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SMART-Plant 22\* Fiera Internazionale del recupero di materia ed energia e dello sviluppo sostenibile

6-9 Novembre 2018 Rimini Italy

KEY ENERGY

Green & Circular Economy

# Water and nutrient circular economy policy support. The Innovation Deal experience

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#### **3rd EUROPEAN NUTRIENT EVENT @ ECOMONDO 2018**

8 - 9 November 2018, Rimini, Italy







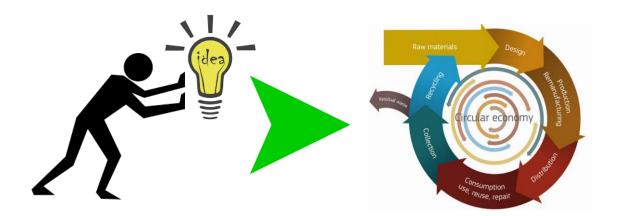




## From WWTP to WRRF

The need for sustainability...

- Increased depletion of resources
- Necessity of reducing carbon footprint



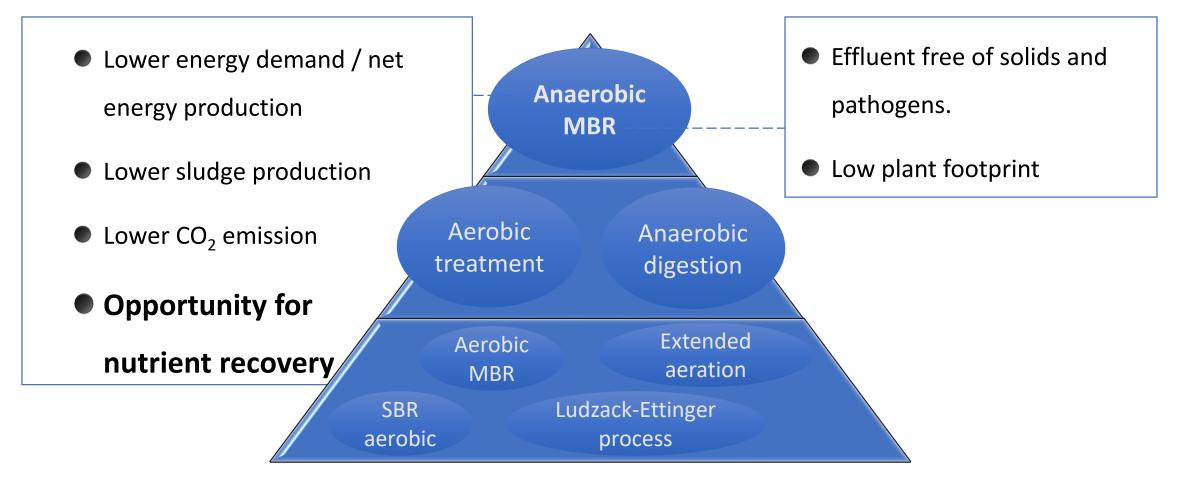






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## From WWTP to WRRF











WWTP vs WRRF: Less energy consumption Less CO<sub>2</sub> emissions Anaerobic **Bioenergy MBR** Wastewater Reclaimed Less **25% less** water biosolids surface production

#### Waste Source of Resources

#### Energy demand 0.2-0.5 kWh/m<sup>3</sup> Net energy SURPLUS of up to 0.2 kWh/m<sup>3</sup> Reduction of up to 80% CO<sub>2</sub> and 100% N<sub>2</sub>O emissions

Limited nutrient recovery potential

Up to 100% of nutrients recovery Energy savings by avoiding fertilizers production:

• N: 0,77 kWh/m<sup>3</sup> reused water (N typical conc. 40 mg/L).

• P: 0,02 kWh/m<sup>3</sup> reused water (P typical conc. 8 mg/L). FERTIGATION significantly enhances SUSTAINABILITY

Biosolids prod. of approx. 0.5 kg VSS/kg COD<sub>Rem</sub> Biosolids prod. of 0.05-0.10 kg VSS/kg COD<sub>Rem</sub>

**Biosolids** 

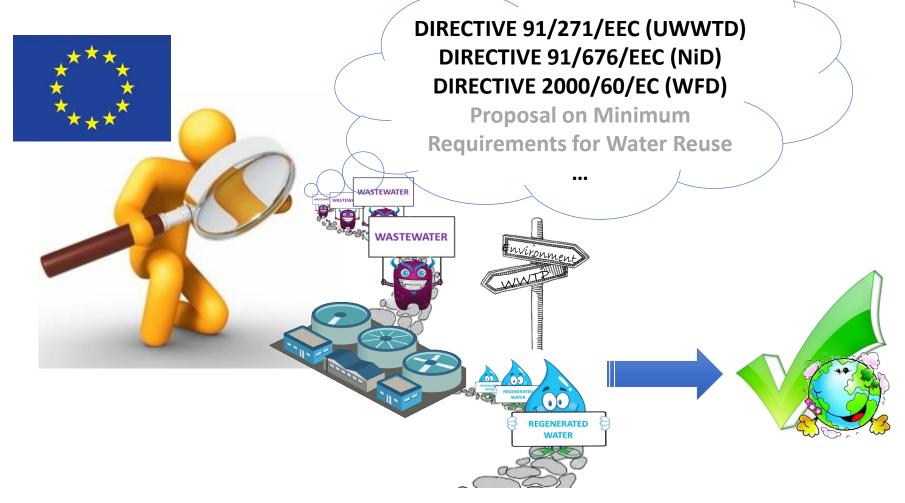






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#### **Environment and health protection...**



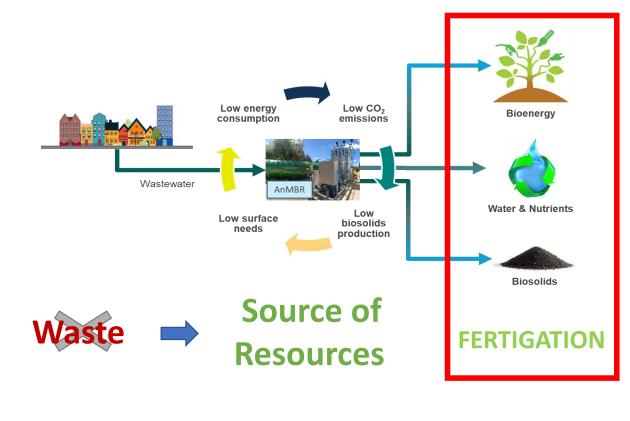






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### **Bottlenecks to circular economy**





Legal



• Social

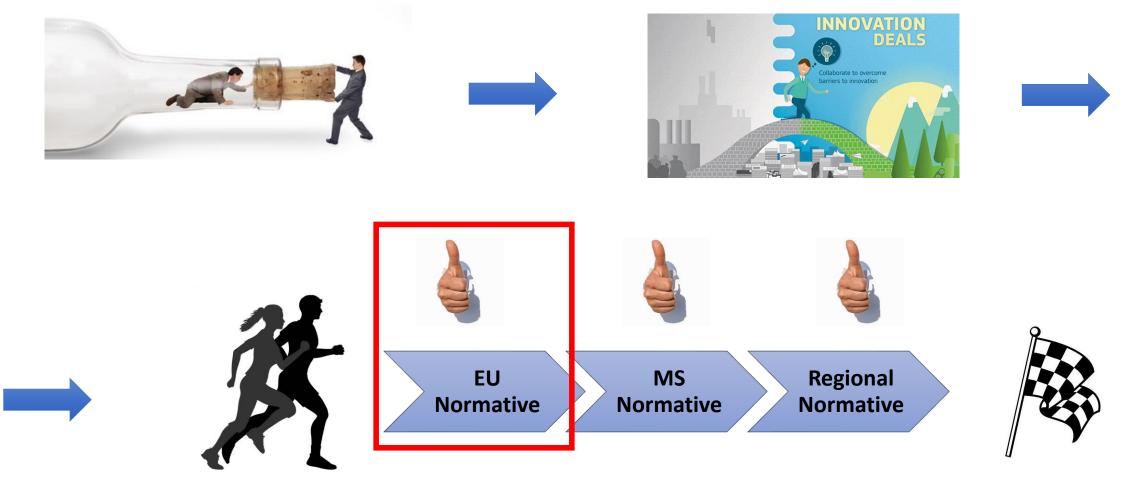






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### **The Innovation Deal experience**







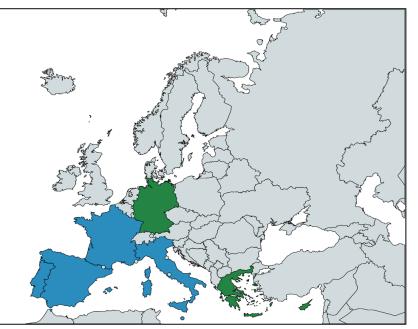






## **INNOVATION DEAL** on Sustainable Wastewater Treatment Combining Anaerobic Membrane Technology and Water Reuse





MSs with direct representation in the Consortium
MSs without direct representation in the Consortium











## **INNOVATION DEAL** on Sustainable Wastewater Treatment Combining Anaerobic Membrane Technology and Water Reuse

- To improve water, energy and nutrients recovery from wastewater through AnMBR technology implementation
- To overcome barriers to water / nutrients reuse within the European Union
- To boost new market niches within the water sector





Ensuring environmental and health protection

Case-by-case approach, Risk Assessment Plan











## **INNOVATION DEAL** on Sustainable Wastewater Treatment Combining Anaerobic Membrane Technology and Water Reuse

Initial premises of our analysis:

- It makes no sense to remove nutrients in the WWTP and latter on to add them in the field.
- Farmers and agriculture users of treated water should be considered not as potential consumers of the effluents, but as active participants of the wastewater treatment and its valorization.
- We have to change from a situation of prohibition to strict quality controls assuming no health or environmental risks.



Legal

Economic



Italian Phosphorus Platform





#### **Identified bottlenecks**

Lack of legal definition of the term discharge and quality standards provisions adopted for wastewater effluents to be used for agriculture.

#### Lack of legal definition of water reuse.

Lack of recognition of the economic and environmental benefits of water reuse within reclaimed water pricing

Health and environmental **risk assessment** about water reuse in agriculture is needed.

#### High initial investment for WWTP upgrading.

Lack of economic assessment of both monetary and non-monetary benefits.

Lack of financial incentives for boosting reclaimed water use in agriculture

Poor development of business models and market research

Technological investment to address the temporal variability of water demand for agricultural irrigation

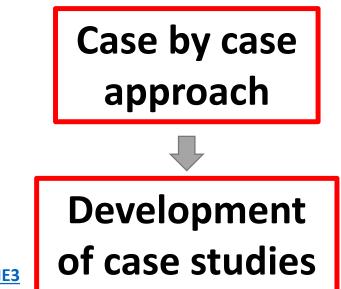
#### Main solutions

To legally define the term **discharge** based on **the fate of the effluent**: reuse or discharge into water bodies

To legally define the term water reuse

To consider water reuse in agriculture as part of wastewater treatment to recover the **nutrients** present in wastewater, reducing mineral fertilizers necessities and to increase water availability and prevent water body depletion.

Alternatively, to consider reclaimed water as a product

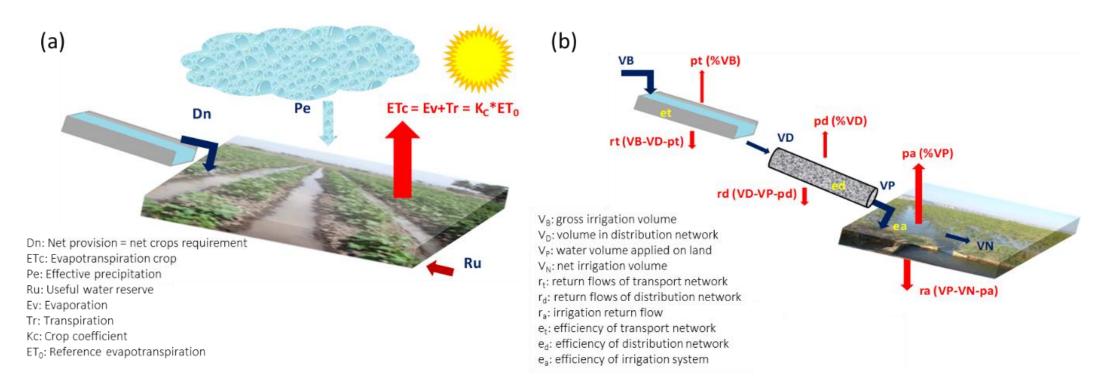




### Problem approach: Water balance at catchment scale

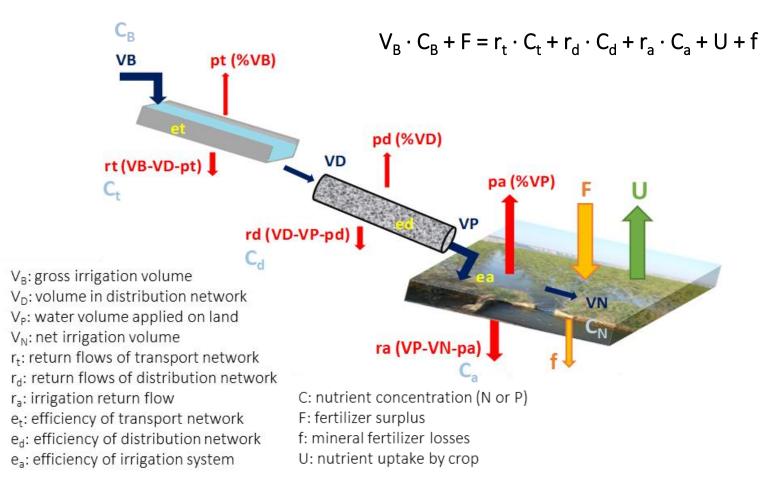
#### a) Water balance applied in cropland

b) Water balance applied in irrigation network





### **Problem approach: Nutrient balance at catchment scale**



#### $V_{P} \cdot C_{P} + F = U + f + r_{a} \cdot C_{a}$

- Flooding → f = 40 kg N/ha/y and 10 kg P/ha/y for citrus (Quiñones et al, 2013)
- Dripping → f = 1% of losses (Elmaloglou et al, 2007)



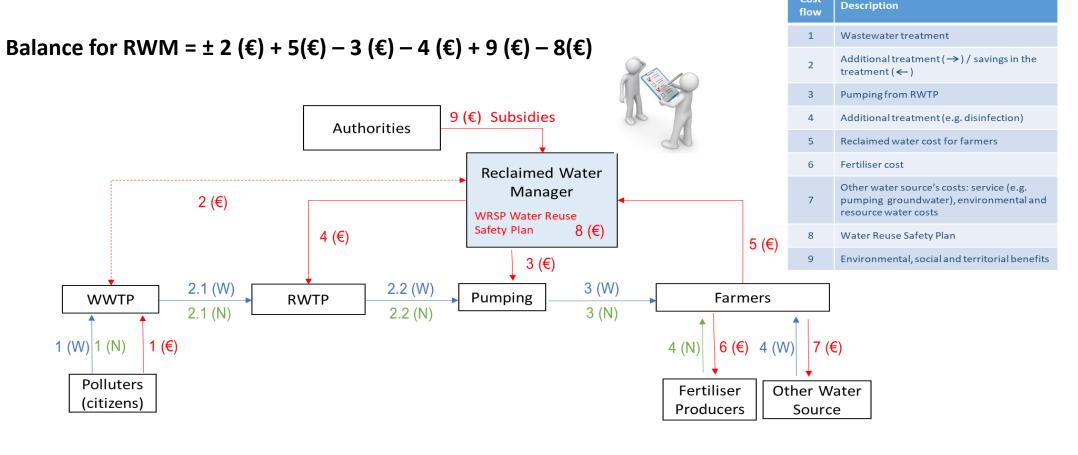




Cost



#### **Economic balance**



 $C_{\text{Total}} = C_{\text{WWT}} + C_{\text{Chemical precipitation}} + C_{\text{Disinfection}} + C_{\text{Pumping}} + C_{\text{Fertilizers}} + C_{\text{Discharged fee}} - C_{\text{Energy recovery}}$ 

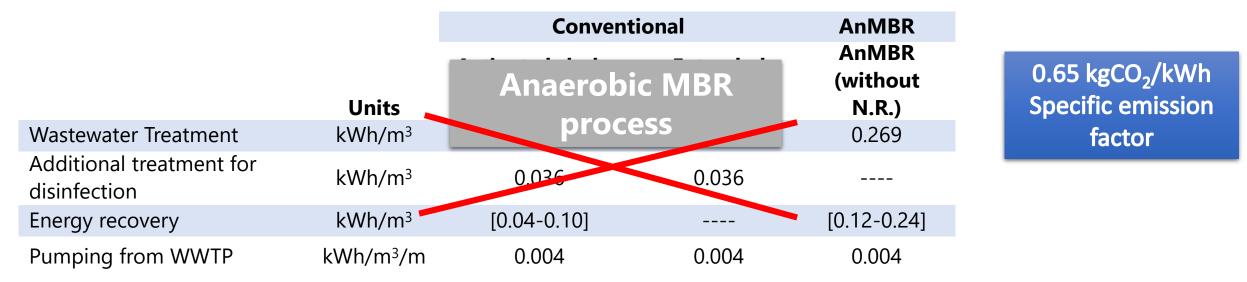






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#### Assessment of CO<sub>2</sub> emissions



#### Energy related to mineral fertilizers production

N-fertilizers: 19.3 kWh/kg N by Haber-Bosh Process

P-fertilizers: 2.11 kWh/kg P (Gellings and Parmenter, 2004)

Total  $CO_2$  emissions =  $CO_2$  treatment +  $CO_2$  pumping +  $CO_2$  fertilizers -  $CO_2$  biogas

www.smart-plant.eu/ENE3

Biological nitrogen removal processes → N<sub>2</sub>O





**Case study I: Oliva (Spain)** 

Italian Phosphorus Platform





Non-sensitive area according to WWTD

Vulnerable zone according to NiD





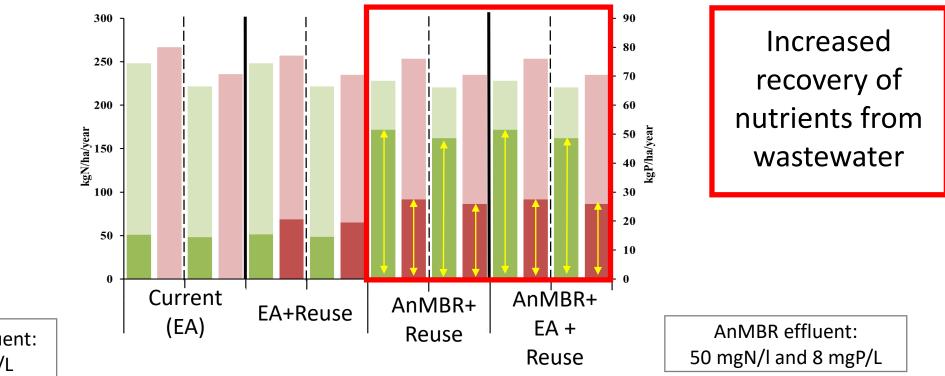






### **Oliva: Nutrient recovery**

■ NT added by water ■ NT added by mineral fertilizers ■ PT added by water ■ PT added by mineral fertilizers



Extended Aeration effluent: 15 mgN/l and 6 mgP/L





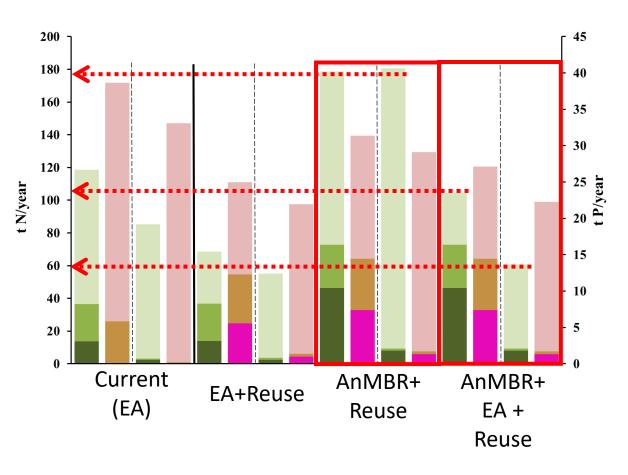




### **Oliva: Nutrient losses**

Nitrogen discharged to coastal water body (non-sensitive area)

N and P discharged
to coastal water body
(non-sensitive area)



- NT losses through network
- PT losses through network
- NT losses in cropland
- PT losses in cropland
- NT discharged in WWTP effluent
- PT discharged in WWTP effluent

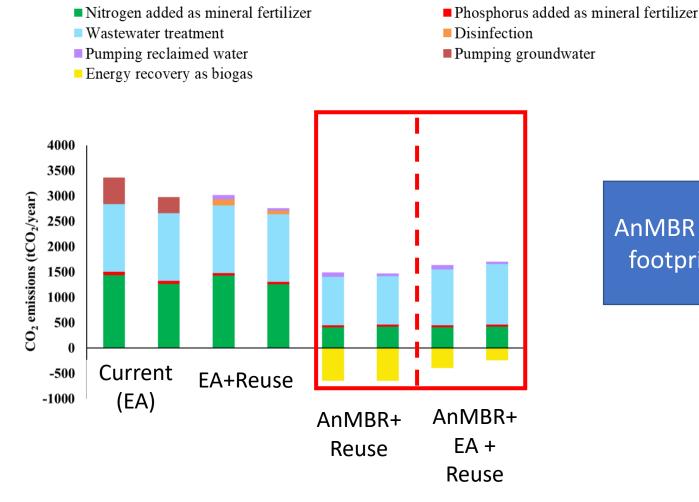








## **Oliva: CO<sub>2</sub> emissions**



# AnMBR allows carbon footprint reduction









Cost flow	Costs	Units	Current Scenario (EA)	EA + Reuse	AnMBR + Reuse	AnMBR + EA + Reuse
1	Wastewater treatment	1000 €/year	257	257	94	157
4	Disinfection	1000 €/year	0	15	0	0
3	Pumping reuse	1000 €/year	0	16	16	16
	Discharge fee	1000 €/year	22	9	9	9
	Total treatment cost	1000 €/year	279	297	119	182
6	Fertilisers	1000 €/year	92	87	31	31
7	Pumping groundwater	1000 €/year	110	0	0	0
	Total farmer cost	1000 €/year	202	87	31	31
	Total	1000 €/year	481	384	150	213
5	Farmer to manager	1000 €/year	0	115	171	171
2	Flow WWTP to manager	1000 €/year	0	13	177	114
	Available for RWM	1000 €/year	0 nart-piant.eu/	98	332	269









## **Case study II: Peschiera Borromeo (Italy)**

Irrigated area:

1500 ha (tomato)

Water demand:

12 hm<sup>3</sup>/year

**Currently:** 

surface water



## Sensitive area according to WWTD

Vulnerable zone according to NiD

#### Discharge to surface water body







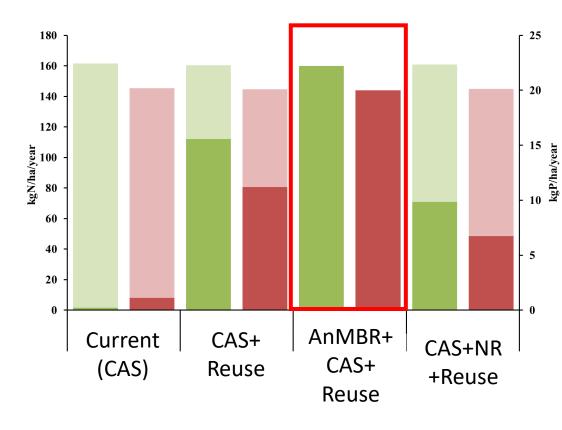


No need for mineral

fertilization

### **Peschiera: Nutrient recovery**

■ NT added by water ■ NT added by mineral fertilizers ■ PT added by water ■ PT added by mineral fertilizers

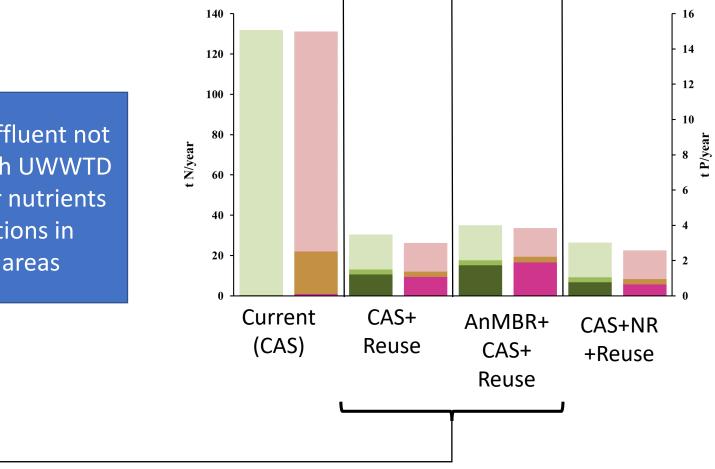


Conventional Activated Sludge effluent: 9,5 mgN/l and 0,6 mgP/L



#### **Peschiera: Nutrient losses**

BUT reused effluent not compliant with UWWTD provisions for nutrients concentrations in sensitive areas



NT losses through network

- PT losses through network
- NT losses in cropland
- PT losses in cropland
- NT discharged in WWTP effluent
- PT discharged in WWTP effluent





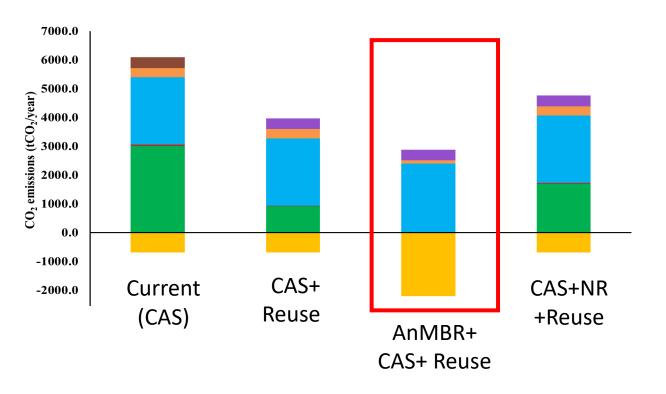




### Peschiera: CO<sub>2</sub> emissions

- Nitrogen added as mineral fertilizer
- Wastewater treatment
- Pumping reclaimed water
- Energy recovery as biogas

- Phosphorus added as mineral fertilizer
- Disinfection
- Pumping groundwater



AnMBR allows carbon footprint reduction









Cost flow	Cost	Units	CAS	CAS + Reuse	AnMBR + CAS + Peuse	CAS + NR + Reuse
	Wastewater treatment	1000€/year	407	407	261	407
1	Disinfection	1000€/year	70	70	24	70
	Chemical precipitation	1000€/year	36	5	23	36
3	Pumping reuse	1000€/year	0	81	81	81
	Total treatment cost	1000€/year	513	563	389	594
6	Fertilisers	1000€/year	171	53	0	97
7	Pumping surface water	1000€/year	81	0	0	0
	Total farmer cost	1000€/year	252	53	0	97
	Total	1000€/year	765	616	389	691
5	Farmer to manager	1000€/year	0	199	252	154
2	Flow WWTP to manager	1000€/year	0	31	206	٥
	Available for RWM	1000€/year	0	149	376	74





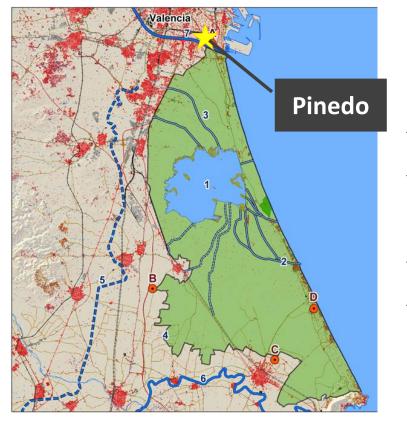


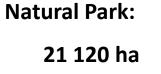


## **Case study III: Pinedo (Spain)**

**Current discharge:** 

- 68 hm<sup>3</sup>/year to non-sensitive coastal body
- 34 hm<sup>3</sup>/year reused in rice fields discharging into the lake





- $\checkmark\,$  Sensitive area according to WWTD
- $\checkmark$  Since 1990 Ramsar site in the list of wetlands of
  - international importance for birds
- $\checkmark\,$  Special protected area acc. Spanish law
- ✓ Vulnerable zone according to NiD



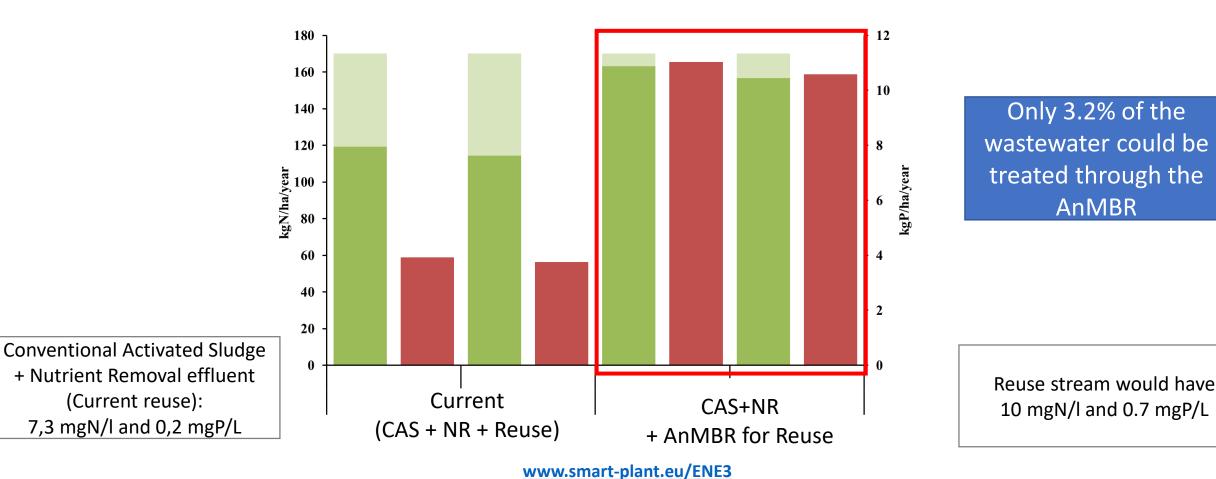






#### **Pinedo: Nutrient recovery**

■ NT added by water ■ NT added by mineral fertilizers ■ PT added by water ■ PT added by mineral fertilizers











## Take home messages – proposals developed by Innovation Deal

- To legally define the terms "discharge" and "water reuse".
- To consider water reuse in agriculture as part of wastewater treatment.
- Alternatively: to consider reclaimed water and its nutrient content as a product (fertilizer).
- To define a risk assessment methodology for water reuse safety plans (WRSP).
- To aim at a sustainable nutrient balance.
- To include the figure of the Reclaimed Water Manager (RWM).
- To carry out a broad economic analyses including both monetary and non-monetary benefits.









### Take home messages – case studies

- Water reuse improves quantitative status of groundwater bodies.
- AnMBR technology combined with fertigation allows:
  - Nutrients recovery **reduces** addition of mineral fertilizers.
  - Reducing carbon footprint
  - Reducing operational costs
  - Increasing economic results for RWM **p**open new market niche.





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# Thank you for your attention

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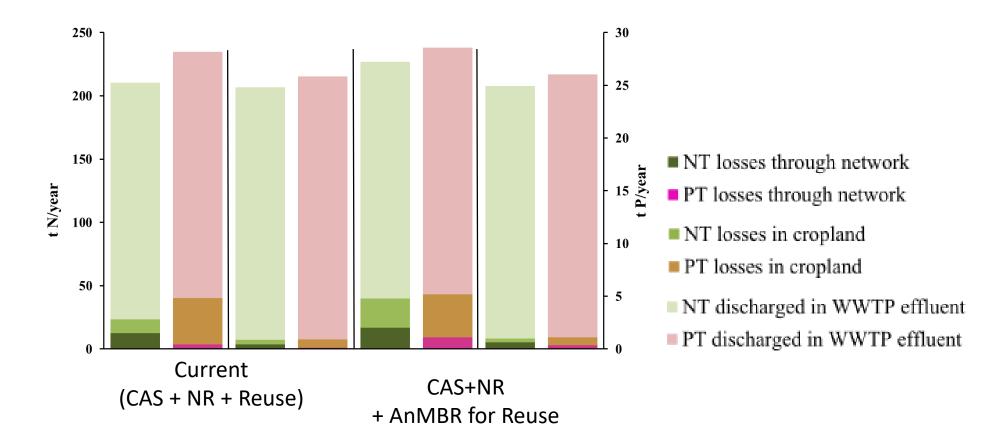






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#### **Pinedo: Nutrient losses**



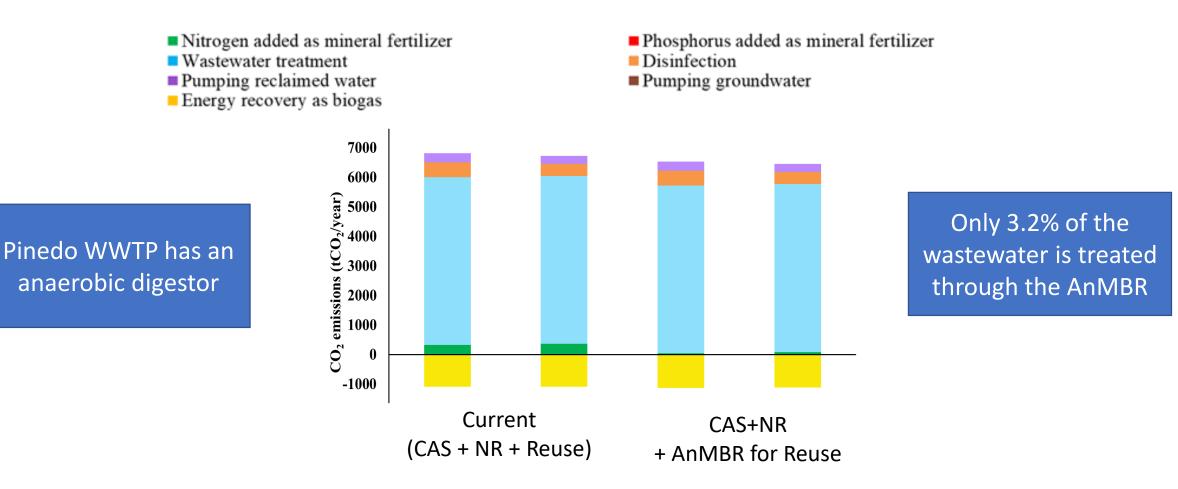






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## **Pinedo: CO<sub>2</sub> emissions**











Cost flow	Costs	Units	CAS + NR + Reuse	CAS + NR + Reuse Optimized	CAS + NR + AnMBR for Reuse	CAS + NR + AnMBR for Reuse Optimized
1	Wastewater treatment	1000€/year	882	882	881	881
4	Tertiary treatment (Disinfection + Chemical treatment+Pumping reuse)	1000€/year	141	120	135	115
3	Pumping reuse AnMBR	1000€/year	0	0	5	4
	Discharge fee	1000 €/year	94	100	94	100
	Total treatment cost	1000 €/year <b>(</b>	1117	1101	1114	1099
6	Fertilisers	1000€/year	37	26	26	24
7	Pumping surface water	1000€/year	0	0	0	0
	Total farmer cost	1000€/year	37	26	26	24
	Total	1000€/year	1154	1128	1140	1123
5	Farmer to manager	1000€/year	0	0	12	3
2	Flow WWTP to manager	1000€/year	0	0	7	6
	Available for RWM	1000€/year <b>(</b>	0	0	0,002	0,001