



This project has received funding
from the EU Horizon 2020
research and innovation
programme under grant
agreement No. 690323



SMART-Plant



Innovative utility partnership to reach economy of scale for phosphorus recycling: technoeconomic assessment

Emilio Caporossi Hera Group – Partnership HERA-IREN-SMAT



3rd EUROPEAN NUTRIENT EVENT @ ECOMONDO 2018

8 - 9 November 2018, Rimini, Italy

www.smart-plant.eu/ENE3





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Summary

- **HERA, IREN and SMAT: who we are**
- **About our innovation partnership**
- **Why struvite recovery?**
- **Techno-economic assessment**



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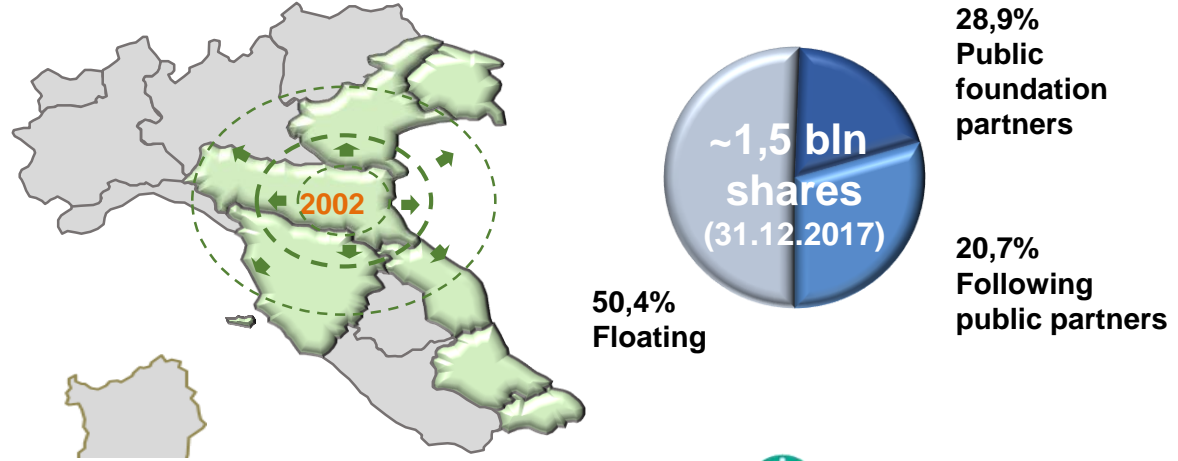


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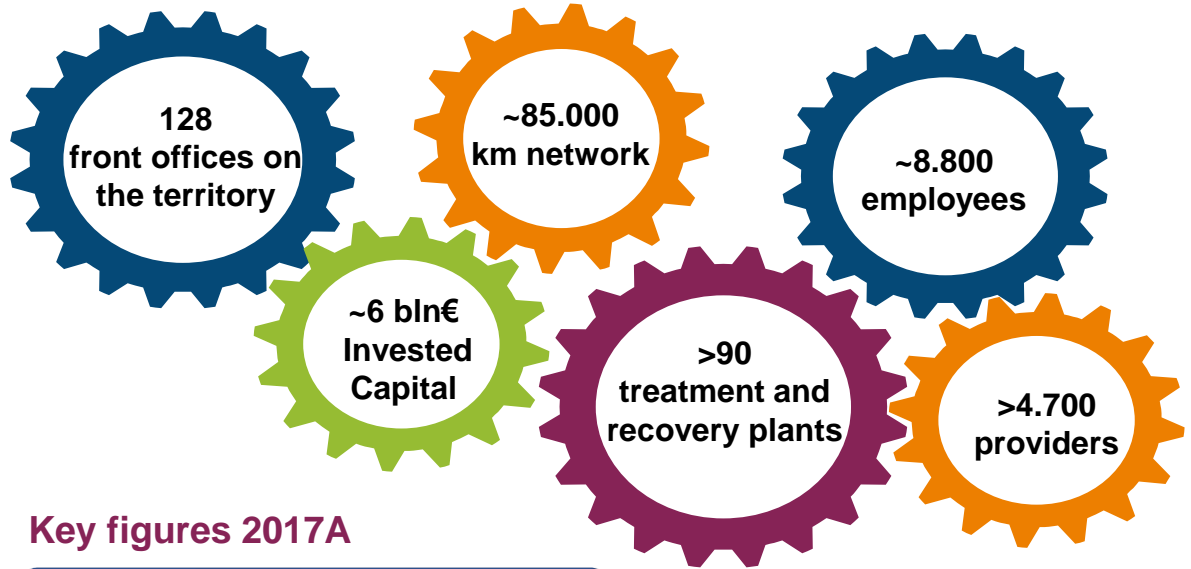


HERA SpA was founded in 2002 through the merge of 11 municipalities and based its following growth on efficiencies and M&As

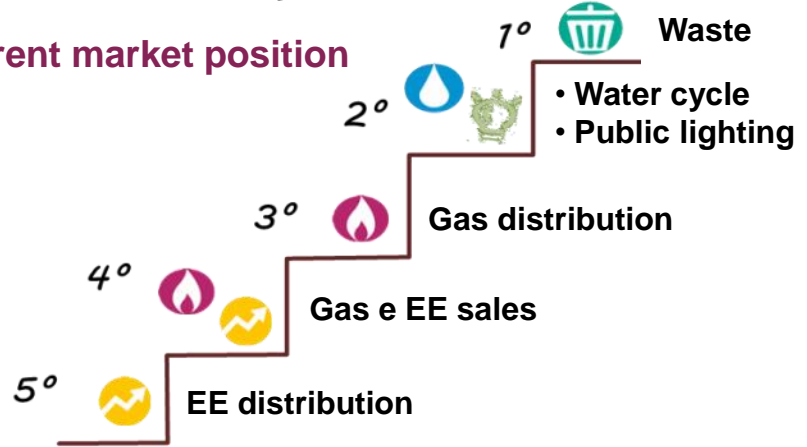
Geographical footprint and shareholders



Assets and industrial platform



Current market position

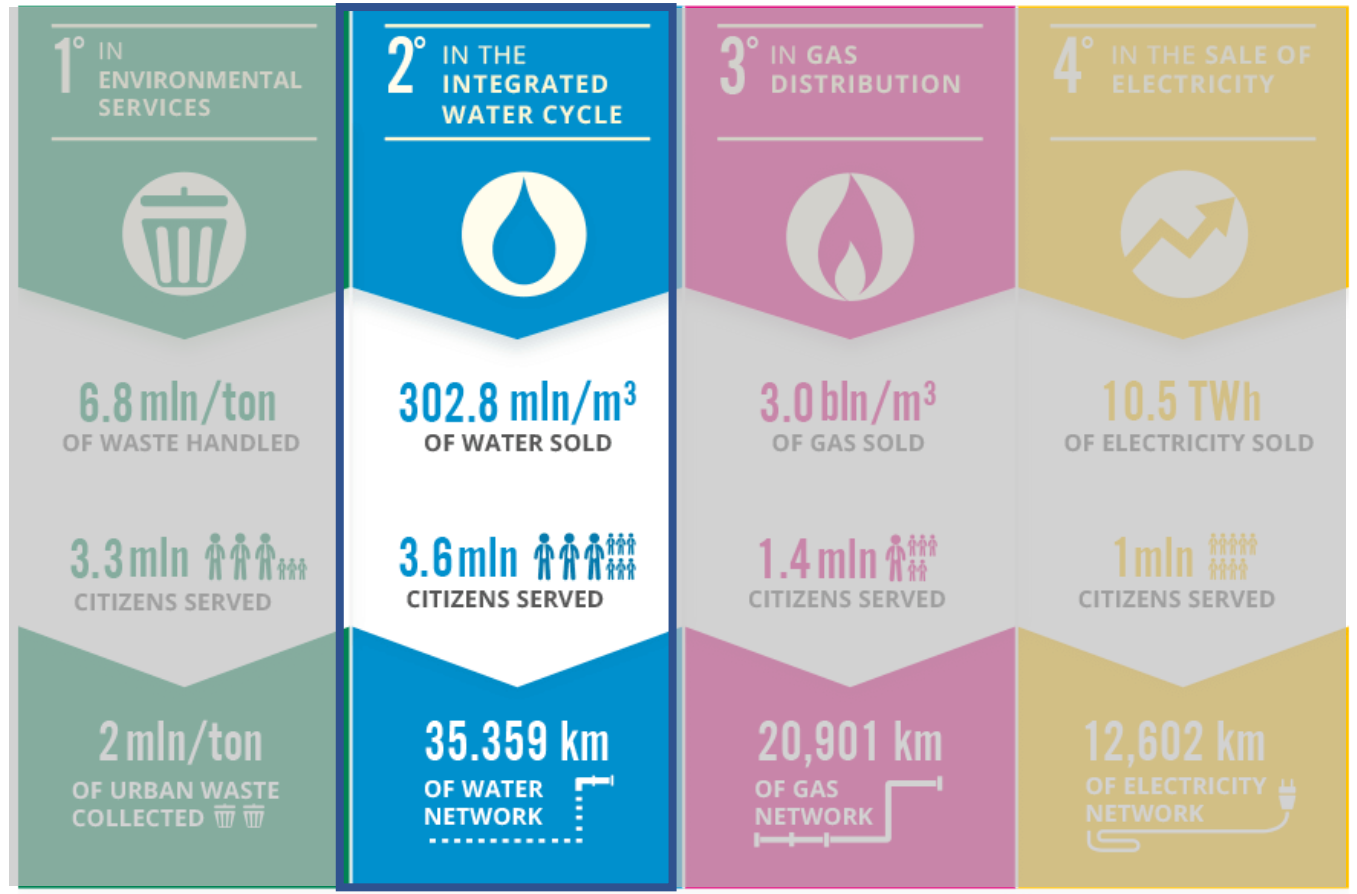


Key figures 2017A

EBITDA	985 mln€
CAPEX*	497 mln€
PFN	2.523 mln€
PFN/EBITDA	2,56 x

MARKET CAP
4,4 bln€

In 15 years Hera achieved a leadership position in all its core businesses



8,847 WORKERS

349 MUNICIPALITIES



The water service: a core business

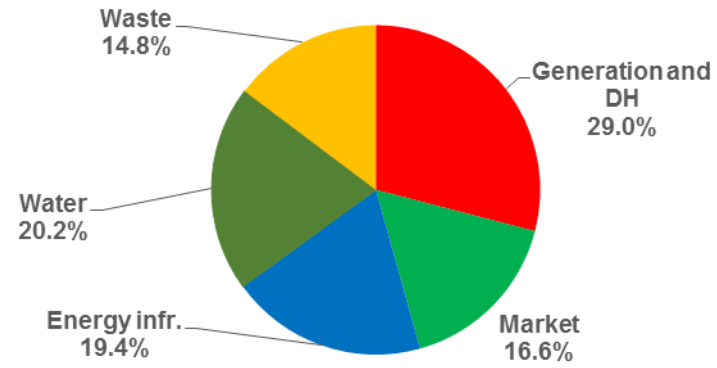
In 2014 Hera joined the **UN Global Compact**

In 2017 Hera joined the **CEO Water Mandate**

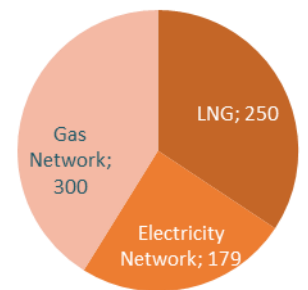
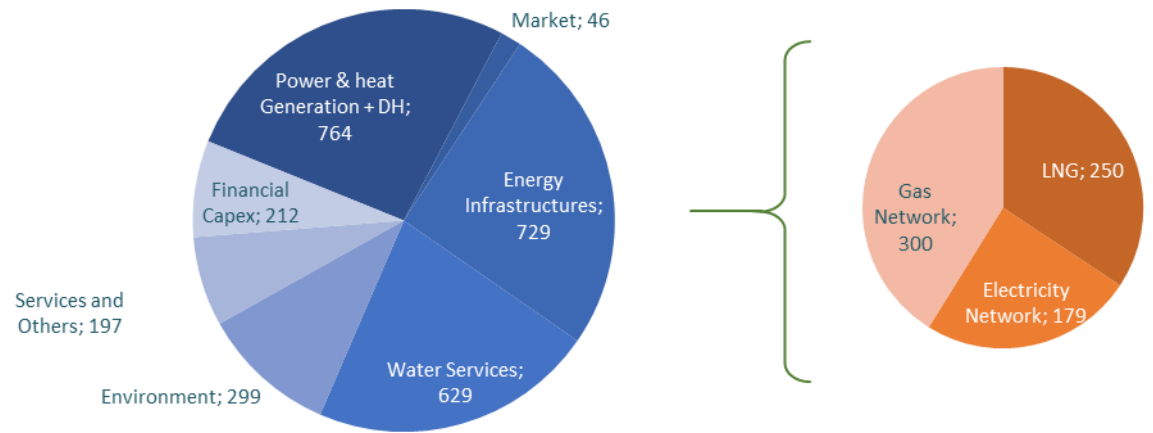


The CEO Water Mandate

IREN Group is structured as an industrial parent company with its main corporate offices in **Reggio Emilia** and its operating units in **Genoa, Parma, Piacenza** and **Turin**, with more **6.200** employees on **11** provinces



EBITDA 2016: **814 € mln**
Breakdown SBU



- Over **2,8 € bln** invested in 2009-2015
- Almost **2/3** invested in the **energy sector** (generation and infrastructure)
- From 2011 to 2013 entered into operation:
 - **2 WTE** (421.000 ton/y and 130.000 tonn/y)
 - **1 cogeneration CCGT** (400 MW)
 - **1 LNG FSRU** (3,75 bln m3/y)



IREN key drivers

ELECTRICAL ENERGY
2,8 GW of installed capacity
8,1 TWh produced in 2015
12,4 TWh sold in 2015
4,0 TWh distributed



DISTRICT HEATING
6 co-generation plant
883 km of DH pipelines
2,9 TWh heat produced in 2015
1st operator in Italy with 820.000 served inhabitants



ENVIRONMENT
3 WTE managed
1,75 mln tons treated in 2015
Waste collection in more than 100 towns



WATER SERVICES
Integrated water cycle management to 2,6 mln inhabitants
162 mln m3 distributed in 2015
25.750 km of pipelines



NATURAL GAS
0,8 mln final users
7.634 km network
1 regasification LNG terminal, 3,75 bln cm/y of authorized capacity (41,7% IREN stake)



OTHER SERVICES
133.000 street lighting point
19.000 traffic lights
Facility management and global service

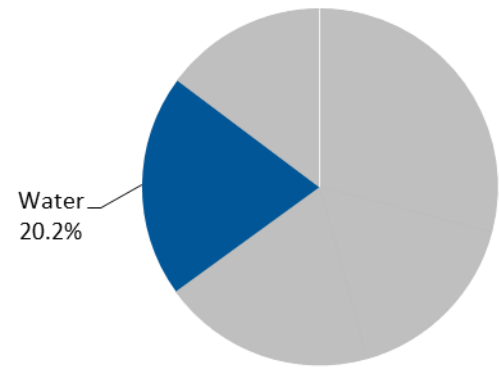


3rd operator in Italy

16.500 km of main water networks

9.300 km of sewerage networks

1.085 high efficiency treatment plants



EBITDA 2016



163 € mln

Integrated Water Services



Italian Phosphorus Platform



SMAT is a wholly public company that manages the Integrated Water Service for almost the entire territory of the Metropolitan City of Turin, 99.02% of the population of the ATO3 Torinese



District → 293
 Area → 6.292 km²
 Citizen served → 2,26 mln
 Users → 404.544

employees → 1000
 Production value → 330 mln €
 EBITDA → 146 mln €
 Profit → 60 mln €



of pipelines → 12.428 km
 Water supplied → 181 mln m³
 Sources – Wells → 1.800
 water purifying → 90

sewerage networks → 9.439 km
 Population equivalent → 2,97 mln PE
 Water treated → 335 mln m³
 Sludge → 23.361 ton (dry)



PE Category	number	PE served
< 2.000	362	117.891
2.000 ÷ 10.000	33	167.943
10.000 ÷ 200.000	16	740.078
Castiglione T.se	1	1.943.851
Total	412	2.969.763

Year 2017



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Partnership between HERA, IREN and SMAT



Accordo Quadro

per la regolamentazione delle attività di ricerca generate in seno all' "Accordo di Partnership per la ricerca applicata e di riservatezza" (sottoscritto in data 8 aprile 2014)

tra

HERA S.p.A., società con sede legale in V.le C. Berti Pichat 2/4 - 40127 Bologna, rappresentata dal Direttore Centrale Innovazione, ing. Salvatore Molè (qui di seguito identificata come "HERA")

e

IREN S.p.A., società con sede legale in Via Nubi di Magellano, 30 - 42123 Reggio Emilia, rappresentata dal Presidente, prof. Francesco Profumo (qui di seguito identificata come "IREN")

e

SMAT S.p.A., società con sede legale in Corso XI Febbraio 14, 10152 Torino, rappresentata dall'Amministratore Delegato, ing. Paolo Romano (qui di seguito identificata come "SMAT")

(collettivamente indicati come i "Partner" o le "Aziende")

Premesso che:

- HERA, IREN e SMAT hanno sottoscritto in data 8 aprile 2014 un Accordo di Partnership per la Ricerca Applicata e la Riservatezza avente le seguenti finalità:
 - la definizione di progetti condivisi di partnership rivolti ai settori ed alle attività connesse al servizio idrico integrato (ed anche in collegamento con altri settori quali igiene ambientale, energetico, ecc.) in cui ricerca, innovazione e formazione siano strettamente legate al contesto economico e produttivo territoriale in modo da realizzare sinergie fra mondo imprenditoriale, Atenei ed Enti di Ricerca che consentano di generare eccellenze nella ricerca applicata;
 - l'internazionalizzazione delle attività di ricerca, anche attraverso la partecipazione a progetti internazionali ed europei;
 - l'individuazione di nuovi modelli e strategie che consentano di rafforzare il legame con il territorio, anche in termini sociali e culturali;



In 2014 HERA, IREN e SMAT signed a collaboration agreement for the joint development of research and technological innovation projects with the aim to:

- ✓ share the best practices
- ✓ rationalize commitments and resources on issues of common interest
- ✓ facilitate access to external financing

In 2018 A2A joined the partnership



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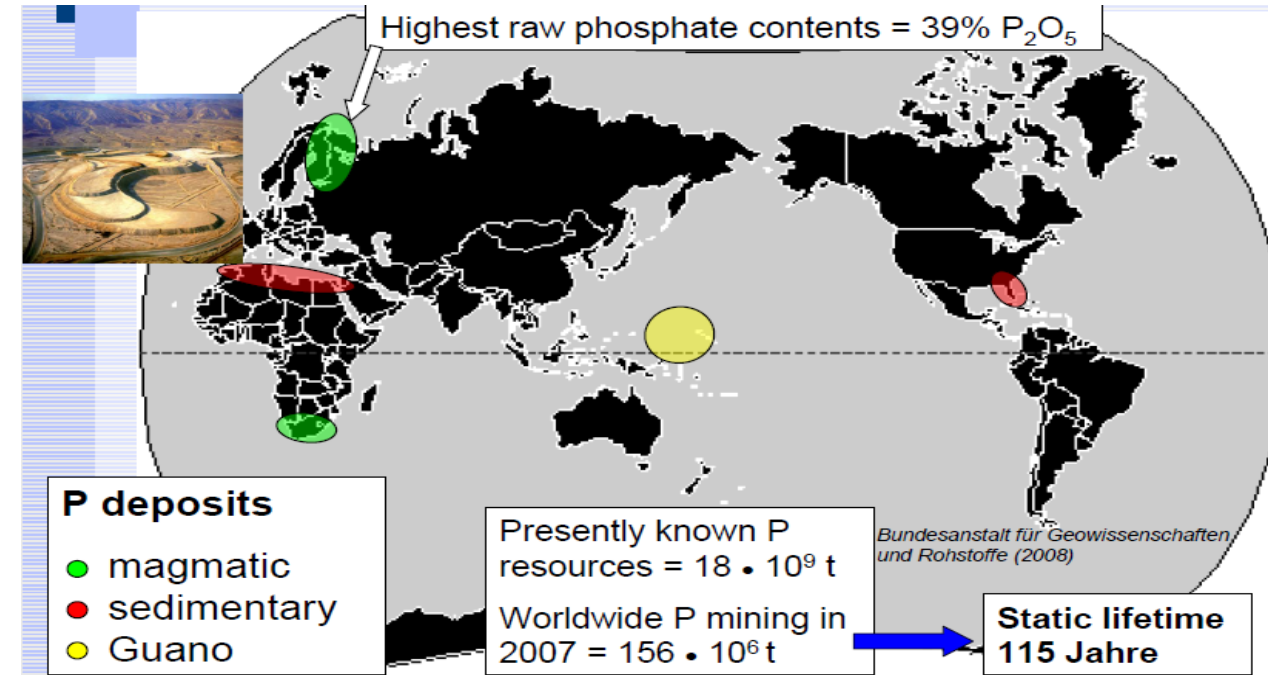
Italian Phosphorus
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WHY STRUVITE RECOVERY?

- P is a EU critical raw material
- Cost variability on the P market
- Possible recovery in existing infrastructure
- EU measures for "Circular Economy"
- Successful EU projects and initiatives: es. P-Rex, STRUBIAS WG
- P platform: European, German, Italian



Struvite is a mineral (an hydrated ammonium and magnesium phosphate), characterized by good fertilized properties. This name derives from the Russian diplomat Heinrich Christoph Gottfried Struve

Struvite recovery from municipal WWTP: a preliminary study

- ✓ A significant sample of WWTPs: Bologna 800.000 PE, Rimini 560.000 PE, Torino 2.000.000 PE, Reggio Emilia 280.000 PE
- ✓ Techno-economic evaluations about the insertion in the process schemes of ad hoc treatment sections for phosphorus recovery
- ✓ Scientific support by three Italian universities: Università Politecnica delle Marche, Università di Trento, Politecnico di Torino

The project team



Emilio Caporossi
Claudio Anzalone
Francesco Avolio



Prof. Francesco Fatone
Anna Laura Eusebi
Alessia Foglia



Loris Canovi
Nicola Bazzurro
Francesca Saggionetto



Prof. Gianni Andreottola



Gerardo Scibilia
Lorenza Meucci



Prof. Maria Chiara Zanetti
Prof. Deborah Panepinto



Struvite recovery from municipal WWTPs: a preliminary study

Goal (for each of a selected group of WWTPs)

Evaluation of the *minimum feasibility conditions for struvite recovery* in relation to:

- plant size
- effective presence of phosphorus in the streams of interest (centrifugals / filter presses / belt presses / thickeners / digesters supernatants)
- compliance with the current process scheme
- availability of space and other constraints
- *cost/benefit analysis*

Main steps

1. definition of contracts for techno-scientific support (Universities)
2. review of recovery processes and their real applications, check of the available commercial technologies (possible contacts with technology suppliers), selection of a small number of WWTPs with good preliminary characteristics
3. analysis and verification of the *technical and economic feasibility* of struvite recovery on the identified plant park
4. *analysis and comparison of the results*
5. production of a *final report*





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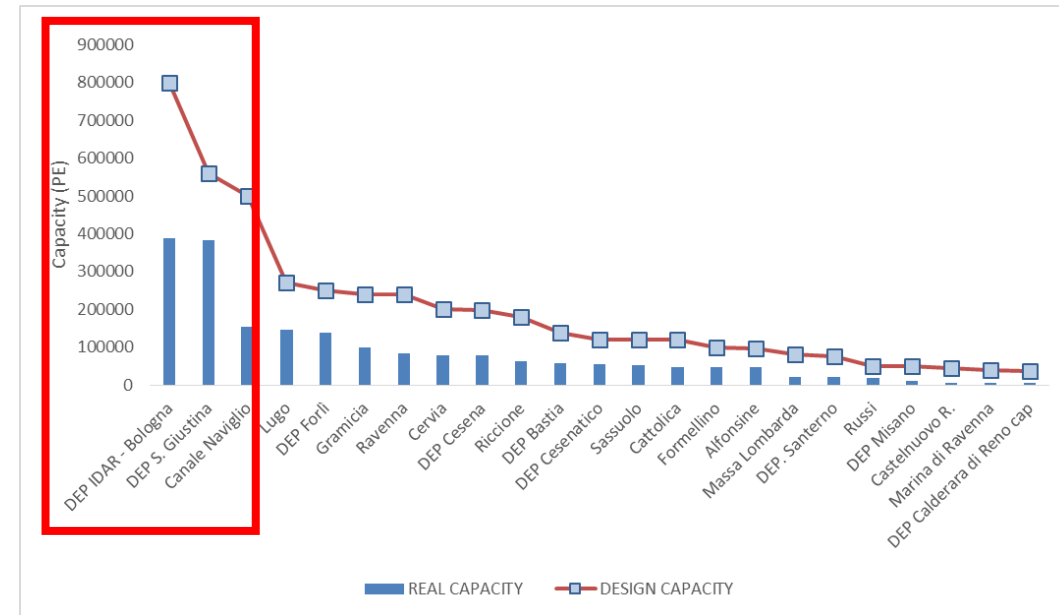
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Techno-economic assessment - HERA

1. Two WWTPs (Bologna 800.000 PE and Rimini 560.000 PE) of HERA were selected on the basis of the actual capacity, of the influent mass loads and of the sludge treatment line configurations

2. Characterization and analysis of the anaerobic supernatants (mainly from the post thickeners and dewatering units)



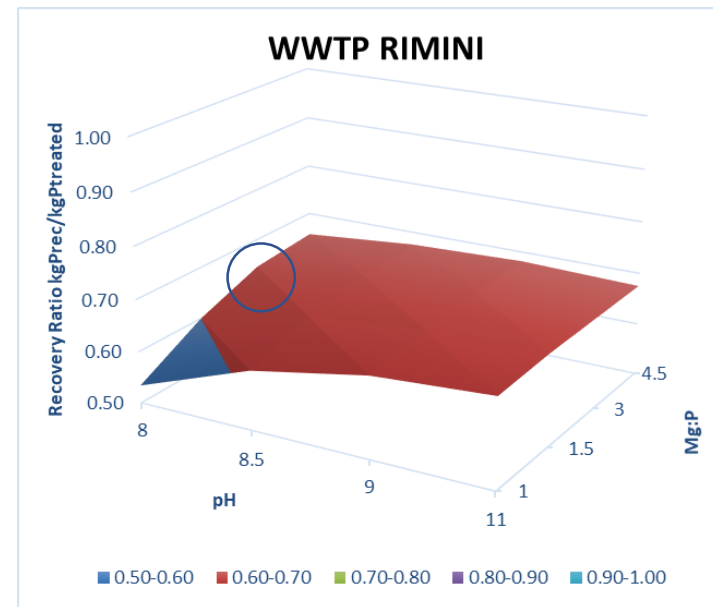
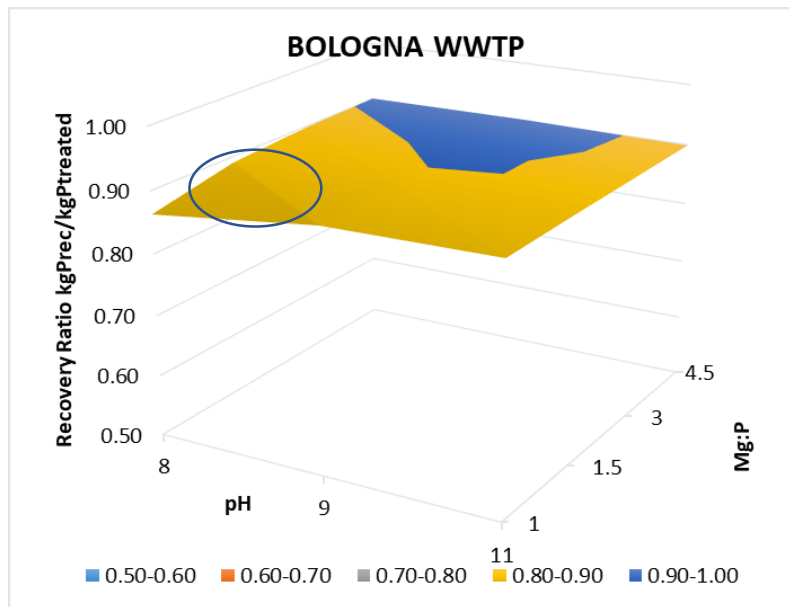
	Q	pH	F	Cl	NO2	NO3	PO4	SO4	Na	NH4	K	Mg	Ca
WWTP	m3/d		mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l
BOLOGNA	833	7.9	0	203	0	0	519	16	94	1110	214	4	44
RIMINI	396	8.1	0	314	0	2.9	157	34.2	205	602	162	5.3	49



Techno-economic assessment - HERA

3. Evaluation of the optimal sustainable operating conditions for Struvite recovery (Mg:P; pH; T) >> MASS BALANCES and DETAILED THERMODYNAMIC MODELING

4. Potential STRUVITE recoverable at different operative conditions



Recovery BOLOGNA WWTP		0.86	0.70	0.50
P rec/P treated				
T	°C	20	20	20
pH		8	8	8
Mg/P		1	1	1
Mg/Ca		3.0	3.0	3.0
Hydroxyapatite	Kg/d	76	76	76
CaSO4	Kg/d	19	19	19
Struvite	Kg/d	961	782	558

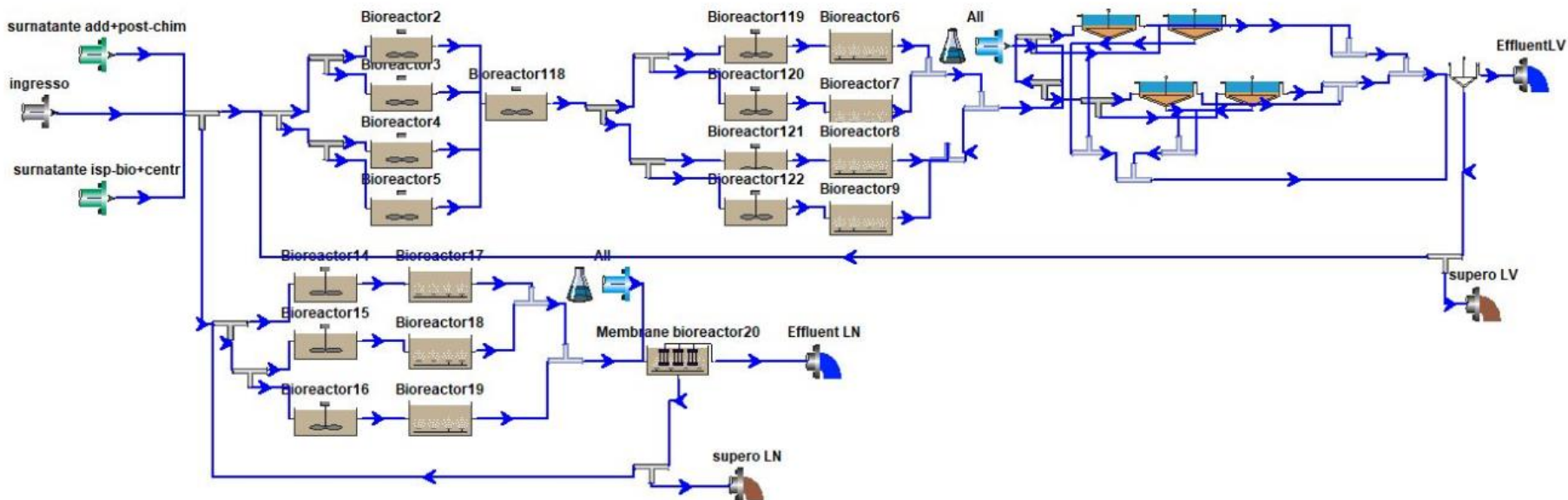
Recovery RIMINI WWTP		0.53	0.59	0.65
P rec/P treated				
T	°C	20	20	20
pH		8.1	8.1	8.5
Mg/P		1	1.5	1.5
Mg/Ca		1.3	2.0	2.0
Hydroxyapatite	kg/d	34	34	34
CaSO4	kg/d	19	19	19
Struvite	kg/d	84	95	104



Techno-economic assessment - HERA

5. Evaluation of the *impacts on the Final Effluents and Sludge (Effluent quality and final P%TS in the sludges)*>> *Validated Simulation* in the WWTPs configurations implemented with P Recovery Unit

R	Actual P%TS	P%in the Future Configurations	
kgPrec/KgPtreated	P%TS	P%TS	
0.86	0.88	0.322	
0.70	0.88	0.430	
0.60	0.88	0.496	
0.50	0.88	0.562	



**Bologna
WWTP**

Techno-economic assessment - HERA

6. Economic Assessment

Costs/Savings Items

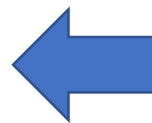
COST	reagents	NaOH (30%) MgCl ₂ *6H ₂ O
	energy	kWh/kg Prec
	extra	EXTRA Maintenance EXTRA Lab. Analysis EXTRA Worker
SAVINGS	sell of struvite	
	save of coagulants	
	save of chemical sludges not disposed	
	save of nitrogen not treated in the water line	
	increment of dewterability	



Specific Costs/Savings in the Case Study of BOLOGNA

		€/kg Prec Costs	€/kg Prec Savings
pH 8 Mg:P 1	R 0.86	-5.7	16.0
pH 8 Mg:P 1	R 0.70	-6.7	15.7
pH 8 Mg:P 1	R 0.60	-7.6	15.8
pH 8 Mg:P 1	R 0.50	-8.8	15.9

7. Discounted Cash Flow Analysis



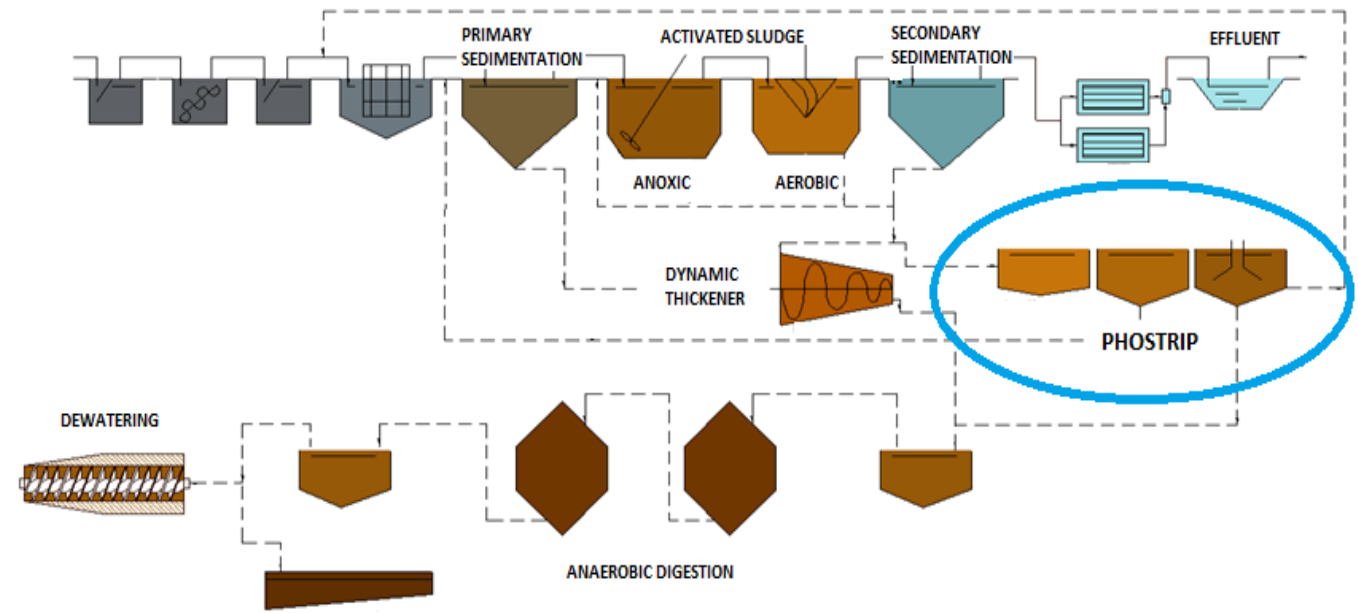
Ref. Costs Struvite Recovery from Aqueous Solution from 8-10 €/kg P rec (*Engle et al., 2016*)



Techno-economic assessment - IREN

WWTP Roncoresi Reggio Emilia - 150.000 PE

We expect to improve the nutrient concentration because the recovery technology will replace the lime dosage.



Liquor flow rate	339 m ³ /day
Ortho-Phosphate concentration	31 mg/l
Ammonia concentration	536 mg/l
Theoretical mass of P recovered	3 kg/day
Theoretical mass of struvite produced*	26071 kg/year

*'Pilot-scale struvite recovery from anaerobic digester supernatant at an enhanced biological phosphorus removal wastewater treatment plant'
A.Britton, F.A. Koch, D.S. Mavinic, A.Adnan, W.K. Oldham, and B. Udala



Techno-economic assessment - SMAT

Torino WWTP

EVALUATION IN PROGRESS

Digested sludge Volume	2555 m ³ /d
Dry substance	2 %
Ortho-Phosphate content	50 mg/l
Ammonium content	700 mg/l



1.350.000 abitanti serviti – 39 comuni serviti – abitanti equivalenti 2.300.000 – potenzialità massima 3.840.000 A.E.
1.350.000 inhabitant – 39 towns – 2.300.000 equivalent inhabitants – maximum capacity 3.840.000 E.I.



Techno-economic assessment - conclusion

- The study highlighted the feasibility of P-recovery with theoretical variable percentages between 0.5-0.7 (P-rec/P-in), in HERA WWTPs
- The costs (capex and opex) for the P-recovery and the market/potential destiny following the recovery have to be defined in more detail
- Valorization through incentives of the recovered P-rec compared to the P-extracted could be a road?
- The potential P-recovery of the three companies on the basis of the citizens served represents about 30% of the Italian citizens served and mapped (source Blue Book 2017)
- The normative question remains open: at the moment the law does not provide for a recovery and considers the struvite a waste
- Possible way out, law permitting, could be the withdrawal from the technology provider



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ANNI



Thank you for your attention



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