FULL-SCALE Nitrogen removal and Phosphorus recovery from reject water via S.C.E.N.A. system

Vincenzo Conca[1], Cinzia Da Ros[1], Anna Laura Eusebi[2], Nicola Frison[1] , Matteo Tartini[3], Luca Girotto[3] , Alberto Piasentin[3] ,Francesco Fatone[2]

Presenting author: Prof. David Bolzonella

david.bolzonella@univr.it

[1] University of Verona, Department of Biotechnology - Verona

[2] Polytechnical University of Marche, Department of SIMAU - Ancona

[3] Alto Trevigiano Servizi srl (ATS), Montebelluna (Treviso)

NAXOS2018

6th International Conference on Sustainable Solid Waste Management

13-16 June 2018

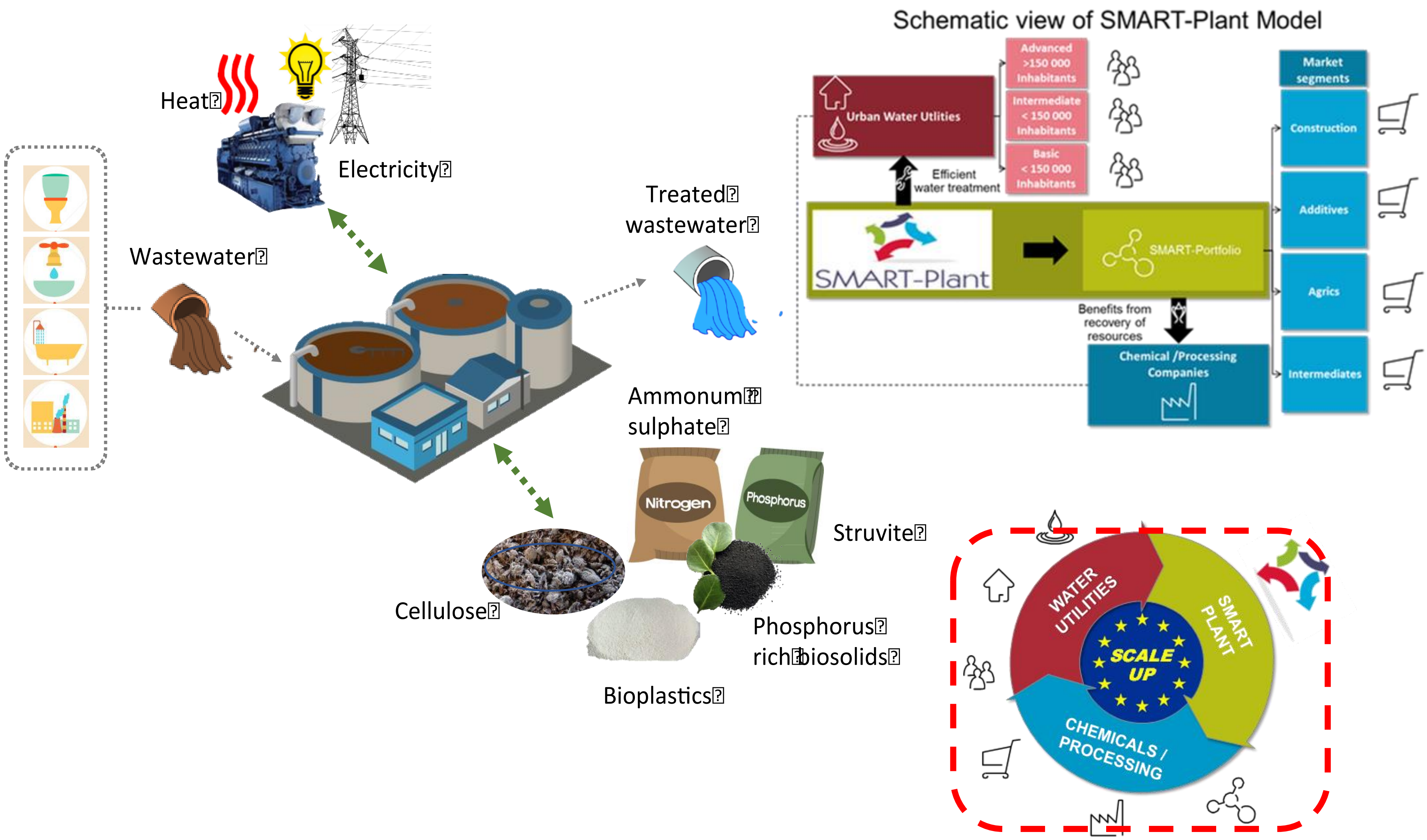
Supported by the Horizon 2020 Framework Programme of the European Union

Horizon 2020 SMART-Plant Project

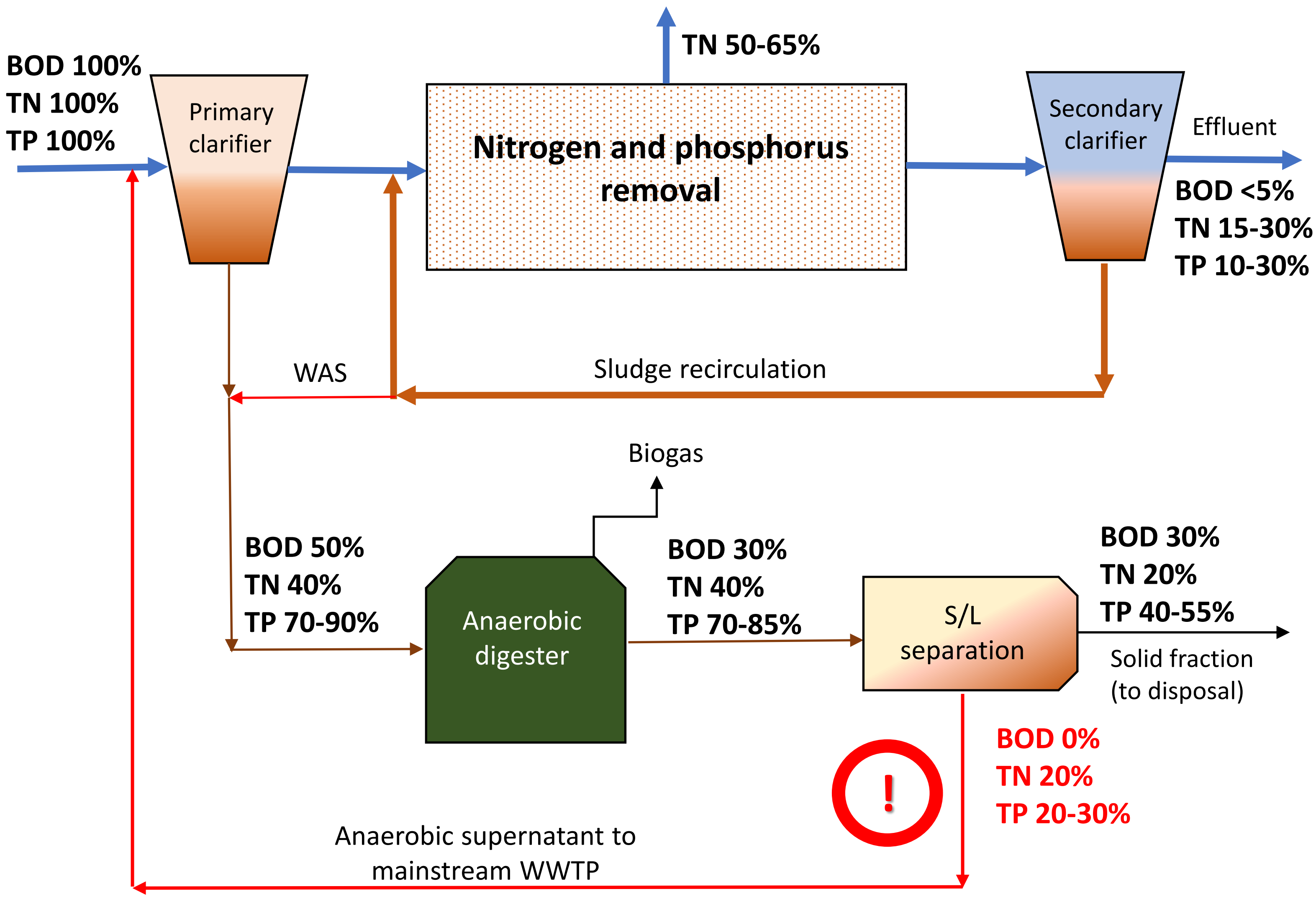
The overall target of SMART-Plant is to validate and to address to the market a portfolio of SMARTechnologies that, singularly or combined, can renovate and upgrade existing WWTPs in wastewater-based bio-refineries.

SMARTech n.	Integrated municipal WWTP	Key enabling process(es)	Scale
1	Uithuizermeeden (Netherlands)	Upstream dynamic fine-screen and post-processing of cellulosic sludge	Demo
2a	Karmiel (Israel)	Mainstream polyurethane-based anaerobic biofilter	Demo
2b	Manresa (Spain)	Mainstream SCEPPHAR	Demo
3	Cranfield (UK)	Mainstream tertiary hybrid ion exchange	Demo
4a	**Carbonera (Italy)**	**Sidestream SCENA+conventional AD**	**FULL-SCALE**
4b	Psyttalia (Greece)	Sidestream SCENA+enhanced AD	Demo
5	Carbonera (Italy)	Sidestream SCEPPHAR	Demo
Downstream SMARTechA	London (UK)	Formulation of recovered cellulosic and PHA materials	Demo
Downstream SMARTechB	Manresa (Spain)	Dynamic composting of P-rich sludge	Demo

Horizon 2020 SMART-Plant Project



Conventional WWTP flow chart

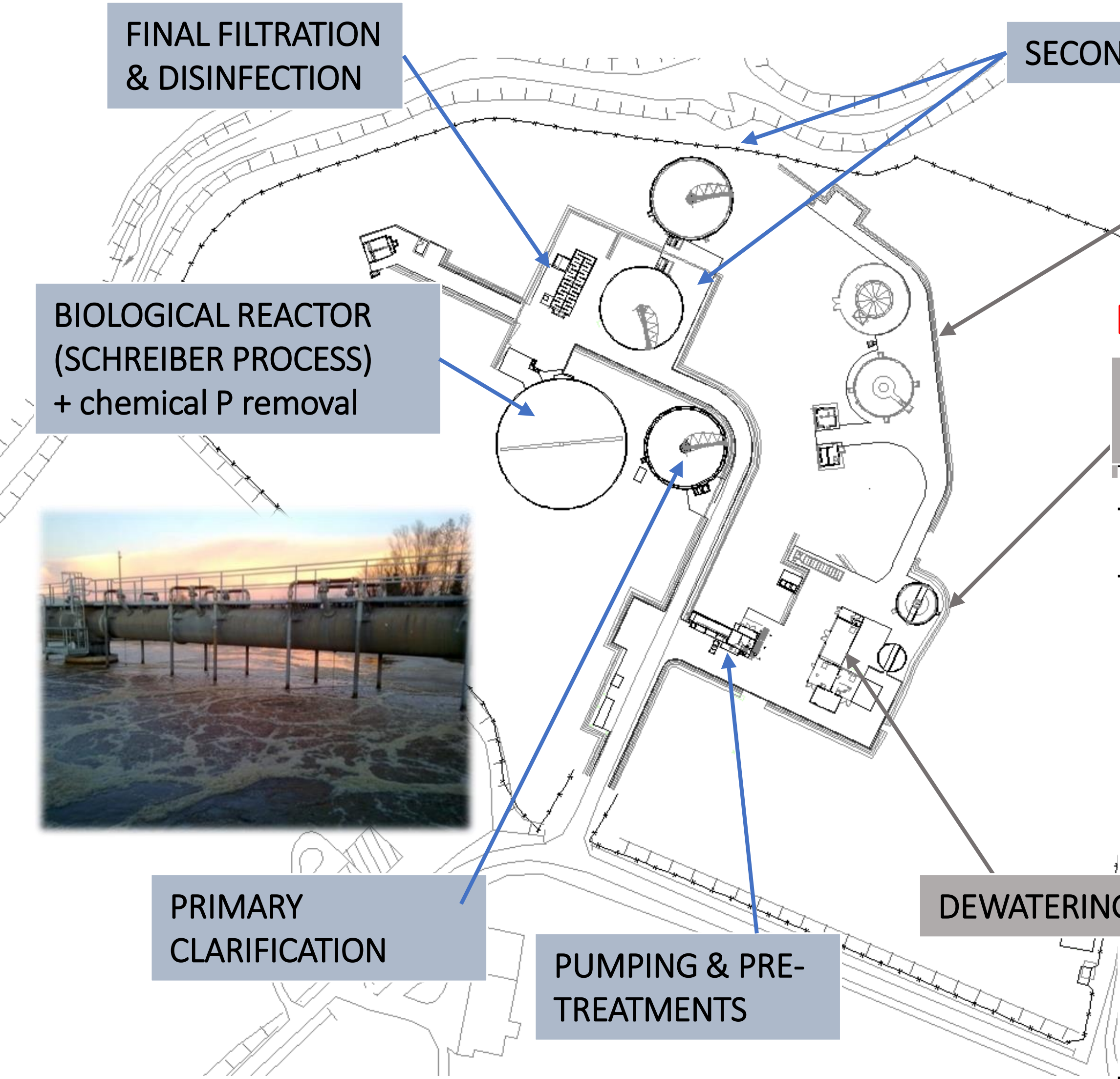


- Reject water is usually recycled in the mainstream of WWTP
- This concentrated stream contains up to 20-30% of the total nitrogen and phosphorus influent

Outline

- **Carbonera WWTP description;**
- **Impact of dynamic thickening implementation on:**
  - **main line nitrogen loading**
  - **energy and sludge reduction**
- **Short-cut Enhanced Nutrients Abatement (S.C.E.N.A) for the via-nitrite treatment of reject water;**
- **Key Performances Indicators and Economical analyses**

Carbonera WWTP (40.000 P.E.)



WATER LINE

N. LINES	TREATMENT	DIMENSIONAL DATA	CHARACTERISTICS AND FLOWS
1	PUMPING STATION	131 m^3	WASTE WATER IN FLOW 15.000 mc/d
2	SCREENING	FREE PASSAGE OF 5 mm	
1	GRIT / OIL REMOVAL	120 m^3 40 m^2	
1	PRIMARY CLARIFIER	1.600 m^3 452 m^2	225 m3/d OF I° + II° SLUDGE OUTFLOW
1	BIO-REACTOR Schreiber system	4.571 m^3 207 m^2	400 m3/d OF II° SLUDGE PRODUCTION
2	SECONDARY CLARIFIER	2.260 m^3 904 m^2	600 m3/h OF SECONDARY SLUDGE RICIRCULATION
1	DISINFECTION	180 m^3 114 m^2	
2	TERTIARY FILTRATION		

Installation of dynamic thickening

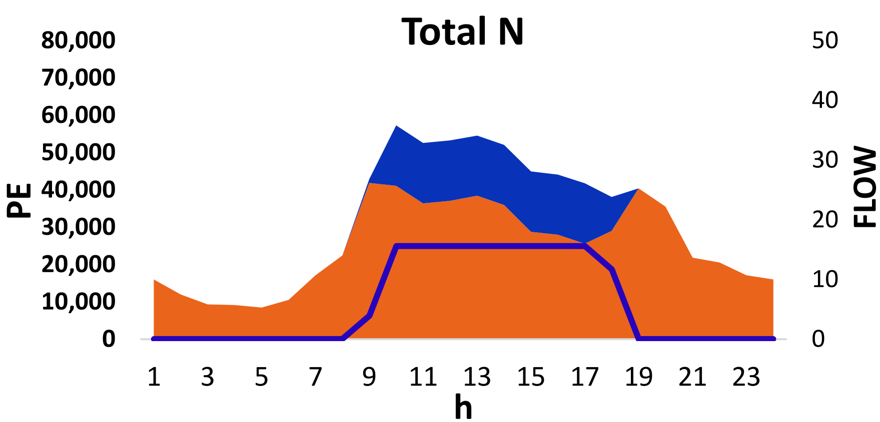
- Flowrate: around 20 m^3/h
- Around 40 m^3/d of mixed sludge concentration: 4,5-5,0 %

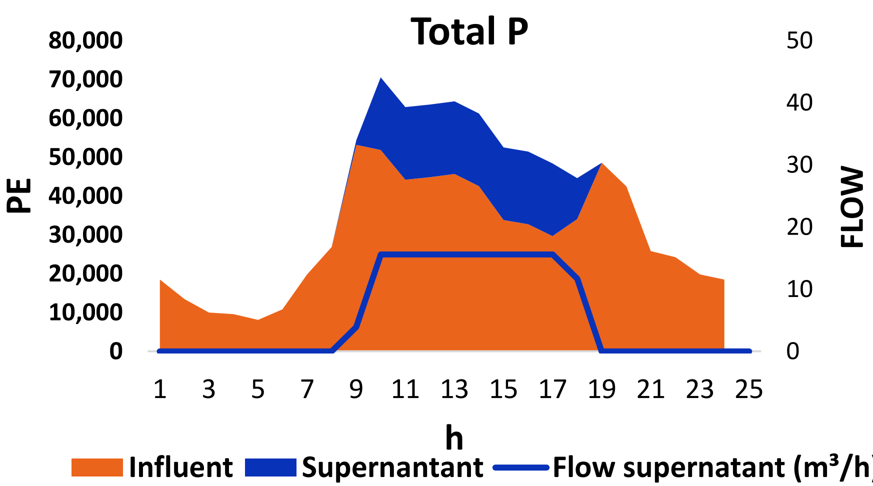
<u>Opposite valves V3/V4, controlled based on level sensors</u>

- around 30 m^3/d fed to the anaerobic digester;

- around 10 m^3/d fed to the fermentation unit;

Characterization of supernatants before dynamic thickening





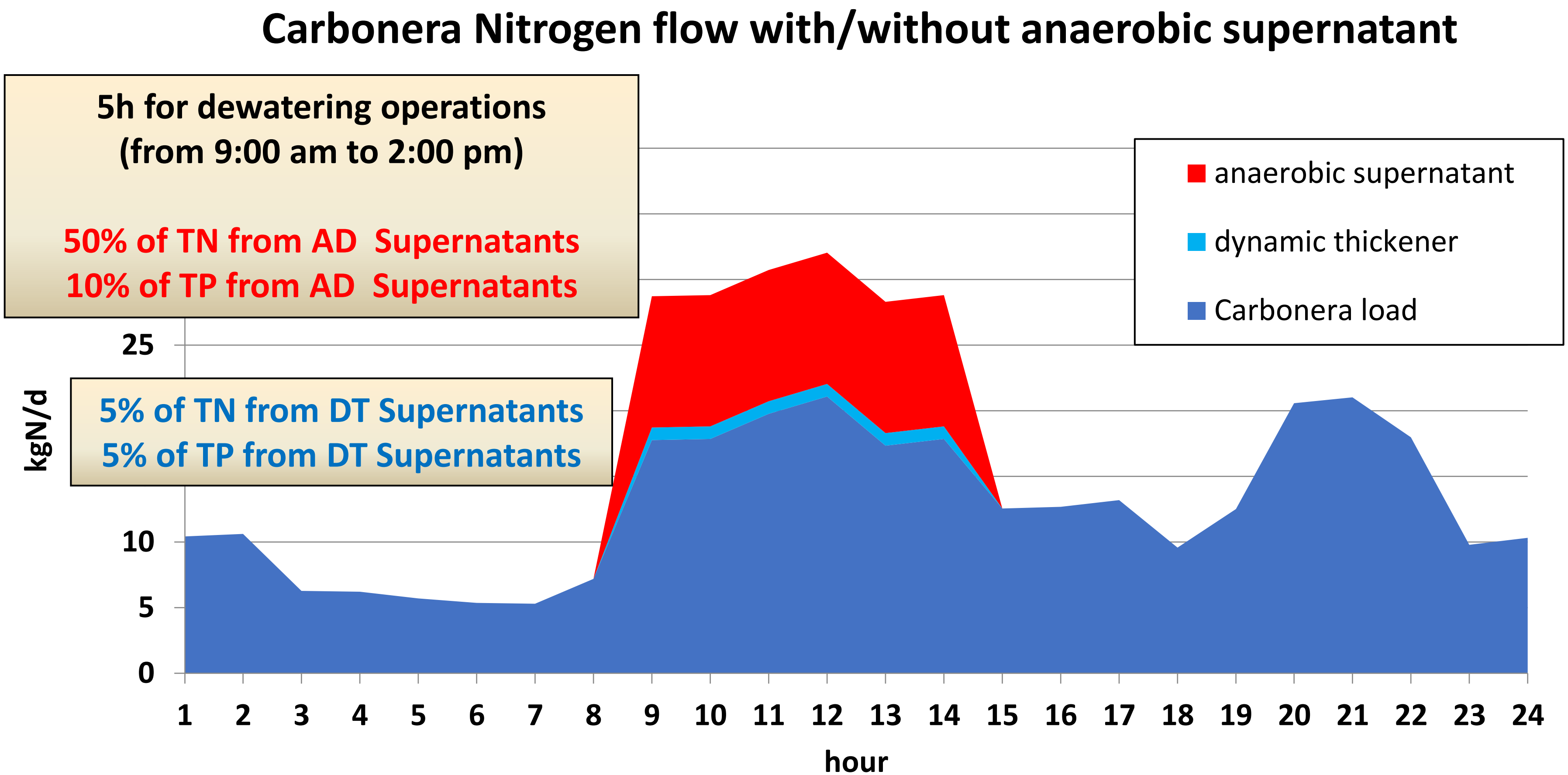
SEWER INFLUENT		
Parameter	Average Conc. mg/l	Load kg/d
Flow		16.972
TN	16	270
NH_4-N	12	202
NO_2-N	<0.5	
NO_3-N	<0.5	
PO_4-P	1,5	25
TP	2	34

SUPERNATANT FLOW		
Parameter	Average Conc. mg/l	Load kg/d
Flow		134
TN	521	70
NH_4-N	511	68
NO_2-N	<0.5	
NO_3-N	<0.5	
PO_4-P	63	8
TP	89	12

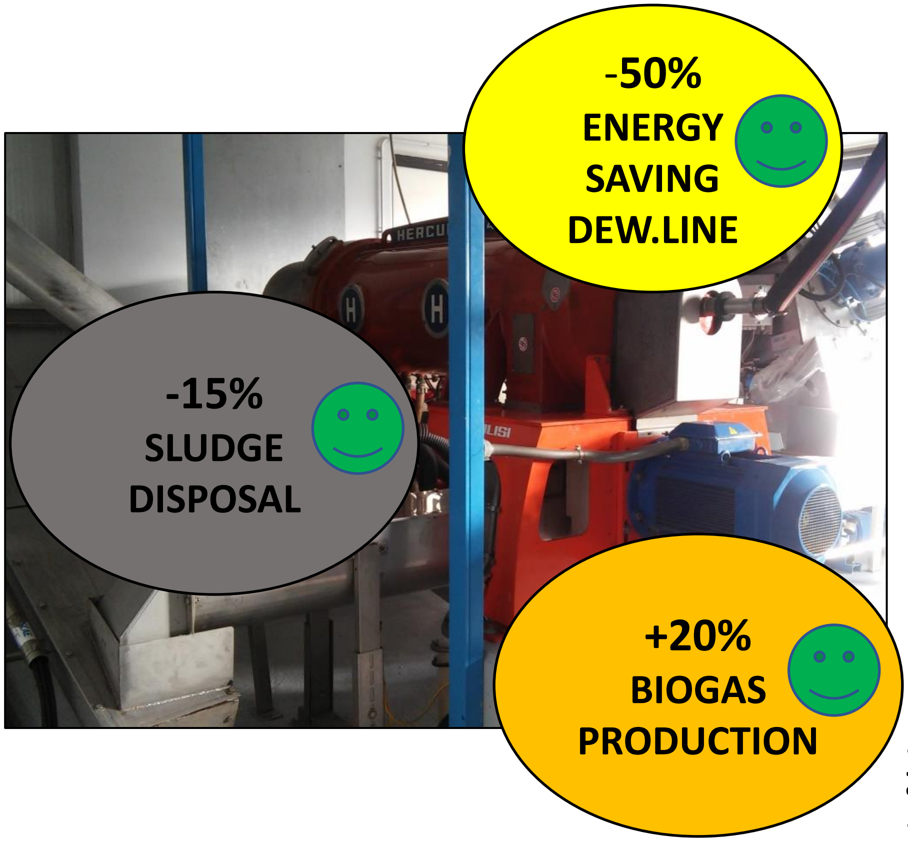
10h for dewatering operations (from 9:00 am to 7:00 pm)
21% of TN AD supernatants
23% of TP AD supernatants

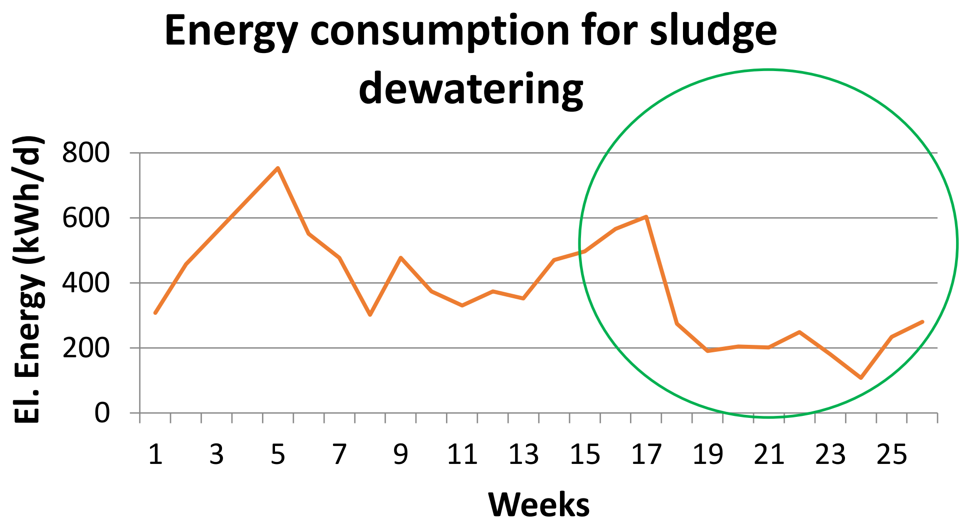
FINAL INFLUENT		
Parameter	Average Conc.mg/l	Load kg/d
Flow		17.106
TN	20	340
NH_4-N	16	270
NO_2-N	<0.5	
NO_3-N	<0.5	
PO_4-P	2,7	33
TP	3	46

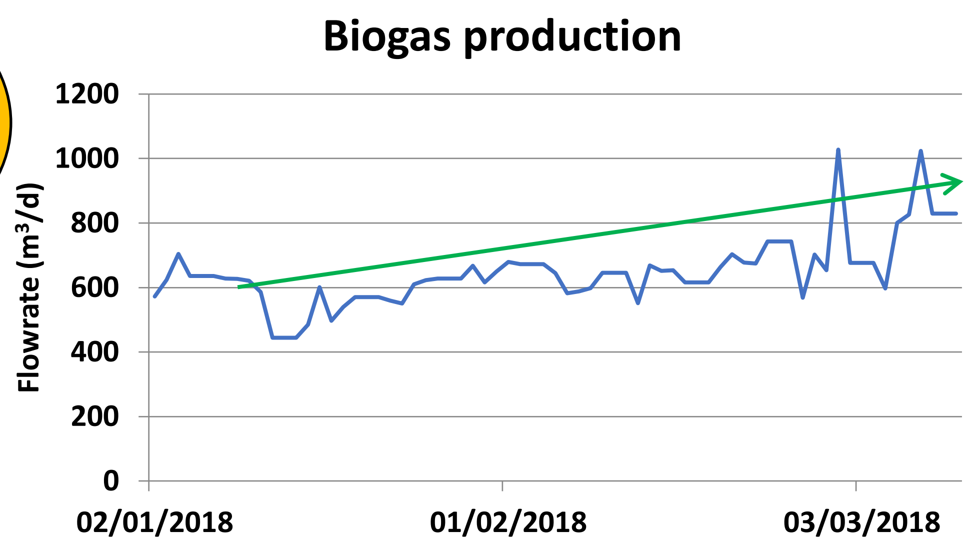
Characterization of reject water with dynamic thickening



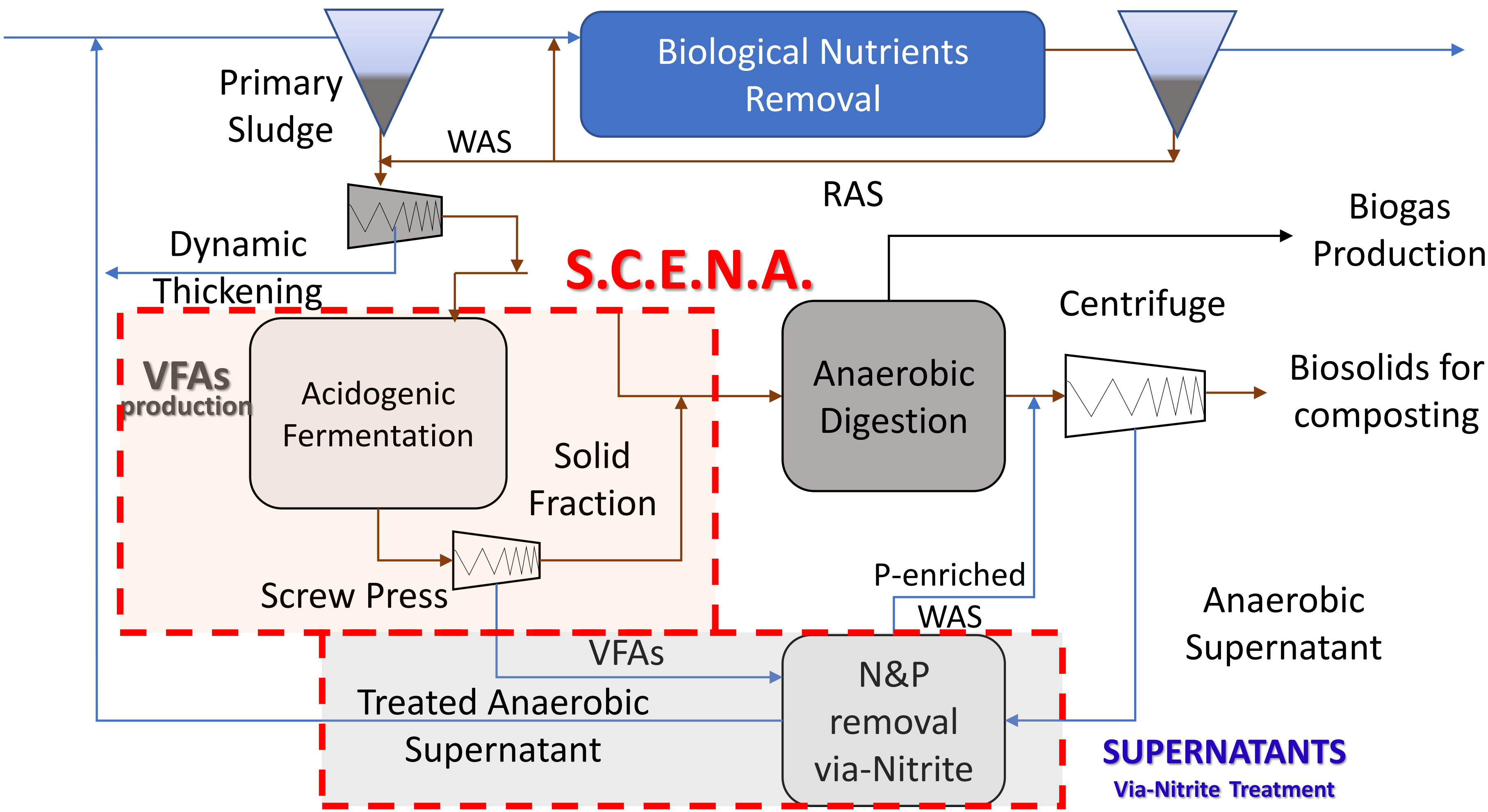
Advantages related to dynamic thickening



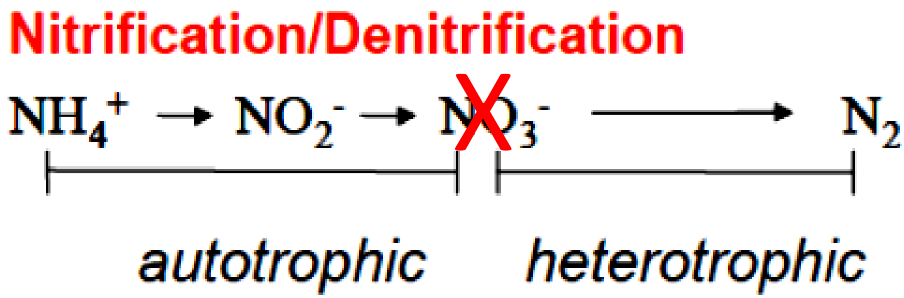




Flowchart of S.C.E.N.A. process in the sidestream of AD



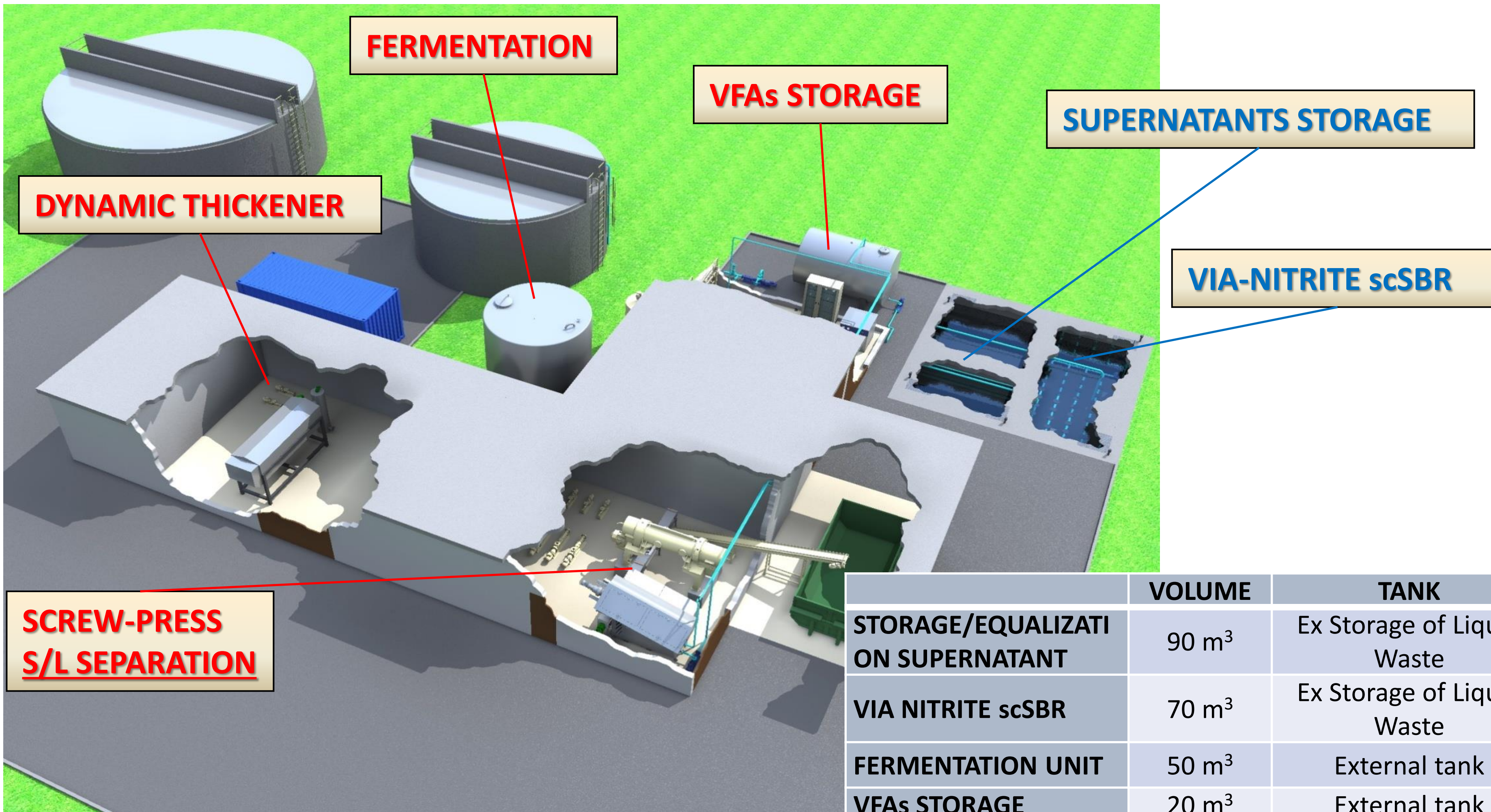
The «via-nitrite» nitrogen removal



Main advantages compared to the conventional nitrogen removal process :

- Higher rates (10-20 times) → smaller reaction volumes
- Reduction of aeration requirements in nitritation stage up to 25%
- Less carbon source requirement during the denitritations stage up to 40%
- Lower sludge production

Implementation of the first full scale S.C.E.N.A. system



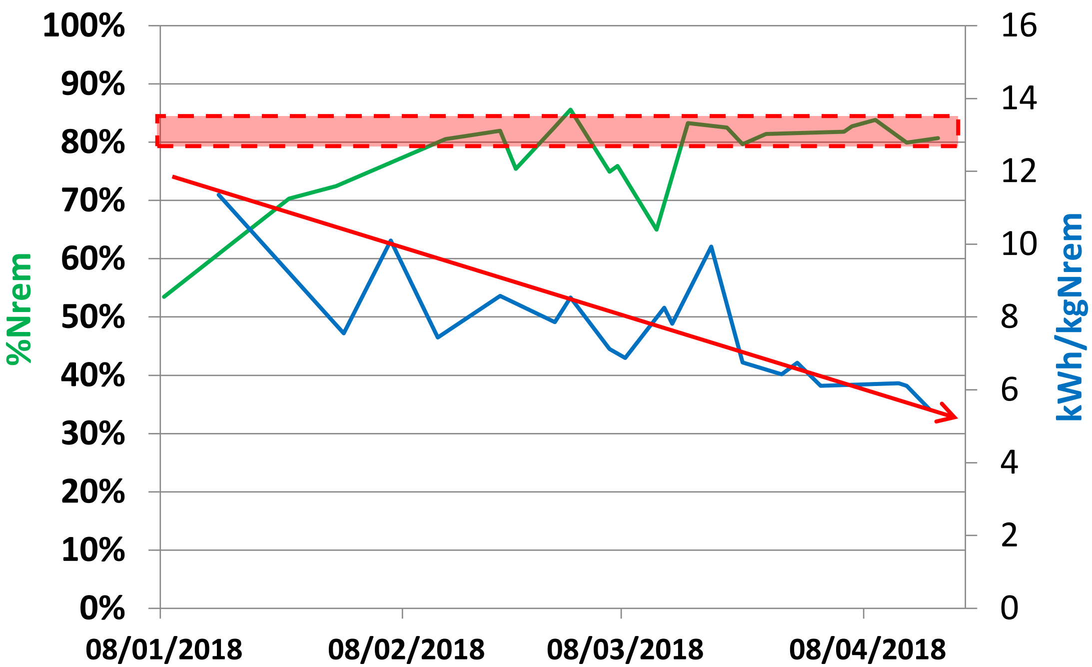
	VOLUME	TANK
STORAGE/EQUALIZATION SUPERNATANT	90 m^3	Ex Storage of Liquid Waste
VIA NITRITE scSBR	70 m^3	Ex Storage of Liquid Waste
FERMENTATION UNIT	50 m^3	External tank
VFAs STORAGE	20 m^3	External tank

Implementation of the first full scale S.C.E.N.A. system

START-UP NOVEMBER 2017

SUPERNATANT TREATING ON S.C.E.N.A. FULL - SCALE	
Flowrate [m3/d]	35 - 40
N load [kgN / d]	35 - 42
P load [Kg P / d]	1 - 2

S.C.E.N.A. performances

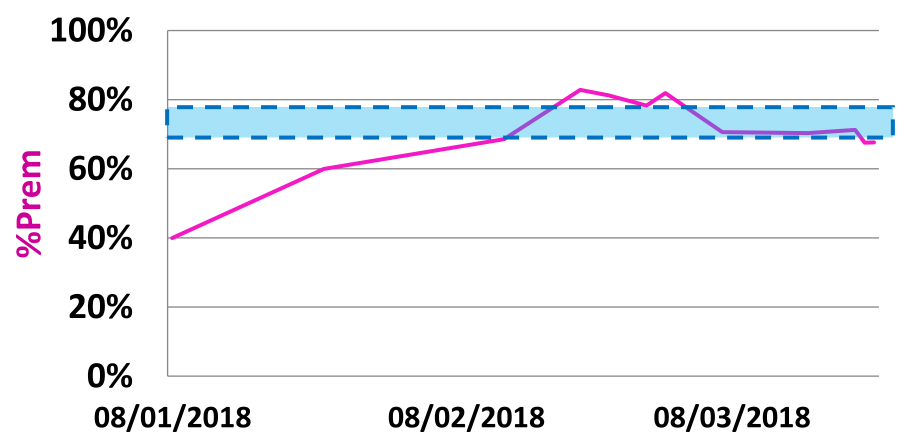


S.C.E.N.A. first results:

✓ 6 kWh/kgNrem;
✓ 82 % TN removed;
✓ 70 % TP removed.

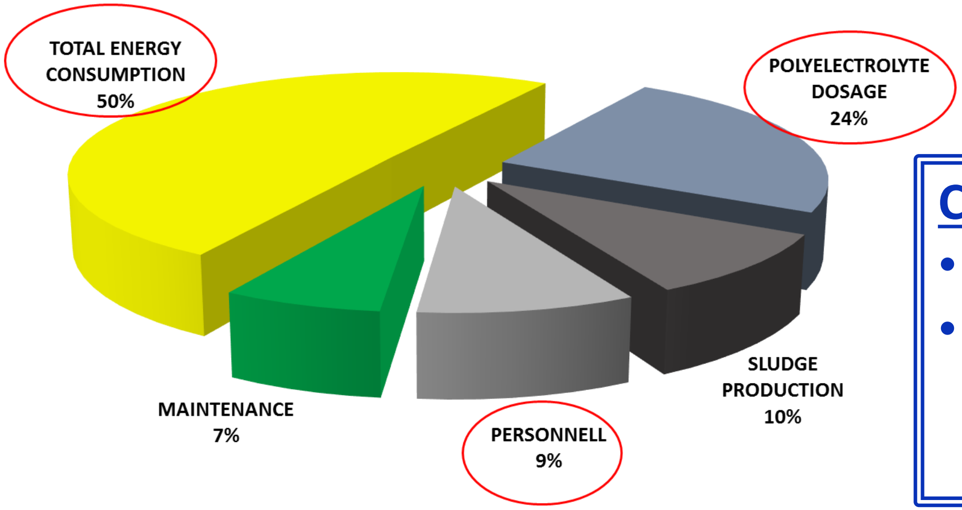
S.C.E.N.A. next targets:

✓ 5 kWh/kgNrem;
✓ 85 % TN removed;
✓ 80 % TP removed.



S.C.E.N.A. OPEX after 4 months

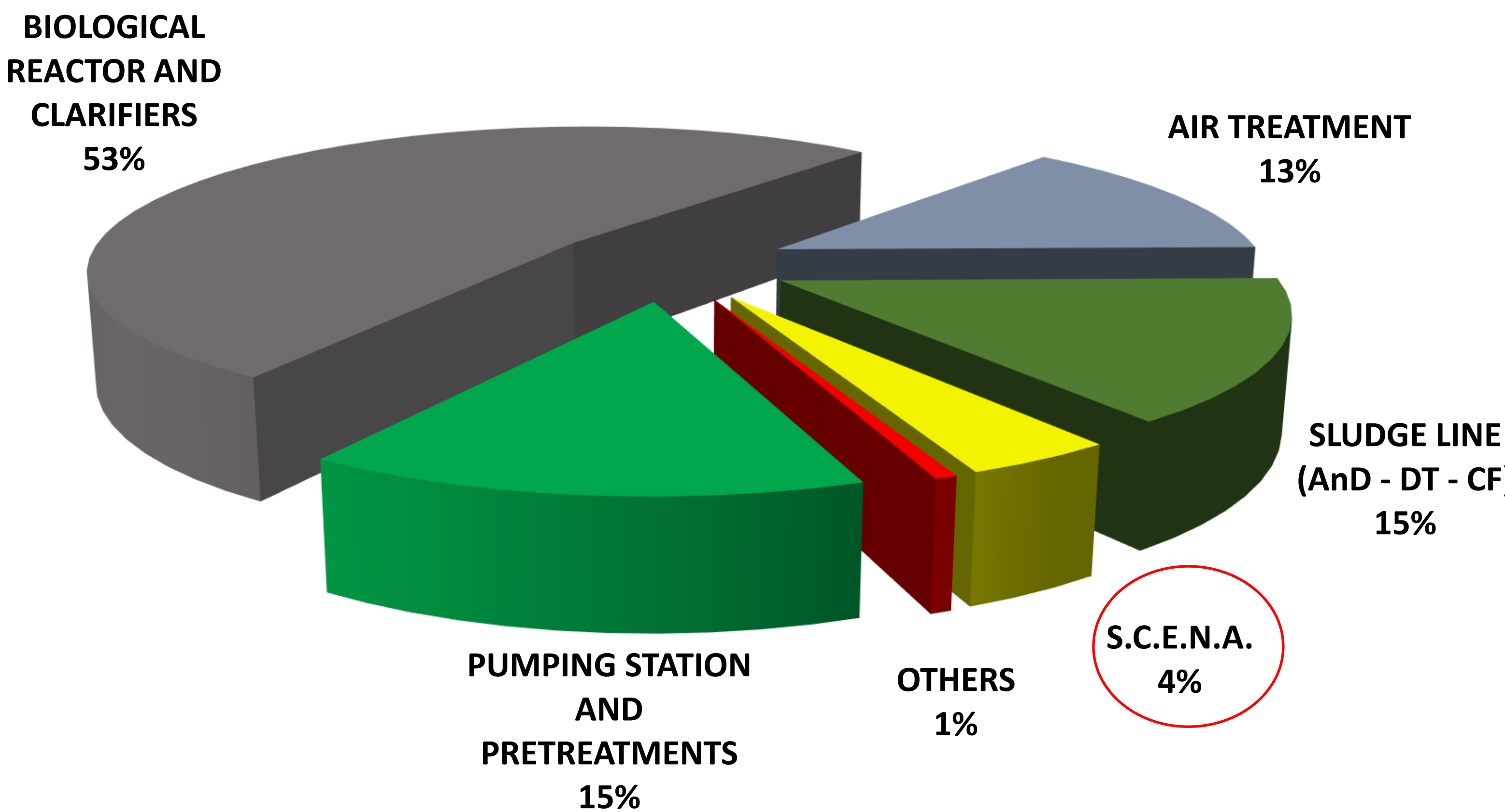
NITROGEN REMOVED = 36 kgN/d			€/kgN rem
STORAGE SUPERNATANT	kWh/d	3,2	0,02
SBR	kWh/d	123,2	0,59
FERMENTER	kWh/d	9,0	0,04
S/L SEPARATOR	kWh/d	23,0	0,11
TOTAL ENERGY CONSUMPTION	kwh/d	158,4	**0,75**
POLYELECTROLYTE DOSAGE	kg/d	9,2	**0,36**
SLUDGE PRODUCTION	kg/d	54,0	**0,15**
PERSONNELL	€/d	4,9	**0,14**
MAINTENANCE			**0,10**
			1,50



Carbonera WWTP main line

- Around 5,4 €/kgN rem
- OPEX reduction for reject water treatment with S.C.E.N.A.: around 70%

Carbonera WWTP energy scenario



energy consumption in Carbonera WWTP around 5000 kWh/d

Conclusions

- ✓ **Dynamic thickening of the sewage sludge increased the efficiency of the sludge treatment line…but careful to the pick of nutrient loadings during sludge dewatering;**
- ✓ **The S.C.E.N.A. process allows the removal of 82% of N and 70% of P via-nitrite from anaerobic supernatant;**
- ✓ **Short period needed for the start-up operations and very stable performances on long-term period;**
- ✓ **Fermentation of thickened mixed sludge was an efficient and cheap way for suitable carbon source production**
- ✓ **The S.C.E.N.A. system allows the reduction of OPEX costs for the treatment of reject water up to 70%**
- ✓ **S.C.E.N.A. energy requirement accounted for only 4% of the overall WWTP**

THANK YOU !

www.smart-plant.eu