Optimizando la línea de lodo.

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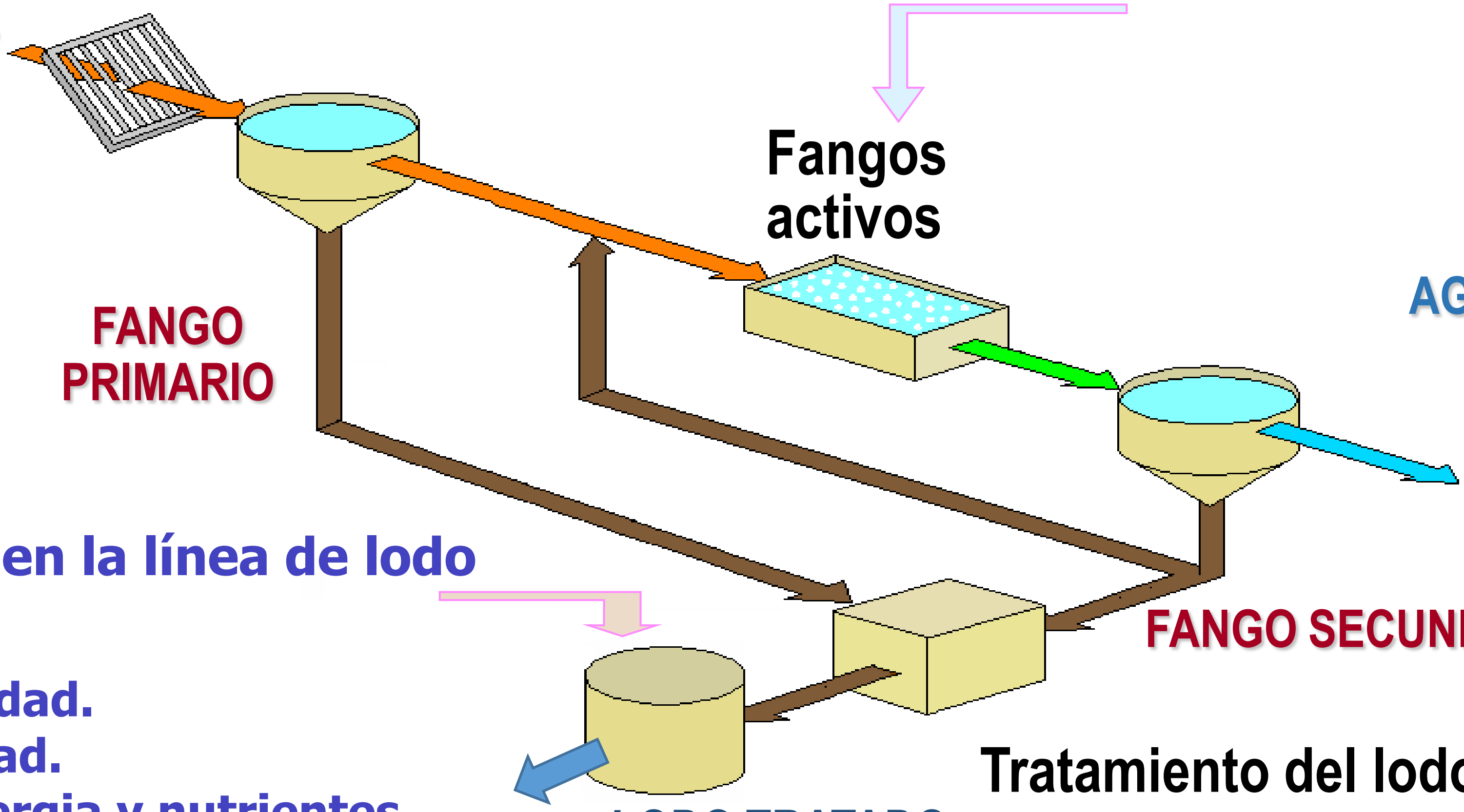
Seminario Técnico META. Lodos: Producción y Aprovechamiento
Oviedo. Julio 2017

1. Actuación en la línea de agua

Reducir cantidad lodo generado



AGUA TRATADADA
Límites de vertido
Normativa clara

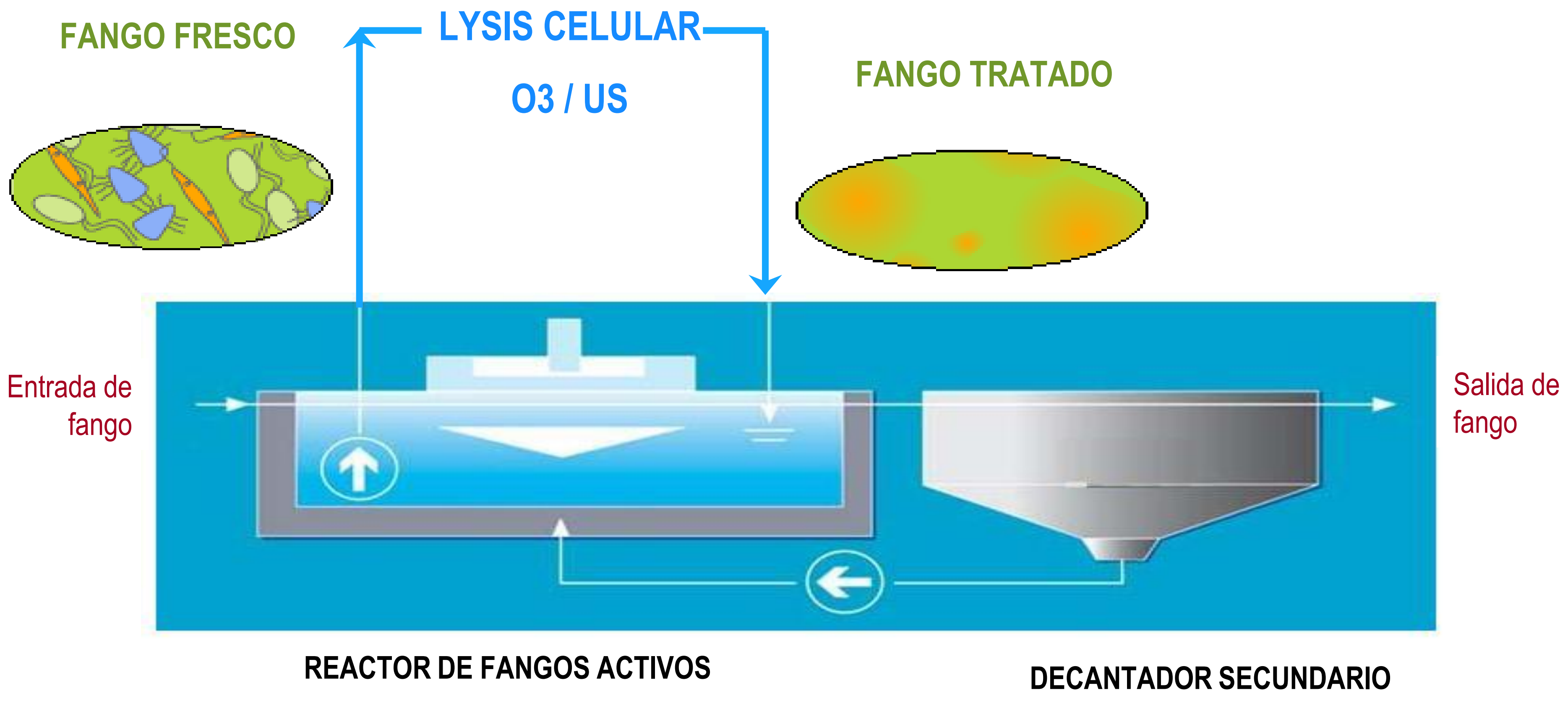
2. Actuación en la línea de lodo

Mejoras en DA.
- Reducir cantidad.
- Mejorar calidad.
- Recuperar energia y nutrientes

LODO TRATADO
No Límites de vertido
Normativa difusa

1. WATER LINE	1.1. Processes reducing global celular yield
	1.2. Processes with lower intrinsic celular yield
2. SLUDGE LINE	2.1. Pre-treatment processes.
	2.2. AD improvements.

1..1. WATER LINE. MINIMIZING GLOBAL SLUDGE PRODUCTION.



1..1. WATER LINE. MINIMIZING GLOBAL SLUDGE PRODUCTION. US LYSIS.

	R1	R2	R3	R4
% TCOD removed	79%	75%	71%	68%
Yield coefficient	**0.34**	**0.17**	**0.11**	**0.06**
% excess sludge reduction with respect to the control	-	50%	69%	82%

EQUIPMENT EFFICIENCY 30% | 66%

	R2	R3	R4	FULL-SCALE
% excess sludge reduction	50%	69%	82%	50%
USE_{WW} (kWh/m³ $_{wastewater}$)	2.1	4.3	6.4	0.8
kWh needed to reduce to**1kg** the quantity of **VSS produced**	26	38	48	13
Investment (c€/m³ wastewater treated)	9.8	19.7	29.5	4.9
Savings (c€/m³ wastewater treated)	0.6	0.8	0.9	0.6
Cost (c€/m³ wastewater treated)	**9.3**	**18.9**	**28.6**	**4.3**
€ to reduce 1 ton sludge production	2,000	2,950	3,730	1,000

Excessive cost for reducing sludge production
Negative energy and economic viability of the process

1.1. WATER LINE. MINIMIZING GLOBAL SLUDGE PRODUCTION. PRETREATMENT

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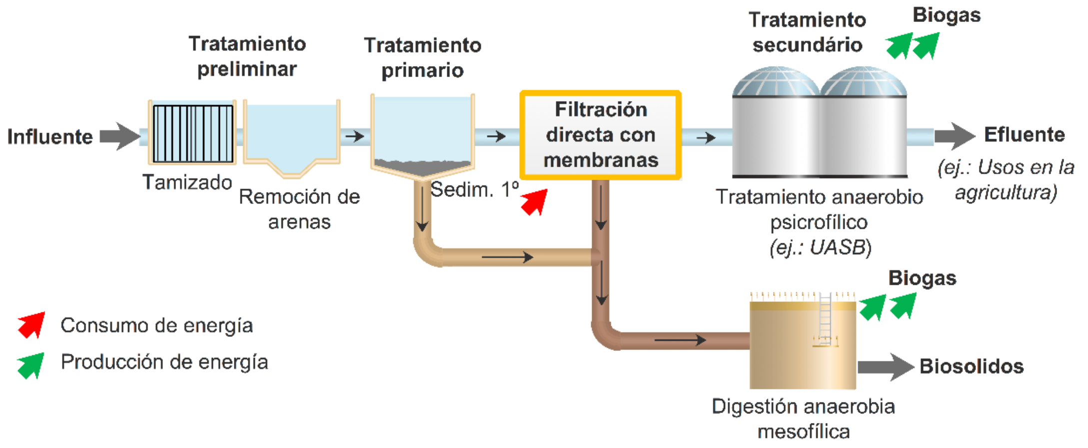
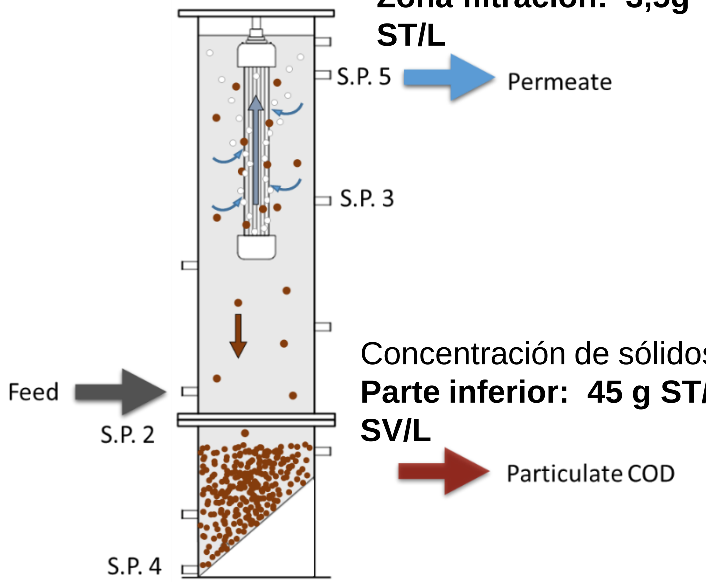


Membrana ZW-10 Zenon
ultrafiltration 0.045 µm
área filtration: 0.93 m^2

Concentración de sólidos
Zona filtración: 3,5g ST/L



Concentración de sólidos
Parte inferior: 45 g ST/L 36 g SV/L

	Feed	Permeate
tCOD (mg/L)	715,7 (± 142,9)	393,5 (± 57,3)
sCOD (mg/L)	402,6 (± 107,5)	393,5 (± 57,3)
TS (mg/L)	831,1 (± 81,9)	661,3 (± 60,8)
VS (mg/L)	422,3 (± 75,5)	275,0 (± 44,4)
TSS (mg/L)	120,8 (± 34,8)	0
VSS (mg/L)	107,5 (± 32,8)	0

	SMY (ml CH_4/gSV_{fed})
Lower section	323 ± 8
Filtration section	295 ± 12
Permeate (16ºC)	284 ± 2

Thiago A. Nascimento , Fanny R. Mejía , F. Fdz-Polanco and Mar Peña Miranda (2017). Improvement of municipal wastewater pretreatment by direct membrane filtration. Env. Tech,. http://dx.doi.org/10.1080/09593330.2016.1271017

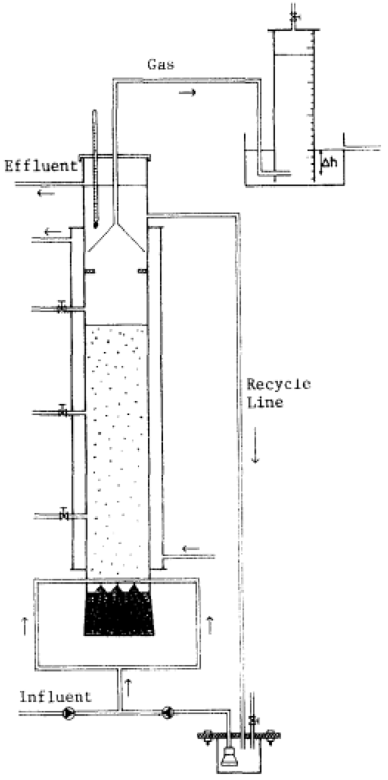


Fig. 2. Scheme of the reactors AFBR-3 and AFBR-4.

20 >T>5 ºC ;
T = 10 ºC
HRT = 2,8 h
OLR = 2,4 – 3,3 g DQO/L.d

Effluent:
COD = 125 mg/L;
BOD = 45 mg/L;
TSS < 25 mg/L

Efficiency
COD > 75%;
BOD > 85%

SANZ I., FDZ-POLANCO F. (1990). "Low Temperature Treatment of Municipal Sewage in Anaerobic Fluidized Bed Reactors". *Water Research. 24(4). 463-469*

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UVa iq tma

Configuración sumergida externa

Configuración sumergida interna

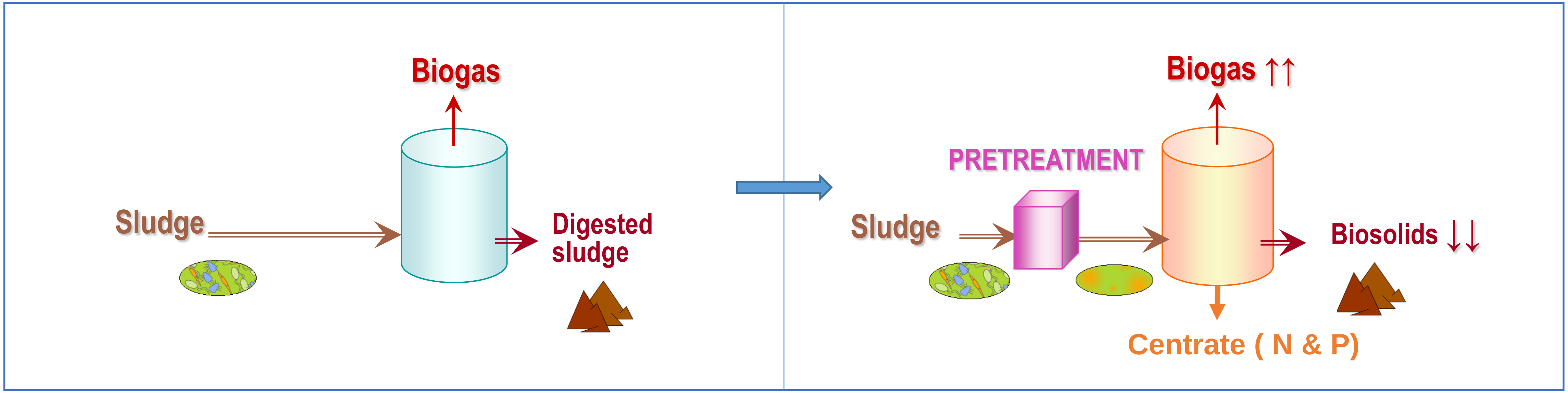
Resultados

THR_{UASB} (h)	VLR (Kg $DQOt/m^3_{UASB}$ d)	DQOt (mg/L)	DBO_5 (mg/L)	Eliminación DQOt (%)
11.4	1.91 ± 0.44	151 ± 46.9	60 ± 20	85.8 ± 2.2
14.2	1.84 ± 0.27	134 ± 26.6	54.2 ± 5.9	88.9 ± 3.2

Operación estable durante más de 3 años
No limpiezas físicas y químicas durante más de 3 años de operación
Flujo de filtrado: 12 -14 L/m2h con TMP 350 – 550 mbar

J. Gouveia , F. Plaza, G. Garralon , F. Fdz-Polanco, M. Peña. Long-term operation of a pilot scale anaerobic membrane bioreactor (AnMBR) for the treatment of municipal wastewater under psychrophilic conditions. Bioresource Technology 185 (2015) 225–233

J. Gouveia, F. Plaza, G. Garralon, F. Fdz-Polanco, M. Peña. A novel configuration for an anaerobic submerged membrane bioreactor (AnSMBR). Long-term treatment of municipal wastewater under psychrophilic conditions. Bioresource Technology 198 (2015) 510–519



TECHNOLOGICAL CHALLENGES
IMPROVE DIGESTION TECHNOLOGY (HRT, OLR)
MAXIMIZE BIOGAS PRODUCTION
MINIMIZE BIOSOLIDS PRODUCTION
AGRICUTURAL SAFE USE (DESTROY PATHOGENS)
PROCESS AND ENERGY INTEGRATION
N & P RECOVERY IN CENTRATE

2.2. SLUDGE LINE. PRETREATMENTS

Pre-treatments

Biological
- Enzymatic treatment
- Incubation of Enzymes

Physical
- Ultrasonic, Pulses
- High pressure homog.
- Centrifuge, grinding

Thermal
- Thermal Hydrolysis (TH)

Chemical
- Acid or alkaline hydrolysis
- Ozonization

Pretreatment	Cell disruption	Biogas increase	Pathogens reduction	Dewaterability
Ball mill	-	-	-	-
Focus pulsed	-	-	-	-
Lysat centrifuge	+	+	-	+
Thermal Hydrolysis	++	++	++	++
High pressure homogenizer	++	++	-	+
Ultrasounds.	++	++	+	-
Enzimatic	++	+	+	+

++ Positive – very high
+ Positive – high
- Negative

2.2. SLUDGE LINE. PRETREATMENTS. TH EVOLUTION

2005- First laboratory pilot

2006- Second laboratory pilot

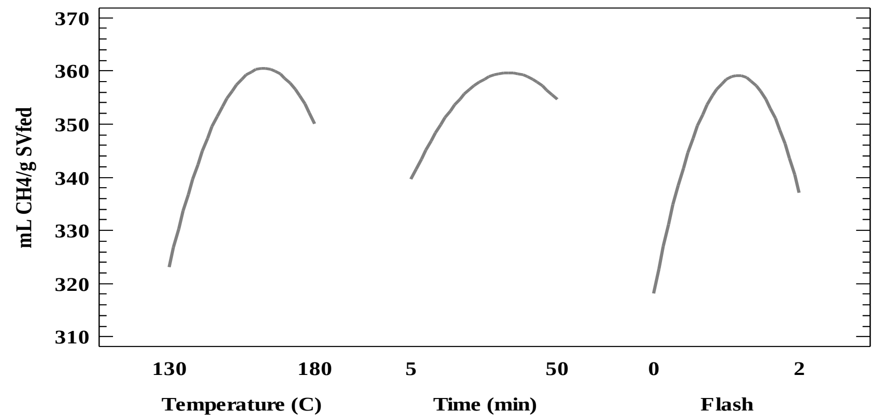
2007- Pilot plant

2012- Continuous thermal hydrolysis (CTH) industrial plant

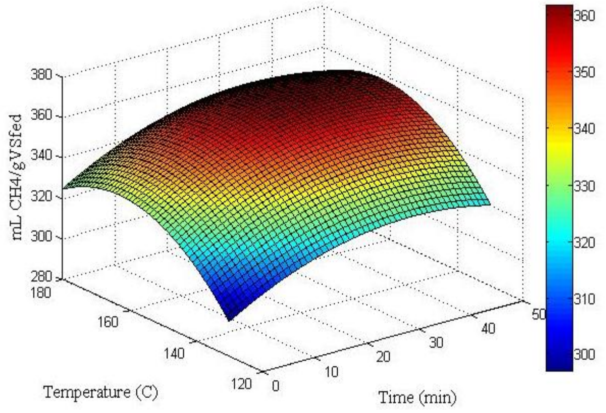
MAIN EXPERIMENTAL RESULTS ON THERMAL HYDROLYSIS:

- Up to 35% more biogas
- Up to 50% less biosolids.
- Sanitized biosolids (Class A EPA)
- Better dewaterability (up to 30% TSS)
- Duplicates OLR to anaerobic digesters (up to 3 Kg SSV/m^3.d)
- Reduces HRT (10 d)
- Reduces viscosity (mixing energy in AD)
- No foam in AD

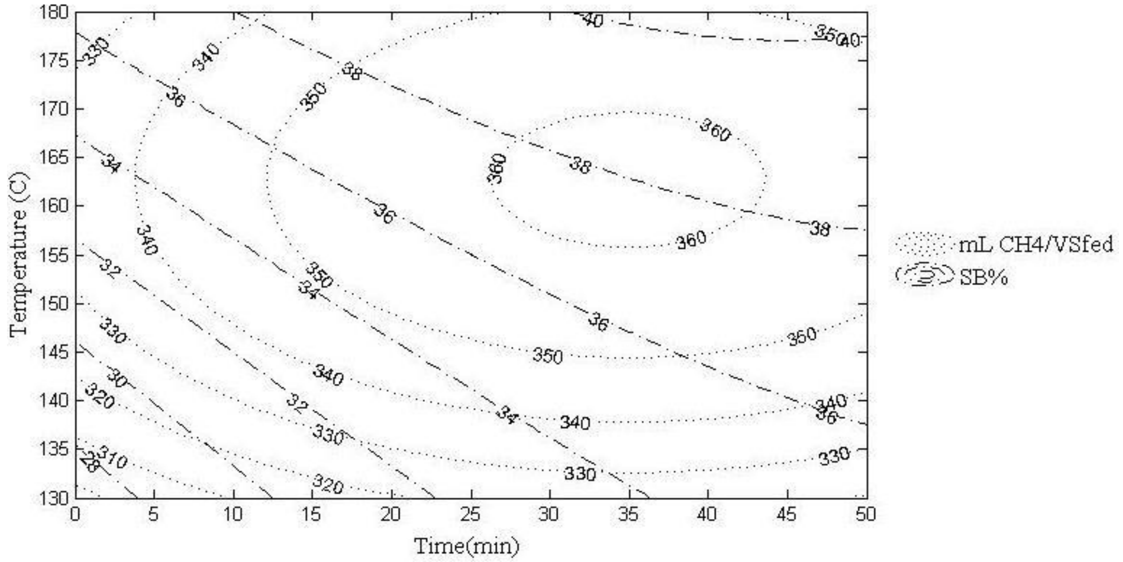
2.2. SLUDGE LINE. PRETREATMENTS. TH OPTIMIZATION



Effect of temperature, time and number of flashes on methane production



Response surface plot. Effect of temperature and time on methane production (Flash = 1).

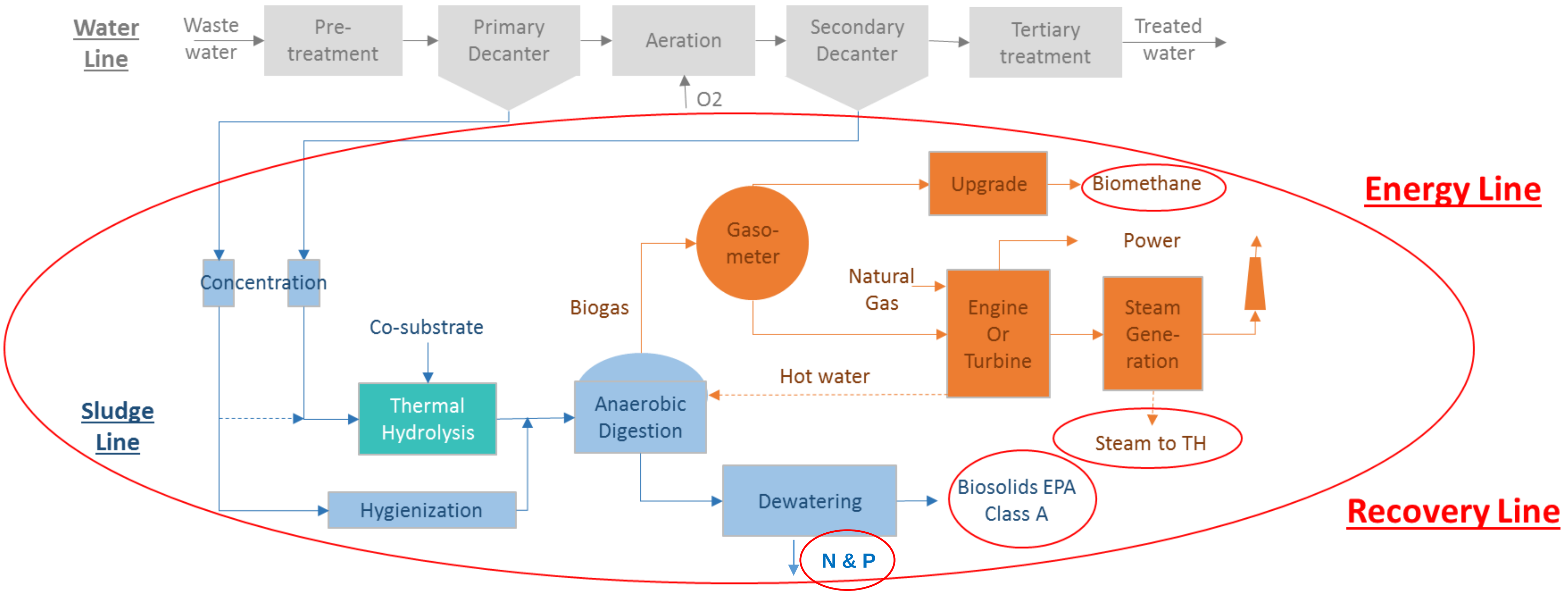


Superimposed contour plots for methane production and solubilisation

I Sapkaite, E Barrado, F Fdz-Polanco, SI Pérez-Elvira

Optimization of a thermal hydrolysis process for sludge pre-treatment. Journal of Environmental Management 192, 25-30

2.2. SLUDGE LINE. PRETREATMENTS. ENERGY INTEGRATION



WARNING. Energy consumed > Energy produced

Thermal Hydrolysis technologies are characterized by:

1. Operating regime
- Batch
- Continuous
- Steady state
- No steady state

2. Mechanisms
- Thermal (cooking)
- Steam explosion (flash)

3. Heat exchange
- Heat exchangers
- Live steam

4. Sludge pressurization
- Pumps
- Pressurization

2.2. SLUDGE LINE. TH. COMPARING TECHNOLOGIES

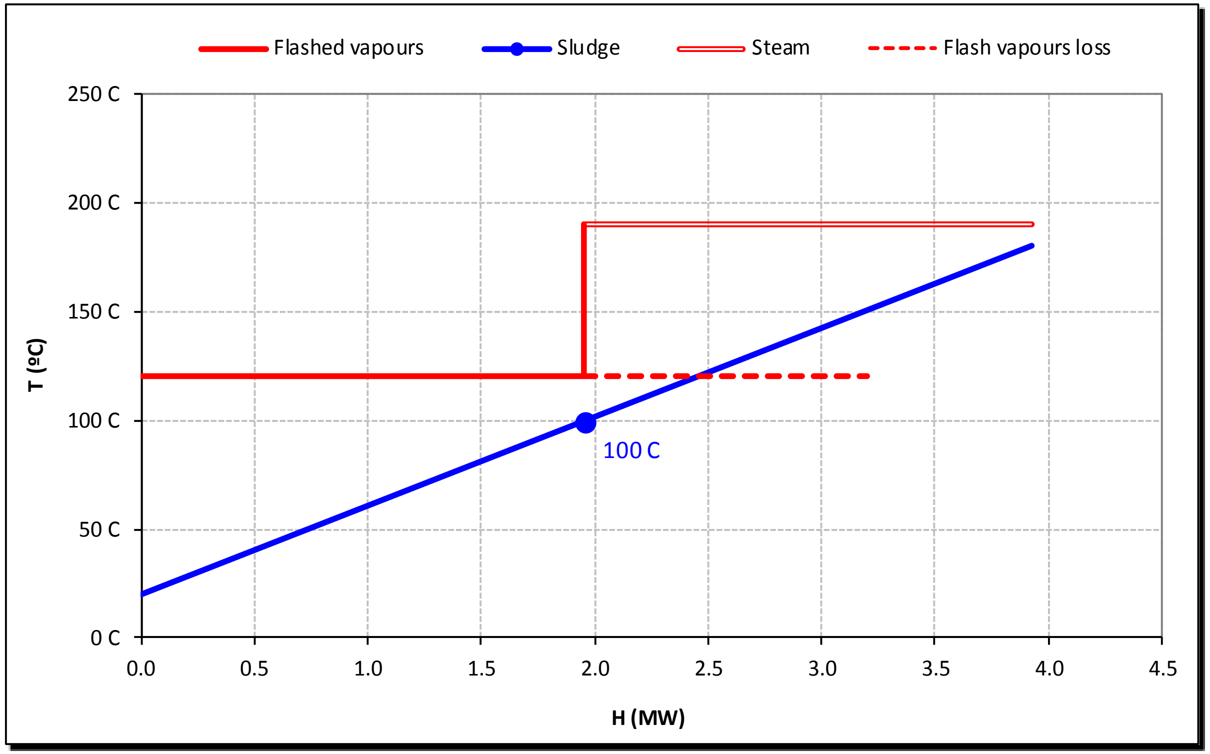
Company	Technology	Regime		Mechanisms				No heat exchangers	No pumps	# instalations in WWTPs	Maintenance	Energy integration	Footprint
		Continuous	Steady state	1. Thermal (cooking time and max. temp.)			2. Steam explosion						
CAMBI	THP	✗	✗	✓	30´	165ºC	✓	✓	✗	54	✗	✗	✗
VEOLIA	Biothelys	✗	✗	✓	30´	165ºC	✗	✗	✗	7	✗	✗	✗
VEOLIA	Exelys	✓	✗	✓	30´	165ºC	✗	✗	✗	6	✗	✗	✗
HAARSLEV	ACH	✓	✗	✓	20´	165ºC	✓	✓	✓	-	✓	✗	✓
Sustec	TurboTec	✓	✗	✓	30´	165ºC	✗	✗	✗	2	✗	✗	✗
ELIQUO	Lysotherm	✓	✗	✓	30´	165ºC	✗	✗	✗	2	✗	✗	✗
Lystek	Lystek	?	✗	✓	45´	<100ºC (Alkali)	✗	✓	✗	3?	✓	✗	✓
suez	Aqualysis	✓	✓	✓	15´	170ºC	✓	✓	✗	1	✗	✗	✓
teCH4	tH4+	✓	✓	✓	< 5´	220ºC	✓✓	✓	✓	-	✓	✓	✓

2.2. SLUDGE LINE. TH. OPTIMAZING TECHNOLOGY

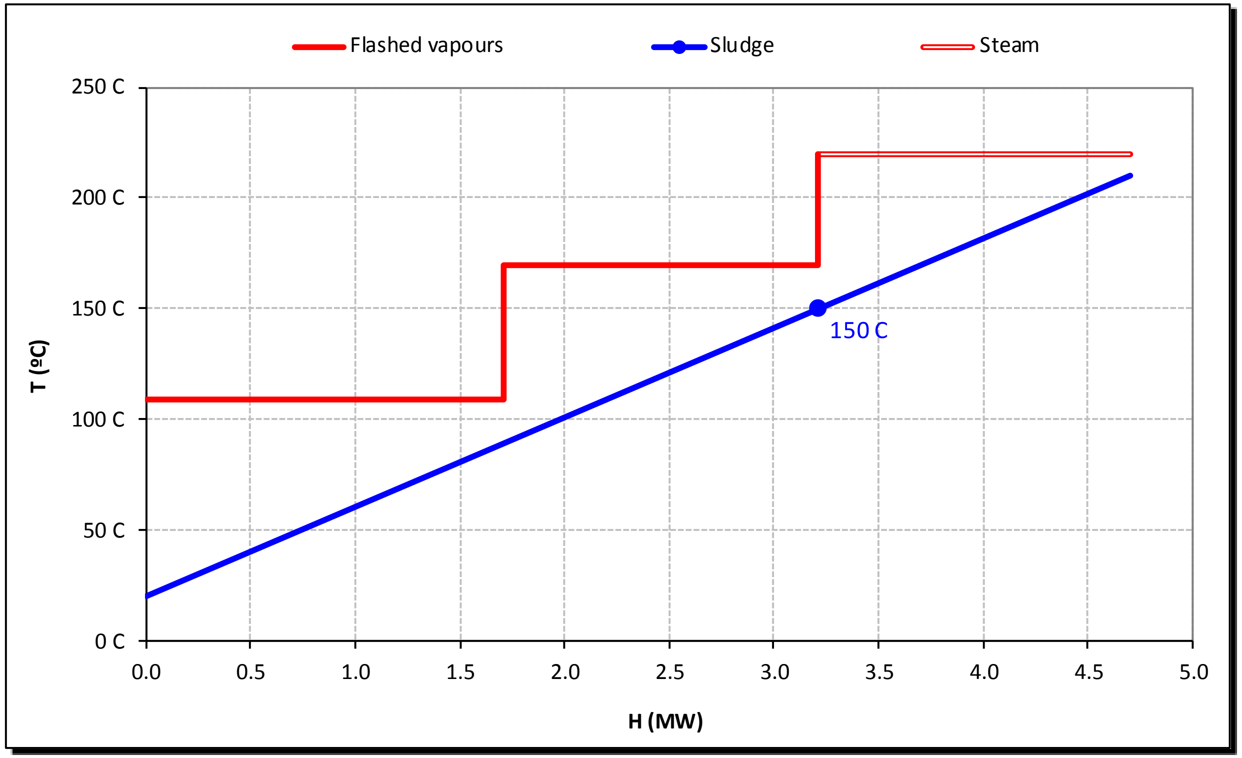
1. Operating regime	2. Mechanisms	3. Heat exchange	4. Sludge pressurization
Continuous	Thermal (cooking)		
Steady state	Steam explosion (flash)	Live steam	Pressurization
STABILITY	ENERGY INTEGRATION & SELF-SUFFICIENCY		ROBUST

Pinch Analysis. Composite curves

Conventional (one pressure level)



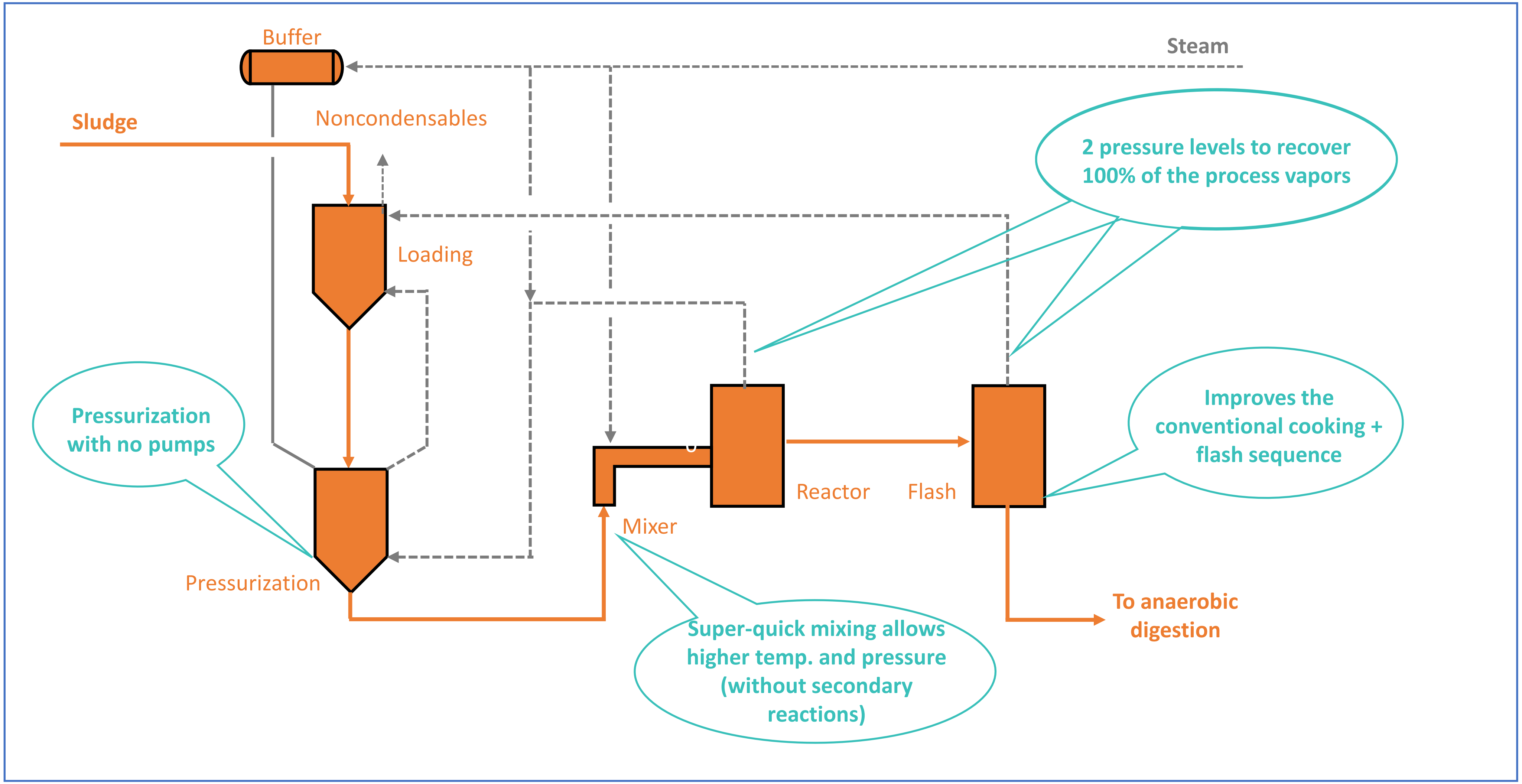
2nd Generation (two pressure levels)



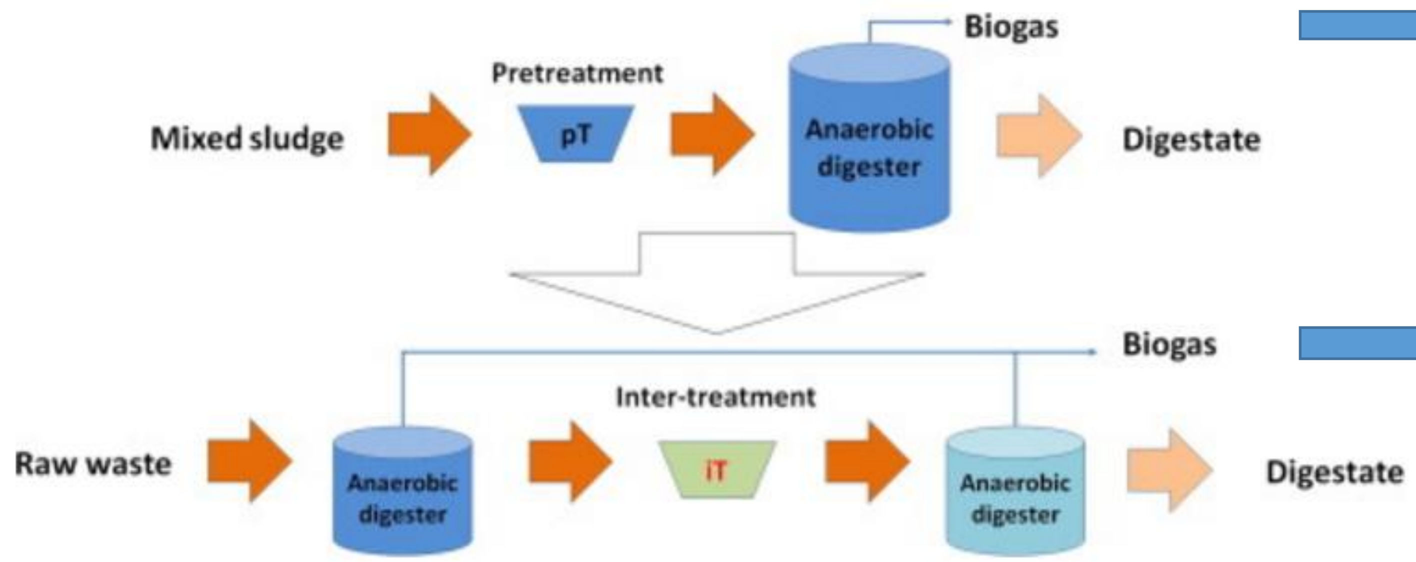
D. Fernández-Polanco, H. Tatsumi (2016). Optimum energy integration of thermal hydrolysis through pinch analysis. Renewable Energy. **Special Issue: Biogas as a Renewable Fuel.** Volume 96, Part B, Pages 1093-1102

2.2. SLUDGE LINE. TH. SECOND GENERATION TH

tH_4^+



2.2. SLUDGE LINE. TH. NEW TRENDS ON TH



pT > 22,5% Conventional

iT > 45% Conventional
iT > 20% pT

Ortega-Martinez, E., Sapkaite, I., Fdz-Polanco ., Donoso-Bravo, A. (2016). "From pre-treatment toward inter-treatment. Getting some clues from sewage sludge biomethanation" Bioresource Technology. 212, pp 227-235

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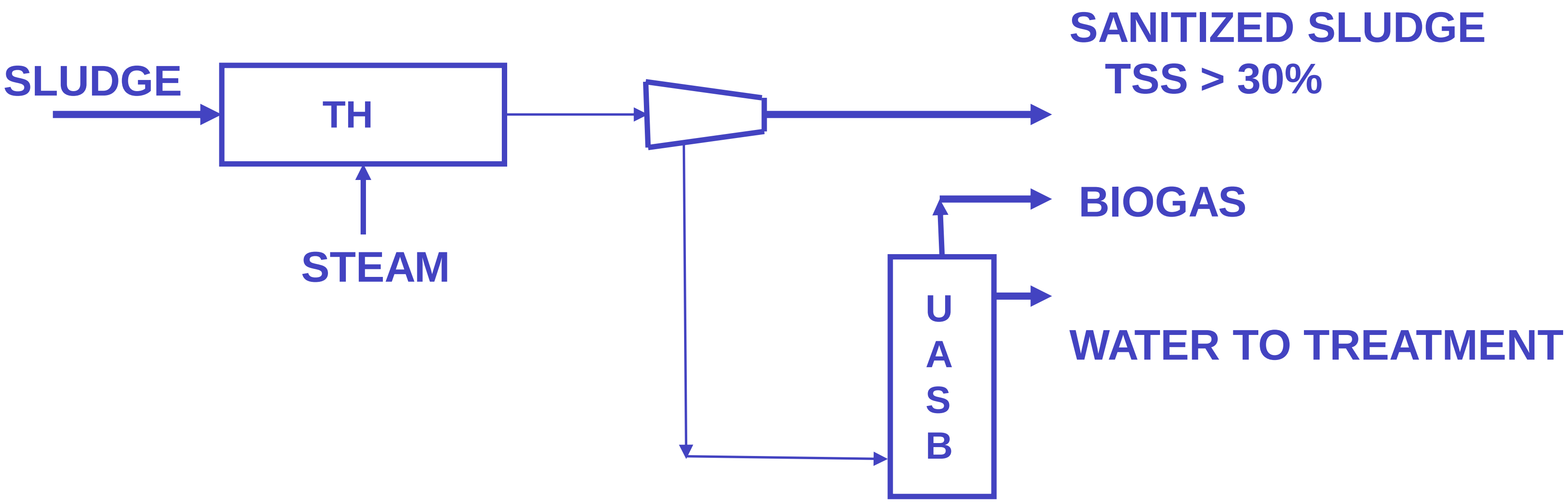


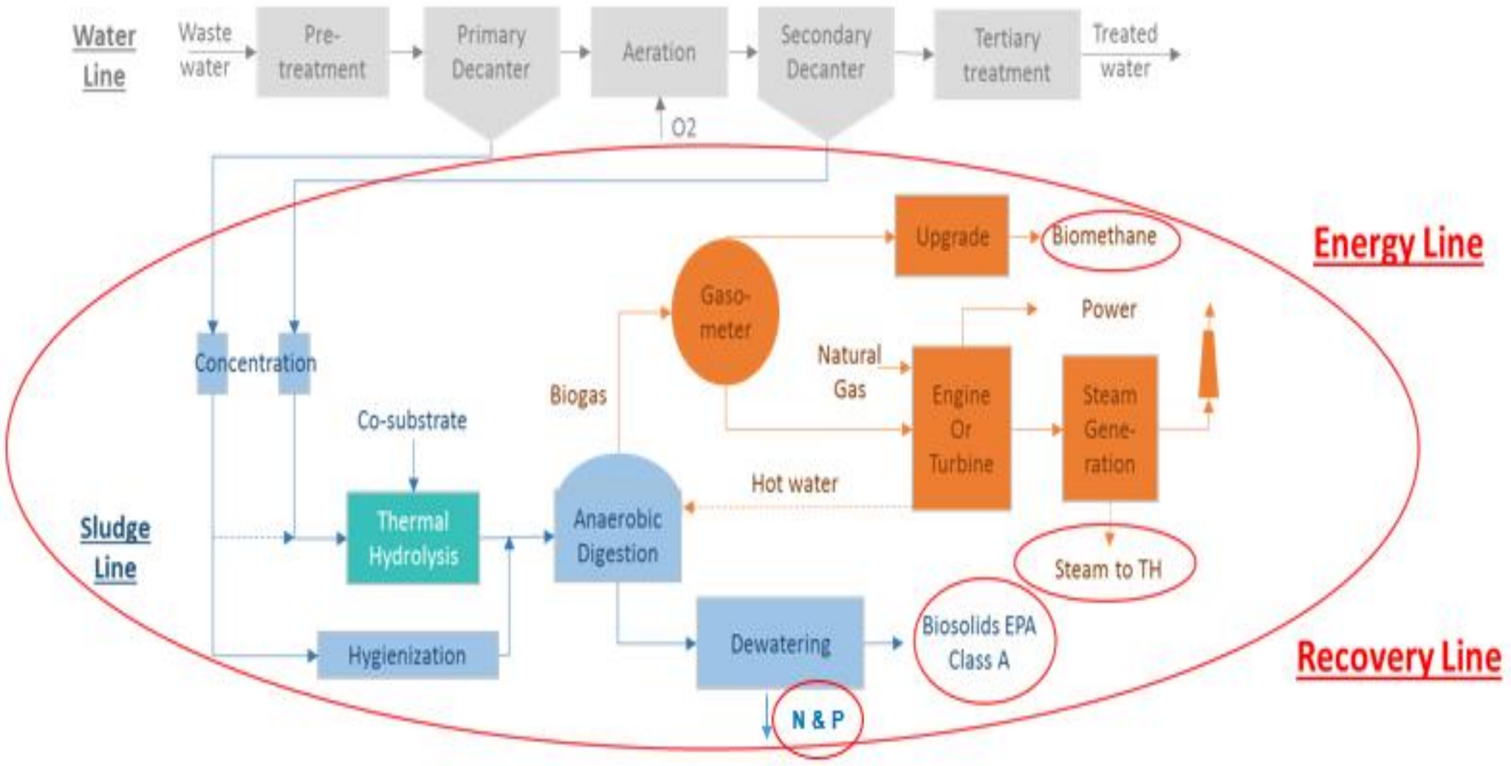
S. I. Pérez-Elvira , I. Sapkaite and F. Fdz-Polanco. (2016). Braz J. Chem. Eng. 33(04), 699 - 704

CONCLUSIONS

1. DIFFERENT TECHNOLOGIES AND APPROACHES.

2. NEW AND CLEAR REGULATIONS FOR SLUDGE DISPOSAL.

3. FROM SLUDGE LINE TO ENERGY & RECOVERY LINES.



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