

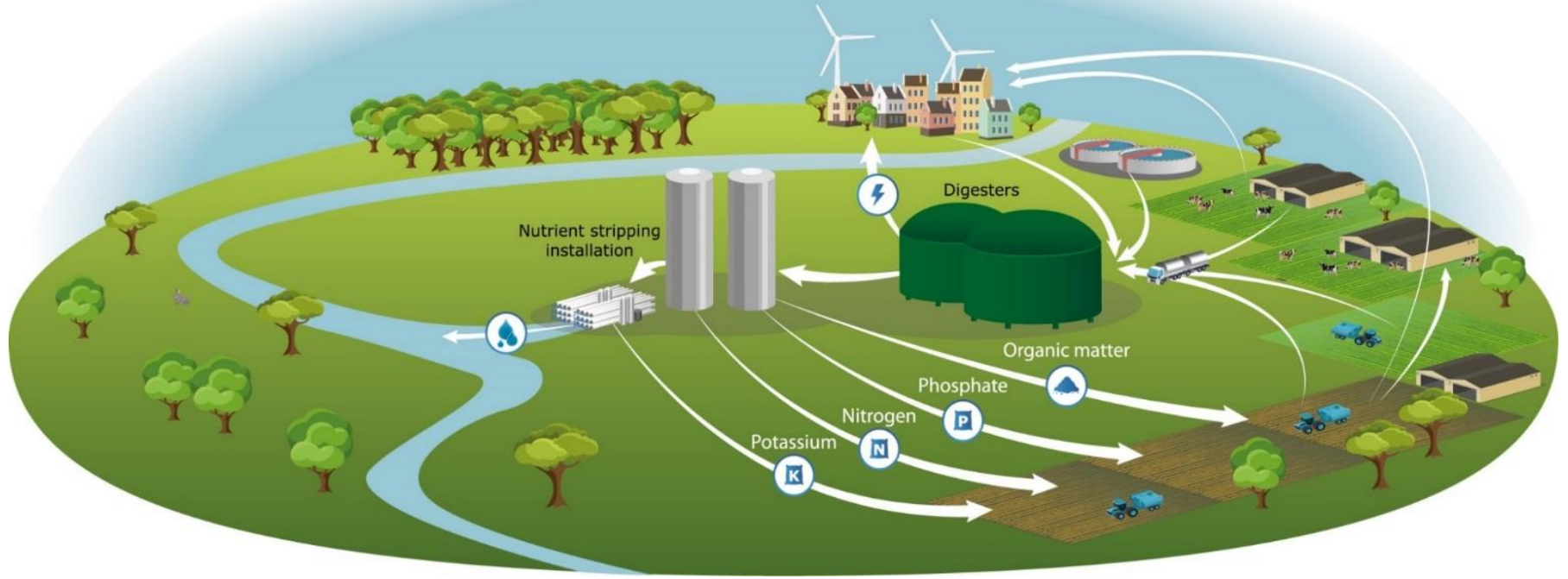
SYSTEMIC: LARGE SCALE ECO-INNOVATION TO ADVANCE CIRCULAR ECONOMY & MINERAL RECOVERY FROM ORGANIC WASTE

Oscar Schoumans, E. Meers, L. Hermann, M. Verbeke and A. Williams



SYSTEMIC

Circular Solutions for Biowaste



SYSTEMIC in a nutshell

5 demonstration plants
(leading pioneers)



**10 Outreach Locations &
18 Associated Plants**
(first followers)

- Performance of nutrient recovery technologies
- Business case development
- Environmental Impact Assessment and LCA
- Policy advise

Innovation at demonstration plants

- Processing capacity: 50.000 – 180.000 ton/year
- Investment in Nutrient Recovery Technologies (pilot → full scale)
- Starting up autumn 2017 and all fully running and monitoring in 2019



Photo Fridays?



Gesellschaft für
Nachhaltige
Stoffnutzung mbH
GNS

Rika Biofuels
INTEGRATED BIOGAS SOLUTIONS

**AM
POWER**



GZV
GROOT ZEVERT VERGISTING

acqua & sole



Technical Innovation at demonstration plants

Feedstocks

- Pig manure
- Poultry litter
- Sewage sludge
- Energy crops
- Agro-industrial residues

Innovative Technologies

- Reverse Osmosis (RO)
- Evaporation
- N-stripping
- P-stripping

End Products

- Biogas
- NK concentrates
- $(\text{NH}_4)_2\text{SO}_4$ fertiliser
- Struvite & Ca phosphate
- Organic fertilisers and soil improvers
- Organic fibres



Downloads: (www.systemicproject.eu)

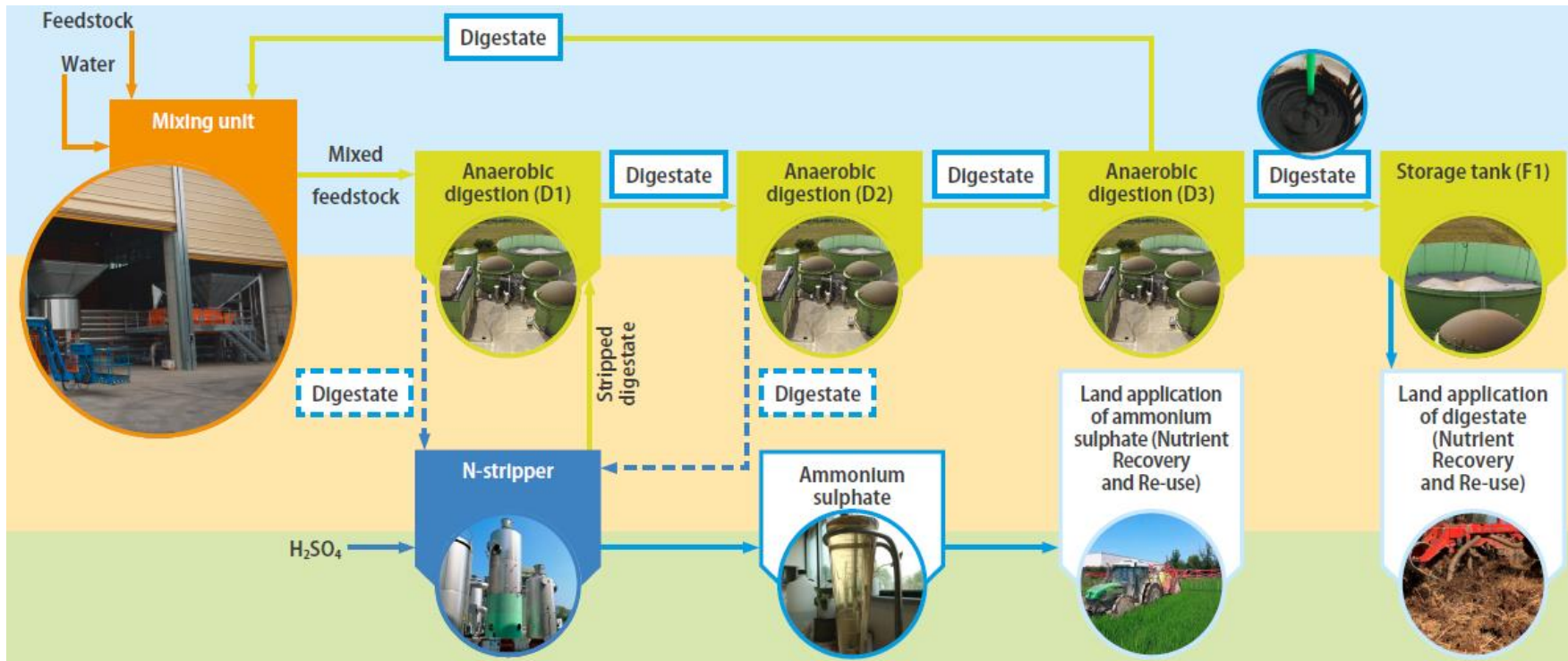
- Technical Factsheets of demoplants
- Newsletter of demoplants

Demonstration plant Acqua & Sole (IT)

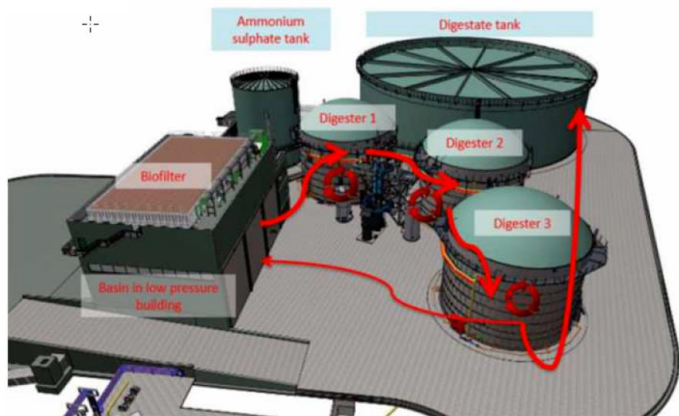
Location:	Vellezzo Bellini (Northern Italy) and built in 2016
Agriculture:	Cereals, mainly rice
Feedstock:	Sewage sludge >80%; domestic food waste
Max capacity:	120 000 tons/year
Digester cap.:	13.500 m ³ (thermophilic: 55 °C & 20 days)
Nutrient recovery:	NH ₃ -stripping a(NH ₄) ₂ SO ₄
Philosophy:	- high NH₃ concentrations can reduce biogas production - minimize ammonia and odour emissions - maximize fertilization effects on nearby 5000 ha agr. land - o digestate as soil improver (low N-content; high N/NH₄) - o (NH₄)₂SO₄ as substitute for synthetic fertilizers



Demonstration plant Acqua & Sole



Demonstration plant Acqua & Sole



Product composition

	Digestate	Ammonium Sulphate
pH	8,6	6
Dry matter (g/kg)	101	363
Organic carbon (g/kg)	33	<1,8
N-total (g/kg)	7,8	74
NH ₄ -N (g/kg)	4,4	74
P-total (g/kg)	2,8	0,011
K-total (g/kg)	0,63	0,012
S (g/kg)	1,1	84
Ca (g/kg)	5,3	0,094
Mg (g/kg)	0,86	0,014

Save costs synthetic fertilizers

Conventional fertilizer	Cost €/t *	Quantity t/y	Total (€)
Urea 46% N	344	3 370	1 159 280
triple superphosphate 46% P ₂ O ₅	369	2 520	929 880
Potash 60% K ₂ O	669	280	187 320
Total Saved Cost			2 276 480

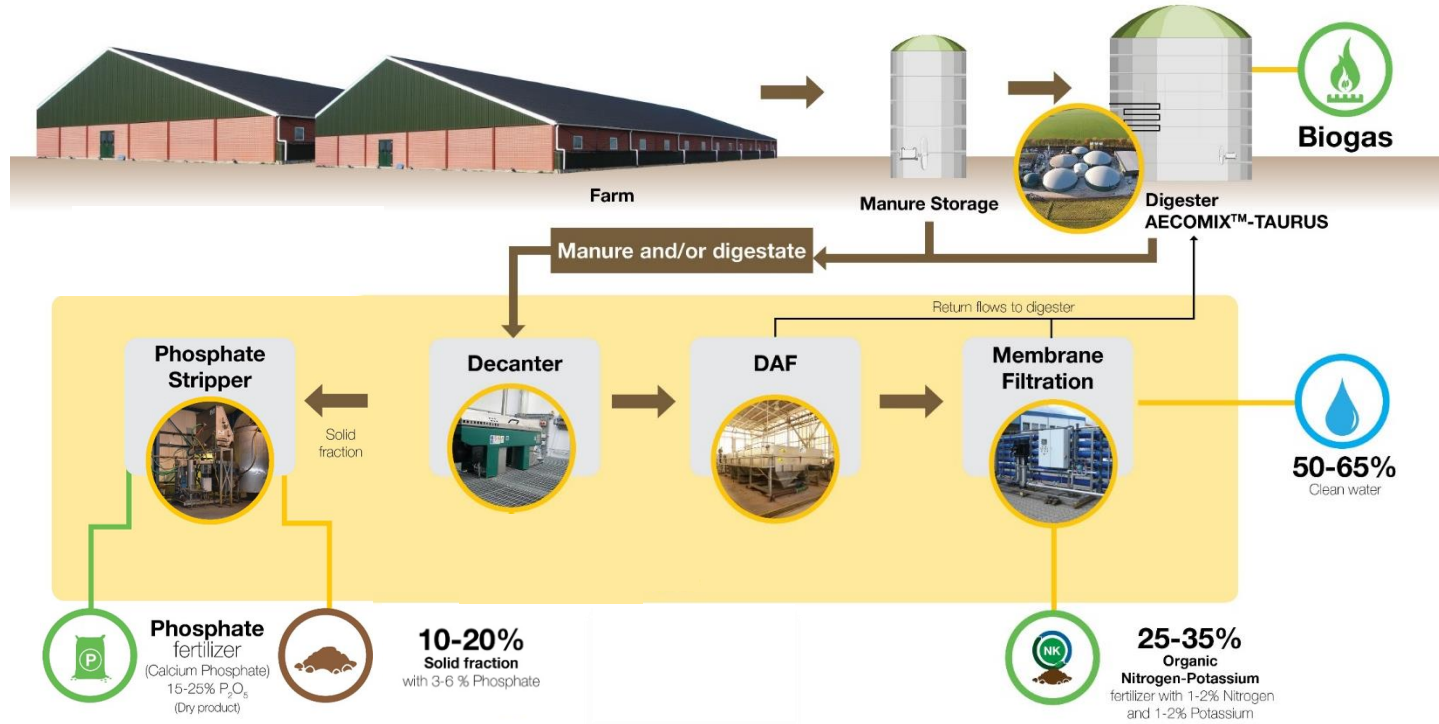
* Source: CCIAA Modena, Average 2017

Demonstration plant Groot Zevert Digestion (NL)

Location:	Beltrum (Eastern Netherlands) and built in 2004
Agriculture:	65% grassland and 35% arable (region Achterhoek)
Feedstock:	Manure >75% (mainly pig) and food & feed waste
Max capacity:	140 000 tons/year
Digester cap.:	15 000 m ³ (mesophilic: 35-38 °C & 20 days)
Nutrient recovery:	P recovery (Ca~P or struvite), RO (NK concentrate; water)
Philosophy:	- Reduce export of manure surplus over long distances (D) - Maximize fertilization effects on agricultural land - o Soil improver with a low N & P-content - o NK concentrate as substitute for synthetic fertilizers - o P precipitate as secondary resource P-fertilizer industry



Demonstration plant Groot Zevert Digestion (NL)



Demonstration plant Groot Zevert Digestion (NL)

Product composition (preliminary results)

	Ingoing digestate	GZV Recovered products		
		NK-fertilizer	Soil Conditioner	P-fertilizer
Dry matter (DM %)	5.8		32	82
Organic Matter (%)	65% of DM	1-3	89% of DM	45% of DM
N-total (g/kg)	6	8-15 NH ₄ -N	5.0	20
P ₂ O ₅ -total (g/kg)	3.5	0.2-0.4	3.2	140
K ₂ O-total (g/kg)	4	8-20	0.2	5
Volume (%)	100	5-10	20	2

Save costs transport:

- Solid fraction (20.000 m³) no long distance transport to Germany any more (> 400 km) a 25 €/m³: savings 0.5 M€ /y
- Liquid fraction (80.000 m³) is reduced by 50%:
Volume 40 000 m³ / y and 10-15 € / m³ → savings 0.4 – 0.6 M€ /y

Demonstration plant AM-Power (BE)

Location:	Pittem (Flanders, Belgium) and built in 2011
Agriculture:	Pig husbandry
Feedstock:	food industry waste + SSFW → 90%
Max capacity:	180 000 tons/year
Digester cap.:	20 000 m ³ (thermophilic, 50-60 days)
Nutrient recovery:	evaporator (concentrated digestate, 20% DM) and dry biosolids)
Philosophy:	- Reduce digestate processing cost - Maximize fertilization effects on agricultural land



- o Blend concentrated digestate and dry biosolids and export it
nutrient depleted regions

Demonstration plant AM-Power (BE)



Demonstration plant AM-Power (BE)

Product composition

	Digestate	Previous process (DAF + RO)		Current process (evaporator/condensator + RO)	
		NK-concentrate	P-rich biosolids	Expected Concentrated digestate	Expected P-rich biosolids
pH	8.7	7.7	7.5	8.7	7.5
Dry Matter (g/kg)	59	43	912	200	912
Organic Matter (g/kg)	32	18	523	62	523
N-total (g/kg)	5.5	5	31	28	31
NH ₄ -N (g/kg)	2.9	4.2	0.88	22	0,88
P-total (g/kg)	1.4	0.01	19	1.7	19
K-total (g/kg)	3.3	4.3	11	21	11

Demonstration plant Benas (DE)

Location:	Ottersberg (Northern Germany) and built in 2006
Agriculture:	Corn production
Feedstock:	crop material (mainly corn) → 82% and chicken manure → 18%
Max capacity:	174 000 tons/year
Digester cap.:	26 000 m ³ (thermophilic: 50 °C & 150 days)
Nutrient recovery:	NH ₃ -stripping from digestate into (NH ₄) ₂ SO ₄ coupled with CaCO ₃ production
Philosophy:	- high NH₃ concentrations can reduce biogas production - maximize fertilization effects on 3 500 ha agr. Land (1000 ha nearby Ottersberg) - o LF/SF digestate as soil improver - o (NH₄)₂SO₄ as substitute for synthetic fertilizers



Demonstration plant Benas (DE)



Demonstration plant Benas (DE)

Product composition

	LF digestate	SF digestate	Ammonium Sulphate	Calcium carbonate	Biogas fibers
pH	8,4	8,5	7,8	7,9	5-7
Dry matter (g/kg)	100	258	226	695	500-900
Organic carbon (g/kg)			0,48	0,73	
N-total (g/kg)	7,4	8,7	46	15	
NH ₄ -N (g/kg)	4,4	4,4	46	14	0,02-0,6
P-total (g/kg)	1,5	2,2	<0,0037	0,16	
K-total (g/kg)	6,6	5,6	0,0058	0,42	
S (g/kg)	1,2	1,6	58	42	1,2
Ca (g/kg)	3,7	4,5	1,2	251	
Mg (g/kg)	0,69	1,3	0,0083	0,4	

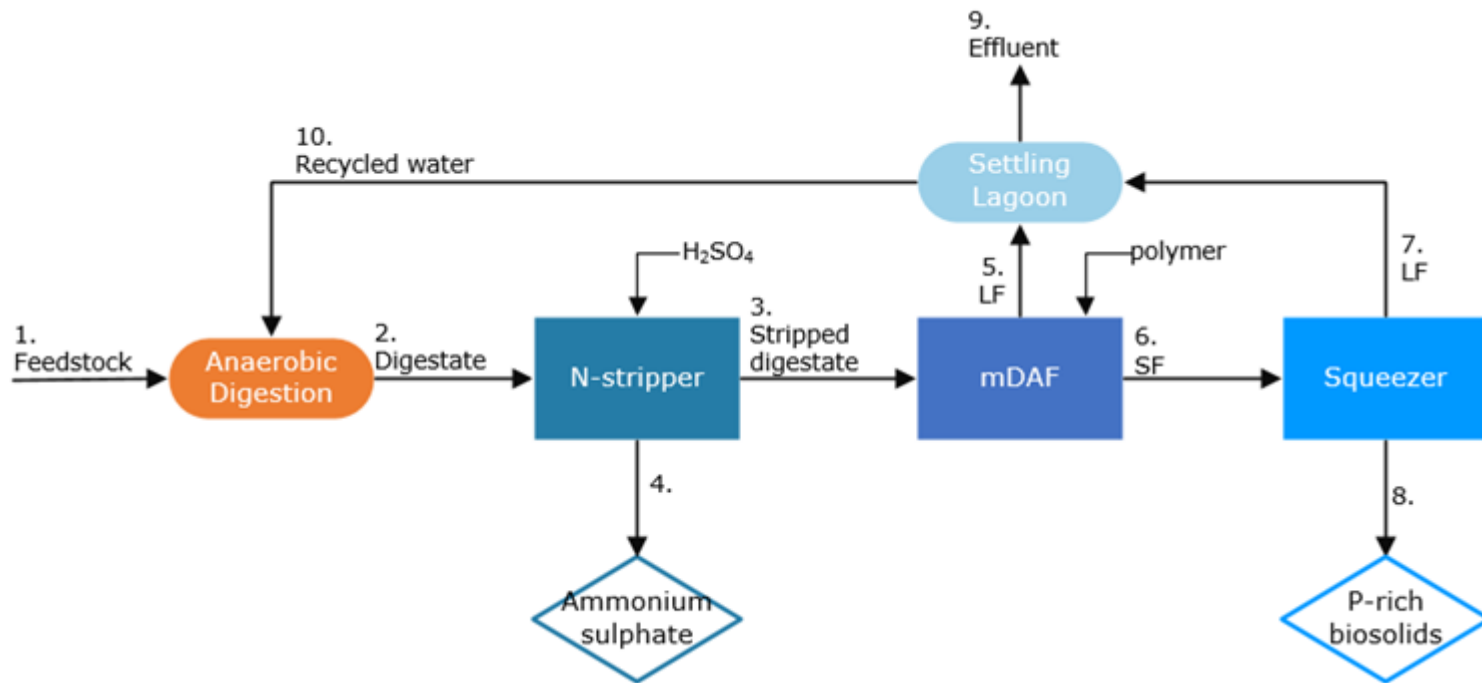
Saved costs:

- Use of Ammonium Sulphate solution: 244 000 €/y
- Use of Calcium carbonate: 63 000 €/y
- Income from fibers: 82 000 €/y

Demonstration plant Fridays (UK)

Location:	Kent (United Kingdom), commissioning by end 2019
Agriculture:	
Feedstock:	chicken manure → 100%
Max capacity:	57 000 tons/year
Digester cap.:	14 000 m ³ (mesophilic: 20 days)
Nutrient recovery:	NH ₃ -stripping from digestate into (NH ₄) ₂ SO ₄ P-recovery as SF digestate
Philosophy:	- high NH₃ concentrations can reduce biogas production - minimize ammonia and odour emissions

Demonstration plant Fridays (UK)



Demonstration plant Fridays (UK)

Predicted product composition

	Digestate	Ammonium Sulphate	P-rich biosolids
pH	9	8,1	7,7
Dry matter (g/kg)	18	592	424
Organic carbon (g/kg)	0,65	0,9	67
N-total (g/kg)	1,1	87	9,9
NH ₄ -N (g/kg)	0,87	87	4,9
P-total (g/kg)	0,24	0,22	2,4
K-total (g/kg)	3,3	0,43	6,4

Product Quality & Environmental Impact Assessment

- Assess product quality and nutrient use efficiency in pot-experiments and field trials
- Environmental Impact modelling
- Life cycle analysis of AD-plant



To quantify the **environmental benefits** of NRR for each specific demoplant and its surroundings

Role of Biogas in the 2050 EU Energy-Mix *(EU-COM, 2018)*

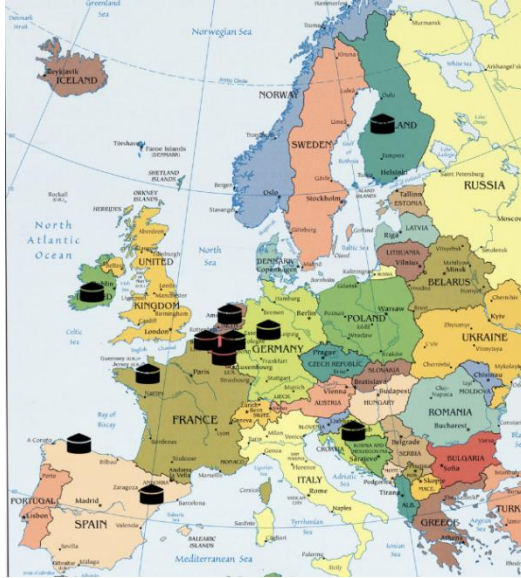
- 2016, gas contributed 245 Mtoe (22%) to the final energy consumption in Europe of which 17 Mtoe (7%) was biogas.
- EU-2050 scenarios estimate a sustainable (without land-use change) biomethane supply of 50-92 Mtoe, compared to a technical potential of 150 Mtoe.
- The transport sector (mainly heavy vehicles) could become a relevant consumer of LBG (Liquid Bio Gas) and CNG (Compressed Natural Gas).
- Biomethane and e-gas (conversion product of captured CO₂ and H₂ from excess electricity) expected to contribute 7-10% to the 2050 energy mix.

SYSTEMIC Key Performance Indicators

KPI #	Name	Unit	Explanation
1	EBITA margin	% / €	Overall OPEX performance of business (excl. interests and amortisation) in percent of revenues
2	EBIT margin	% / €	Overall OPEX & CAPEX performance of business (excl. interests) in percent of revenues
3	Substrate productivity € revenues / substrate	€ / t	Measures the overall financial productivity of substrates, i.e. total revenues of the plant per ton of substrate processed. Indicator of the overall financial productivity of processed substrates regardless from which activity (cost centre) of the digestion plant.
4	Substrate productivity ¹ € feedstock / substrate	€ / t	Measures the feedstock related financial productivity of substrate, i.e. revenues/costs (gate-fees/purchasing price) per ton of feedstock processed. Indicator for the direct revenues or costs from feedstock/substrate processed and influenced by the selection of feedstock and conditions of contracts with suppliers.
5	Substrate productivity ² € energy / substrate	€ / t	Measures the energy related financial productivity of substrate, i.e. net revenues from energy supplies (feed-in tariffs, feed-in premiums, green certificates) per ton of feedstock processed. Indicator for the direct revenues from energy and influenced by the selection of substrates, the type of energy carrier and the price/tariff of energy supplied.
6	Substrate productivity ³ € effluents / substrate	€ / t	Measures the effluent related financial productivity of substrates, i.e. net revenues/costs of effluents or products (digestate, recycled products) per ton of feedstock processed. Indicator for the revenues or costs of handling/disposing the solid and liquid materials coming out of the digester and are influenced by NRR systems and use/sale of recycled products.
7	Biogas productivity	€ / m ³	Measures the energy related financial productivity of biogas, i.e. the net revenues from energy supplies per m ³ of biogas supplied. Indicator for the revenues generated from a given biogas output and influenced by the choice of final energy carrier supply and tariff.



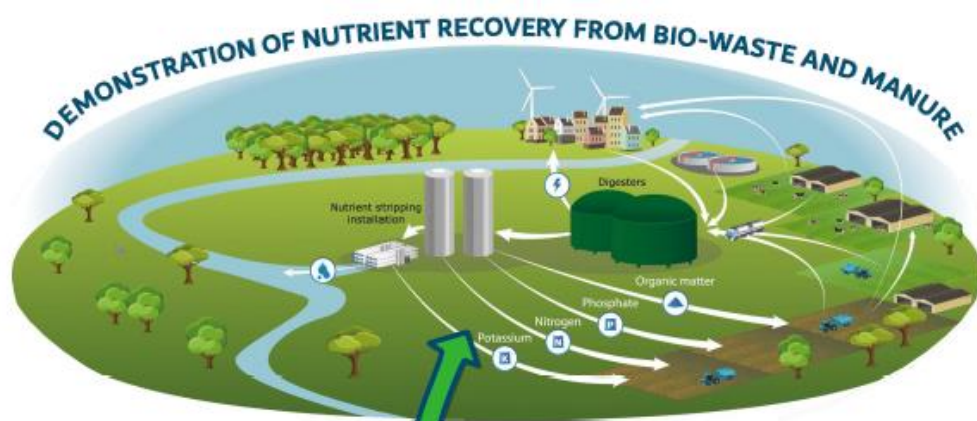
First followers: Plants interested in NRR techniques



10 Outreach Locations:
Business opportunities



18 Associated Plants:
“just info and join meetings”

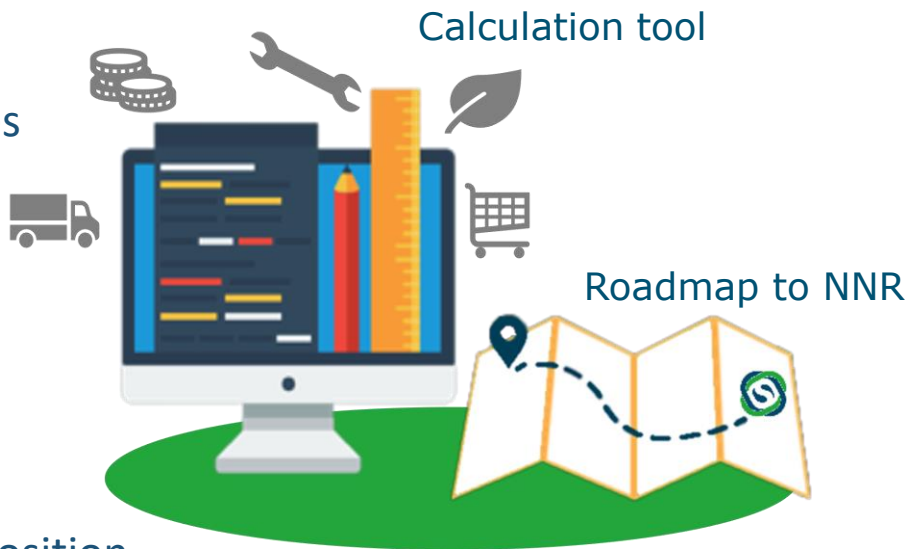


Tool

Online tool for biogas plant owners:

Virtually experiment with NRR technologies

- Input: digestate composition
- Select: NNR technology train
- Output:
 - Mass -& nutrient balance:
end products and estimated composition
 - Cost estimation (excl. Disposal cost/marketing profit for end products)



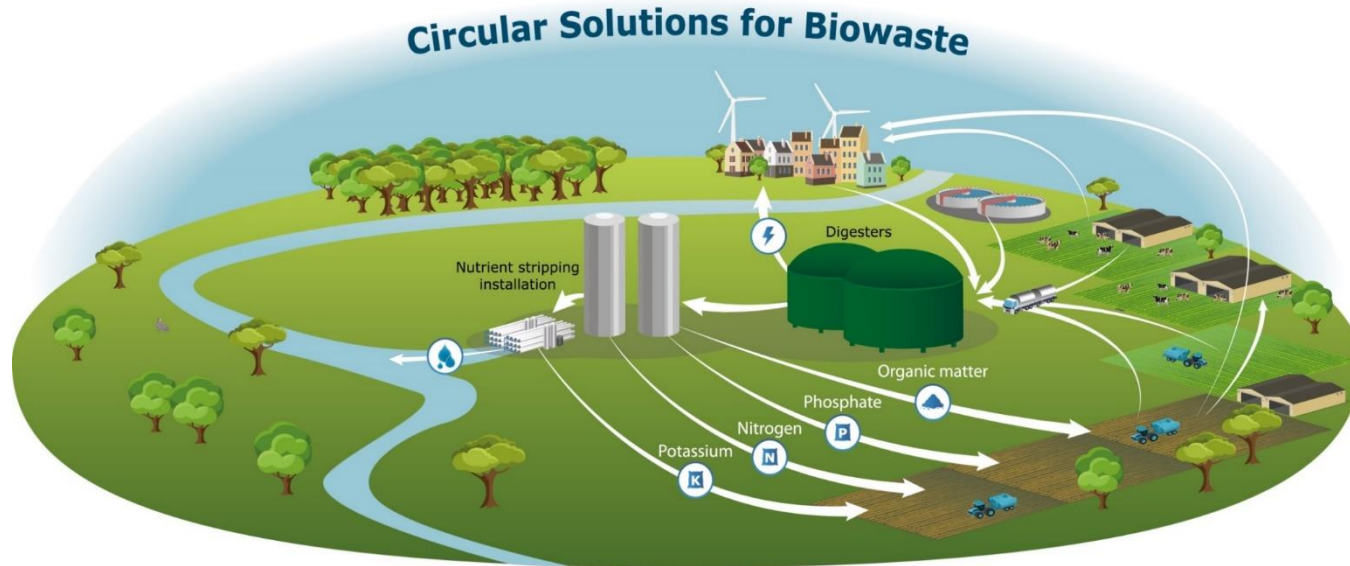
Policy advice

Policy advice to overcome innovation barriers e.g.

- Policy-Science workshops (2018) on Nitrate Directive
(all products of manure even in processed form are still manure →
limit of 170 kg N per ha in vulnerable zone).
- Meeting & visits policymakers: regional, ..., Members EP
- New Fertiliser Regulation & SAFEMANURE



Roadmap



Developing a roadmap for the transition towards a circular economy for nutrients and bioawaste

Conclusions (max 4)

- A lot of experiences has been obtained dealing with the constructing NRR technologies and demonstrating nutrient recovery at large biogas plants (four of the five plants are operational).
- Most plants will have economic benefits from nutrient recovery, but the financial impact is still not substantial (market development). Sustainability aspects are an important next step to address additional benefits.
- Knowledge exchange is very important for the first followers (interaction between plant owners, product quality, KPI, ...).



Thank you for your attention



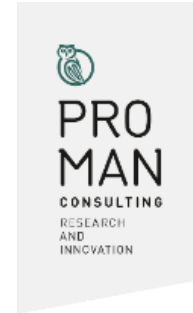
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SYSTEMIC Partners



Horizon 2020

Demonstration plant Acqua & Sole

Percentage of crop needs with Acqua & Sole digestate fertilization			
Nutrient category	Nutrient	Corn	Rice
Macro nutrients	N	63%	86%
	P ₂ O ₅	100%	100%
	K ₂ O	25%	26%
Meso nutrients	CaO	100%	100%
	MgO	46%	83%
	S	100%	100%
Micro nutrients	B	80%	60%
	Cu	100%	100%
	Fe	100%	100%
	Mn	100%	57%
	Si		100%
	Zn	100%	100%