Run4Life project.
Current results and exploitation pathways

Nicolás Morales Pereira
Run4Life Project Manager

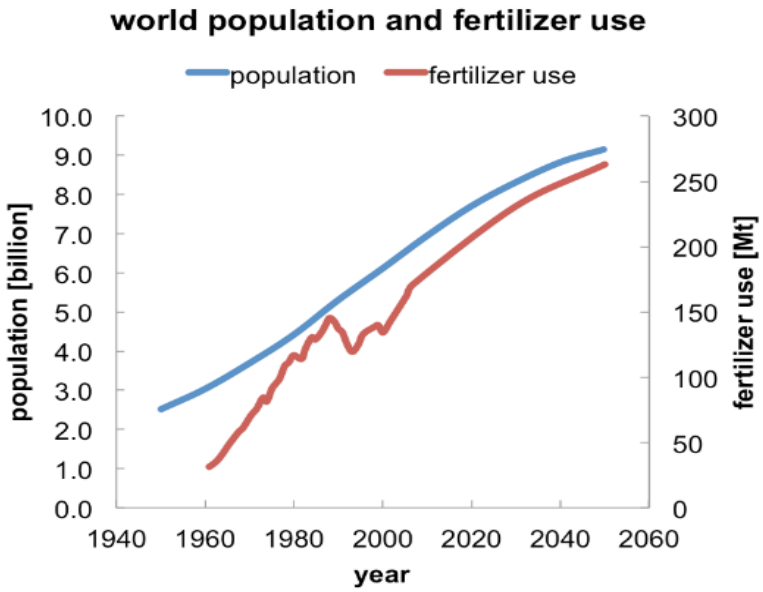
17th December 2020,
ULTIMATE Meeting on Nutrient Recovery

The Run4Life project receives funding from the EU Horizon 2020 Research and Innovation programme, under G.A. No 730285.

Nutrients in wastewater

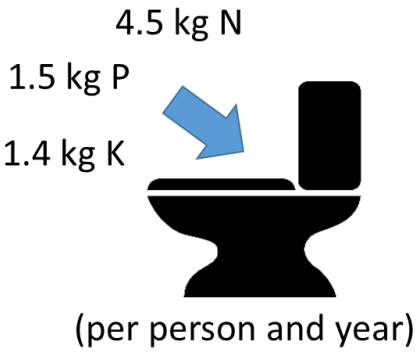
Context

- Global demand for food ↑
- Global demand for fertilisers ↑
- Phosphorus: not renewable, localised reserves
- Nitrogen: “Fertilizer from air” but highly energy demanding



Nutrients in wastewater (WW)

A potential pollutant – and important **resource** - currently not exploited in the conventional, centralised and linear approach based in the **old concept of Cloaca Maxima**



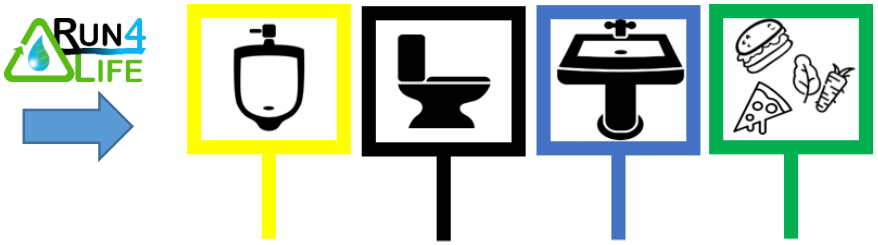
(per person and year)

Horizon 2020, GA 730285.

Run4Life change of concept

Run4Life: decentralised resource recovery at the source

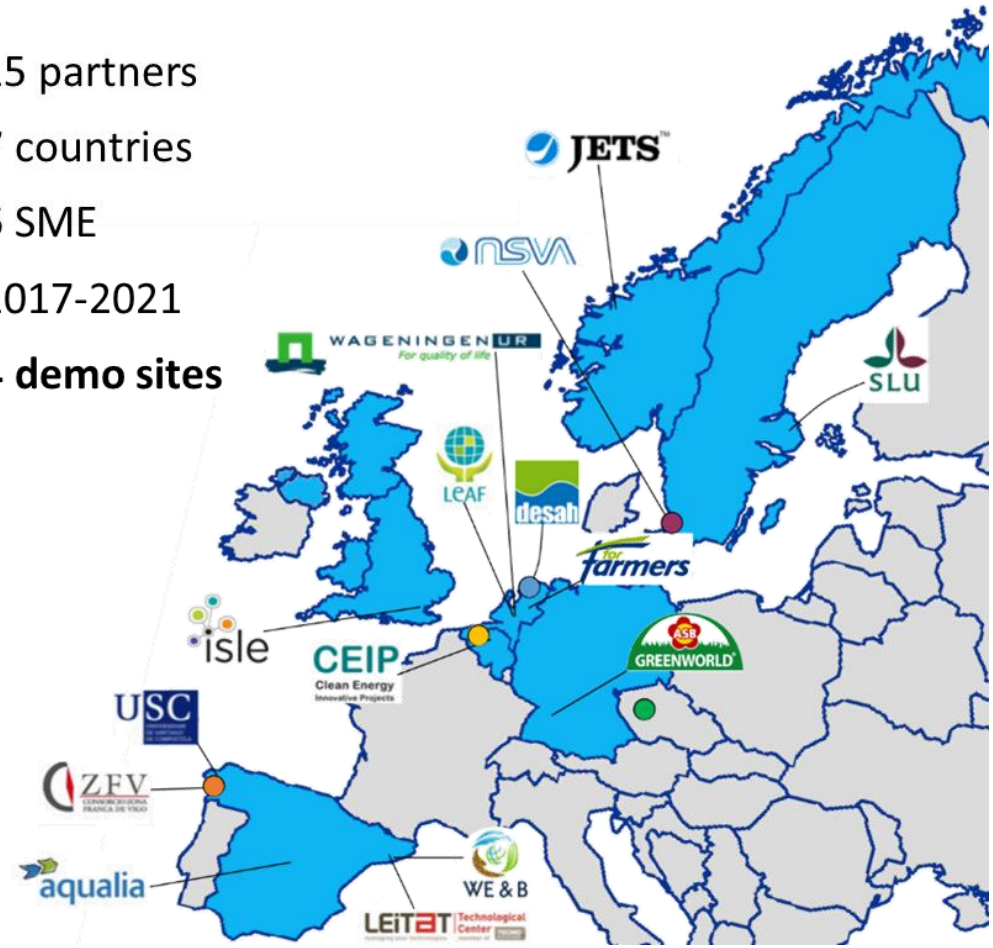
1. **Separation** at source
   - Black water (BW), kitchen waste (KW) and grey water (GW)
2. Technological **innovations** and **new business models.**
3. Break barriers to implementation: **market** uptake, and **social and legal** acceptance



Horizon 2020, GA 730285.

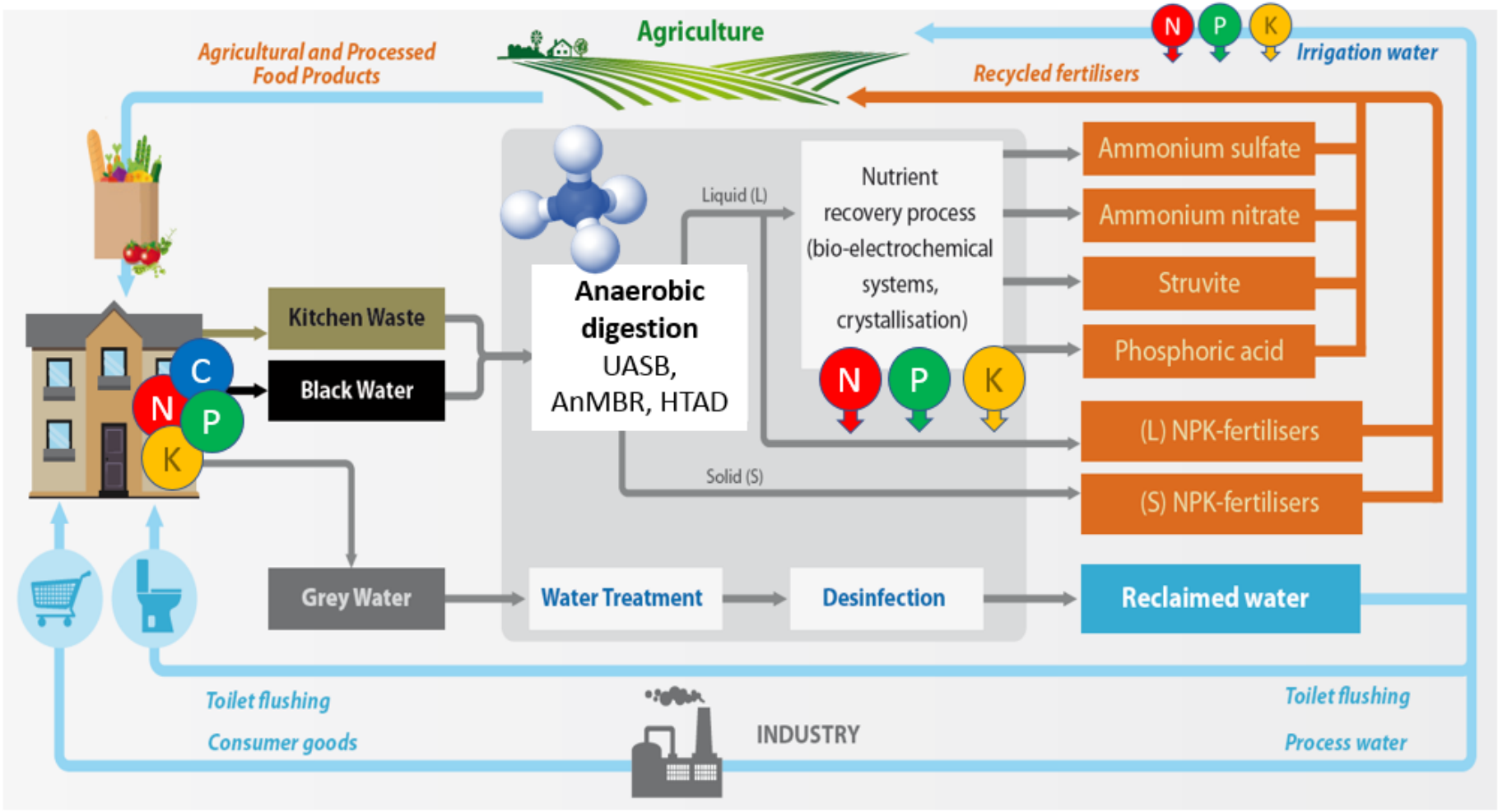
Run4Life project. General data and demo sites

- 15 partners
- 7 countries
- 6 SME
- 2017-2021
- **4 demo sites**



Horizon 2020, GA 730285.

Run4Life General flowchart



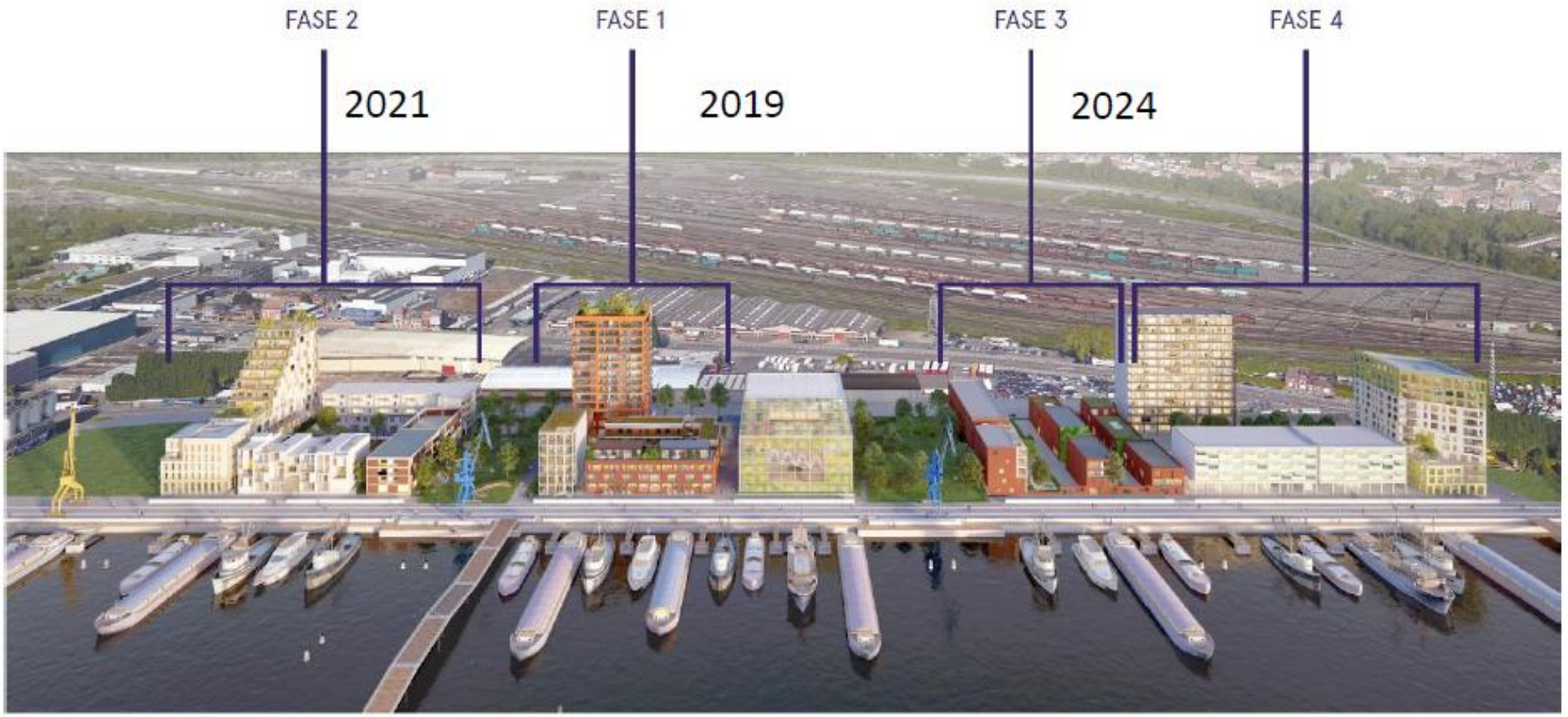
Horizon 2020, GA 730285.

Demo sites and technologies

Nieuwe Dokken - Ghent, Belgium (1200 p.e.)

CEIP Clean Energy Innovative Projects

DuCoop



>400 Housing units+ City complex (schools, sports infrastructure etc.)

Horizon 2020, GA 730285.

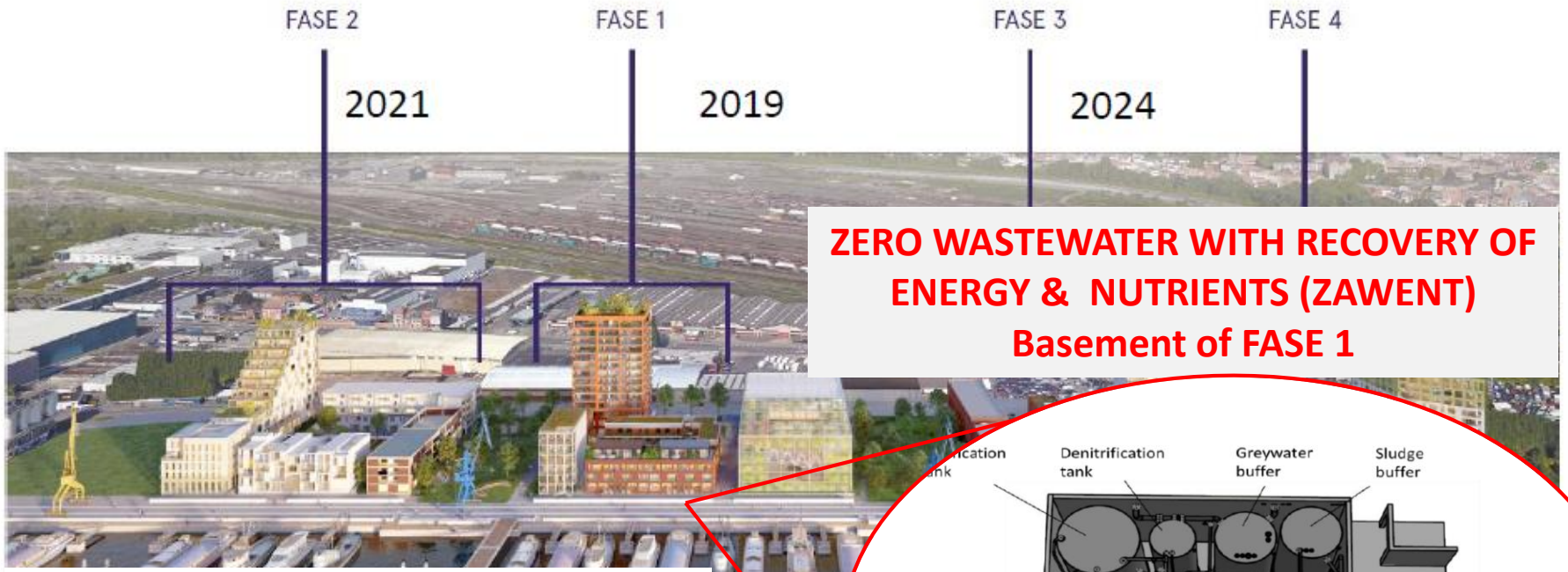
RUN4LIFE

Demo sites and technologies

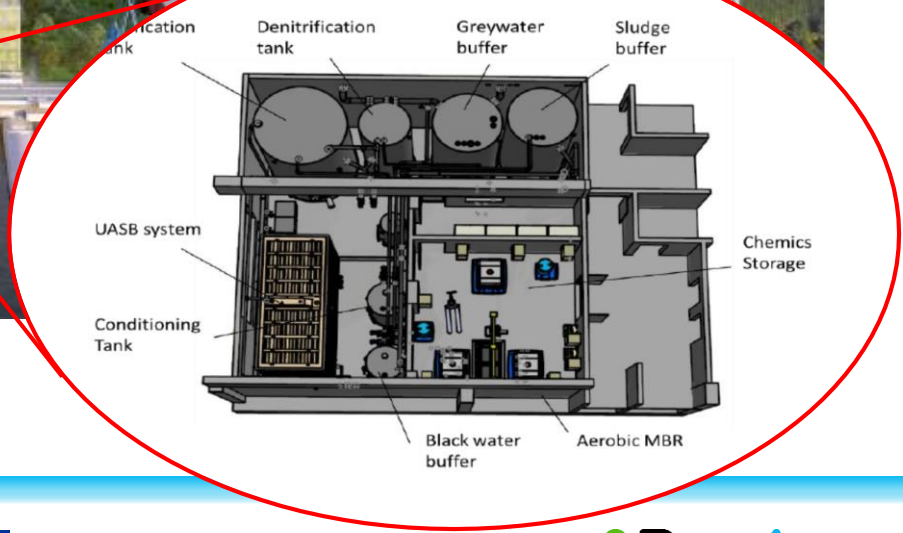
Nieuwe Dokken - Ghent, Belgium (1200 p.e.)

CEIP Clean Energy Innovative Projects

DuCoop



ZERO WASTEWATER WITH RECOVERY OF ENERGY & NUTRIENTS (ZAWENT)
Basement of FASE 1



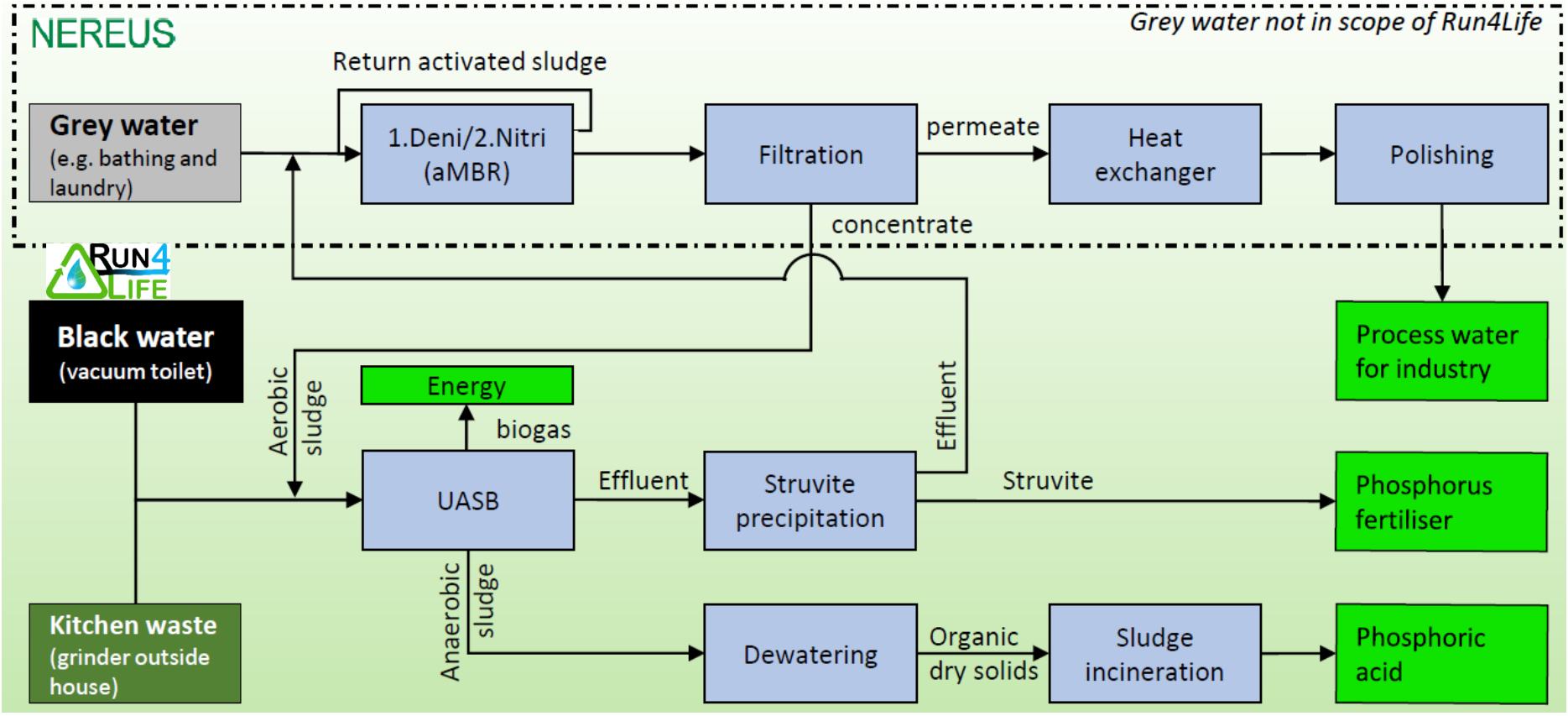
- 2500 MWh wasteheat
  - 2/3 process heat Christeyns
  - 1/3 from wastewater
- 30.000 m³ water
- 1.500kg green fertilizer

Horizon 2020, GA 730285.

RUN4LIFE

Demo sites and technologies

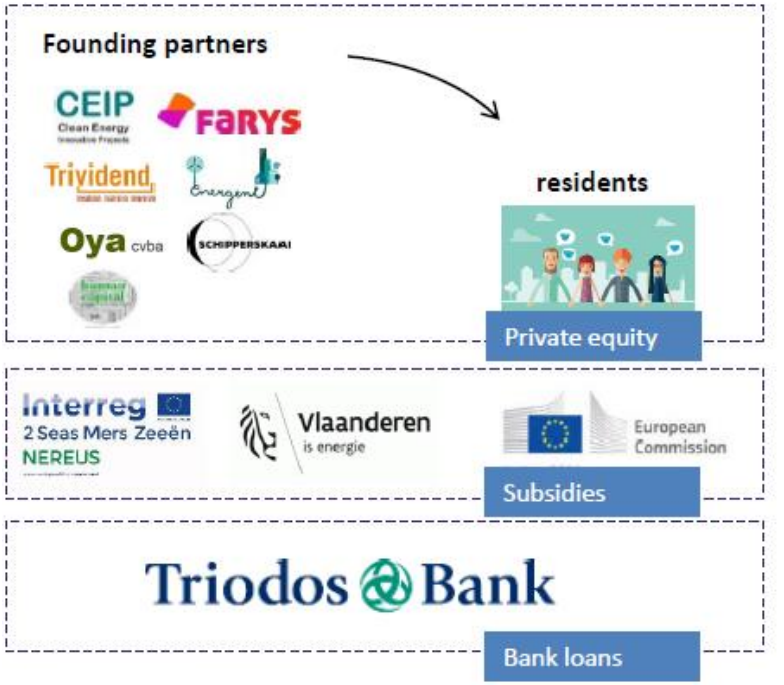
Nieuwe Dokken - Ghent, Belgium (1200 p.e.)

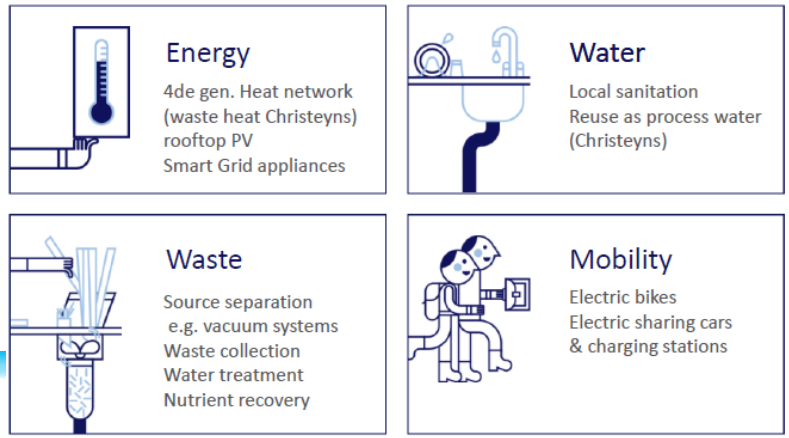


Horizon 2020, GA 730285.

Exploitation: Cooperative business model

Nieuwe Dokken - Ghent, Belgium (1200 p.e.)





How & why a cooperative legal entity?

- **Cooperation** with citizen participation allow for:
  - Flexible capital
  - Legal limit of 6% IRR
  - Securing **fair price** setting

DuCoop

- **Financial stimulus** for end users (correct use of the systems)

- Governance **participation** by **inhabitants**
  - Representation in Board and General Assembly
  - Voting right in General Assembly
  - Strong involvement / ambassadors

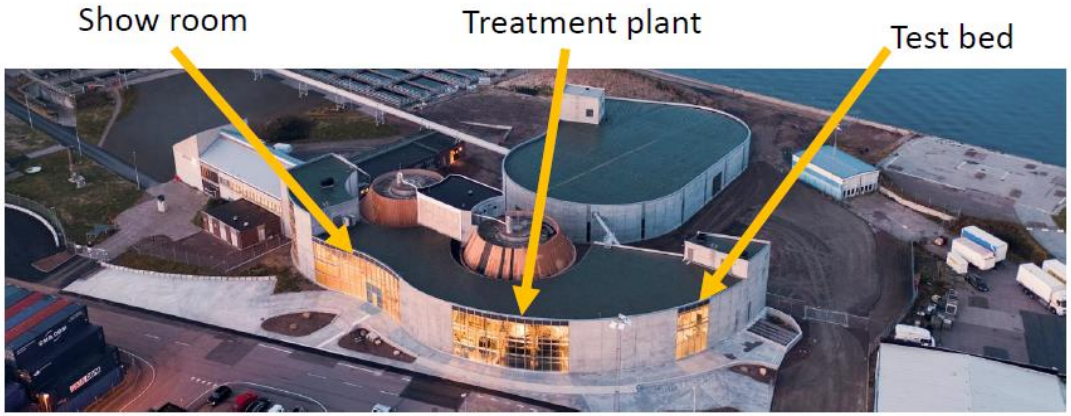
Horizon 2020, GA 730285.

RUN4LIFE

Demo sites and technologies

Oceanhamnen (H+) - Helsingborg, Sweden (1800 p.e.)

- Innovative waste and wastewater management system.
- Around 320 apartments and several office buildings

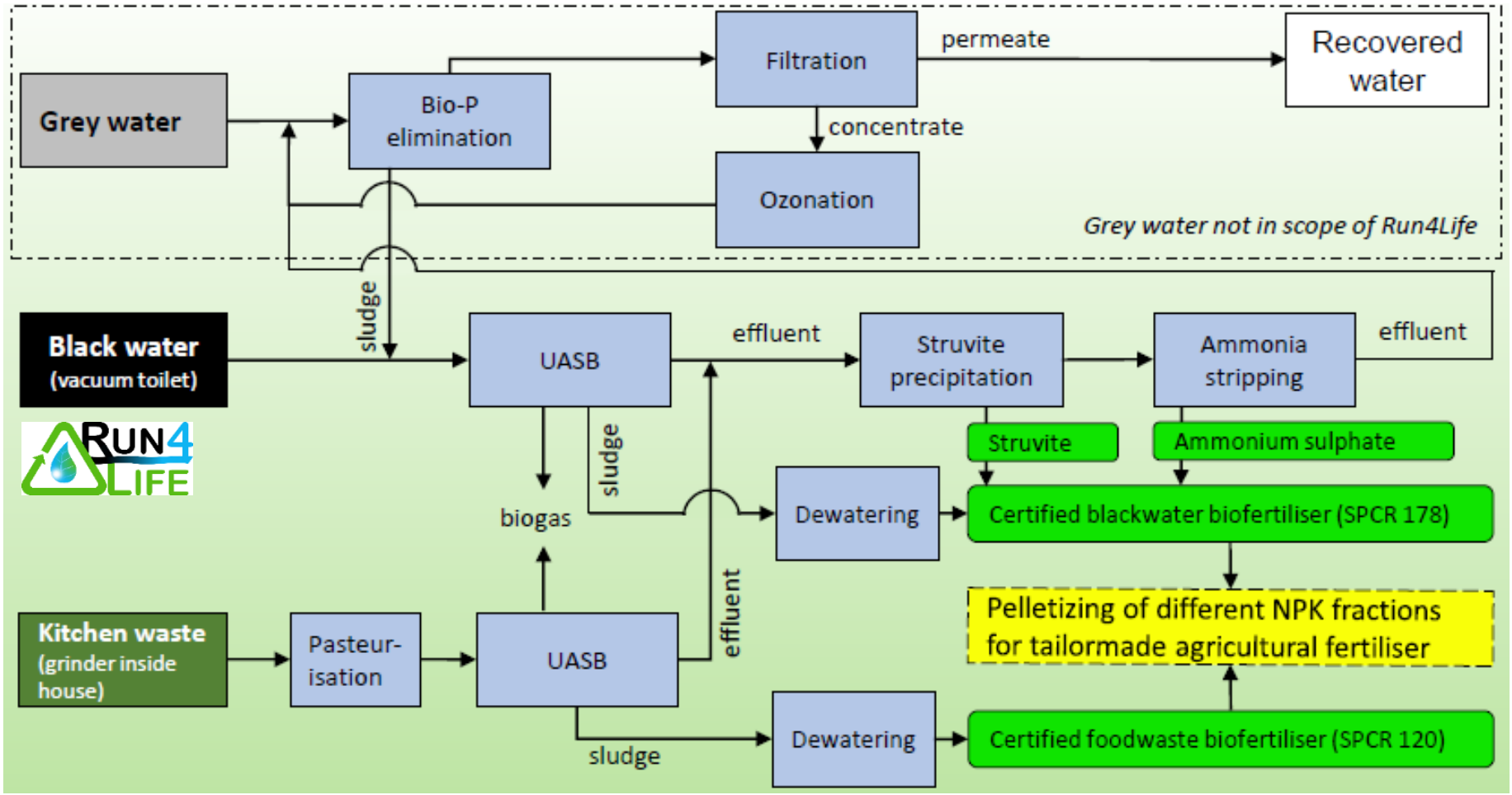


- Local treatment system
- Reco Lab: Recovery laboratory, test-bed facility
- Educational showroom

Horizon 2020, GA 730285.

Demo sites and technologies

Oceanhamnen (H+) - Helsingborg, Sweden (1800 p.e.)



Horizon 2020, GA 730285.

Exploitation: Tailor made fertilizer

Oceanhamnen (H+) - Helsingborg, Sweden (1800 p.e.)

NPK pellet

- **Dewatered food waste sludge** from anaerobic digester (certified as biofertilizer using national certification system)
- **Struvite** (EU end of waste classified as a product)
- **Ammonium sulphate** (EU end of waste classified as a product)
- Commercial **potassium chloride**

Accepted by farmers in Sweden:

- **The products are clean** (free from heavy metals and organic pollutants)
- **Concentrated** (at least 5% of nitrogen, but preferably up to 20%)
- Spread using **conventional equipment**

Horizon 2020, GA 730285.

Demo sites and technologies

Lemmerweg - Sneek, the Netherlands (32 houses)

Black water
(ultra low flush vacuum toilet)

biogas

HTAD

NPK liquid fertiliser

NPK solid fertiliser

Agricultural fertiliser

Horizon 2020, GA 730285.

Demo sites and technologies

Lemmerweg - Sneek, the Netherlands (32 houses)

Innovations: ULF Toilets

- Normal (gravity sewer) toilets: 4-9 L/flush
- Conventional vacuum toilets: 0.8-1.5 L/flush
- **ULF vacuum toilets: 0.4-0.7 L/Flush**

Benefits

-notable water savings

-smaller piping dimensions

-**highly concentrated blackwater**

> 40 g COD/L

Horizon 2020, GA 730285.

Demo sites and technologies

Lemmerweg - Sneek, the Netherlands (32 houses)

Innovations: (H)TAD

One step for 3 processes (innovation)

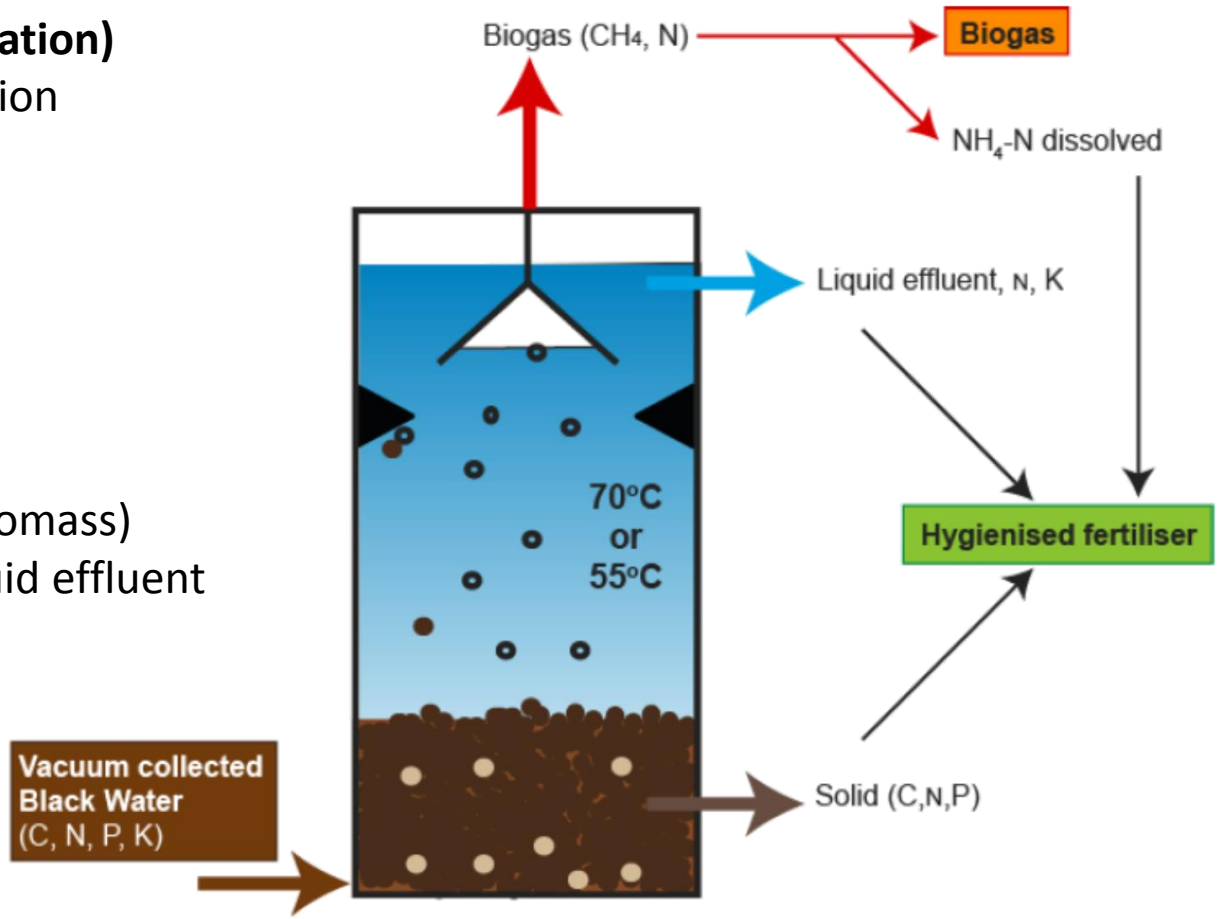
- Treatment and biogas production
- Fertiliser production
- Hygienisation

2 main fertiliser streams:

- liquid effluent
- sludge

Most P ends up in the sludge (biomass)

Most N and K ends up in the liquid effluent



Horizon 2020, GA 730285.

Demo sites and technologies

Lemmerweg - Sneek, the Netherlands (32 houses)

(H)TAD reactor performance:

Parameter	Unit	Reference 35 °C	Desah 70 °C	Desah 60 °C	Desah 55 °C (ongoing)
HRT	d	11 ± 1.0	14.9 ± 5.0	10.9 ± 1.0	Ongoing
OLR	gCOD/L/d	0.7 ± 0.1	1.72 ± 0.39	3.5 ± 1.1	
COD in	gCOD/L	10.1 ± 1.8	23.7 ± 2.0	41.7 ± 9.3	
COD_T Removal	**%**	**79.1 ± 4.9**	**42.2 ± 14.8**	**56.5 ± 17.9**	
Methanization	**% of COD_{rem}**	**87.3 ± 16.4**	**41.4 ± 12.3**	**51.9 ± 17.6**	

- COD removal and methanization increase with decreasing T
- The balance between hygenisation and methane production seems to be around 55ºC. (up to 80 % methanization at lab scale).

Horizon 2020, GA 730285.

Demo sites and technologies

Lemmerweg - Sneek, the Netherlands (32 houses)

(H)TAD reactor performance:

Fertiliser Production

	Reference		Run4Life	
	Influent (35°C)	Effluent (35°C)	Influent (60°C)	Effluent (60°C)
Total N (g/L)	1.4	1.3	3.8	2.9
NH4-N (g/L)	0.8	1.1	1.5	1.8
Total P (mg/L)	120	96	960	340
PO4-P (mg/L)	101	89	420	164
CARBA (CFU)	0.9	0.03	Not Detected	Not Detected
TBX E.coli (CFU)	5.9	3.6	5.5	Not Detected
ESBL (CFU)	3.9	1.2	3.9	Not Detected

Horizon 2020, GA 730285.

Exploitation: (H)TAD and ULF toilets

Lemmerweg - Sneek, the Netherlands (32 houses)

Full scale installations for decentralised sanitation and resource recovery

Niche market cases:

- New build districts
- High rise buildings
- Sustainable resorts
- Areas with no sewer connection / no capacity for increased sewage flow

- ULF Toilet useful if technology downstream take profit from the ultra concentration of blackwater → Recovery of energy/nutrients

Horizon 2020, GA 730285.

Demo sites and technologies

Porto do Molle Business Centre - Vigo, Spain (250 people)

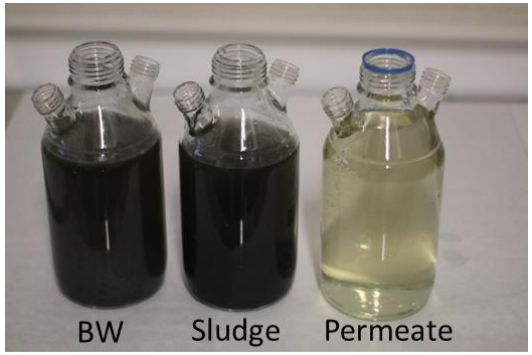
Horizon 2020, GA 730285.

Demo sites and technologies

Porto do Molle Business Centre - Vigo, Spain (250 people)

AnMBR treating BW at room temperatura (25 ºC).
Flow: 0.8-1.5 m^3/d
Stable operation: 8-10 LMH
COD BW inlet: 1425 ± 823 mg/L
COD removal: 94 %

Steady state biogas production ≈ 0.25 m^3/d
Methane ≈ 73%.

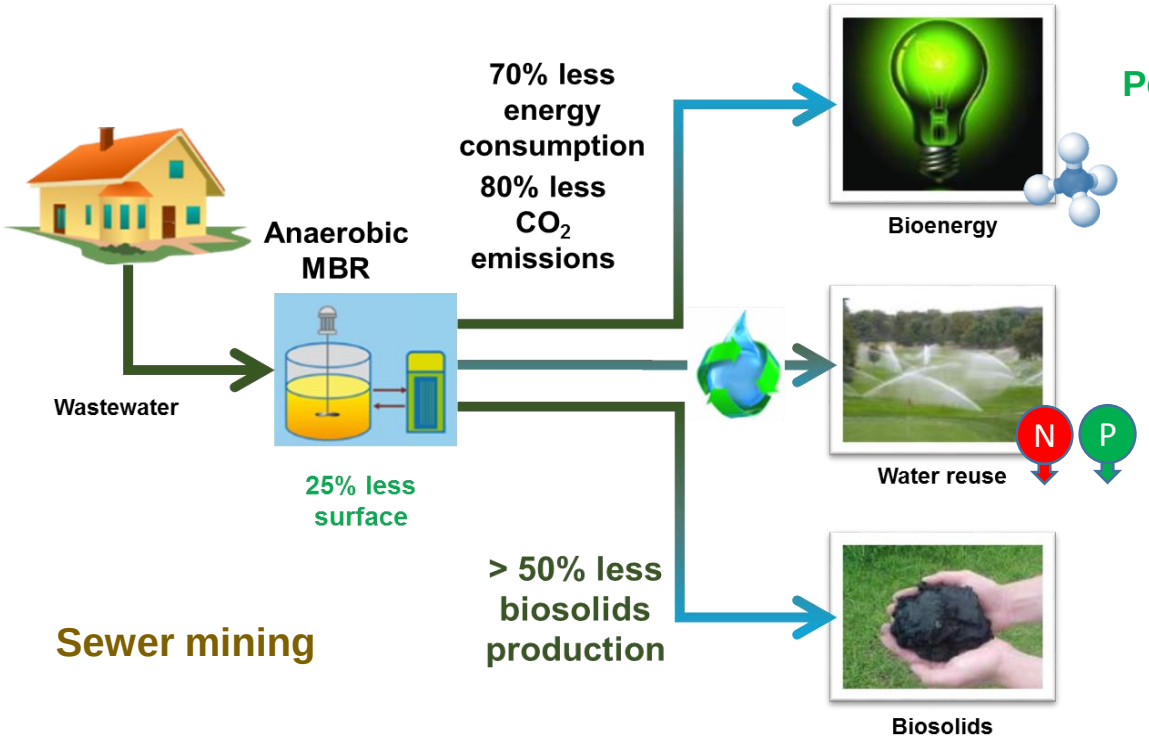


Parameter	Blackwater	Treated water
Total P (mg/L)	20 ± 10	17 ± 5
N-NH_4^+ (mg/L)	115 ± 40	130 ± 45
Total N (mg/L)	190 ± 70	195 ± 90
Potassium (mg/L)	120 ± 30	110 ± 30
pH	7.3 ± 0.3	7.15 ± 0.15
Alcalinity (mg IC/L)	133 ± 47	117 ± 30

Horizon 2020, GA 730285.

Exploitation

Anaerobic Membrane Bioreactor AnMBR



Potential Net Energy production of > 0.1 kWh/m³

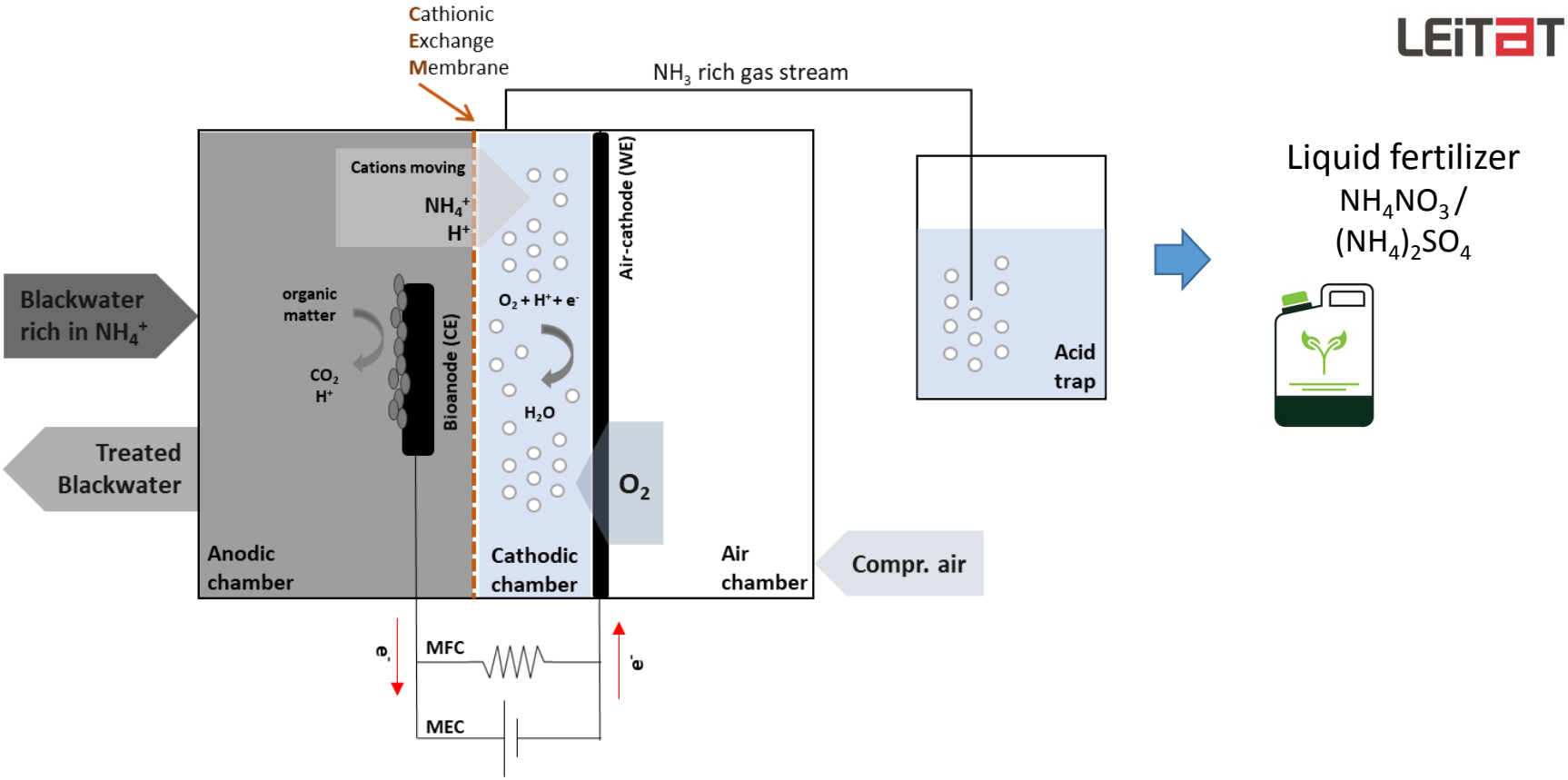
Sewer mining

Disinfected Nutrient Rich Water for Irrigation

Horizon 2020, GA 730285.

Demo sites and technologies

Innovations: Nitrogen recovery with BioElectrochemical Systems (BES)



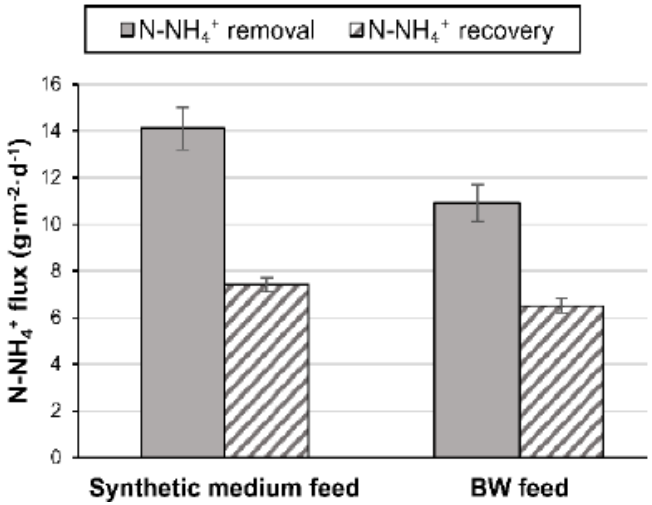
Operating as MEC in a 5 d batch

- Recovering up to 61% of initial N present in BW (1 g N/L)
- Rate of 12.8 g N/m^2/d

Horizon 2020, GA 730285.

Demo sites and technologies

Innovations: Nitrogen recovery with BioElectrochemical Systems (BES)



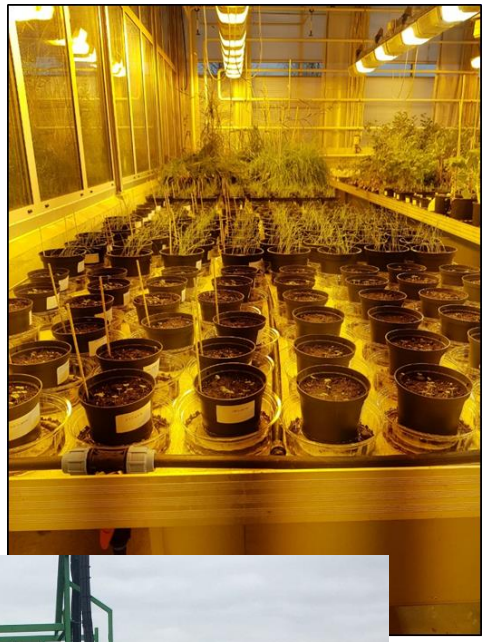
≈40-50% N recovery in the acid trap as liquid fertilizer

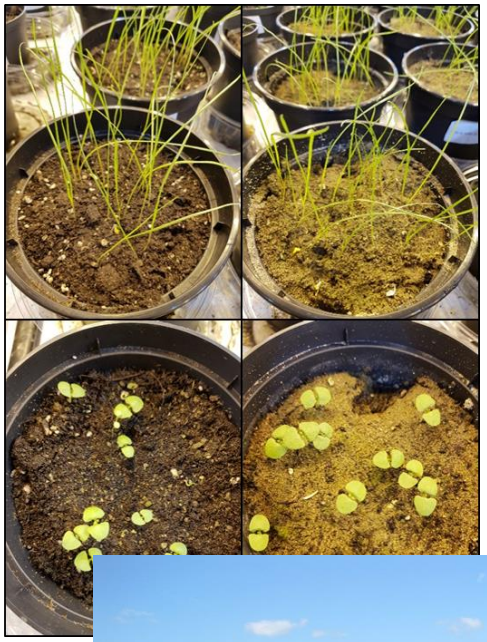
	Reference MEC in literature	Run4Life MEC system
Applied potential (V)	0.6-2.12[1,2]	0.2
Current density (A/m²)	1.89-30[1,2]	2.78
$N\text{-}NH_4^+$ removal efficiency (%)	34.3-51[1]	81
$N\text{-}NH_4^+$ recovery efficiency (%)	79-94[2]	60
Energy consumption	6.04-20.5 kWh per kg of nitrogen removed [3,4]	1.61 kWh per kg of nitrogen removed[4]
		2.24 kWh per kg of nitrogen recovered[4]

>50% reduction respect SOA

Horizon 2020, GA 730285.

Pot and field fertilizer tests





Horizon 2020, GA 730285.

Contact details

Nicolás Morales Pereira
Run4Life Project Manager
Nicolas.Morales.pereira@fcc.es

Hamse Kjerstadius,
Development engineer NSVA
hamse.kjerstadius@nsva.se

Paraschos Chatzopoulos
R&D Process Engineer Desah BV
P.Chatzopoulos@desah.nl

Miriam van Eekert,
Wageningen University
miriam.vaneekert@wur.nl

Lieven Demolder
Clean Energy Innovative Projects CVBA
lieven.demolder@cleanenergyinvest.be

Daniel Todt
dt@ecomotive.no

Eduard Borràs Camps PhD
Senior Researcher.
eborras@leitat.org

www.run4life-project.eu

www.linkedin.com/in/run4life-project

twitter.com/RUN4LIFE_H2020

Horizon 2020, GA 730285.