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

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e-EUBCE 2020



## Castiglione Torinese WWTP



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



## Castiglione Torinese WWTP

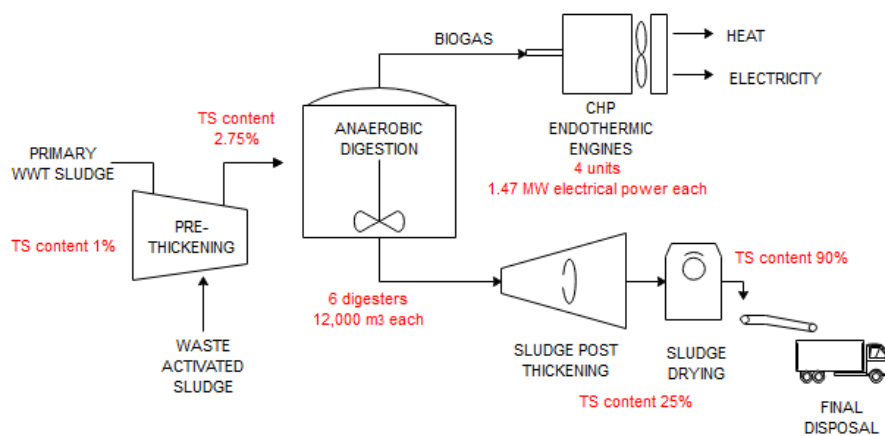


### Objective: Sludge treatment and anaerobic digestion stage optimization

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.

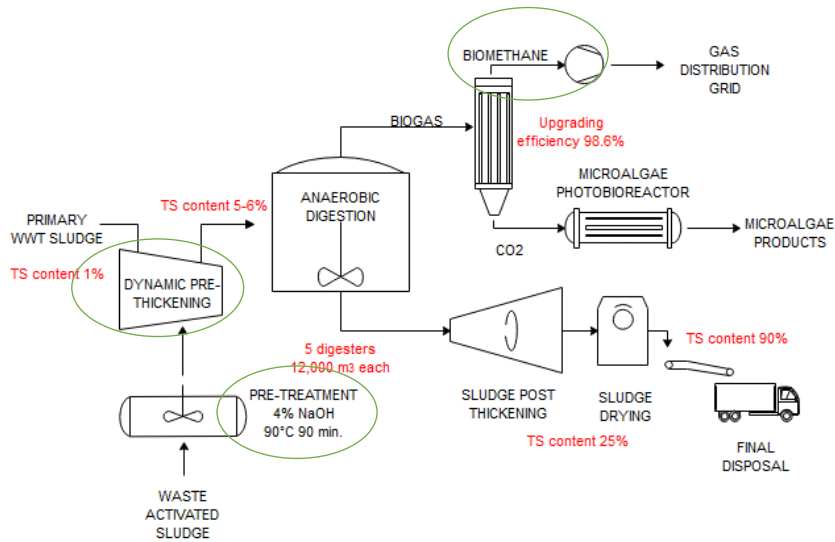


## Present process





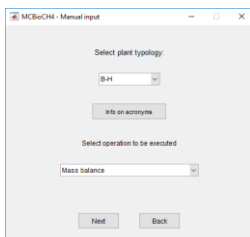
## Optimized process simulation



## Evaluation model



MCBioCH<sub>4</sub> is a MATLAB® - 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



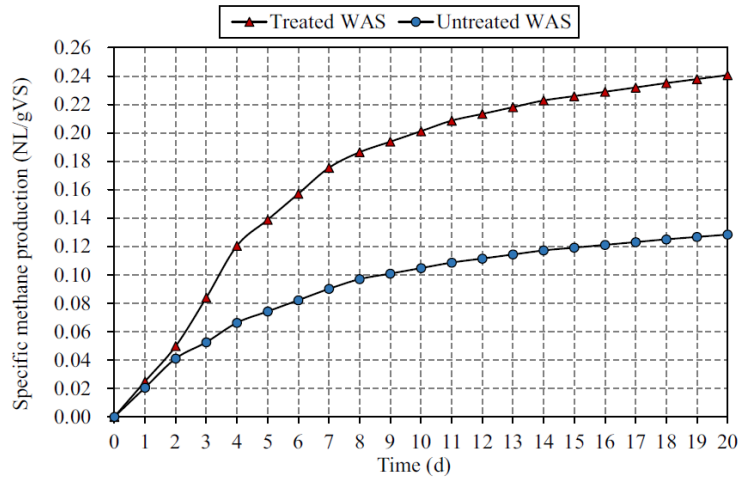
**Emission balance** → Cradle-to-grave emissions of the process  
→ Emission avoidance due to fossil fuel replacement



## WAS pre-treatment tests and results



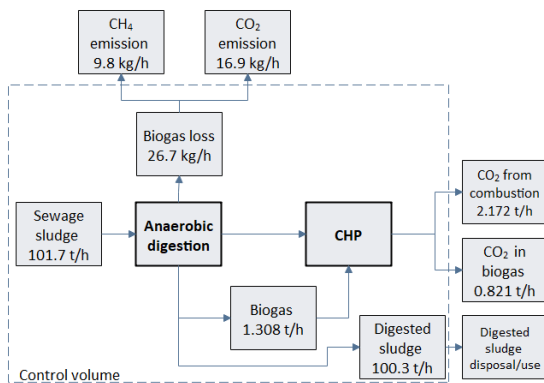
- Raw and treated WAS were digested in mesophilic conditions (38 °C) in 6 L batch reactors.
- The biogas produced was collected in 5 L Tedlar bags
- Test lasted 20 days
- Results showed that the thermo-alkali treatment determined an increase in SBP and SMP of 46.2% and 86.1%, respectively



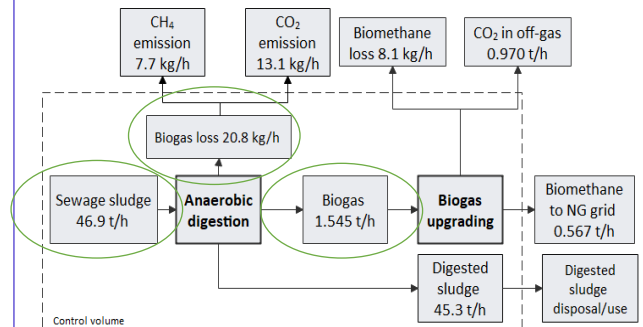
## Full process simulation - Mass balance



### Present situation



### Optimized configuration

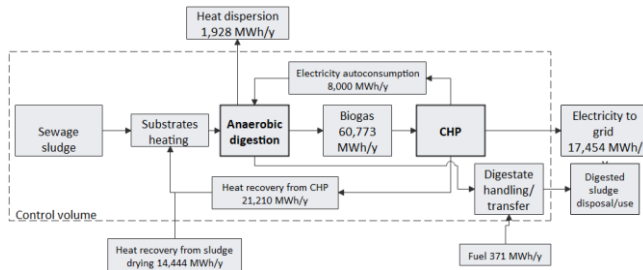




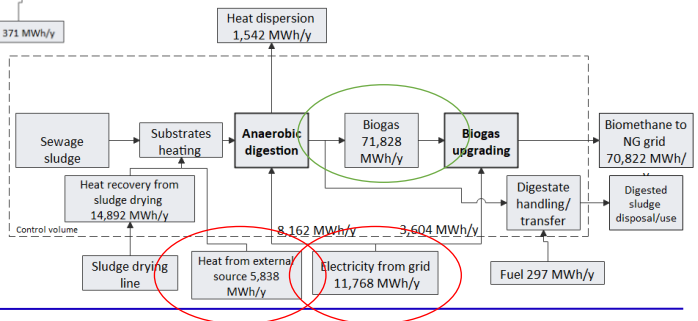
## Full process simulation - Energy balance



Present situation



Optimized configuration



## Full process simulation - Greenhouse gas balance



Input parameter/value	Present		Alternative		Difference
	t CO <sub>2</sub> eq/y	t CO <sub>2</sub> eq/m <sup>3</sup> biogas y	t CO <sub>2</sub> eq/y	t CO <sub>2</sub> eq/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

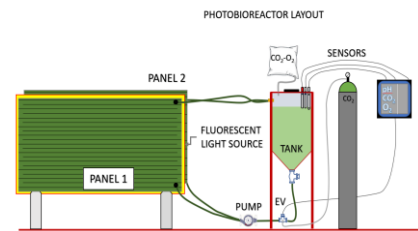


→ Optimization would provide important positive impacts on the overall energy and mass balance of the WWTP sludge line:

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

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