Agricultural waste and residue management for a circular bio-economy: Shared EU and China impact-oriented solutions

22nd-23rd October 2018
Beijing, China

Converting Waste/Wastewater Organic Matter into Valuable Biodegradable Plastics: 3 Pilot-Scale Studies in the frame of H2020 Programme

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3 Projects in the frame of H2020 Programme

https://www.smart-plant.eu/

Scale-up of low-carbon footprint material recovery techniques in existing wastewater treatment plants (SMART-Plant)

Call: WATER-1b-2015 - Demonstration/pilot activities (IA)

GA 690323, 4 years, started June 1° 2016, 29 partners, 10 countries

EU Grant: 7 536 300 €

Coordinator: Francesco Fatone, Technical University of Marche, Italy

http://noaw2020.eu/

No Agro-Waste - Innovative approaches to turn agricultural waste into ecological and economic assets (NoAW)

Call: WASTE-7-2015 - Ensuring sustainable use of agricultural waste, co-products and by-products (RIA)

GA 688338, 4 years, started October 1° 2016, 32 partners, 15 countries

EU Grant: 6 887 570 €

Coordinator: Nathalie Gontard, INRA-Montpellier, France

www.resurbis.eu

REsources from URban BIo-waSte (RES URBIS)

Call CIRC-05-2016: **Unlocking the potential of urban organic waste (RIA)**

GA 730349, 3 years, started January 1° 2017, 21 partners, 8 countries.

EU Grant: 2 996 688 €

Coordinator: Mauro Majone, Sapienza University of Rome, Italy

3 projects with some common features

Focusing on **"waste" streams** as a renewable and largely available resource (no land, no water, no energy is needed to produce it)

Mild biotechnologies basen on **open microbial cultures** (no axenic cultures, no OGMs)

→

The organic fraction of municipal solid waste
Municipal wastewater
Park/garden waste
Agricultural and food-industry wastewater and waste

A large portfolio of bioproducts with market value under investigation (e.g. cellulose, biofuels, biofertilizers, biosolvents, biomethane and biohythane) and one in common: **polyhydroxyalkanoate (PHA) and derived bioplastics and biocomposites**

Also taking care of

✓ **the whole technology chain** — **Different industrial sectors to be linked each other**, each one having its own business targets, needs and specifications.

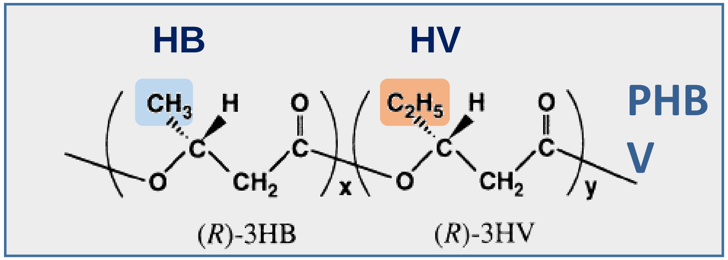
✓ **territorial conditions** — Affordable economic strategies to be tailored with respect to territorial **clusters**, i.e by taking into account present collection and management systems and where available "feedstock " is large enough

✓ **technical and non technical constraints** — Regulatory (e.g. **"end of waste"**), environmental, and social constraints, as function of local, regional and national conditions

Why focusing on PHA?

Product related Pro's

PHA is not a single polymer but a family of copolymers with tunable composition and properties,
so that, PHA can be the main constituent of several bioplastics, with a wide portfolio of applications.



- Biodegradable commodity film
- Advanced packaging interlayer film
- Specialty durables (such as electronics)
- Biocomposites with fibers for construction sector
- Controlled C-release materials for environmental remediation

Production process Pro's

- A novel PHA production process (**open microbial cultures instead of pure strains**), which can better cope with **large heterogeneity of the waste feedstock**,
- An upstream step, the **acidogenic fermentation**, which is both robust and tunable
- Overall, PHA production process is mostly **biological, under mild conditions and reliable**.
- Thus, an **easier integration with existing biological plants for waste and wastewater treatment**.
- Combining no-cost feedstock and novel processes, the **cost of PHA can significantly decrease**

Appealing: PHA is 3 times "Bio"

- Produced from renewable feestock (**but no food**)
- Produced through biological process (**but no OGM**)
- Easily and "truly" **biodegradable**

and it's not recycled: it's virgin material

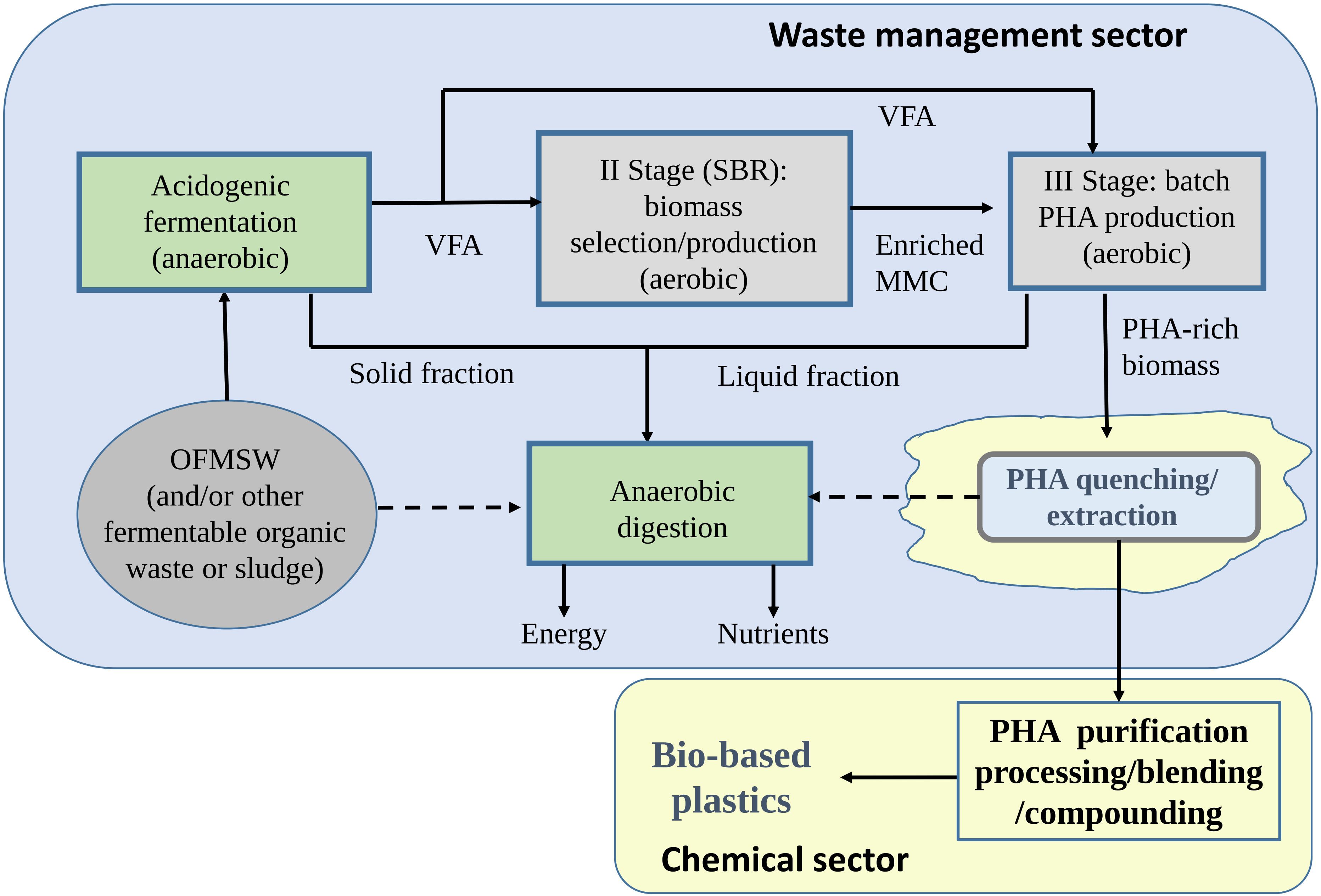
Applications and economics

High market potential

As higher as more PHA cost decreases; but still higher value than biogas and compost

Already under investigation at TRL 6

Typical process for PHA production from MMC and organic waste



Pilot scale optimisation of PHA production process from biowaste

Although the main steps of MMC process are largely validated at lab-scale, **pilot scale experimentation is essential for several reasons**

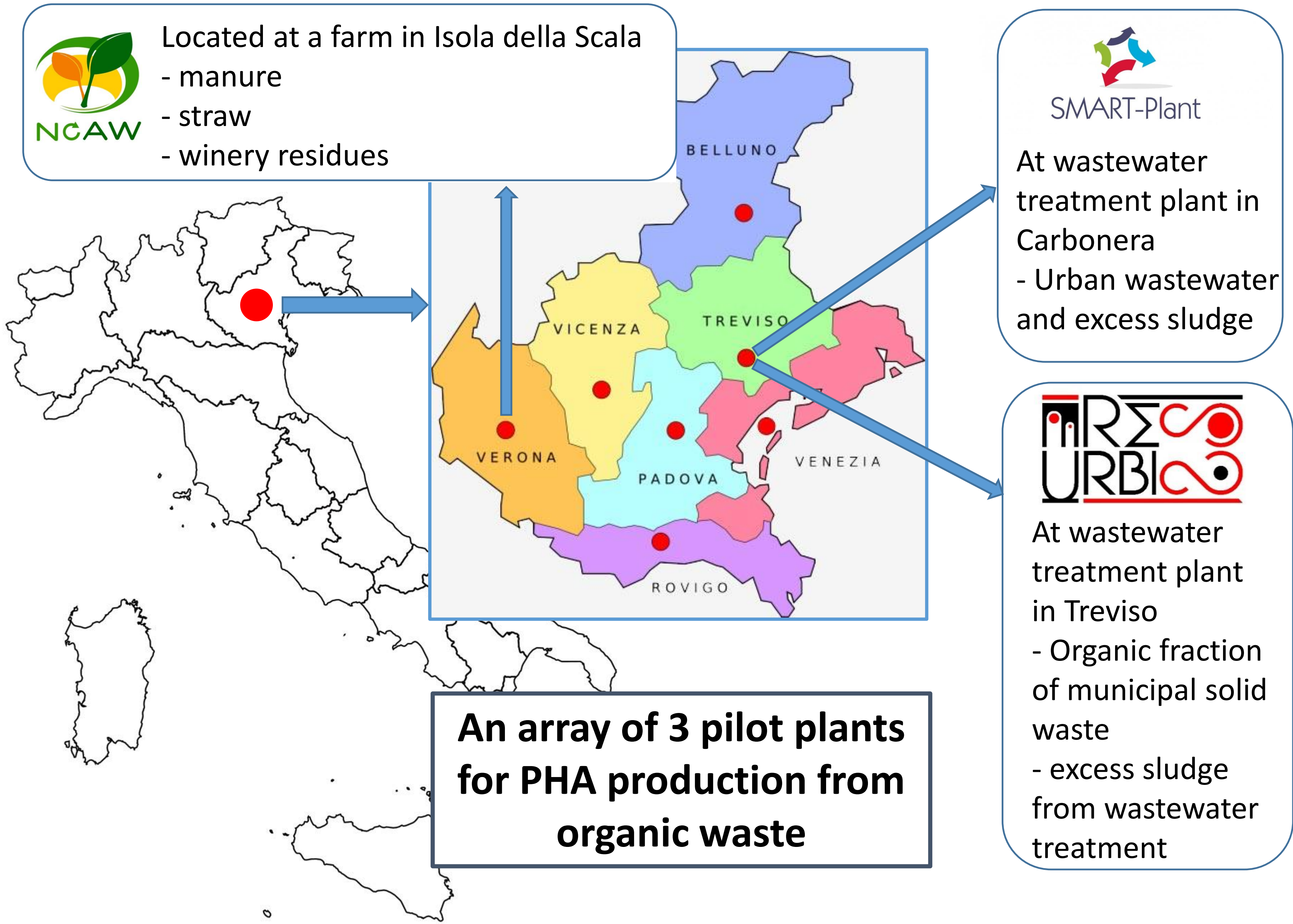
Process-related challenges

- Given the process has many steps, pilot-scale is essential to supply **robust technical-economic data**, especially because cost decrease remains a key target
- Long term experimentation with "true" waste feedstock is needed to address effects of **feedstock heterogeneity**
- An integrated process is required for **optimal management of water/solid overflows** and related energy recovery. This is also essential for making appropriate LCA
- The **extraction step** still requires optimization (as milder conditions as possible)

Product-related challenges

- PHA batches have to be steadily produced and delivered to investigate **downstream processing**, especially by using conventional industrial equipments (i.e in the range 1-10 Kg/batch).
- **Contaminant migration** and abatement and possible transfer into the products has to be investigated under close-to reality conditions.

Exploring micropollutant migration and/or abatement in novel waste-to-product technologies is a "hot spot" for full exploitation of circular economy principles.


NCAW
Located at a farm in Isola della Scala
- manure
- straw
- winery residues
BELLUNO
VICENZA
TREVISO
VERONA
PADOVA
VENEZIA
ROVIGO
SMART-Plant
At wastewater treatment plant in Carbonera
- Urban wastewater and excess sludge
RES URBIS
At wastewater treatment plant in Treviso
- Organic fraction of municipal solid waste
- excess sludge from wastewater treatment
An array of 3 pilot plants for PHA production from organic waste

NCAW

Full-scale Anaerobic Digestion plant, “La Torre”, Verona Cooperativa Agricola

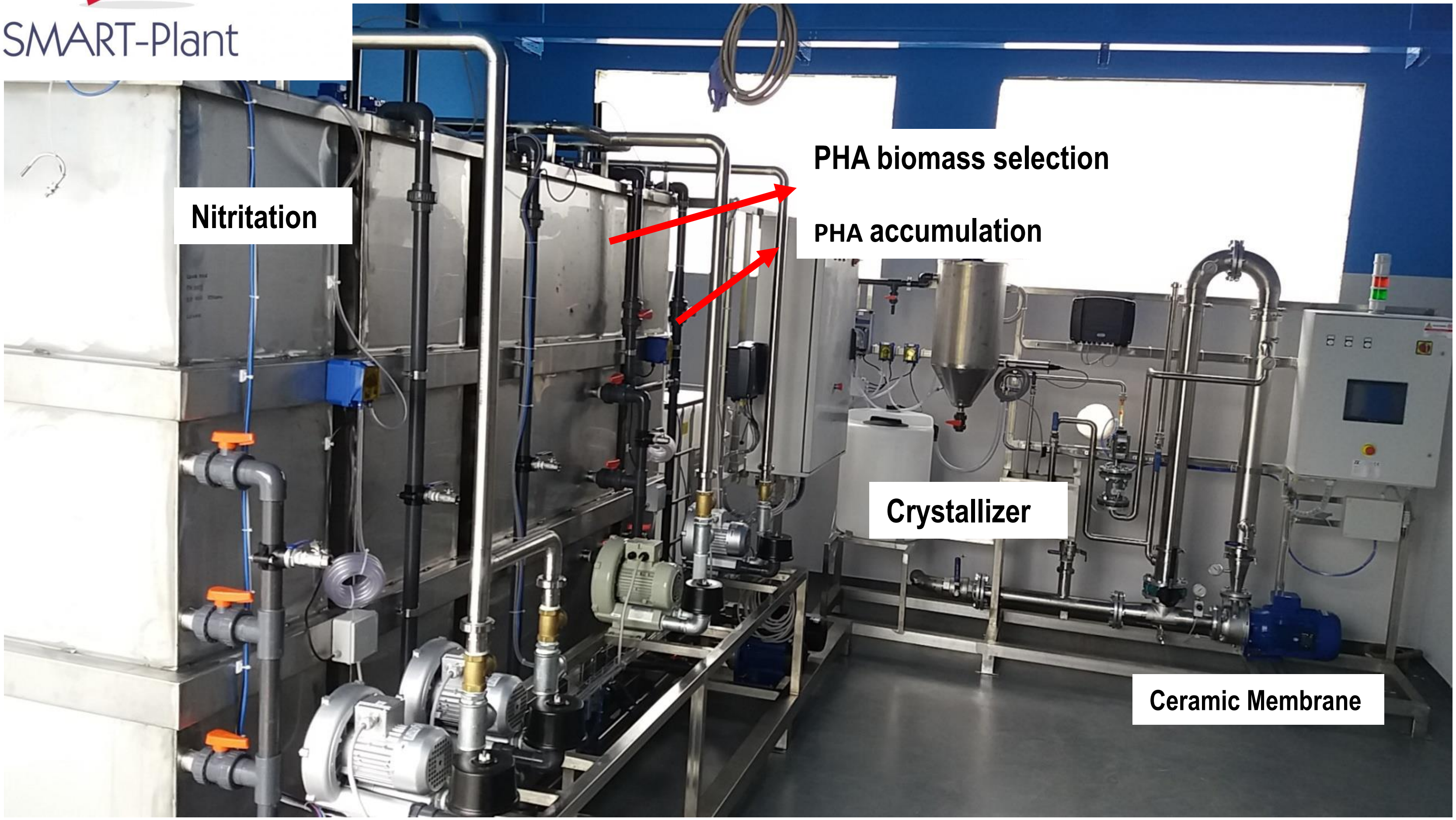
LA TORRE
Cooperativa Agricola Zootecnica

INNOVEN
INNOVATION FOR THE ENVIRONMENT

UNIVERSITÀ di VERONA

SAPIENZA
UNIVERSITÀ DI ROMA

SCEPPHAR pilot scale (Smartech 5): TRL 5



Start-up: 28/08/2017

Potential recoveries: 0.7-0.8 kgPHA/day; up to 300 gStruvite/day)

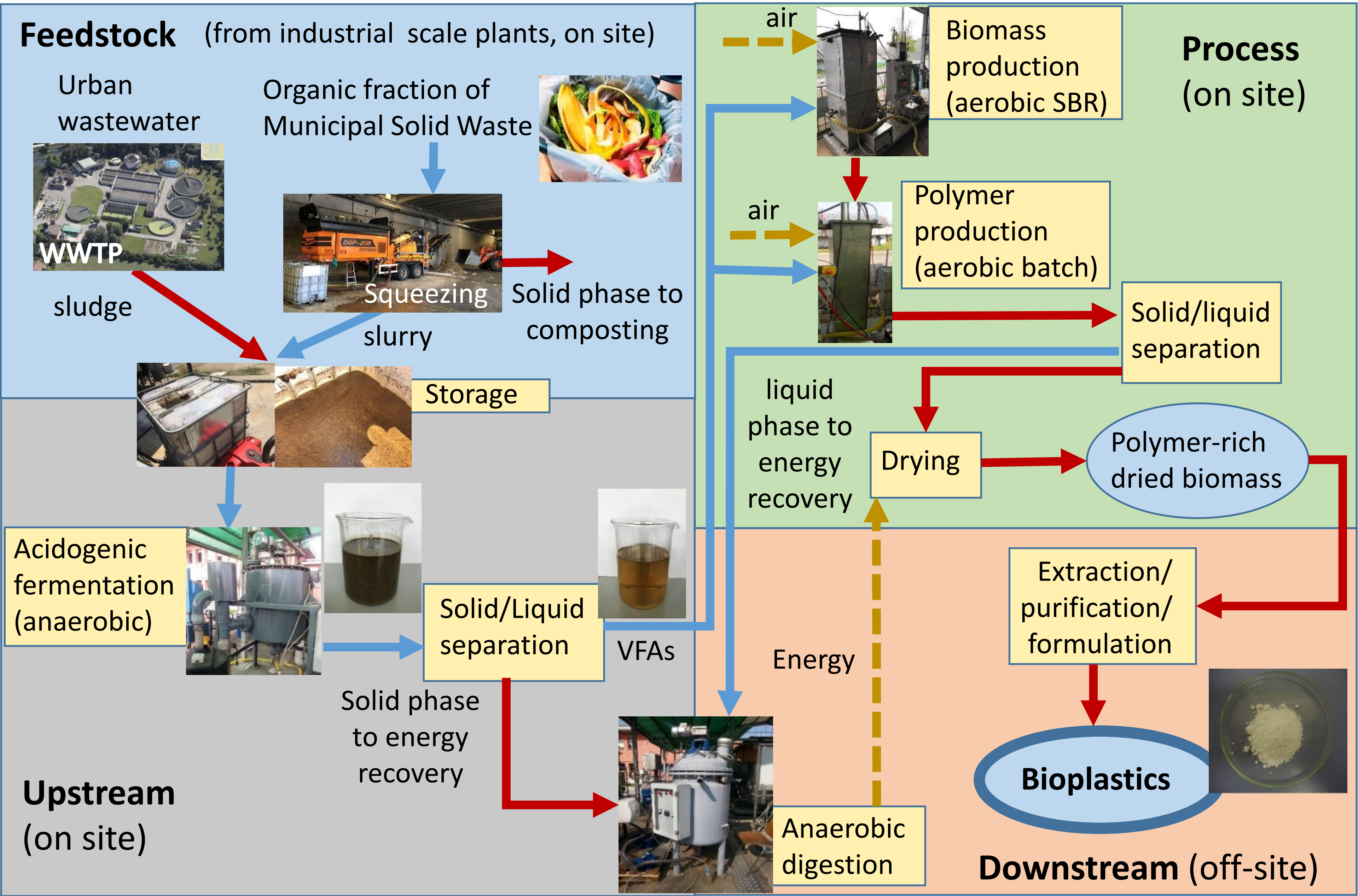
UNIVERSITÀ di VERONA
UNIVERSITÀ POLITECNICA DELLE MARCHE
SMART-Plant
Supported by the Horizon 2020 Framework Programme of the European Union

High Technology Readyness Level (TRL 5-6): pilot scale investigation is a key-feature of RES URBIS approach

Pilot scale platform of Universities of Venice and Verona at the wastewater treatment plant of Treviso (held by Alto Trevigiano Servizi, ATS)

Joint PHA production pilot plant, by Universities of Venice and Rome «Sapienza»

Flow-sheet of biopolymer production from urban biowaste (pilot scale plant in Treviso, Italy)



Step 1: Acidogenic fermentation

Fermenter operating conditions

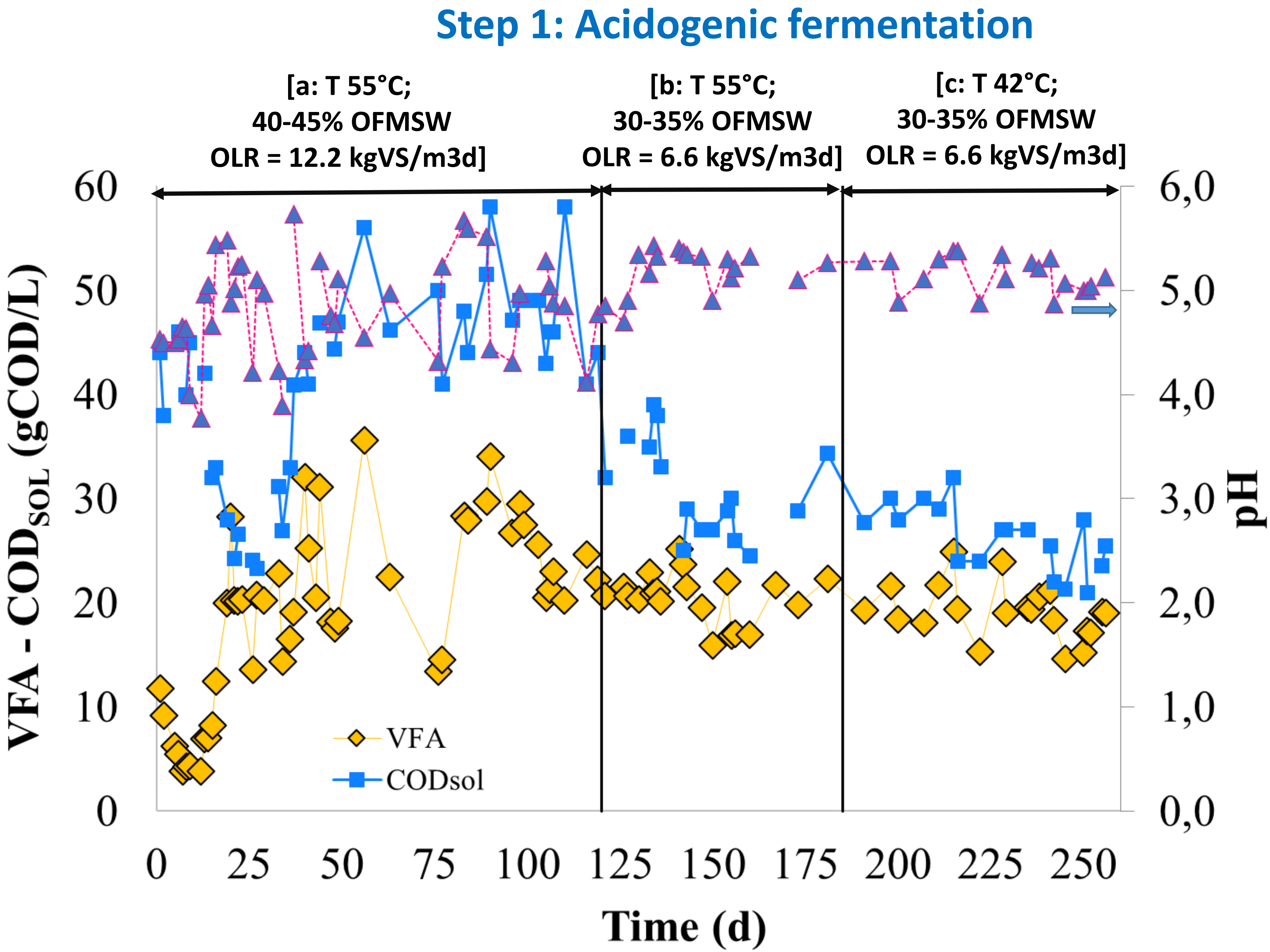
- The acidogenic fermenter is fed during the weekdays with the OFMSW-SS mixture (at different ratios)

Working Volume = 380 L

HRT = 6 days

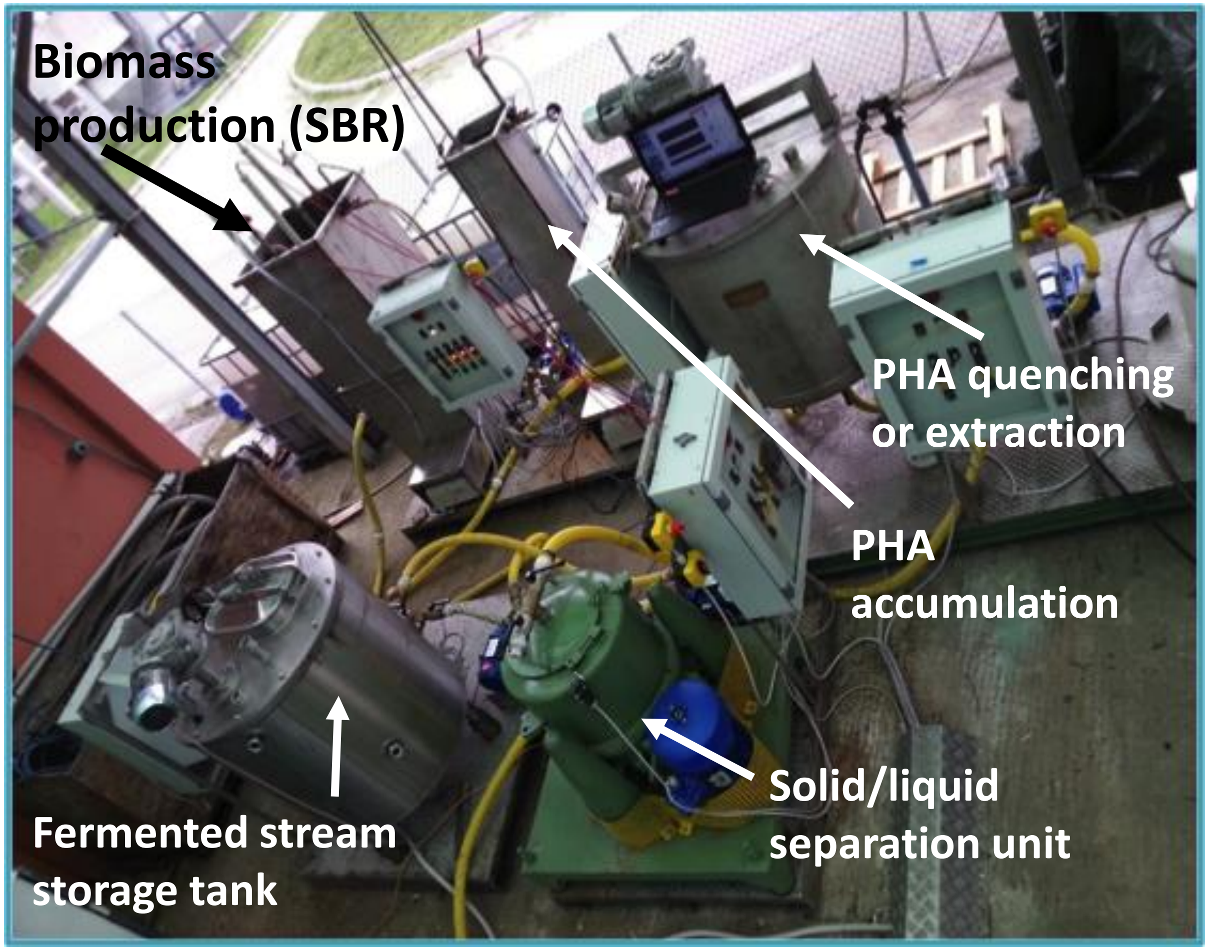
OLR = 6.6-12.2 kgVS/m^3d

T = 42°C - 55°C


Step 1: Acidogenic fermentation
[a: T 55°C;
40-45% OFMSW
OLR = 12.2 kgVS/m3d]
[b: T 55°C;
30-35% OFMSW
OLR = 6.6 kgVS/m3d]
[c: T 42°C;
30-35% OFMSW
OLR = 6.6 kgVS/m3d]
VFA - COD_{SOL} (gCOD/L)
pH
Time (d)
VFA
CODsol
0
10
20
30
40
50
60
0,0
1,0
2,0
3,0
4,0
5,0
6,0
0
25
50
75
100
125
150
175
200
225
250

Step 2: Biomass selection/production in the SBR

Pilot Plant for PHA production



SBR start-up

V = 160 L

OLR ≈3.0 $kgCOD/m^3d$

SRT = 1 d

HRT = 1 d

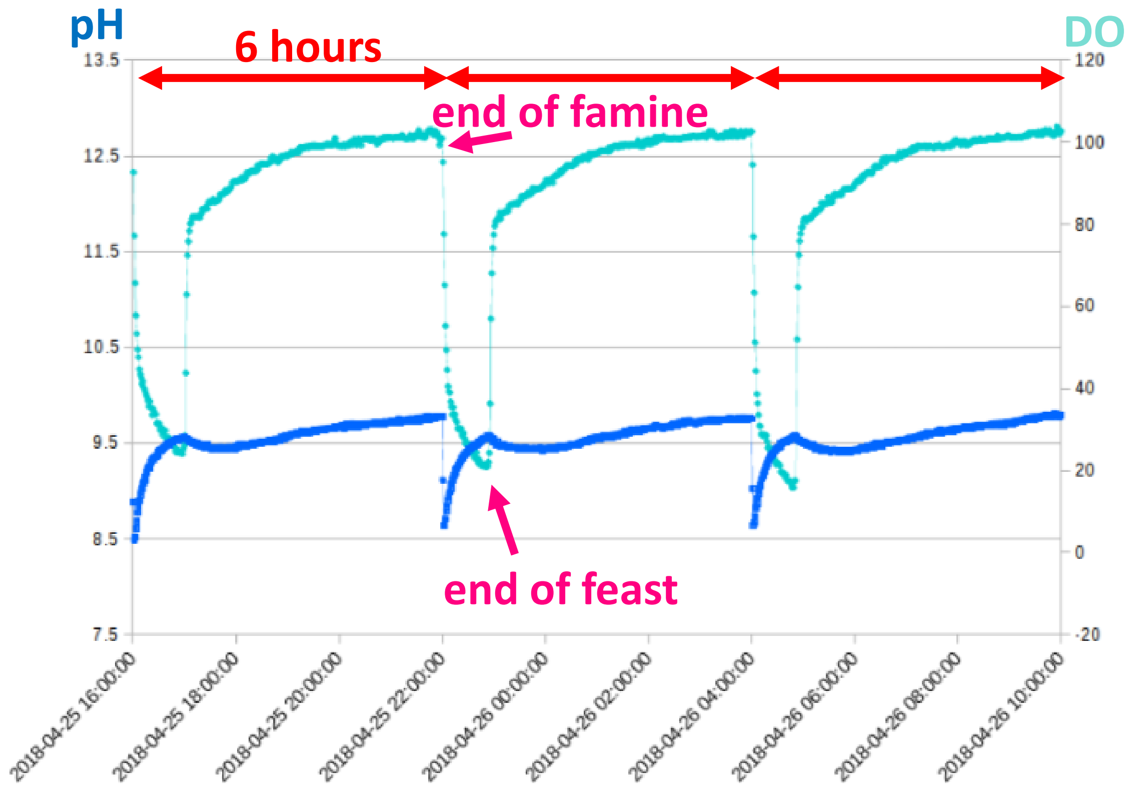
pH = 8.0-8.5 (uncontrolled)

T = uncontrolled

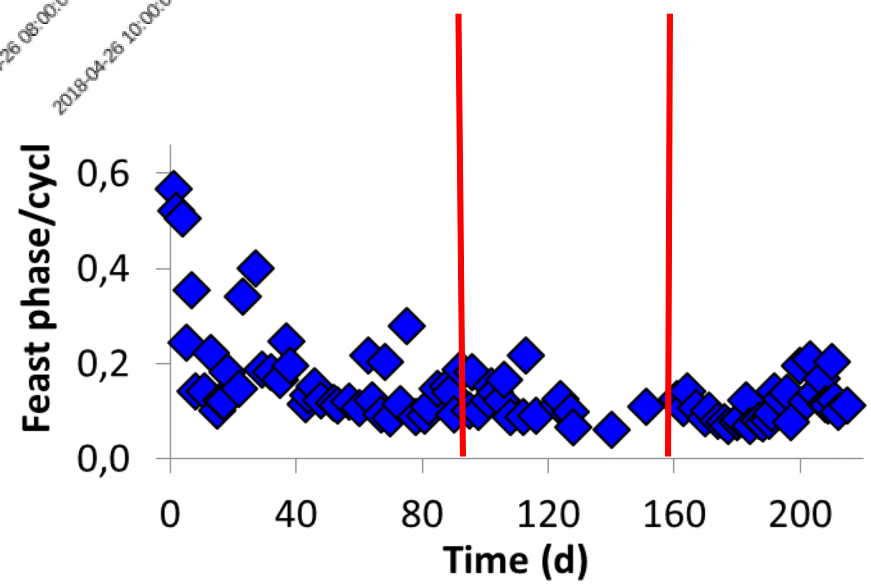
Cycle length = 6 h

- Feeding 3 min
- Reaction (a) 345 min
- Withdrawal 2 min
- Reaction (b) 10 min

Step 2: Biomass selection/production in SBR



- O_2 (% saturation) and pH profiles shows short feast period
- Efficient selective pressure in favour of PHA-storing microorganisms



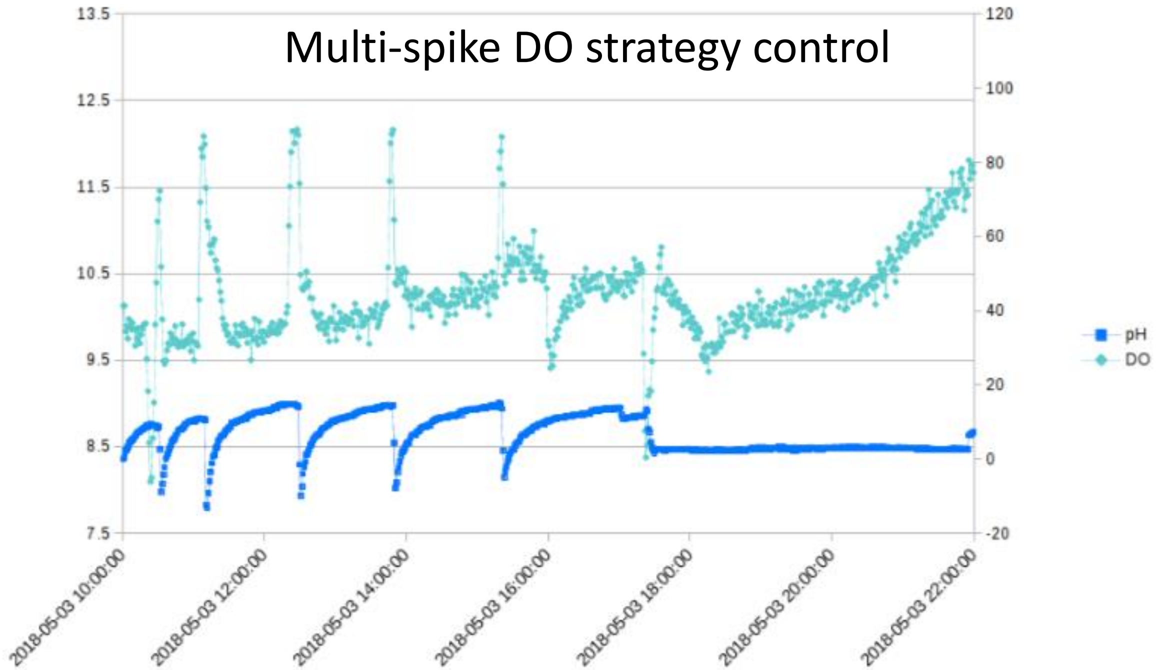
Step 3: PHA accumulation

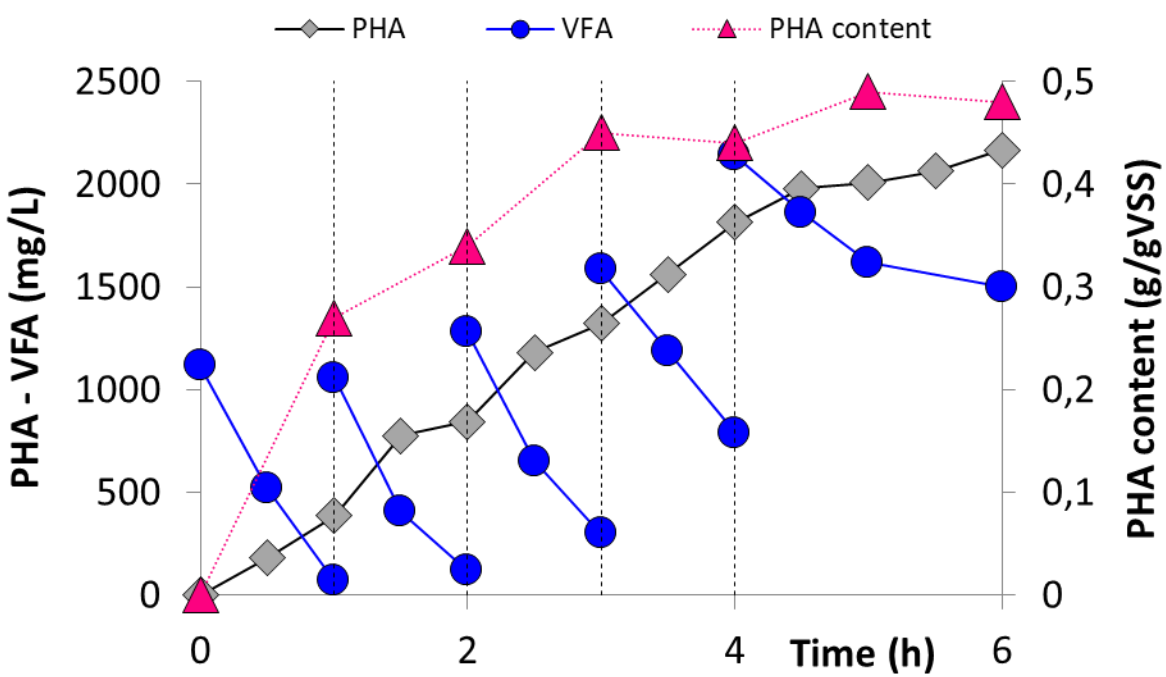
Under higher organic load (i.e. longer feast, no famine), PHA is accumulated to a higher concentration

Given nutrients are available, new active biomass is produced, which also accumulates PHA (higher PHA volumetric productivity)

PHA is accumulated up to 50% of cell dry weight

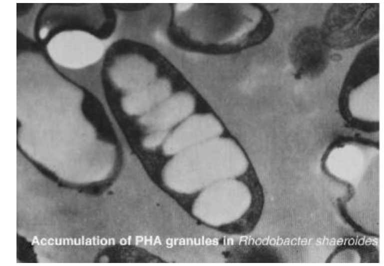
PHA yield on VFA = 0.5 COD/COD
Storage rate = 280 mgPHA/gX/h
PHA composition=90/10 (wt %, HB/HV)





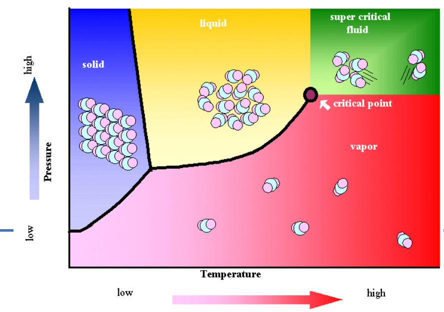
Task 2.4 PHA extraction

To test different extraction processes either at pilot or lab-scal

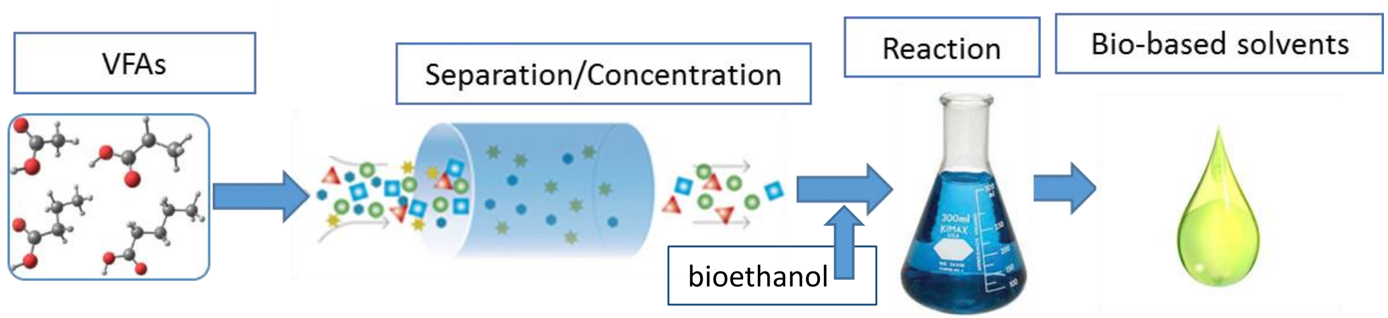


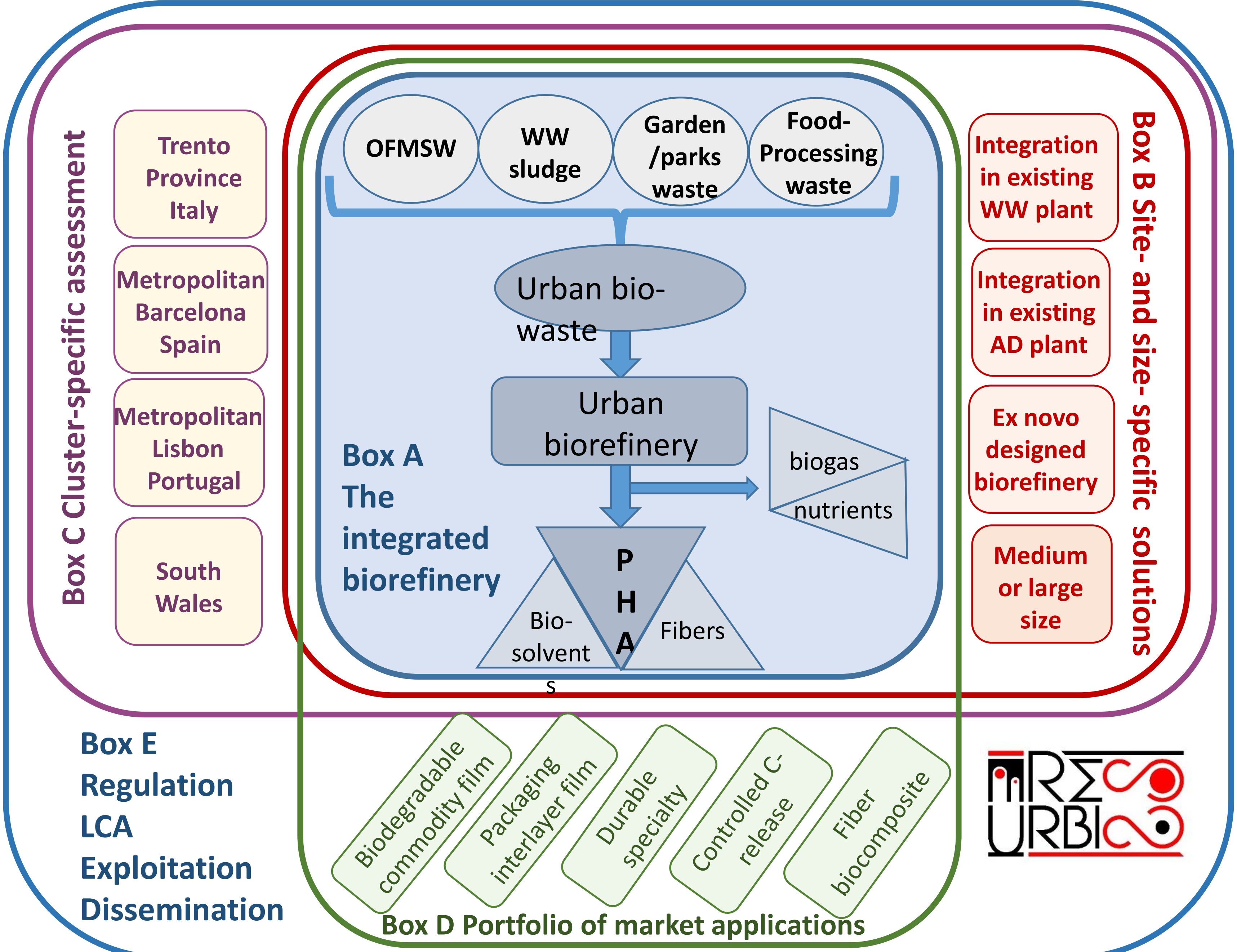
BIOTREND (SME)
Objective: to extract different grades of PHA using proprietary approach based on **inorganic reagents and mild conditions (no chlorine compounds)**

Univ. of Rome and Venice
Objective: develop and optimize an innovative extraction process based on **supercritical fluids**



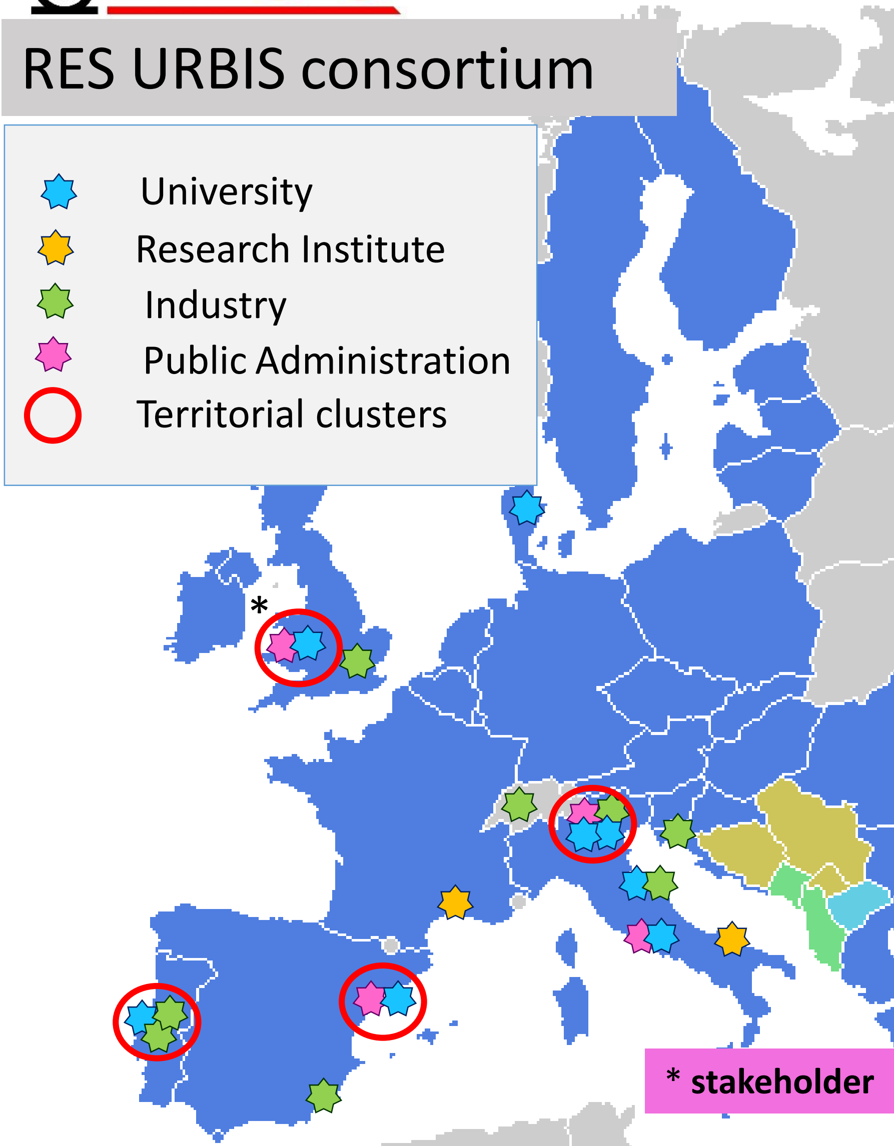
Italian National Research Council and Univ. of Rome
Objective: lab-scale testing of **bio-based solvents** (ethyl esters) produced from VFA mixture (Task 2.3)





The RES URBIS box-model

RES URBIS consortium



Partner	Work package
Process-related challenges	WP2
University of Roma “La Sapienza” (Italy)	
New University of Lisbon (Portugal)	
University Ca Foscari of Venice (Italy)	
University of Barcelona (Spain)	
University of South Wales (UK)	
University of Bologna(Italy)	
Biotrend (Portugal)	
CNR – IRSA(Italy)	
Inst. Nat. Recherche Agronomique (France)	
Product-related challenges	WP3
BioInicia (Spain)	
Mi-Plast (Croatia)	
SABIO (Italy)	
Territorial clustering	WP1
Aguas do Tejo Atlantico (Portugal)	
Barcelona Metropolitan Area (Spain)	
Province Autonoma di Trento(Italy)	
Rhondda Cynon Taff County Council (UK) *	
Economics and exploitation	WP5 WP6
InnoExc (Switzerland)	
Bio-Based and Biodegradable Industries Association (UK)	
Regulation, safety, environmental and social aspects	WP4 WP1
Technical University of Denmark (Denmark)	
National Institute for work safety (Italy)	
University of Verona (Italy)	

Is it worthwhile to put all this effort together?
Let's go to estimate potential impacts

Based on a preliminary mass balance of the new technology chain, an **OFMSW collection area of about 3,000,000 inhabitants** might guarantee the throughput of ~ **6-8 Kton PHA/year**.

Co-treatment with other urban biowaste (excess sludge, markets and park/garden waste) from the same area can increase the production capacity to ~ **18-20 kton PHA/year**.

This PHA production capacity would result into revenues of **~ 60-80 million EUR per year**, margins of **~ 30-40%** and the creation of **~** 100 new jobs for the cluster.

Under assumption of co-treatment, sustainable operative margins can be achieved even at smaller size, e.g from **500.000 inhabitants**. This is the smallest cluster being considered in the RES URBIS (Province of Trento).

According to population distribution in Europe (BBSR 2011), there are **115 Metropolitan Areas** which have more than **500.000 inhabitants** each and an average size of 3 million.

Thus, **~ 343 million people live in metropolitan areas** that have a suitable size to exploit the RES URBIS approach, which means a **potential** of producing up to **2,2 million ton PHA per year** (excluding food-processing waste), 8.8 billion € and **~** 10 000 new green jobs in Europe.

This PHA production is more than 10 times the present PHA production capacity worldwide but still less than 5% of present consumption of oil-based plastics in Europe.

Thanks for your attention

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For more information on projects:

www.resurbis.eu

http://noaw2020.eu/

https://www.smart-plant.eu/

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