



**NATIONAL TECHNICAL UNIVERSITY OF ATHENS  
POSTGRADUATE COURSE ON AUTOMATION SYSTEMS  
SCHOOL OF MECHANICAL ENGINEERING**

# **Biogas from source-sorted organic municipal waste: The case study of Athens, Greece**

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# Introduction

- the annual increase in waste amounts to 2-3%
- in Europe it is produced more than 3Gtons/year of waste
- Landfilling is a source of aesthetic, health and environment problems
- Anaerobic digestion solves the problems of waste treatment while producing compost and energy in the form of biogas

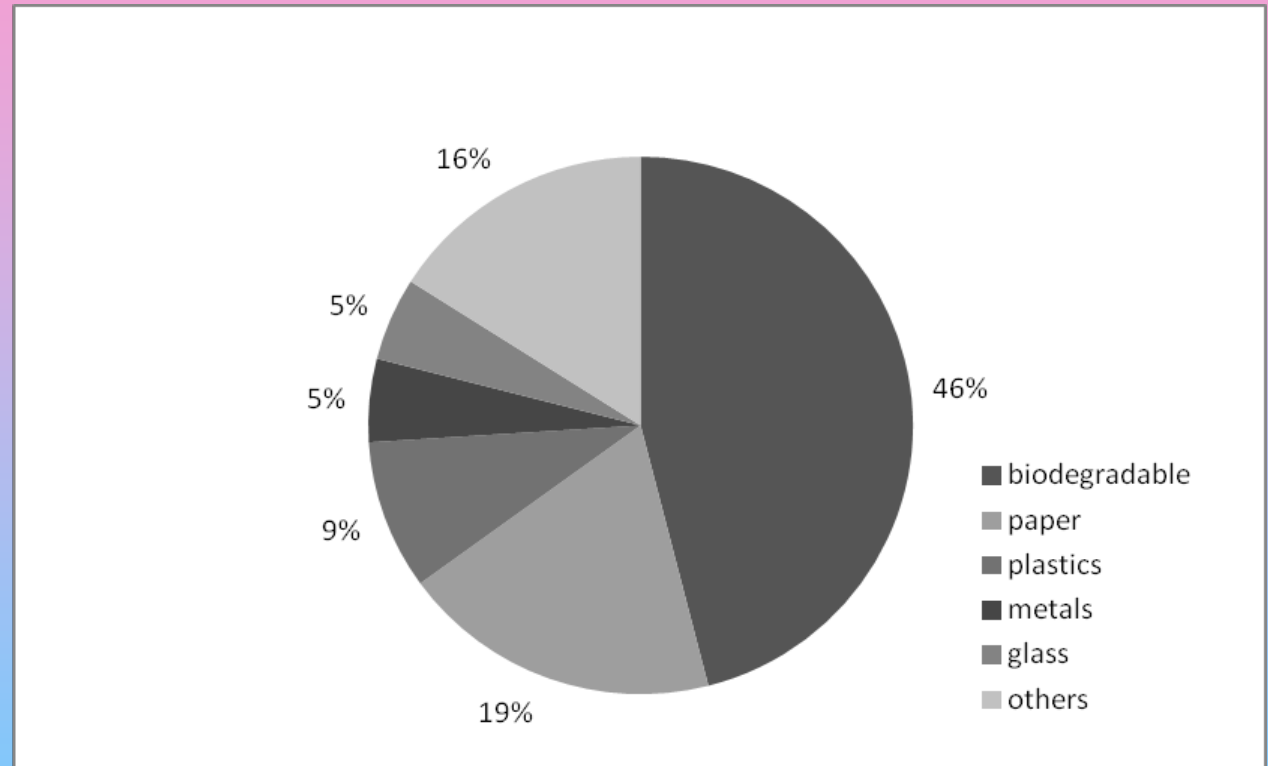
This research presents:

a feasibility study of a possible dry mesophylic anaerobic digestion unit installation in Attica (35600ton/y of fresh substrate of the SS-OFSMW)

# The situation of municipal solid waste in Attica

Waste composition differs with:

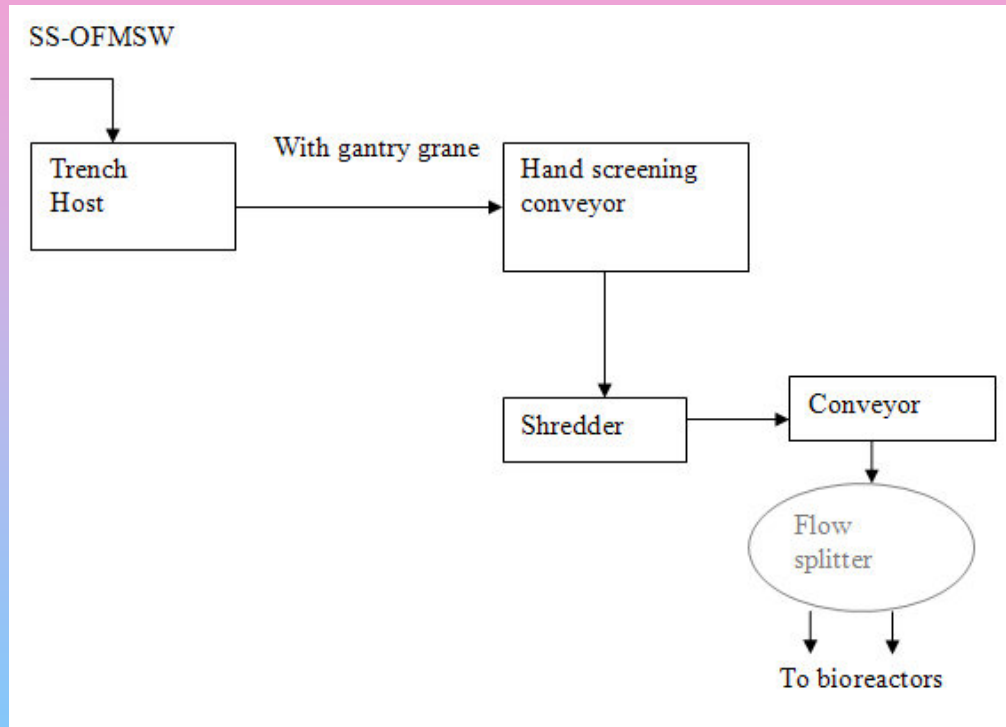
1. standard of living,
2. consumption patterns,
3. mobility of the population,
- and
4. the seasons of the year



The collection of SS-OFMSW in Attica is now under consideration

# Design of the anaerobic digestion unit

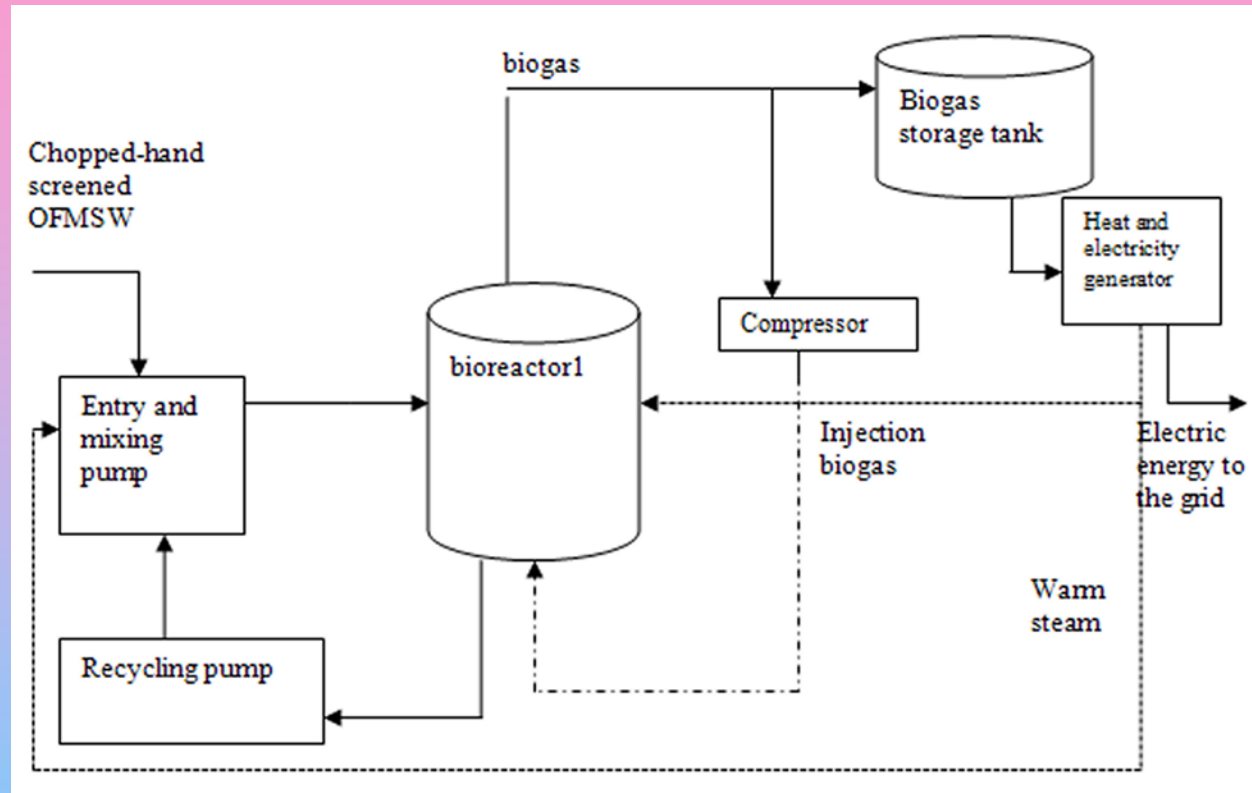
Preprocessing unit



The preprocessing step consists of a trench host (capacity of 115-132m<sup>3</sup>), 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

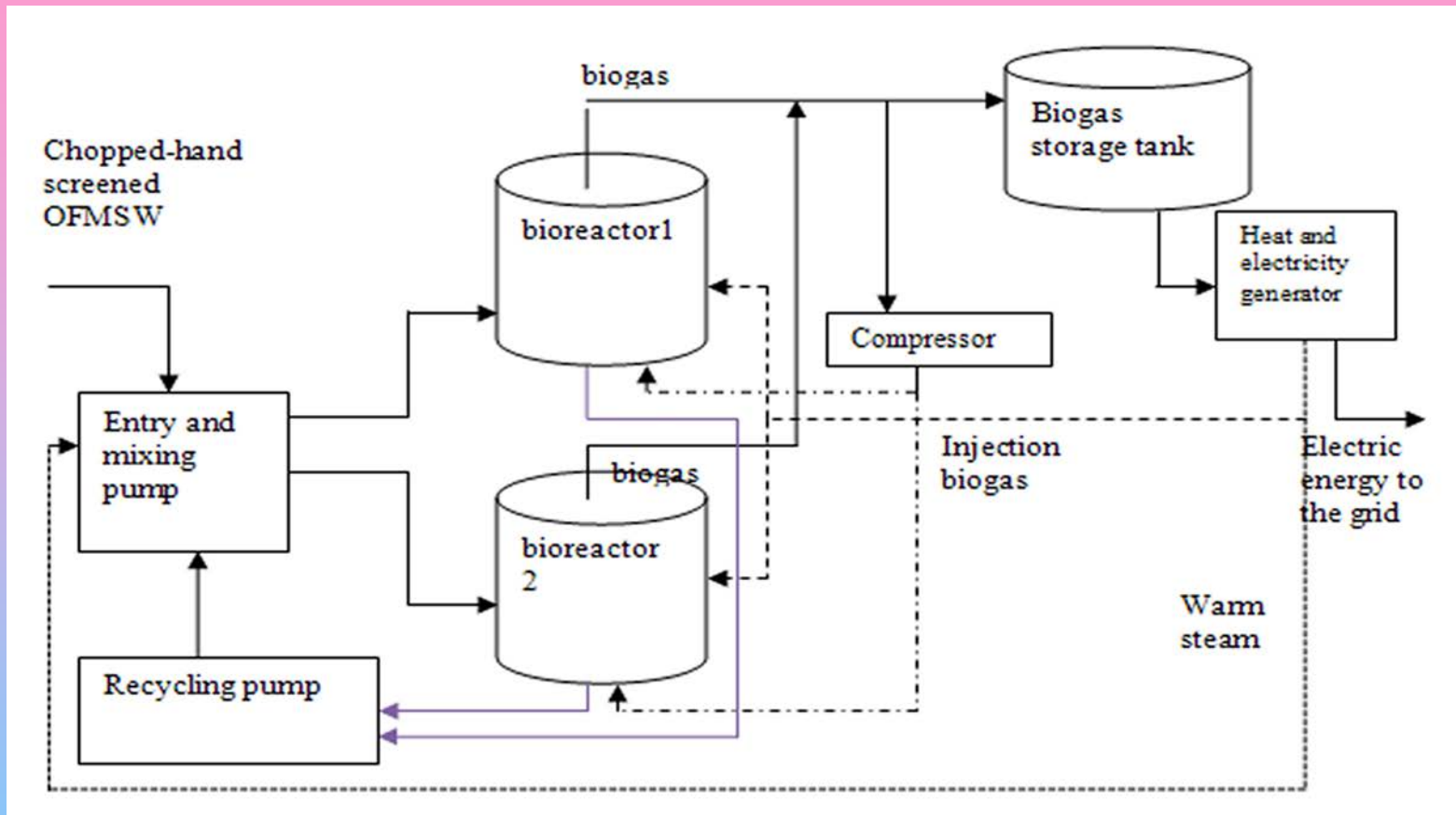
# The processing unit

## Case 1



pumps mixing of substrate and recycling of leachate, **one** dry substrate bioreactor, biogas storage tank, biogas compressor and a heat and electricity generator

## Case 2



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

# Assumptions

Parameters	Values
Unit capacity	36500 ton/y of fresh substrate of SS-OFSMW
Composition of SS-OFSMW	60-70% food waste with $d_{fw}=0.74\text{ton/m}^3$ and 40-30% garden waste with $d_{gw}=0.3\text{ton/m}^3$
Substrate concentration	33% TS VS=78% TS
Methane potential	$0.4\text{m}^3\text{CH}_4/\text{kgVS}_{in}$ (STP)
First order kinetic model with constant	$k=0.2-0.4\text{d}$
HRT	26d
Biogas methane content	56%
TS reactor	23-25%
$T_{\text{reactor}}$	35°C
Annual CHP operation hours	7500h/y
Methane value	10kWh/m <sup>3</sup>

# Results

<b>Technical characteristics</b>	<b>Case 1</b>	<b>Case 2</b>
Bioreactor capacity (m <sup>3</sup> )	3779	1889 (x2)
CHP power (MW)	2	



# Input-Output

Mass input (kg/d)	100000		
VS input (kg/d)	25740		
TS input (kg/d)	33000		
Biogas mass (kg/d)	20571		
Output mass (kg/d)	79429		
TS output (kg/d)	21417 (to compost)		
Biogas yield (average) (m <sup>3</sup> /kgVS <sub>in</sub> )	0.632		
Methane yield (average) (m <sup>3</sup> /kgVS <sub>in</sub> )	0.355		
CO <sub>2</sub> volume (m <sup>3</sup> /d) (STP)	7159		
Electric power efficiency (%)	35	Electric power (kWh/d)	31892
Heat value efficiency (%)	50	Heat (kWh/d)	45560
Απώλειες (Losses) %	15		

# Economical Aspects

	Case 1			Case 2		
Formulas	Tsilemou et al	Vallini et al	Greek data	Tsilemou et al	Vallini et al	Greek data
Investment cost (millions €)	13.4	13.1	9	14.8	14.3	11
Operational cost (€/ton)	36	-	32	40	-	37

# Discussion

- the climate of Attica is ideal for mesophilic application
- the choice of a first order kinetic model is simple and easy in application and used in the case of complex substrate like SS-OFMSW
- the use of two bioreactors, in Case 2, reduces the possibility of a total failure
- the mesophilic process can produce approximately 160m<sup>3</sup> of biogas per ton of fresh substrate (consistent with large-scale studies in Italy and Spain)
- assuming an average electricity consumption of 3-4MWh/y/household Athens the anaerobic digestion unit could supply almost 4000-3000 households in the Municipality of Athens. Or by treating the 9% of Athens waste an area of 9000 habitans (like a small island) can be annually supplied with electricity
- If electric energy is sold to the national grid then the annual profit of energy production will be around 2900000€/y (assuming a selling price of 0.25€/kWh)
- the pay back of the investment will be around 5-7 years.

# Conclusions

- a techno-economically study of a possible anaerobic digestion unit construction in Attica, (35600ton/y of fresh substrate of SS-OFSMW)
- 2 configurations are taken into consideration.
- the mesophilic process can produce approximately 160m<sup>3</sup> of biogas per ton of fresh substrate and generate 11641 MWhe/y.
- It will manage waste treatment problem and will produce a satisfactory amount of electric energy.

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