure is produced than can be applied on agricultural land within the N and P application limits. Currently, the surplus amount of manure, mainly pig manure, is exported to Germany. This practice is associated with high costs (disposal costs for pig manure are € 20-25/m^3) and high CO_2 emissions due to transport, whereas mineral fertilizer is still widely used in addition to the animal manure application.

The aim of the project is to use regional recovered nutrients from animal manure and sewage sludge and replace mineral fertilisers and provide products that can be used within the nearby region of the plant hence preventing long-distance transport. This will ensure more efficient use of animal manure and reduction in the transport for the export of the surplus manure. The Green Mineral Mining Centre is the main processing installation of the project and aims to offer a more sustainable solution by processing co-digestated manure in NK concentrates, mineral P fertiliser and nutrient poor organic matter. This project contributes to a more circular economy and potentially reduces the emissions of greenhouse gasses.

The underlying principle of the project is to use animal manure more efficient, by processing the nitrogen, phosphorus and organic matter rich components of manure into separate products, that can be applied more efficiently. This will allow for higher application of the NK concentrate, which can replace mineral N fertilizer, and increase the application of organic matter that is low in nutrients.

Pig manure is treated in an anaerobic digester, together with co-products, and thereafter separated into a solid and a liquid fraction. The liquid fraction is treated by a combination of DAF, micro-filtration and RO to produce a NK concentrate with 1-2% N. The solid fraction, containing most of the phosphorus, is treated with sulphuric acid to extract the phosphorus which are subsequently recovered in the form of struvite or calciumphosphate. The remaining fibrous organic matter contains little nutrients.

The project is located in the region Achterhoek in the province of Gelderland in the Netherlands. The Achterhoek region has a pilot status allowing farmers to use NK-concentrates from manure, under conditions, as a synthetic fertiliser (i.e. on top of the N-application limit for manure). The nutrient poor organic matter will be used as a soil improver in The Netherlands or as an ingredient for potting soil.

55 Manure processing and replacing mineral fertilizers – The Netherlands

The recovered phosphorus will be exported as a concentrated product to regions outside the Netherlands with a demand for P-fertilisers.

The Green Mineral Mining Centre, which is located in this region, provides the NK concentrate to the pilot farms. This technology is currently constructed at a large anaerobic digester, treating 100.000 tons of pig manure, in Beltrum, Gelderland, The Netherlands. The effectiveness of the new fertilizer products is tested in the field, i.e. effect on crop growth, soil quality and nitrate leaching.

In 2018 a group of 10 dairy farmers in the region used the NK concentrate on grassland, in 2019 the group is extended to 75 dairy farmers and ultimately 150 dairy farmers will participate in this pilot project. The project consists of four components: i) production of high-quality fertilisers, ii) distribution and use of the fertilisers, iii) scientific monitoring and iv) advice and market development.

More info on the project can be found at: https://kunstmestvrijeachterhoek.nl/?lang=en
And for the Green Mineral Mining Centre the SYSTEMIC factsheet:
https://systemicproject.eu/wp-content/uploads/2018/07/D1.6_Update_Factsheets_Demo_Plants.pdf

55 Manure processing and replacing mineral fertilizers – The Netherlands

TRL (Technology Readiness Level) – how close is your solution to the market?

Use the slider above to position the current TRL* of your proposed solution

* TRLs are a type of measurement system used to assess the maturity level of a particular technology. Where a topic description refers to a TRL, the following definitions apply, unless otherwise specified:

• TRL 1 – basic principles observed • TRL 2 – technology concept formulated • TRL 3 – experimental proof of concept • TRL 4 – technology validated in lab • TRL 5 – technology validated in relevant environment (industrially relevant environment in the case of key enabling technologies) • TRL 6 – technology demonstrated in relevant environment (industrially relevant environment in the case of key enabling technologies) • TRL 7 – system prototype demonstration in operational environment • TRL 8 – system complete and qualified • TRL 9 – actual system proven & running in operational environment

Please provide some sentences explaining your Technology Readiness Level

A full-scale demonstration plant is currently under construction at Groot Zevert Vergisting in The Netherlands. This is one of the demonstration plants of the H2020 project SYSTEMIC. The demonstration plant is expected to be operational from April 2019 onwards and will process 100,000 of co-digestated pig manure into NK mineral concentrates, struvite and nutrient-poor soil improver.

If the proposed solution/ technique is currently at low TRL (≤5), is upscaling foreseen within the next year(s)?

If the proposed solution/ technique is currently at high TRL (≥7), is there any product already being produced from the proposed solution/ technique?

- *If yes, what is the name of the product :*
  Yes, in 2018 the focus was on the production and application of “Green Meadow Fertilizer”, a product with higher N and K content and low P content, produced from animal manure (mainly pig manure) and ammonium sulphate, recovered from sewage sludge. From April 2019 onwards large scale production of the NK mineral concentrates, struvite and nutrient-poor soil improver.

- *Short description of the product*
  NK mineral concentrate, struvite, nutrient poor organic matter.

- *Are there any EC/MS Authority permits already for use of the product (title or link if available)?*
  YES, a derogation has been granted for this project, to use the new fertilizer products on top of the animal manure limits from the Nitrates Directive

55 Manure processing and replacing mineral fertilizers – The Netherlands

POTENTIAL LINKAGE TO THE PROJECT

Indicate to which agro-typology under study and which potential research line of the project, your proposed solution/technique contributes :

X	Pig Production
	Poultry Production
X	Cattle Farming
X	Open field cultivation of cereals or maize
	Open air cultivation of vegetables
	Orchards
	Agro-energy systems (e.g. biogas)
X	Animal Byproduct processing (e.g. manure processing)

Innovative solutions for optimized nutrient & GHG in animal husbandry	
Innovative soil, fertilisation & crop management systems & practices	X
Tools, techniques & systems for higher-precision fertilization	
Biobased fertilisers (N, P) and soil enhancers (OC) from agro-residues	X
Novel animal feeds produced from agro-residues	
Other, please specify :	

56 Application of ammonia water from digestate treatment

AIM OF THE TECHNOLOGY

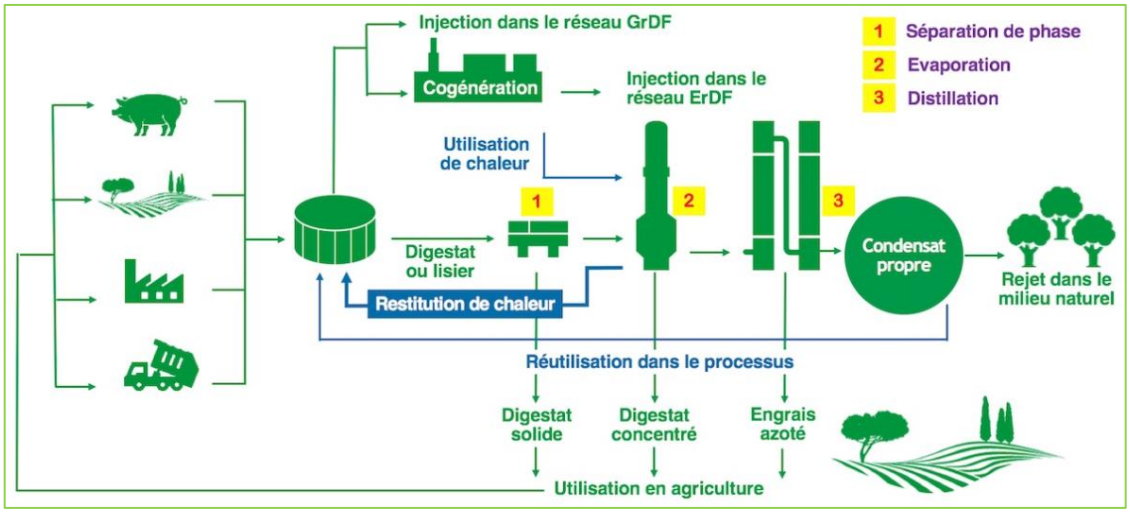


Image : https://www.bioenergie-promotion.fr/50082/france-evaporation-rend-le-traitement-des-digestats-plus-rentable/

Provide a brief description of the proposed management solution or technique.

- *What is the purpose/aim of the innovative solution/technique?*
  The aim of the technique is the removal of nitrogen (N) from the liquid matter (manure or thin fraction from digestate). This is done by vacuum stripping (in a 1st step = evaporation) and recovery of the ammonia as ammonia water in a second step (= distillation). This distillation can be done by using steam, H_2SO_4 or HNO_3, producing ammonia water, ammonia sulphate and ammonia nitrate respectively.
  Compared to Ammonia-sulphate and -nitrate, ammonia water can be considered a “cleaned” form of recuperated nitrogen (N). The concentration of the ammonia water is about 15 to 20%. The technique as such is operational (no further research required), though the application / market value of the ammonia water (= “engrais azote” in the scheme above) is too low to guarantee uptake of the technology in the market.
  It is this latter aspect that should further be researched.

- *What is the underlying working principle?*
  See also the figure above. After the separation, the liquid fraction is further treated for N recovery. This treatment consists of the combination of vacuum stripping (= evaporation) and steam distillation, resulting in the production of ammonia water.

- *What is the current and foreseen scale of operations (e.g. kg, tonnes/year)?*
  The technique for the full scale production is already operational at full scale (e.g. 120 kg ammonia water / hr)

- *Why is it innovative when compared to existing (farming) practices?*
  Innovation should be done on the matter of the application of the ammonia water. It might be used as a substitute for Ureum in DeNox installations, though the legislative framework does

not allow this application. Added value of the flow compared to other fertilisers should be researched for application on the field.
As long as the "added value" of producing the cleaner ammonia water is not proven in the market, the application of the technique will be limited.

- *How does it improve the Nitrogen-Phosphorus and/or Carbon cycles in agriculture?*
  Impact will only be on the N-cycle. It is an existing, working technology that can help the recycling of N. If there would be a clear indication of how the ammonia water can be applied, the adaption of the technology in the market would increase significantly.

- *Add a separate line on the location of your management solution: "Currently this technology / technique / management solution is applied in ……. (city, region, country))."*
  The technology is already applied in (at least) 3 digester-sites in Flanders. With more to come, if the valuable ammonia-water can create added value.

TRL (Technology Readiness Level) – how close is your solution to the market?

Use the slider above to position the current TRL* of your proposed solution

* TRLs are a type of measurement system used to assess the maturity level of a particular technology. Where a topic description refers to a TRL, the following definitions apply, unless otherwise specified:

• TRL 1 – basic principles observed • TRL 2 – technology concept formulated • TRL 3 – experimental proof of concept • TRL 4 – technology validated in lab • TRL 5 – technology validated in relevant environment (industrially relevant environment in the case of key enabling technologies) • TRL 6 – technology demonstrated in relevant environment (industrially relevant environment in the case of key enabling technologies) • TRL 7 – system prototype demonstration in operational environment • TRL 8 – system complete and qualified • TRL 9 – actual system proven & running in operational environment

Please provide some sentences explaining your Technology Readiness Level

The ammonia water is being produced at full scale level, though the disposal is problematic (and discouraging). The research that should be done is twofold : (1) investigate possible applications of the ammonia water available as it is, (2) research (existing) technologies that would significantly increase the market value of the product

If the proposed solution/ technique is currently at low TRL (≤5), is upscaling foreseen within the next year(s)?

If the proposed solution/ technique is currently at high TRL (≥7), is there any product already being produced from the proposed solution/ technique?

- *If yes, what is the name of the product:*
  Ammonia water.

- *Short description of the product:*
- *Are there any EC/MS Authority permits already for use of the product (title or link if available)?*

56 Application of ammonia water from digestate treatment

POTENTIAL LINKAGE TO THE PROJECT

Indicate to which agro-typology under study and which potential research line of the project, your proposed solution/technique contributes :

	Pig Production
	Poultry Production
	Cattle Farming
	Open field cultivation of cereals or maize
	Open air cultivation of vegetables
	Orchards
X	Agro-energy systems (e.g. biogas)
X	Animal Byproduct processing (e.g. manure processing)

Innovative solutions for optimized nutrient & GHG in animal husbandry	
Innovative soil, fertilisation & crop management systems & practices	
Tools, techniques & systems for higher-precision fertilization	
Biobased fertilisers (N, P) and soil enhancers (OC) from agro-residues	X
Novel animal feeds produced from agro-residues	
Other, please specify :	

57 Recovered organic materials and composts for precision fertilization of orchards and vineyards

AIM OF THE TECHNOLOGY

Provide a brief description of the proposed management solution or technique.

- *What is the purpose/aim of the innovative solution/technique?*
  The proposed technology aims to apply organic fertilizers (manure, slurry, compost) in vineyards and orchards, at variable rate (VRT).

- *What is the underlying working principle?*
  Based on digital maps related to crop status (NDVI, leaf nutrients), soil fertility (apparent electrical conductivity, pH, organic matter, N, P, K, Ca, Mg, Na) and crop needs, VRT fertilization recommendations will be established in order to maximize the organic fertilizers use, but avoiding over-application of nutrients. If needed, based on organic fertilizers VRT application, VRT fertilization with mineral fertilizers will be established for the nutrients whose needs were not fulfilled by the organic fertilizer.

- *What is the current and foreseen scale of operations (e.g. kg, tonnes/year)?*
  Portugal has the 4th larger area of vineyards in Europe, with a total of 200 000 ha. The area of orchards has been increasing (7% since 2012) with a total area of 38 300 ha (7th area in Europe). Consequently, there is a huge potential for recycling nutrients from organic materials in these crops.

- *Why is it innovative when compared to existing (farming) practices?*
  Orchards and vineyards are traditionally fertilized with mineral fertilizers and the standard nutrient recommendation strategy involves determining an average fertilizer need for the field and applying a single rate to the entire field. This traditional technique does not account for the soil fertility spatial variability within the field and, consequently, less fertile areas of the field may not receive enough fertilizer to increase their fertility and other areas may receive more than the optimum amount of fertilizer. We believe that precision application of organic materials will motivate farmers to adopt such strategy that ensures the efficient and sustainable management of fertilization. The use of a more precise organic material application, in the right amount and place, will generate an increase of yield in orchards and vineyards and lead the poorest areas of the fields to a greater status of fertility, making the whole field more homogeneous and improving the Nitrogen, Phosphorus and Carbon cycles in agriculture.

- *How does it improve the Nitrogen-Phosphorus and/or Carbon cycles in agriculture?*

57 Recovered organic materials and composts for precision fertilization of orchards and vineyards

In southern Europe, soil fertility is highly related to organic matter contents, whose levels are reaching extremely low values in some regions. In this context, the use of organic materials for fertilization, and the implementation of variable rate application (VRT) seems to be an efficient solution to ensure NPC recycling and increase soil productivity within the fields with a specific target: closing the NPC loop.

- *Add a separate line on the location of your management solution: "Currently this technology / technique / management solution is applied in ……. (city, region, country))."*
  Currently, the Portuguese company HERCULANO (Oliveira de Azemeis, Portugal) is developing VRT technology for slurry tankers and NPK sensors for in situ analysis of slurries. So, within a few years, this technology will be available for orchards and vineyards.

TRL (Technology Readiness Level) – how close is your solution to the market?

Use the slider above to position the current TRL* of your proposed solution

* TRLs are a type of measurement system used to assess the maturity level of a particular technology. Where a topic description refers to a TRL, the following definitions apply, unless otherwise specified:

• TRL 1 – basic principles observed • TRL 2 – technology concept formulated • TRL 3 – experimental proof of concept • TRL 4 – technology validated in lab • TRL 5 – technology validated in relevant environment (industrially relevant environment in the case of key enabling technologies) • TRL 6 – technology demonstrated in relevant environment (industrially relevant environment in the case of key enabling technologies) • TRL 7 – system prototype demonstration in operational environment • TRL 8 – system complete and qualified • TRL 9 – actual system proven & running in operational environment

Please provide some sentences explaining your Technology Readiness Level

Application at farm scale will be developed and used during the project

If the proposed solution/ technique is currently at low TRL (≤5), is upscaling foreseen within the next year(s)?

YES.

If the proposed solution/ technique is currently at high TRL (≥7), is there any product already being produced from the proposed solution/ technique?

- *If yes, what is the name of the product:*
- *Short description of the product*
- *Are there any EC/MS Authority permits already for use of the product (title or link if available)?*

57 Recovered organic materials and composts for precision fertilization of orchards and vineyards

POTENTIAL LINKAGE TO THE PROJECT

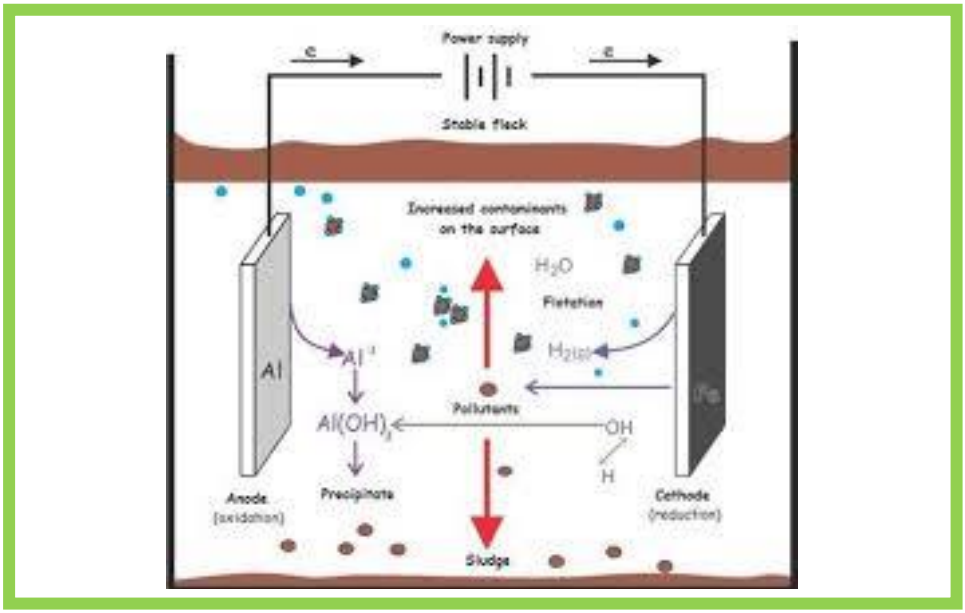
Indicate to which agro-typology under study and which potential research line of the project, your proposed solution/technique contributes :

X	Pig Production
X	Poultry Production
X	Cattle Farming
	Open field cultivation of cereals or maize
	Open air cultivation of vegetables
X	Orchards
	Agro-energy systems (e.g. biogas)
X	Animal Byproduct processing (e.g. manure processing)

Innovative solutions for optimized nutrient & GHG in animal husbandry	
Innovative soil, fertilisation & crop management systems & practices	X
Tools, techniques & systems for higher-precision fertilization	X
Biobased fertilisers (N, P) and soil enhancers (OC) from agro-residues	
Novel animal feeds produced from agro-residues	
Other, please specify :	

58 Electro Coagulation for separation of manure or digestate

AIM OF THE TECHNOLOGY



Provide a brief description of the proposed management solution or technique.

- *What is the purpose/aim of the innovative solution/technique?*
  Electrocuagulation is a technique used at different types of waste water for the separation of P and suspended solids. The technology is an innovative replacement for traditional coagulation-flotation systems. The main benefit is that it drastically reduces the use of chemical reagents.

- *What is the underlying working principle?*
  Using electricity (electro coagulation) for the separation of flocs (and therefore removal of P) from wastewater.

- *What is the current and foreseen scale of operations (e.g. kg, tonnes/year)?*
  Currently still in pilot / research for some of the industrial sectors (e.g. paper industry). Operational up to 1 ton/hr.

- *Why is it innovative when compared to existing (farming) practices?*
  It would be interesting to research the possibilities this technique has on manure and/or (liquid) digestate.
  Some first tests with were done at the laboratory of NOAH Water Solutions (www.noahws.be) but were not very promising. Literature show though that it might be a promising technology. So further research on the possibilities should be done.
  From literature it shows that there are operational systems, though the technology is not applied in Flanders.

- *How does it improve the Nitrogen-Phosphorus and/or Carbon cycles in agriculture?*
  Separation always remains an important step in the recuperation of N, P and Carbon. Every new type of separation should be researched. If this step would lower the operational costs for separation significantly, it might be an option.

58 Electro Coagulation for separation of manure or digestate

- *Add a separate line on the location of your management solution: "Currently this technology / technique / management solution is applied in ……. (city, region, country))."*
  This technology is under research for other types of wastewater (not manure and digestate) in Flanders.

TRL (Technology Readiness Level) – how close is your solution to the market?

Use the slider above to position the current TRL* of your proposed solution

* TRLs are a type of measurement system used to assess the maturity level of a particular technology. Where a topic description refers to a TRL, the following definitions apply, unless otherwise specified:

• TRL 1 – basic principles observed • TRL 2 – technology concept formulated • TRL 3 – experimental proof of concept • TRL 4 – technology validated in lab • TRL 5 – technology validated in relevant environment (industrially relevant environment in the case of key enabling technologies) • TRL 6 – technology demonstrated in relevant environment (industrially relevant environment in the case of key enabling technologies) • TRL 7 – system prototype demonstration in operational environment • TRL 8 – system complete and qualified • TRL 9 – actual system proven & running in operational environment

Please provide some sentences explaining your Technology Readiness Level

TRL 4 - 5 : According to literature, this is a promising technology. It would already be operation at some plants. It has shown effective on full scale installations of several types of wastewater (e.g. paper industry) but should be investigated / adjusted to have it ready for implementation in the digestate or manure treatment.

If the proposed solution/ technique is currently at low TRL (≤5), is upscaling foreseen within the next year(s)?

YES.

If the proposed solution/ technique is currently at high TRL (≥7), is there any product already being produced from the proposed solution/ technique?

- *If yes, what is the name of the product :*
- *Short description of the product*
- *Are there any EC/MS Authority permits already for use of the product (title or link if available)?*

58 Electro Coagulation for separation of manure or digestate

POTENTIAL LINKAGE TO THE PROJECT

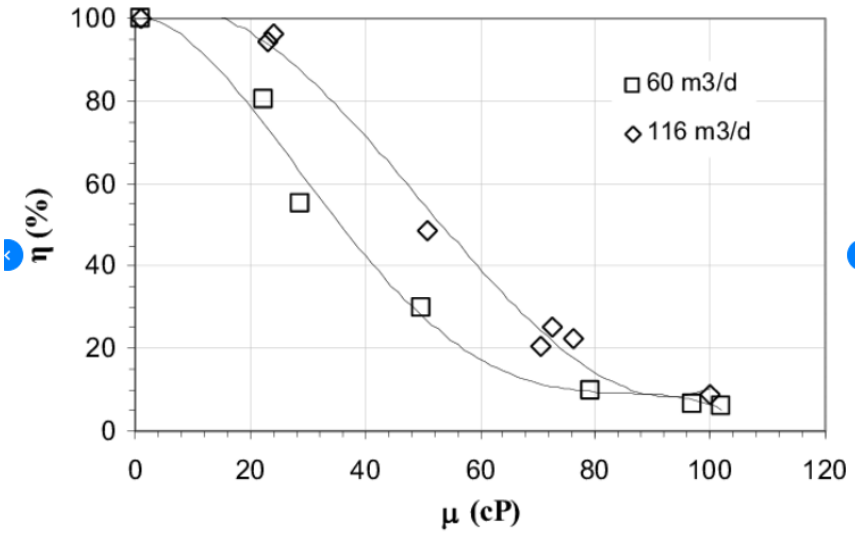
Indicate to which agro-typology under study and which potential research line of the project, your proposed solution/technique contributes :

	Pig Production
	Poultry Production
	Cattle Farming
	Open field cultivation of cereals or maize
	Open air cultivation of vegetables
	Orchards
X	Agro-energy systems (e.g. biogas)
X	Animal Byproduct processing (e.g. manure processing)

Innovative solutions for optimized nutrient & GHG in animal husbandry	
Innovative soil, fertilisation & crop management systems & practices	
Tools, techniques & systems for higher-precision fertilization	
Biobased fertilisers (N, P) and soil enhancers (OC) from agro-residues	X
Novel animal feeds produced from agro-residues	
Other, please specify :	

59 Impact of (and on) viscosity on manure and digestate treatment

AIM OF THE TECHNOLOGY



Separation efficiency as a function of the liquid viscosity. The inlet solids concentration and mean diameter were constant and equal to 0.1% and 900 μm.

Source figure : SPE Paper Number 94673-PP : Experimental Analysis of Swirl Tubes as Downhole Desander Device; J.Alves Martins, E.Spanó Rosa and R.de Oliviera Souza.

Provide a brief description of the proposed management solution or technique.

- *What is the purpose/aim of the innovative solution/technique?*
  Nowadays, when assessing the treatment of digestate, mostly dry matter, nitrogen and phosphorous are the points of attention. Nevertheless, it should be researched what the impact of the viscosity of the materials is on the actual efficiency of the treatment steps. A digestate with a higher viscosity might have a totally different composition of the thick fraction coming from a centrifuge then a digestate with low viscosity. So far, viscosity has not been assessed or modelled.
  For “managing” the digestate (and digestate products) it would be useful to know the impact this factor has on the effiencies, in combination with certain techniques that might alter the viscosity (e.g. electrokinetic treatment, etc.). If this parameter becomes “manageable”, the composition of the digestate product become also more “manageable”, what helps to close the loop.

- *What is the underlying working principle?*
  When doing separation of the digestate (in for example a centrifuge or a belt press), the viscosity will have a great impact on the efficiency of the separation. As can be seen from research done for the oil production (see figure), the impact is significant.
  If it would be possible to model the separation efficiency linked to the viscosity, it might be possible to better manage the separation efficiency on the matter of N, P and C.

- *What is the current and foreseen scale of operations (e.g. kg, tonnes/year)?*
  Separation is done at all scales of digesters. For Flanders, the most regular separation systems work on a flow of about 3 – 8 ton/hr.

59 Impact of (and on) viscosity on manure and digestate treatment

- *Why is it innovative when compared to existing (farming) practices?*
  Nowadays focus is only on the dry matter and gradually more and more on the nutrients, but not direct link to viscosity is considered yet. The viscosity of the digestate is influenced by different process parameters : feedstock to the digester, retention time in the digester, temperature in the digester, etc. If adjusting these process parameters would increase the efficiency of the separation, the "nutrient-management" of a biogas plant might increase significantly.

- *How does it improve the Nitrogen-Phosphorus and/or Carbon cycles in agriculture?*
  The more you can control the efficiency, the better you will be able to organize the NPC-cycles.

- *Add a separate line on the location of your management solution: "Currently this technology / technique / management solution is applied in ……. (city, region, country))."*
  The technique of separation is applied worldwide.

TRL (Technology Readiness Level) – how close is your solution to the market?

Use the slider above to position the current TRL* of your proposed solution

* TRLs are a type of measurement system used to assess the maturity level of a particular technology. Where a topic description refers to a TRL, the following definitions apply, unless otherwise specified:

• TRL 1 – basic principles observed • TRL 2 – technology concept formulated • TRL 3 – experimental proof of concept • TRL 4 – technology validated in lab • TRL 5 – technology validated in relevant environment (industrially relevant environment in the case of key enabling technologies) • TRL 6 – technology demonstrated in relevant environment (industrially relevant environment in the case of key enabling technologies) • TRL 7 – system prototype demonstration in operational environment • TRL 8 – system complete and qualified • TRL 9 – actual system proven & running in operational environment

Please provide some sentences explaining your Technology Readiness Level

As it is more a managing technique – a TRL is hard to consider.
Separation techniques as such are widespread and used, so TRL 9.

If the proposed solution/ technique is currently at low TRL (≤5), is upscaling foreseen within the next year(s)?

If the proposed solution/ technique is currently at high TRL (≥7), is there any product already being produced from the proposed solution/ technique?

- *If yes, what is the name of the product :*
- *Short description of the product*
- *Are there any EC/MS Authority permits already for use of the product (title or link if available)?*

59 Impact of (and on) viscosity on manure and digestate treatment

POTENTIAL LINKAGE TO THE PROJECT

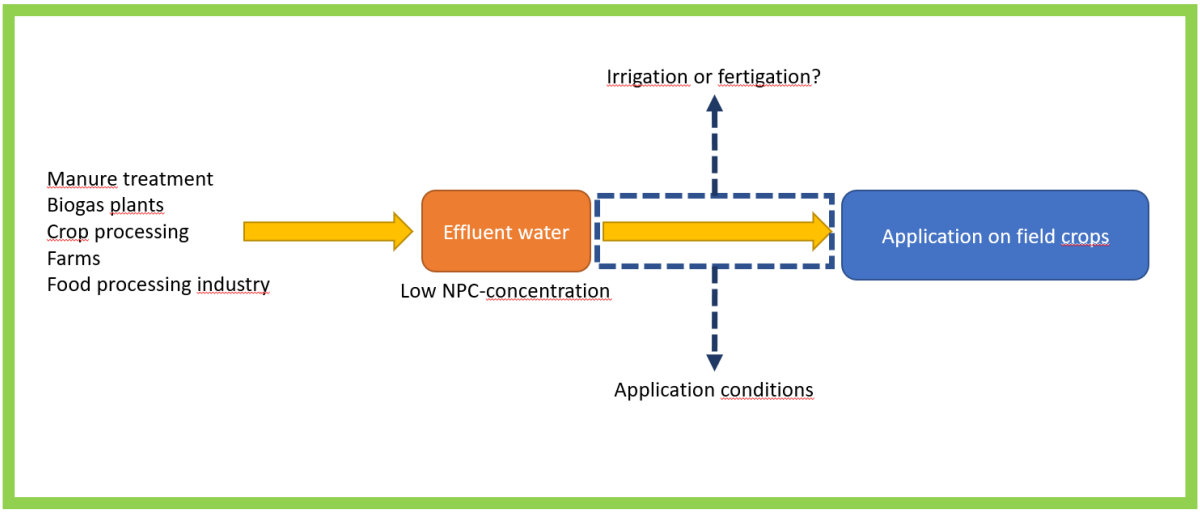
Indicate to which agro-typology under study and which potential research line of the project, your proposed solution/technique contributes :

	Pig Production
	Poultry Production
	Cattle Farming
	Open field cultivation of cereals or maize
	Open air cultivation of vegetables
	Orchards
X	Agro-energy systems (e.g. biogas)
X	Animal Byproduct processing (e.g. manure processing)

Innovative solutions for optimized nutrient & GHG in animal husbandry	
Innovative soil, fertilisation & crop management systems & practices	
Tools, techniques & systems for higher-precision fertilization	
Biobased fertilisers (N, P) and soil enhancers (OC) from agro-residues	X
Novel animal feeds produced from agro-residues	
Other, please specify :	

60 IRRIGATION / FERTIGATION: use of effluent on arable land

AIM OF THE TECHNOLOGY



Provide a brief description of the proposed management solution or technique.

- *What is the purpose/aim of the innovative solution/technique?*
  It is expected that due to the climate change, bigger parts of Europe will know longer and more severe periods of drought on a frequent (yearly?) basis. In order to cope with these scarcity of water in the agricultural sector, it is important to make an overview of all possible sources of water that can be applied on arable land, knowing that in times of drought consumption of high quality ground water for irrigation is forbidden.
  Effluent from different types of installations (e.g. manure treatment installations, biogas plants, Crop processing, Farms and food processing industry) can be a valuable alternative to the high quality ground water, though at this point it's use for this purpose is not sufficiently known yet as there are some legal and practical items still to tackle :
  Those effluents still contain a lower level of NPC-concentration. At this point it is unclear whether or not these effluents need to be considered as soil enhancers for this or not (note : if considered a soil enhancer, the legal framework that comes along is a lot more controlling);
  The application of this type of effluents on arable fields is not sufficiently tested yet. Some effluents reach up to a quality in which they can be discharged in surface water, though might still contain quite some salt concentration. Can these effluent be applied on all types of crops? What are the exact limits (e.g. salt concentration etc.) for certain crops? Etc.
  The research to be done should therefore focus on providing both producers and receivers of these effluents clear information on the legal framework and the practical implementation that comes along with the application on arable land.

- *What is the underlying working principle?*
  In the above mentioned installations, the liquid fraction that results from the production process is processed up to a certain level. Some of them can be discharged in surface water, others are still too concentrated for discharging in the surface water and are to be applied on land as soil enhancers even though the nutrient concentrations are very low.
  This effluent can bring a significant added value to the field in periods of drought – though all aspects should be considered (e.g. salt concentration) and the legal framework (in Flanders) is not accurate yet whether to consider the use of effluent as fertigation or irrigation.

60 IRRIGATION / FERTIGATION: use of effluent on arable land

- *What is the current and foreseen scale of operations (e.g. kg, tonnes/year)?*
  During the drought period in the Summer of 2018 the application of effluent from wastewater treatment plants was already performed in Flanders – though without the required framework. Taking into account the predictions to have similar periods of drought in the upcoming years, the application of effluent on the fields for irrigation / fertigation will increase significantly.

- *Why is it innovative when compared to existing (farming) practices?*
  Nowadays, the irrigation of the arable fields is done by applying high quality ground water. The application of fertilizers is done in a separate step – applying manure and other types of soil enhancers. Application of effluent on the arabale land is not done as the impact is unknows – both due to a gap in the legal framework (irrigation / fertigation) as to the unknown impact of using effluent (e.g. salt concentration, other production parameters).

- *How does it improve the Nitrogen-Phosphorus and/or Carbon cycles in agriculture?*
  When considering only effluent that can be discharged in surface water, the N and P values that are “recycled” are relatively low. Nevertheless, it would be an important asset for creating interlinkages between the different stakeholders involved in the agricultural sector and it’s processing industry. If there would be a sustainable cooperation in water, the cooperation on other levels might also be smoothened. On top of that, in case the effluent would be continuously used as irrigation / fertigation water instead of being discharged to the surface water, one might consider to adjust the N and P concentration in the effluent based on the needs of the arable land.

- *Add a separate line on the location of your management solution: “Currently this technology / technique / management solution is applied in ……. (city, region, country)).”*
  Not Relevant.

60 IRRIGATION / FERTIGATION: use of effluent on arable land

TRL (Technology Readiness Level) – how close is your solution to the market?

Use the slider above to position the current TRL* of your proposed solution

* TRLs are a type of measurement system used to assess the maturity level of a particular technology. Where a topic description refers to a TRL, the following definitions apply, unless otherwise specified:

• TRL 1 – basic principles observed • TRL 2 – technology concept formulated • TRL 3 – experimental proof of concept • TRL 4 – technology validated in lab • TRL 5 – technology validated in relevant environment (industrially relevant environment in the case of key enabling technologies) • TRL 6 – technology demonstrated in relevant environment (industrially relevant environment in the case of key enabling technologies) • TRL 7 – system prototype demonstration in operational environment • TRL 8 – system complete and qualified • TRL 9 – actual system proven & running in operational environment

Please provide some sentences explaining your Technology Readiness Level

This doesn't concern a new technology, but more a management solution, so a bit difficult to provide a TRL level.

If the proposed solution/ technique is currently at low TRL (≤5), is upscaling foreseen within the next year(s)?

YES.

If the proposed solution/ technique is currently at high TRL (≥7), is there any product already being produced from the proposed solution/ technique?

- *If yes, what is the name of the product :*
- *Short description of the product*
- *Are there any EC/MS Authority permits already for use of the product (title or link if available)?*

60 IRRIGATION / FERTIGATION: use of effluent on arable land

POTENTIAL LINKAGE TO THE PROJECT

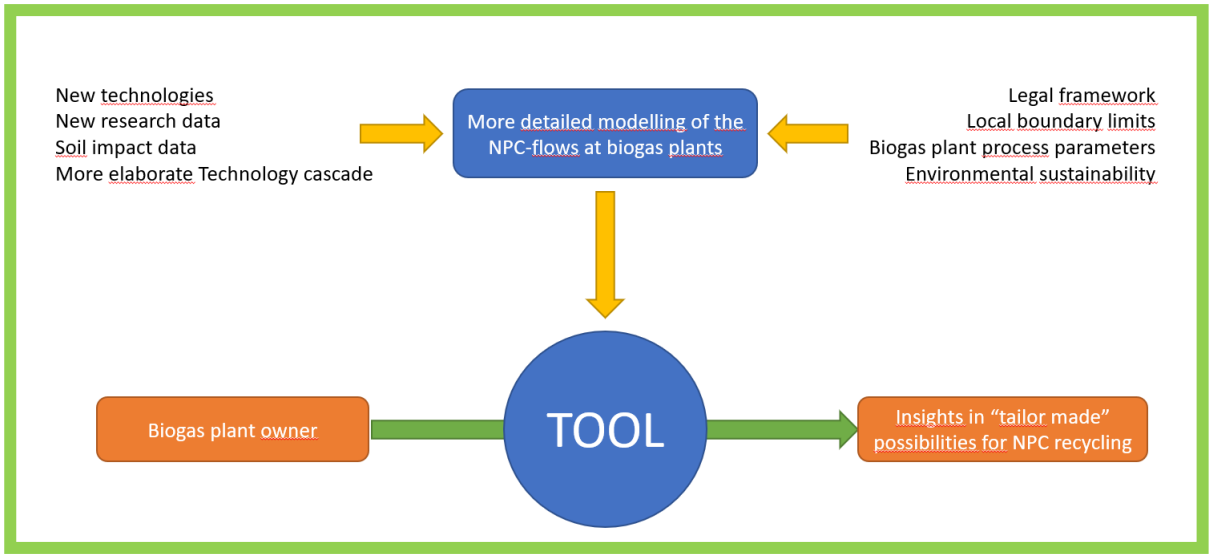
Indicate to which agro-typology under study and which potential research line of the project, your proposed solution/technique contributes :

X	Pig Production
X	Poultry Production
X	Cattle Farming
X	Open field cultivation of cereals or maize
X	Open air cultivation of vegetables
X	Orchards
X	Agro-energy systems (e.g. biogas)
X	Animal Byproduct processing (e.g. manure processing)

Innovative solutions for optimized nutrient & GHG in animal husbandry	
Innovative soil, fertilisation & crop management systems & practices	
Tools, techniques & systems for higher-precision fertilization	
Biobased fertilisers (N, P) and soil enhancers (OC) from agro-residues	X
Novel animal feeds produced from agro-residues	
Other, please specify :	

61 Tailor made digestate products (tool development)

AIM OF THE TECHNOLOGY



Provide a brief description of the proposed management solution or technique.

- *What is the purpose/aim of the innovative solution/technique?*
  The disposal of digestate products is one of the bigger bottlenecks that are experienced at the biogas plants in Flanders. If the digestate products could be more "tailor-made" (i.e. with an optimal NPK composition for certain crops) this would certainly be a big step forwards in tackling this bottle neck. Nowadays (at most biogas plants), the actual composition of the digestate(products) is not taken into account when selecting the feed to the digester yet. In order to do so, a decent modelling of the NPK-flows in the overall system should be developed and made available as a tool. This model should take into account all boundary conditions that can influence the balances : type of feedstock, period of storage prior to digestion, reactor volume, reactor temperature, interaction with other types of feedstock (?), digestate treatment technologies, digestate characteristics (dry and organic matter content, viscosity, ….), possible additives to the digestate, etc. Of course there is also the influence of the residence time in the reactor which is significant and makes it harder to calculate the direct in-out composition of the digestate.

- *What is the underlying working principle?*
  Modelling of the N & P flows on farm scale level. Drawing a "general" model that fits all different Biogas-plants in detail is impossible, due to changing process set-up or local conditions. When using the tool linked to the model, the biogas-plant owners should be able to have a first impression of what is possible for his specific plant.

- *What is the current and foreseen scale of operations (e.g. kg, tonnes/year)?*
  Current status : in the FP7 INEMAD project United Experts developed an excel tool for a first estimation, based on the most basic technology solutions. This tool should be extrapolated to also include new technologies or set-ups and include so higher level of basic modelling. In order to do this modelling, a pilot or full scale plant should be monitored very closely in order to be able to provide a model. Lab scale trials might be a good start, but they might not be representative for the full scale plants that don't have the same level of control over the process.

61 Tailor made digestate products (tool development)

- *Why is it innovative when compared to existing (farming) practices?*
  Nowadays selection of input to digesters is mainly focusing on the biogas production potential, without taking into account the N and P concentration that is produced through the end products. Providing a model that would support management on the level of nutrients (including the financial management) would be a big step forward.

- *How does it improve the Nitrogen-Phosphorus and/or Carbon cycles in agriculture?*
  If it would be possible to provide this "tailor made" digestate products, the application as fertilizer in agriculture would increase significantly.

- *Add a separate line on the location of your management solution: "Currently this technology / technique / management solution is applied in ……. (city, region, country))."*
  Not Relevant.

TRL (Technology Readiness Level) – how close is your solution to the market?

Use the slider above to position the current TRL* of your proposed solution

* TRLs are a type of measurement system used to assess the maturity level of a particular technology. Where a topic description refers to a TRL, the following definitions apply, unless otherwise specified:

• TRL 1 – basic principles observed • TRL 2 – technology concept formulated • TRL 3 – experimental proof of concept • TRL 4 – technology validated in lab • TRL 5 – technology validated in relevant environment (industrially relevant environment in the case of key enabling technologies) • TRL 6 – technology demonstrated in relevant environment (industrially relevant environment in the case of key enabling technologies) • TRL 7 – system prototype demonstration in operational environment • TRL 8 – system complete and qualified • TRL 9 – actual system proven & running in operational environment

Please provide some sentences explaining your Technology Readiness Level

This doesn't concern a new technology, but more a management solution, so a bit difficult to provide a TRL level.

If the proposed solution/ technique is currently at low TRL (≤5), is upscaling foreseen within the next year(s)?

YES.

If the proposed solution/ technique is currently at high TRL (≥7), is there any product already being produced from the proposed solution/ technique?

- *If yes, what is the name of the product :*
- *Short description of the product*
- *Are there any EC/MS Authority permits already for use of the product (title or link if available)?*

61 Tailor made digestate products (tool development)

POTENTIAL LINKAGE TO THE PROJECT

Indicate to which agro-typology under study and which potential research line of the project, your proposed solution/technique contributes :

	Pig Production
	Poultry Production
	Cattle Farming
	Open field cultivation of cereals or maize
	Open air cultivation of vegetables
	Orchards
X	Agro-energy systems (e.g. biogas)
X	Animal Byproduct processing (e.g. manure processing)

Innovative solutions for optimized nutrient & GHG in animal husbandry	
Innovative soil, fertilisation & crop management systems & practices	
Tools, techniques & systems for higher-precision fertilization	
Biobased fertilisers (N, P) and soil enhancers (OC) from agro-residues	X
Novel animal feeds produced from agro-residues	
Other, please specify :	

62 Blending of raw and treated organic materials to produce organic fertilisers (NPC)

AIM OF THE TECHNOLOGY

Images courtesy of Public Domain

Provide a brief description of the proposed management solution or technique.

- *What is the purpose/aim of the innovative solution/technique?*
  The aim of the solution that it is proposed is to close de loop between the producers of bio-residues in livestock production, and the farmers, which, currently, are much dependent on mineral fertilizers. The proposed solution should allow the formulation of organic fertilizers to be used in crops with specific requirements in terms of fertilization. The solution proposed should avoid over application of some nutrients and a more efficient use of nutrients by plants, contributing to a more carbon and nutrient efficient use of fertilizers in agriculture in Europe, linking the producers of wastes with farmers necessities in terms of fertilization.

- *What is the underlying working principle?*
  The underlying working principle is that it is necessary to link the producers of wastes with farmers necessities in terms of fertilization.
  In order to allow that, it is important to evaluate the following issues, using the Portuguese context as case study:

  1. Characterize the fertilizers and organic amendments market:
  - Do a list of the consumption of mineral fertilizers used by farmers, not only in terms of quantity but also in terms of the formulations of N:P:K to each crop.
  - Quantify the organic amendments used and relate then with an area of consumption.

  2. Characterize the production of animal manures in livestock activities
  - Quantify the quantity of manures and slurries produced in Portugal per region.
  - Quantifying which of those manures and slurries are applied to agricultural soil in a raw state (origin and quantity).
  - Quantify which of those manures and slurries are applied to agricultural soil after some treatment with the aim of improving their characteristics, namely hygienization, stabilization, nutrient availability, environmental safety (e.g., physical separation, chemical stabilization by acidification or alkalization, drying, anaerobic digestion, composting, others).
  - Quantify which of those manures and slurries are not reintroduced in the production chain.

3. Characterize the physicochemical composition of manures and slurries available in the market (raw or treated)

Characterize the manures and slurries available in the market, their physicochemical composition and their mineralization behavior, in order to evaluate their potential capacity to provide immediately available nutrients (those that can replace mineral fertilizers), and their capacity to slow release of nutrients.

4. Blending of organic-materials for the formulation of on-demand fertilizers, to improve N and P use efficiency and to obtain sub-products with variable composition on those nutrients

This blending of organic-materials will consider different formulation according to manures and slurries available in the market (raw or treated) with the aim of preparing "on demand fertilizers". Those formulations may only be reached with the supplementation of:

- Urban residues (e.g., treated sewage sludge, urban organic waste, ...);
- Agro-industrial residues (e.g., biomass ashes, paper mill sludge…);
- Mineral fertilizers.

5. Evaluate the fertilizer value of the blendings prepared when applied to soil

With the aim of evaluating the performance of the blendings in soil, some incubation and plots trial will be conducted. This will allow the assessment of nutrients immediately availability to plants, as well assess as their mineralization capacity, which will discriminate between the immediate or slow release of nutrients.

6. Confirmation of the potential of the solution to close the CNP cycle

Evaluate the loss of the nutrients in terms of the volatilization of N in ammonia emissions, the emission of greenhouse gases (GHG) and possible problems of nutrient leaching to groundwater and runoff to superficial water.

7. Evaluation of the potential risks of the application of the blendings to soil

Verify the accumulation and the transfer of heavy metals to plants or soil.

8. Create a web-information platform

Create a web-information platform, user friendly, where the information would be available to farmers directly, advising on blending possibilities for a tailored fertilizer according to the crop, and where/how those materials can be found (prices and supplies). This can, expectedly, boost the market of bio-based fertilizer.

- *What is the current and foreseen scale of operations (e.g. kg, tonnes/year)?*

The application of organic materials (manures and slurries) to soils is a strategy already implemented in Portugal. However, farmers don't consider the fertilizer composition of those materials. It is known that manures have the ability of supplying N and P, but it is necessary to assess all the nutrients provided by the blending, in order to supply the quantities required – rational fertilization.

Only in the European Union (EU-28) in 2015, total fertilized agricultural area was of 152 691 000 ha, consuming an average of 74.4 kg N/ha and of 7.4 kg P/ha, which gives an idea about the dimension of the fertilizers market («Agri-environmental indicator - mineral fertiliser consumption», 2015).

Moreover, this bio-based fertilizers, can represent lower costs to farmers in the fertilization process, which can be very significant nowadays, because expenses associated with mineral fertilization are increasing (in Portugal, from 2017 to 2018, the costs associated with fertilizers and soils improvers increased 7.5%).

- *Why is it innovative when compared to existing (farming) practices?*

62 Blending of raw and treated organic materials to produce organic fertilisers (NPC)

Currently, most fertilizers used by farmers to supply essential nutrients to their cultures rely on fossil mineral resources, and their consumption tend to increase with increasing world population. Because of that, it is very important to use secondary raw materials for their supplementation. For instance, fertilizers produced from phosphorus (P) rich bio-wastes are becoming increasingly interest, not only because their production is expected to increase in the future, but also due to resource depletion, supply risks, and heavy metal contamination of fossil phosphate resources. In fact, bio-residues, which are traditionally used as organic amendments in agricultural soils, with the main aim of providing organic matter, have potential to fulfil crop nutrient requirements, including N, P, K and S, in addition to other elements, and are currently termed as bio-based fertilizers.

However, several constraints and challenges must be faced and overcome, namely:

- Bio-residues have a complex matrix and heterogeneous composition,
- Nutrient content in bio-based fertilizers may not be immediately available as in mineral fertilizers and their recovery by plants may not be as efficient,
- Odour and lack of stability of some of these materials,
- Human health and environmental risks associated with their application,

- *How does it improve the Nitrogen-Phosphorus and/or Carbon cycles in agriculture?*
  The formulation of bio-based fertilizers will allow the production of tailored fertilizers, with the adequate N and P crop necessities. Farmers ask for products with well-known and constant composition as well as on-demand ratios of N, P and K. An important part the bio-wastes which are currently produced by livestock production are currently used as organic soil amendments, but their nutrient supply is sub-valorised, and it is not quantified. All the bio-residues produced at the animal production level should be reintroduced in the production cycle, creating better synergies between animal breeding and crop production, in a circular economy perspective. In fact, the production of bio-residues is sometimes geographically disconnected, with a surplus production in some places and the demand for fertilizers far apart from their origin. The solution proposed should overcome this constraint and link both activities.

- *Add a separate line on the location of your management solution: "Currently this technology / technique / management solution is applied in ……. (city, region, country))."*
  Currently, the use of organic materials (manures and slurries) as soil improvers is a strategy already implemented in all the Portuguese territory (as well as in other EU countries). However, farmers don't consider the fertilizer composition of those materials. So, it is necessary to assess the nutrients provided by those materials and balance the quantities needed by the crop, to apply the actual quantity of nutrients required – rational fertilization – preparing tailored fertilizers.

62 Blending of raw and treated organic materials to produce organic fertilisers (NPC)

TRL (Technology Readiness Level) – how close is your solution to the market?

Use the slider above to position the current TRL* of your proposed solution

* TRLs are a type of measurement system used to assess the maturity level of a particular technology. Where a topic description refers to a TRL, the following definitions apply, unless otherwise specified:

• TRL 1 – basic principles observed • TRL 2 – technology concept formulated • TRL 3 – experimental proof of concept • TRL 4 – technology validated in lab • TRL 5 – technology validated in relevant environment (industrially relevant environment in the case of key enabling technologies) • TRL 6 – technology demonstrated in relevant environment (industrially relevant environment in the case of key enabling technologies) • TRL 7 – system prototype demonstration in operational environment • TRL 8 – system complete and qualified • TRL 9 – actual system proven & running in operational environment

Please provide some sentences explaining your Technology Readiness Level

Some first tests were performed at farm scale but we intend to reach a TRL 6 in the next 3 years

If the proposed solution/ technique is currently at low TRL (≤5), is upscaling foreseen within the next year(s)?

YES.

If the proposed solution/ technique is currently at high TRL (≥7), is there any product already being produced from the proposed solution/ technique?

- *If yes, what is the name of the product:*
- *Short description of the product*
- *Are there any EC/MS Authority permits already for use of the product (title or link if available)?*

POTENTIAL LINKAGE TO THE PROJECT

Indicate to which agro-typology under study and which potential research line of the project, your proposed solution/technique contributes:

X	Pig Production
X	Poultry Production
X	Cattle Farming
X	Open field cultivation of cereals or maize
X	Open air cultivation of vegetables
X	Orchards
	Agro-energy systems (e.g. biogas)
X	Animal Byproduct processing (e.g. manure processing)

Innovative solutions for optimized nutrient & GHG in animal husbandry	
Innovative soil, fertilisation & crop management systems & practices	X
Tools, techniques & systems for higher-precision fertilization	
Biobased fertilisers (N, P) and soil enhancers (OC) from agro-residues	X
Novel animal feeds produced from agro-residues	
Other, please specify :	

63 Precision fertilization of Maize using organic materials

AIM OF THE TECHNOLOGY

Provide a brief description of the proposed management solution or technique.

- *What is the purpose/aim of the innovative solution/technique?*
  The main purpose of the solution proposed is to combine precision fertilization and manure application in maize crop. Till now, manure is applied as a basal fertilization and the variability of soil in terms of P content is not taken into consideration. This can lead to P accumulation in soil.

- *What is the underlying working principle?*
  To avoid such problem, we propose to apply manure as basal fertilization based on P requirements established using precision farming tools. The basal fertilization might be complemented with mineral N application if needed. In such situation and when maize is irrigated, mineral N fertilization might be replaced by slurry liquid fraction application.

- *What is the current and foreseen scale of operations (e.g. kg, tonnes/year)?*
  Maize producers are very receptive to solutions that lead to a reduction of production costs and we believe that such solution will be adopted by a large number of producers with impacts on thousands hectare.

- *Why is it innovative when compared to existing (farming) practices?*
  By using GPS georeferencing, precision fertilization is able to adjust fertilizer application rates according to each specific location of the field. It is well known that soil properties and specifically nutrient contents vary significantly over space of farm fields. Until recently the precision agriculture tools that enable variable rate applications were not easily accessible. Today, the whole process of variable rate application, that involves the assessment of the spatial variability of soil nutrient contents and the creation of fertilizer prescription maps as well as the implementation in the field, is much smoother and is already being put to practice in many farms across Europe.

- *How does it improve the Nitrogen-Phosphorus and/or Carbon cycles in agriculture?*

63 Precision fertilization of Maize using organic materials

By applying fertilizer and manure site-specifically the advantages, that result from the better match between what is available and what is needed, are three-sided: production cost and environmental footprint reduction and crop yield increases.

- *Add a separate line on the location of your management solution: "Currently this technology / technique / management solution is applied in ……. (city, region, country))."*
  To test the solution, we will perform a field experiment at a farm field that will later be used in a dissemination event. In the field trial we will compare uniform rate and variable rate manure and fertilizer application at the scale of 30 ha fields.
  The key aspects for the process to work are: 1) mapping soil nutrient content and properties; 2) chemical analysis of the manure; 3) Create the prescription map; 4) have the application machinery equipped with GPS and VRT controls.

TRL (Technology Readiness Level) – how close is your solution to the market?

Use the slider above to position the current TRL* of your proposed solution

* TRLs are a type of measurement system used to assess the maturity level of a particular technology. Where a topic description refers to a TRL, the following definitions apply, unless otherwise specified:

• TRL 1 – basic principles observed • TRL 2 – technology concept formulated • TRL 3 – experimental proof of concept • TRL 4 – technology validated in lab • TRL 5 – technology validated in relevant environment (industrially relevant environment in the case of key enabling technologies) • TRL 6 – technology demonstrated in relevant environment (industrially relevant environment in the case of key enabling technologies) • TRL 7 – system prototype demonstration in operational environment • TRL 8 – system complete and qualified • TRL 9 – actual system proven & running in operational environment

Please provide some sentences explaining your Technology Readiness Level

All the tools needed for precision fertilization have been tested at farm scale so it will be easy and fast to reach higher TRL level. It is already being used by farmers for mineral fertilization. Agricultural machinery makers are developing the technology for regular manure spreaders. It is already at the market level for regular broadcast spreaders.

If the proposed solution/ technique is currently at low TRL (≤5), is upscaling foreseen within the next year(s)?

YES.

If the proposed solution/ technique is currently at high TRL (≥7), is there any product already being produced from the proposed solution/ technique?

- *If yes, what is the name of the product :*
- *Short description of the product*
- *Are there any EC/MS Authority permits already for use of the product (title or link if available)?*

63 Precision fertilization of Maize using organic materials

POTENTIAL LINKAGE TO THE PROJECT

Indicate to which agro-typology under study and which potential research line of the project, your proposed solution/technique contributes :

X	Pig Production
X	Poultry Production
X	Cattle Farming
X	Open field cultivation of cereals or maize
	Open air cultivation of vegetables
	Orchards
	Agro-energy systems (e.g. biogas)
	Animal Byproduct processing (e.g. manure processing)

Innovative solutions for optimized nutrient & GHG in animal husbandry	
Innovative soil, fertilisation & crop management systems & practices	X
Tools, techniques & systems for higher-precision fertilization	
Biobased fertilisers (N, P) and soil enhancers (OC) from agro-residues	
Novel animal feeds produced from agro-residues	
Other, please specify :	

64 Combining Conservation Agriculture and organic fertilization to close the NPC loop

THE AIM OF THE TECHNOLOGY

Provide a brief description of the proposed management solution or technique.

- *What is the purpose/aim of the innovative solution/technique?*
  The main purpose of the solution proposed here is to combine manure application and no-tillage agriculture.

- *What is the underlying working principle?*
  The use of organic materials such as manure combine with conservation agriculture should be a solution to reach more sustainable results. Furthermore, it also means a reduction of production costs by replacing costly mineral fertilizers with free or cheaper organic fertilizers. The main challenge is to ensure that nutrient losses to water (N and P) air, namely ammonia and greenhouse gases (CO_2, CH_4, N_2O) emissions after manure application in no-till conditions are minimized as well as that such practice allows a good nutrient use efficiency.

- *What is the current and foreseen scale of operations (e.g. kg, tonnes/year)?*
  The crop area cultivated using conservation agriculture in Europe has increased from 1.564.100 ha in 2008/2009 to 3.557.200 ha in 2015/16, an increase of 127,4% with significant adoption in Spain, Italy, Finland, France, Romania, Poland, UK, Switzerland and Germany[1]. However, the extent of conservation agriculture in Portugal increased only from 25.000 ha in 2008/09 to 32.000 ha in 2015/16, what represents only 0,89% of the total agricultural area in Portugal[1, 2].
  The main reason for this small adoption of the technology in Portugal is related with the weak results obtained by some farmers due to the incorrect application of conservation practices[3].
  Indeed, the real perspective of benefits obtained with such practices arises only when conservation practices as a whole are correctly adopted. Thus, besides no tillage or minimum soil mobilization, the permanent soil cover with crop residues and/or cover crops and also, crop rotation are mandatory[4].

[1] Kassam, A., Friedrich, T. & Derpsch, R. Global spread of Conservation Agriculture Global spread of Conservation Agriculture. *Int. J. Environ. Stud.* 00, 1–23 (2018).
[2] FAO. Conservation Agriculture - Revised version. Rome, Italy (2017). Available in <http://www.fao.org/publications/card/en/c/981ab2a0-f3c6-4de3-a058-f0df6658e69f/> Acessed in 02/20/2019.
[3] Carvalho, M. & Freixial, R. Sementeira Direta em Portugal: Causas frequentes para o insucesso. Grandes Culturas. Agr
[4] FAO. Country Profiles (2016). Available in <http://www.fao.org/countryprofiles/index/en /?iso3=PRT > Acessed in 02/20/2019. otec (2014).

64 Combining Conservation Agriculture and organic fertilization to close the NPC loop

The main organic materials actually used in combination with conservation agriculture in Portugal are solid manure or slurry (dairy cattle manure, pig manure, dairy cattle slurry and pig slurry) produced on farm or imported from neighbour farms. The application rates varies from 10 to 20 tonnes per hectare and application are generally performed each year or each two years. It is to refer that the main limitation for a wider use of manure in farms adopting conservation agriculture in Portugal is the limited availability of manure in the production area even if the use of animal manure is seen as an interesting option.

- *Why is it innovative when compared to existing (farming) practices?*
  Conservation agriculture is an agricultural production system that seeks to improve the soil characteristics in order to get high and sustainable crop yields while lowering the production costs and ensuring the conservation of natural resources[5].

- *How does it improve the Nitrogen-Phosphorus and/or Carbon cycles in agriculture?*
  The benefits of conservation agriculture and organic fertilization on the CNP cycles are well known but to allow an increase of manure utilization in combination with conservation agriculture as a solution for closing the NCP loop, some questions still need to be answered, namely:
  Availability of nutrients for plants: It is expect an increase in N and P immobilization rate when manure is applied on soil cover with crop residues (i.e. cereals straw). How does it affect crop yield? On the other hand, with the continuous decomposition of organic matter, there is a trend to increase the availability of nutrients to the plants with potential increases of crop yield in the long term**.**
  Greenhouses gases emissions:
  a) CO_2: The accumulation of straw in soil works like a carbon sink. Is this behavior kept when a N rich material (as slurry) is applied? In conservation agriculture there is less energy consumption due to less use of machinery, therefore fewer CO_2 emissions are expected.
  b) CH_4: A decrease of methane emissions are expected with improved soil porosity achieved with the increase of soil organic matter content. On the other hand, a higher water content in soil is expected leading to potential increases of methane emissions.
  c) N_2O emissions: will N_2O emissions increase because of the mosaic of aerobic/anaerobic sites induced by the maintenance of soil moisture for longer time periods? Will denitrification be boosted by the combination (organic material + no tillage)
  NH_3 emissions: High amounts of NH_3 should be released when the slurry is applied. Currently, farmers irrigate immediately after slurry application to enhance infiltration in soil. Manure acidification is an important strategy to minimize ammonia emissions. Such treatment can also influence the nutrient availability for plants, as well as decrease other gases emissions such as CH_4 and N_2O. Slurry acidification may decrease the nitrification rate and could help in the reduction of nitrate loss by leaching. Moreover, slurry acidification promotes the P solubilisation.
  NO_3 leaching: The greater aeration and pore continuity in no-tillage soils can lead to higher nitrification and leaching rates. Nonetheless, It could be changed by the manure application period (i.e. before the most abundant rain) and presence of living plants that can use the available N.
  Phosphorus losses: Since P is mainly lost by erosion and attending that in conservation agriculture the soil is always covered, the risk of P runoff should be limited.

[5] Carvalho, M. & Lourenço, E. Conservation agriculture - A portuguese case study. *J. Agron. Crop Sci.* 200, 317–324 (2014).

64 Combining Conservation Agriculture and organic fertilization to close the NPC loop

- *Add a separate line on the location of your management solution: "Currently this technology / technique / management solution is applied in ……. (city, region, country))."*
  The use of organic fertilizers is actually in practice in some Portuguese farms from Alentejo (South Portugal) that adopted no-tillage as soil conservation measure.

TRL (Technology Readiness Level) – how close is your solution to the market?

Use the slider above to position the current TRL* of your proposed solution

* TRLs are a type of measurement system used to assess the maturity level of a particular technology. Where a topic description refers to a TRL, the following definitions apply, unless otherwise specified:

• TRL 1 – basic principles observed • TRL 2 – technology concept formulated • TRL 3 – experimental proof of concept • TRL 4 – technology validated in lab • TRL 5 – technology validated in relevant environment (industrially relevant environment in the case of key enabling technologies) • TRL 6 – technology demonstrated in relevant environment (industrially relevant environment in the case of key enabling technologies) • TRL 7 – system prototype demonstration in operational environment • TRL 8 – system complete and qualified • TRL 9 – actual system proven & running in operational environment

Please provide some sentences explaining your Technology Readiness Level

All the tools needed in this solution are currently in use at farm scale. The main challenge is the prediction of the fertilizing value of manure in no-till conditions.

If the proposed solution/ technique is currently at low TRL (≤5), is upscaling foreseen within the next year(s)?

If the proposed solution/ technique is currently at high TRL (≥7), is there any product already being produced from the proposed solution/ technique?

- *If yes, what is the name of the product :*
- *Short description of the product*
- *Are there any EC/MS Authority permits already for use of the product (title or link if available)?*

64 Combining Conservation Agriculture and organic fertilization to close the NPC loop

POTENTIAL LINKAGE TO THE PROJECT

Indicate to which agro-typology under study and which potential research line of the project, your proposed solution/technique contributes :

	Pig Production
	Poultry Production
	Cattle Farming
X	Open field cultivation of cereals or maize
	Open air cultivation of vegetables
	Orchards
	Agro-energy systems (e.g. biogas)
	Animal Byproduct processing (e.g. manure processing)

Innovative solutions for optimized nutrient & GHG in animal husbandry	
Innovative soil, fertilisation & crop management systems & practices	X
Tools, techniques & systems for higher-precision fertilization	X
Biobased fertilisers (N, P) and soil enhancers (OC) from agro-residues	
Novel animal feeds produced from agro-residues	
Other, please specify :	

65 Struvite as a substitute of synthetic P fertilizer

AIM OF THE TECHNOLOGY

Struvite from sludge and struvite from liquor

Provide a brief description of the proposed management solution or technique.

- *What is the purpose/aim of the innovative solution/technique?*
  Placement of phosphorus (P) to the list of critical raw materials[1] created clear demand for P recovery technologies which would allow for production and utilization of phosphorus in more sustainable manner. The most common solution for P recovery is phosphorus precipitation in form of struvite.

- *What is the underlying working principle?*
  Struvite is a mineral, chemically formulated as magnesium ammonium phosphate hexahydrate or MAP ($MgNH_4PO_4 \times 6H_2O$). Several studies on struvite have focused on improving the recovery from wastewater treatment plants – municipal, swine and dairy wastewaters, semiconductor water, anaerobic digesters, urine, and manure [2, 3] exanimating which physicochemical conditions and technologies are the most efficient for the struvite recovery regarding the source of input. Depending on the source material struvite quality may differ. The most distinct variation can be observed between the struvites produced from sludge liquor (rather pure) and the one produced directly from the sludge (containing more impurities).
  The relevance and impact of the different ions, pH, P: N: Mg ratio and mixing on the struvite precipitation has been already thoroughly explained [4, 5, 6, 7]. From these reports it is evident that

[1] European Commission, 2014. Report on critical raw materials for the EU. European Commission.
[2] Zarebska, A., Romero Nieto, D., Christensen, K., V., Fjerbæk Søtoft, L. and Norddahl, B., 2014. Ammonium Fertilizers Production from Manure: A Critical Review. Critical Reviews in Environmental Science and Technology, 45:14, 1469-1521.
[3] Battistoni, P., De Angelis, A., Pavan, P., Prisciandaro, M., Cecchi, F., 2001. Phosphorus removal from a real anaerobic supernatant by struvite crystallization. Water Research 35, 2167–2178.
[4] Le Corre, K., S., Valsami-Jones, E., Hobbs, P., Parsons, S., A., 2005. Impact of calcium on struvite crystal size, shape and purity. Journal of Crystal Growth 283 (3-4), 514-522.
[5] Pastor, L., Mangin, D., Ferrer, J., Seco, A., 2010. Struvite formation from the supernatants of an aenarobic digestion pilot plant. Bioresource Technology 101, 118-125.
P-REX project, 2012-2015. 7th Europen Framwork program. Main P-REX deliverables, Zenodo (http://doi.org/10.5281/zenodo.242550).
[6] Jordaan, E., M., Ackerman, J., Cicek, N., 2010. Phosphorus removal from anaerobically digested swine wastewater through struvite precipitation. IWA Publishing.
[7] Huang, H., Xu, C., Zhang, W., 2011. Removal of nutrients from piggery wastewater using struvite precipitation and pyrogenation technology. Bioresource Technology 102, 2523–2528.

the presence of Ca ions can affect the crystallization meaningfully, and that Mg: Ca ratio should be kept at the value lower than 2. The optimal P: N: Mg molar ratio was selected to be around 1:1:1, and optimal pH around 9. Various kinetics models were employed in order to define and explain the crystal growth. Most researches [8, 9] got satisfying results when applying the simple first order kinetics. On the other hand, the complexity of all the ion interactions in the precipitation process needs further research. The different reactors types can have a significant effect on the good precipitation efficiency. The most used reactors are the fluidized bed reactor (FBR) and continuous stirred reactor (CSTR), besides the specific Rem Nut technology , and attempts to use microbial electrolysis cell (MEC).

- *What is the current and foreseen scale of operations (e.g. kg, tonnes/year)?*

In the last 10 years, a break-through of P salt technologies let to the development tens of process (on full scale), from which main are further briefly described.

The Airprex® process from CNP-Technology Water and Biosolids GmbH is a struvite precipitation technology that uses sewage sludge as source material. Struvite is formed by the addition of magnesium chloride salts ($MgCl_2$) in an air lift reactor, followed by a sand washer (PREX project).

Waterschap Velt en Vecht is the first Dutch water board to implement struvite technology. At their WWTP struvite is formed by submitting sewage sludge to a stream of carbon dioxide (CO_2) stripped by bubble aeration in which magnesium is added.

The STRUVIA™, a modification of the phosphorus recovery technology Phostrip (Showo Kankyo Systems K.K.) (SKS) by Veolia Water, recovers P in form of struvite from sludge liquor. The technology consists of a continuous stirred tank reactor (CSTR) containing special mixing technology (Turbomix®) and a lamella settler on. Mg is done in form of $MgCl_2$ and sodium hydroxide (NaOH) is used for pH adjustment to 8-9 (PREX project).

The Pearl® process combined with WASSTRIP® is a successful solution made by OSTARA Nutrient Recovery Technologies Inc. (Vancouver, Canada). Their technology treats the sludge liquor via crystallization reactor installed after the dewatering unit to form struvite by dosing of $MgCl_2$ and increasing pH with NaOH. The specific design of mixing and harvesting reactor enables uniform crystal size. Struvite is dried in a fluidized bed dryer allowing the stability of the pellets (e.g. moisture content) to remain at the same level for long term use (PREX project). Production capacity: Europe-21000 t/a; North America-23000t/a (Ostara-NRS-Overview-Handout, 2017)

The NuReSys can be applied to both centrate and digestate. It combines stripper and crystallizer (CSTR). Struvite is formed with the addition of $MgCl_2$ (personal communication, 2018). Production capacity: Humana Milchunion~600kg/d; Agristo~600-800kg/d; Clarebout Potatoes 1~1 800kg/d; Clarebout Potatoes 2~1700-2000kg/d; Aquafin ~55kg/d; Land Van Cuijck ~ 400 kg/d; Apeldoorn ~ 1500kg/d (NuReRys References, 2019)

The Crystalactor is developed by the Dutch consultancy and engineering company DHV. Main reactions are situated in the fluidized-bed type crystallizer in which is placed a cylindrical reactor, partly filled with seed material with up flow. The process can lead to various products such are pellets of magnesium phosphate, calcium phosphate, struvite or potassium magnesium phosphate, based on chemical adjustment and process optimization.

[8] Nelson, N., O., Mikkelsen, R., L., Hesterberg, D., L., 2003. Struvite precipitation in anaerobic swine lagoon liquid: effect of pH and Mg:P ratio and determination of rate constant. Bioresource Technology, 89 (3) 229-236.
[9] Rahaman, M., S., Ellis, N., and Mavinic, D., S., 2008. Effects of various process parameters on struvite precipitation kinetics and subsequent determination of rate constants. Water Sci Technol. 57(5):647-54.

65 Struvite as a substitute of synthetic P fertilizer

The Phospaq technology from Paques recovers struvite from dewatering reject streams. Process is performed in a CSTR (Continuous Stirred Tank Reactor) by aeration (pH adjustment) and addition of magnesium oxide (MgO) as magnesium source[10, 11, 12].

- *Why is it innovative when compared to existing (farming) practices?*
  P recovery in form of struvite is the most economically feasible, as well promising technology from the point of energy and climate change impact. The slow-release properties and its high quality is what distinguishes struvite among other fertilizers. The agronomic effectivity of struvite originating from wastewaters has been tested and published in 80 peer reviewed articles. It was reported that struvite has an equal effectivity for phosphorus compared with regular mineral phosphorus fertilizers or even better[13]. Lower environmental risk of leaching and higher efficiency were found to be extra benefits[14].

- *How does it improve the Nitrogen-Phosphorus and/or Carbon cycles in agriculture?*
  Its slow release characteristics have direct impact on the closing the disturbed cycles while at the same time providing the benefit for the agriculture.

- *Add a separate line on the location of your management solution: "Currently this technology / technique / management solution is applied in ……. (city, region, country)).*According to the STRUBIAS draft report (2017) strvite precipitation technologies can be located in several locations in EU (see table below).

[10] Egle, L., Rechberger, H., Krampe J., Zessner, M., 2016. Phosphorus recovery from municipal wastewater: An integrated comparative technological, environmental and economic assessment of P recovery technologies. Science of the Total Environment 571, 522–542.
[11] Huygens, D., Saveyn, H., Eder, P., and Delgado Sancho L., 2017. DRAFT STRUBIAS Technical Proposals. DRAFT nutrient recovery rules for recovered phosphate salts, ash-based materials and pyrolysis materials in view of their possible inclusion as Component Material Categories in the Revised Fertiliser Regulation. Interim Report. Circular Economy and Industrial Leadership Unit, Directorate B - Growth and Innovation, Joint Research Centre - European Commission.
[12] Ye Y., Ngo, H., H., Guo, W., Liu, Y., Li, J., Liu, Y., Zhang, X., Jia, H., 2017. Insight into chemical phosphate recovery from municipal wastewater. Science of the Total Environment 576, 159–171.
[13] Systemic, 2018. Struvite – factsheets. Available from: https://systemicproject.eu/wp-content/uploads/2018/06/Factsheet-product-Struvite-Final-23052018.pdf
[14] Vaneeckhaute, C., Janda, J., Meers, E., & Tack, F. M. G. 2015. Efficiency of Soil and Fertilizer Phosphorus Use in Time: A Comparison Between Recovered Struvite, FePO 4-Sludge, Digestate, Animal Manure, and Synthetic Fertilizer. In *Nutrient Use Efficiency: from Basics to Advances.* 73-85.

Struvite as a substitute of synthetic P fertilizer

Table 10: Overview of facilities that produce recovered phosphate salts in the European Union (data adopted from Kabbe, 2017 and Ehlert et al., 2016a)

Technology	recovered P-salt	input material	Location and operator	year of initiation
AirPrex®	struvite	municipal waste water	MG-Neuwerk (DE), Niersverband	2009
AirPrex®	struvite	municipal waste water	Wassmannsdorf (DE), Berliner Wasserbetriebe	2010
AirPrex®	struvite	municipal waste water	Echten (NL), Drents Overijsselse Delta	2013
AirPrex®	struvite	municipal waste water	Amsterdam-West (NL), Waternet	2014
AirPrex®	struvite	municipal waste water	Uelzen (DE), SE Uelzen	2015
AirPrex®	struvite	municipal waste water	Salzgitter Nord (DE), ASG	2015
AirPrex®	struvite	municipal waste water	Wolfsburg (DE), SE Wolfsburg	2016
ANPHOS	struvite	municipal waste water	Land van Cuijk (NL), Aa en Maas	2011
EloPhos®	struvite	municipal waste water	Lingen (DE), SE Lingen	2016
EXTRAPHOS (Budenheim)	DCP	municipal waste water	MZ-Mombach (DE), Wirtschaftsbetrieb Mainz	2017
Gifhorn	struvite/CaP	municipal waste water	Gifhorn (DE), ASG	2007
NASKEO	struvite	municipal waste water	Castres (FR)	2015
NuReSys®	struvite	waste water (potato industry)	Harelbeke (BE), Agristo	2008
NuReSys®	struvite	waste water (potato industry)	2x Niewkerke (BE), Clarebout Potatoes	2009/12
NuReSys®	struvite	waste water (potato industry)	Waasten (BE), Clarebout Potatoes	2012
NuReSys®	struvite	waste water (pharmaceutical industry)	Geel (BE), Genzyme	2014
REPHOS® (NuReSys)	struvite	waste water (dairy industry)	Altentreptow, DE, Remondis Aqua	2006
NuReSys®	struvite	municipal waste water	Leuven (BE), Aquafin	2013
NuReSys®	struvite	municipal waste water	Schiphol Airport (NL), Evides	2014-2015
NuReSys®	struvite	municipal waste water	Land van Cuijk (NL), Logisticon	2015
NuReSys® - ELIQUO	struvite	municipal waste water	Apeldoorn (NL), Vallei & Veluwe	2016
NuReSys®	struvite	municipal waste water	Braunschweig Steinhof (DE), SE|BS / AVB	2018/19
PEARL® (OSTARA)	struvite	municipal waste water	Slough (UK), Thames Water	2013
PEARL® (OSTARA)	struvite	municipal waste water	Amersfoort (NL), Vallei & Veluwe	2015
PEARL® (OSTARA)	struvite	municipal waste water	Madrid (ES), Canal de Isabel II	2016
PHORWater	struvite	municipal waste water	Calahorra (ES), El Cidacos	2015 (demo)
PHOSPAQ™	struvite	municipal waste water	Olburgen (NL), Waterstromen	2006
PHOSPAQ™	struvite	municipal waste water	Lomm (NL), Waterstromen	2008
PHOSPAQ™	struvite	municipal waste water	Nottingham (UK), Severn Trent Water	2014
PHOSPAQ™	struvite	municipal waste water	Tilburg (NL), Waterchap de Dommel	2016
PhosphoGREEN (SUEZ)	struvite	municipal waste water	Aaby (DK), Aarhus Water	2013
PhosphoGREEN (SUEZ)	struvite	municipal waste water	Marselisborg (DK), Aarhus Water	2018
PhosphoGREEN (SUEZ)	struvite	municipal waste water	Herning (DK), Herning Water	2016
STRUVIA™	struvite	municipal waste water	Helsingør Southcoast (DK), Forsyning Helsingør	2015
Stuttgart	struvite	municipal waste water	Offenburg (DE), AZV	2011 (demo)
Stuttgart	struvite	municipal waste water	MSE Mobile Schlammentwässerungs GmbH	2015 (pilot)
Unknown	K-struvite	manure and livestock stable slurries	4 x Stichting Mestverwerking Gelderland (NL)	2010

-

65 Struvite as a substitute of synthetic P fertilizer

TRL (Technology Readiness Level) – how close is your solution to the market?

Use the slider above to position the current TRL* of your proposed solution

* TRLs are a type of measurement system used to assess the maturity level of a particular technology. Where a topic description refers to a TRL, the following definitions apply, unless otherwise specified:

• TRL 1 – basic principles observed • TRL 2 – technology concept formulated • TRL 3 – experimental proof of concept • TRL 4 – technology validated in lab • TRL 5 – technology validated in relevant environment (industrially relevant environment in the case of key enabling technologies) • TRL 6 – technology demonstrated in relevant environment (industrially relevant environment in the case of key enabling technologies) • TRL 7 – system prototype demonstration in operational environment • TRL 8 – system complete and qualified • TRL 9 – actual system proven & running in operational environment

Please provide some sentences explaining your Technology Readiness Level

>TRL6.

If the proposed solution/ technique is currently at low TRL (≤5), is upscaling foreseen within the next year(s)?

If the proposed solution/ technique is currently at high TRL (≥7), is there any product already being produced from the proposed solution/ technique?

- *If yes, what is the name of the product:*
  struvite (e.g. Crystal Green).

- *Short description of the product*

- *Are there any EC/MS Authority permits already for use of the product (title or link if available)?*
  There are in some countries. Struvite products of Pearl in the United States/United Kingdom and NuReSys in Belgium (e.g. http://www.phosphorusplatform.eu/images/download/OVAM-Agristo-struvite-accreditation-2009.pdf).

65 Struvite as a substitute of synthetic P fertilizer

POTENTIAL LINKAGE TO THE PROJECT

Indicate to which agro-typology under study and which potential research line of the project, your proposed solution/technique contributes:

	Pig Production
	Poultry Production
	Cattle Farming
X	Open field cultivation of cereals or maize
X	Open air cultivation of vegetables
X	Orchards
X	Agro-energy systems (e.g. biogas)
X	Animal Byproduct processing (e.g. manure processing)

Innovative solutions for optimized nutrient & GHG in animal husbandry	X
Innovative soil, fertilisation & crop management systems & practices	X
Tools, techniques & systems for higher-precision fertilization	X
Biobased fertilisers (N, P) and soil enhancers (OC) from agro-residues	X
Novel animal feeds produced from agro-residues	
Other, please specify :	

66 Application of digestate in large scale orchards

AIM OF THE TECHNOLOGY

Provide a brief description of the proposed management solution or technique.

- *What is the purpose/aim of the innovative solution/technique?*
  Vinka – a fruit and vegetable processing company from Croatia, started an investment in planting 7,56 ha of raspberry orchard using different types of fertilizers – including digestate from locally based biogas installation. In the phase of soil preparation, the company applied the combination of $Ca(OH)_2$, thick fraction of digestate and cattle manure.
  If taking into consideration that the vast majority of Croatian farmers don´t apply digestate in agricultural production, one could conclude that digestate application can be considered as an innovative solution/technique. More importantly, the company also used a digestate that was produced in the near proximity of the orchard meaning that closing of nutrient cycles on a local level is supported as well as dependence on nutrients (due to geopolitical situation across the globe) is being reduced. The digestate applied was produced in a biogas plant Energy Gradec d.o.o. using mostly different agro residues from agricultural production (cattle and pig manure/slurry, corn silage, soy molasses). At the moment, the plant is not using agro streams generated at the processing line of Vinka (peas stems, sweet corn husks/piston/stems, pepper seeds loge, carrots and potatoes epidermis, onion peels, cauliflower flowers, cherries juice and pulp) but an intention of the company is to prepare an analysis of the biogas potential of these streams and if financially sustainable process it in the biogas plant (digestate).
  Since digestate is a nutrient-rich substance, it will be interesting to see how its application will affect orchard´s growth and company´s environmental impact (save of energy, cut consumption of fossil fuels, reduction of carbon footprint) and investment costs (lower cost of mineral fertilizer purchase).

- *What is the underlying working principle?*
  The underlying working principle in the specific case refers to the application of digestate in the beginning of the project. In the phase of soil preparation, the company technologists decided to implement the combination of $Ca(OH)_2$ in concentration of 1,00 t/ha, thick fraction of digestate in concentration of 50,00 t/ha and thick fraction of cattle manure in concentration of 33,00 t/ha. Next to organic fertilizers, 30 grams/plant of mineral fertilizer (NPK 7-20-30) was also applied. The digestate was applied using Strautmann fertilizer spreader. The cattle manure and digestate was applied once in the beginning of the orchard setup and due to the orchard principal used (raised bed) it has not been foreseen to use it again.

66 Application of digestate in large scale orchards

- *What is the current and foreseen scale of operations (e.g. kg, tonnes/year)?*
  The foreseen scale of operation is one-time application of digestate while for the further management of the orchard, one will use fertirigation system and combination of mineral fertilizers Novalon (NPK 20-20-20) and Vital Power Phos (NPK 7-21-0). It is yet to be decided whether the company will use digestate as an additional fertilizer. Laboratory analysis was conducted on the digestate applied and it had the following content: DM content - 4,04 %, pH (H_2O) 7,91, total N conc. 0,35 %, total P conc. 0,80 %, total K conc. 7,5 %, total Ca conc. 1,49 % and total Mg conc. 0,65 %. Next to digestate analysis several soil analysis have been conducted over time which will directly bring value to research.

- *Why is it innovative when compared to existing (farming) practices?*
  Innovation of this technique/management solution reflects in the fact that use of digestate in Croatia is not a widespread agricultural practice. At the moment there is only 31 biogas plants built, generating around 28 MWel. Furthermore, when digestate is applied it is usually for the energy crop production and not in long-term plantations.
  On the other hand, EC reports indicate that although Croatian biogas market is considered moderate, the feedstock potential could be the driving force since agriculture plays an important role for the country and consequently there is a huge amount of agricultural waste to be used for biogas production[1].
  Furthermore, use of digestate as a fertilizer has its advantages over the application of manure (which is considered as the most common choice of farmers) for main fertilization of orchards in Croatia. Digestate has significantly less odour, inactivity of viruses, bacteria and parasites if treated correctly, higher content of nitrogen and phosphorus. Soil digested with digestate is richer in oxygen that contributes to humus and increases soil fertility.
  In the concrete case, orchard technologists haven´t stated any specific positive nor negative remark regarding the digestate application. However, since the orchard is made of a multiannual crop (raspberries), remains open to see the real and long-term effect of digestate application on the crop and its yield / quality.

- *How does it improve the Nitrogen-Phosphorus and/or Carbon cycles in agriculture?*
  Use of digestate contributes to the Nitrogen and Carbon cycles in agriculture. Numerous research findings indicate that digestate from agricultural biogas plants cannot only be a good fertilizer but also an effective mean to close the *carbon cycle* in the soil for a more sustainable agriculture. The increase of soil organic matter can enhance soil fertility and stability and maintain soil *nitrogen*. It can also increase soil biodiversity, while reducing erosion, leaching and water pollution[2]. During anaerobic digestion the total amount of nutrients generally remains stable. Also, by applying locally produced digestate that contains variety of nutrients (N, P, K, S, micronutrients etc.) one closes cycle of nutrients distribution within the same region.

- *Add a separate line on the location of your management solution: "Currently this technology / technique / management solution is applied in ……. (city, region, country))."*
  Currently this management solution is applied in Vinkovci, Vukovar Srijem County, Croatia.

[1] EC, Optimal Use of biogas from waste streams, 2017.
https://ec.europa.eu/energy/sites/ener/files/documents/ce_delft_3g84_biogas_beyond_2020_final_report.pdf
[2] G. Bezzi et al, Biogasdoneright ® model: Soil Carbon Sequestration and Efficiency in Agriculture, 2016.
http://www.besustainablemagazine.com/cms2/long-term-use-of-biogas-digestate-stores-carbon-and-increases-soil-fertility/

66 Application of digestate in large scale orchards

TRL (Technology Readiness Level) – how close is your solution to the market?

Use the slider above to position the current TRL* of your proposed solution

* TRLs are a type of measurement system used to assess the maturity level of a particular technology. Where a topic description refers to a TRL, the following definitions apply, unless otherwise specified:

• TRL 1 – basic principles observed • TRL 2 – technology concept formulated • TRL 3 – experimental proof of concept • TRL 4 – technology validated in lab • TRL 5 – technology validated in relevant environment (industrially relevant environment in the case of key enabling technologies) • TRL 6 – technology demonstrated in relevant environment (industrially relevant environment in the case of key enabling technologies) • TRL 7 – system prototype demonstration in operational environment • TRL 8 – system complete and qualified • TRL 9 – actual system proven & running in operational environment

Please provide some sentences explaining your Technology Readiness Level

Application of digestate in large scale orchards may have been applied across EU already, but it is considered to be an innovative management solution in Croatia. When investigating existing research databases, there were no specific research found on application of digestate in raspberry plantation. Since this solution refers to existing technology, TRL is considered to be high. It is strongly believed that this case and its further scientific research could depict some of the most relevant information for other stakeholders (effect on agricultural production, budget overview etc.) and more importantly create new market value in Croatia and surrounding countries.

If the proposed solution/ technique is currently at low TRL (≤5), is upscaling foreseen within the next year(s)?

If the proposed solution/ technique is currently at high TRL (≥7), is there any product already being produced from the proposed solution/ technique?

- *If yes, what is the name of the product:*
  Solution is actually application of digestate in specific agricultural production (orchard - raspberry) .

- *Short description of the product*
  Characteristics and amount of digestate applied as well as mechanisation used are described earlier in the text.

- *Are there any EC/MS Authority permits already for use of the product (title or link if available)?*

66 Application of digestate in large scale orchards

POTENTIAL LINKAGE TO THE PROJECT

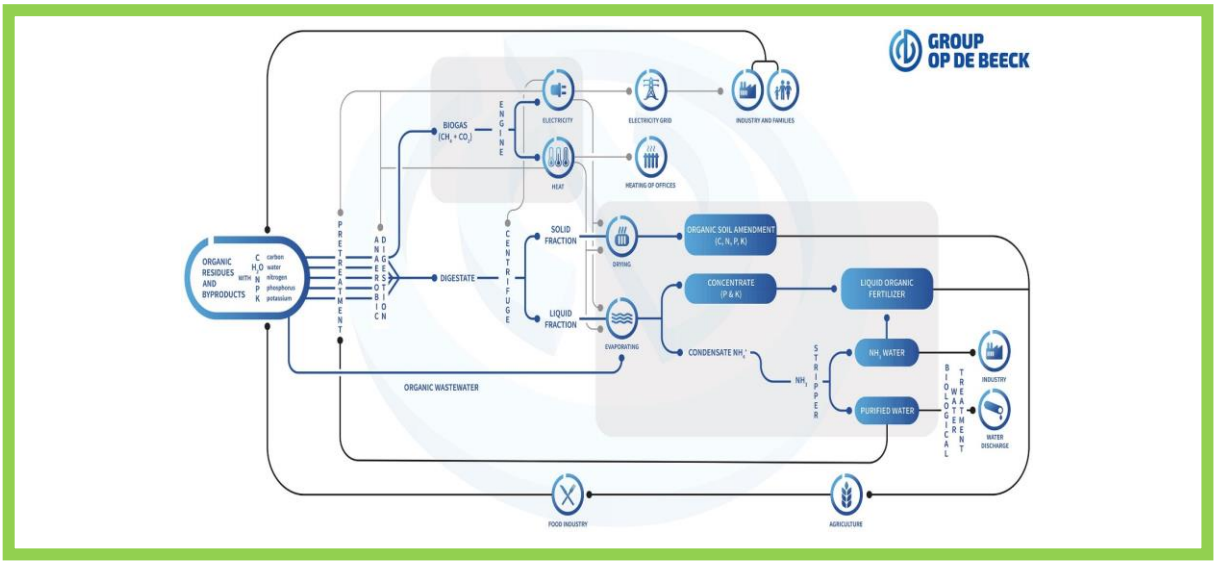
Indicate to which agro-typology under study and which potential research line of the project, your proposed solution/technique contributes:

	Pig Production
	Poultry Production
	Cattle Farming
	Open field cultivation of cereals or maize
	Open air cultivation of vegetables
X	Orchards
	Agro-energy systems (e.g. biogas)
	Animal Byproduct processing (e.g. manure processing)

Innovative solutions for optimized nutrient & GHG in animal husbandry	
Innovative soil, fertilisation & crop management systems & practices	X
Tools, techniques & systems for higher-precision fertilization	
Biobased fertilisers (N, P) and soil enhancers (OC) from agro-residues	
Novel animal feeds produced from agro-residues	
Other, please specify :	

67 Treatment of liquid fraction of digestate from digestion of food wastes for production of ammonia water and mineral concentrate

AIM OF THE TECHNOLOGY



Provide a brief description of the proposed management solution or technique.

- *What is the purpose/aim of the innovative solution/technique?*
  Closing the nutrient cycle is of the objectives of Group op de Beeck NV for the end-processing of organic by-products and residues (from the processing of food wastes of both vegetable and animal origin) that can no longer be used for other purposes. However, while anaerobic digestion for a long time was considered a final stage in the processing of organic by-products and residues, in the eyes of Group Op de Beeck it is an essential intermediate step in efficient nutrient recovery. The digestion process is therefore to be followed by subsequent steps in order to close the entire cycle.

- *What is the underlying working principle?*
  During the anaerobic digestion process part of the carbon present in the organic waste is converted into biogas (biogas installation of 7,5 MW electrical production). The carbon that is not converted into biogas, remains in the digestate (i.e. the digested material) together with the nutrients. In the next phase the solid fraction of the digestate is dried at the Op de Beeck NV site until a high-quality organic soil improver is obtained. Finally, the liquid, aqueous fraction is evaporated and fully purified into re-usable or dischargeable water. During this final process all nutrients that are still present are recovered and concentrated into two by-products that can be applied for both agricultural and industrial processes. The purified water is mainly re-used on its own site.

- *What is the current and foreseen scale of operations (e.g. kg, tonnes/year)?*
  35000 tonnes of organic waste (food wastes of both vegetable and animal origin)
  NH_3-water : ca. 2500 t/y
  Concentrate : ca. 15 000 t/y

- *Why is it innovative when compared to existing (farming) practices?*

67 Treatment of liquid fraction of digestate from digestion of food wastes for production of ammonia water and mineral concentrate

For NH_3: In most applications nitrogen is converted to nitrogen gas in a biological waste water treatment. Nitrogen is emitted to the air and is a few 100 km's away again taken from the air to produce mineral fertilizers. With the technology on our site we try to bypass a part of this pathway by directly produce an high concentrate N-product.
For Concentrate: By concentrating our end product (organic fertilizer) the product can be transported on a bigger distance to regions where there's still a demand for nutrients. On top, the product has a higher value for the farmers. By adjusting our process parameters or blending our product with other byproducts we can produce (liquid) organic fertilizers on demand.

- *How does it improve the Nitrogen-Phosphorus and/or Carbon cycles in agriculture?*
  Unlike the conventional treatment techniques, where nutrients such as carbon often end up in the atmosphere and so are lost, because of the successive processing steps all essential elements in the delivered wastes are valorised and recovered as much as possible. As a result the nutrient cycle is fully closed

- *Add a separate line on the location of your management solution: "Currently this technology / technique / management solution is applied in ……. (city, region, country))."*
  Currently this technology is applied in Flanders, Belgium.

67 Treatment of liquid fraction of digestate from digestion of food wastes for production of ammonia water and mineral concentrate

TRL (Technology Readiness Level) – how close is your solution to the market?

Use the slider above to position the current TRL* of your proposed solution

* TRLs are a type of measurement system used to assess the maturity level of a particular technology. Where a topic description refers to a TRL, the following definitions apply, unless otherwise specified:

• TRL 1 – basic principles observed • TRL 2 – technology concept formulated • TRL 3 – experimental proof of concept • TRL 4 – technology validated in lab • TRL 5 – technology validated in relevant environment (industrially relevant environment in the case of key enabling technologies) • TRL 6 – technology demonstrated in relevant environment (industrially relevant environment in the case of key enabling technologies) • TRL 7 – system prototype demonstration in operational environment • TRL 8 – system complete and qualified • TRL 9 – actual system proven & running in operational environment

Please provide some sentences explaining your Technology Readiness Level

Our process is mainly composed of proven technologies. However, not only the process steps are important, also the order of the different process steps is important. Here we differ from other installations and we do have a lot of inhouse know-how.
Also finding the right applications for the different end products is in a continuous development. Certainly for the NH3-water.

If the proposed solution/ technique is currently at low TRL (≤5), is upscaling foreseen within the next year(s)?

If the proposed solution/ technique is currently at high TRL (≥7), is there any product already being produced from the proposed solution/ technique?

- *If yes, what is the name of the product:*
  AgroMi and Ammonia Water**.**

- *Short description of the product:*
  Concentrate that is rich in phosphor (0,5%) and potassium (2%) and Total nitrogen of 1,5% [AgroMi] and Ammonia water with 20% Total nitrogen.

- *Are there any EC/MS Authority permits already for use of the product (title or link if available)?*
  Digestate and derived products like concentrates are known products. There also are different certificates and authorizations for the use of it. F.e. grondstoffenverklaring OVAM, keuringsattest Vlaco, ontheffing FOD Meststoffen, mestcode VLM, etc. Concerning the NH3-water this is less standard. I would think we are the first installation to hold the permits we do have now.

67 Treatment of liquid fraction of digestate from digestion of food wastes for production of ammonia water and mineral concentrate

POTENTIAL LINKAGE TO THE PROJECT

Indicate to which agro-typology under study and which potential research line of the project, your proposed solution/technique contributes:

	Pig Production
	Poultry Production
	Cattle Farming
	Open field cultivation of cereals or maize
	Open air cultivation of vegetables
	Orchards
	Agro-energy systems (e.g. biogas)
X	Animal Byproduct processing (e.g. manure processing)

Innovative solutions for optimized nutrient & GHG in animal husbandry		
Innovative soil, fertilisation & crop management systems & practices		
Tools, techniques & systems for higher-precision fertilization		
Biobased fertilisers (N, P) and soil enhancers (OC) from agro-residues		X
Novel animal feeds produced from agro-residues		
Other, please specify :	Processing of food wastes	X

68 Integration of UAV/Drone and optical sensing technology into pasture systems

AIM OF THE TECHNOLOGY

In pasture systems the presence of grazing animals leads to concentration of nitrogen from the grazed grass in intense hot spots due to urine and dung deposits. It is not uncommon for the N loading in urine patches to exceed 700 kg N/ha equivalent[1] and these patches are hotspots for N losses from the system as ammonia[2], the potent greenhouse gas N_2O[3], other reduced forms of N and through N leaching[4]. Although, ryegrass in temperate climates such as Ireland has been shown yield response to annual N rates of up to 300 and 400 kg N/ha[1] the temporal and spatial concentration of urine and dung N means that N efficiency in these patches is relatively lower than unaffected areas. Management in this area holds great-untapped potential to move towards closure of nitrogen and greenhouse gas emission loops in pasture based animal systems. Optical sensing technologies have been shown to be effective for identifying nitrogen status of other crops[5] and their integration into pasture systems using drones has opened up opportunities for rapid generation of spatial mapping. The aim is to use the technology to a) guide pasture management decisions, b) guide spatially sensitive fertiliser N applications which avoid applying more N to areas which already have excessive N loading due to urine and/or dung patches thus improving system N use efficiency and reduce greenhouse gas emissions from these systems.

Provide a brief description of the proposed management solution or technique.

- *What is the purpose/aim of the innovative solution/technique?*
  To identify urine and dung patches in pasture systems and to use the maps generated to guide precision fertiliser application, which avoids applying more N to these patches of excessive N

- *What is the underlying working principle?*

1 Forrestal, P.J., Krol, D.J., Jahangir, M., Lanigan, G.J. and Richards, K.G. 2016. An evaluation of urine patch simulation methods for pasture system nitrous oxide emission estimation. *Journal of Agricultural Science.* doi:10.1017/S0021859616000939; http://dx.doi.org/10.1016/j.scitotenv.2016.06.016
2 Fischer, K., Burchill, W., Lanigan, G.J., Kaupenjohann, M., Chambers, B., Richards, K.G. and Forrestal, P.J. 2016. Ammonia emissions from cattle dung, urine and urine with dicyandiamide. *Soil Use and Management*. 32: 83-91. doi: 10.1111/sum.12203
3 Krol, D.J., Carolan, R., Minet, E., McGeough, K.L., Watson, C.J., Forrestal, P.J., Lanigan, G.J. and Richards, K.G. 2016. Improving and disaggregating N2O emission factors for ruminant excreta on temperate pasture soils. *Science of the Total Environment*. 568: 327-338.
4 Selbie, D.R., Buckthought, L.E. and Shepherd, M.A. 2015. The challenge of the urine patch for managing nitrogen in grazed pasture systems. Advances in Agronomy 129, 229-292.
5 Forrestal, P.J., Kratochvil, R.J. and Meisinger, J.J. 2012. Late-season corn measurements to assess soil residual nitrate and nitrogen management. *Agronomy Journal* 104:148-157. doi:10.2134/agronj2011.0172

68 Integration of UAV/Drone and optical sensing technology into pasture systems

It is not uncommon for the N loading in urine patches to exceed 700 kg N/ha equivalent[5] and these patches are hotspots for N losses from the system as ammonia[1], the potent greenhouse gas N_2O[4], other reduced forms of N and through N leaching[3]. Optical sensing technologies have been shown to be effective for identifying nitrogen status of other crops[5] and have application in grassland.

- *What is the current and foreseen scale of operations (e.g. kg, tonnes/year)?*
  The initial testing and development will use on of the Johnstown Castle dairy farm farmlets of circa 20 ha. It is anticipated that the use of this technology could be upscaled to cover grassland farms of large size.

- *Why is it innovative when compared to existing (farming) practices?*
  Current farming systems apply N fertiliser uniformly to the entire paddock uniformly, including to the urine patches which already have excessive N loading

- *How does it improve the Nitrogen-Phosphorus and/or Carbon cycles in agriculture?*
  Without incurring a yield penalty circa 20% of the paddock area will not need to receive fertiliser N in a given application; thereby fertiliser and system N use efficiency is directly improved. Greenhouse gases in the form of N_2O are reduced due to reduced N loading to labile carbon rich urine and dung patches. There are energy savings associated with using less fertiliser N

  Add a separate line on the location of your management solution: "Currently this technology / technique / management solution is applied in ……. (city, region, country))."
  The management solution will initially be developed and refined at the Teagasc Johnstown Castle Dairy Farm located in Wexford, Ireland. It is anticipated that the solution developed will be suitable for use in temperate grassland systems where animals are grazing around Ireland and Europe.

68 Integration of UAV/Drone and optical sensing technology into pasture systems

TRL (Technology Readiness Level) – how close is your solution to the market?

Use the slider above to position the current TRL* of your proposed solution

* TRLs are a type of measurement system used to assess the maturity level of a particular technology. Where a topic description refers to a TRL, the following definitions apply, unless otherwise specified:

• TRL 1 – basic principles observed • TRL 2 – technology concept formulated • TRL 3 – experimental proof of concept • TRL 4 – technology validated in lab • TRL 5 – technology validated in relevant environment (industrially relevant environment in the case of key enabling technologies) • TRL 6 – technology demonstrated in relevant environment (industrially relevant environment in the case of key enabling technologies) • TRL 7 – system prototype demonstration in operational environment • TRL 8 – system complete and qualified • TRL 9 – actual system proven & running in operational environment

Please provide some sentences explaining your Technology Readiness Level

While the system is not in use in practice the individual component knowledge has been observed at experimental level. The technologies and application will be developed in this work it is expected that within the project the TRL level will be increased to at TRL 6-7

If the proposed solution/ technique is currently at low TRL (≤5), is upscaling foreseen within the next year(s)?

YES.

If the proposed solution/ technique is currently at high TRL (≥7), is there any product already being produced from the proposed solution/ technique?

- *If yes, what is the name of the product :*
- *Short description of the product*
- *Are there any EC/MS Authority permits already for use of the product (title or link if available)?*

68 Integration of UAV/Drone and optical sensing technology into pasture systems

POTENTIAL LINKAGE TO THE PROJECT

Indicate to which agro-typology under study and which potential research line of the project, your proposed solution/technique contributes :

	Pig Production
	Poultry Production
X	Cattle Farming
	Open field cultivation of cereals or maize
	Open air cultivation of vegetables
	Orchards
	Agro-energy systems (e.g. biogas)
	Animal Byproduct processing (e.g. manure processing)

Innovative solutions for optimized nutrient & GHG in animal husbandry	X
Innovative soil, fertilisation & crop management systems & practices	X
Tools, techniques & systems for higher-precision fertilization	X
Biobased fertilisers (N, P) and soil enhancers (OC) from agro-residues	
Novel animal feeds produced from agro-residues	
Other, please specify :	

69 Drying poultry manure and converting it to standardized product

AIM OF THE TECHNOLOGY

Source : http://www.seconov.ca

Provide a brief description of the proposed management solution or technique.

- *What is the purpose/aim of the innovative solution/technique?*

The farm EARL “La Vallée” (the valley) is a poultry farm with about 64 000 laying hens and about 28 000 renewal pullets. The poultry droppings production is from 800 up to 1000 tons a year.

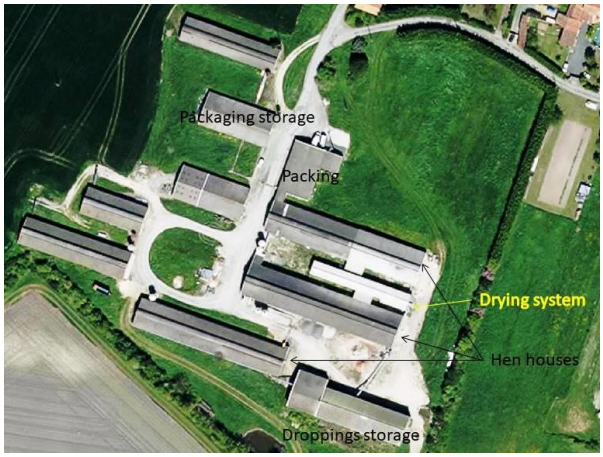
According to the regulation proposed in the French environmental code, the farm was been authorized under the status of the Installations Classified for the Protection of the Environment (nomenclature n° 2111-1) with a prefectoral authorization of 26/06/96. But in this background, the poultry droppings are considered as wastes and their management needs a spreading plan. Moreover, the raw poultry droppings are a very fermentable material with odor nuisances and variable characteristics.

So, in 2004, the farm has installed a fertilizer manufacturing unit to transform poultry manure into a stabilized and homogenous material which is able to be certified according to the french standard NFU 42-001. The product is no more a waste but a distributable product on the market.

- *What is the underlying working principle?*

The poultry droppings are dried with a SECONOV - http://www.seconov.ca/default.htm - drying system.

69 Drying poultry manure and converting it to standardized product



The poultry droppings are collected on treadmills in the hen houses and brought to a drying tunnel. The system uses the heat collected by the ventilation of the air in the hen houses. The transformed poultry droppings are brought with a conveying tunnel in a storage to be mixed and homogenized and to be stocked.

- *What is the current and foreseen scale of operations (e.g. kg, tonnes/year)?*
  The medium annual production is 540 tons (85% DM). With this production, the farm can use some for its own inputs needs and the society can sell the rest to several farms in the districts of Charente-Maritime, Charente and Vienne, inside the New Aquitannia region.

- *Why is it innovative when compared to existing (farming) practices?*
  In France, in many cases, the poultry manures are usually used within a spreading plan without treatment. Other neighbouring farms than this which products the manure can propose arable area to be spread, to participate to the spreading plan, but the constraints in a spreading plan prevent from selling the recovery material.
  The system set up by "EARL La Vallée" leads to a marketable product with guarantee of homogenous characterization.

- *How does it improve the Nitrogen-Phosphorus and/or Carbon cycles in agriculture?*
  The poultry are fed with the own farm's grains or from neighbouring farms. The poultry manure brings back N, P and K elements to the soil from which they came.
  The advices for use propose to employ the poultry droppings before corn, sunflower and rapeseed as first fertilizing input. The French regulation asks for a ten-years report with the review of the N fertilizing balance of the farm’s crops which received manure.

69 Drying poultry manure and converting it to standardized product

Bilan global de fertilisation azotée

Exploitation : RICHARD

Campagne : 2003 - 2004

Quantité d'azote organique sur l'exploitation

	Nombre (Nb)	Production d'azote totale /animal (en kg N) (PN)	Quantité d'azote totale (en kg N) (PNT=Nb x PN)	Nombre de mois en bâtiment ou en plein air hivernal (M)	Azote maîtrisable ou sur plein air (en kg N) N maîtr.=PNT x M/12	Azote pâturage (en kg N) N pât.=PNT-N maîtr.
Poules pond	64 225	0,45	28 901	12,00	28 901	0
Poulett Fut Pon	28 000	0,08	2 240	12,00	2 240	0
TOTAL restant sur l'exploitation			*31 141*		*31 141*	*0*
			Total azote organique	=	Total azote maîtrisable	+ Total azote pâturage

Exportations d'azote par les récoltes

Cultures récoltées	Total surfaces (ha) (s)	Rendement moyen (Rdt)	Exportations d'azote (kg N/q ou t MS) (EN)	Exportations N (en kg N) / ha =Rdt*EN	Exportations N (en kg N) totales =Rdt x EN x S
BLE TENDRE	58,54	91	2,50	228	13 319
MAIS GRAIN	17,75	119	2,20	262	4 646
- import de paille	(tonnage) =		6 u N/t		0
+ export de paille	(tonnage) =		6 u N/t		0
TOTAL	*76,29*				*17965*
					Exportations totales d'azote

* *dérobée*

SAU totale	*SPE*	*Surface pâturée*	*SPE pâtures*
76,29 ha	*76,29 ha*	*0,00 ha*	*0,00 ha*

Synthese

Solde du bilan prévisionnel =	exportations totales d'azote - (total azote organique+impot-export) / SAU	= *128 kg N/ ha*
Pression N produit au pâturage/ha =	total azote au pâturage / SAU pâtures	= *0 kg N/ ha*
Exportations moyennes par les cultures/ha =	exportations totales d'azote / SAU	= *235 kg N/ ha*

PRESSION D'AZOTE ORGANIQUE PAR HECTARE EPANDABLE **doit etre < 170 et < exportations moyennes/ha**

Pression N organique/ha épandable =	Total N organique - Export N organique + Import N Organique / SPE + (SAU pâtures - SPE pâtures)	= *108 kg N/ ha*

- *Add a separate line on the location of your management solution: "Currently this technology / technique / management solution is applied in (city, region, country))."*
  The solution is applied in the region but with few units : one farm in the neighbouring district of Deux-Sèvres uses a similar system.

TRL (Technology Readiness Level) – how close is your solution to the market?

Use the slider above to position the current TRL* of your proposed solution

* TRLs are a type of measurement system used to assess the maturity level of a particular technology. Where a topic description refers to a TRL, the following definitions apply, unless otherwise specified:

• TRL 1 – basic principles observed • TRL 2 – technology concept formulated • TRL 3 – experimental proof of concept • TRL 4 – technology validated in lab • TRL 5 – technology validated in relevant environment (industrially relevant environment in the case of key enabling technologies) • TRL 6 – technology demonstrated in relevant environment (industrially relevant environment in the case of key enabling technologies) • TRL 7 – system prototype demonstration in operational environment • TRL 8 – system complete and qualified • TRL 9 – actual system proven & running in operational environment

Please provide some sentences explaining your Technology Readiness Level

The system has been running for years in the farm EARL la Vallée but it is not disseminated among the country.

69 Drying poultry manure and converting it to standardized product

In fact the farmer have to create a new unit to add to his exploitation whose status is different under the french regulation about professional activities and under french regulation about Installation Classified for the Protection of the Environment.
So this administrative step and the extension of the farm field of activity may be a bottleneck to the increase of this kind of recycling solution.

If the proposed solution/ technique is currently at low TRL (≤5), is upscaling foreseen within the next year(s)?

If the proposed solution/ technique is currently at high TRL (≥7), is there any product already being produced from the proposed solution/ technique?

- *If yes, what is the name of the product :*
  There is no commercial name. The designation comes from the french standard and is "Dried poultry droppings".

- *Short description of the product*
  The farm EARL gives the stock of dried poultry droppings to the society SARL "La Vallée" to sell it as a fertilizer. This product matches to the sixth case of fertilizer in the category n°4.6.1 "Fertilizer NPK totally from animal or vegetal origin and organo-mineral fertilizers" from the french standard NF U42-001. This product matches to the obtaining way “dried product obtained from poultry excrements desiccation without adding anything but vegetal substrate".
  This is an example of the marking expected by the law on a factsheet given with the product :

ENGRAIS NF U 42-001 ANALYSES DU 07/09/18
Engrais organique NPK entièrement d'origine animale ou végétale.
Engrais à base de déchets animaux et/ou végétaux.
Composition sur brut – teneurs minimum garanties :

Azote (N) :	4,31%
dont Azote organique :	4,16%
Phosphore (P2O5) :	2,96%
Potassium (K2O) :	3,12%

«A n'utiliser qu'en cas de besoin reconnu ; ne pas dépasser la dose prescrite pour couvrir les besoins de la culture»
Masse livrée : cf. ticket de bascule joint et bon de livraison

  It's found
  - the reference to the standard
  - the both elements of the name
  - the characterization

- *Are there any EC/MS Authority permits already for use of the product (title or link if available)?*
  YES. The fertilizer has to match to specifications from french standard NFU 42-001 and the treatment plants matches to the french regulation about Installation Classified for the Protection of the Environment : the unit of dried poultry production has been declared and registered by prefectoral administration as the category n°2170-2 “Manufacturing fertilizers and growing medium from organic matters.

69 Drying poultry manure and converting it to standardized product

POTENTIAL LINKAGE TO THE PROJECT

Indicate to which agro-typology under study and which potential research line of the project, your proposed solution/technique contributes :

	Pig Production
X	Poultry Production
	Cattle Farming
	Open field cultivation of cereals or maize
	Open air cultivation of vegetables
	Orchards
	Agro-energy systems (e.g. biogas)
X	Animal Byproduct processing (e.g. manure processing)

Innovative solutions for optimized nutrient & GHG in animal husbandry	X
Innovative soil, fertilisation & crop management systems & practices	
Tools, techniques & systems for higher-precision fertilization	
Biobased fertilisers (N, P) and soil enhancers (OC) from agro-residues	
Novel animal feeds produced from agro-residues	
Other, please specify :	

70 Agroforestry: smart combination of orchards and animal production

AIM OF THE TECHNOLOGY

Figure 1: Agroforestry on a pig farm (no date)

Provide a brief description of the proposed management solution or technique.

- *What is the purpose/aim of the innovative solution/technique?*
  The purpose of this technique is to plant trees on pig farms, a practice that can offer some advantages compared to the conventional pig farms. By planting trees, more shaded spaces are created, and this can increase animal welfare and lead to higher meat productivity.
  In the scope of Nutri2Cycle this could be interesting because the trees could act as a buffer for nutrients. It will additionally result in a more efficient use of the soil, as it is possible to plant fruit trees, such as apple trees, and have both a pig farm and an orchard in the same space. All these advantages would lead to a more sustainable agriculture. Another advantage is that the soil is better protected against erosion.

- *What is the underlying working principle?*
  Agroforestry basically means planting trees in combination with another type of agriculture. This solution could be rolled out to other animals as well and can thus be seen as a smart combination of orchards and animal production.

- *What is the current and foreseen scale of operations (e.g. kg, tonnes/year)?*
  Agroforestry is something that is already well implemented in southern Europe. In Flanders it is done on a small scale (approximately 52 farmers / 126,6 ha – all types of agroforestry). Specific for pig farming approximately 20 farmers in Flanders are using this technique.

- *Why is it innovative when compared to existing (farming) practices?*
  It is innovative because agroforestry is combining a more efficient use of space and sustainable agriculture.

- *How does it improve the Nitrogen-Phosphorus and/or Carbon cycles in agriculture?*
  Nutrient leaching will be less likely to happen. Planting trees will also lead to a better uptake of C and a better microclimate. On this way agroforestry can help closing NPC cycles.

70 Agroforestry: smart combination of orchards and animal production

- *Add a separate line on the location of your management solution: "Currently this technology / technique / management solution is applied in ……. (city, region, country))."*
  Southern Europe. In Flanders, this technique is still low-profile.

TRL (Technology Readiness Level) – how close is your solution to the market?

Use the slider above to position the current TRL* of your proposed solution

* TRLs are a type of measurement system used to assess the maturity level of a particular technology. Where a topic description refers to a TRL, the following definitions apply, unless otherwise specified:

• TRL 1 – basic principles observed • TRL 2 – technology concept formulated • TRL 3 – experimental proof of concept • TRL 4 – technology validated in lab • TRL 5 – technology validated in relevant environment (industrially relevant environment in the case of key enabling technologies) • TRL 6 – technology demonstrated in relevant environment (industrially relevant environment in the case of key enabling technologies) • TRL 7 – system prototype demonstration in operational environment • TRL 8 – system complete and qualified • TRL 9 – actual system proven & running in operational environment

Please provide some sentences explaining your Technology Readiness Level

Although it is still low-profile, this technique is already implemented on some farms.

If the proposed solution/ technique is currently at low TRL (≤5), is upscaling foreseen within the next year(s)?

If the proposed solution/ technique is currently at high TRL (≥7), is there any product already being produced from the proposed solution/ technique?

- *If yes, what is the name of the product:*
  Some pig meat is already on the market, but on small scale on local farms (not in supermarkets).

- *Short description of the product:*

- *Are there any EC/MS Authority permits already for use of the product (title or link if available)?*
  NO.

70 Agroforestry: smart combination of orchards and animal production

POTENTIAL LINKAGE TO THE PROJECT

Indicate to which agro-typology under study and which potential research line of the project, your proposed solution/technique contributes:

X	Pig Production
	Poultry Production
X	Cattle Farming
	Open field cultivation of cereals or maize
	Open air cultivation of vegetables
X	Orchards
	Agro-energy systems (e.g. biogas)
	Animal Byproduct processing (e.g. manure processing)

Innovative solutions for optimized nutrient & GHG in animal husbandry	X
Innovative soil, fertilisation & crop management systems & practices	
Tools, techniques & systems for higher-precision fertilization	
Biobased fertilisers (N, P) and soil enhancers (OC) from agro-residues	
Novel animal feeds produced from agro-residues	
Other, please specify :	

71 Practices for increasing soil organic matter content in Dutch soils

AIM OF THE TECHNOLOGY

Provide a brief description of the proposed management solution or technique.

In 2018 the Dutch government started a programme to stimulate the uptake of practices that increase the soil organic matter content in soils. This programme, so called *Smart Land Use Programme*, is contributing to both the sustainable soil strategy that was presented in May 2018 and to the climate targets that are part of the national climate agreement. In this agreement a specific target for soil carbon sequestration is included, of 0,5 Mton CO_2 per year in the year 2030.

The *Smart Land Use programme* consists of different projects, of which the majority are pilot studies where farmers are testing different practices that increase soil organic matter. In addition to the pilots, also projects focussing on monitoring, modelling and incentives are part of the programme. In 2018 pilots started for the arable sector with practices on improved crop rotation, minimum tillage and additional application of organic matter (e.g. compost). For the dairy sector the practices maintaining permanent grassland, maize sown in strips in grassland (see picture above) and species rich grassland are being tested. 15 farms in six different networks of farmers are testing the different practices in the current pilots. The practices on arable land are tested in Zeeland, Flevoland and the Veenkoloniën, and the practices for the dairy sector are tested in Gelderland, Brabant and Friesland.

The underlying principle is that increasing soil organic matter can improve soil quality and improve the recycling of nutrients. Soil organic matter acts as a buffer for nutrients and can therefore reduce nitrogen losses due to leaching. Many of the practices are not new, but so far not widely applied by farmers, partly due to lack of knowledge, and partly because of barriers, e.g. investment costs or legislation. The benefit of the programme is that all practices and pilots are assessed following the same measurement protocol and analysis of the results, and to create large scale awareness on soil organic matter practices.

71 Practices for increasing soil organic matter content in Dutch soils

TRL (Technology Readiness Level) – how close is your solution to the market?

Use the slider above to position the current TRL* of your proposed solution

* TRLs are a type of measurement system used to assess the maturity level of a particular technology. Where a topic description refers to a TRL, the following definitions apply, unless otherwise specified:

• TRL 1 – basic principles observed • TRL 2 – technology concept formulated • TRL 3 – experimental proof of concept • TRL 4 – technology validated in lab • TRL 5 – technology validated in relevant environment (industrially relevant environment in the case of key enabling technologies) • TRL 6 – technology demonstrated in relevant environment (industrially relevant environment in the case of key enabling technologies) • TRL 7 – system prototype demonstration in operational environment • TRL 8 – system complete and qualified • TRL 9 – actual system proven & running in operational environment

Please provide some sentences explaining your Technology Readiness Level

Most of the soil organic matter practices have been tested and applied, but often not at large scale or in other countries.

If the proposed solution/ technique is currently at low TRL (≤5), is upscaling foreseen within the next year(s)?

If the proposed solution/ technique is currently at high TRL (≥7), is there any product already being produced from the proposed solution/ technique?

- *If yes, what is the name of the product :*
- *Short description of the product:*
  No specific product, range of practices.

- *Is there any EC/MS Authority permits already for use of the product (title or link if available)?*
  NO.

71 Practices for increasing soil organic matter content in Dutch soils

POTENTIAL LINKAGE TO THE PROJECT

Indicate to which agro-typology under study and which potential research line of the project, your proposed solution/technique contributes :

	Pig Production
	Poultry Production
X	Cattle Farming
X	Open field cultivation of cereals or maize
	Open air cultivation of vegetables
	Orchards
	Agro-energy systems (e.g. biogas)
	Animal Byproduct processing (e.g. manure processing)

Innovative solutions for optimized nutrient & GHG in animal husbandry	
Innovative soil, fertilisation & crop management systems & practices	X
Tools, techniques & systems for higher-precision fertilization	
Biobased fertilisers (N, P) and soil enhancers (OC) from agro-residues	X
Novel animal feeds produced from agro-residues	
Other, please specify :	

72 Composting its own cattle manure monitoring the temperature

AIM OF THE TECHNOLOGY

Provide a brief description of the proposed management solution or technique.

- *What is the purpose/aim of the innovative solution/technique?*

The farm GAEC Chagneaud is a breeding farm for meat with 800 cattle a year and a unit for Orylag rabbit breeding *(see informations at the end)*.

In 2009, the farmers had to solve their effluents issue : As the farm is in the heart of a Natura 2000 area , only 80 ha of their 500 ha of meadows are able to receive the manure.

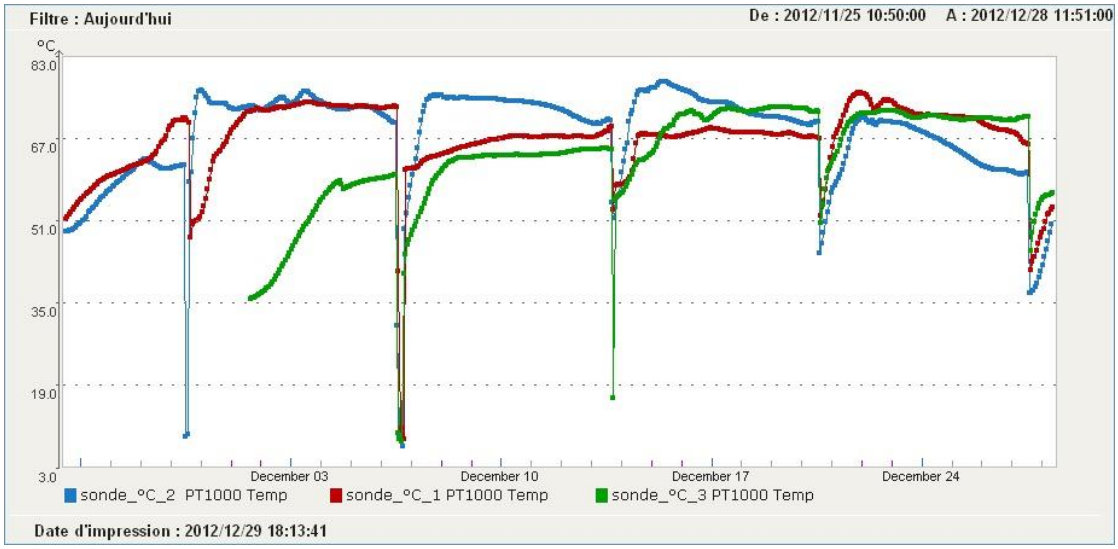
So, they decide to set up a composting plant to transform the farm's cattle manure into compost using rabbit liquid manure to get a stabilized and sanitized product ready to be spread with less limits than manure and authorized to to be sold on the market.

- *What is the underlying working principle?*

The manure is collected in the stalls and brought to the composting shed to be windrowed.

On the fermentation area, the aerobic and hot degradation of organic matters is monitored with the temperature increase or decrease thanks to probes.

72 Composting its own cattle manure monitoring the temperature



Each coloured curve matches to the temperature monitoring by a different probe on the windrow.

The compost is mixed with a rake (see picture below).

The purpose is to keep the temperature higher than 55°C during five weeks. The moisture is assured with the rabbit liquid manure.
The compost is stored on the maturing area before analysis and delivery.

- *What is the current and foreseen scale of operations (e.g. kg, tonnes/year)?*
  The actual annual production is 2300 tons of compost from 5000 tons of manure. This production is broadcasted on the district, to farms with arable crops.

72 Composting its own cattle manure monitoring the temperature

- *Why is it innovative when compared to existing (farming) practices?*
  Today, the manure management in farms is often a storage during one or more months but without monitoring system of manure evolution.
  The case of GAEC Chagneaud is innovative with the set-up of a unit specially used to treat the manure and to manufacture a marketable soil improver.

- *How does it improve the Nitrogen-Phosphorus and/or Carbon cycles in agriculture?*
  The N and P elements from forage and from crops for feeding are returned to the fields and pasture from which they came. Since the composted manure is marketable, it is returned to the grain farms where the straw comes from for breeding: there is also a return for element C with the transfer of organic matter.

- *Add a separate line on the location of your management solution: "Currently this technology / technique / management solution is applied in ……. (city, region, country))."*
  The solution is applied in the country.

72 Composting its own cattle manure monitoring the temperature

TRL (Technology Readiness Level) – how close is your solution to the market?

Use the slider above to position the current TRL* of your proposed solution

* TRLs are a type of measurement system used to assess the maturity level of a particular technology. Where a topic description refers to a TRL, the following definitions apply, unless otherwise specified:

• TRL 1 – basic principles observed • TRL 2 – technology concept formulated • TRL 3 – experimental proof of concept • TRL 4 – technology validated in lab • TRL 5 – technology validated in relevant environment (industrially relevant environment in the case of key enabling technologies) • TRL 6 – technology demonstrated in relevant environment (industrially relevant environment in the case of key enabling technologies) • TRL 7 – system prototype demonstration in operational environment • TRL 8 – system complete and qualified • TRL 9 – actual system proven & running in operational environment

Please provide some sentences explaining your Technology Readiness Level

The process has been going from several years, with a part of production sold to crop farms in the department but there are still only a few farms in France with such a system of monitoring to give the warranty of quality for the composted manure as marketable soil improver.

If the proposed solution/ technique is currently at low TRL (≤5), is upscaling foreseen within the next year(s)?

If the proposed solution/ technique is currently at high TRL (≥7), is there any product already being produced from the proposed solution/ technique ?

- *If yes, what is the name of the product :*
  Compost GAEC Chagneaud

- *Short description of the product:*
  Organic soil improver as compost from cattle and rabbit manure.
  The composted material is an organic soil improver from cattle and rabbit manure. The name of this kind of product is “Organic soil improver from livestock effluents composting”. It matches to the third kind of the french standard NF U44-051 : “Composted liquid or solid manures or poultry droppings”.
  For the characterization, see informations at the end.

- *Are there any EC/MS Authority permits already for use of the product (title or link if available)?*
  YES. The compost can be used as a product only if it matches to specifications from french standard NF U44-051.
  Moreover, the treatment plants matches to the french regulation of Installation Classified for the Protection of the Environment : number 2780.

72 Composting its own cattle manure monitoring the temperature

POTENTIAL LINKAGE TO THE PROJECT

Indicate to which agro-typology under study and which potential research line of the project, your proposed solution/technique contributes :

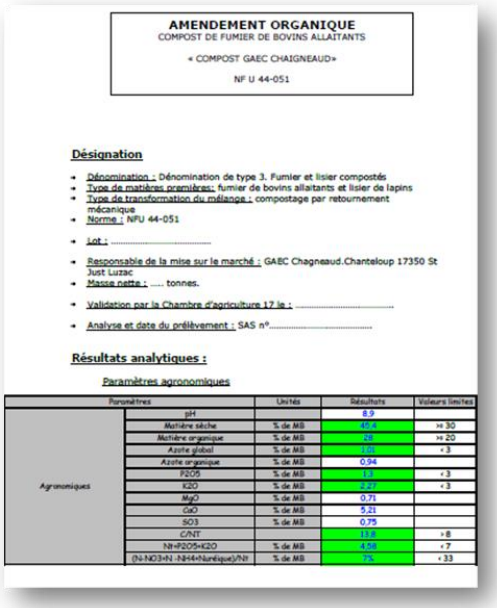
	Pig Production
	Poultry Production
X	Cattle Farming
	Open field cultivation of cereals or maize
	Open air cultivation of vegetables
	Orchards
	Agro-energy systems (e.g. biogas)
X	Animal Byproduct processing (e.g. manure processing)

Innovative solutions for optimized nutrient & GHG in animal husbandry	
Innovative soil, fertilisation & crop management systems & practices	X
Tools, techniques & systems for higher-precision fertilization	
Biobased fertilisers (N, P) and soil enhancers (OC) from agro-residues	
Novel animal feeds produced from agro-residues	
Other, please specify :	

72 Composting its own cattle manure monitoring the temperature

If you have any other information you want to share with us, please insert in the box below

Orylag® is a rabbit breed raised for its fur and its meat : http://www.orylag.com/



AMENDEMENT ORGANIQUE
COMPOST DE FUMIER DE BOVINS ALLAITANTS
« COMPOST GAEC CHAIGNEAUD»
NF U 44-051

Désignation

- Dénomination : Dénomination de type 3. Fumier et lisier compostés
- Type de matières premières: fumier de bovins allaitants et lisier de lapins
- Type de transformation du mélange : compostage par retournement mécanique
- Norme : NFU 44-051
- Lot : .....
- Responsable de la mise sur le marché : GAEC Chagneaud.Chanteloup 17350 St Just Luzac
- Masse nette : ..... tonnes.
- Validation par la Chambre d'agriculture 17 le : .....
- Analyse et date du prélèvement : SAS n°.....

Résultats analytiques :

Paramètres agronomiques

Paramètres		Unités	Résultats	Valeurs limites
Agronomiques	pH		8.9	
	Matière sèche	% de MB	40.4	>= 30
	Matière organique	% de MB	28	>= 20
	Azote global	% de MB	1.06	< 3
	Azote organique	% de MB	0.94	
	P2O5	% de MB	1.3	< 3
	K2O	% de MB	2.27	< 3
	MgO	% de MB	0.71	
	CaO	% de MB	3.21	
	SO3	% de MB	0.75	
	C/N		13.8	> 8
	N+P2O5+K2O	% de MB	4.58	< 7
	(N-NO3+N -NH4+NuréiqueN	% de MB	7%	< 33

73 Precision arable farming using bio based fertilizers in potato growing

AIM OF THE TECHNOLOGY

Provide a brief description of the proposed management solution or technique.

- *What is the purpose/aim of the innovative solution/technique?*
  The potato grower VandenBorne Aardappelen started a project in autumm 2018 with a 5 ha trial field where at the end of the project all fertilization will be done by some type of organic fertilizer, like compost, solid and liquid manure and manure split at source.
  On 5 ha they will phase out chemical fertilizer free in a period of 4 years. The strategy is to reach 100% chemical fertilizer free while maintaining optimal yield in potatoes by phasing out chemical N in 4 year to 70%, 50%, 25% and fourth year 0%. The trail will be performed on 4 plots, one plot with low EC, one plot with high EC and 2 reference plots.
  The focus is to close the nutrient cycle in collaboration with a local dairy farmer. The soil life will be rebalanced to improve nutrient uptake from animal manure. It is technically possible to stop at once with chemical fertilizer, however the soil is not ready yet for optimal yield without chemical fertilizer. Research has shown the yield is higher after 3 years when the chemical fertilizer gift is slowly build down than the suddenly stopped. To improve soil life the soil will be treated with the biostimulant Biovin. Biovin is a soil improver with a large amount of useful soil bacteria and fungi to start and maintain soil life. The needed N is complemented with the manure. A trial with slurry, solid straw-manure and separated cow manure will be done to see if it has advantages in the programme.
  The development of soil life and potato yield is followed by sensoring. About 40 data layers per point will be collected for a 3 year period, tracking everything possible with drones, sensors and sampling, including manure NPK dosage at application. The result is a massive dataset to see if the strategy works, if the yield is sufficient and why. There is 6 years of historic data to benchmark the yield result and interaction on the trial field to exclude the weather conditions in approach. The result of the project will be fact based, benchmarked with 6 years 100% chemical farming on the same zones.

73 Precision arable farming using bio based fertilizers in potato growing

Data collection will be as follows:

The actions mentioned below are considered as the very basics for a field trial managed and monitored by the Practice centre for Precision Agriculture. Standard activities to prepare the field (ploughing or spading, organic manure application, planting) and crop protection included.
Land rent per treatment zone. Treatment zones are strips of 33 m width receiving the same treatment, and containing 3 plots (repetitions) of 30 m * 30 m.
Preparation of the experimental set-up. The soil scan is taken into account to make sure plots of treatments are conducted in similar soil conditions.
Local weather information from Reusel
Registering cultivation measures and registering all field measurements.
Data-analysis on the results of the experiments, including analyses of the test probes. All these data enables us to perform (simple) statistical analyses and to draw conclusions on the functionality of the products which have been tested.
A concise final report: 3-5 page's report, in which the main results including illustrations will be presented.
Soilscan with the Dualem-21(h)s. Based on this soilscan we are able to map the spatial variability in electrical conductivity (EC). EC is an indicator for the organic matter content, water-holding capacity and nutrient content.
3 test probings (sampling) of the plant parameters within the growing season (e.g. beginning of july, beginning of august and prior to haulm destruction/harvest) are conducted for each plot. For each plot 50 euro/probing is taken into account. Probing includes haulm measurements, tuber measurements, Dualex clorophyll measurements and plant sap measurements on N
Mechanical harvest with yield monitoring system Probotiq YieldMaster^{PRO} (Only for potato or sugarbeet)
To supplement both basic and standard towards your needs
Soilsampling with the Fritzmeier Profi 60 on penetration resistance; collected soil samples for organic matter and pH.
Analysis of collected soil samples for organic matter and pH (liming package + advice included).
Soil analysis *Bemestingswijzer uitgebreid*: both pH, OM, total nutrient stock and plant available stock within the soil (N, S, P, K, Ca, Mg, Na, B, Mn, Cu, Zn, SE, Co, Si and Fe). The price is about 85,- euro per sample, including advice.
Petiole analysis for all nutrients (nova cropcontrol & hortinovan)
UAV-flights with a MicaSense-altum (multispectral: RGB, Red-edge, NIR and Thermal), including data-processing, data-analyses and configuring. Multispectral images enable us to calculate vegetation-indices, which can be an indicator for the nitrogen and/or the chlorophyll content in the plant. The analyses of the UAV-images can also be performed at plot-level.
Analyses of the UAV-images performed at plot-level. (final and intermediate)
Fritzmeier Isaria measurements (Crop Sensor for biomass and nitrate content in the foliage). Usually 5 measurements, but up to weekly measurements (combined with crop protection) is possible.
Data processing Fritzmeier Isaria (final or intermediately)
Measurements of the nitrate, potassium and phosphate leaching to the groundwater during the growing season with monitoring wells at 2,5 - 3m depth.

73 Precision arable farming using bio based fertilizers in potato growing

- *What is the underlying working principle?*
  Pius Floris, producer bio-stimulant: "When a soil has been treated in a conventional manner for decades, it needs some time to kick off from the salt chemical fertilizer. This fertilizer has minimized soil life over the years and made it inactive. With soil life we mean the fungi and bacteria besides the worms, nematodes etc. It is a fact that salt works bactericidal and so it does also in the soil. Also the fungi (including mycorrhiza) suffer severely from this. This creates an imbalance, different pathogens take their chance. It is unfortunately not the case that the balance is restored in one year. Also the switchover to a biological production system takes more than two years because the harmful substances need that time to break down or to minimize, so that there are no residuals to end up in the plants. Focus is to develop a strategy to help the soil life to switch to chemical fertilizer free growing of potatoes while remaining high yields in the meantime.
  From experiences with pasture land and a 5 year CO2 project in Spain, it turned out to be a few years before a soil recovers in such a way that a balance is created.
  There has been a 5 year project (LIFE11 ENV/ES/000535) in which, among others, PHC and University of Valladolid have shown that soil life can be restored. www.operacionco2.com
  To achieve this, a system must be followed that can be applied in agriculture.
  The three core values are:
  1. No more chemical fertilizer
  2. No brassica's as 'fertilizer crop' (groenbemester) (these plant species break down mycorrhiza)
  3. No deep intensive tillage anymore (max 12-15 cm)"
  Source : PlantHealthCure, Pius Floris, producer of Biovin

- *What is the current and foreseen scale of operations (e.g. kg, tonnes/year)?*
  Start with 5 ha field trial.
  See also example Ökoprojekt Kaindorf in Austria where such a project has been running successfully for years. www.oekoregion-kaindorf.at Also the Province of Friesland has signed a cooperation with Ökoregion Kaindorff at 11 November 2018.

- *Why is it innovative when compared to existing (farming) practices?*
  The innovative character of the project lies within the focus on rebalancing soil life to improve nutrient uptake from organic fertilizers, instead of chemical fertilizer. This in combination with optimal soil treatment, crop care, irrigation, yield monitoring. The newest precision agriculture techniques will be applied, like DualEM soil scan & harvest potention maps, moist/weather sensors & DSS, drones/canopy maps; precision manure/compost spreaders, precision sprayers, precision irrigation, vision harvest monitoring.

- *How does it improve the Nitrogen-Phosphorus and/or Carbon cycles in agriculture?*
  Chemical fertilizers will be replaced by natural fertilizers.
  The soil life will be restored, improving the nutrient uptake from the natural fertilizers.
  The precision agriculture techniques will guarantee the plants in every m2 get what they need for optimum growth, planning on farm level is optimised, the input of sources, like manure, is planned in advance, so can be optimised in time. Compared to standard practice 100% organic fertilisation decreases the input of 370 kg KAS, 600kg Patentkali (Potassium fertiliser) plus an amount of Phosphate that differs per region.

- *Add a separate line on the location of your management solution: "Currently this technology / technique / management solution is applied in ……. (city, region, country))."*

73 Precision arable farming using bio based fertilizers in potato growing

Currently this solution is applied from Reusel, in NL Province Brabant and BE province Antwerp. Arrangements are made to upscale this staring 2019 with 4 other growers in NL.

TRL (Technology Readiness Level) – how close is your solution to the market?

* TRLs are a type of measurement system used to assess the maturity level of a particular technology. Where a topic description refers to a TRL, the following definitions apply, unless otherwise specified:

• TRL 1 – basic principles observed • TRL 2 – technology concept formulated • TRL 3 – experimental proof of concept • TRL 4 – technology validated in lab • TRL 5 – technology validated in relevant environment (industrially relevant environment in the case of key enabling technologies) • TRL 6 – technology demonstrated in relevant environment (industrially relevant environment in the case of key enabling technologies) • TRL 7 – system prototype demonstration in operational environment • TRL 8 – system complete and qualified • TRL 9 – actual system proven & running in operational environment

Please provide some sentences explaining your Technology Readiness Level

100% organic fertilisation is applied in EKO agri. All precision techniques are working with handwork (not plug and play as market asks for, TRL7/8). THE COMBINATION and INTEGRATION of these techniques is to be optimised /tested in practice: **TRL5/6**

If the proposed solution/ technique is currently at low TRL (≤5), is upscaling foreseen within the next year(s)?

YES.

If the proposed solution/ technique is currently at high TRL (≥7), is there any product already being produced from the proposed solution/ technique?

- *If yes, what is the name of the product :*
  components yes, f.i. DualEMscan & soil maps.

- *Short description of the product*
  Scanning of electro-magnetic conductivity in soil on 10-30-60-200cm leading to a buffer capacity (=yield potential) of the soil, to be used for variable manuring and variable distance potato planting. NIR sensor on slurry dispenser installed.

- *Are there any EC/MS Authority permits already for use of the product (title or link if available)?*

73 Precision arable farming using bio based fertilizers in potato growing

POTENTIAL LINKAGE TO THE PROJECT

Indicate to which agro-typology under study and which potential research line of the project, your proposed solution/technique contributes :

	Pig Production
	Poultry Production
	Cattle Farming
X	Open field cultivation of cereals or maize
X	Open air cultivation of vegetables
	Orchards
	Agro-energy systems (e.g. biogas)
	Animal Byproduct processing (e.g. manure processing)

Innovative solutions for optimized nutrient & GHG in animal husbandry	
Innovative soil, fertilisation & crop management systems & practices	X
Tools, techniques & systems for higher-precision fertilization	X
Biobased fertilisers (N, P) and soil enhancers (OC) from agro-residues	
Novel animal feeds produced from agro-residues	
Other, please specify :	

74 Pig manure processing into separated N and K fertilisers and water re-usable for agro-application

AIM OF THE TECHNOLOGY

Provide a brief description of the proposed management solution or technique.

- *What is the purpose/aim of the innovative solution/technique?*
  The proposed solution is a novel way to process manure with the aim to produce separate N and K fertilizers while producing grey water to be reused in agricultural applications.

- *What is the underlying working principle?*
  Nowadays, manure processing is predominantly oriented towards reducing its nutrient content to allow better manure disposal. The current farming practice consists of separating raw manure into a solid and a liquid fraction (=primary treatment). The solid fraction is exported to be used as a P fertilizer in nutrient poor regions, while the liquid fraction undergoes biological treatment (= secondary treatment). The resulting N poor liquid fraction is next spread over land as a fertilizer.
  The underlying working principle is to produce specific fertilizers and recuperate water through the replacement of the biological treatment by a N stripper installation. In this way 2 streams are produced: 1) a pure N fertilizer (form dependent on the used acid) and 2) a K rich watery stream. This watery stream can be further processed using wetland technology which effluent can be used for minimally low-grade applications (e.g., cleaning water, irrigation water, etc.). Alternatively, this water can be further processed with membrane technology for a limited up-concentration which results in a KCl fertilizer suitable for K demanding crops such as potatoes.

- *What is the current and foreseen scale of operations (e.g. kg, tonnes/year)?*
  This technology is already applied at tonnage scale in a pilot (stripping), the constructed wetlands are actual systems which are already proven and running in operational environment, while the membrane technology to obtain K fertilizers has been tested in a pilot installation.

- *Why is it innovative when compared to existing (farming) practices?*
  The novelty of this process relies on the uses given to the two fractions of manure for crop production or reduction of the natural water resources. Unlike the existing (farming) practices which mainly deal with a proper disposal of the manure fractions in the environment.

- *How does it improve the Nitrogen-Phosphorus and/or Carbon cycles in agriculture?*

74 Pig manure processing into separated N and K fertilisers and water re-usable for agro-application

This technique could be beneficial specifically for the N cycle by:
1) avoiding N emissions originating from the biological treatment
2) producing a separate N fertilizer and K fertilizer

- *Add a separate line on the location of your management solution: "Currently this technology / technique / management solution is applied in ……. (city, region, country))."*
  Currently this technique is applied in the Flanders region, Belgium. The actual upgrading towards reusable water and N/K fertilizers has been assessed and positively evaluated during pilot projects.

TRL (Technology Readiness Level) – how close is your solution to the market?

Use the slider above to position the current TRL* of your proposed solution

* TRLs are a type of measurement system used to assess the maturity level of a particular technology. Where a topic description refers to a TRL, the following definitions apply, unless otherwise specified:

• TRL 1 – basic principles observed • TRL 2 – technology concept formulated • TRL 3 – experimental proof of concept • TRL 4 – technology validated in lab • TRL 5 – technology validated in relevant environment (industrially relevant environment in the case of key enabling technologies) • TRL 6 – technology demonstrated in relevant environment (industrially relevant environment in the case of key enabling technologies) • TRL 7 – system prototype demonstration in operational environment • TRL 8 – system complete and qualified • TRL 9 – actual system proven & running in operational environment

Please provide some sentences explaining your Technology Readiness Level

There are three TRL levels that can be distinguished for this proposal:
1) Stripping of liquid fraction of manure: TRL 7
2) Constructed wetlands: TRL 9
3) Membrane filtration of resulting wetland effluent to produce K fertiliser: TRL 5-6

If the proposed solution/ technique is currently at low TRL (≤5), is upscaling foreseen within the next year(s)?

If the proposed solution/ technique is currently at high TRL (≥7), is there any product already being produced from the proposed solution/ technique?

If yes, what is the name of the product:

The stripping / scrubbing pilot unit installed at a pig farm in Gistel, Flanders currently processes approximately 8.000 t/y of pig manure per year.

The Constructed Wetlands at the abovementioned farm are currently receiving and processing 25.000 t/y pig manure effluents. The operational capacity of the wetland systems is higher than that of the stripping/scrubbing unit which itself was built at a later stage. At the same farm there is also a biological nitrification / denitrification reactor of which the N-poor effluents are also downstream treated by these wetlands.

A pilot membrane installation was successfully operated at pilot scale on this farm, producing both clean re-usable water as well as K-rich (and N-/P poor) concentrate.

- *Short description of the product*

74 Pig manure processing into separated N and K fertilisers and water re-usable for agro-application

Different products are coming from this process chain, the most important being: recovered Nitrogen in mineral form, re-usable water, K-rich concentrate stream useable for irrigation and K-fertilisation.

- *Are there any EC/MS Authority permits already for use of the product (title or link if available)?* NO

POTENTIAL LINKAGE TO THE PROJECT

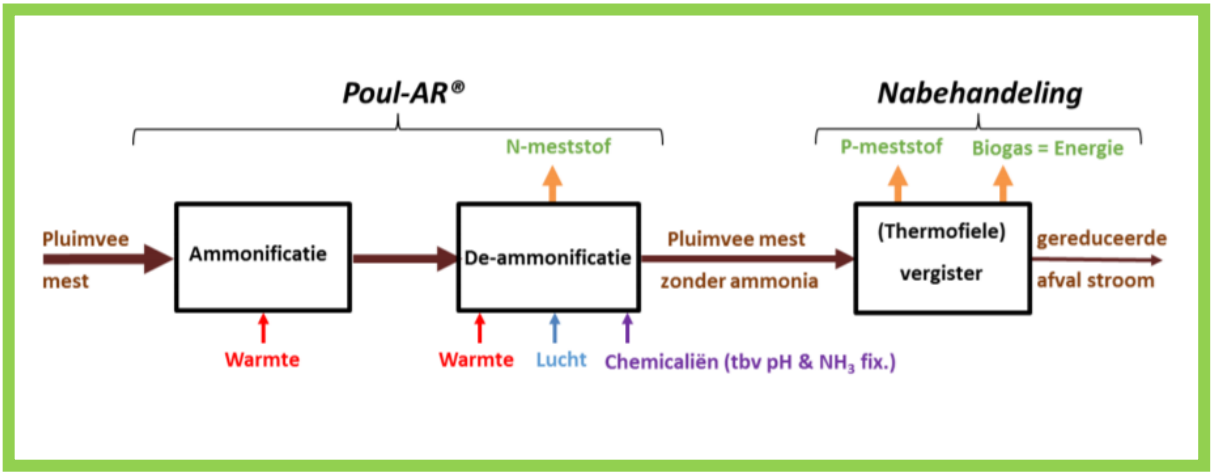
Indicate to which agro-typology under study and which potential research line of the project, your proposed solution/technique contributes:

X	Pig Production
	Poultry Production
	Cattle Farming
	Open field cultivation of cereals or maize
	Open air cultivation of vegetables
	Orchards
	Agro-energy systems (e.g. biogas)
X	Animal Byproduct processing (e.g. manure processing)

Innovative solutions for optimized nutrient & GHG in animal husbandry	X
Innovative soil, fertilisation & crop management systems & practices	
Tools, techniques & systems for higher-precision fertilization	
Biobased fertilisers (N, P) and soil enhancers (OC) from agro-residues	X
Novel animal feeds produced from agro-residues	
Other, please specify :	

75 Ammonification & De-ammonification as a pretreatment for N-recovery

AIM OF THE TECHNOLOGY



Provide a brief description of the proposed management solution or technique.

- *What is the purpose/aim of the innovative solution/technique?*
  The company Colsen b.v. has developed a system for significant recovery of N from poultry manure. This system is called “Pour-AR” and consist of a 2 step pre-treatment : “ammonification” and “de-ammonification”. The level of ammonia in the poultry manure would be reduced from 30.000 to 2.000 ppm by performing this pre-treatment. Although this pretreatment is done at higher temperatures, there is no loss of biomass potential.
  The ammonia is recovered as ammonia-sulphate or ammonia phosphate.
  Application of this technique for the recovery of N from other types of manure should be further researched. Issue might be that the concentration level of other types of manures is significantly lower than chicken manure. Therefor it should be researches what combinations are feasible to get positive results.

- *What is the underlying working principle?*
  The Poul-AR pretreatment consists of 2 steps:
  - Step 1 “Ammonification” : in which the majority of the N present is transferred to ammonia. This is done by increasing the temperature. There is no pH drop or addition of chemicals at this step
  - Step 2 “De-ammonification” in which the ammonia present in the manure is stripped and recovered as ammonia-sulphate or – nitrate. The temperature is further increased.

- *What is the current and foreseen scale of operations (e.g. kg, tonnes/year)?*
  Current status is that there is a container “pilot” available that can treat 100 to 250 kg/day.
  A full scale plant for chicken manure is being constructed and should be operational by the end of 2019.

- *Why is it innovative when compared to existing (farming) practices?*
  The standard system for the Poul-AR technology is chicken manure. Application of other manures (possible in combination with other flows / manures) should be further researched in cooperation with Colsen BV.

75 Ammonification & De-ammonification as a pretreatment for N-recovery

- *How does it improve the Nitrogen-Phosphorus and/or Carbon cycles in agriculture?*
  The efficiency of the Poul-AR system on chicken manure is high. If this level could also be attained for other types of manure, this would make a significant difference.

- *Add a separate line on the location of your management solution: "Currently this technology / technique / management solution is applied in ……. (city, region, country)).”*
  Colsen B.V. is a company from the Netherlands located in Hulst.
  The full scale Poul-AR installation will also be built in the Netherlands..

TRL (Technology Readiness Level) – how close is your solution to the market?

Use the slider above to position the current TRL* of your proposed solution

* TRLs are a type of measurement system used to assess the maturity level of a particular technology. Where a topic description refers to a TRL, the following definitions apply, unless otherwise specified:

• TRL 1 – basic principles observed • TRL 2 – technology concept formulated • TRL 3 – experimental proof of concept • TRL 4 – technology validated in lab • TRL 5 – technology validated in relevant environment (industrially relevant environment in the case of key enabling technologies) • TRL 6 – technology demonstrated in relevant environment (industrially relevant environment in the case of key enabling technologies) • TRL 7 – system prototype demonstration in operational environment • TRL 8 – system complete and qualified • TRL 9 – actual system proven & running in operational environment

Please provide some sentences explaining your Technology Readiness Level

TRL 8 – for the Poul-AR concept on chicken manure, as the first full scale plant will be constructed. It might serve as a lighthouse company for others in the sector.
TRL 4 – for the application of other types of manures in the Poul-AR technology. Yet to be tested and developed.

If the proposed solution/ technique is currently at low TRL (≤5), is upscaling foreseen within the next year(s)?

YES.

If the proposed solution/ technique is currently at high TRL (≥7), is there any product already being produced from the proposed solution/ technique?

- *If yes, what is the name of the product:*
  Ammonia sulphate or Ammonia nitrate.

- *Short description of the product*
  Both product can be produced at a high concentration: 52 % for ammonia nitrate, and 36% for ammonia sulphate.

- *Are there any EC/MS Authority permits already for use of the product (title or link if available)?*

75 Ammonification & De-ammonification as a pretreatment for N-recovery

POTENTIAL LINKAGE TO THE PROJECT

Indicate to which agro-typology under study and which potential research line of the project, your proposed solution/technique contributes:

X	Pig Production
X	Poultry Production
X	Cattle Farming
	Open field cultivation of cereals or maize
	Open air cultivation of vegetables
	Orchards
X	Agro-energy systems (e.g. biogas)
X	Animal Byproduct processing (e.g. manure processing)

Innovative solutions for optimized nutrient & GHG in animal husbandry	X
Innovative soil, fertilisation & crop management systems & practices	
Tools, techniques & systems for higher-precision fertilization	
Biobased fertilisers (N, P) and soil enhancers (OC) from agro-residues	X
Novel animal feeds produced from agro-residues	
Other, please specify :	

76 Nitrate sensor for optimal grassland management

AIM OF THE TECHNOLOGY

Provide a brief description of the proposed management solution or technique.

- *What is the purpose/aim of the innovative solution/technique?*
  The aim of the Nitrate Sensor is to measure Nitrogen/Nitrate in grassland (soil). Measures of Nitrogen/Nitrate can optimize grassland management. When you know the real time N in soil you can choose the right moment for harvesting and grazing (cows). The purpose of the innovative technique is apply fiber-optic sensors for soil parameters.

- *What is the underlying working principle?*
  Nitrogen fertilization increases the production and the raw protein of grass. However, the availability of nitrogen in the soil is difficult to estimate because of the dynamic nature of nitrogen. A soil yields a certain amount of nitrogen from organic matter (NLV) that is released during the growing season. It is un clear when the nitrogen supply starts in the spring and how this continues in the year.
  The working principle of the Nitrate Sensor is based on fluorescent coatings that can be used for stand-alone monitoring of soil parameters. Currently the focus is on plant-available nitrate.

- *What is the current and foreseen scale of operations (e.g. kg, tonnes/year)?*
  At the moment, the scale of operations is very low. In the project sensors are tested in field trials (peat). This will be expanded to sand and clay in 2019, with a maximum of 3 sensors.

- *Why is it innovative when compared to existing (farming) practices?*
  The most innovative point is the possibility to measure real time nitrate in soil and to predict the nitrogen during a year. In case of the nitrate sensor the most innovative point is the fact that no intermediate calibration is needed, that the sensor can be exposed to dry periods for long time and that the sensor signals correlate to plant-available nitrate.

- *How does it improve the Nitrogen-Phosphorus and/or Carbon cycles in agriculture?*
  The sensor contributes to better understanding of the mineral utilization and the expansion of the feed supply. When you can provide for the needs of Nitrogen on your farm, you have to purchase less nitrogen/protein. This close the nitrogen cycle a little bit more.

76 Nitrate sensor for optimal grassland management

- *Add a separate line on the location of your management solution: "Currently this technology / technique / management solution is applied in ……. (city, region, country))."*
  Currently the sensors are applied in field trials in The Netherlands.

TRL (Technology Readiness Level) – how close is your solution to the market?

Use the slider above to position the current TRL* of your proposed solution

* TRLs are a type of measurement system used to assess the maturity level of a particular technology. Where a topic description refers to a TRL, the following definitions apply, unless otherwise specified:

• TRL 1 – basic principles observed • TRL 2 – technology concept formulated • TRL 3 – experimental proof of concept • TRL 4 – technology validated in lab • TRL 5 – technology validated in relevant environment (industrially relevant environment in the case of key enabling technologies) • TRL 6 – technology demonstrated in relevant environment (industrially relevant environment in the case of key enabling technologies) • TRL 7 – system prototype demonstration in operational environment • TRL 8 – system complete and qualified • TRL 9 – actual system proven & running in operational environment

Please provide some sentences explaining your Technology Readiness Level

In 2018, a first sensor has been tested in a lab. After that, the sensor has been tested in a mowing pilot during summer time on peat land.

If the proposed solution/ technique is currently at low TRL (≤5), is upscaling foreseen within the next year(s)?

YES.

If the proposed solution/ technique is currently at high TRL (≥7), is there any product already being produced from the proposed solution/ technique?

- *If yes, what is the name of the product :*
- *Short description of the product*
- *Are there any EC/MS Authority permits already for use of the product (title or link if available)?*

76 Nitrate sensor for optimal grassland management

POTENTIAL LINKAGE TO THE PROJECT

Indicate to which agro-typology under study and which potential research line of the project, your proposed solution/technique contributes :

	Pig Production
	Poultry Production
X	Cattle Farming
X	Open field cultivation of cereals or maize
	Open air cultivation of vegetables
	Orchards
	Agro-energy systems (e.g. biogas)
	Animal Byproduct processing (e.g. manure processing)

Innovative solutions for optimized nutrient & GHG in animal husbandry	
Innovative soil, fertilisation & crop management systems & practices	X
Tools, techniques & systems for higher-precision fertilization	X
Biobased fertilisers (N, P) and soil enhancers (OC) from agro-residues	
Novel animal feeds produced from agro-residues	
Other, please specify :	