13th IWA Specialized Conference on Small Water and Wastewater Systems (SWWS)
5th IWA Specialized Conference on Resources-Oriented Sanitation (ROS)

14 - 16 September 2016

Extension of the SMART-Plant concept to small wastewater treatment plants

Francesco Fatone and the SMART-Plant Consortium

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The SMART-Plant Consortium

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Contents

- The Horizon2020 SMART-Plant innovations and technical-economic sustainability in small WWTPs

ALTERNATIVE SMALL AND DECENTRALIZED SOLUTIONS?

- Co-treatment of municipal wastewater and organic waste
- Centralized treatment vs sewer mining (the new «concept» of decentralization): the WATINTECH project
- Decentralized nutrient recovery: the URBANLOOP project

Resources embedded to municipal wastewater

Parameter	Value
Reusable water (m^3/capita year)	91,3
Cellulose (kg/capita year)	6,6
Biopolymers; PHA (kg/capita year)	3,3
Phosphorus in P precursors (kg/capita year)	0,9
Nitrogen in N precursors (kg/capita year)	4,6
Methane (m^3/ capita year)	12,8
Organic Fertilizer (P-rich compost) (kg/capita year)	9,1

Verstraete et al. (2009) *Bioresource Technology* 100, 5537–5545
Salehizadej and van Loosdrecht (2004) *Biotechnology Advances* 22, 261–279

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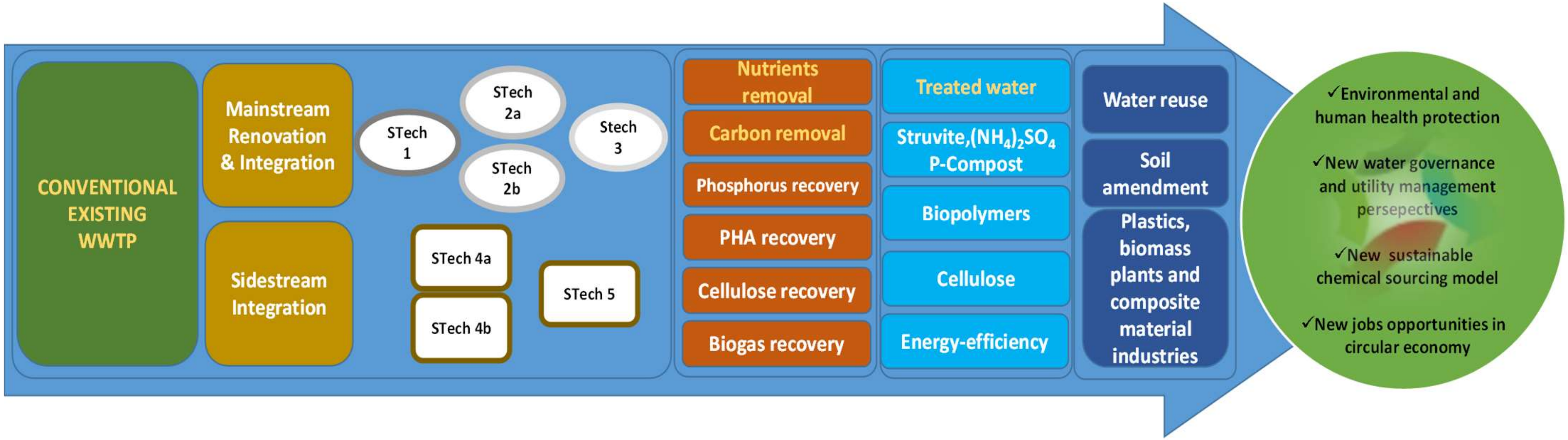
SMART-Plant overall target



The overall target of SMART-Plant is to validate and to address to the market a portfolio of SMARTechnologies that, singularly or combined, can renovate and upgrade existing wastewater treatment plants and give the added value of instigating the paradigm change towards efficient wastewater-based bio-refineries.

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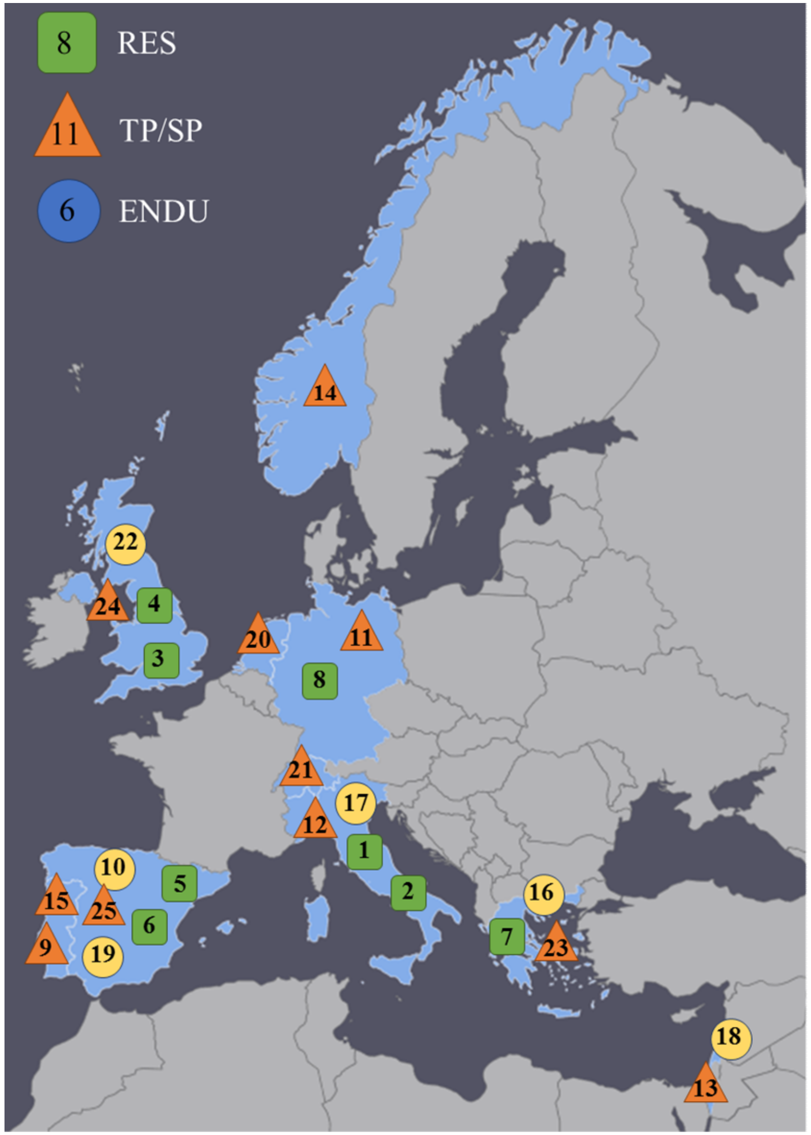
The SMART-Plant partners



Countries of the SMART-Plant project

Partners from EU and associated countries:

1. UNIVR
2. UR
3. UBRUN
4. CU
5. UAB
6. UVIC-UCC
7. NTUA
8. KWB
9. BIOTR
10. SOC
11. BYK
12. SCAE
13. AGRB
14. SALSNES
15. IBET
16. EYDAP
17. ATS
18. MEKOROT
19. AdM
20. BWA
21. EXC
22. STW
23. AKTOR
24. ECODEK
25. WSC

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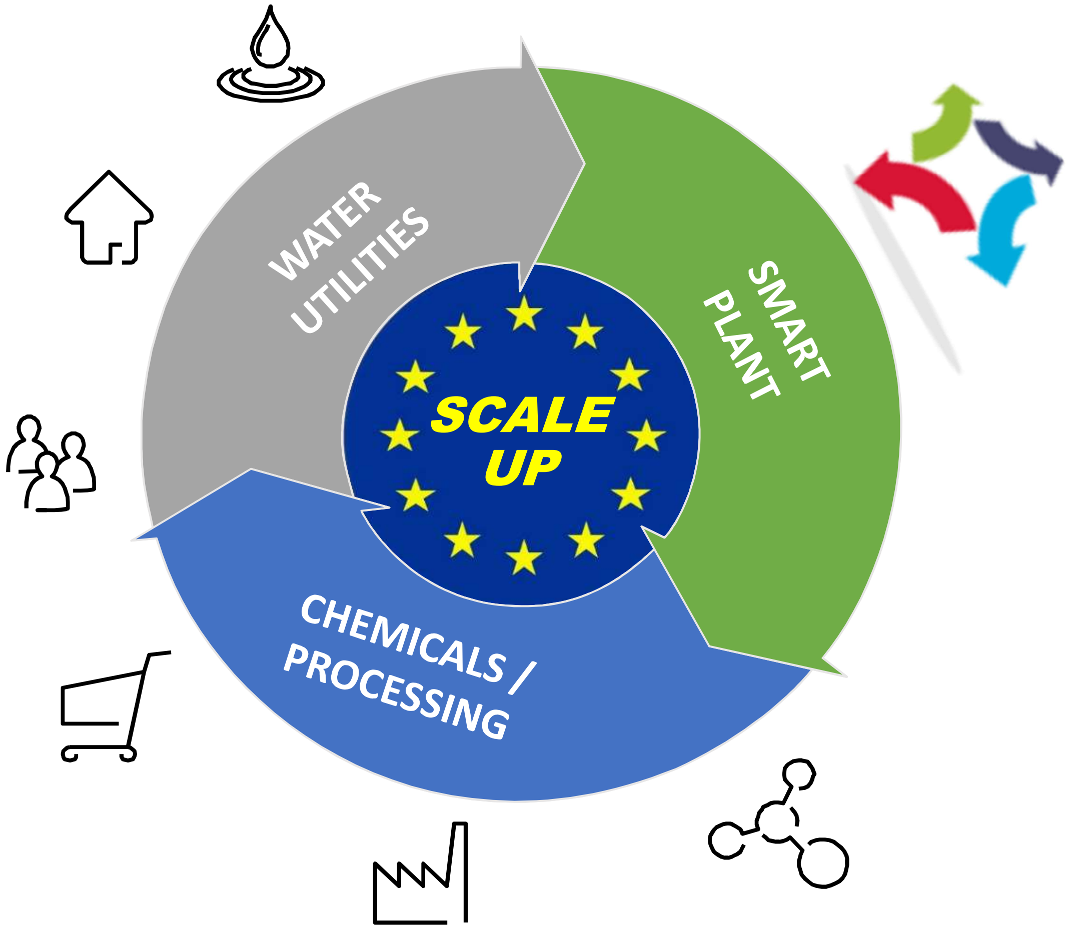
SMART-Plant open the pathway to deliver circular economy



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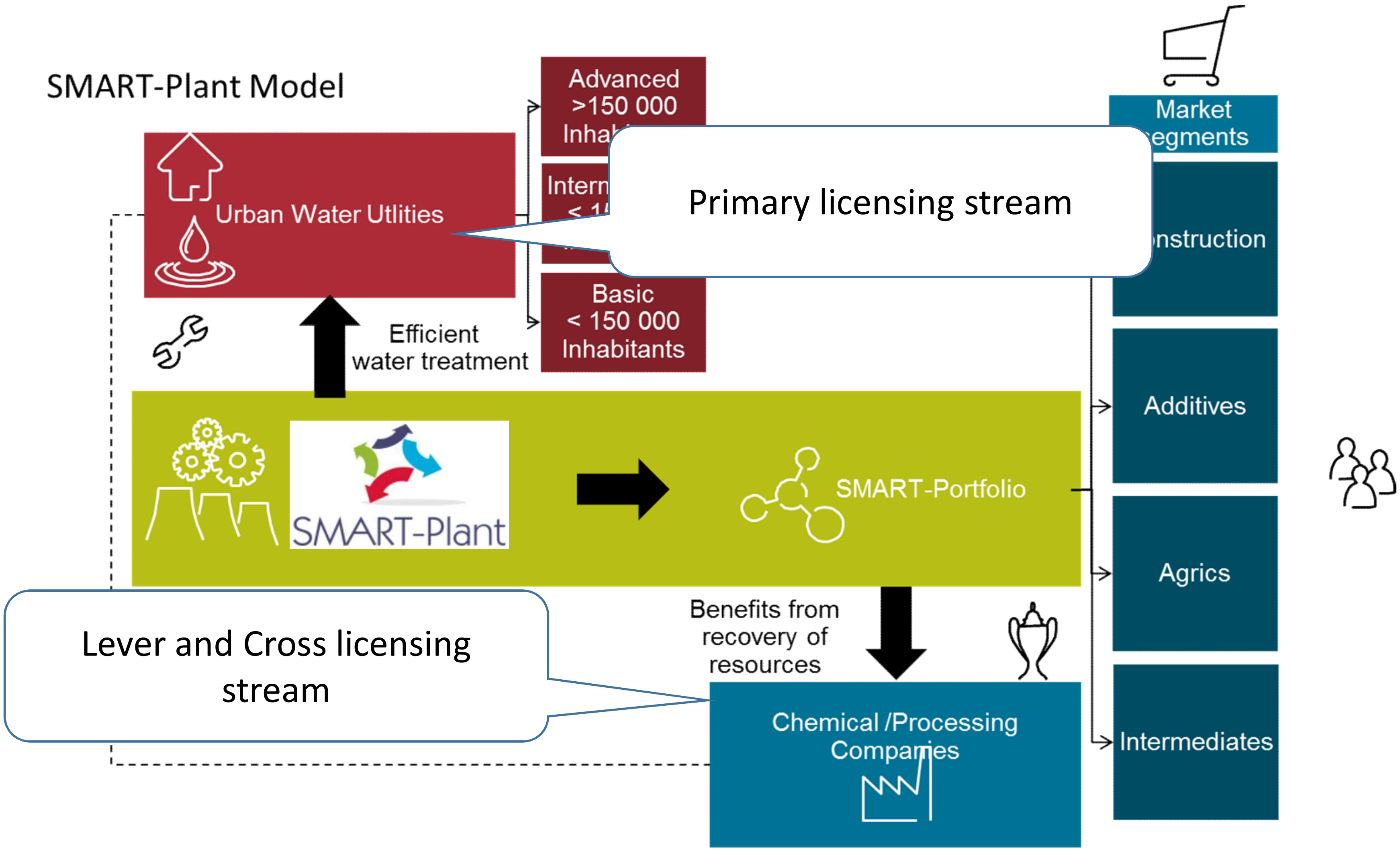
SMART-Plant Business plan and market deployment strategy



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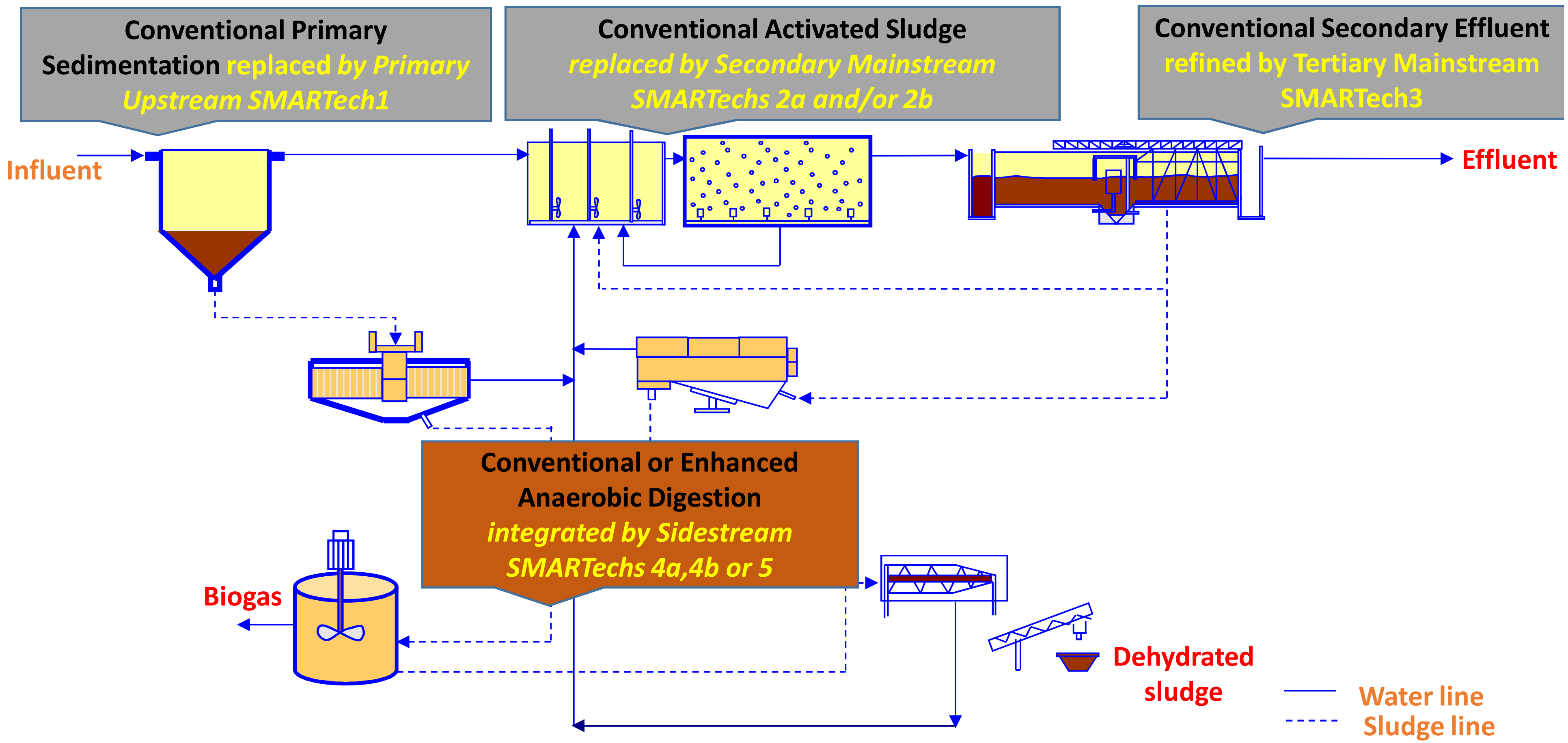
The SMARTechnologies



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The SMART-Plant integrated WWTPs

SMARTech n.	Integrated municipal WWTP	Key enabling process(es)	SMART-product(s)
1	Uithuizermeeden (Netherlands)	Upstream dynamic fine-screen and post-processing of cellulosic sludge	Cellulosic sludge, refined clean cellulose
2a	Karmiel (Israel)	Mainstream polyurethane-based anaerobic biofilter	Biogas, Energy-efficient water reuse
2b	Manresa (Spain)	Mainstream SCEPPHAS	P-rich sludge, PHA
3	Cranfield (UK)	Mainstream tertiary hybrid ion exchange	Nutrients
4a	Carbonera (Italy)	Sidestream SCENA+conventional AD	P-rich sludge, VFA
4b	Psyttalia (Greece)	Sidestream SCENA+enhanced AD	P-rich sludge
5	Carbonera (Italy)	Sidestream SCEPPHAR	PHA, struvite, VFA

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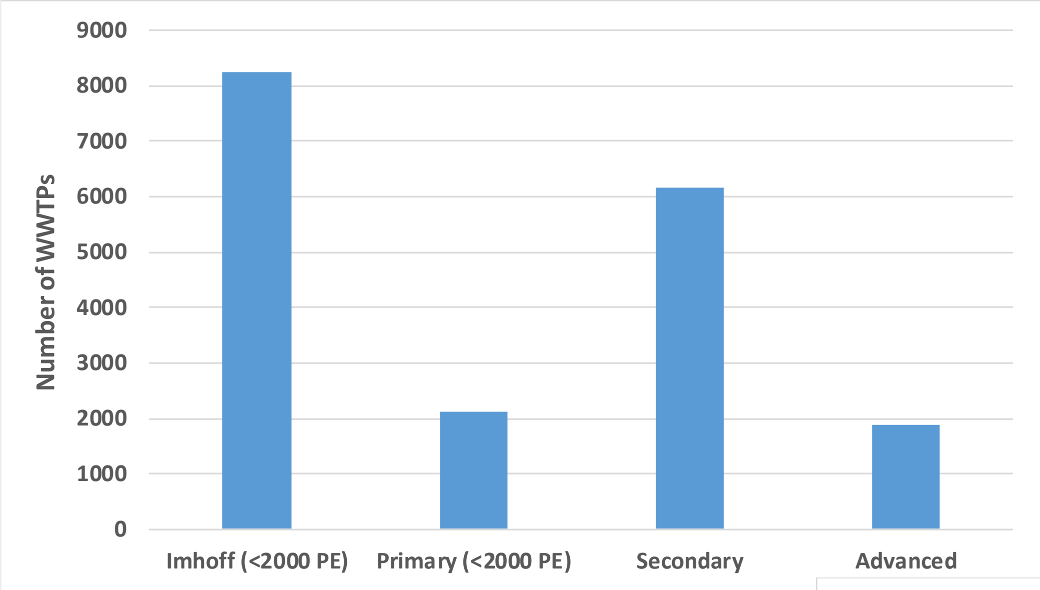
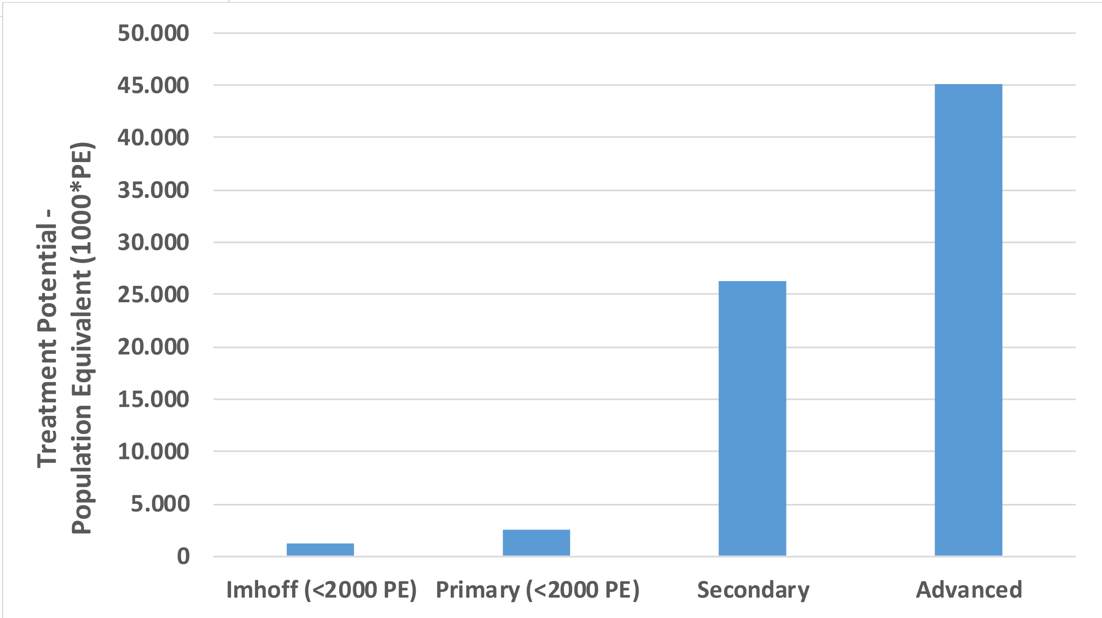
Is “small” relevant in Italy?



But: N and P effluent quality standard must be achieved for each WWTP if the agglomeration is larger than 100 000 PE



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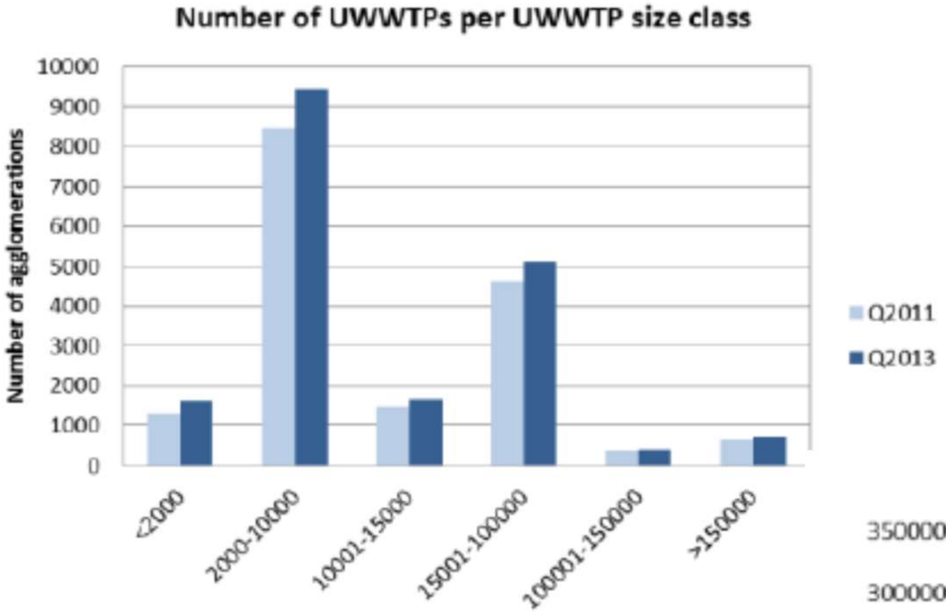
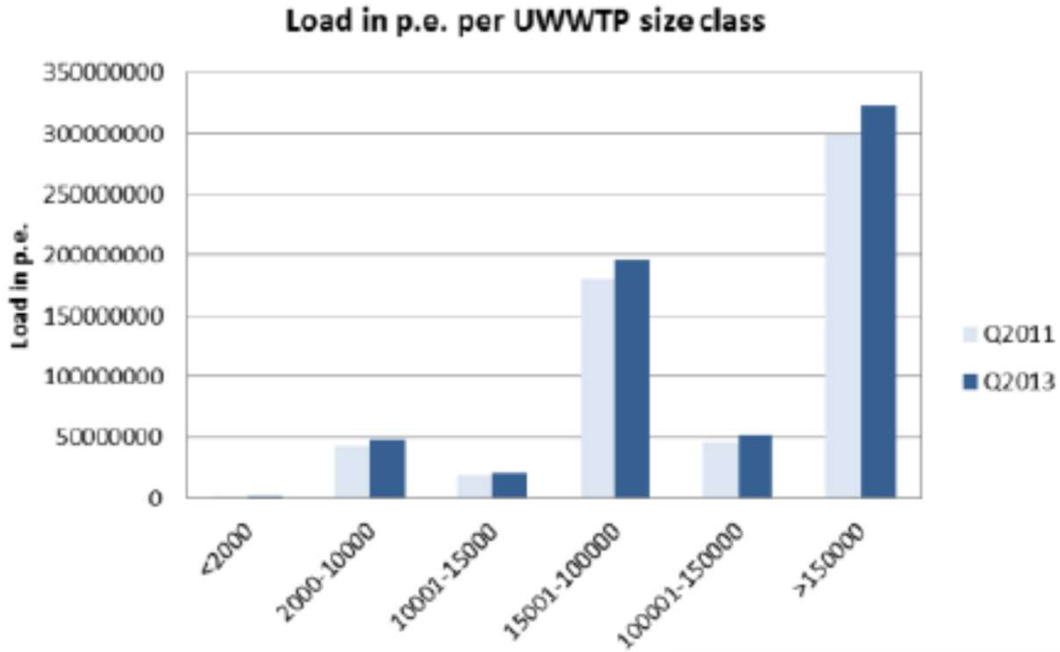
And in the EU?





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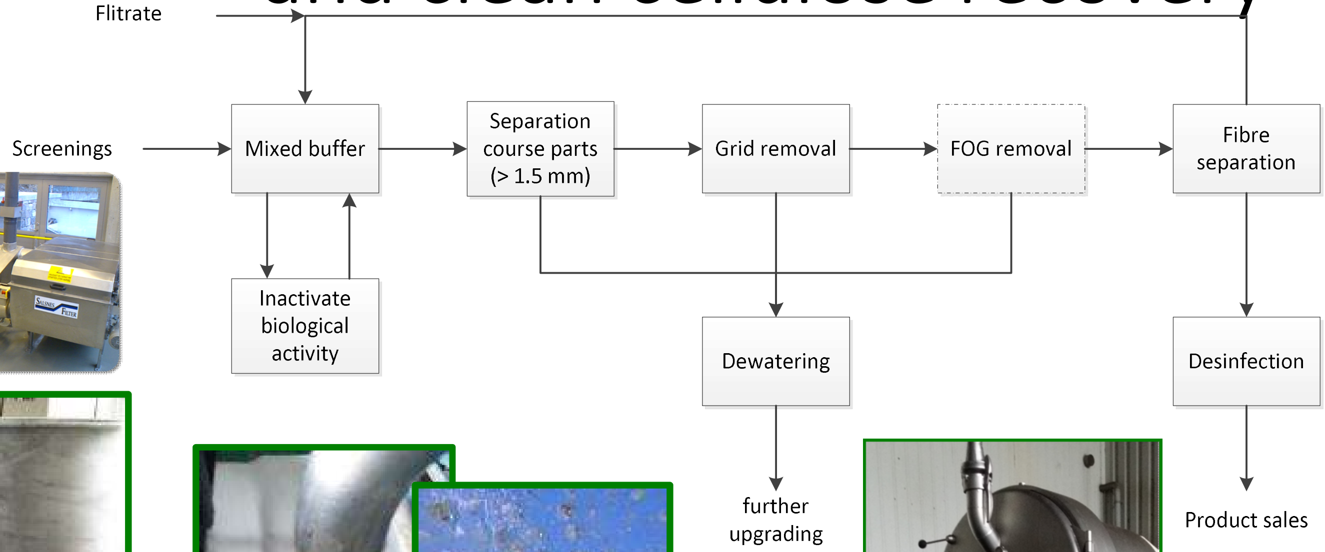
SMARTech1: Primary (upstream) dynamic sieving and clean cellulose recovery



Inactivation biological activity

Separation course parts

Sand-/grid removal

Fibre separation

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SMARTech1: Primary (upstream) dynamic sieving and clean cellulose recovery

- 79% cellulose fiber,
- 5 % other organics,
- 6% inorganic (ash)
- 10% other contaminants (average in The Netherlands).

potentially marketable product, but the economic feasibility depends mainly on savings at the WWTP

salsnes Filter

BWA

Market development

✓ Marketing and valorization of recovered cellulose
  - ✓ Reuse in asphalt
  - ✓ Raw material for composite (Brunel)
  - ✓ Insulation materials (In development, not sure yet)

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Extension to existing small WWTPs?

- ✓ At WWTPs larger than 20 000 PE, not having primary sedimentation, the payback period of a RBF installation would be about 5-8 years.
- ✓ At WWTPs larger bigger than 80 000 PE the payback is closer to 8 years.
- ✓ If primary sedimentation is present, the payback period would be 10-12 years
- ✓ In case of a fully- or over-loaded WWTP, finescreens could prevent an extension of the biology and secondary clarifiers, making it a good alternative for other solutions.

Source: BWA, internal communication

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Extension to existing small WWTPs?

From the preliminary market studies (to be detailed within SMART-Plant) **BWA** learned that:

- at least 800-1200 kg/d (30000-70000 PE) clean cellulose must be recovered to upgrade it economically at WWTP level. 1 WWTP however is not enough to create a stable discharge channel. Our first estimate is that we would need at least 2000-3000 kg/day (100000-170000 PE) of cellulose for profitable valorization.

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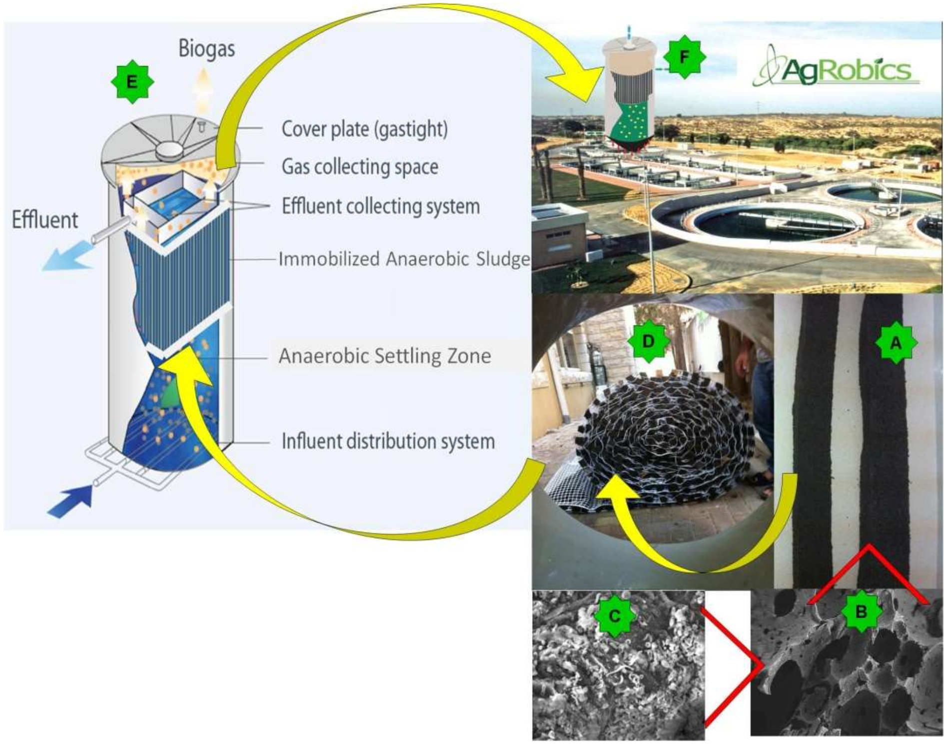
SMARTech2a: Secondary mainstream biogas recovery by polyfoam biofilter

1. An innovative anaerobic immobilized polymeric biofilter.
2. Reaction volume -25 m^3 will be designed and installed in the WWTP of Karmiel (North of Israel)
3. Characteristics:
- 100-120 m^3/d (480 PE).
- Removal of 30-40% of CODf
- Additional of 25% biogas
- Reduction of 25-30% energy consumption.

4. Operation optimization, monitoring and validation:
- biogas yield
- biomass activity
- treated effluent quality



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SMARTech2a: Secondary mainstream biogas recovery by polyfoam biofilter

- **Compact system**
- **Flexible to fluctuations**
- **Tested in full scale**

Extendible to small WWTPs

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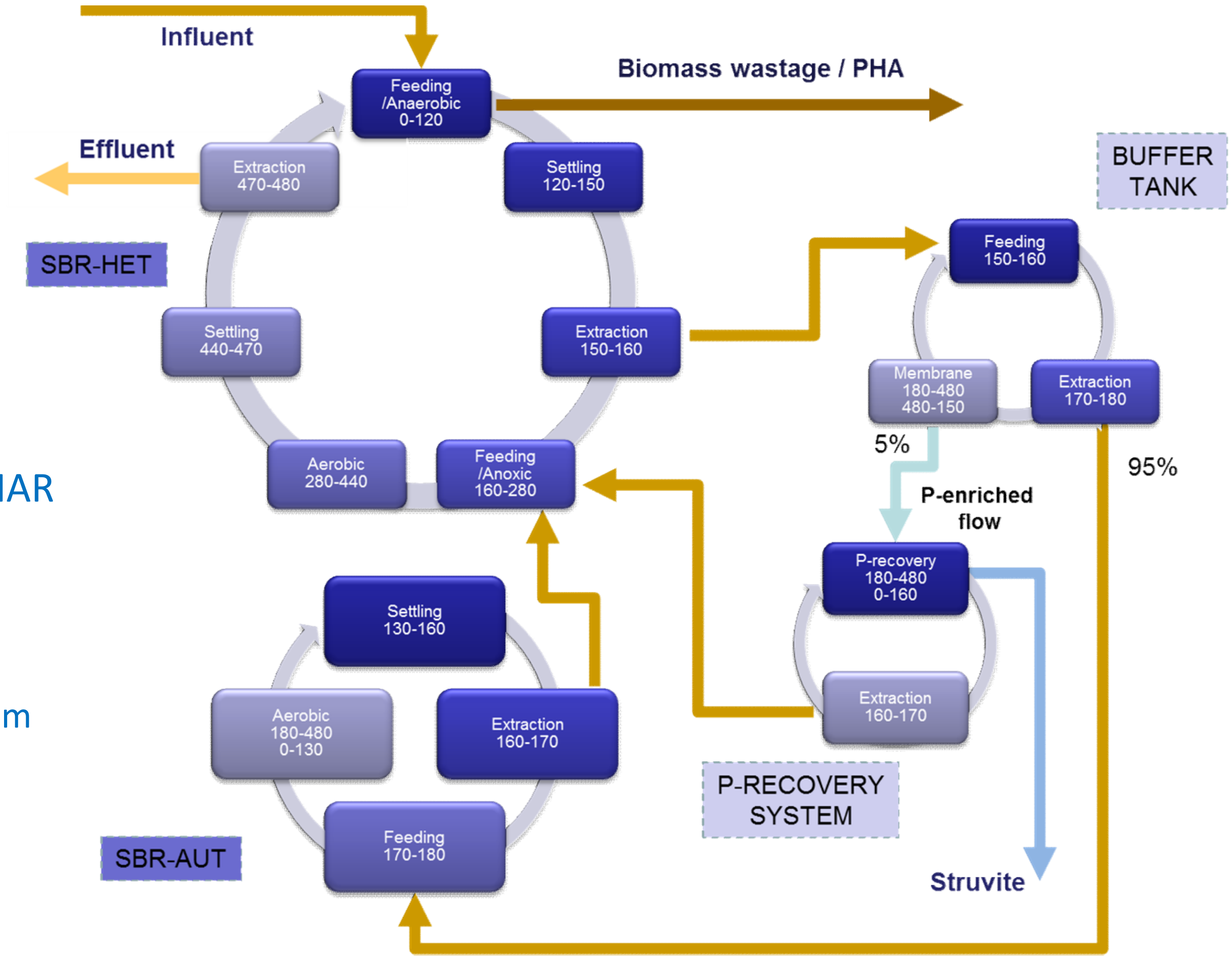
SMARTech2b: Secondary mainstream SCEPPHAR



SMARTech2b

Mainstream SCEPPHAR

- Two SBR
- Buffer tank
- P-recovery system

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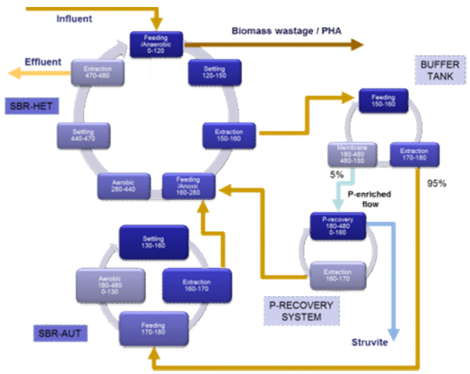
SMARTech2b: Secondary mainstream SCEPPHAR

SMARTech2b

Mainstream SCEPPHAR

- Two SBR
- Buffer tank
- P-recovery system



Two sludge system with separated SRT control for each SBR:

- **More stable nitrification throughout the year**
- **Selection of optimal SRT for PHA production**

Higher N removal by nitritation/denitritation:

- **Up to 25% less aeration requirements**
- **Up to 40% lower COD requirements**

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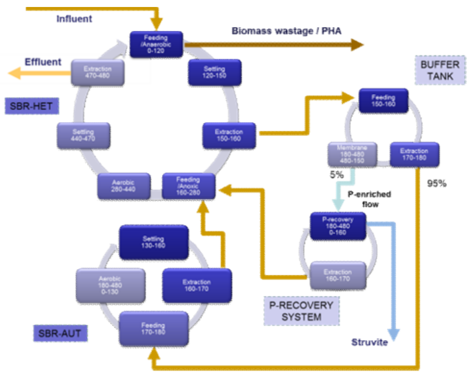
SMARTech2b: Secondary mainstream SCEPPHAR

SMARTech2b

Mainstream SCEPPHAR

- Two SBR
- Buffer tank
- P-recovery system



Most part of P is removed with an anaerobic water extraction:

- **5% of the reactor volume extracted at the end of the anaerobic phase contains > 60% of P in the influent**
- **P concentration is 6x P influent, facilitating P-recovery**

Anaerobic biomass purge:

- **Increased PHA content in the biomass: up to 20%**
- **Sludge with much lower PolyP content: avoids undesired struvite precipitation in the anaerobic digester**

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SMARTech2b: Secondary mainstream SCEPPHAR

- **Improved effluent quality (lower N & P)**
- **Lower operational costs**
- **P and PHA recovery**

New design for small WWTP!

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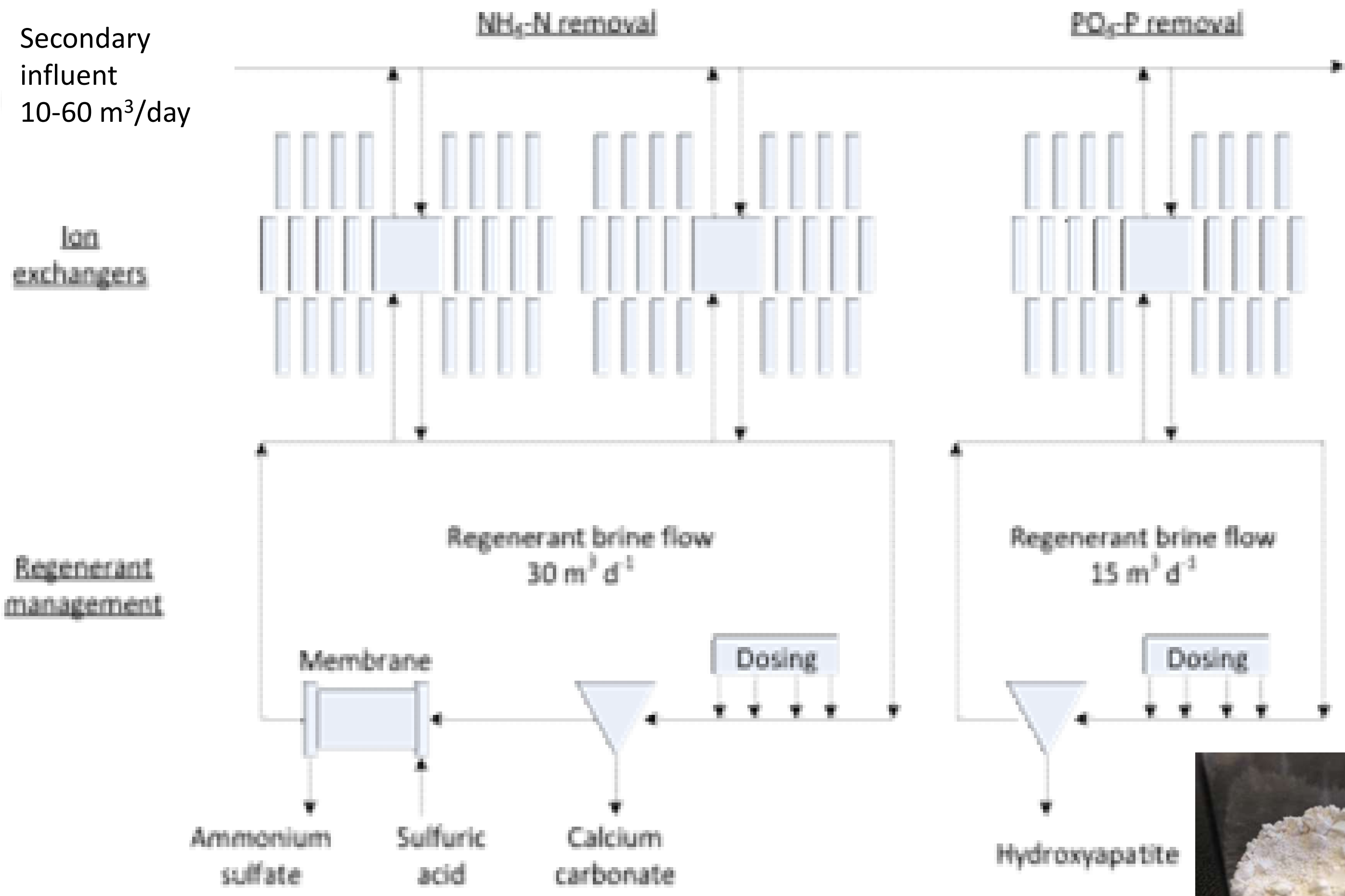
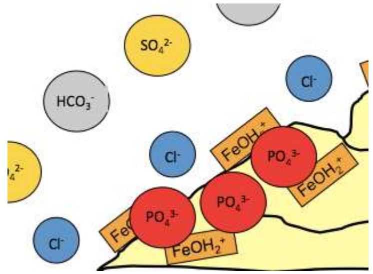
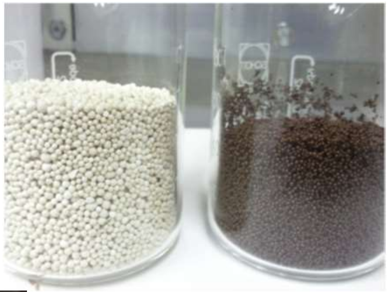
SMARTech3: Tertiary nutrient recovery by mesolite and nano ion exchange







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SMARTech3: Tertiary nutrient recovery by mesolite and nano ion exchange

- **Automatic adsorption system**
- **Able to achieve very low (required) effluent P and N concentration**
- **N and P recovery is added value**
- **Tested in demo (small) scale**

Extendible to small WWTPs!

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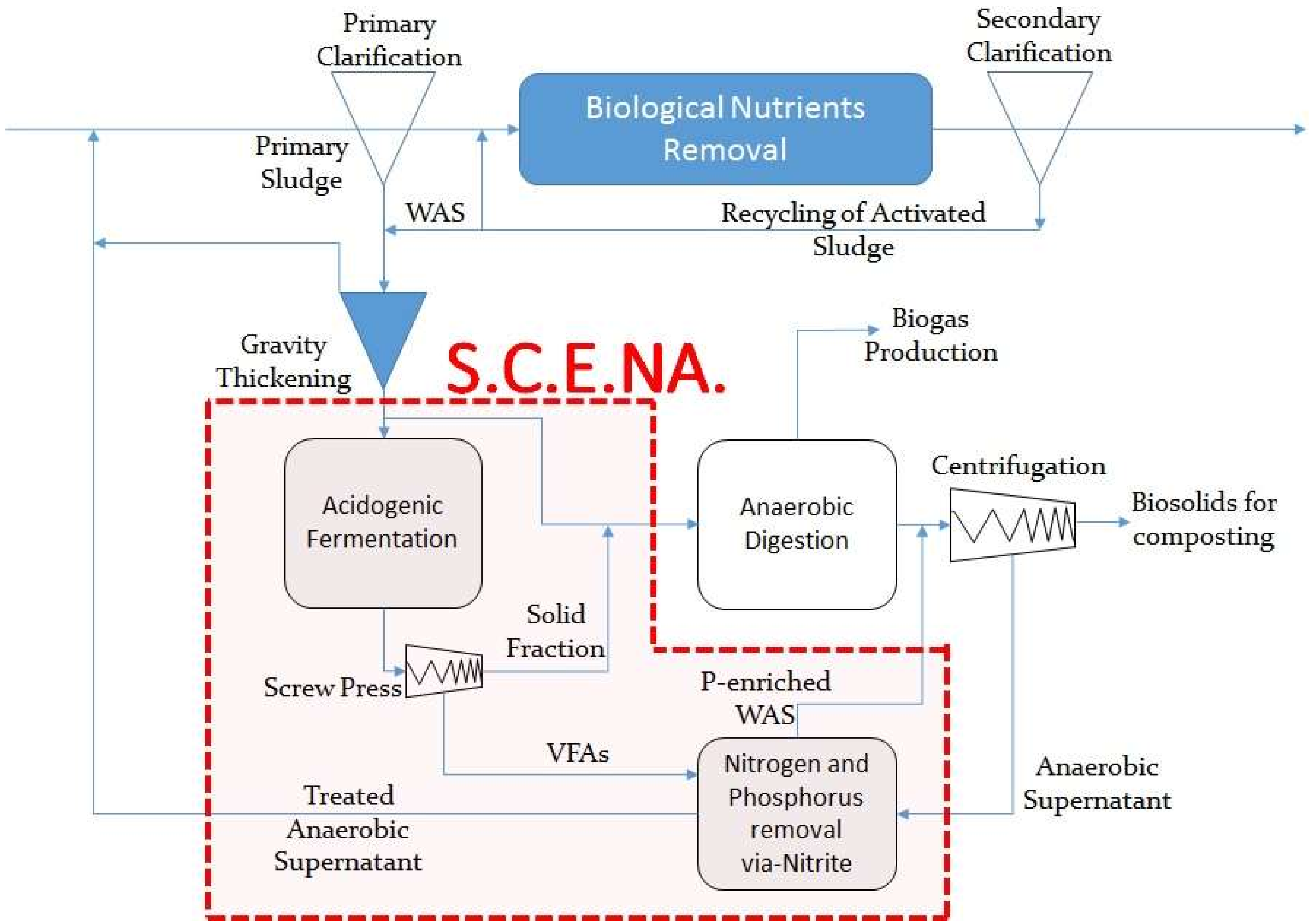
SMARTech4a/b Sidestream S.C.E.N.A.



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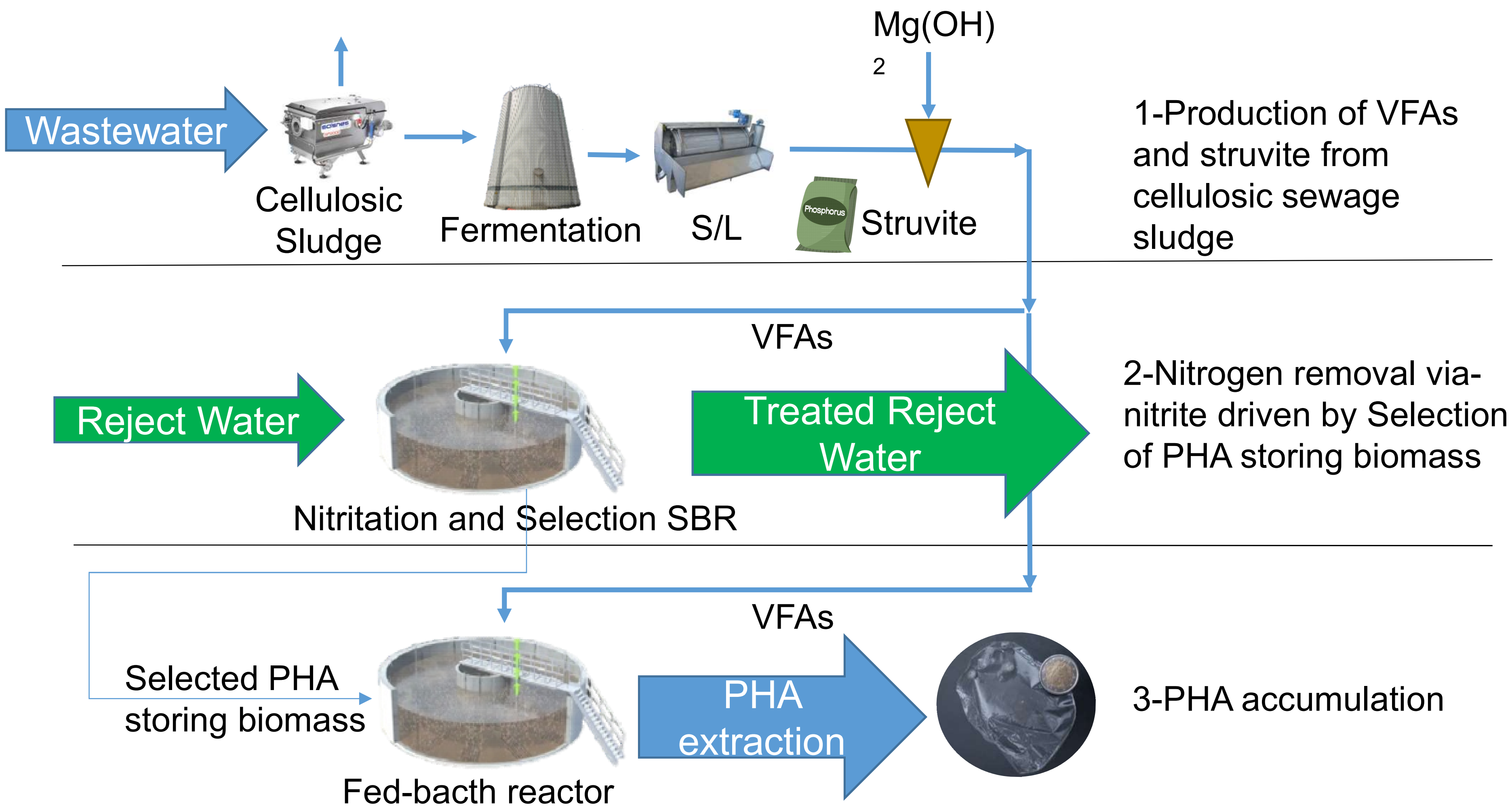
SMARTech5 Sidestream SCEPPHAR



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PHA and BioP in small WWTPs?

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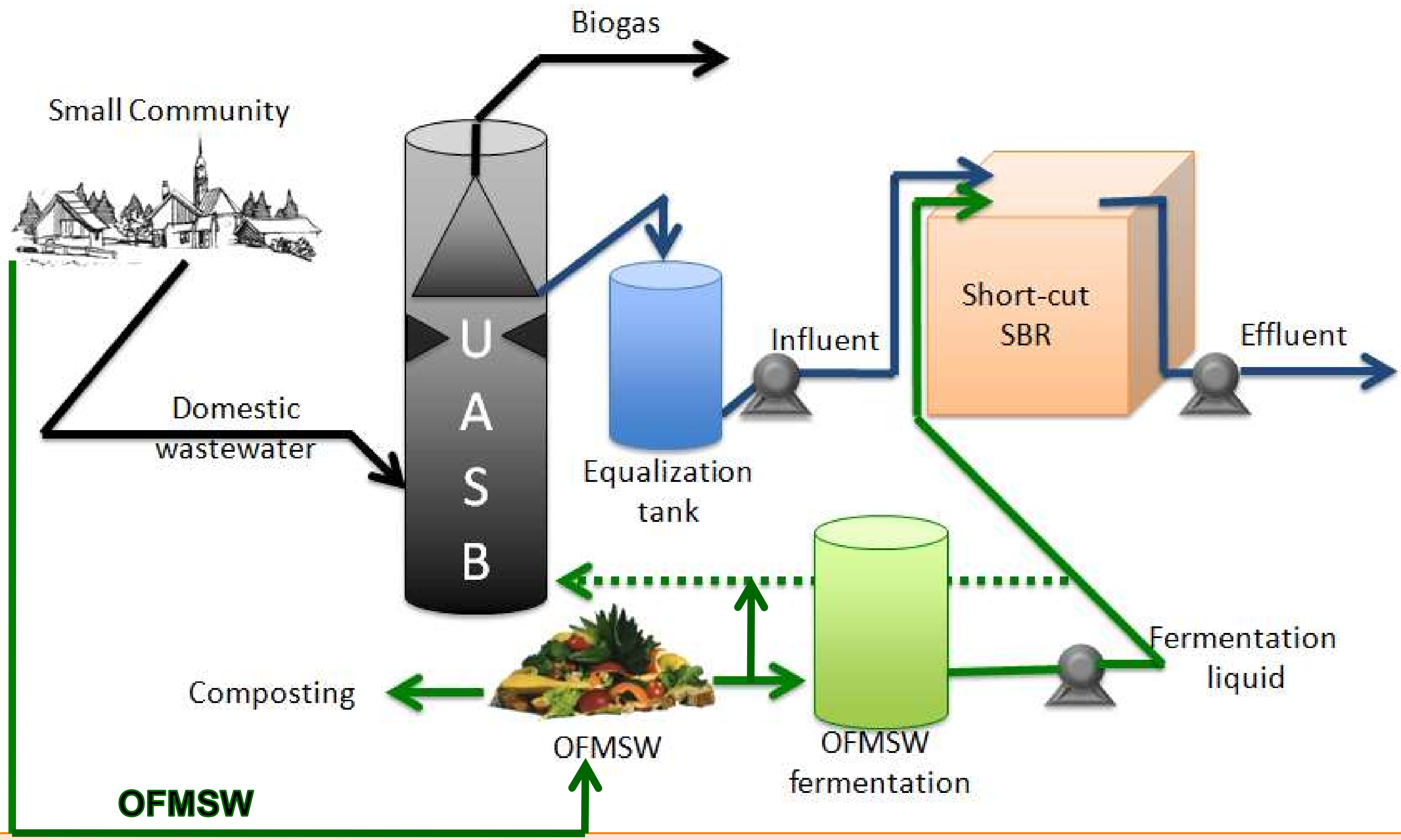
PHA and BioP in small WWTPs



Integrated system for the treatment of municipal wastewater by applying foodwaste derived external carbon source

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WATINTECH (coordinated by ICRA)

WATINTECH will develop effective decentralized treatment concepts for sewage and urban run-off to recover:

- Water
- Energy (methane)
- Value-added products (caustic, oxygen)

A key innovation of WATINTECH will be the smart integration of different water sources and decentralized and centralized infrastructure creating novel synergies.

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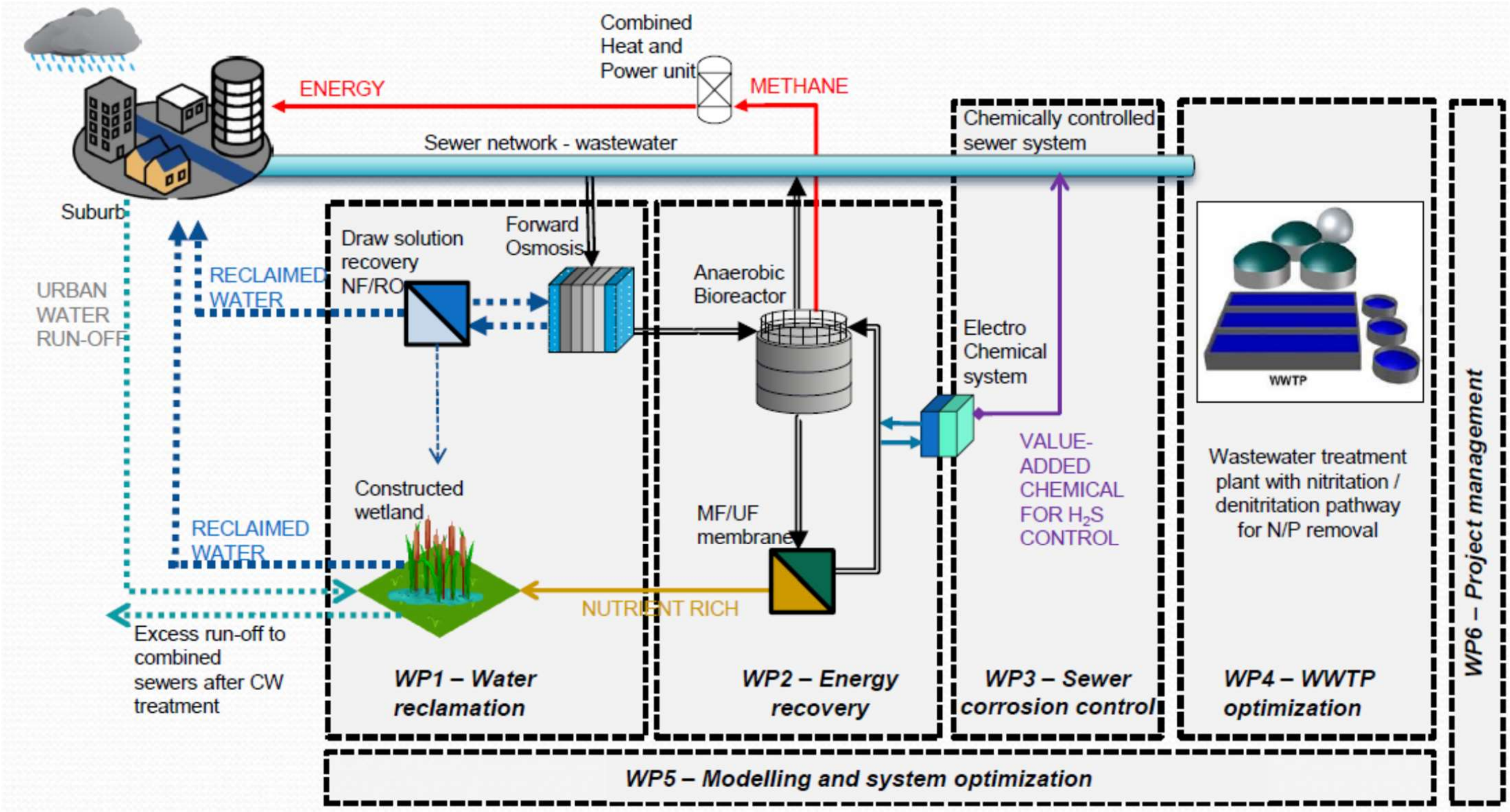
WATINTECH



Courtesy of ICRA

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URBANLOOP (coordinated by UdG)

Universitat de Girona Campus Aigua

ICRA Catalan Institute for Water Research

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Final considerations

- Thousands small WWTPs will need revamp/renovation to reach lower effluent standard of N and P. This challenge could be a great opportunity to boost decentralized water reuse in water scarce area
- The SMART-Plant business model focuses on medium-large WWTPs. Local reuse would fit better to small systems
- Some SMARTechnologies can be extended to small WWTPs and achieve energy efficiency and better performances
- When focusing on new small and decentralized concepts integrated municipal treatments and/or sewer mining concepts are promising and worthy of investigation

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Thank you for your attention!

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