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A techno-economical case study of a thermophylic anaerobic digestion plant in Attica Region, Greece

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Introduction

- Anaerobic biological degradation :process of organic matter decomposition in the presence of microorganisms and in the absence of oxygen. Product: Biogas
- Biogas: 55-65% methane, carbon dioxide and traces of other gases.
  - ➢ It has good calorific value
  - ➢ can be used directly as a fuel or indirectly for electricity generation

Anaerobic digestion: considered an alternative environmentally friendly method of waste management, while an important renewable energy source

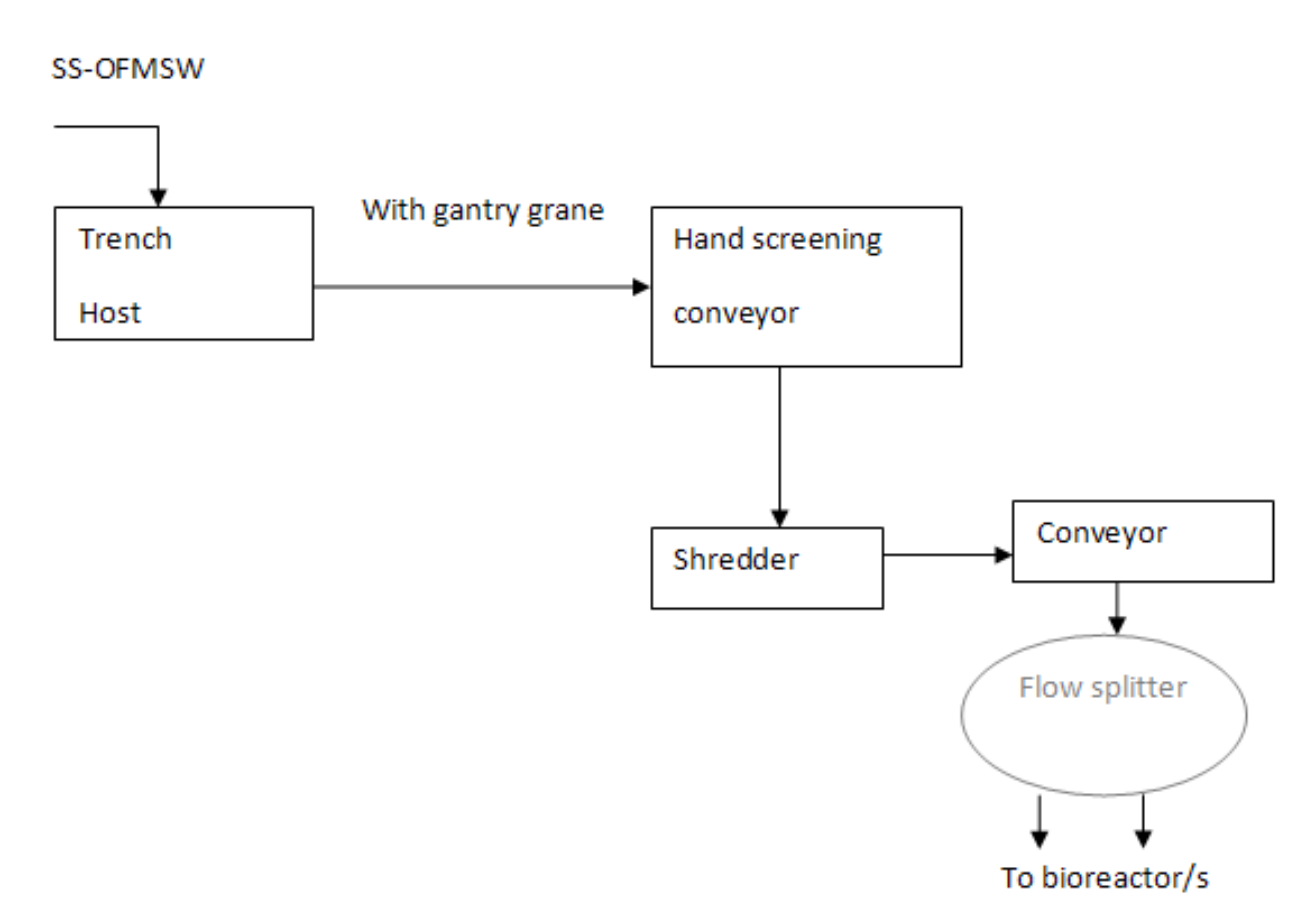
This study: a techno-economically study of a possible thermophilic anaerobic biological degradation unit installation in Attica, (35600ton/y of fresh substrate of the SS-OFSMW)

The situation of municipal solid waste in Attica

- biodegradable materials (46%)
- composition of the organic fraction of municipal solid waste varies from food waste, vegetable and fruit waste to garden waste (leaves and grass)
- In Attica there is no policy to separate the organic fraction of municipal waste at source, as it happens in the European Union, although such approach is now under consideration

Design of the anaerobic digestion unit

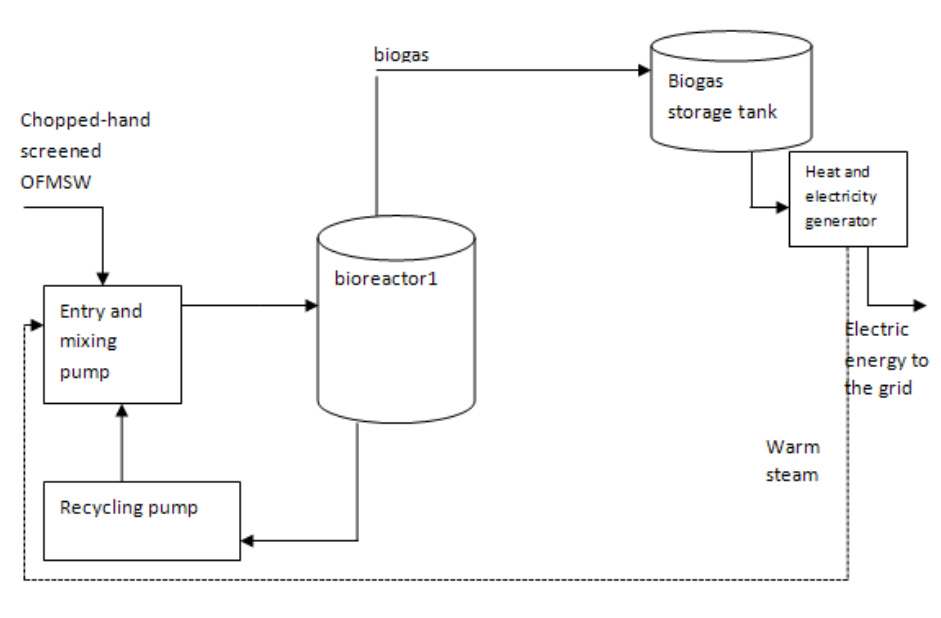
Preprocessing unit



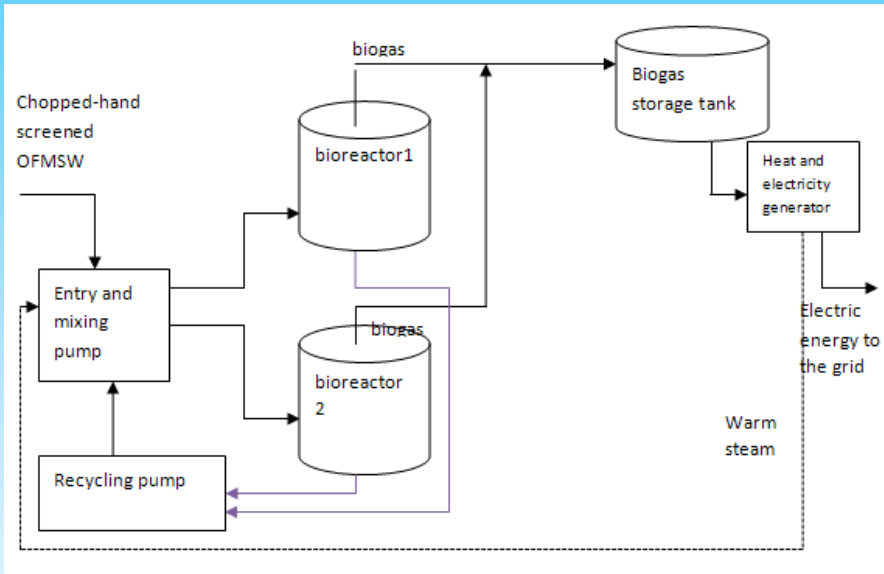
a trench host (capacity 122-140m3), gantry crane for transferring material from the trench in hand screening conveyor, shredder and a conveyor that will lead the product in the bioreactor/s

Processing unit

Case 1



Case 2



pumps mixing of substrate and recycling of leachate, two dry substrate bioreactors, biogas storage tank, and a heat and electricity production unit

Technical Characteristics

Technical characteristics	**Case 1**	**Case 2**
Bioreactor capacity (m^3)	2326	1163 (x2)
Biogas storage tank capacity (m^3)	3251	
CHP power (MW)	2.5	

Assumptions

- The anaerobic biological processing unit will treat 100ton/d of fresh substrate of SS-OFSMW
- The composition of SS-OFSMW will be 60-70% food waste with d_{fw}=0.75ton/m3 and 40-30% garden waste with d_{gw}=0.3ton/m3).
- Substrate with 35%TS and VS=78%TS
- Methane potential: 0.44m3CH4/kgVSin (STP)
- First order kinetic model with constant k=1.6d
- HRT=16d
- Biogas methane content 56%
- Treactor=55^{o}C
- Annual CHP operation hours 7500h/y
- Methane value 10kWh/m3

Input-Output

Mass input (kg/d)	100000		
VS input (kg/d)	27300		
TS input (kg/d)	35000		
Biogas mass (kg/d)	26133		
Output mass (kg/d)	73867		
TS output (kg/d)	19439 (to compost)		
Biogas yield (average) ($m^3/kgVS_{in}$)	0.76		
Methane yield (average) ($m^3/kgVS_{in}$)	0.424		
CO_2 volume (m^3/d) (STP)	9095		
Electric power efficiency (%)	35	Produced Electric power (kWh/d)	40513
Heat value efficiency (%)	50	Produced Heat (kWh/d)	57875
Losses %	15		

Economic Aspects

- case 1 will have an investment cost around 15.4M€, could be decreased further considering Eurozone recession rates and the economical crisis in Greece to 12M€.
- for Case 2 the estimated investment cost rises 20% higher.

Discussion

- the use of two bioreactors, in case 2, reduces the possibility of suspending the operation of the entire unit
- the thermophilic process can produce approximately 200m^3 of biogas per ton of fresh substrate. (consistent with large-scale studies in the European Union where it is produced 100-200m^3biogas/ton)
- will produce almost 14787 MWh/y. Assuming an average electricity consumption of 3-4MWh/y/householdAthens it could supply almost 5000-4000 households in the Municipality of Athens. So by treating the 9.6% of annual organic waste produced in Athens it can be covered the 1.8-2.3% of Athens municipality electric energy demand.

Conclusions

- The AD unit will manage 35600ton/y of fresh substrate of SS-OFSMW.
- It consists of a pre-processing step (screening with hands-cutting) and the main anaerobic biological treatment.
- Both cases of installing one and two thermophilic bioreactos are taken into consideration.
- The thermophilic process can produce approximately 200m^3 of biogas per ton of fresh substrate and almost 14787 MWh/y.

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