Implementation of Food Waste Management in Greek Municipalities under a Circular Economy Perspective

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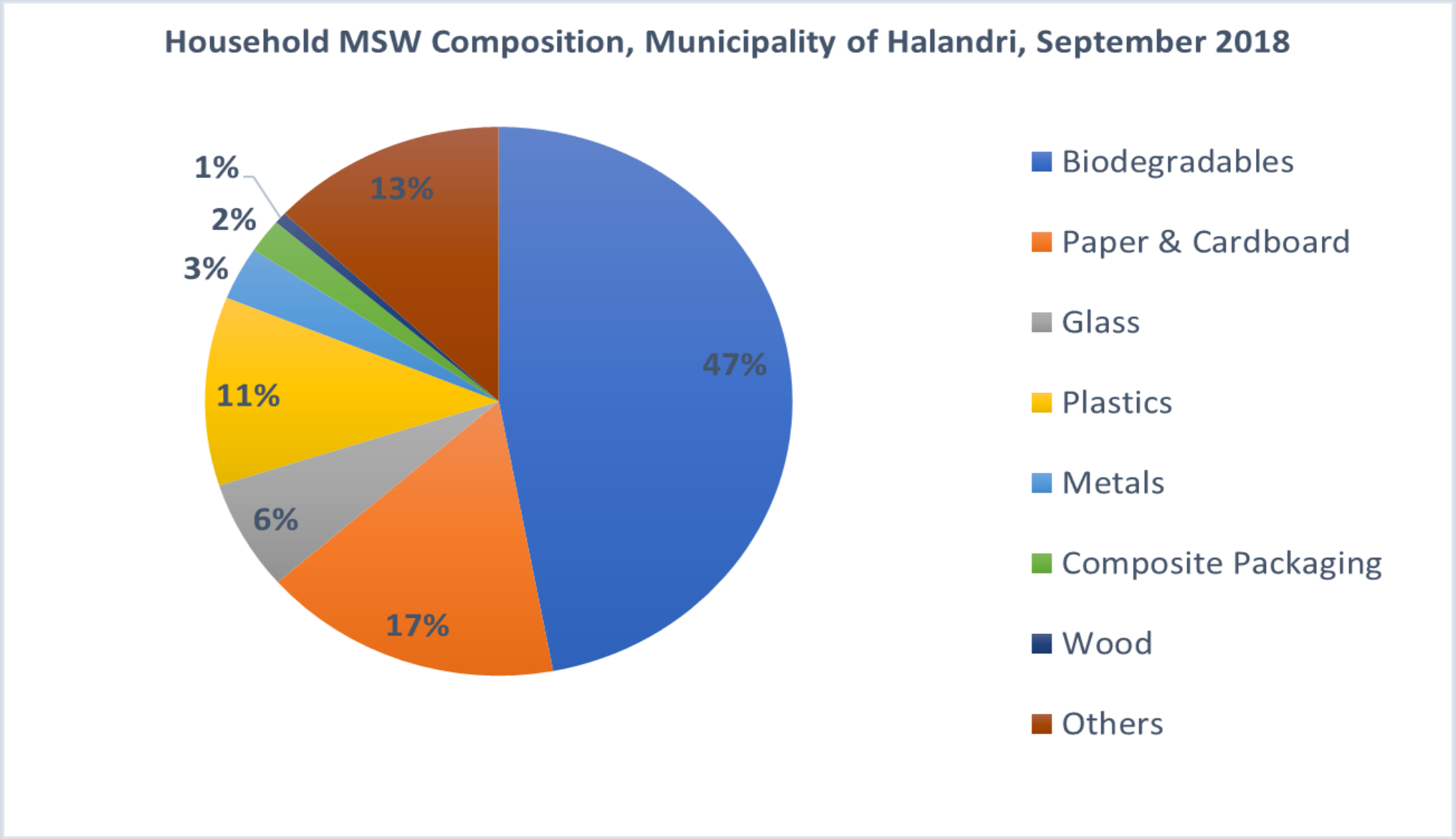
FOOD WASTE

- ✓ The biodegradable MSW corresponds to 30-50% of the total MSW generated
- ✓ Food waste is the biggest fraction of the biodegradable MSW
- ✓ In Europe, 88 million tons of food are wasted annually
- ✓ When food waste is landfilled it leads to increased GHG emissions
- ✓ Food Waste consists of materials rich in sugars, minerals, and proteins that could be used for other processes as substrates or raw materials.

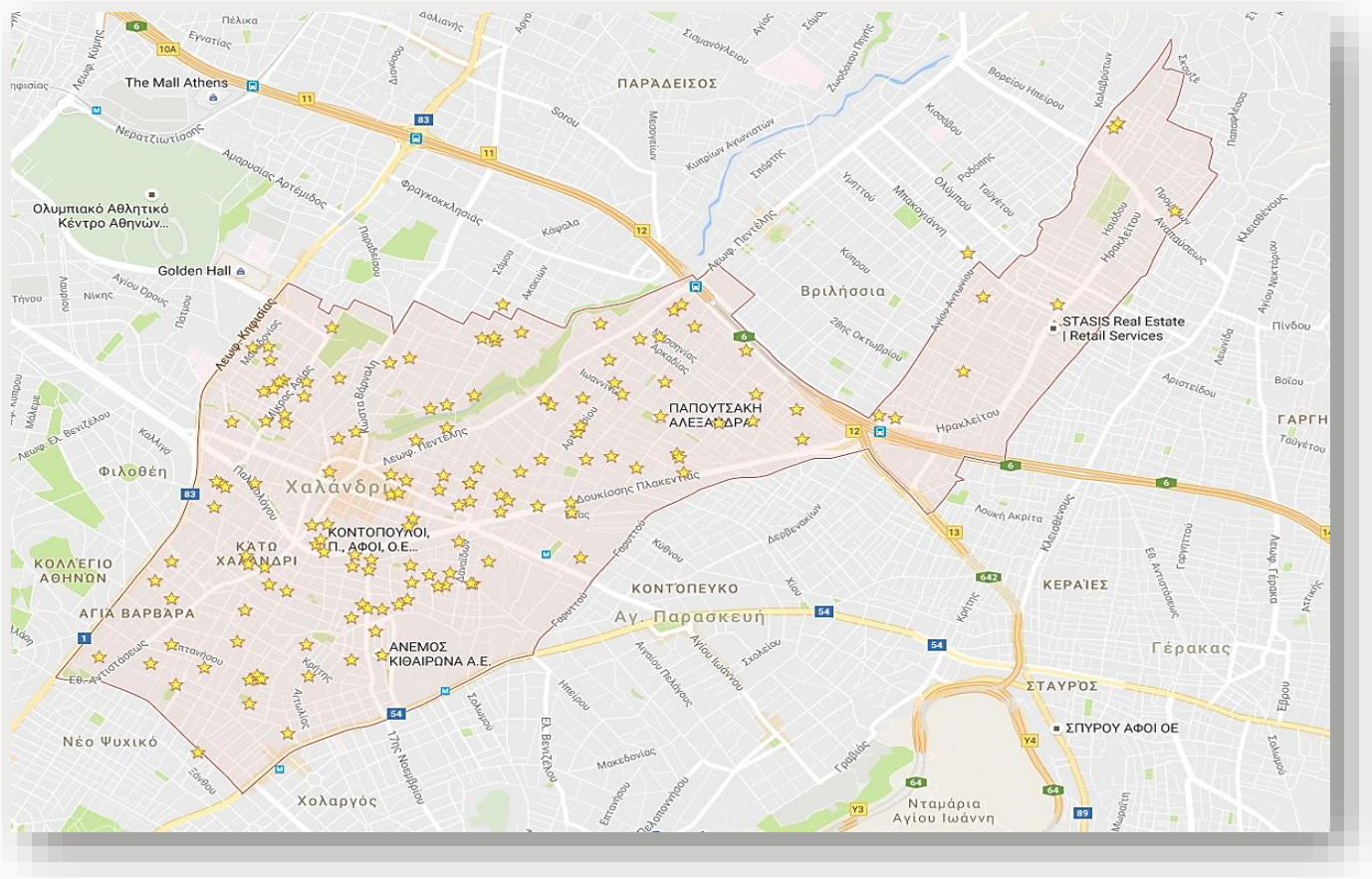
Municipal Waste composition



✓ In the framework of Waste4Think, a Horizon 2020 project, we have developed at pilot scale separate collection and valorization of Household Food Waste (HFW).

HALANDRI

250 households
800 citizens



citizens

Biodegradable Bags

30L bins

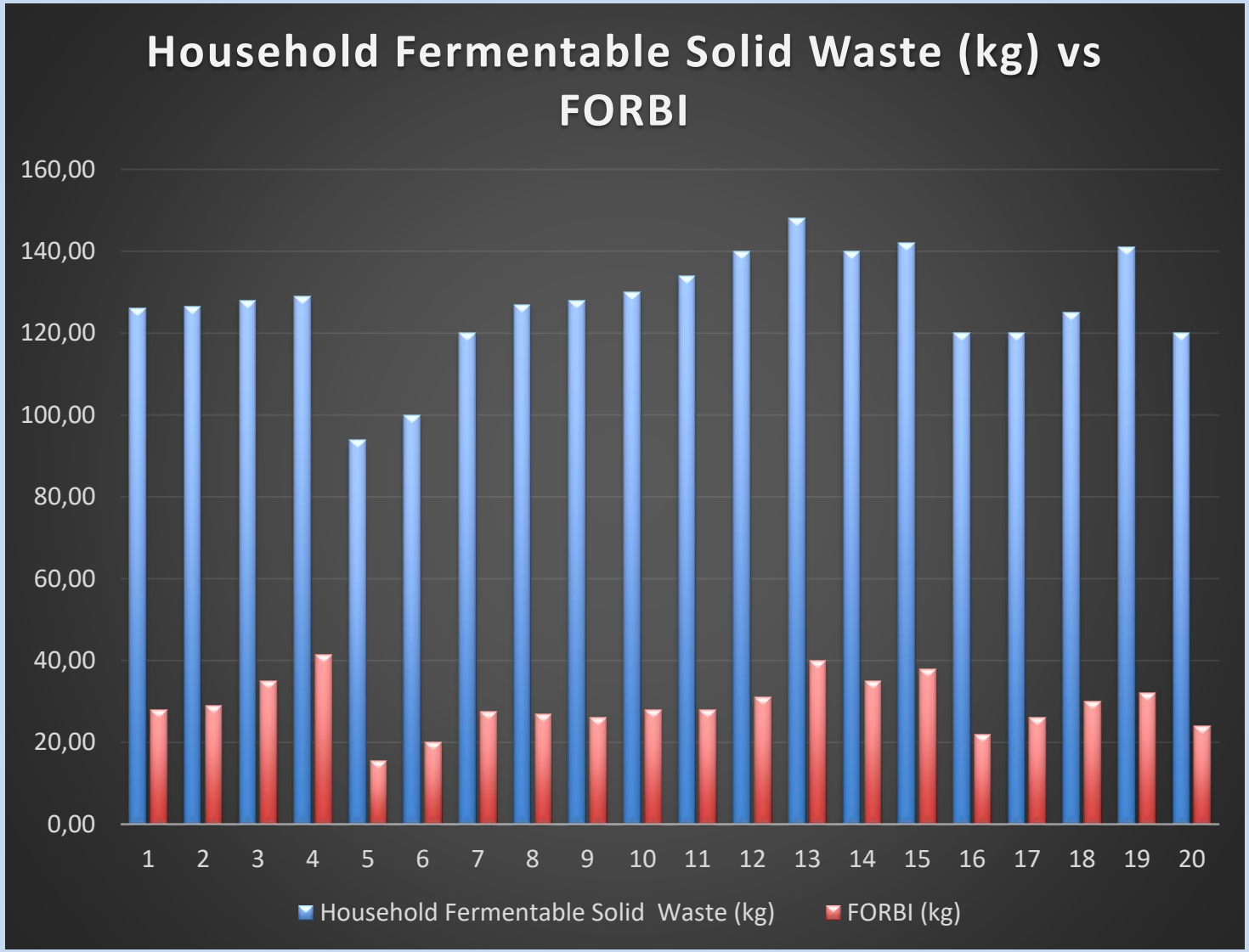
120L bins

Halandri's pilot drying and shredding unit

Dryer (92-98^{0}C)/shredder for the production of **FORBI** (Food Residue Biomass product).

FORBI (FOod Residue BIomass) advantages

- Has 1/4 to 1/5 the weight of biowaste, implying reduced transportation costs
- Has low-moisture and may be stored for prolonged periods of time without deterioration
- Is homogeneous
- Does not emit odors
- May be used for producing fuels, energy and other products



- Collection and treatment of HFW
- In 1 month collected 4021 kg HFW from 800 citizens.
- Produced 1006 kg of FORBI
- HFW weight reduced by **77%**

FORBI CHARACTERISTICS

Component	%, w/w, dry basis
Protein	13.7 ± 0.4
Lipids	12.3 ± 0.1
Extractives (mainly sugars)	27.3 ± 1.7
Starch	10.7 ± 0.1
Pectins	3.3 ± 0.8
Cellulose	10.3 ± 0.1
Hemicellulose	11.3 ± 0.2
Total lignin	6.8 ± 0.1
Ash	7.2 ± 0.3

FORBI valorization

1. Gaseous Biofuels (Methane, Hydrogen, Hythane)
2. Liquid Biofuels (Bioethanol)
3. Compost
4. Solid biofuels (pellets)
5. AF for the cement industry
6. Direct production of Electricity (microbial fuel cell technology)
7. Adsorbent
8. Animal Feed

HIGH TRL

Biogas

Alternative fuel for cement industry

Compost

FORBI valorization

1. **Gaseous Biofuels (Methane, Hydrogen, Hythane)**
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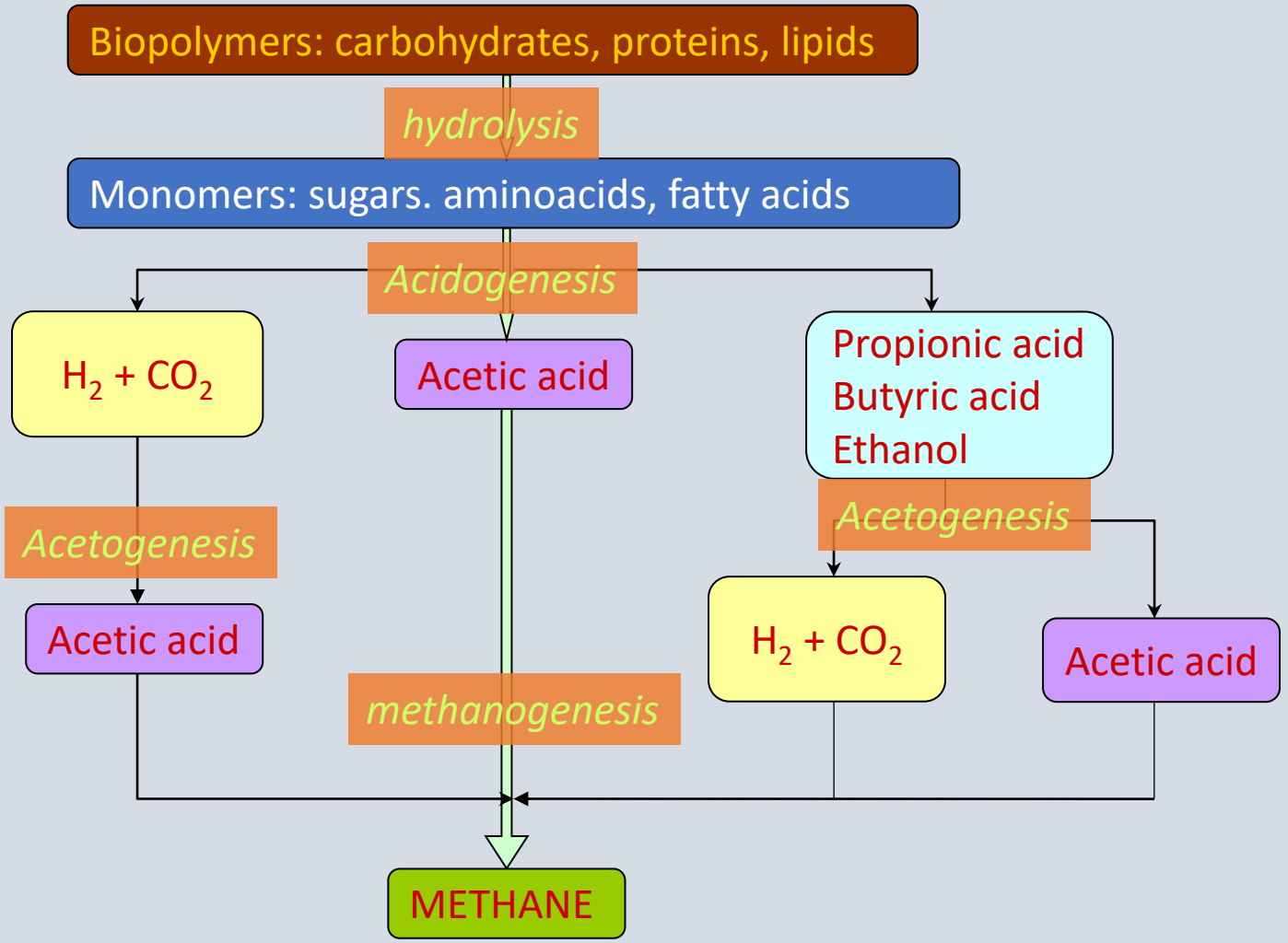
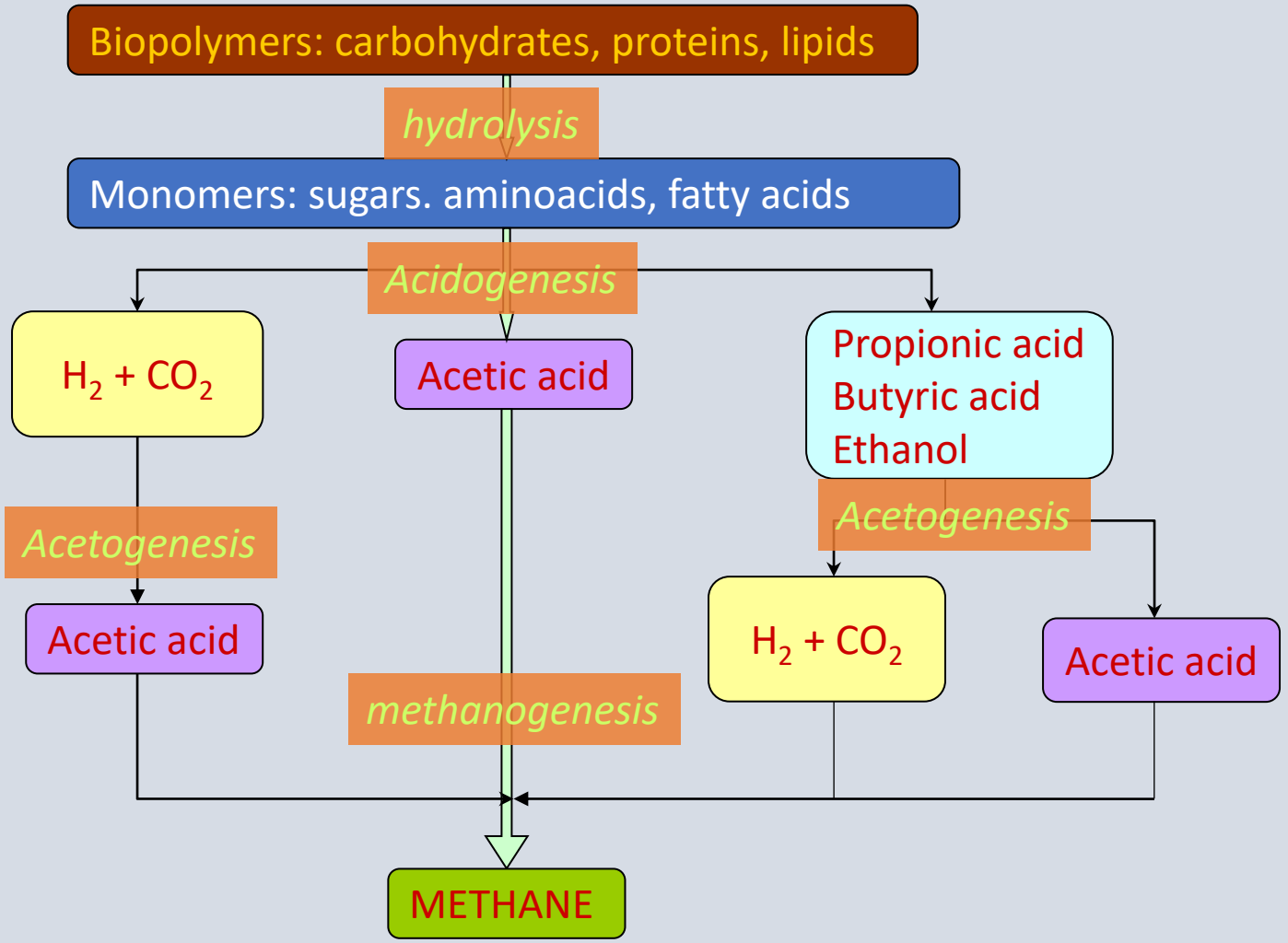
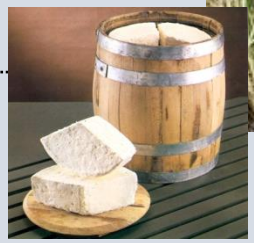
Anaerobic digestion



Fermentative hydrogen production





Why hydrogen ?

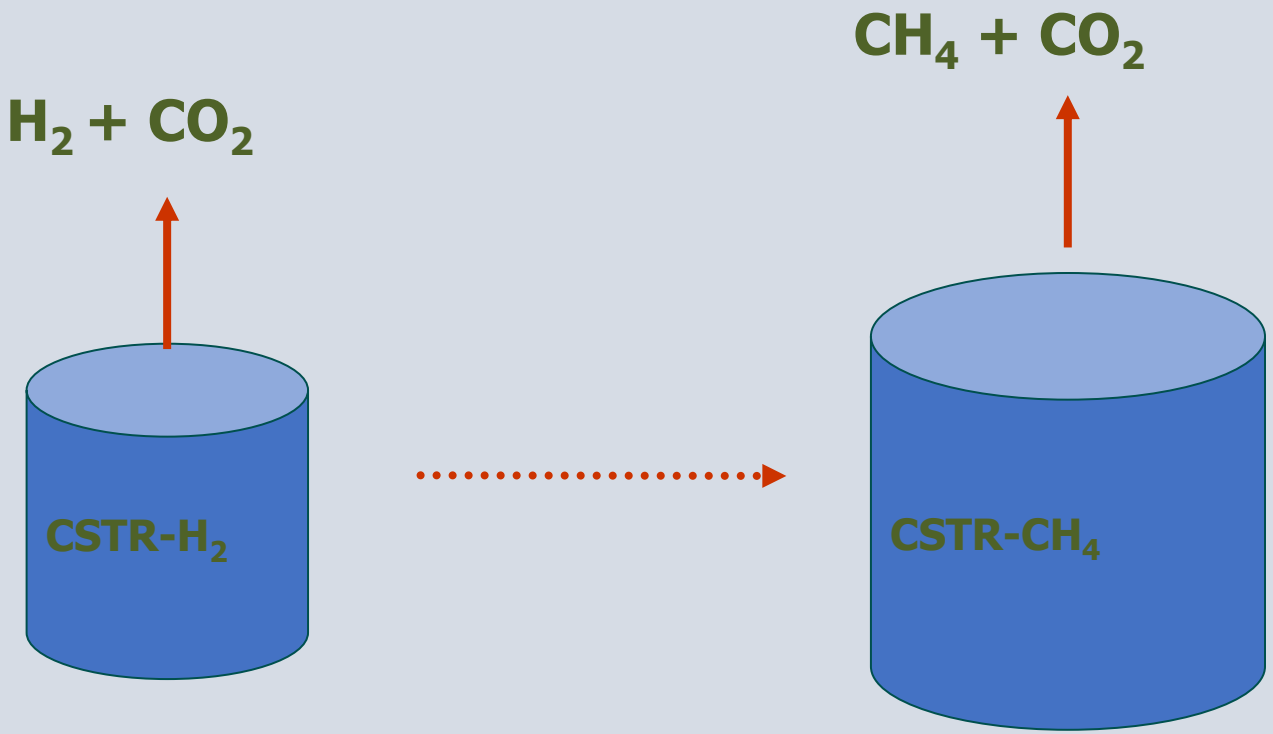
- A clean and environmentally friendly fuel which produces water instead of greenhouse gases, when burned
- Possesses a high-energy yield (142MJ/kg)
- Could be used to produce electricity through fuel cells

Parameters affecting fermentative hydrogen production

- pH
- H_2 partial pressure
- Hydraulic Retention Time (HRT)
- Temperature
- Nutrients concentration
- Initial carbohydrates concentration
- Organic loading

Production of HYTHANE

- Two-stage process for the production of methane and hydrogen
- Contains 10-15% hydrogen
- Superior engine performance as a gaseous fuel



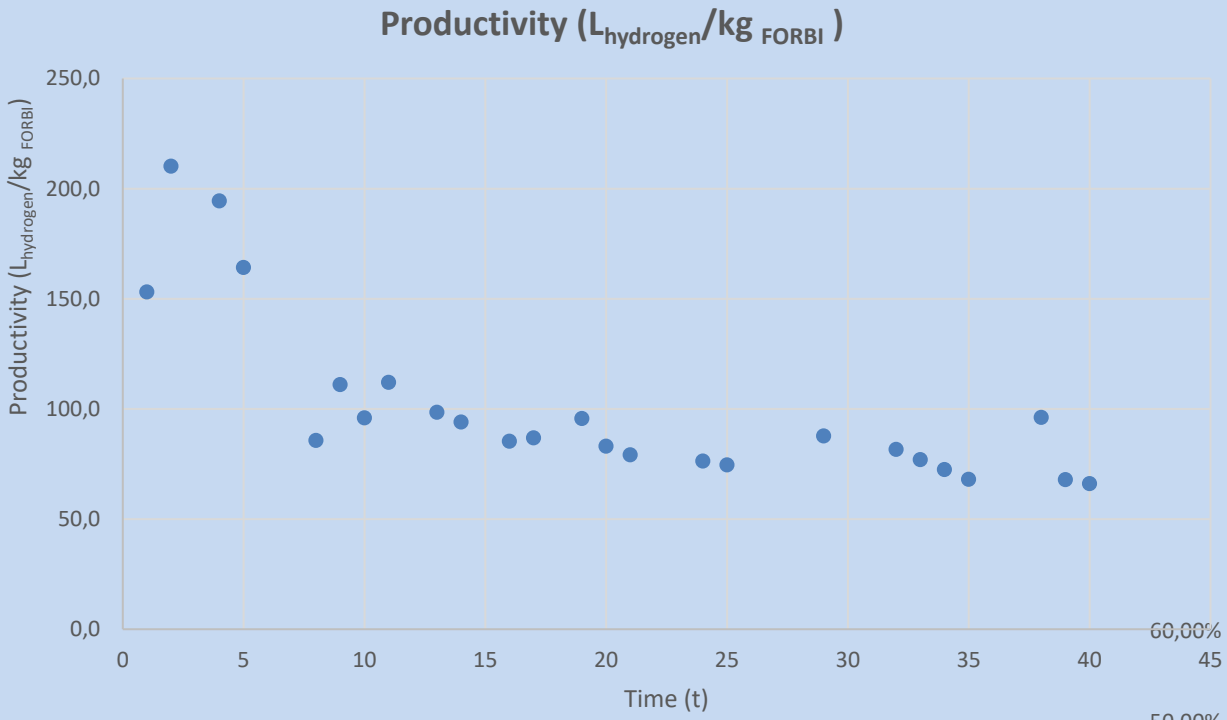
GASEOUS BIOFUELS PRODUCTION (BIOHYDROGEN)

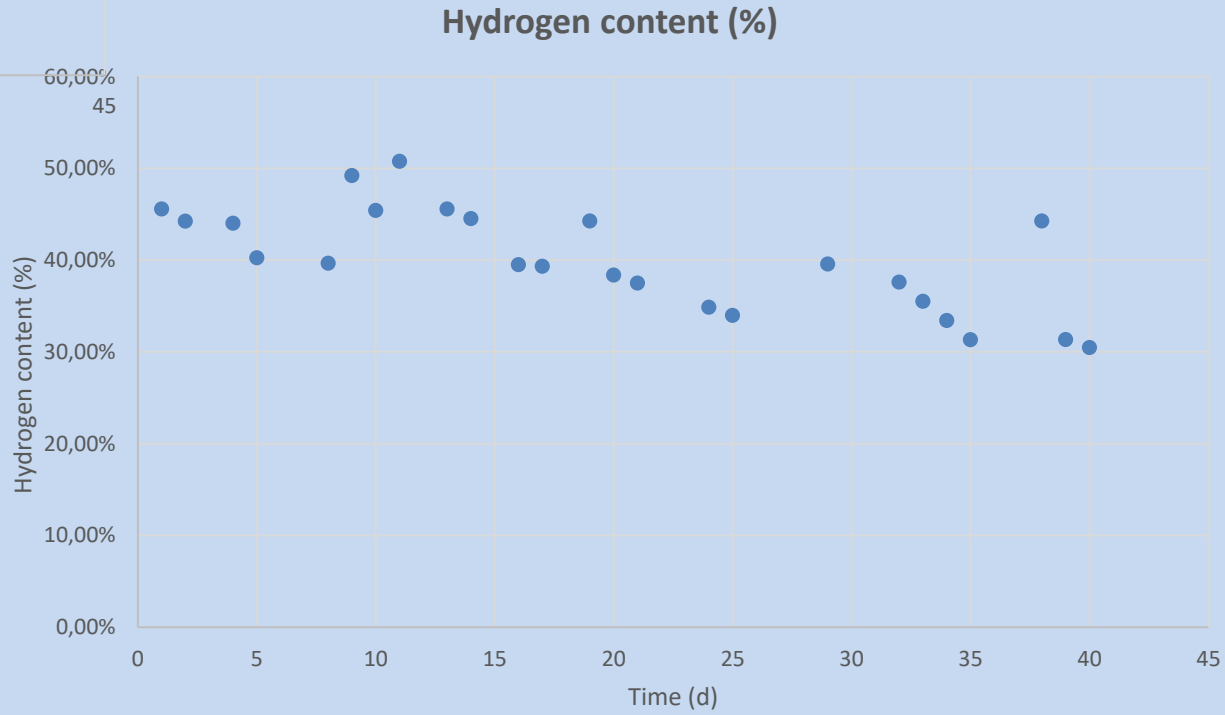
-500 L CSTR acidogenic reactor

-Thermophilic conditions (50^{o}C)

-HRT 5d

-40g FORBI/L feed as a suspension.





-biogas average productivity: 585 L/d

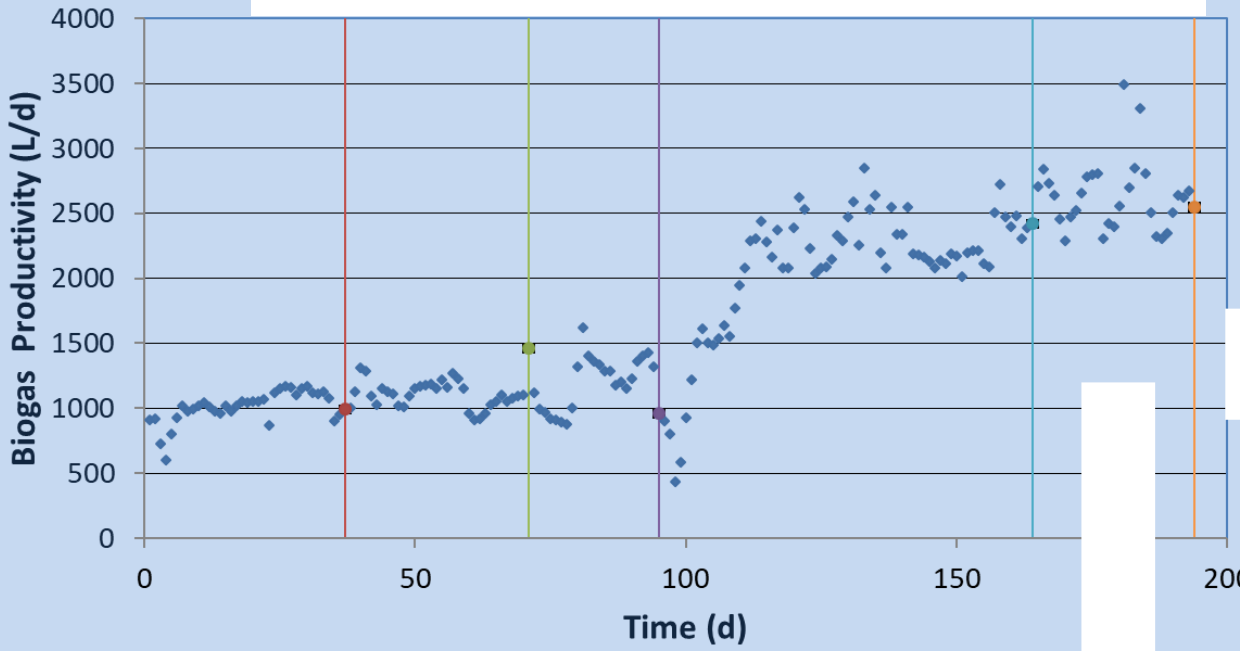
-hydrogen yield: 110L $_{hydrogen}$/kg $_{FORBI}$

-average hydrogen content: 40%.

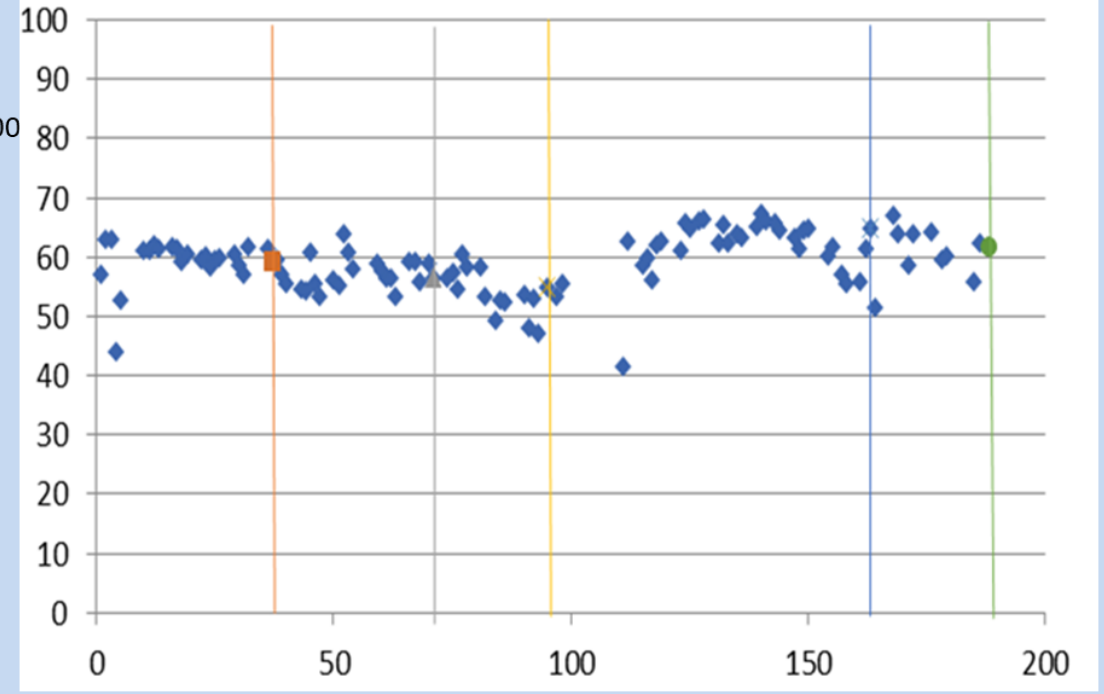
BIOMETHANE

- Methanogenic Reactor (4m^3)
- Mesophilic conditions (35-40^oC)
- HRT 40 d
- Feed 15g FORBI/L

Biogas productivity



Biomethane produced (%)

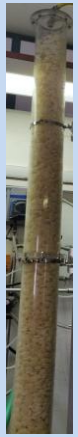


-Biogas productivity 2,5 m^3 /d

-Methane yield 492 L/kg FORBI

-Methane content 65%.

Biogas upgrade and conversion to bioCNG
The upgraded biogas contained almost 99% CH_4 and <4ppm H_2S.



CO_2

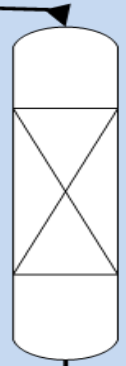
Amine Scrubber

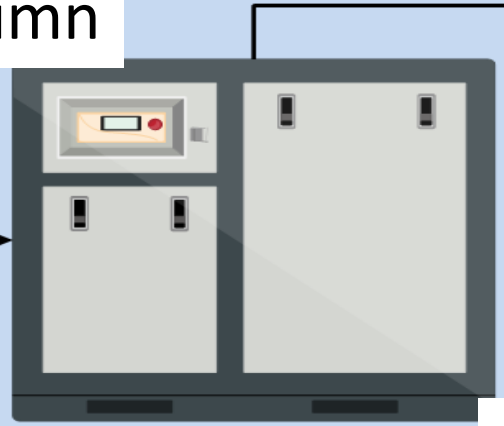
Stripper

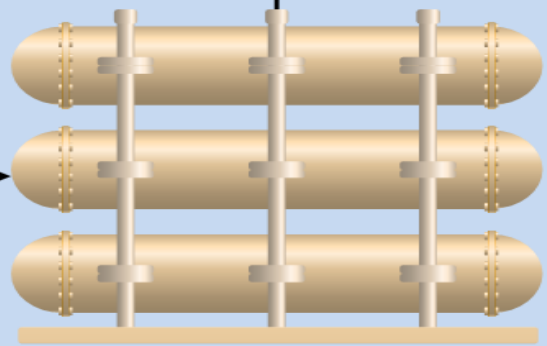
0,27 kg bioCNG per kg of FORBI!

Silica column

Floating gasholder







Buffer tanks

Compressor

Raw biogas


WASTE
4think

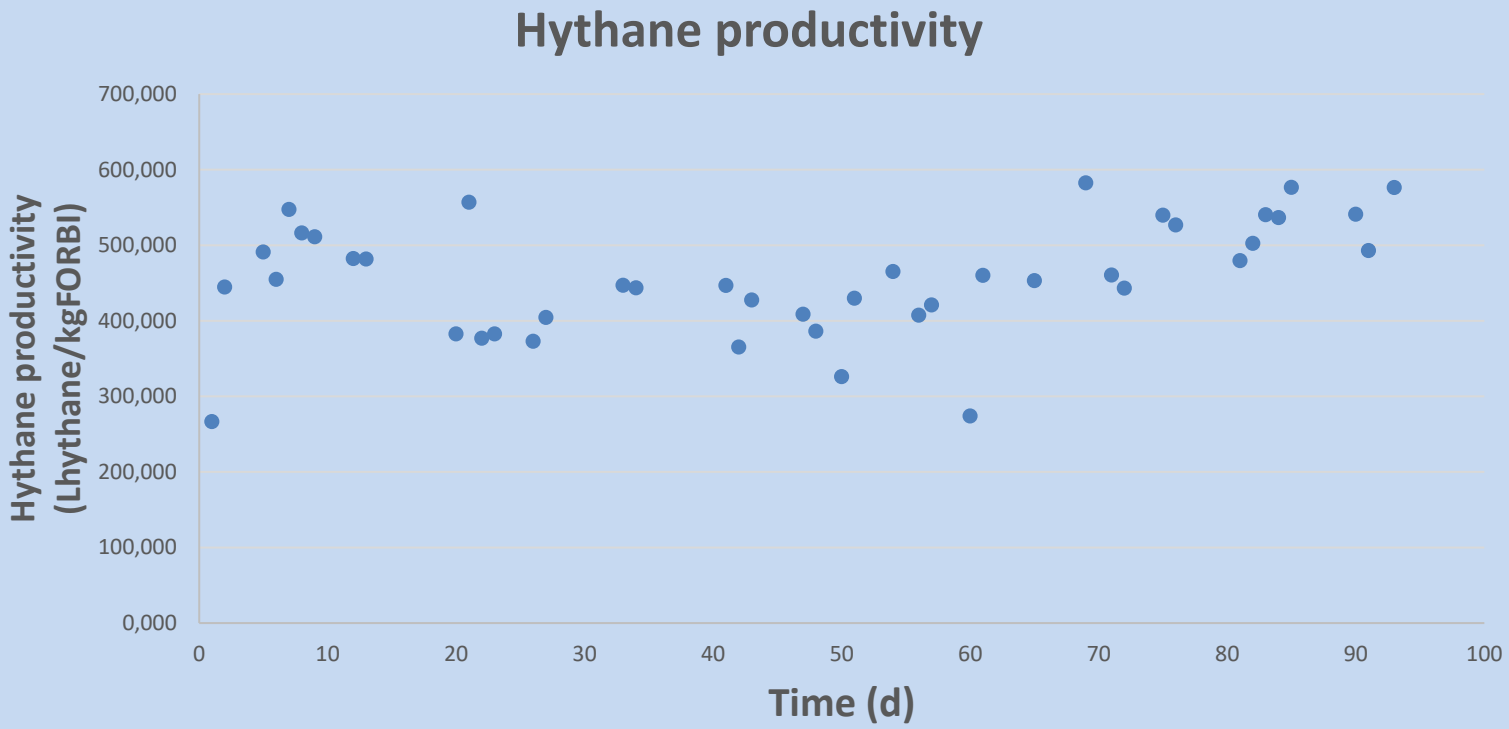

WASTE
4think

Circular economy

Alternative potential uses of biogas

- bioCNG production
- In a combined heat and power process (CHP)
- Injected into the natural gas network

bioCNG production from HYTHANE pilot scale



- **Biogas productivity 3 m^3 /d**
- **550 L HYTHANE/kg FORBI**
- **10% hydrogen/90%methane**

FORBI valorization

1. Gaseous Biofuels (Methane, Hydrogen, Hythane)
2. **Compost**
3. AF for the cement industry

Compost production from FORBI and prunings

A pilot-scale (4 tons) windrow composting process was carried out, by using FORBI and prunings (1:1) as feedstock.

Main characteristics of compost

pH	9.3
Moisture %	13.6
Organic matter%	64.8
Nitrogen %	2.6
Phosphorus %	0.7
Potassium %	1.8
E. Coli (cfu/g)	<10
Salmonella σε 25 g	ND
Faecal coliforms	<10
Enterobacteriaceae (cfu/g)	<10

- Good N:P:K ratio
- Rich in organic matter

Distribution of packaged compost produced from the municipal household food waste and green waste in Halandri

FORBI valorization

1. Gaseous Biofuels (Methane, Hydrogen, Hythane)
2. Compost
3. **AF for the cement industry**

Use of FORBI as an alternative fuel for the cement industry

- The replacement of fossil fuels in the cement industry leads to:
  - Reduction of energy cost
  - Saving of natural resources
  - Reduction of CO_2 emissions
- **Examples of alternative fuels**:

  Automotive tires, used oils, sludge, refinery sludge, meat meal, agricultural residues, RDF (urban waste fuel), SRF (industrial waste fuel)

Use of FORBI as an alternative fuel for the cement industry

EN 15359 classification

Property	Unit	Class				
		1	2	3	4	5
NCV	MJ/Kg	≥25	≥20	≥15	≥10	≥3
Cl	%weight (dry basis)	≤0,2	≤0,6	≤1,0	≤1,5	≤3
Hg	mg/MJ	≤0,02 ≤0,04	≤0,03 ≤0,06	≤0,08 ≤0,16	≤0,15 ≤0,30	≤0,50 ≤1,00

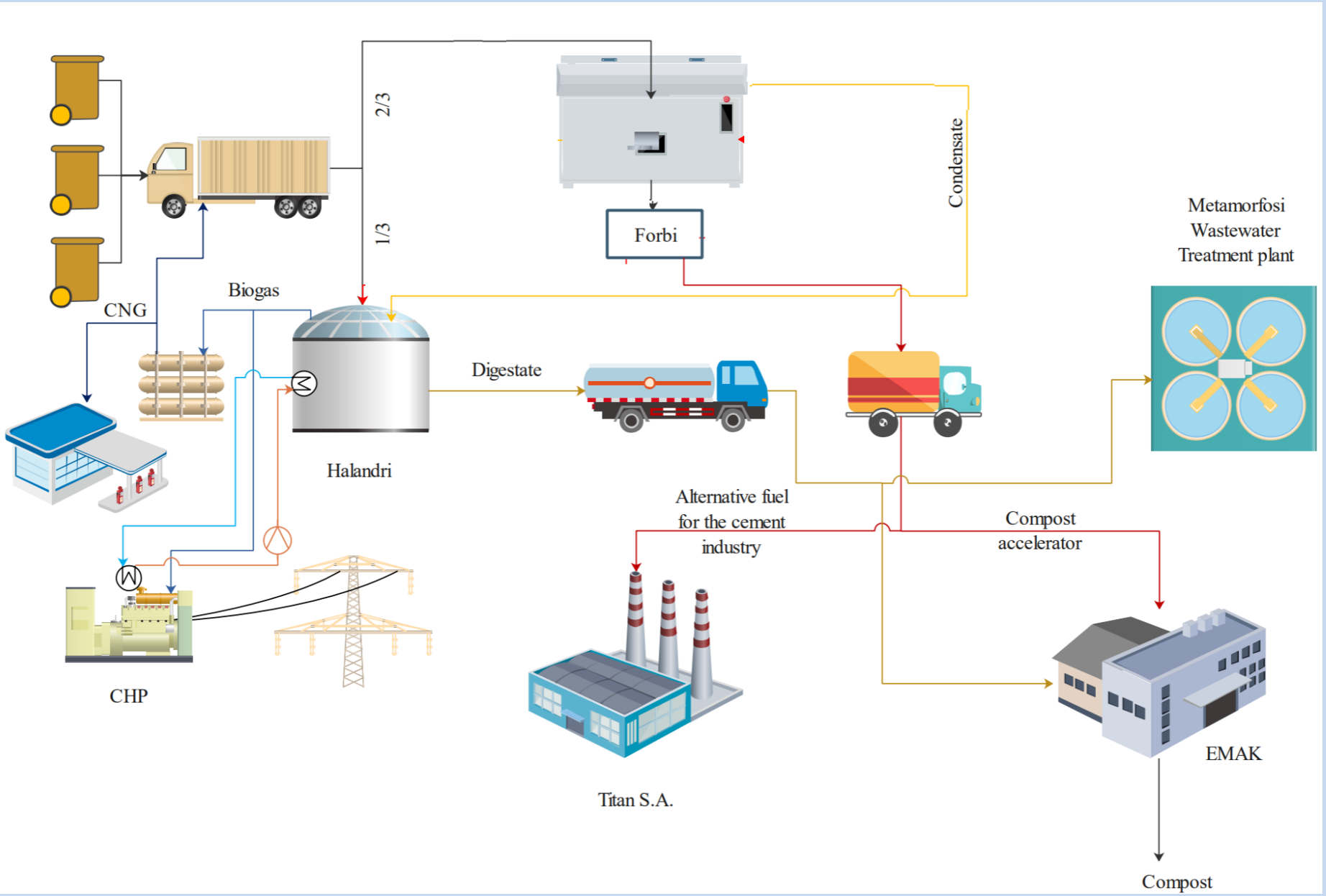
- Class 3 NCV (18MJ/Kg)
- Class 2 Cl d.m. (0,5%b.w.)
- Class 1 Hg (0,006mg/MJ)

- **FORBI may be used as is as an AF for the cement industry!**

Testing of FORBI in TITAN cement industry

- 8,3 tons of FORBI stored over a period of 3 years were used.
- The material was very well preserved and had no undesirable odors.
- The material was found to be excellent from an operational point of view.

Plant with capacity 30 tons/d



7 tons/d FORBI
- Compost enhancer
- Alternative fuel

- 210 kWh/d thermal energy
- 333 kg/d bioCNG

Revenues
250,000 €/ year

Savings from gate fees
and fuels 650,000 €/ year

Overall economic benefit
900,000 €/ year !

ENI CBCMED
Cooperating across borders in the Mediterranean

Project funded by the EUROPEAN UNION

REGIONE AUTÒNOMA DE SARDIGNA
REGIONE AUTONOMA DELLA SARDEGNA

SIRCLES

SIRCLES

Supporting Circular Economy Opportunities for Employment and Social Inclusion

Spain | Greece | Palestine | Jordan | Lebanon | Tunisia | Italy

SIRCLES GOAL

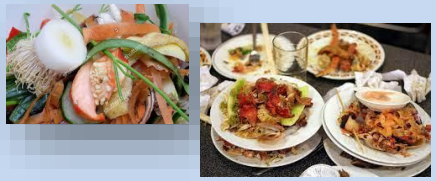
- To develop new ways of managing biowaste collected at the source, treatment , composting and use in agriculture
- To create job opportunities and promote social inclusion through the participation in a circular economy model
- NEETs and women are given priority

*"Not in Education, Employment, or Training"

Andros, Greece composting pilot plant

Korthi wastewater treatment plant

SIRCLES Project - Andros



HORECA,shops,citizens

Biodegradable bags

60L/120L bins

SIRCLES training

19 NEETS and women were trained and worked for a few months in the composting facility

Training included:

- Theory of composting
- Practical training
- Introduction to enterpreneurship

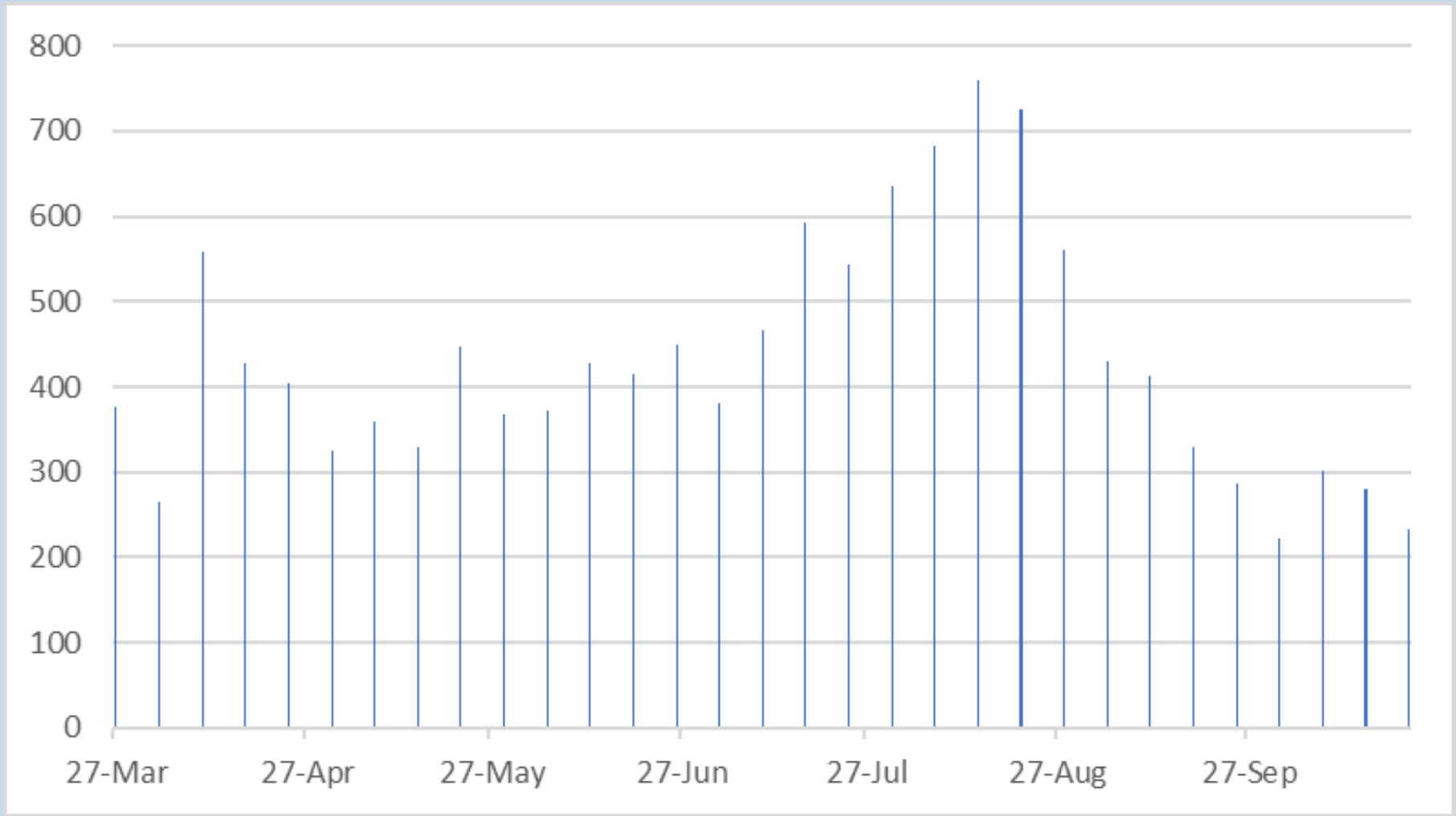

THIS SITE HAS BEEN REHABILITATED UNDER
ENI CBCMED
SIRCLES
Implemented by
ΥΛΟΠΟΙΗΣΗ
National Technical University of Athens
EARTH


2023/2/10 20:00


SIRCLES
SIRCLES
Στις σακούλες
συλλέγονται
δεν συλλέγονται

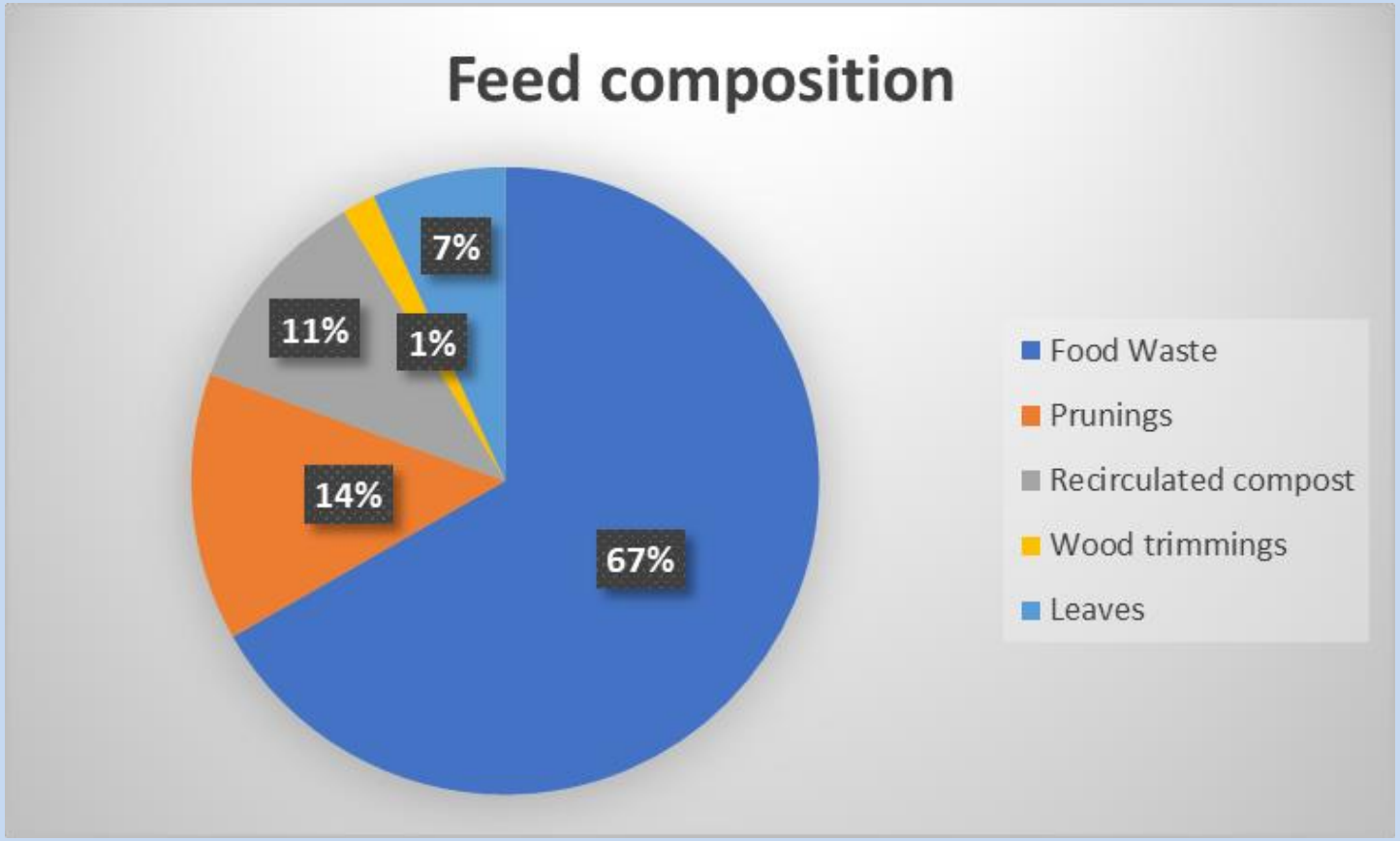

SARTORI AMBIENTE

Weekly collection (kg)

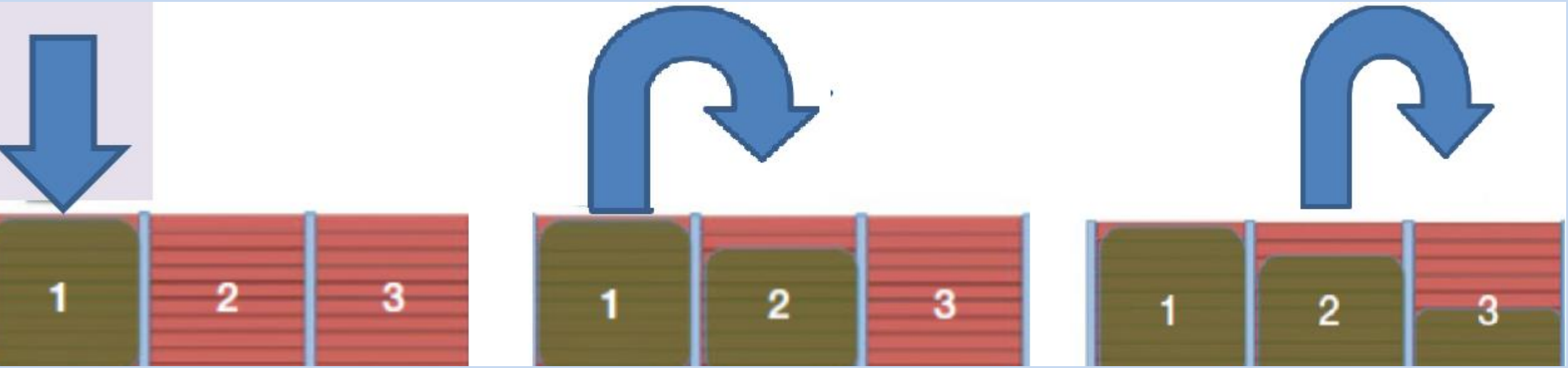


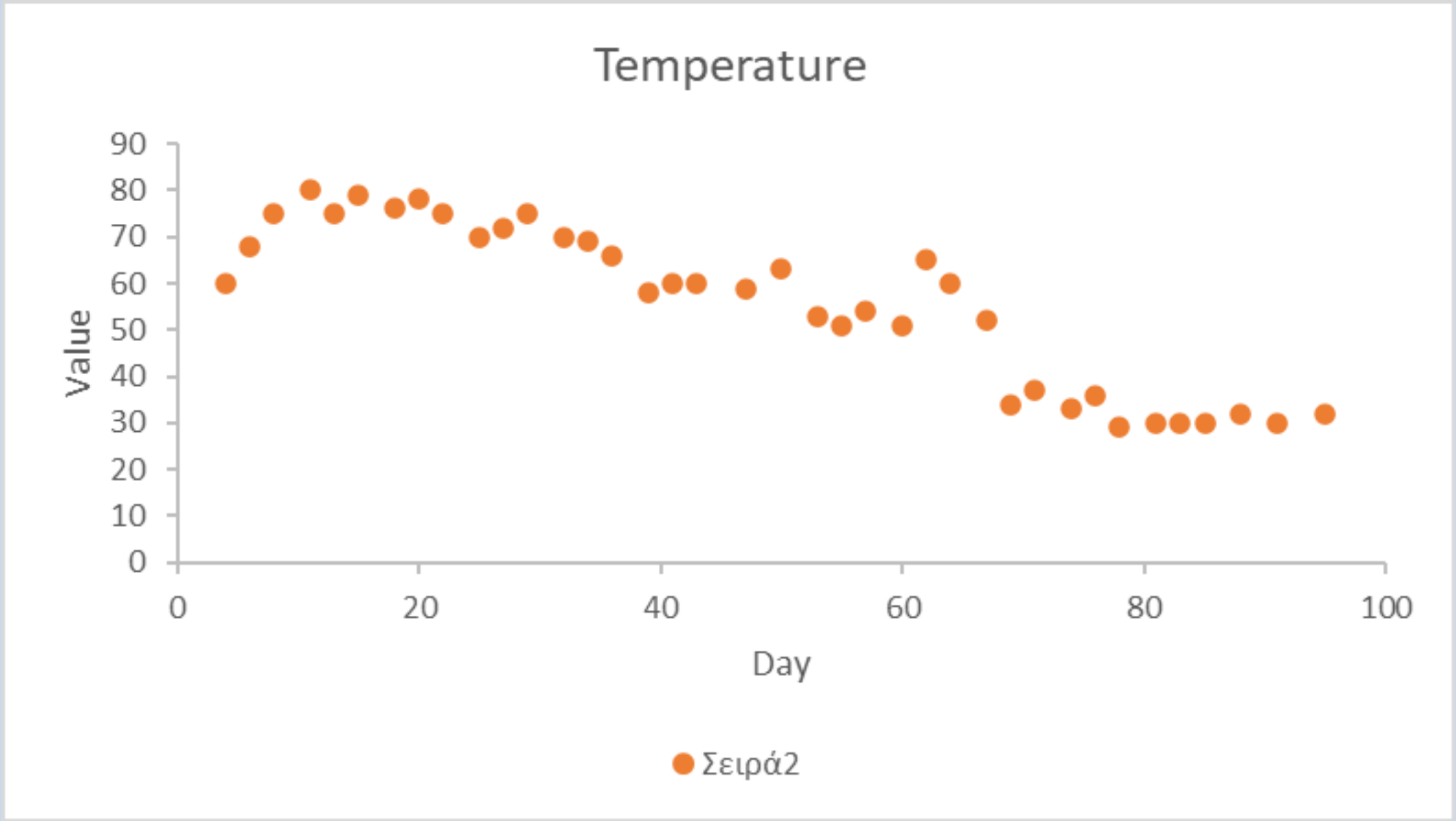
Prunings shredding

In 7 months the unit received 13.5 tons of biowaste
5 tons of compost have already been produced



Treatment


1
2
3
1
2
3
1
2
3


Temperature
Value
90
80
70
60
50
40
30
20
10
0
0
20
40
60
80
100
Day
Σειρά2

Sieving and bagging, characterization

pH	8
Moisture %	6,9
Electrical conductivity (ms/cm)	6
Organic matter%	70,9
Ash	22,2
Organic Carbon%	39,7
Nitrogen %	2,6
C/N Ratio	15,3
Phosphorus %	0,88
Potassium %	1,2
Calcium	8,4
Magnesium	0,43
E. Coli (cfu/g)	<10
Salmonella σε 25 g	Not Detected
Faecal coliforms	<10
Germination Index	80

Application of compost

CONCLUSION

Food waste is a valuable resource and if managed properly it may become an important resource for energy, biofuels and valuable products such as compost, instead of being a nuisance!

Thank you for your attention!!!!