UNIVERSITÀ DI PISA

3rd International Seminar on Water Resources Management
Governance and Performance of water utilities: tools and best practices

Friday 27 January 2016

Pisa, Italy

Innovation and circular economy in municipal wastewater treatment: the European experience of SMART-Plant

Francesco Fatone and the SMART-Plant Consortium

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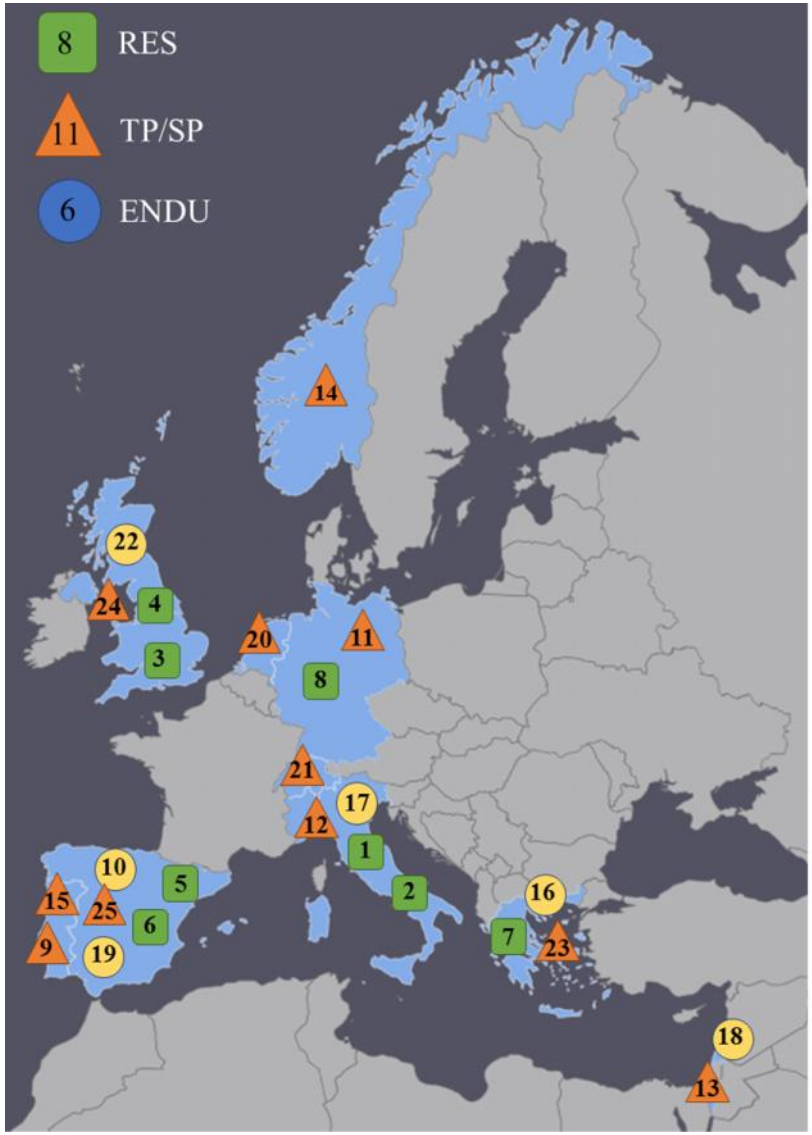
The SMART-Plant Consortium

The SMART-Plant partners



- 8 Research Organizations
- 12 Technology/Service Providers
- 6 Water utilities

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SMART-Plant

Outline

- Water utility pathways in a circular economy
- The SMART-Plant business model and exploitation strategy
- The SMART-Plant innovative technologies
- The SMART-Plant barriers
- The SMART-Plant perspectives

Water utility pathways in the circular economy

Water utilities can become engines for the circular economy by following three interrelated pathways:

- **The water pathway**
- **The material pathway**
- **The energy pathway**

Water Utility Pathways in a Circular Economy

IWA the international water association

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The water pathway

Potable water
Non-potable water
Wastewater
Reclaimed water
Greywater
Rainwater

Water Utility Pathways in a Circular Economy

IWA the international water association

1 Upstream investments
2 Rainwater harvesting
3 Greywater recycling for non-potable reuse
4 Greywater for agriculture and aquaculture
5 Reused water for agriculture and aquaculture
6 Reused water for industry
7 Direct potable reuse
8 Leakage / Water loss
9 Reduction in water consumption
x Onsite treatment

The materials pathway

- Recovered materials
- Organic matter
- Water
- Gas

1. Resource efficiency
2. Wastewater sludge and products thereof for agriculture
3. Organic waste added to wastewater sludge
4. Drinking water sludge to agriculture or industry
12. Effluent gas reuse

Products

5. Bioplastics
6. Fertiliser (non-agricultural)
7. Paper & Cellulose
8. Building materials
9. Proteins & Feed
10. Metals & Minerals
11. Human health products

Water Utility Pathways in a Circular Economy

IWA the international water association

The energy pathway

- Organic energy
- Heat
- Topographic energy
- Other renewable energy
- Water
- Recovered materials

1. Energy saving at treatment plants & distribution systems
2. Energy reduction and recovery at home
3. Electricity produced from distribution systems
4. Heat produced from distribution systems
5. Wastewater biosolids to energy production (gas, electricity & heat)
6. Renewable energy

Pathway Drivers and Enablers

- **Consumers**
- **Industry**
- **Regulation**
- **Infrastructure**
- **Urban and Basin Economies**

Water Utility Pathways in a Circular Economy

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Pathway Boosters

- Integrated Urban Resource Management
- Connecting to Stakeholders beyond Traditional Boundaries (Urban and Basin)
- Leadership
- Innovation
- New Business Models

Water Utility Pathways in a Circular Economy

IWA the international water association

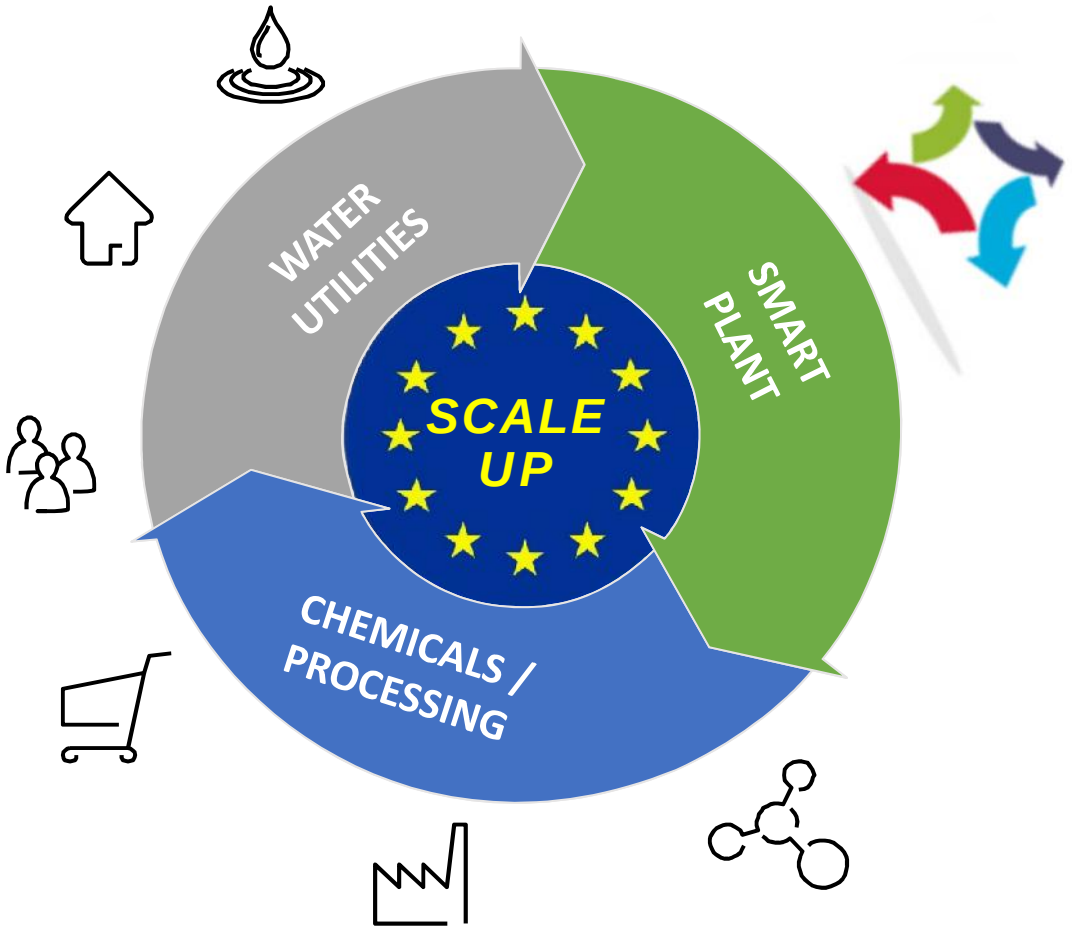
Pathway junctions

- Water-Wise Communities
- Industry
- Wastewater Treatment Plants
- Drinking Water Treatment Plants
- Agriculture
- Natural Environment
- Energy Generation

Water Utility Pathways in a Circular Economy

1. What is SMART-Plant
2. SMART-Plant model
3. SMART-Plant portfolio of resources
4. SMART-Plant benefits
5. SMART-Plant next steps

SMART-Plant open the pathway to deliver circular economy

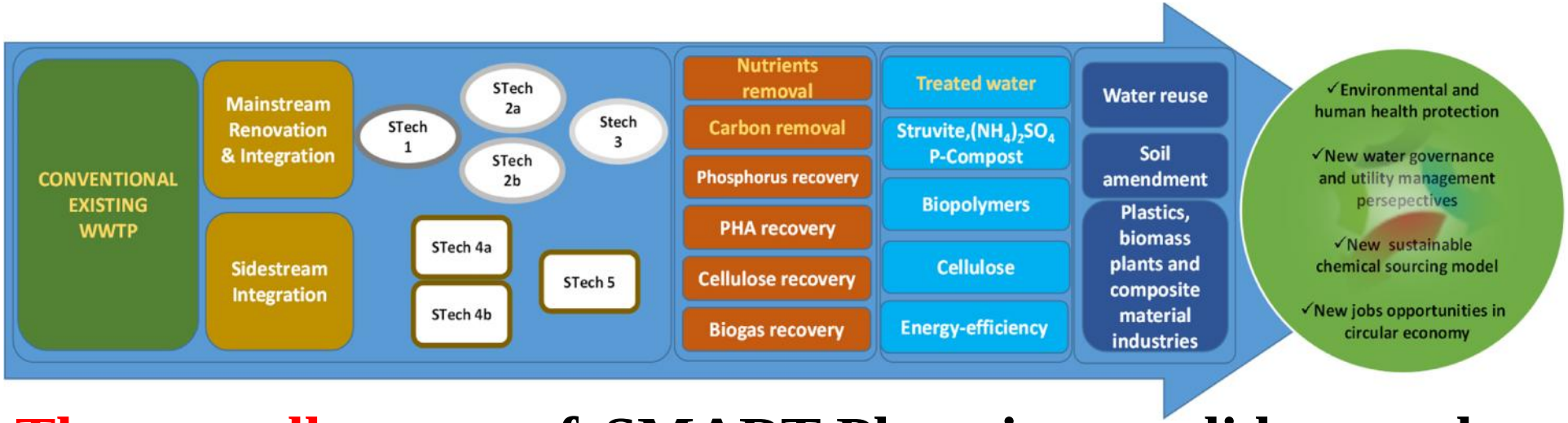


Resources embedded to municipal wastewater

Parameter	Value
Reusable water (m^3/capita year)	80-120
Cellulose (kg/capita year)	5-7
Biopolymers; PHA (kg/capita year)	2-4
Phosphorus in P precursors (kg/capita year)	0.5-1.5
Nitrogen in N precursors (kg/capita year)	4-5
Methane (m^3/ capita year)	12-13
Organic Fertilizer (P-rich compost) (kg/capita year)	9-10

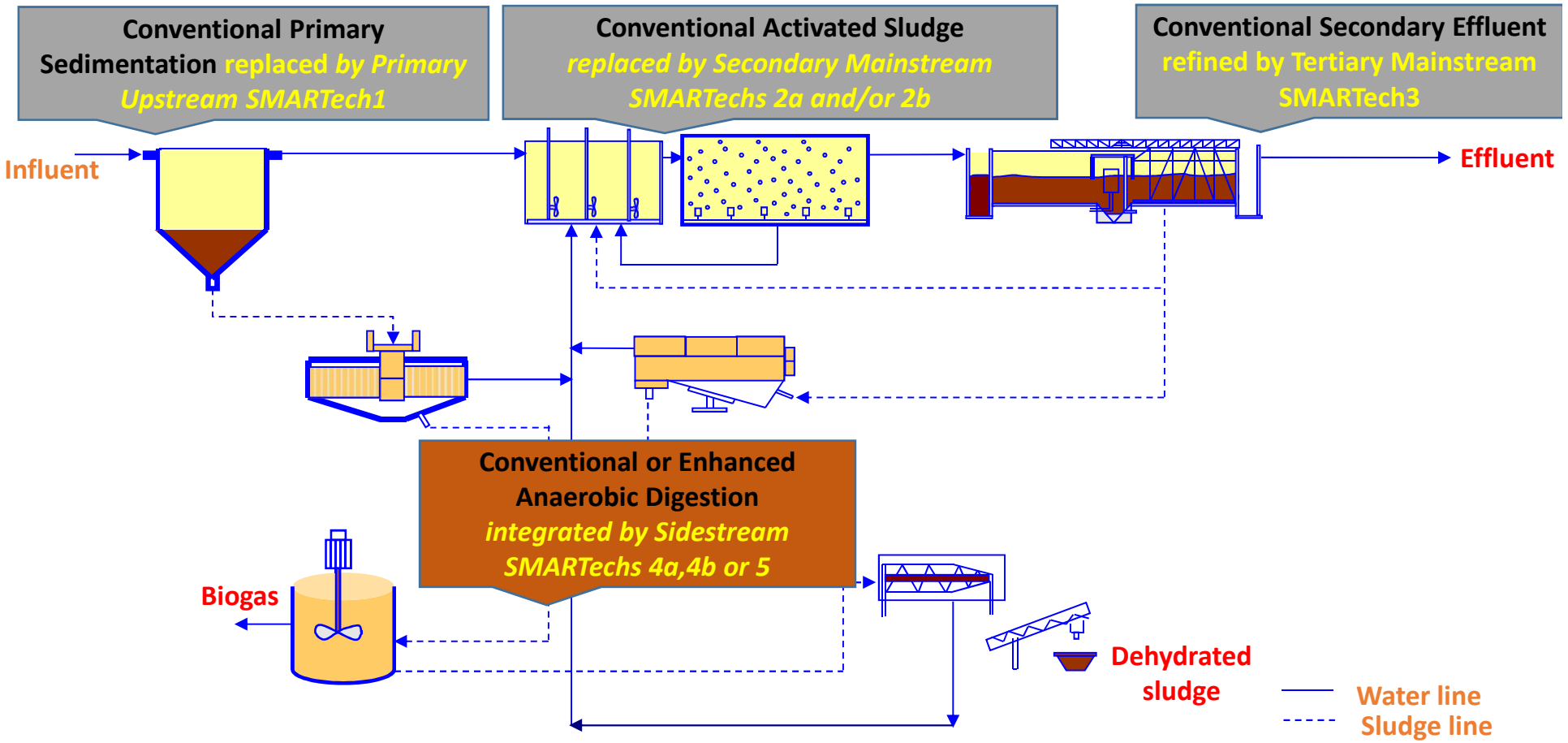
Verstraete et al. (2009) *Bioresource Technology* 100, 5537–5545
Salehizadej and van Loosdrecht (2004) *Biotechnology Advances* 22, 261–279

The 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.

The SMARTechnologies



The SMART-Plant integrated WWTPs

SMARTech n.	Integrated municipal WWTP	Key enabling process(es)	SMART-product(s)
1	Geestmerambacht (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 SCEPPHAR	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

Advantages for water treatment, with resource recovery

SMART- Plant toward a Circular Water Cycle !

WasteWater treatment efficiency

Circular Economy in the Water Cycle

Resource recovery

SMART/Plant approach offers significant benefits >

- for water utilities, it reduces waste to be disposed, with associated savings
- For chemicals and material sectors, it provides a opportunity for raw material supply
- For chemicals& water value chains, it opens new opportunities for PPP models

Circular Economy Leader

The merger between water treatment and resource recovery, provided by SMART-Plant is a great opportunity for the water utlities and chemicals / material processing industry to enable synergis through new circular models

AGENDA

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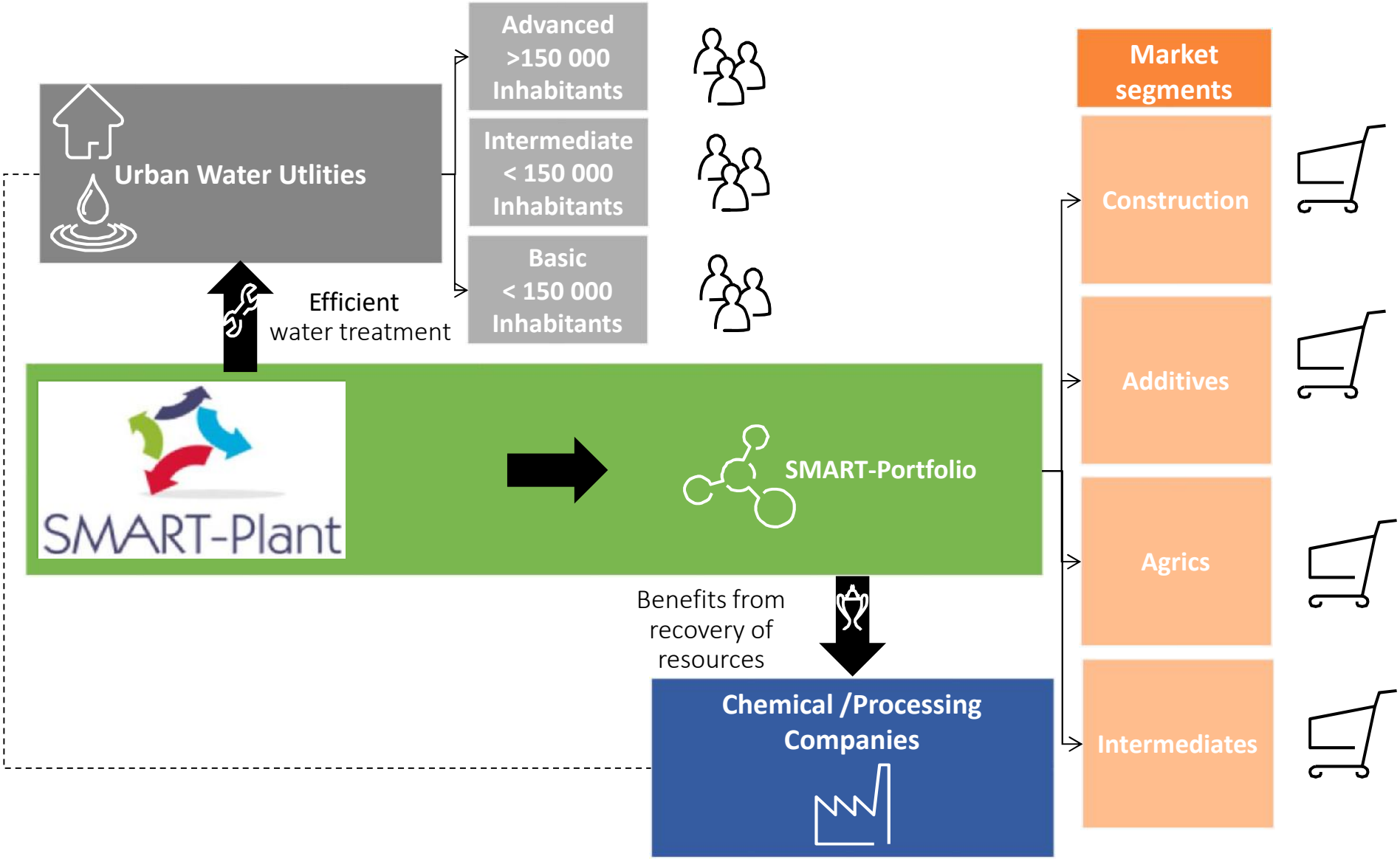
Schematic view of SMART-Plant Model



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SMART-Plant portfolio encompasses 4 segments

SMART-Plant strategic pillars

Construction

- Compounds PHB / cellu-lose under developmen t by ECODEK
- key product grades ba-sed on market end use

Additives

- Key additive applications for plastics, oil & gas and constructio n under are evaluation with support from BYK

Intermediates

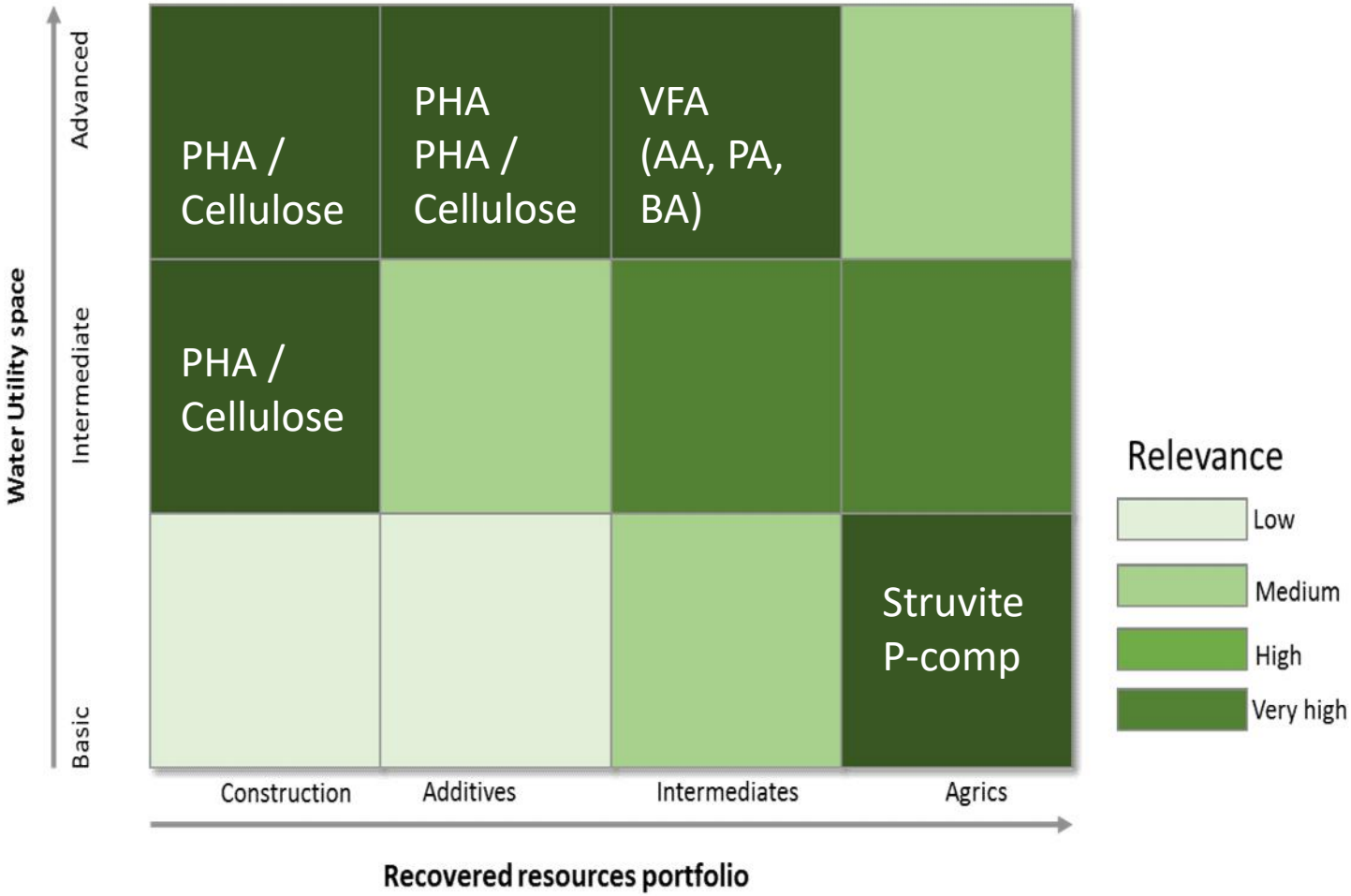
- VFA, as AA, BA, PA recovered from SMARTechn ologies uses as chemical intermediat es are under assessment

Agriculture

- Struvite and P rich compost use for agriculture, in selected European countries is under assessment

SMART- Product portfolio with key product offer by strategic pillar to guide exploitation

End use for recovered resources fit to water utility plants



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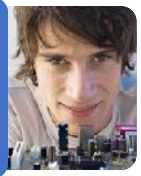
SMART-Plant delvers a multifolded set of benefits

Efficient advanced technologies for wastewater plants, to improve nutrients removal and overall compliance in existing plants

Benefits from nut-rients recovery

Benefits from energy efficiency



Benefits from reduced sludge

Revenue streams from resource recovery ready for the chemicals / plastics / construction industry segments

More efficient waste water plants with reduced waste and energy footprint

Raw material sources for the Chemicals value chain

Economic benefits depends on the actual scenario

	UWWTPs size < 150 K PE	UWWTPs size > 150 K PE
Case SMART-Plant recovery N and P		
Saving N Removal EUR/PE/Y		
Thereof Energy from Biogas		
Saving P Removal EUR/PE/Y		
Thereof Energy from Biogas		
Total		
PHA EUR/PE/Y		
Cellulose EUR/PE/Y		
Struvite EUR/PE/Y		
NH4SO4 EUR/PE/Y		
P rich composte EUR/PE/Y		
Butyrric acid EUR/PE/Y		
Propionic acid EUR/PE/Y		
Acetic acid EUR/PE/Y		
Total (theoretical) EUR/PE/Y		
Possible scenarios		
Subtotal PHA/Struvite EUR/PE/Y		
Subtotal VFA/Struvite EUR/PE/Y		
Subtotal Cellulose/PHA EUR/PE/Y		
Subtotal NH4SO4/P compost EUR/PE/Y		
AVERAGE EUR/PE/Y		
Operating costs - EUR/PE/Y (est 30/20%)		
EBITDA (average) products EUR/PE/Y	6,31 €/PE/Y	7,21 €/PE/Y
Total benefits (top down)		
	17,02 €/PE/Y	17,87 €/PE/Y

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5. SMART-Plant barriers and next steps

Main SMART-Plant barriers towards the closed cycle

- Regulatory barriers (**Innovation Deal** proposed)
- Market uptake
- Customer acceptance and public perception
- Stability of the secondary raw material characteristics
- Water utility sceptical approach towards innovation and circular economy

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The target is to make the entire SMART-Plant platform commercially available through a JV among partners

Target
One Common Platform

- All SMART-Plant technologies to be available:
  - Large choice of technology fit
  - Flexibility for customisation
- Follow Sustainability Leadership Principles
- Expertise in the end market for recovered resources is the key enabler
- Right fit approach for technology is the guide

SMART-Plant target is to be leader for the circular economy in the water cycle by focusing on right fit of technology and market adoption for recovered resources

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Thank you, and follow us!