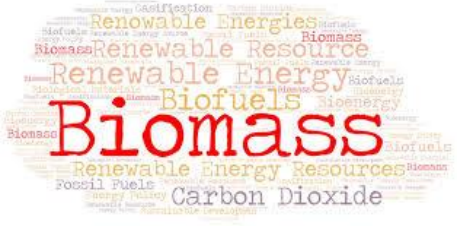
National Technical University of Athens
School of Chemical Engineering
Unit of Environmental Science & Technology

Municipal biowaste: The way forward and the role of local authorities



Maria Loizidou

NTUA Professor

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9th International Conference on Sustainable Solid Waste Management, 15-18 June 2022, Corfu, Greece

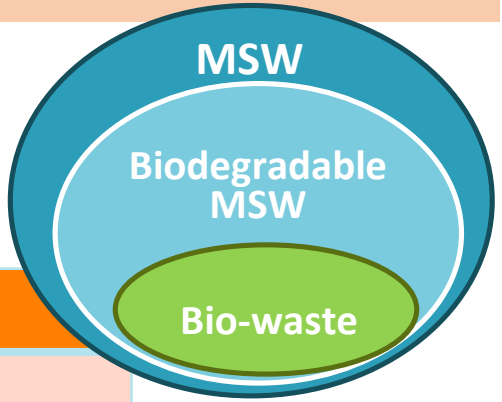
Biowaste

It includes:

- ✓ biodegradable garden and park waste
- ✓ food and kitchen waste from households, restaurants, caterers and retail premises, and
- ✓ comparable waste from food processing plants.

It does **NOT** include:

- ✗ forestry or agricultural residues,
- ✗ manure,
- ✗ sewage sludge, or
- ✗ other biodegradable waste (e.g. natural textiles, paper or processed wood).



European Waste Catalogue	
Description	**EWC Code**
Biodegradable kitchen and canteen waste	20 01 08
Waste from markets	20 03 02
Biodegradable garden and park wastes	20 02 01

Food waste

Every step of the food chain uses resources and generates more waste & pollution

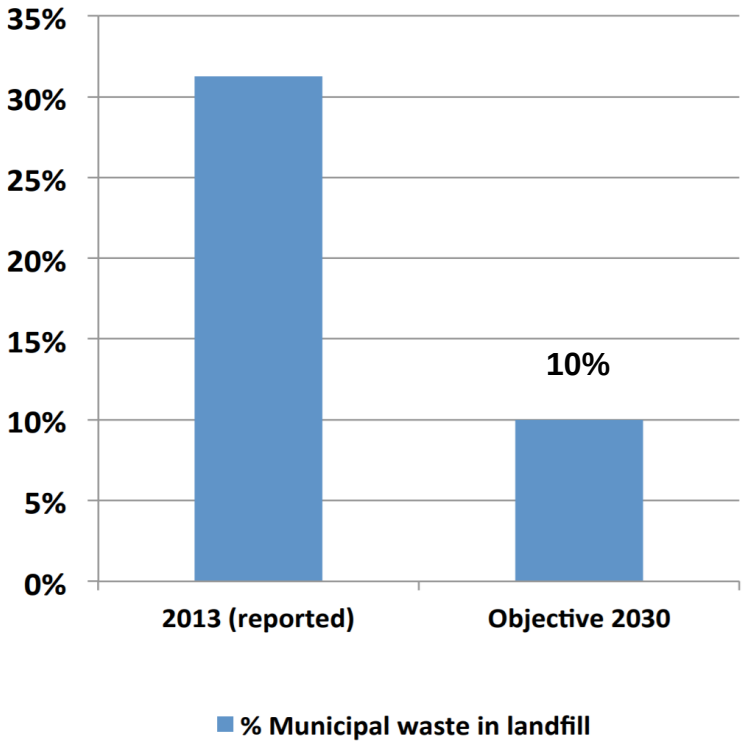
DEVELOPING ECONOMIES WASTE 40% OF FOOD DURING THE **FIRST** TWO STEPS OF THE VALUE CHAIN

- Poor harvesting techniques
- Poor storage facilities
- Poor transportation infrastructure

DEVELOPED ECONOMIES WASTE 40% OF FOOD DURING THE **LAST** TWO STEPS OF THE VALUE CHAIN

- Retailers encourage over consumption
- Stores and markets throw away food in good condition
- Consumers buy and cook more than needed

EU LEGISLATION REVISION
New targets for MSW landfilling



- Member States should reduce MSW ending at landfills to **10%** until **2030.**
- Bio-waste separate collection

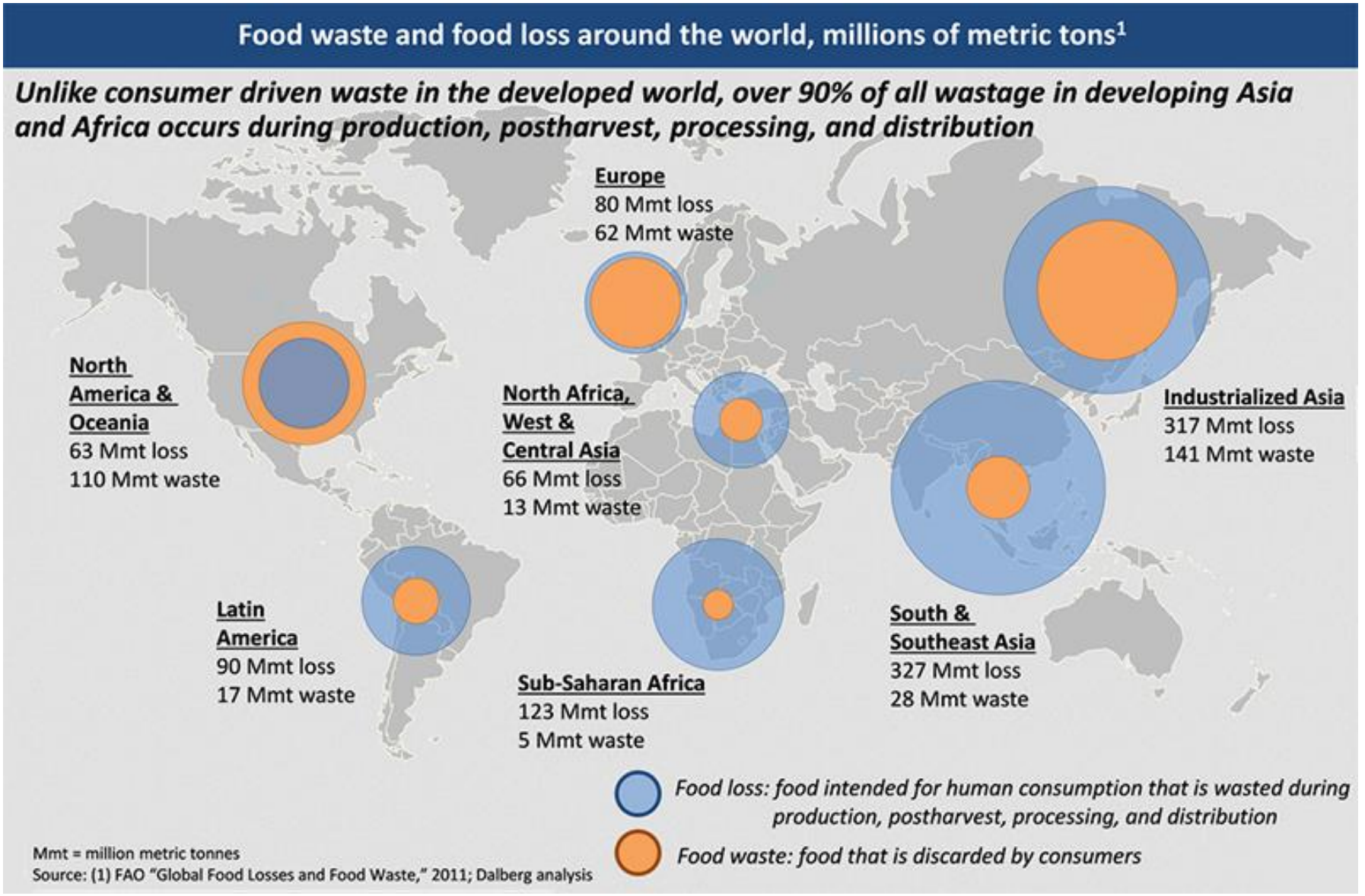
Member States should reduce food waste:
by **30%** until **2025** &
by **50%** until **2030.**

Food waste as a problem in the world

GLOBALLY:

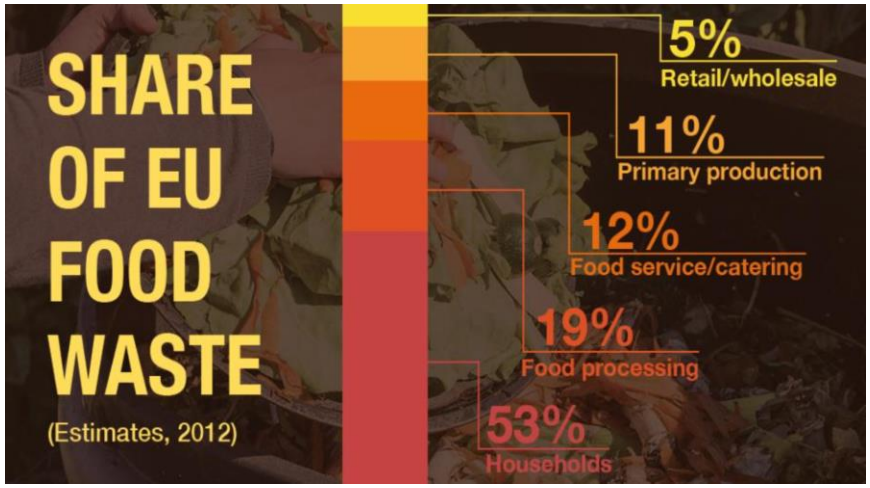
- Every year **1/3 of the world production** of food ends up in the trash
- **1.3 billion tons** of food still perfectly edible are lost or wasted, enough to **feed 3 billion people**
- **3.3 Giga-tonnes of GHG emissions** is the carbon footprint of FW (8% of global GHG emissions)
- **3 times the water volume of Lake Geneva** is used to produce food that is lost/wasted
- **30% of world's agricultural land** is occupied to produce food that is never consumed

- **Increase in food prices**: The more food we waste, the higher the demand on the global market, which drives up prices.


Food waste and food loss around the world, millions of metric tons[1]
Unlike consumer driven waste in the developed world, over 90% of all wastage in developing Asia and Africa occurs during production, postharvest, processing, and distribution
Europe
80 Mmt loss
62 Mmt waste
North America & Oceania
63 Mmt loss
110 Mmt waste
North Africa, West & Central Asia
66 Mmt loss
13 Mmt waste
Industrialized Asia
317 Mmt loss
141 Mmt waste
Latin America
90 Mmt loss
17 Mmt waste
Sub-Saharan Africa
123 Mmt loss
5 Mmt waste
South & Southeast Asia
327 Mmt loss
28 Mmt waste
Food loss: food intended for human consumption that is wasted during production, postharvest, processing, and distribution
Food waste: food that is discarded by consumers
Mmt = million metric tonnes
Source: (1) FAO "Global Food Losses and Food Waste," 2011; Dalberg analysis

Food waste as a problem in EU

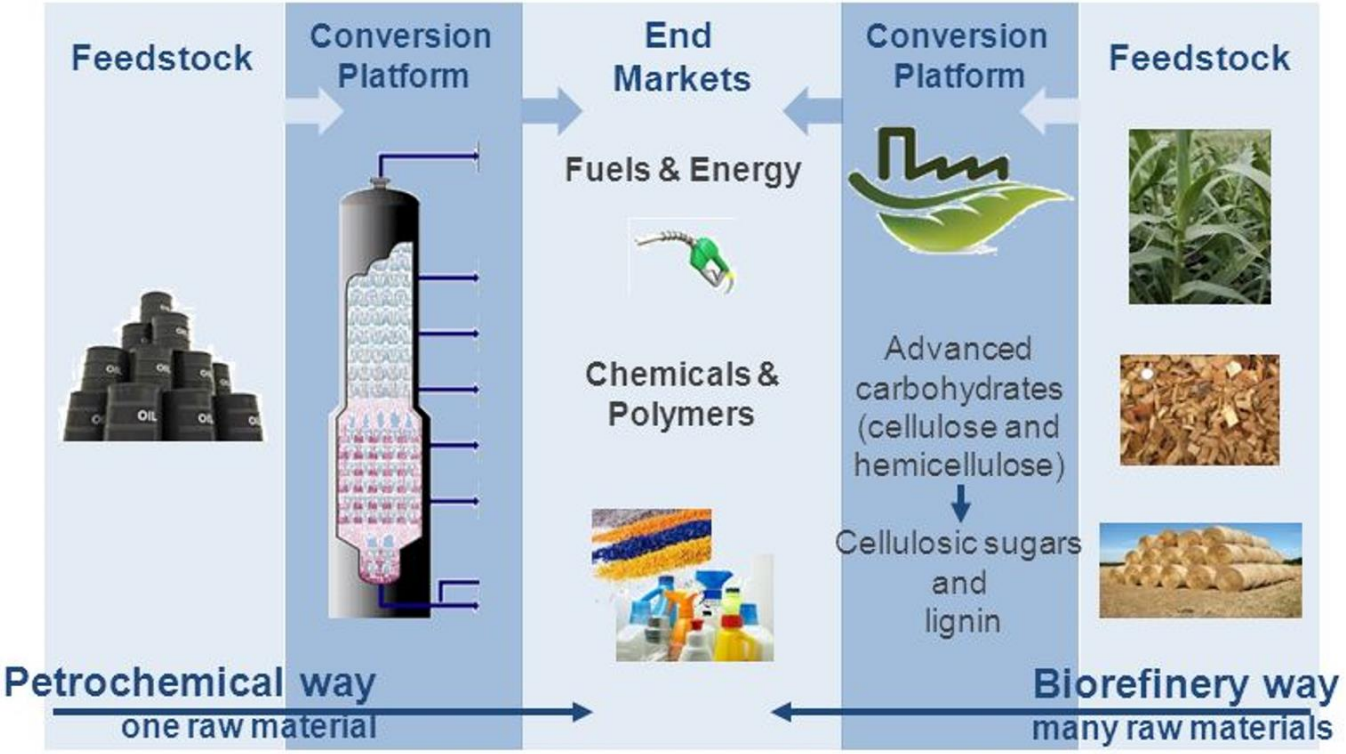
IN EUROPE:



- **53% of EU FW** comes from households: OUR OWN kitchen is the guilty!

- Every year **88 million tonnes of food (or 173 kg FW per person per year)** ends up in the trash – **could feed 200 million people.**
- **20% of EU food production is lost or wasted**
- **170 Million tonnes of CO_2 emissions** emitted from production and disposal of EU food waste
- **143 billion euros** related costs (**almost 600 €** per year per household)

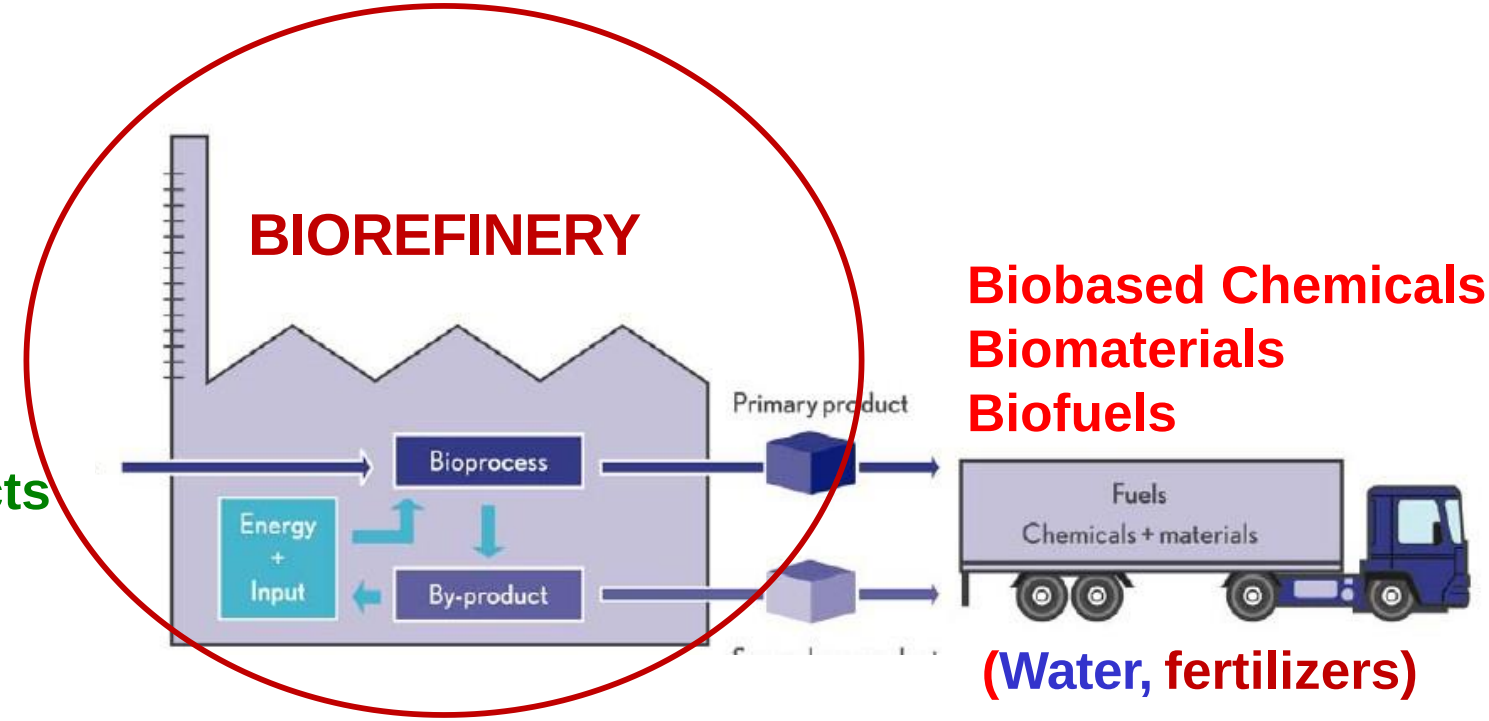
Biorefinery to valorize biowaste:
the alternative concept to petroleum-based processes and products



Biorefinery:
Is the alternative concept to today's fuel-based refineries which produces fuels, chemicals, energy etc. from biomass-based materials

Biowaste Biorefinery

Organic Byproducts & waste



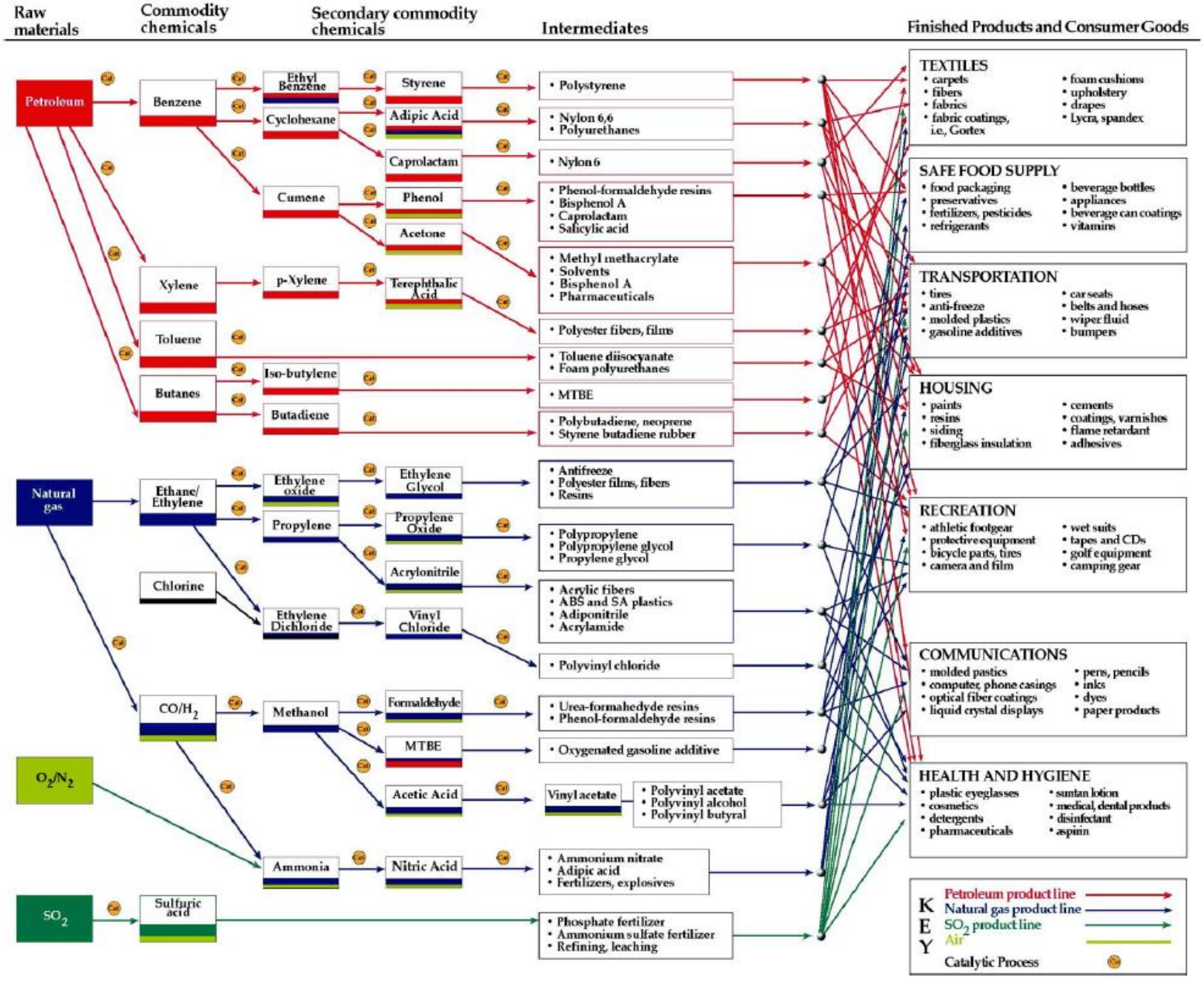
Biobased Chemicals
Biomaterials
Biofuels

(Water, fertilizers)

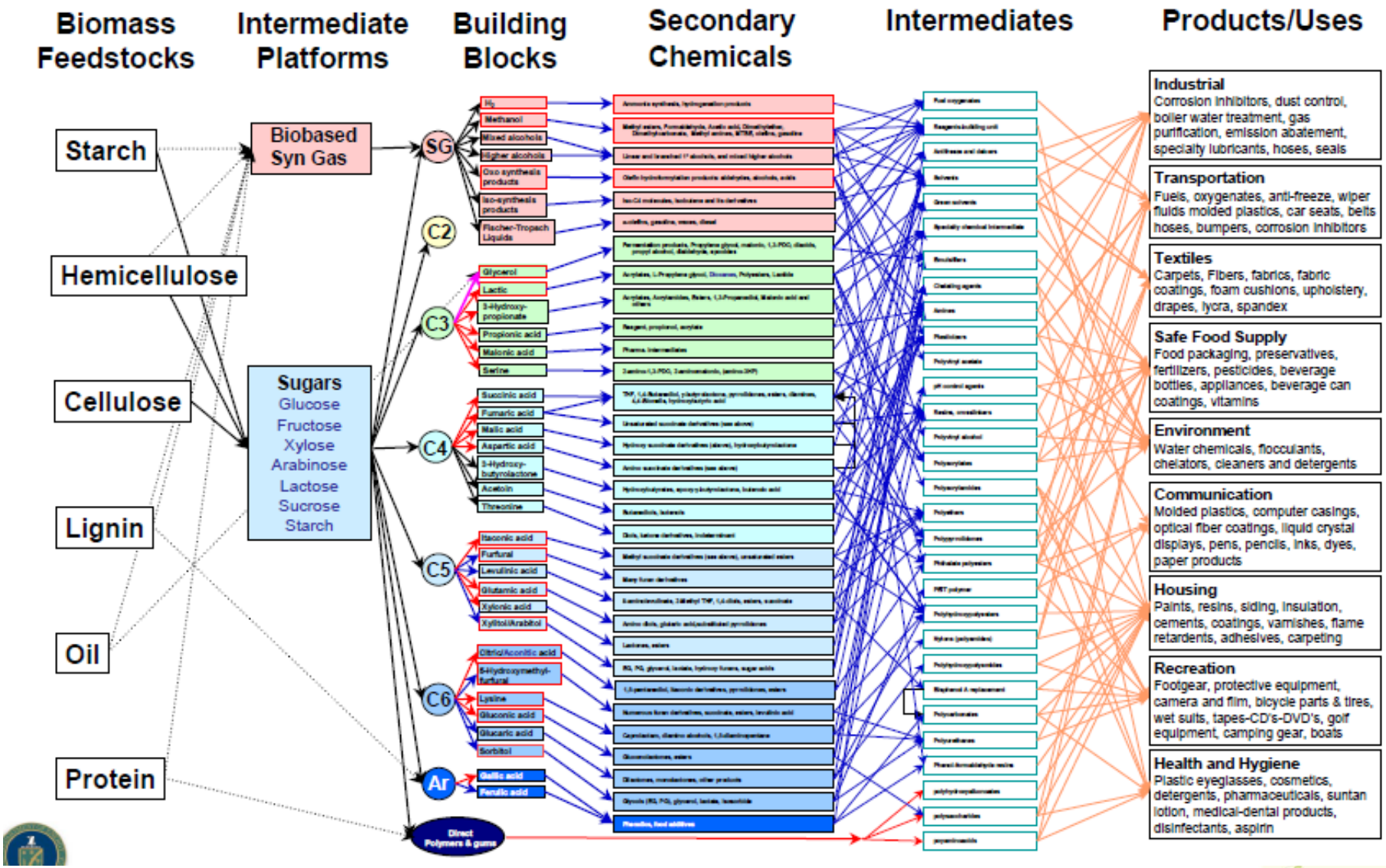
Optimal biorefinery concepts should achieve:

- minimal energy and water consumption,
- no generation of waste,
- high biomass to product conversion yield,
- low production cost and environmental impact, and
- high societal acceptance.

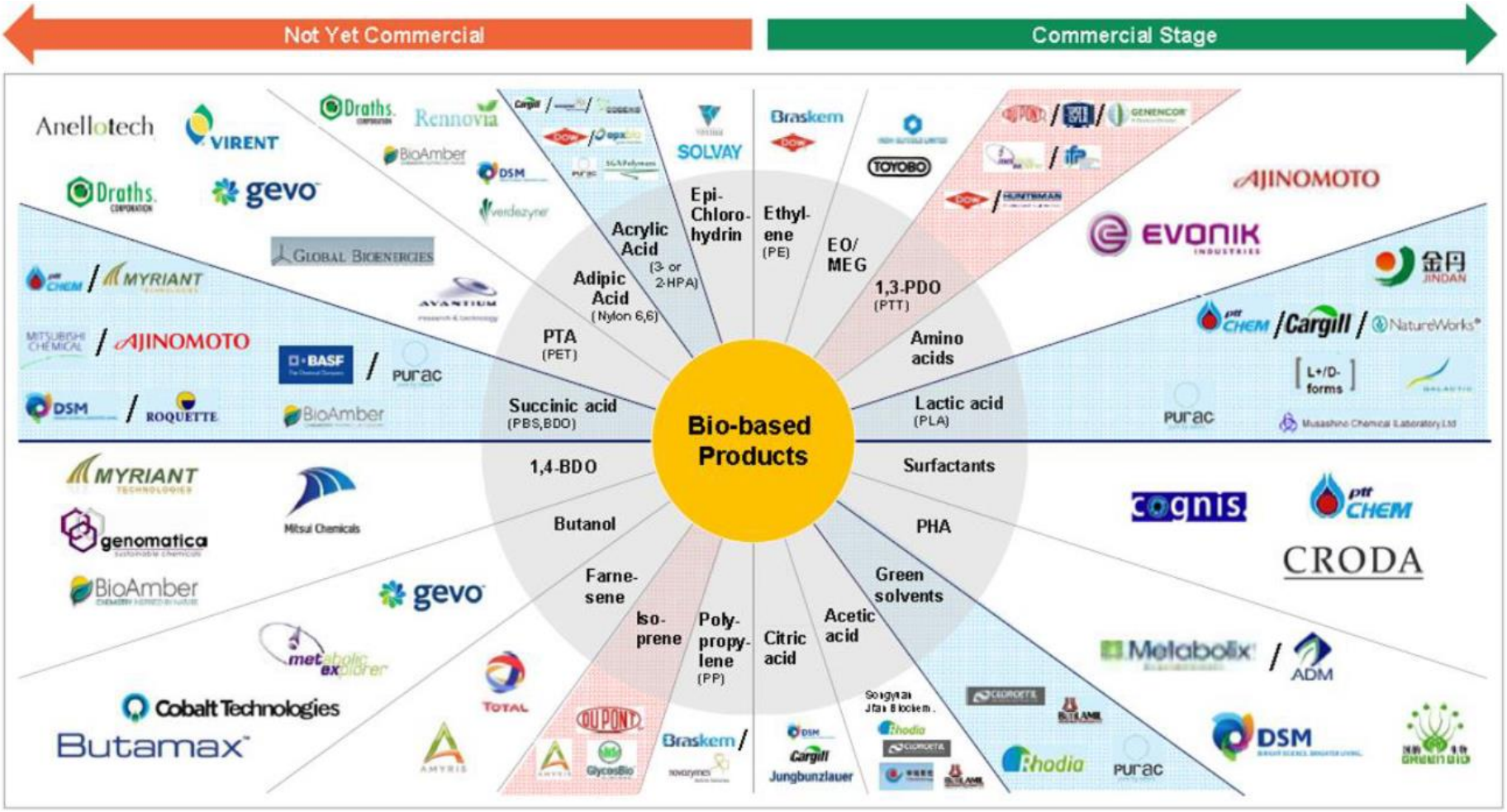
Flow-Chart for Products from Petroleum-based Feedstocks



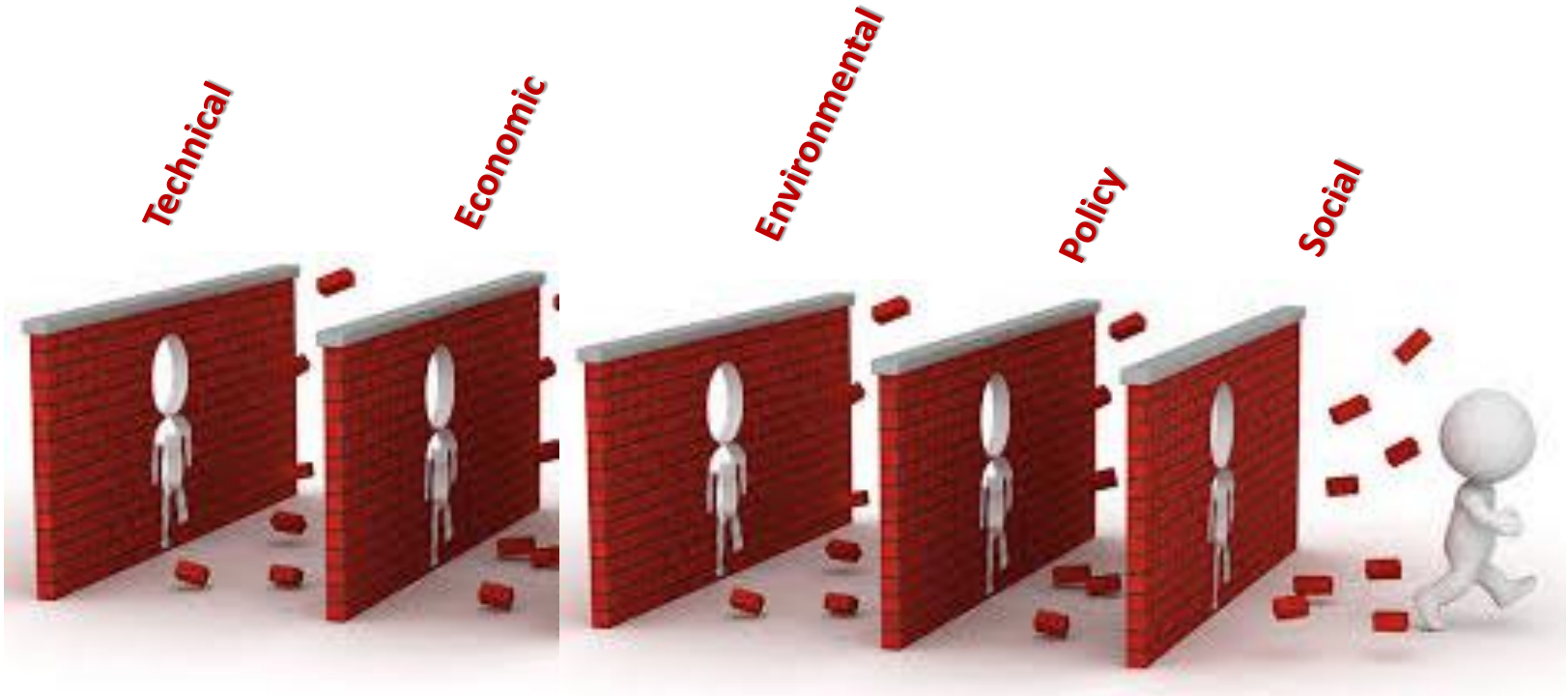
Bio-based Product Flow-chart for Biomass Feedstocks



Biomaterials competitive landscape



Barriers

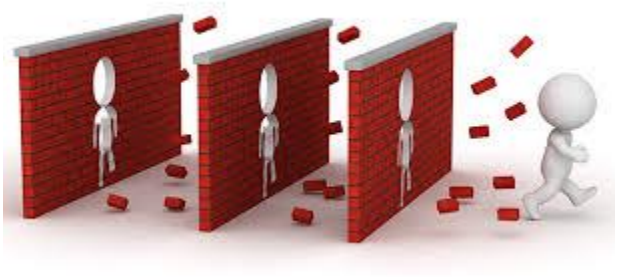


Technical barriers

- The collection network remains a challenge as it is an unorganized sector, so efforts should be made to render it much faster and easier.
- The scale-up design should ensure reliable and continuous supply of feedstock.
- The purification of end-products should be ensured.
- The quality of end-products should meet the product's specifications and standards.
- Regarding biofuel products, their compatibility with the conventional fuel distribution network is of vital importance.

The successful commercialisation of the integrated process requires favourable economics for each step along the value chain from biomass/biowaste to added-value products.

Barriers



ECONOMIC BARRIERS

- Feedstock Costs
- Storage and Delivery
- Feedstock Conversion Technologies and Costs
- Infrastructure Investments for Biorefineries
- Infrastructure Investments for end-product Distribution

POLICY BARRIERS

- Blend Wall
- Uncertainties in Government Policies
- Nonfederal Laws, Rules, Regulations, and Incentives Affecting Biomass Energy

ENVIRONMENTAL BARRIERS

- Life-Cycle GHG Emissions
- Air and Water-Quality Effects from Biorefineries
- Water Use for Irrigating Feedstock and in Biorefineries

SOCIAL BARRIERS

- Knowledge, Attitudes, and Values of Farmers and Forest Owners
- Consumer Knowledge, Attitudes, and Values about Biofuels
- Information and Outreach

ATHENS-BIOWASTE
LIFE+ project

- **Project title and acronym:** «Integrated management of bio-waste in Greece – The case study of Athens**, ATHENS-BIOWASTE**»
- **PROJECT LOCATION:** Athens, Greece
- **BUDGET INFO:** 1,339,930.00 € (50% EC Co-funding)
- **DURATION: Start:** 01/09/11**- End:** 31/08/2014
- **PROJECT'S IMPLEMENTORS:**
  - **Coordinating Beneficiary:** National Technical University of Athens
  - **Associated Beneficiaries:**
    - Association of Communities and Municipalities in the Attica Region
    - EPTA – Environmental Engineers – Consultants
    - Municipality of Athens
    - Municipality of Kifissia

ATHENS-BIOWASTE BACKGROUND and AIMS

- ATHENS-BIOWASTE established and promoted sustainable biowaste management in Greece using the municipalities of Athens and Kifissia as case study areas.
  - Separate collection systems in the Municipalities of Athens and Kifissia
  - Collection and composting of biowaste at the MBT facility of EDSNA
  - Developing appropriate bio-waste management software tool
  - Drafting recommendations for the amendment of the current technical specifications included in Greek legislation
  - Raising environmental awareness and knowledge in citizens and other stakeholders regarding management of bio-waste

Kifissia Municipality
Biowaste *door to door* collection system

120-360L bin for apartment blocks

Bin collection at common building area

10L bin per household (including biobags)

Bin collection outside the resident

35-50L for single-family detached residents

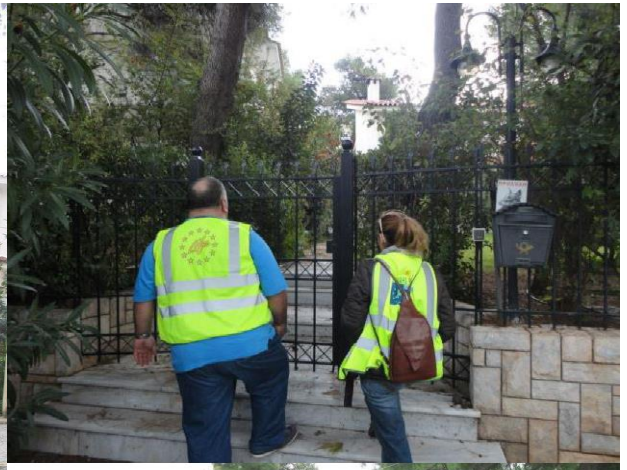
Athens Municipality
Biowaste *kerbside* collection system

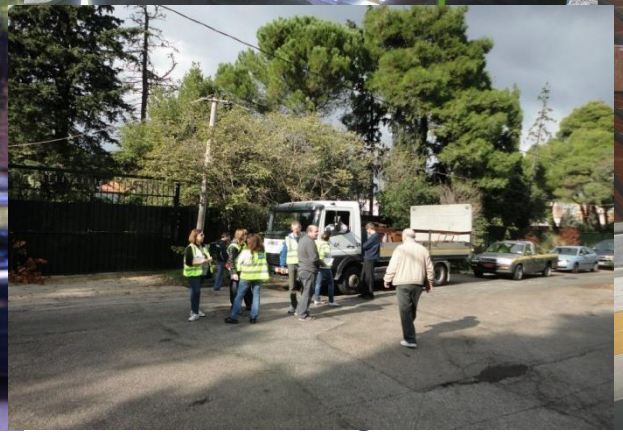
10L bin per household (including biobags)

30-50L bin per bar restaurant etc. (including biobags)

Implementation of the separate collection program in the selected areas

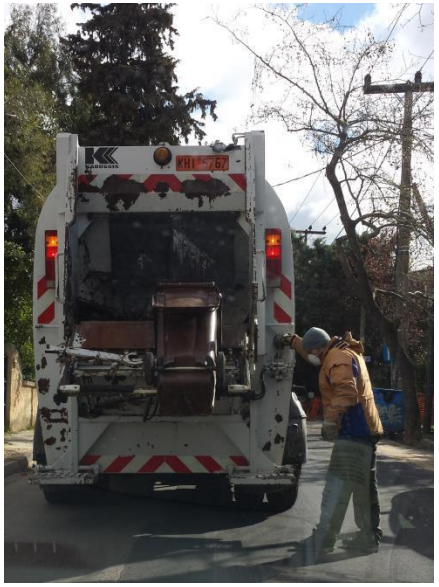
Distribution of bins and biodegradable bags to households





Implementation of the separate collection program in the selected areas

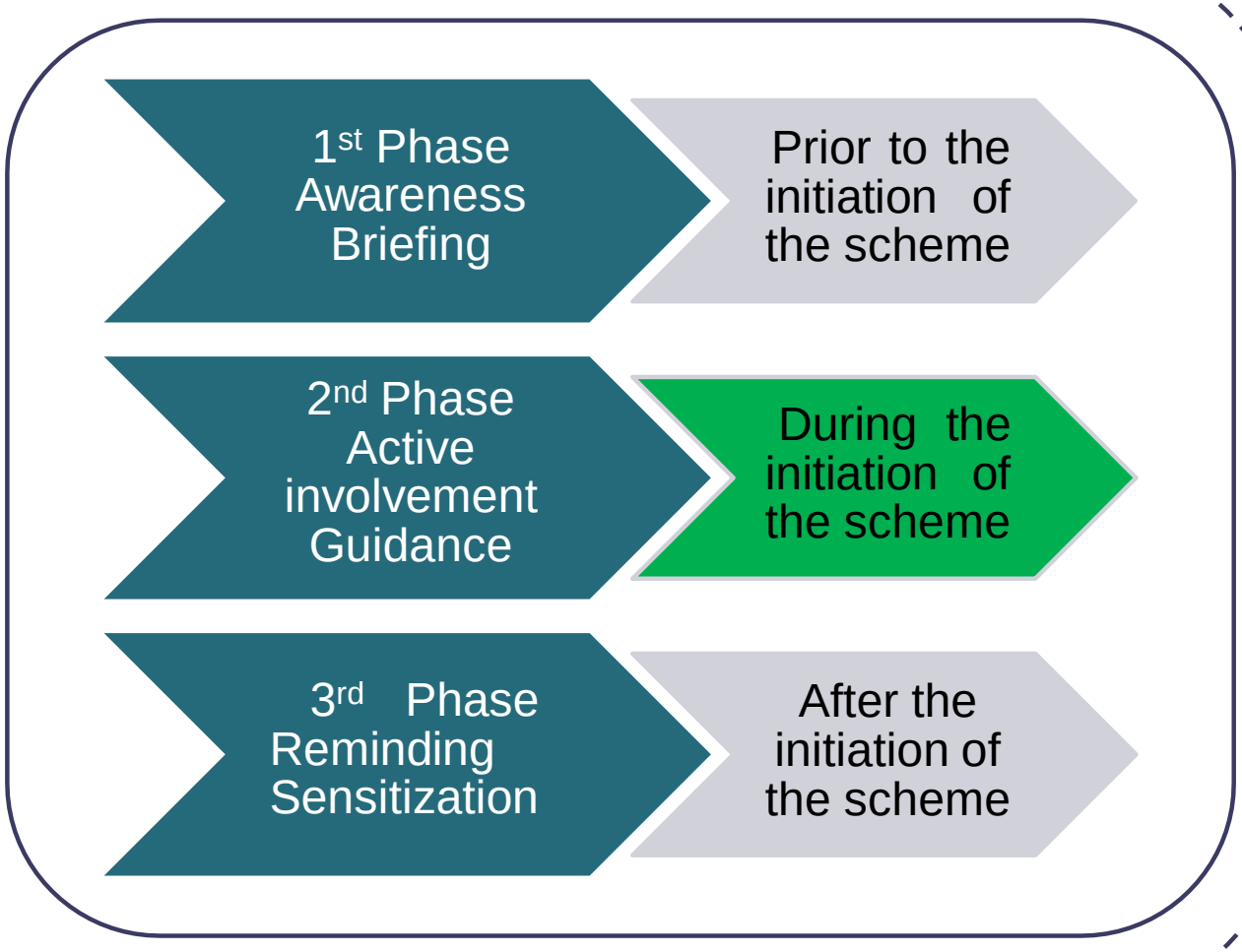
Collection and Transportation of source separated biowaste



Planning of the awareness campaign

Horizontal Actions

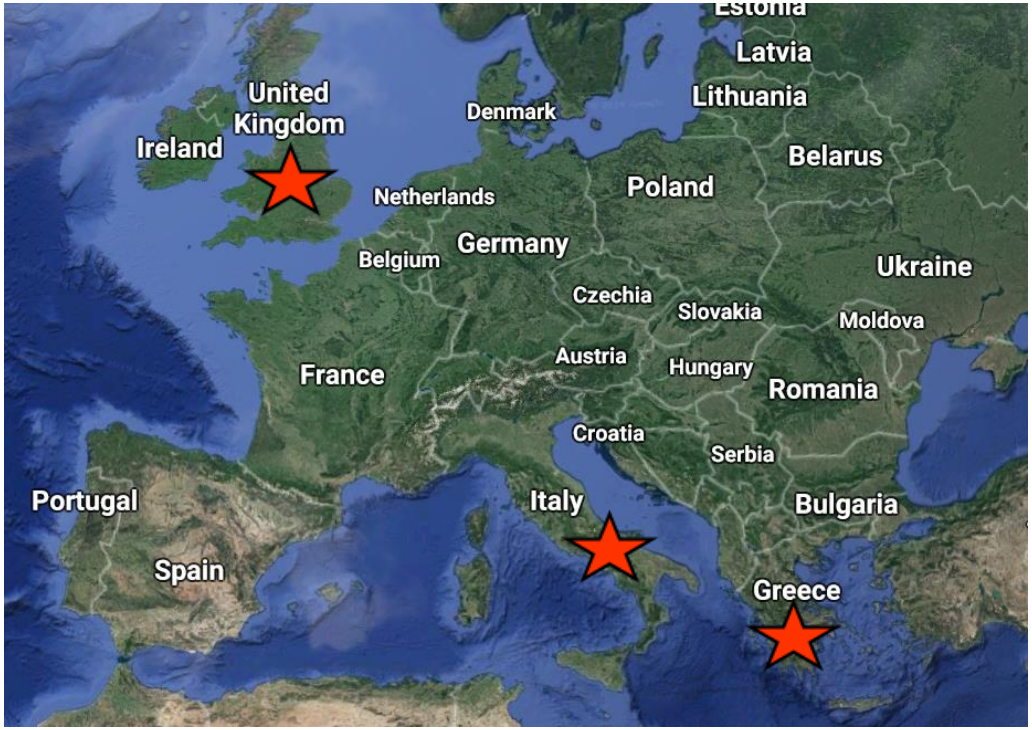
- Website
- Facebook profile
- Project Logo & banner
- Hotline



A circular economy system
for multi-source biomass conversion to added value products

LIFE18 CCM/GR/001180
With the contribution of the LIFE Programme of the European Union

Project Duration: 01/10/2019 – 31/05/2023
Total project budget: 2,636,693 €
EU financial contribution (55%): 1,450,181 €



Coordinating Beneficiary:

NATIONAL TECHNICAL UNIVERSITY OF ATHENS (NTUA)

Beneficiaries:

MUNICIPALITY OF LAVREOTIKI

FEDERATION OF HELLENIC FOOD INDUSTRIES

HELLENIC PETROLEUM S.A.

ENVIRECO CONSULTING S.A

SATISTICA LTD.

NEVIS - NOVEL ENVIRONMENTAL SOLUTIONS S.A.

UNIVERSITA DEGLI STUDI DI VERONA

Background information on LIFE CIRCforBIO

Aim of LIFE CIRCforBIO project

The overall aim of the CIRCforBIO project proposal is to:

- achieve **high GHG emission savings** from the substitution of fossil fuels with advanced biofuels
- promote the realization of the **circular economy concept for biomass**.

This will be achieved through:

- the implementation and **demonstration of an innovative biorefinery** concept for the production of **bioethanol, used oil** (raw material for biodiesel) and **other bioproducts** using municipal and industrial biomass
- the **creation of an interactive platform** for facilitating the realisation of the circular economy concept for 2nd generation biomass in Greece.

The project is co-funded by the EU through LIFE programme for the Environment and Climate action

Biowaste sources

- Municipal biomass (LAVRIO)
  - food waste (households and restaurants)
  - spent coffee grounds (cafeterias)
  - bread waste (bakeries)
  - agricultural residues (agricultural cooperatives)
- Industrial biomass (SEVT)
  - potato peel waste (potato chips industry)
  - brewer’s spent grains (breweries)
  - orange peels and apple pomace (juice industry)

The project is co-funded by the EU through LIFE programme for the Environment and Climate action

Main expected impact of LIFE CIRCforBIO

- **Biorefinery capacity:** 1tn/d feedstock-biomass
- **Production capacity:**
  - 30-60 L/d EtOH
  - & 15-20 kg/d used oil
- **Energy production**: 69,500kWh/y from biofuels and biogas
- More than **100% GHG emission savings** generated from the biorefinery
- Reduction of **raw materials consumption**: ~4,5tn mineral fertilisers substitution

The project is co-funded by the EU through LIFE programme for the Environment and Climate action

CIRCforBIO

Feedstock collection system

(I) Municipal biomass from LAVRIO

Due to (a) compatibility reasons with the new MSW plan of LAVRIO, (b) existing equipment (bins) that has been provided by Attica Region recently and (c) expected funding from national sources for biowaste source separation equipment

The source separation scheme in LAVRIO will be applied

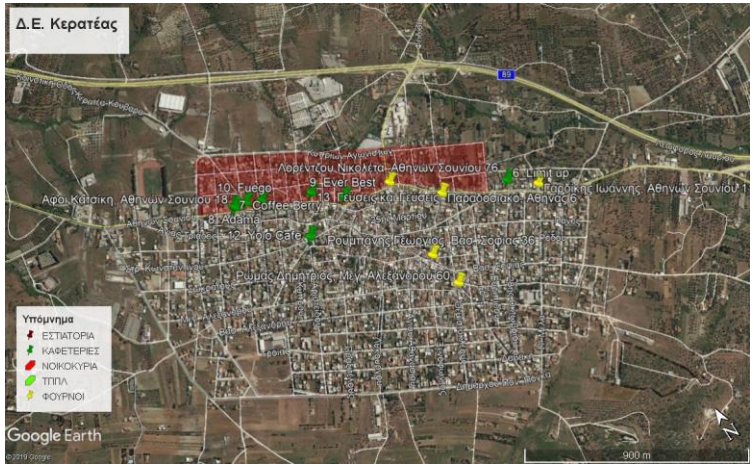
- In 25 ha pilot area in Keratea municipal unit of 515 households
  - 1350 inhabitants
  - 5% of total LAVRIO population
- In 100 F&B businesses in LAVRIO (businesses outside the case study area are also considered)
  - caterings (restaurants),
  - coffee shops,
  - bakeries

The project is co-funded by the EU through LIFE programme for the Environment and Climate action

Feedstock collection system

Lavrio case study area

- Total area: 0.34 km^2
- 273 hh selected (≤3 hh/building)
- 24.8% of the total population of the study area



Keratea case study area

- Total area: 0.25 km^2
- 218 hh selected (≤3 hh/building)
- 42.3% of the total population of the study area

The project is co-funded by the EU through LIFE programme for the Environment and Climate action

Feedstock collection system

Household collection system

Road container

240L bin

10L bin & biobag

- Food waste is placed in a 10L kitchen bucket using 10L biobags (1 and 2) (one 10L bin for each household).
- Filled biobags are disposed in an outdoor collection bins 240L (3), which will be placed in public areas.
- The sorted biowaste disposed in the 240L bins will be collected by the municipality's cleaning service (4) every two to three days.

The project is co-funded by the EU through LIFE programme for the Environment and Climate action

CIRCforBIO

Feedstock collection system

50L bin & biobag

240L bin

Businesses collection system

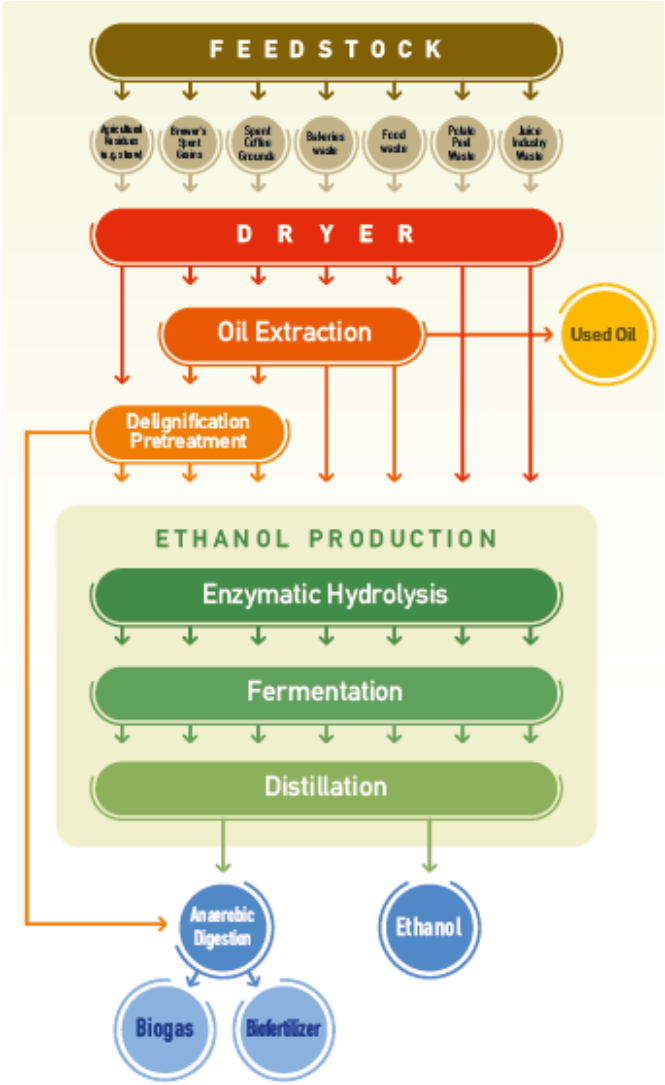
Road container

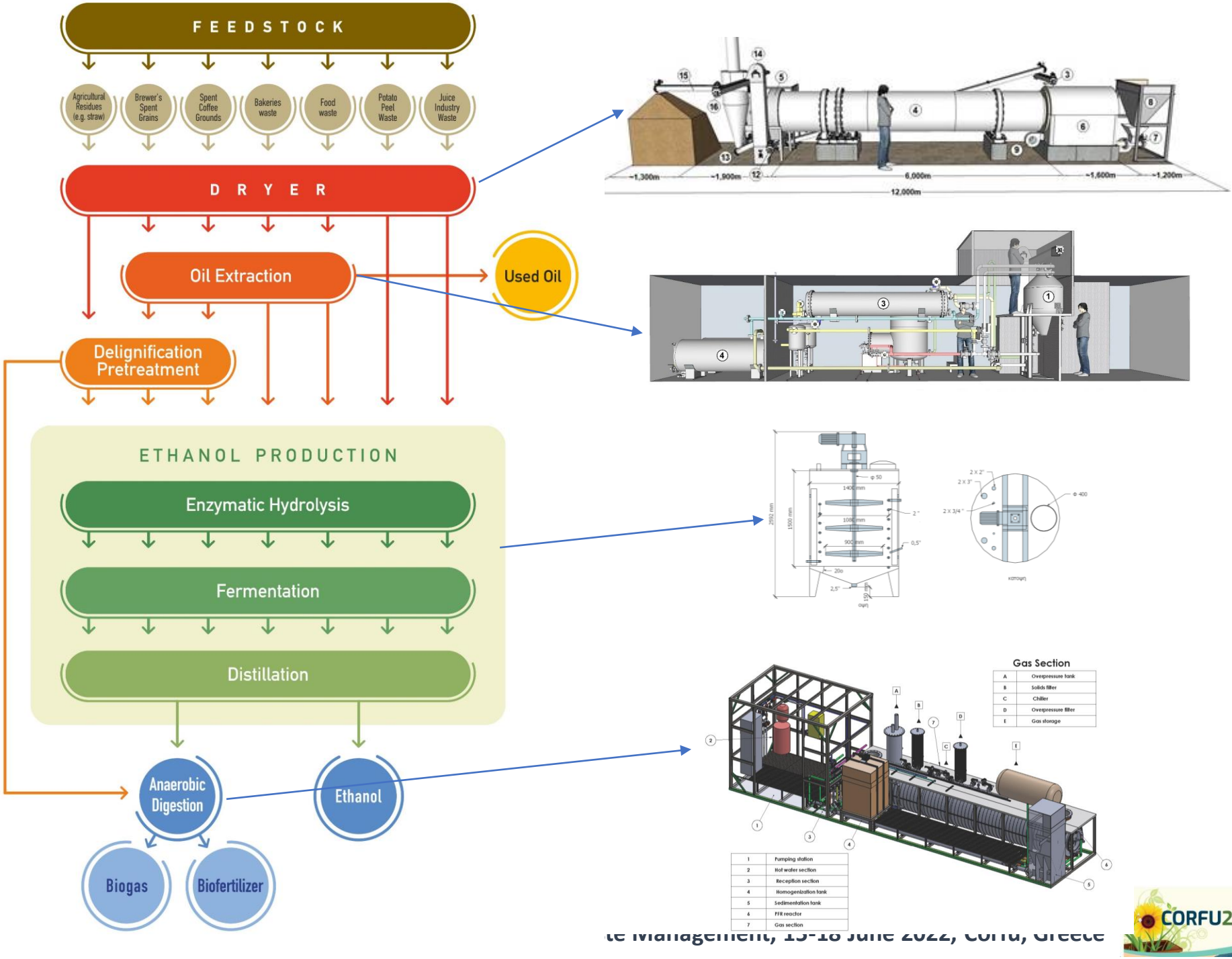
- Food waste is placed in a 50L kitchen bin using 50L biobags (1 and 2) (one 50L bin for each business)
- Filled biobags are disposed in an outdoor collection bin 240L (3), which will be placed in a public areas
- The sorted biowaste disposed in the 240L bins will be collected by the municipality's cleaning service (4) every two to three days.

The project is co-funded by the EU through LIFE programme for the Environment and Climate action

CIRCforBIO

Treatment scheme

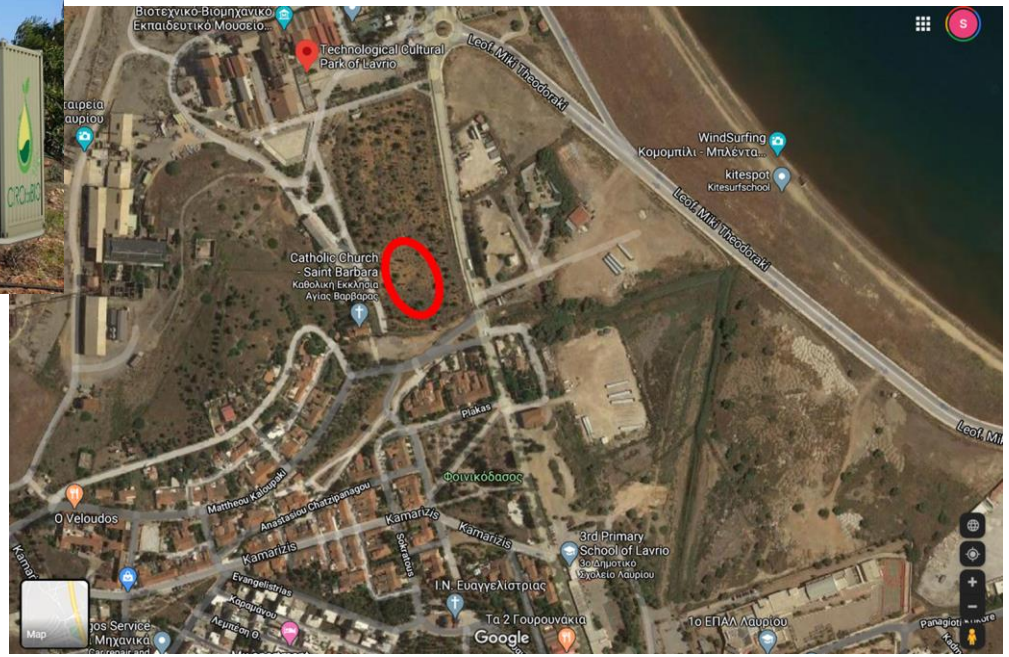



FEEDSTOCK
Agricultural Residues (e.g. straw)
Brewer's Spent Grains
Spent Coffee Grounds
Bakeries waste
Food waste
Potato Peel Waste
Juice Industry Waste
DRYER
Oil Extraction
Used Oil
Delignification Pretreatment
ETHANOL PRODUCTION
Enzymatic Hydrolysis
Fermentation
Distillation
Anaerobic Digestion
Ethanol
Biogas
Biofertilizer
~1,300m
~1,900m
6,000m
~1,600m
~1,200m
12,000m
Gas Section
A Overpressure tank
B Solids filter
C Chiller
D Overpressure filter
E Gas storage
1 Pumping station
2 Hot water section
3 Reception section
4 Homogenization tank
5 Sedimentation tank
6 PFR reactor
7 Gas section

Pilot plant installation

It was decided that the biorefinery will be installed

- in Technological Park of Lavrio (permission granted by LTCP)
- inside containers.

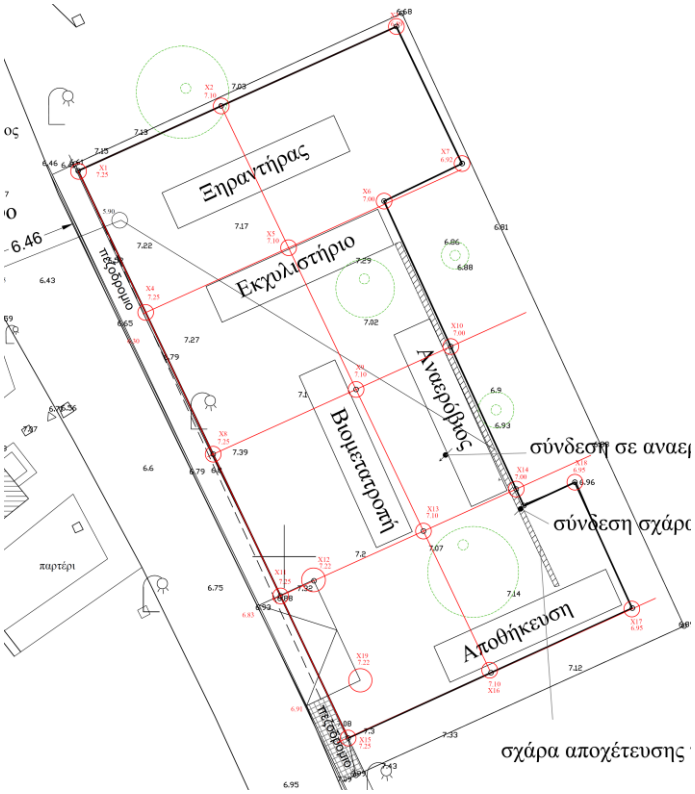


The project is co-funded by the EU through LIFE programme for the Environment and Climate action

Civil works for the preparation of the demo installation area at LTCP

Before

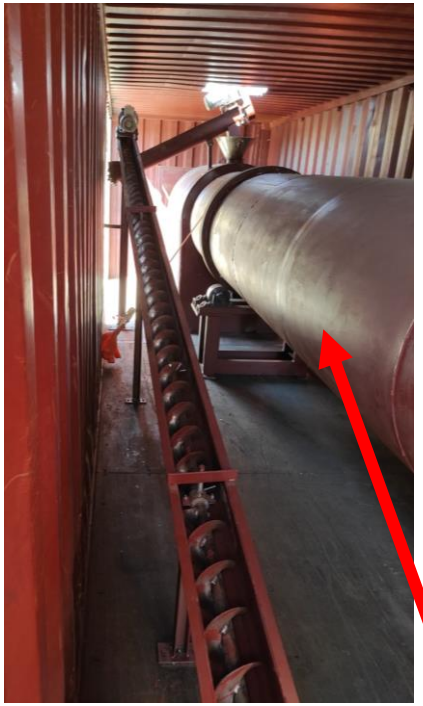
Initiation of civil works
03/06/2022



To avoid rent payments the civil works initiated just before the finalization of the first units of the biorefinery unit (i.e. earth works, asphalt, electricity and water supply, connection to the sewage etc)

Dryer unit for the thermal treatment of feedstock

Dryer placed at the LTCP

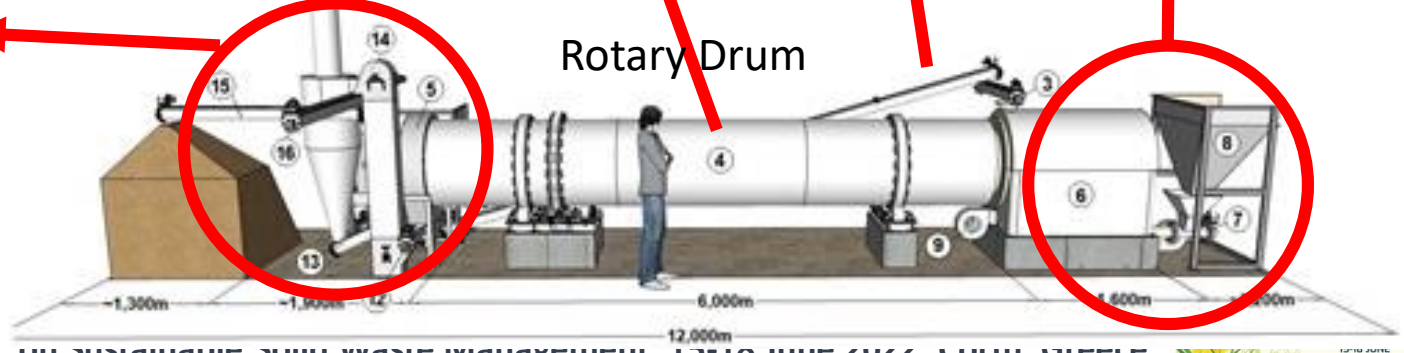


Feedstock
Screw conveyor

Feedstock supply area (front)
Cyclone separator (back)

Biomass boiler
for heat supply

Rotary Drum



Oil extraction unit

Pending tasks

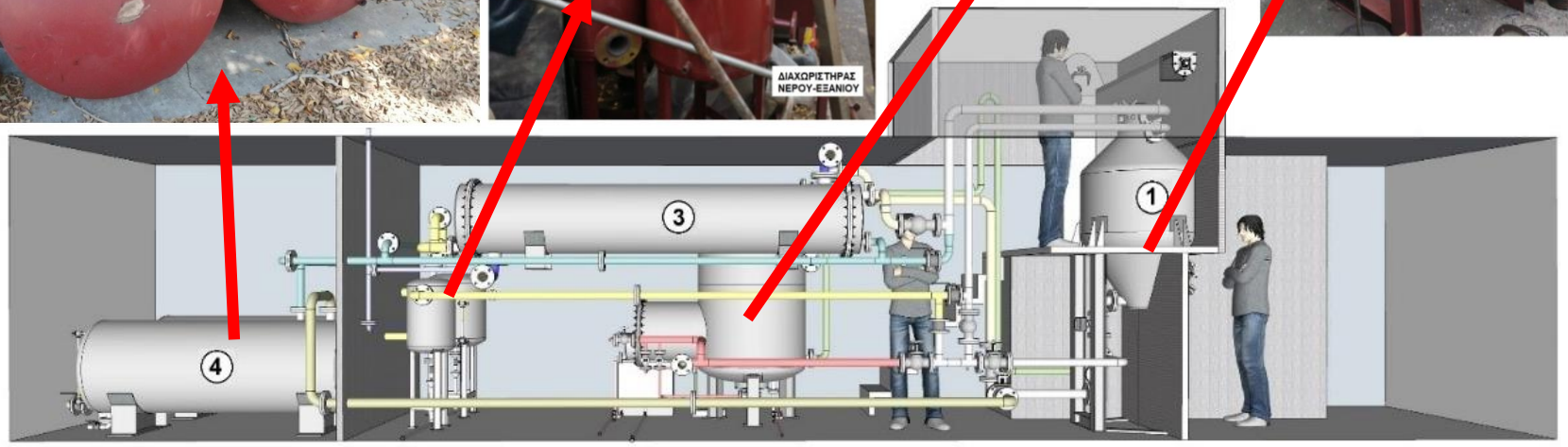
- Piping system
- Electric Motors connection
- Setting unit into container

Distillation tank

Oil extraction tank

Hexane tanks

Hexane/ Water separating tanks



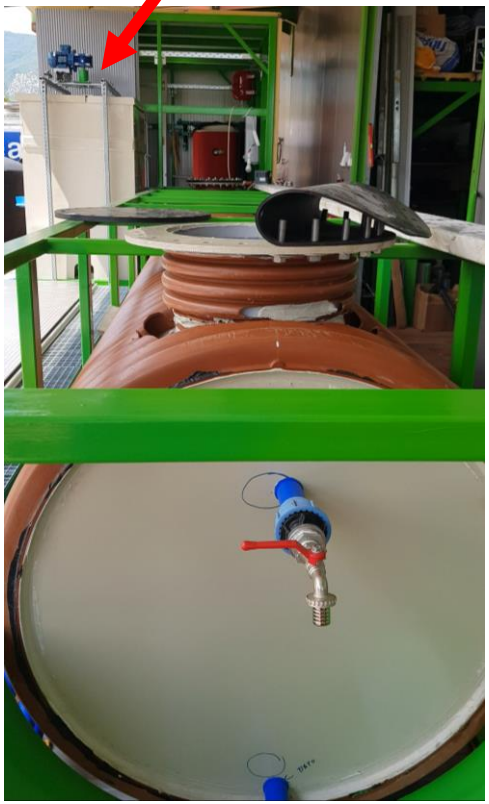
AD unit

Hot water system

Biogas boiler

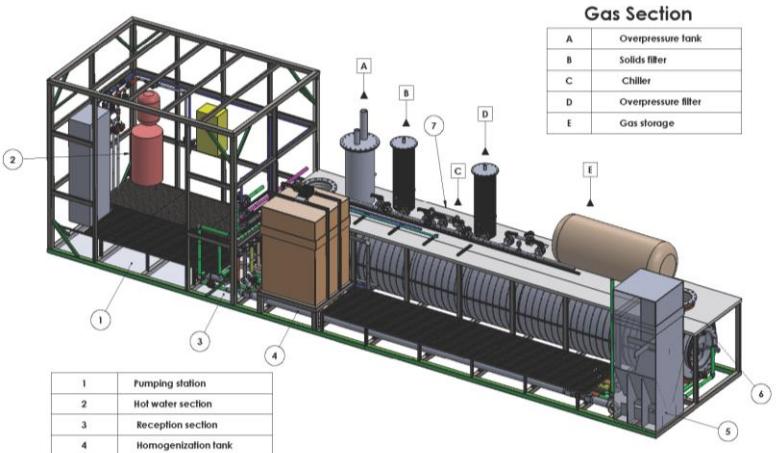
PFR reactor

Homogenization tank

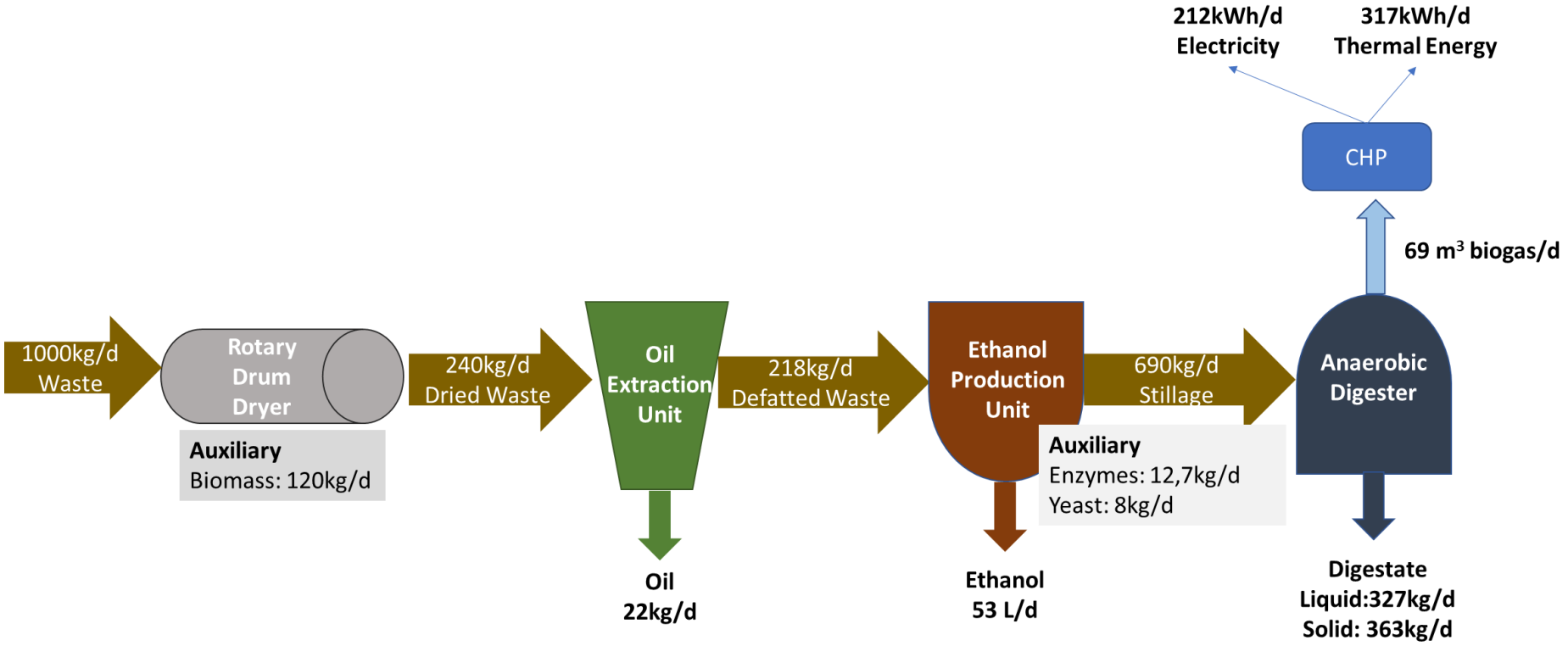


Pending tasks

- Biogas equipment
- Electrical connections & PLC
- Preliminary testing operation



Integrated Biorefinery 1tn/d



Preliminary Economic Assessment

Machinery Cost[1] Biorefinery 1tn/d

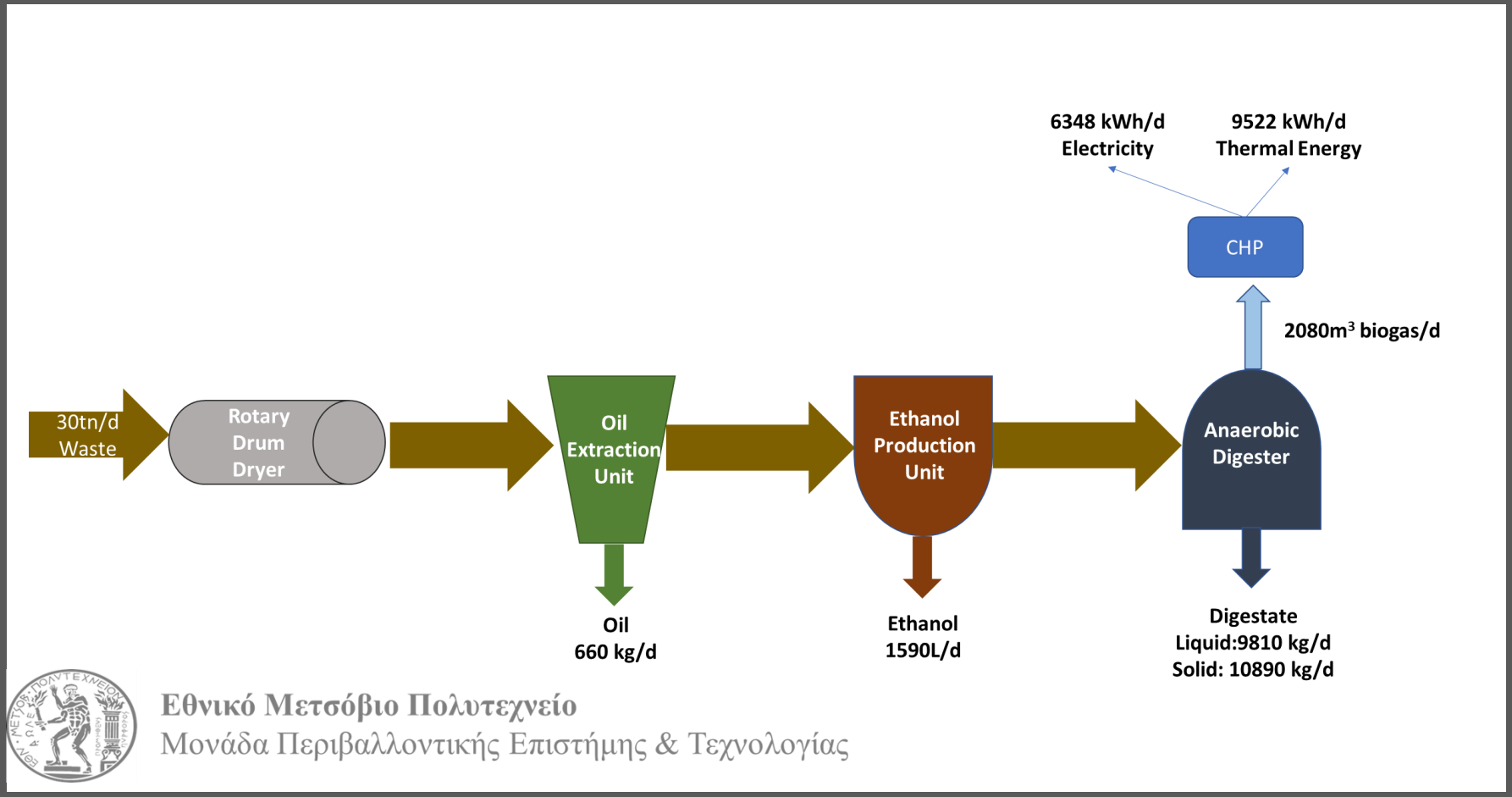
Process Unit	Cost (€)
Dryer	152.000
Oil extraction unit	193.000
Bioconversion unit	100.000
Anaerobic digestion unit	155.500
Total	**600.500**

[1]Excluding Combined Heat and Power (CHP)

Market Price

Product	Cost
Oil	0,8€/kg
Bioethanol	1,2€/kg
Electricity	0,22€/kWh
Organic Fertiliser	0,05€/kg

Biorefinery 30tn/d



Εθνικό Μετσόβιο Πολυτεχνείο
Μονάδα Περιβαλλοντικής Επιστήμης & Τεχνολογίας

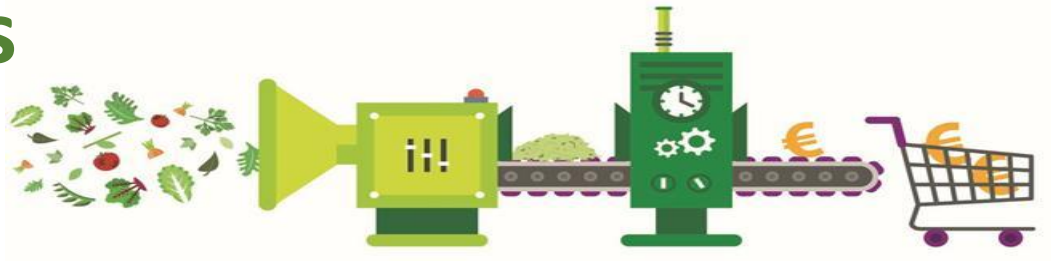
Preliminary Economic Assessment

Machinery Cost
Biorefinery 30 tn/d

6.500.000 €

Product	Cost	Production	Revenue (€/d)
Oil	0,8€/kg	660 kg	528
Bioethanol	1,2€/kg	1980 kg	1908
Electricity	0,22€/kWh	6348 kWh	1397
Organic Fertiliser	0,05€/kg	10890 kg	545
Total			**4377**

Conclusions



Huge, unexploited flows of biowaste

Development of integrated biorefineries

Appropriate technical, economic and scientific strategies in multi-disciplinary approach can help to develop a sustainable biorefinery by addressing the circular bioeconomy goals and bridging the gap between waste remediation and product recovery.

THANK YOU FOR YOUR ATTENTION!

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