

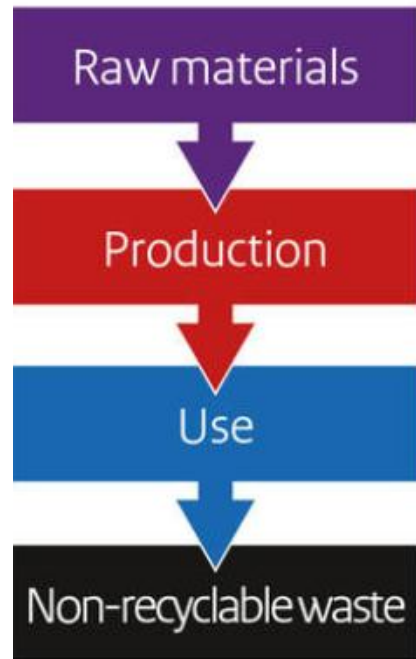


Circular economy of water from buildings to wastewater treatment plants

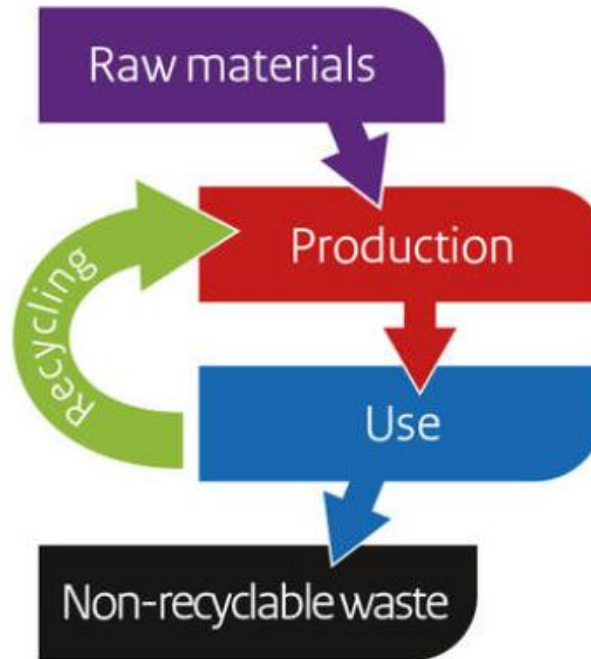
Julien Le Roux & Régis Moilleron

From linear economy to circular economy

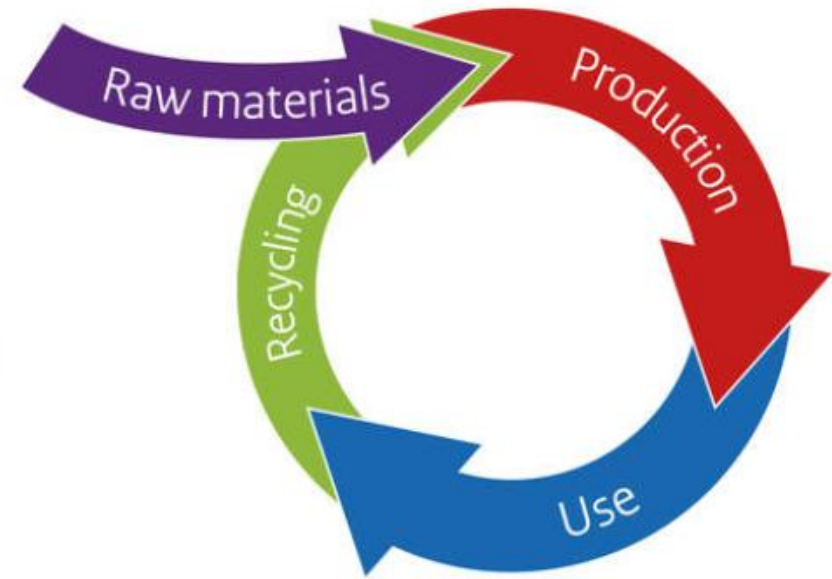
Linear Economy



Reuse economy



Circular economy

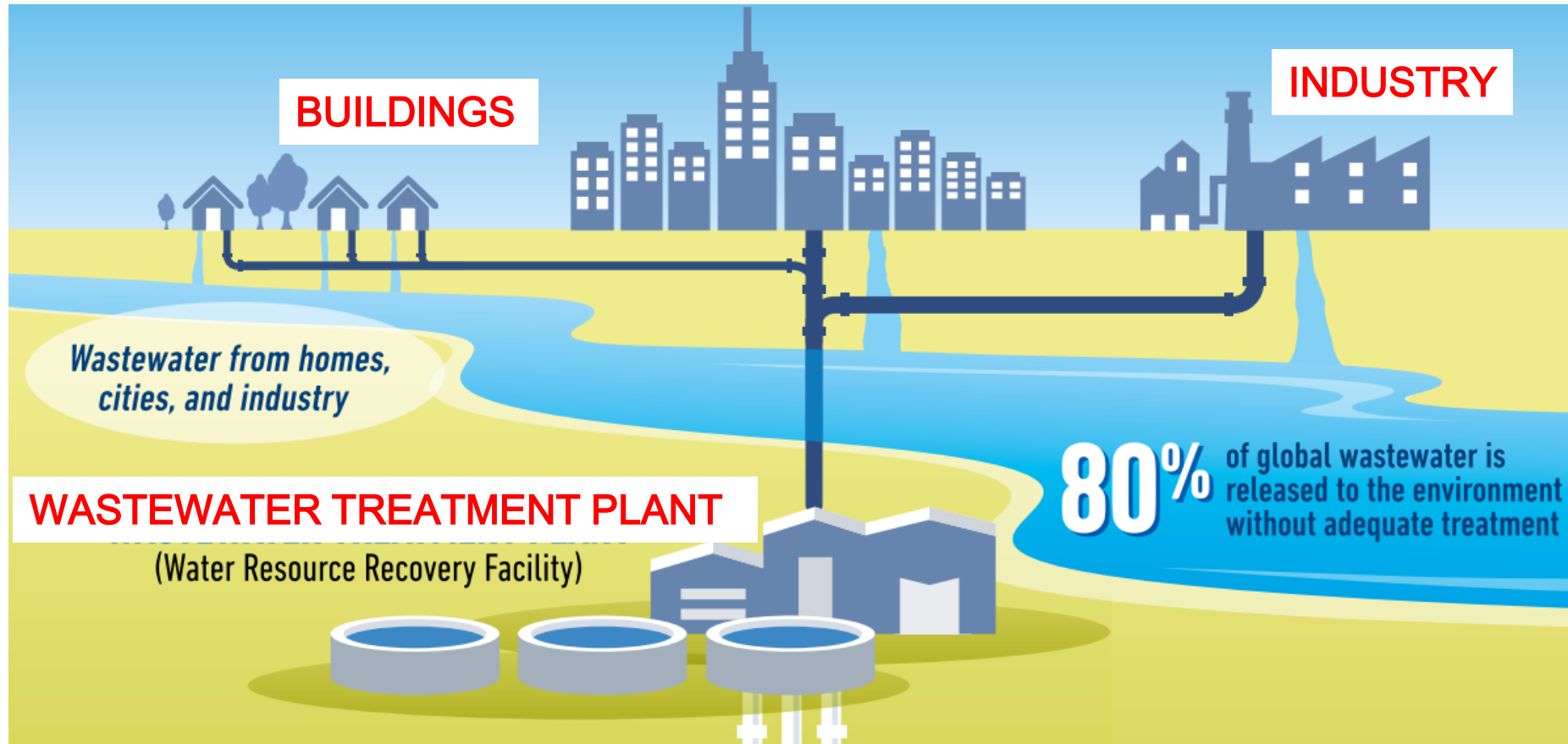


No concern on product's ecological footprint
Prioritizing profits over sustainability

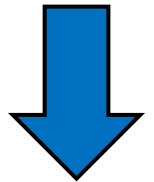
Reducing waste, promoting reuse and
recycling material production

Implementation of circular economy to wastewater field

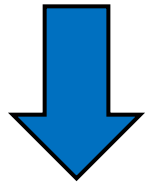
General scheme



Wastewater



Sewer network



WWTP



Implementation of circular economy to wastewater field

General scheme

The **WWTP** becomes **a water resource facility**

- **WATER**

- Nutrient recycling*

- Reduce both fertilizers demand & consumption of water and energy.

- Water reuse*

- Agriculture and land irrigation, toilet flushing, groundwater replenishing

- **SLUDGE**

- Biosolids*

- Phosphorous recycling (struvite precipitation)

- Energy recovery*

- Biogas production from anaerobic digestion



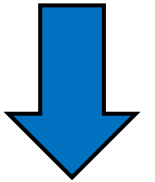
Implementation of circular economy to wastewater field

Alternative scheme

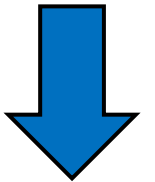
Circular approaches can be implemented at different levels:

- *Dwellings*
 - Energy recovery from greywater to produce hot water → energy savings
- *Buildings*
 - Energy recovery from greywater to produce hot water → energy savings
 - Reuse of greywater after phytoremediation for toilet flushing → water savings
 - Phyte'up project*
 - Separation at source of urine → nutrients recovery,
 - OCAPI project*
- *Sewer network*
 - Energy savings for public facilities (swimming pools, gyms, offices...)
- *Wastewater treatment plant*

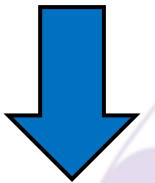
Dwellings



Buildings



Sewer network



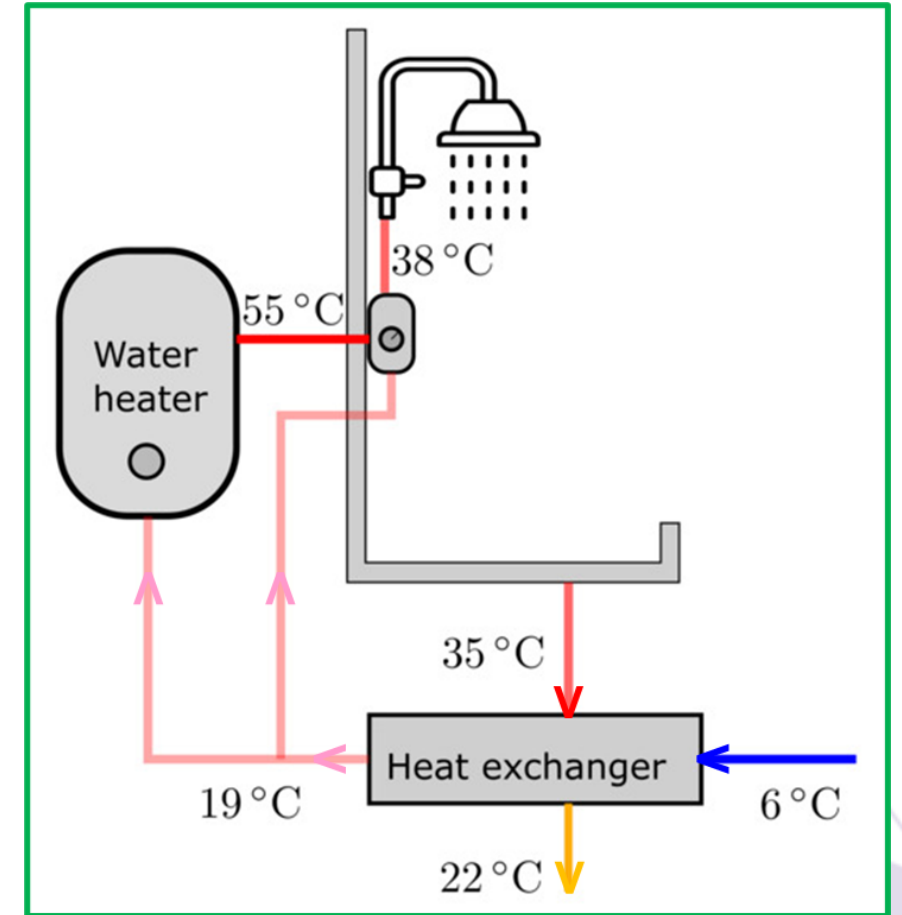
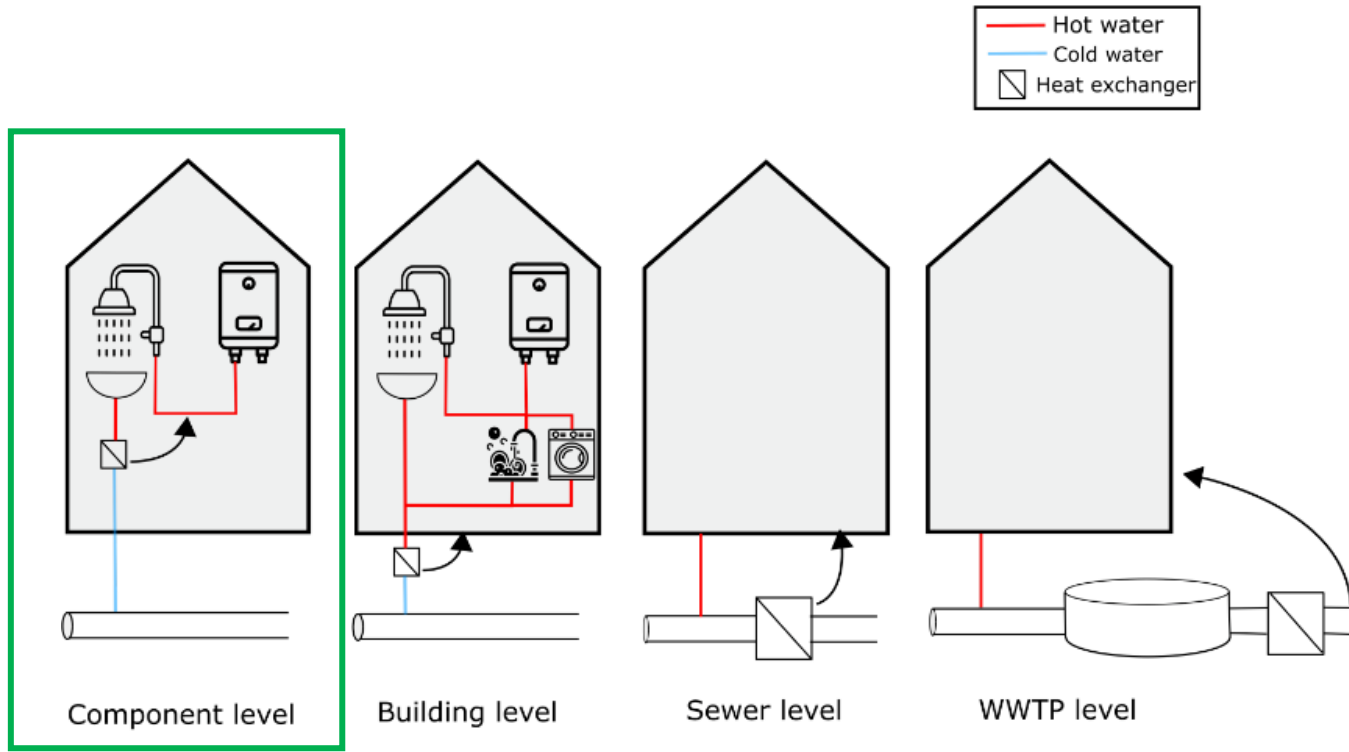
WWTP



Implementation of circular economy to wastewater field

Alternative scheme

Heat recovery at different scales

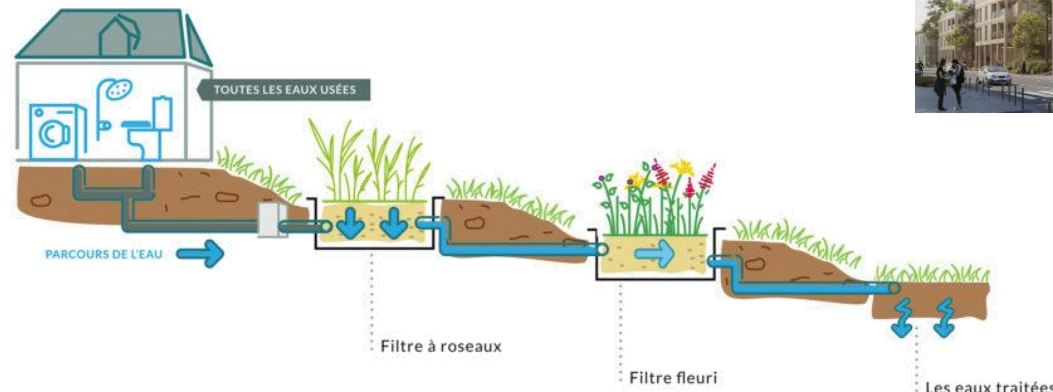


The shower component

Building level - Phyte'up project

General principle

- Reuse of greywater in buildings
 - Heat recovery, toilet flushing, greenspace irrigation
 - Restrictive regulations... evolving
 - Main obstacle: what quality(s) for what use(s)?
- Adaptation of the principle of phytoremediation in a context of reduced or even non-existing land availability...
 - Transfer to roof: constraints?
 - How to reproduce the filtration processes?



Building level - Phyte'up project



Rooftop phytoremediation

- Environmental benefits
 - Cooling in summer and warming in winter by 1 to 3°C
 - Increase of biodiversity
- Benefits for users
 - Reduction in water consumption (20% minimum - 32%)
 - Reduction in the volume of water returned to the sanitation network
 - Awareness of the impact of everyday practices on the quality of gray water

Demonstrators under construction

Collective housing
for social landlord



Olympic Village
Emergency Center



Company headquarters

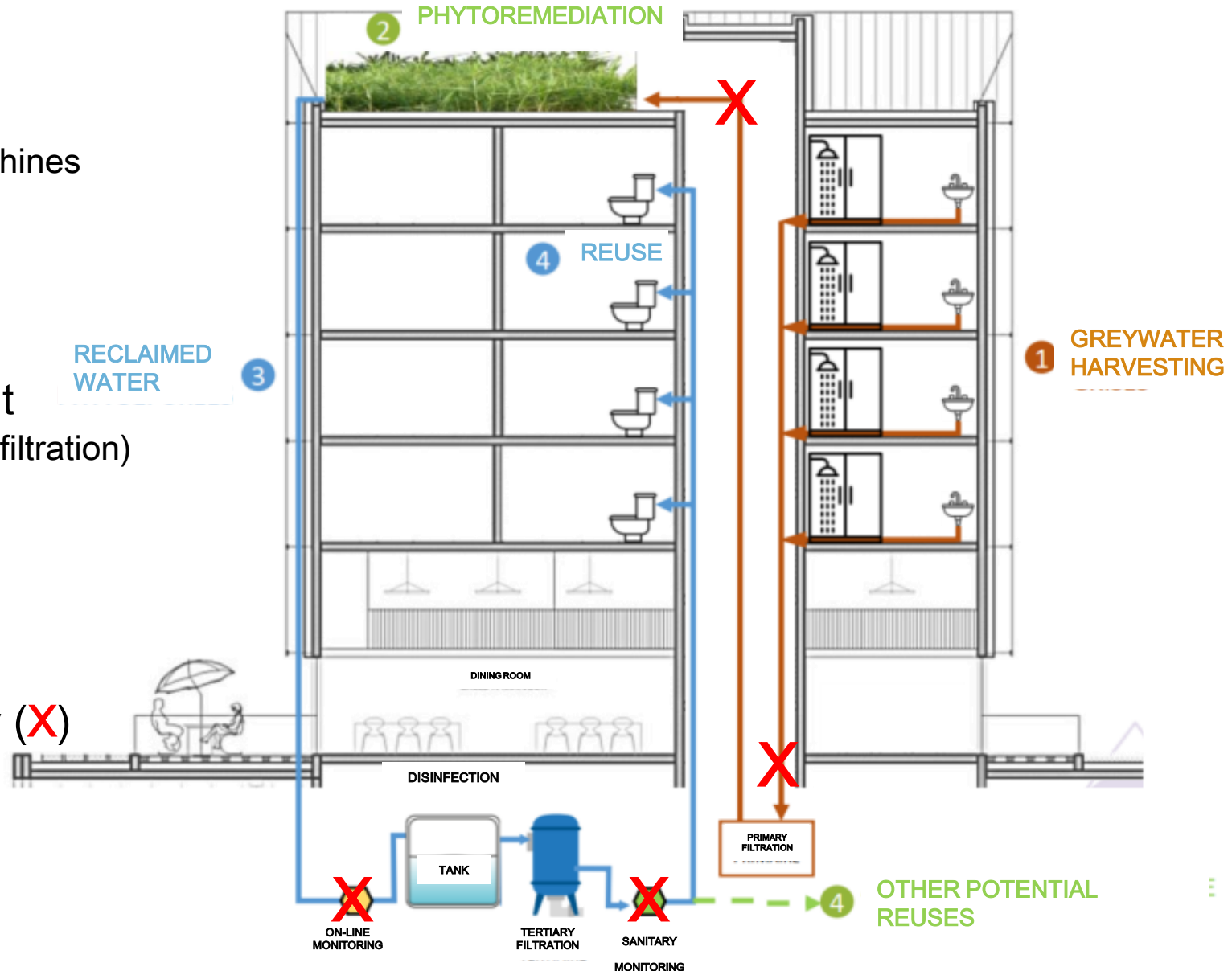


Building level - Phyte'up project



Demonstrator principles

1. Greywater harvesting
 - From showers & washing machines
 - *Pre-treatment* (filtration)
2. Phytoremediation
3. Reclaimed water treatment
 - *Post-treatment* (disinfection & filtration)
4. Reuse within buildings
 - Toilet flushing
 - Greenspace irrigation
5. Monitoring of water quality (X)
 - Raw greywater
 - Reclaimed water
 - Disinfected water

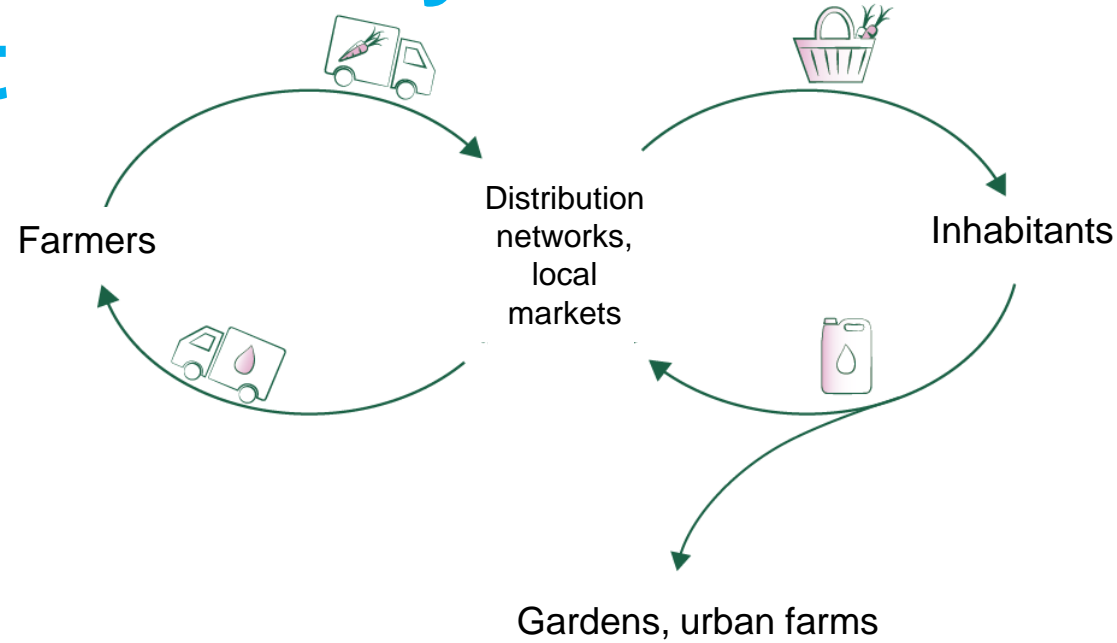


Building level - and beyond : OCAPI project



OCAPI

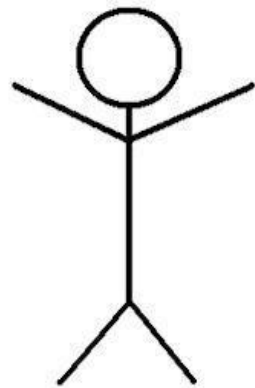
www.leesu.fr/ocapi



Yearly
needs



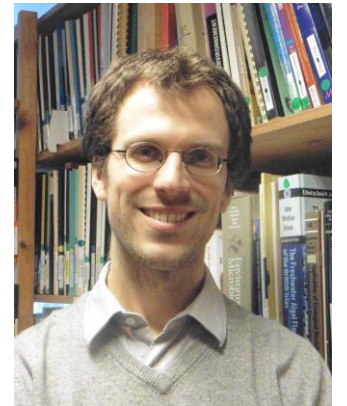
4,6 kg of N
(proteins)



4 kg of N
(urea)

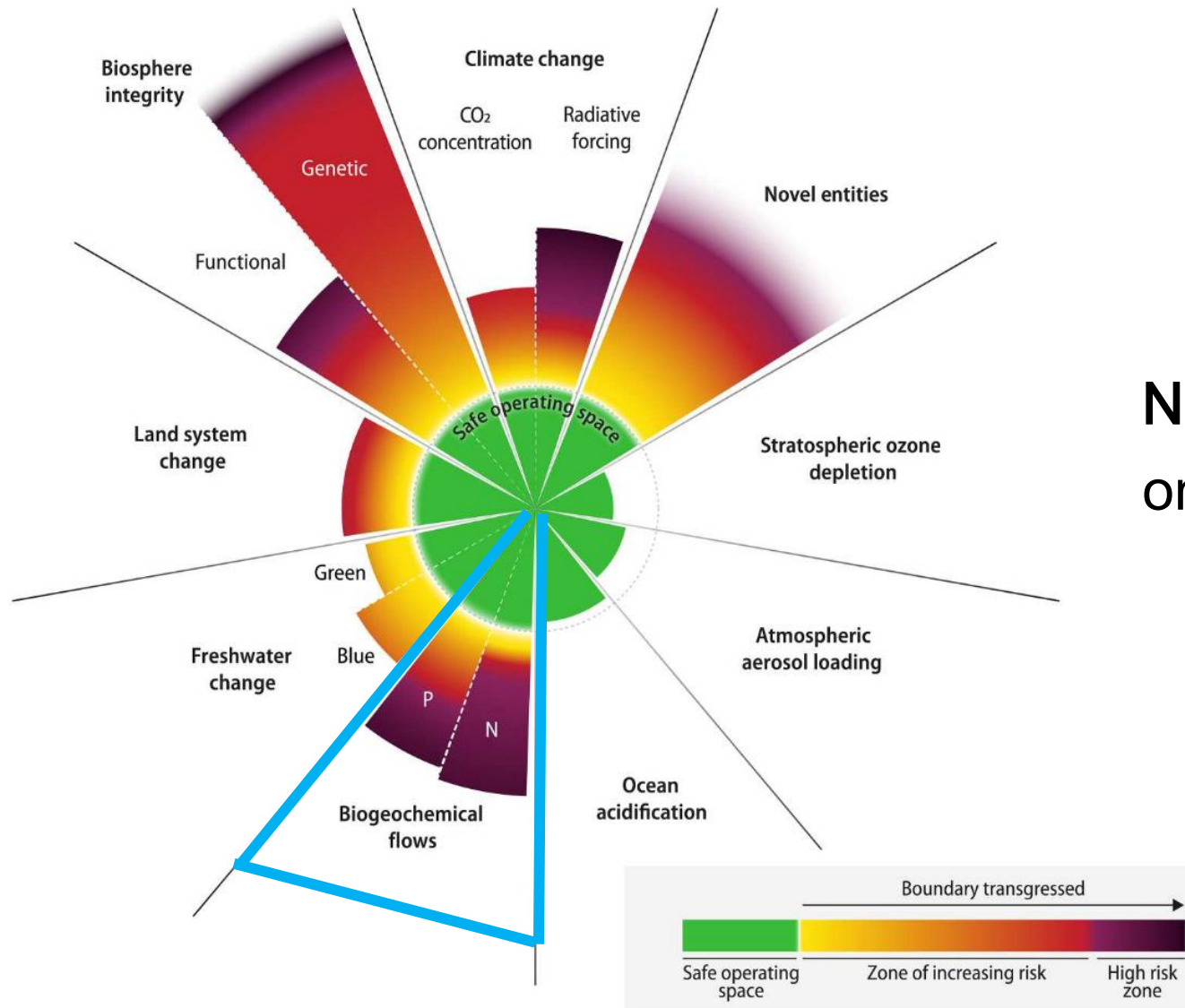


0,6 kg de N



Fabien Esculier:
PhD thesis in 2018
Researcher at Leesu

Planetary boundaries



Nitrogen and phosphorus cycles:
one of the six transgressed boundaries



The nitrogen path to our plates

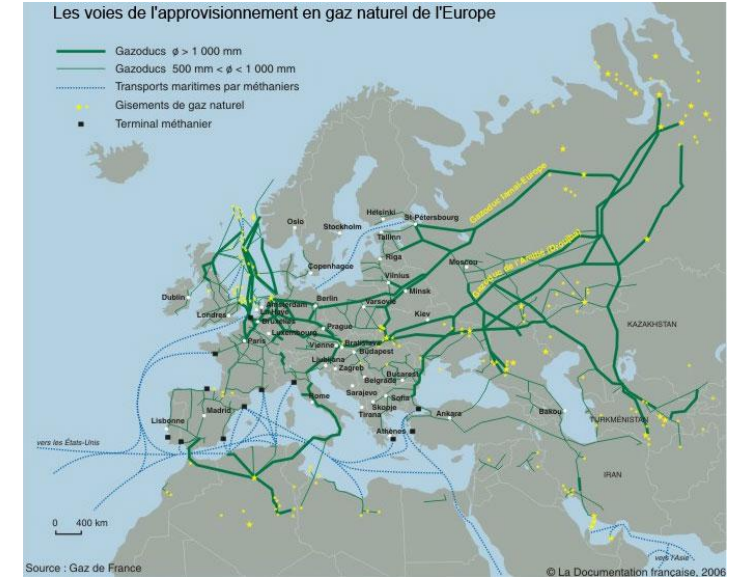


→
 N_2

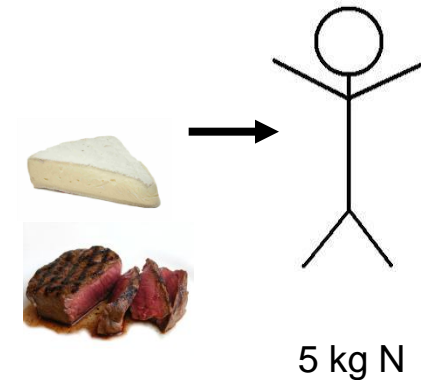
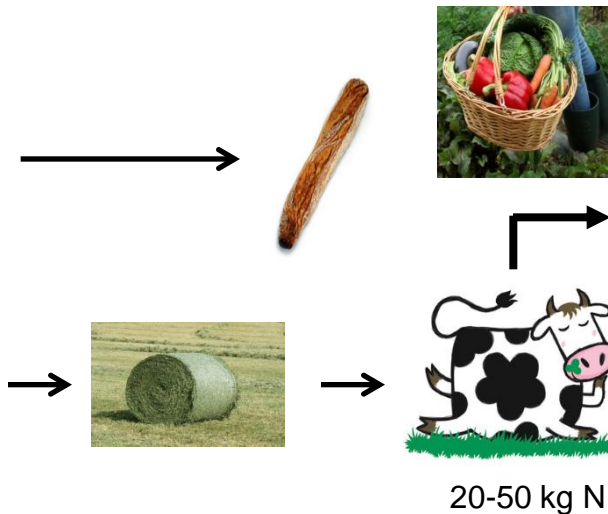
Haber-Bosch process



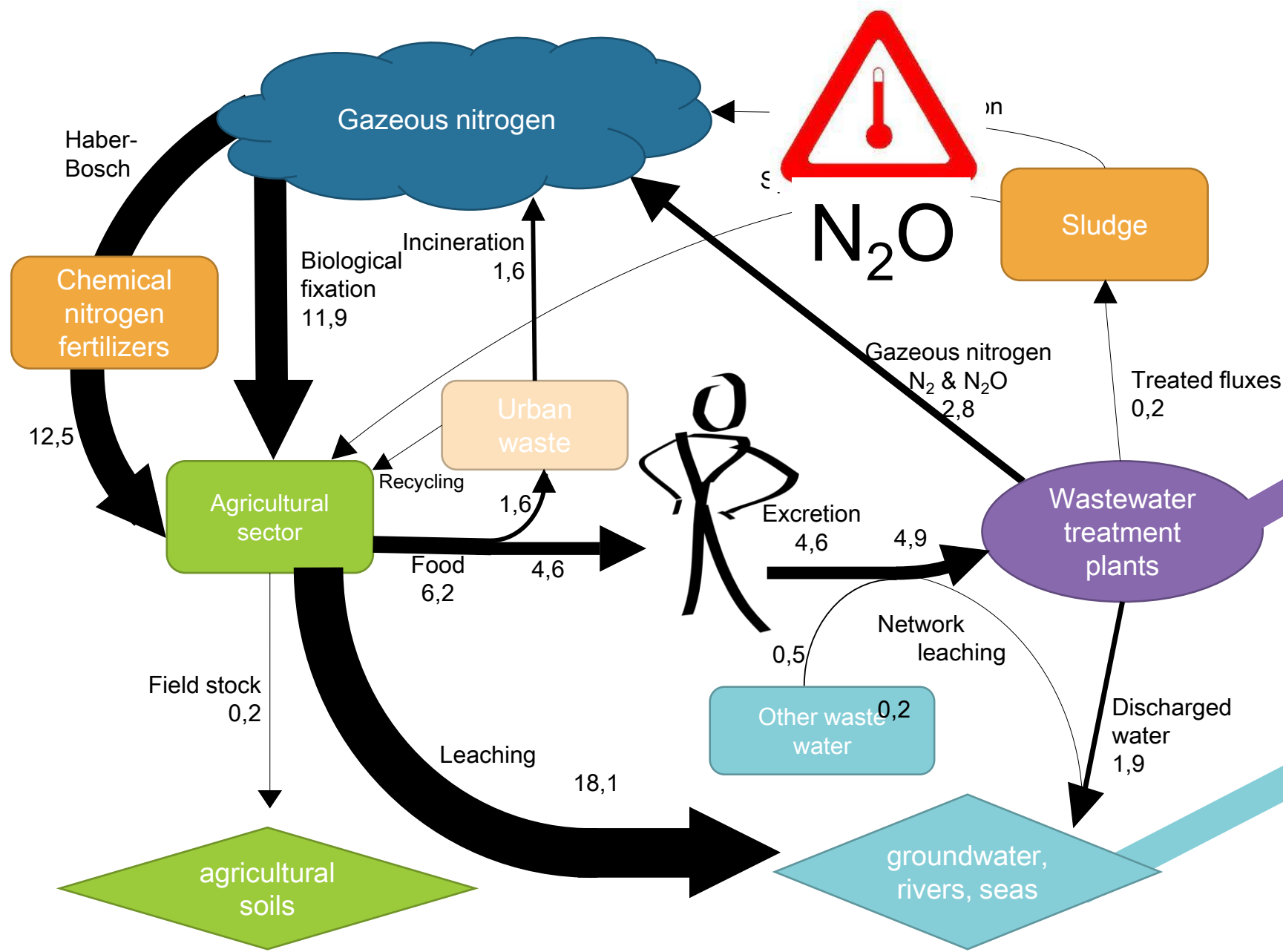
←
Methane
(natural gas)




Chemical
fertilizers ↓



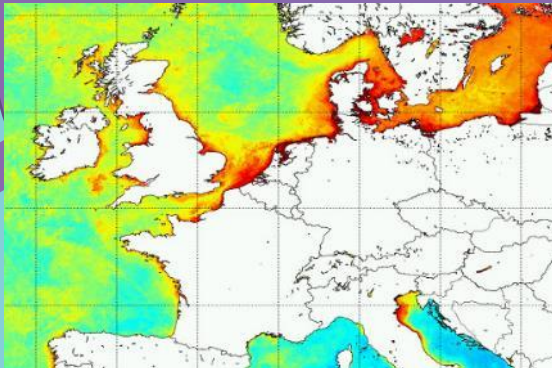
A crazy nitrogen cycle? (kgN/year/inhab)




eutrophication



nt



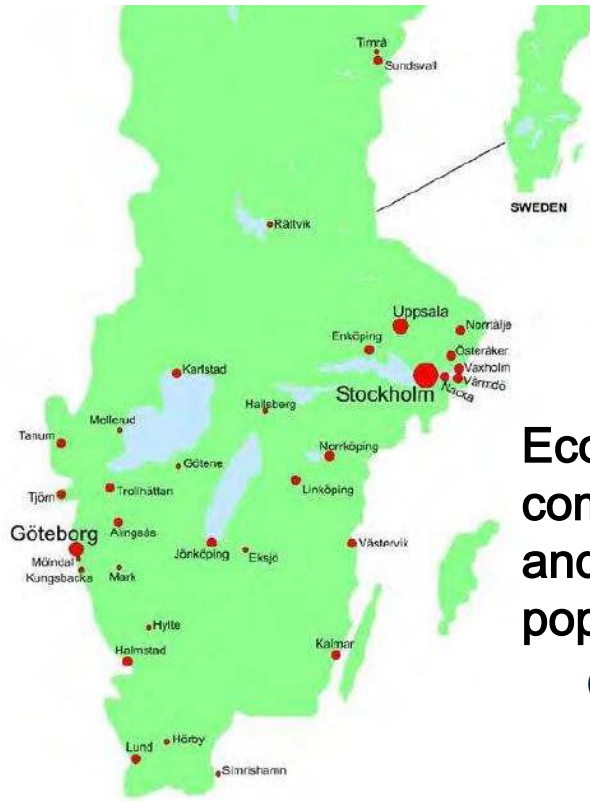


A few examples: Sweden, since 1990



2006 : (Vinneras, 2013)

- 120.000 dry toilets with urine separation
- 15.000 water-closets with urine separation



Eco-villages with
committed residents
and a low density of
population

(1995-2006)



Switzerland: EAWAG since 1996



Nitrification + distillation



Aurin (authorized for agriculture in Switzerland)



Netherlands



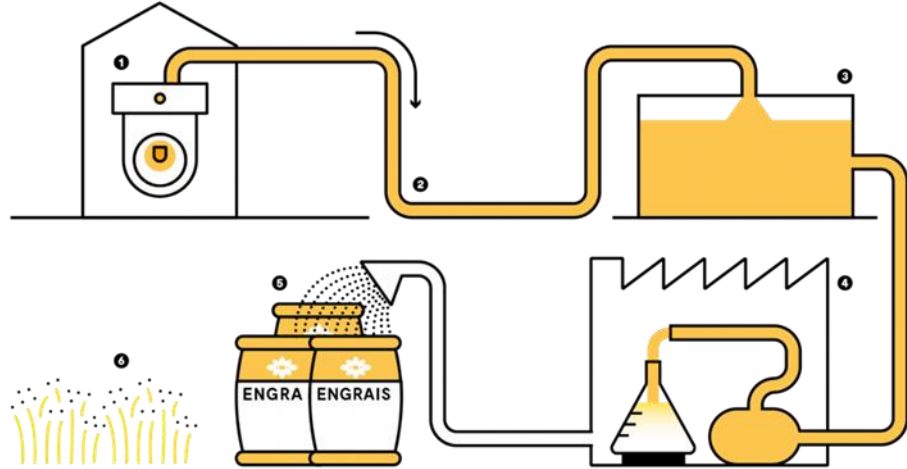
Ammonium sulfate and struvite
synthesis from urine (Saniphos)



France



P&Ma



47 000 L/y:
Used for green
spaces in Paris



Saint-Vincent-de-Paul neighborhood - Paris
2018-2020 then 2024: 1st project for whole
neighborhood (600 dwellings)
with urine diversion

Paris-Saclay - Urinagri project



Valorisation agricole des urines humaines

Essais en cours sur le Plateau de Saclay



Saclay, Ferme de la Martini  re (Avril 2022)



Experimental building with urine separation



- 18-20 m³ / year
- Spreading on 1 ha
 - 6 story building
 - 10 men's urinals
 - intermediate storage tank
 - Nitrification filter (Pitribon)
 - Activated carbon filter
 - Final storage
 - Spreading twice a year





2022: first study with **wheat** to know the efficiency of urine fertilizer

2023: **corn** field study to determine the impact on productivity (Trou Salé farm / Julien Thierry)

Med-UrinAgri Project started in 2023: wheat and determine accumulation of **pharmaceuticals in soil**

- Four tests:
 - Reference (no nitrogen)
 - Non-treated urine
 - Treated urine
 - Aurin (treated)
- Target screening analyses (INRAE)
- Non-target screening (LEESU)



Conclusion: new paradigms for water management

- Possibilities of **circularity** in the WWTP
- Potential efficient **solutions** at other scales (at the source, in buildings...)



BUT

- **Obstacles:** **regulation** (quality of reclaimed water in buildings must be the same as tap water), **infrastructure in place** difficult to modify (sewer networks)
- **Levers:** integration of new solutions in **sewer networks** (heat exchangers), and in **new buildings** (source separation)

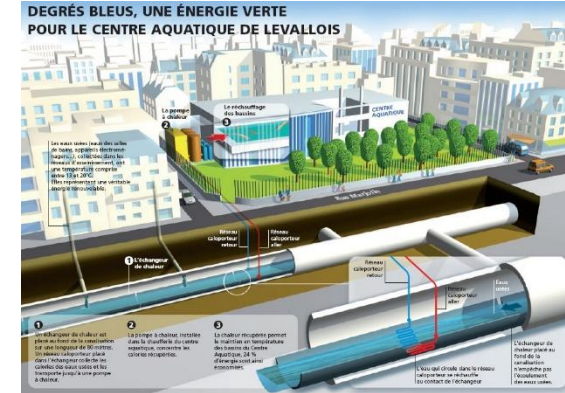


Conclusion: new paradigms for water management

Make **stakeholders** aware that other approaches than centralized systems exist and have proven their efficiency

Citizen acceptance and involvement is critical!

Combination of **engineering sciences** and **social sciences**



Swimming pool heated
with wastewater



Sewer trunk
with heat exchanger



Hvala na pažnji



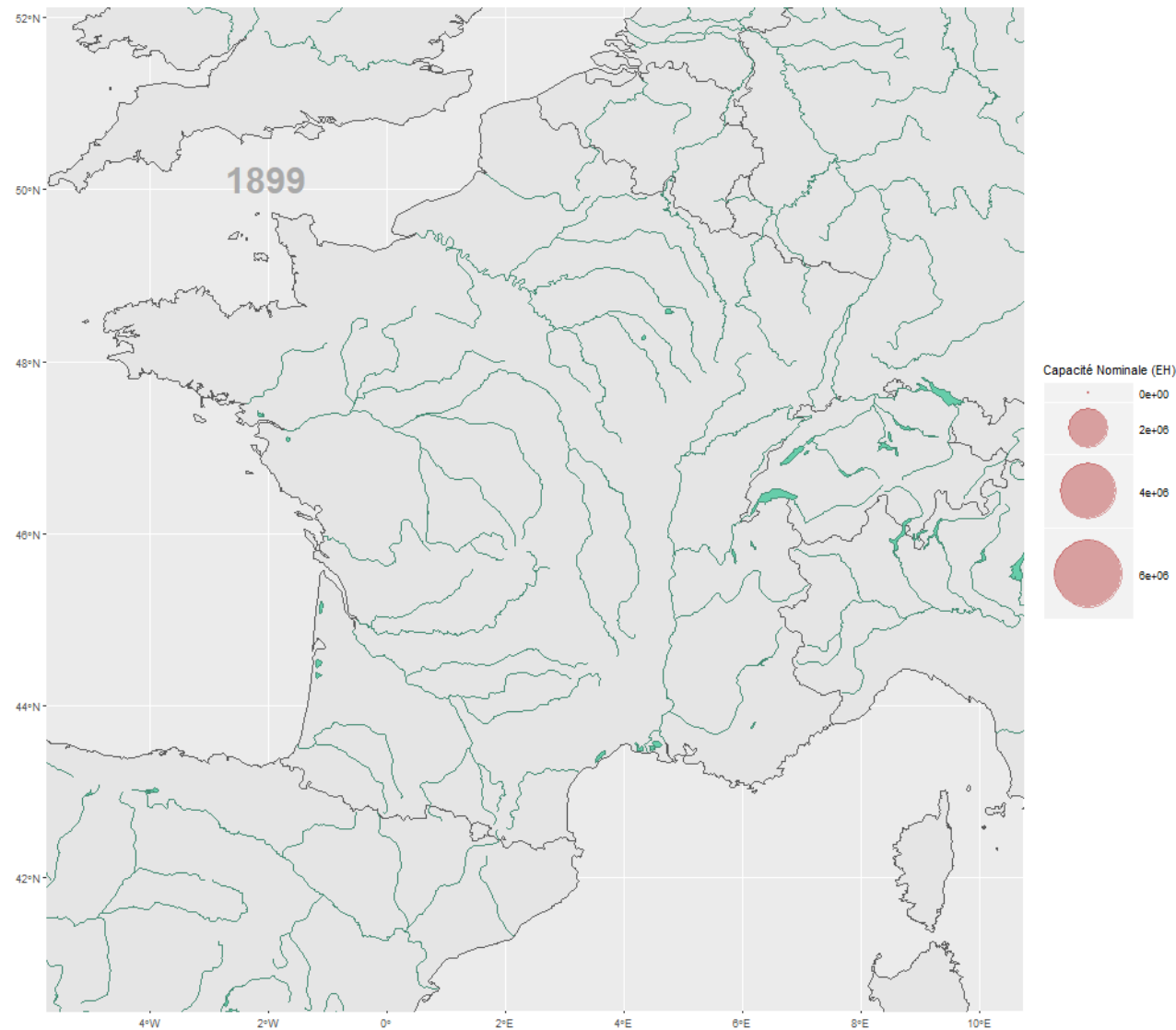
www.smartwatertwin.pmf.uns.ac.rs

smartwatertwin@pmf.uns.ac.rs



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geo.data.gouv.fr

~ 22 000 WWTPs in France

~ 100 million inh. equivalents

~80% compliance with regulation

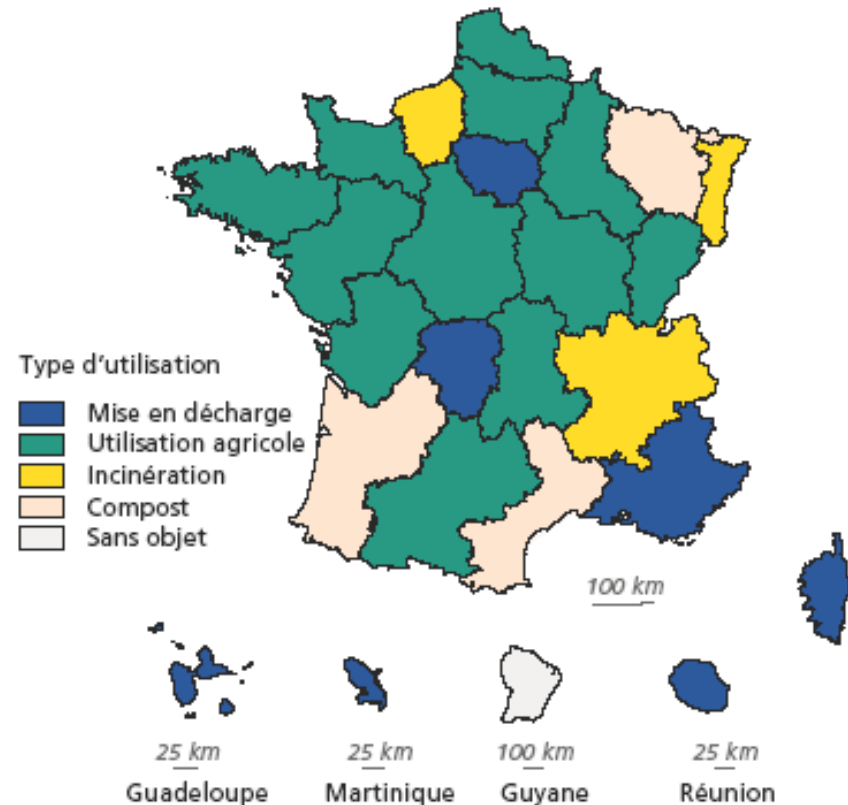
60% with N/P removal (3^{ary} treatment)

20% with C removal only (2^{ndary})

60% of sludge used in agriculture



Utilisation principale des boues en 2004 par région



Source : Ifen-Scees, enquête Eau 2004.

Main use of sludge in each region

Mostly used in agriculture

