RHODES 2024

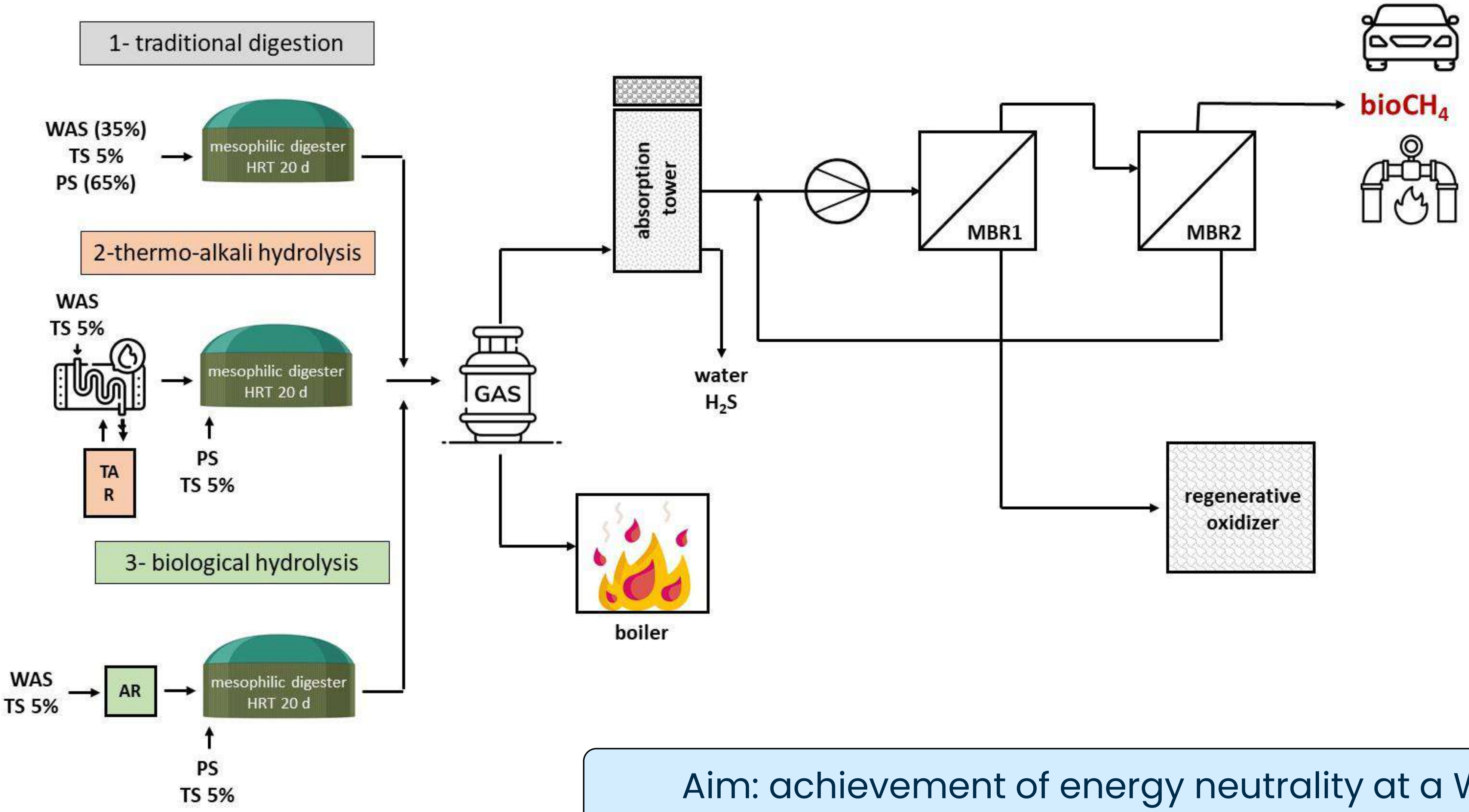
11° International Conference on Sustainable Solid Waste Management
19-22 June 2024

Techno-economic analysis of thermo-alkali and biological pre-treatments applied to WAS

Politecnico di Torino
1859

B. Ruffino, G. Campo, A. Cerutti and M.C. Zanetti
DIATI, Politecnico di Torino, Italy

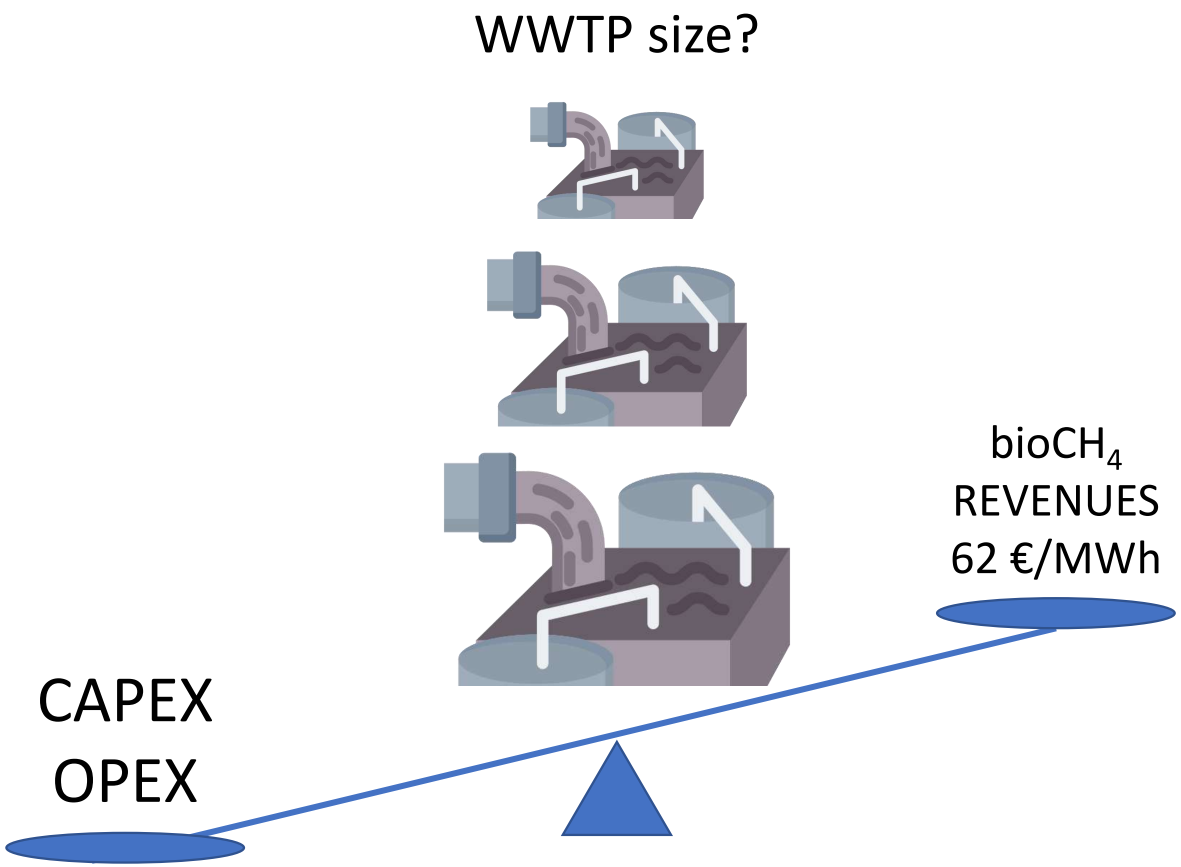
Is this scheme sustainable?



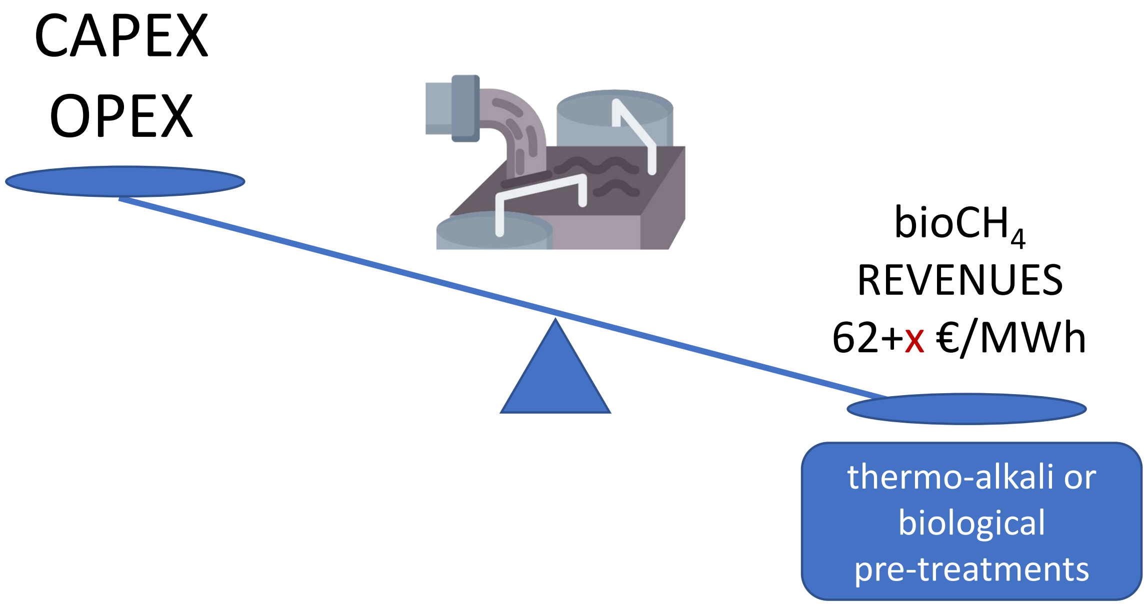
Aim: achievement of energy neutrality at a WWTP

Aim of the study

Phase 1 – No pre-treatments

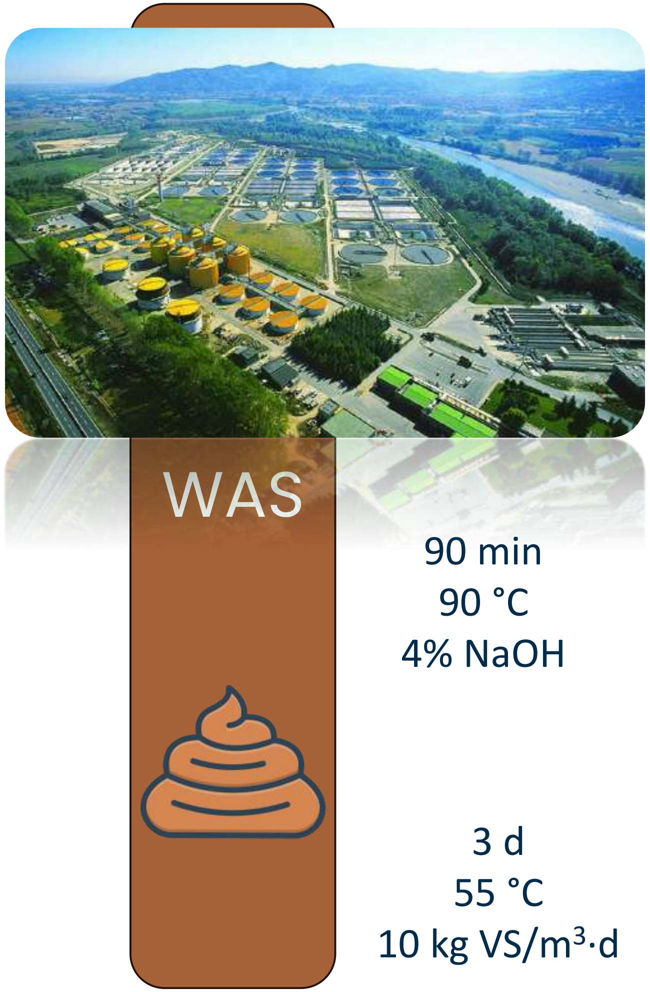


Phase 2 – Application of pre-treatments



Materials and Methods

3 Pilot-scale tests



90 min
90 °C
4% NaOH

35 L

240 L

HRT = 20 d
OLR = 1.3 kg VS/m^3·d
38 °C

240 L

HRT = 20 d
OLR = 0.6 kg VS/m^3·d
38 °C

3 d
55 °C
10 kg VS/m^3·d

10 L

10 L

HRT = 20 d
OLR = 1 kg VS/m^3·d
38 °C

Materials and Methods

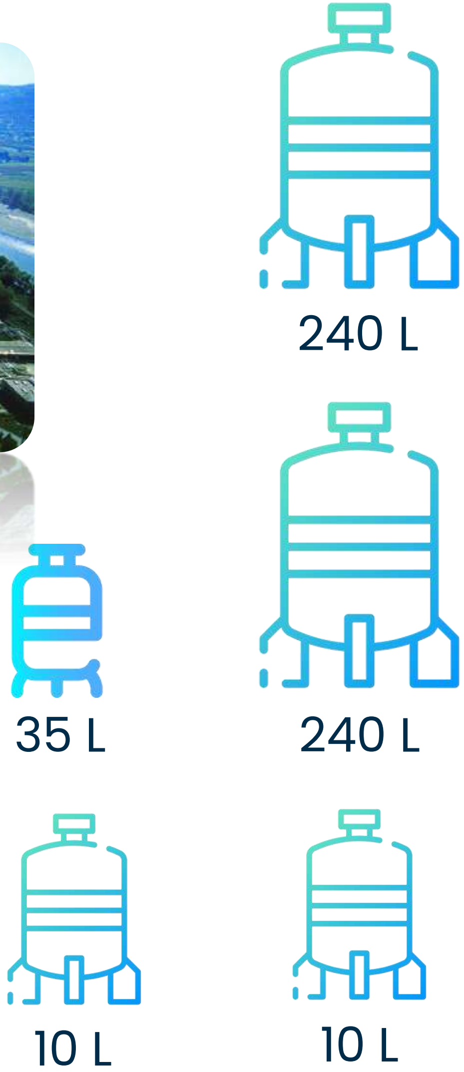
$$NPV = \sum_{t=0}^{n} \frac{(I_t - O_t)}{(1+i)^t}$$

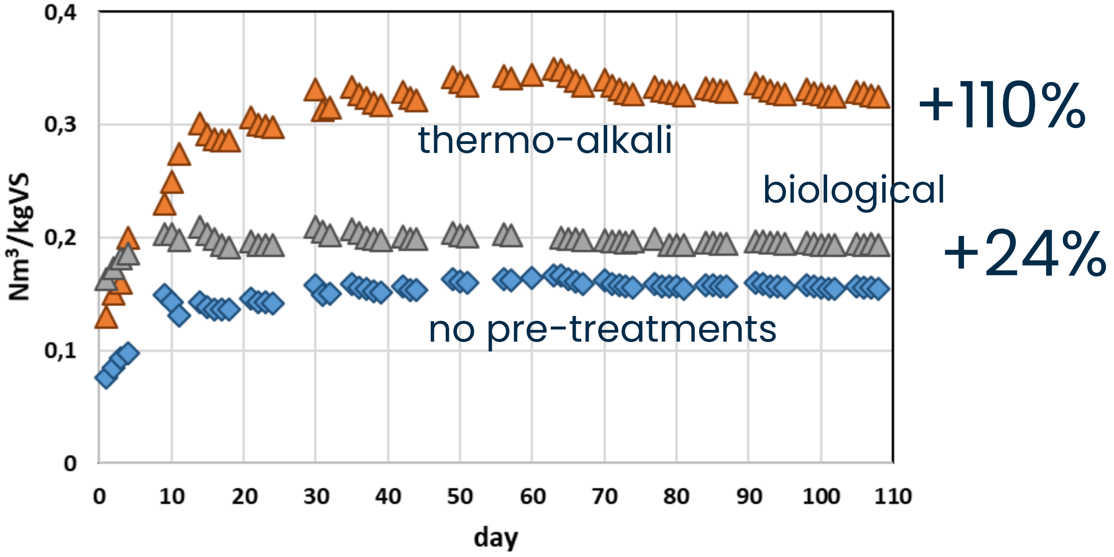
- Energy costs
- Membrane operating costs
- NaOH purchase

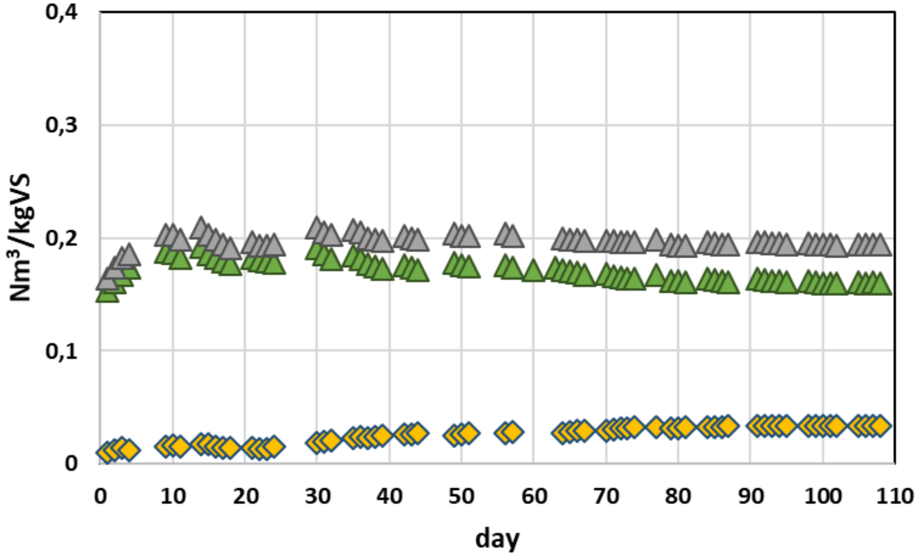
Component	Cost function ($)	Capacity unit	Year	CEPCI	ER	Reference
Pre-treatment tank	$575622 \cdot \left(\frac{V_{PT}}{3000}\right)^{0.8}$	m^3	2016	541.7	1.48	Mirmasoumi et al., 2018
Main digester	$840222 \cdot \left(\frac{V_{AD}}{3000}\right)^{0.8}$	m^3	2016	541.7	1.48	Mirmasoumi et al., 2018
AR digester	$840222 \cdot \left(\frac{V_{AR}}{3000}\right)^{0.8}$	m^3	2016	541.7	1.48	Mirmasoumi et al., 2018
Boiler for heat generation	$\frac{1}{1.12} \cdot 180 \cdot P_{boiler}$	kW	2012	584.6	1.37	Petrollese and Cocco, 2020
Gasometer	$\frac{1}{1.12} \cdot 40 \cdot V_{gasometer}$	m^3	2012	584.6	1.37	Sanaye and Yazdani, 2022
Absorption tower for H_2S removal	$\frac{1}{1.12} \cdot 15974.13 \cdot (Q_{biogas}{}^{0.3555})$	m^3/h	2011	585.7	1.37	Sanaye and Yazdani, 2022
Demister	$0.01 \cdot cost\ desulfurization$	$	2011	585.7	1.37	Sanaye and Yazdani, 2022
Regenerative oxidizer	$2.664 \cdot 10^5 + 13.98 \cdot Q_{biogas}$	scfm	1999	390.6	2.06	Sorrels, 2017
Membrane	165·A	m^2	2015	556.8	1.44	Valenti et al., 2016
Compressor	1000·P	kW	2015	556.8	1.44	Valenti et al., 2016
Heat exchanger	$32800 \cdot \left(\frac{A}{80}\right)^{0.68} \frac{661.7}{370.6} \cdot 6.4$	m^2	2005	468.2	1.72	Sanaye and Yazdani, 2022

(scfm, standard cubic foot per minute, 1 scfm = 1.699 m^3/h)

Results and Discussion



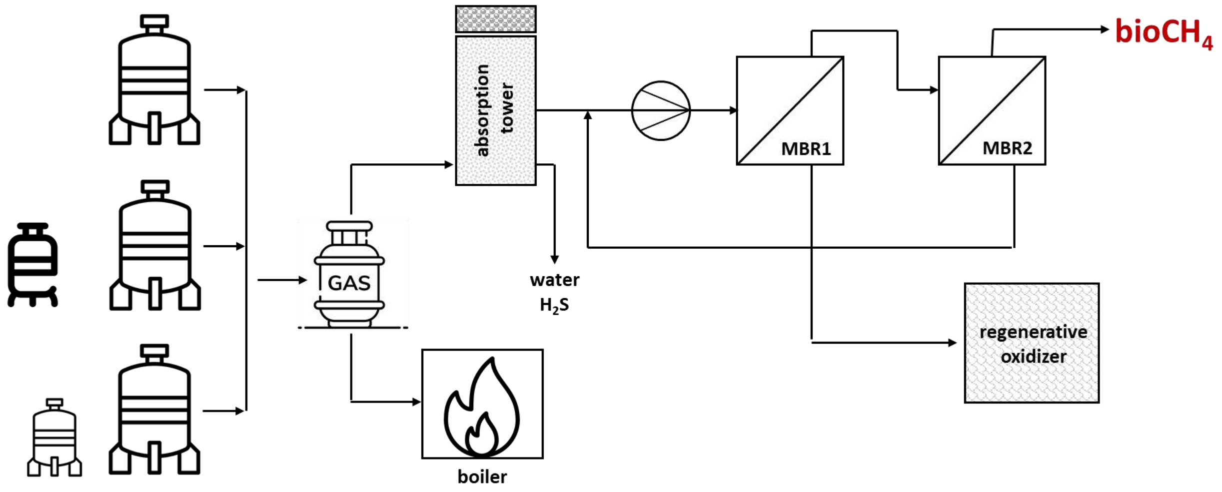


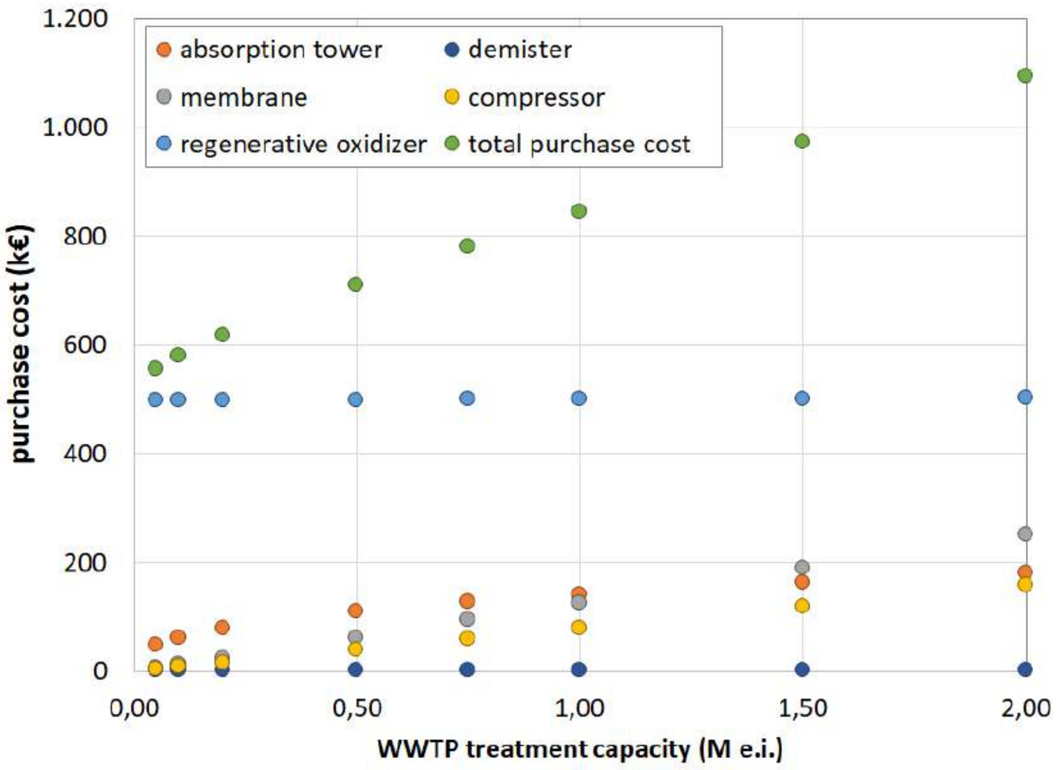


Results and Discussion

Preliminary economic assessment

Pieces of equipment	WWTP 100,000 e.i. Purchase cost (€)	WWTP 1,000,000 e.i. Purchase cost (€)
Main digester(s)	605,013	3,817,377
Boiler for heat generation	14,992	102,961
Gasometer	10,296	138,631
Absorption tower for H_2S removal	60,990	140,466
Demister	610	1405
Regenerative oxidizer	498,242	499,908
Membrane	11,960	124,992
Compressor	7521	78,600
TPC	1,209,625	4,904,339





Conclusions

- A WWTP size of at least 500,000 e.i. was necessary to recover the initial investment made for the installation of the biogas upgrading plant after 10 years, when the biomethane was sold at 62 €/MWh, that is the price fixed by the in-force Italian decree on biomethane;
- The results of the pilot-scale tests highlighted a clear superiority of the thermo-alkali pre-treatment over the BH, being the first able to increase the WAS productivity by 110% with respect to the control (untreated WAS), compared to only +23.6% obtained with the TPAD scheme.
- The extra biogas production obtained with the biological pre-treatment was of too limited extent to compensate both the higher amount of heat necessary for the pre-treatment and the purchase cost of the additional reactor. The biomethane price capable of compensating the investment rose to 72 €/MWh.
- Notwithstanding the high productivity of the thermo-alkali pre-treated WAS, the introduction of this kind of pre-treatment in the WWTP sludge line was able to increase the revenues from biomethane selling by only 2 €/MWh, for a WWTP of 500,000 e.i.
- The results of the present study can provide useful data to WWTP managers who want to introduce WAS pre-treatments combined with interventions for biogas upgrading in an existing or new sludge line of a WWTP.

This research was partially funded by SMAT, Società Metropolitana Acque Torino.
The authors wish to thank Giovanna Zanetti, from PoliTO, for CHN analyses,
Eugenio Lorenzi and Gerardo Scibilia, from SMAT, for fruitful discussions

RHODES 2024

11° International Conference on Sustainable Solid Waste Management
19-22 June 2024

Thanks for your kind attention!

barbara.ruffino@polito.it

Techno-economic analysis of thermo-alkali and biological pre-treatments applied to WAS

Politecnico di Torino
1859

B. Ruffino, G. Campo, A. Cerutti and M.C. Zanetti
DIATI, Politecnico di Torino, Italy