

Optimizing Sewage Sludge Digestion in Wastewater Treatment Plants: a Case Study from the Largest WWTP in Italy

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## Optimizing Sewage Sludge Digestion in Wastewater Treatment Plants: A Case Study from the Largest WWTP in Italy

Marco Ravina

S. Borzooei, G. Campo, A. Cerutti, L. Meucci, D. Panepinto, V. Riggio, B. Ruffino, G. Scibilia, M.C. Zanetti

Politecnico di Torino - Department of Environment, Land and Infrastructure Engineering

Società Metropolitana Acque Torino - Research Center

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## Castiglione Torinese WWTP



2,000,000 equivalent inhabitants  
inflow rate 25,000 m<sup>3</sup>/h



## Castiglione Torinese WWTP



Post-thickening / dewatering

Anaerobic digestion

Pre-thickening

inflow 300-350 m<sup>3</sup>/h

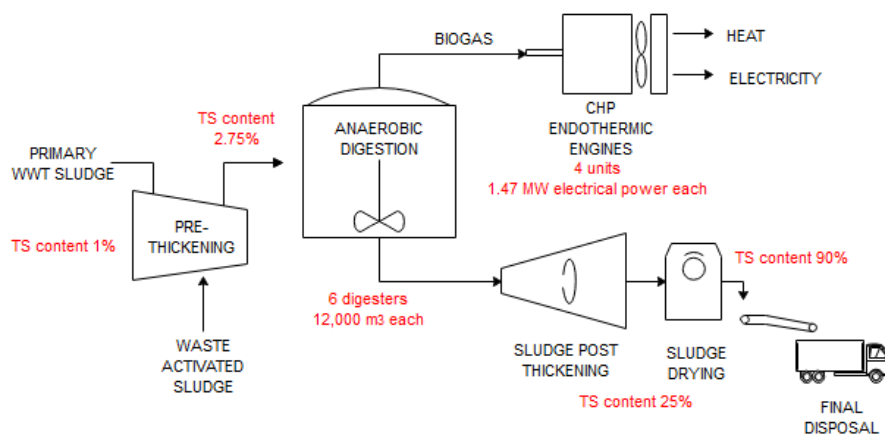
**Objective: Sludge treatment and anaerobic digestion stage optimization**

1. Evaluation of combined thermal and chemical pre-treatments (named hybrid pre-treatments) on waste activated sludge (WAS)
2. Evaluation of the introduction of a biogas upgrading process to biomethane

in terms of mass, energy and greenhouse gas emission balance.

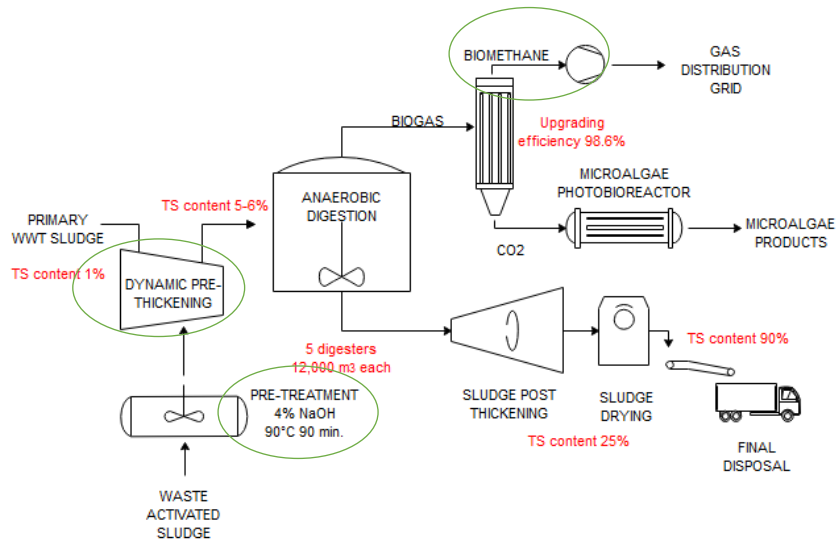


## Present process





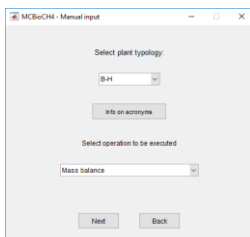
## Optimized process simulation



## Evaluation model



MCBioCH<sub>4</sub> is a MATLAB<sup>®</sup> - based standalone application fully equipped with graphical user's interface



**Mass balance** → Biogas/biomethane production  
→ GHG losses from AD process  
→ GHG losses from upgrading process



**Energy balance** → Biomethane energy content & useful energy  
→ Cradle-to-grave energy accounting  
→ Plant energy auto-consumption



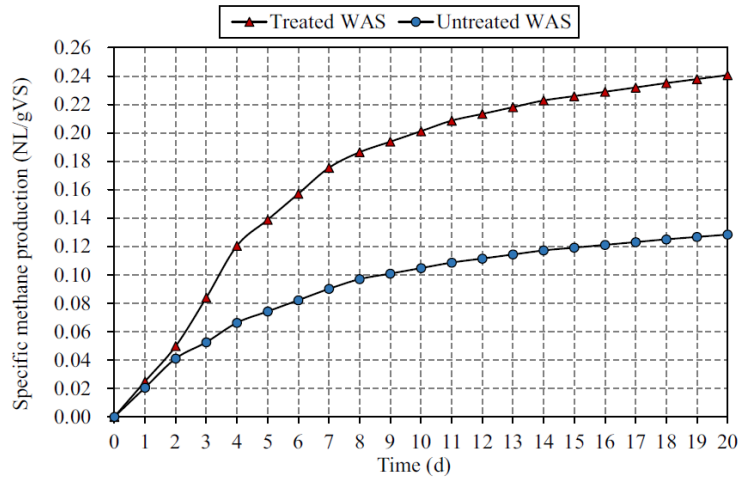
**Emission balance** → Cradle-to-grave emissions of the process  
→ Emission avoidance due to fossil fuel replacement



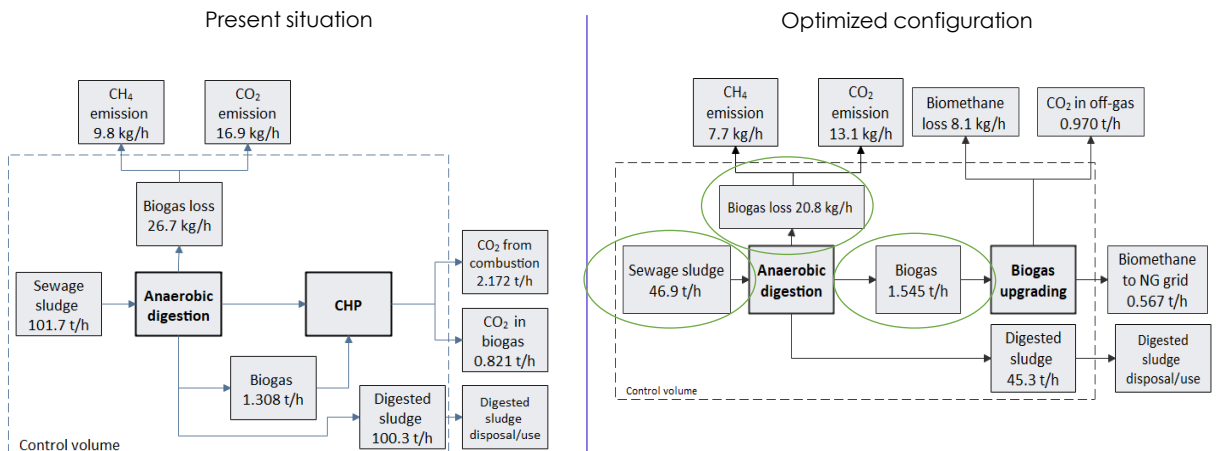
## WAS pre-treatment tests and results



- Raw and treated WAS were digested in mesophilic conditions (38 °C) in 6 L batch reactors.
- The biogas produced was collected in 5 L Tedlar bags
- Test lasted 20 days
- Results showed that the thermo-alkali treatment determined an increase in SBP and SMP of 46.2% and 86.1%, respectively



## Full process simulation - Mass balance

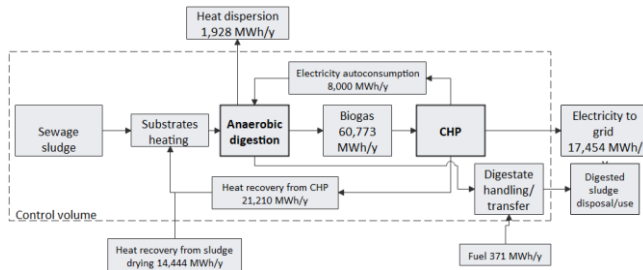




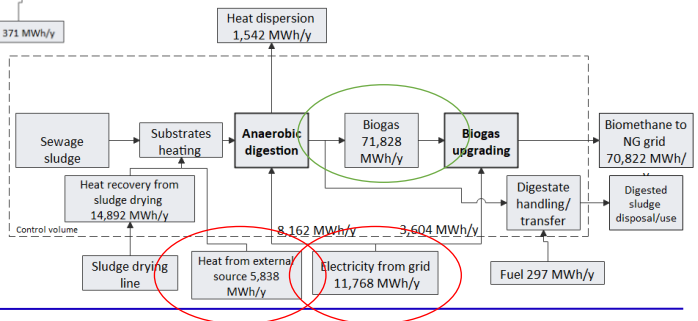
## Full process simulation - Energy balance



Present situation



Optimized configuration



## Full process simulation - Greenhouse gas balance



Input parameter/value	Present		Alternative		Difference
	t CO <sub>2</sub> <sub>eq</sub> /y	t CO <sub>2</sub> <sub>eq</sub> /m <sup>3</sup> biogas y	t CO <sub>2</sub> <sub>eq</sub> /y	t CO <sub>2</sub> <sub>eq</sub> /m <sup>3</sup> biogas y	
Total CH <sub>4</sub> loss from the process	2,437	0.213	3,883	0.287	+34%
Total CO <sub>2</sub> loss from the process	147	0.013	115	0.008	-39%
Net electricity production	-5,883	-0.514	-	-	-
Biomethane replacing natural gas	-	-	-14,594	-1.078	-
Thermal energy auto-consumption covered by external source	-	-	1,203	0.089	+100%
Electricity auto-consumption covered by external source	-	-	3,967	0.293	+100%
Energy consumption for digestate handling/transfer	117	0.010	93	0.007	-30%
<b>Produced GHG emissions</b>	<b>2,701</b>	<b>0.236</b>	<b>9,261</b>	<b>0.684</b>	<b>+180%</b>
<b>Avoided GHG emissions</b>	<b>-5,883</b>	<b>-0.514</b>	<b>-14,594</b>	<b>-1.078</b>	<b>-109%</b>
<b>GHG emission balance</b>	<b>-3,182</b>	<b>-0.278</b>	<b>-5,333</b>	<b>-0.394</b>	<b>-41%</b>



## Conclusion

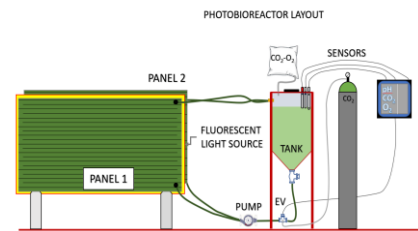


→ Optimization would provide important positive impacts on the overall energy and mass balance of the WWTP sludge line:

1. the installation of a dynamic thickener would allow a **reduction of the sludge volume** entering into the digestion process. Consequently, the thermal energy auto-consumed in the digestion stage would be lower than the present.
2. biogas **production would be around 20% higher** than the methane fraction contained in the biogas actually produced.
3. energy saving and the increased specific biomethane production would **improve the overall GHG balance** of the system

Next steps:

- Further tests and implementation at the field scale
- Integration of a microalgae photo-bioreactor for CO<sub>2</sub> capture



# Thank you

marco.ravina@polito.it