WRB

WASTE RECOVERY BIOREFINERY

The Next Generation Waste Management Technology

SUMMARY

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WASTE RECOVERY
BIOREFINERY

The presentation describes a “biorefinery plant”, able to recover into hydrocarbonates and other valuable materials, organic-based solid waste materials.

The biorefinery is a complex industrial plant that, integrating different technologies, is able to produce high-value hydrocarbonats, starting from organic-based materials.

The plant is able to useorganic easte materials from different origin, such as: Agricultural, Forest, Industrial and Urban.

In particular, the plant is able to produce hydrocarbonats starting from any solid waste matters, having sufficient organic-based content.

SUMMARY

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WASTE RECOVERY BIOREFINERY

The production of hydrocarbonats from waste materials:

- Does Not substract land to agricultural sector;
- Reduces Enviromental impact drived from the mismanagement of agricultural waste;
- Promotes the maintenance and good forest management
- Solves the problem of the organic waste of industrial origins;
- Solves the problem of municipal solid waste;
- Does Not require any input of energy of fossil sources.

The generation of hydrocarbons produced from “Waste matters” allows to contain costs of production at extremely competitive levels, often lower than those from fossil origins.

The Plant Philosophy

The industrial production of materials and energy is today based on massive non-renewable fossil sources

The exploitation of these resources, however, impacts negatively on environment.

The use of residues of organic nature as “raw materials”, alternatives to fossil resources, can significantly limit the environmental impact, increasing the economic sustainability of many industrial activities.

To date, the production and the subsequent disposal of wastes is a serious problem at global level.

The concept of “Zero Waste” is based on the idea of considering any waste material, produced by human activities, as a possible resource for other processes or users.

Recycling is a practice thet contributes to reduce, near zero, the waste disposal into landfills.

The Plant Philosophy

The nature of organic waste, due to their biological origin, makes them interesting feedstock, from which is possible to recover natural molecules of industrial interest, biomaterials and biofuels.

Such transformations can be done through application of industrial processes, like the one perfomed inside biorefineries.

The biorefinery allows to exploit the organic waste, to obtain products of interest for different industrial sectors.

The fuel market and chemical industry are among the industrial sectors that will take more advantage from the products of the biorefineries.

Actual Waste Disposal Management Systems

Estimated Solid Waste Management Costs by Disposal Method

NOTE : This is a compilation table from several WORLD BANK documents, discussions with the World's Bank Thematic Group on solid waste, Carl Bar Tone and other industry and organizational colleagues. Costs associated with uncollected waste -more than half of all waste generated in LOW Income countries are not included

COUNTRIES, BY INCOME	LOW	LOWER MID	UPPER MID	HIGH
INCOME (GDP/CAPITA)	up to 876 USD	$876 - 3.465	$3.466-10.725	above $10.725
Waste Generation (KG/Capita/Year)	220	290	420	780
Collection Efficiency (% collected)	43%	68%	85%	98%
COST OF COLLECTION AND DISPOSAL (USD/TONNE)				
COLLECTION	20-50	30-75	40-90	85-250
SANITARY LANDFILL	10-30	15-40	25-65	40-100
OPEN DUMPING	2-8	3-10	N/A	N/A
COMPOSTING	5-30	10-40	20-75	35-90
Waste to Energy Incineration	N/A	40-100	60-150	70-200
ANAEROBIC DIGESTION	N/A	20-80	50-100	65-150

ACTUAL WASTE ANAGEMENT PHILOSOPHY

VS

BIOREFINERY WASTE RECOVERY PHILOSOPHY

The WASTE RECOVERY plant philosophy is to transform a waste in a pure raw material to be use to manufacture high quality products

Unlike the common waste management philosophy that is oriented to reuse, recycle or recover to energy a waste product, we consider more appropriate to transform the waste in pure raw materials like hydrocarbons, metals and inert sand, from witch it is possible to create products with the same quality levels of the standard commercial products but with a lower environmental impact and at a more competitive cost .

See Next Page >>

ACTUAL WASTE ANAGEMENT PHILOSOPHY

VS

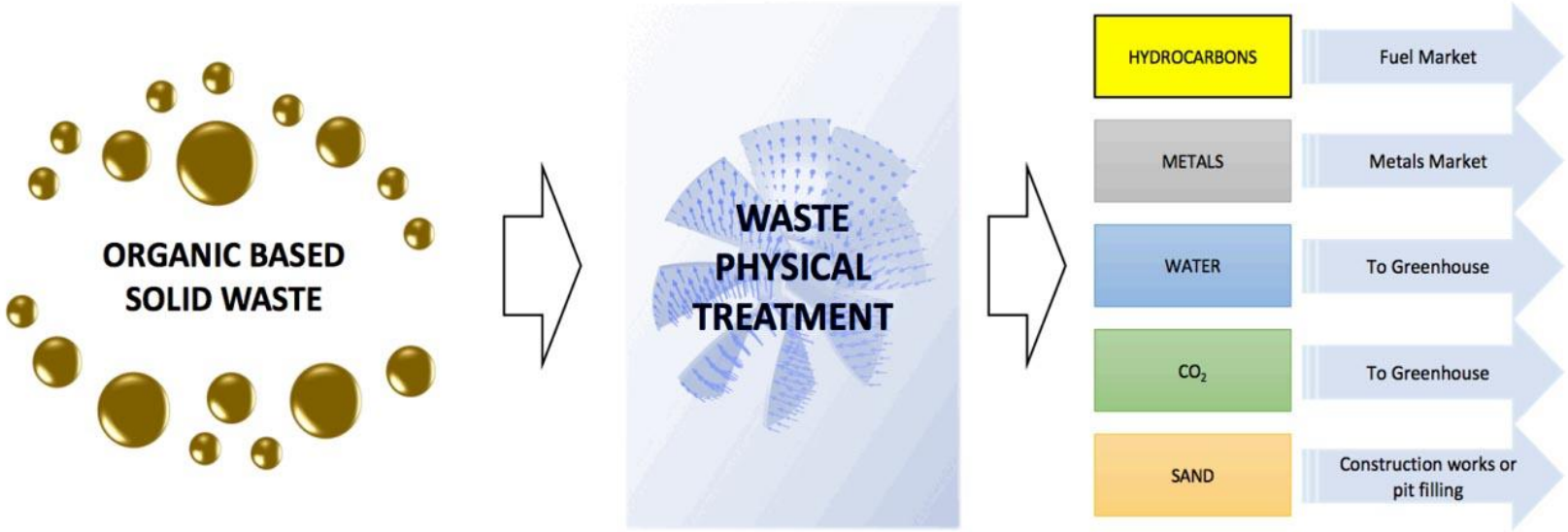
BIOREFINERY WASTE RECOVERY PHILOSOPHY

WASTE MANAGEMENT- BENCHMARK

	ACTUAL WASTE MANAGEMENT	BIOREFINERY WASTE RECOVERY
COLLECTING ECONOMY	SORTING, COLLECTING (VERY EXPENSIVE AND DIFFICULT TO APPLY IN THE REAL WORLD)	UNSORTED COLLECTING (WASTE IS MOVED FROM SELECTION PROCESS TO INCINERATION TO LANDFILL, USING LARGE QUANTITYOF ENERGY AND PRODUCING A STRONG ENVIRONMENTAL FOOTPRINT)
PRODUCT VALORIZATION	REUSE AND RECYCLING (VERY EXPENSIVE PROCESS TO GET VERY LOW QUALITY PRODUCTS WITHOUT A REAL MARKET IF NOT SUBSIDIZED)	ROW MATERIAL PRODUCTION (COMMODITIES PRODUCTION WITH MARKET HIGHQUALITY AND VALUE)
ENVIRONMENTAL IMPACT	LONG CHAIN PROCESS (WASTE IS MOVED FROM SELECTION PROCESS TO INCINERATION TO LANDFILL, USING LARGE QUANTITYOF ENERGY AND PRODUCING A STRONG ENVIRONMENTAL FOOTPRINT)	ONE STEP PROCESS (WASTE IS MANAGED IN A SINGLE PLANT VALORIZING ROW MATERIALS WITHOUT ANY EXTERNAL ENERGY REQUIREMENT)
LANDFILL	LANDFILL REQUIRED (ANY STEP OF THE SELECTION PROCESS AND THE INCINERATION, PRODUCES WASTE MATERIALS THAT MUST BE LANDFILLED)	LANDFILL NOT STRICTLY REQUIRED (THE ONLY PRODUCT OF THE PROCESS THAT IS NOT STRICTLY VALORIZED IS THE “SAND” THAT CAN BE USED IN MANY DIFFERENT WAYS OR OTHERWISE LANDFILLED IN AN INERT LANDFILL)

Working Principles

The basic concept is to valorize, the raw materials content of an organic-based solid waste, using physical

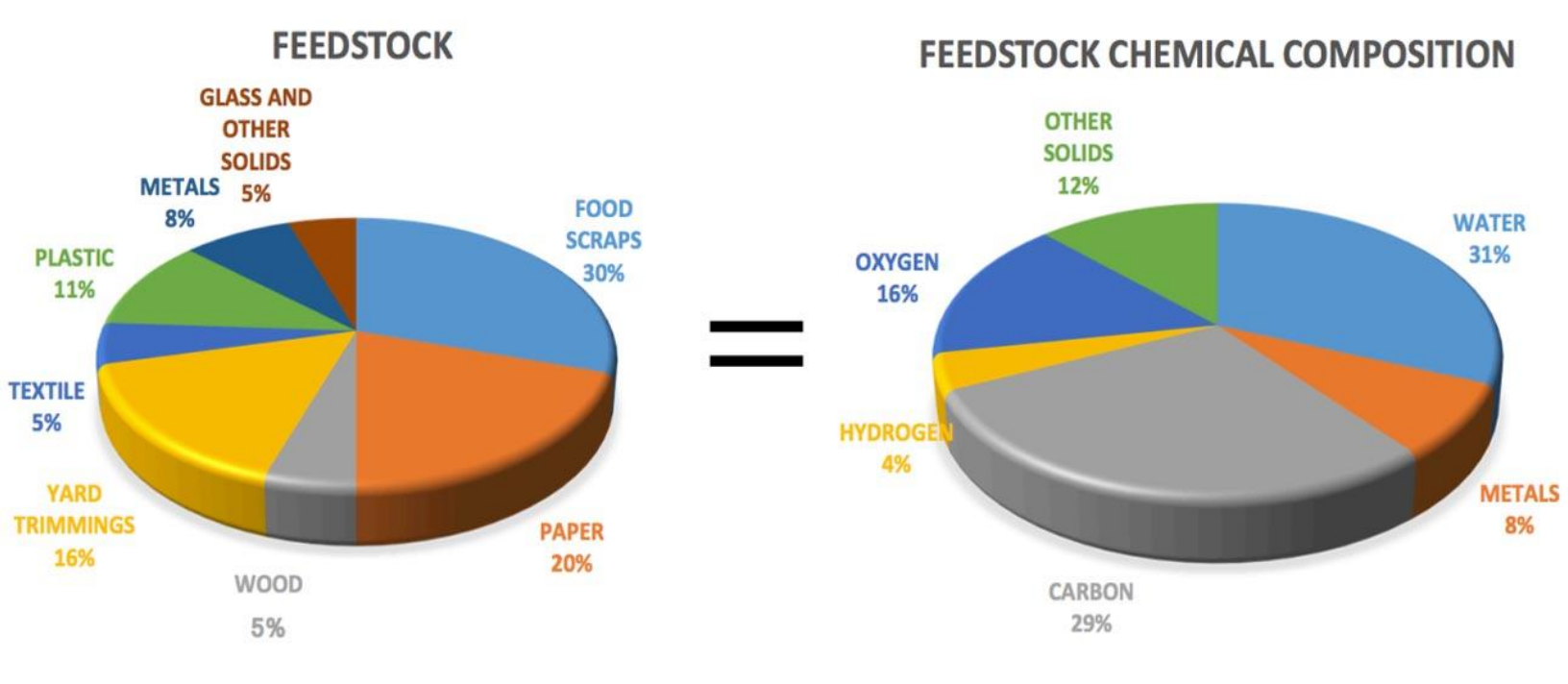


THE FEEDSTOCK

The plant can manage any kind of solid, not dangerous, organic-based waste:
- With an average calorific value grater than 1.5 kWh/kg;
- Sorted or unsorted;
- With a water content up to 50%
- With a solids content up to 30%
- From municipal, industrial and agricultural origin

Valorizing the chemical components of the feedstock producing valuable raw materials.

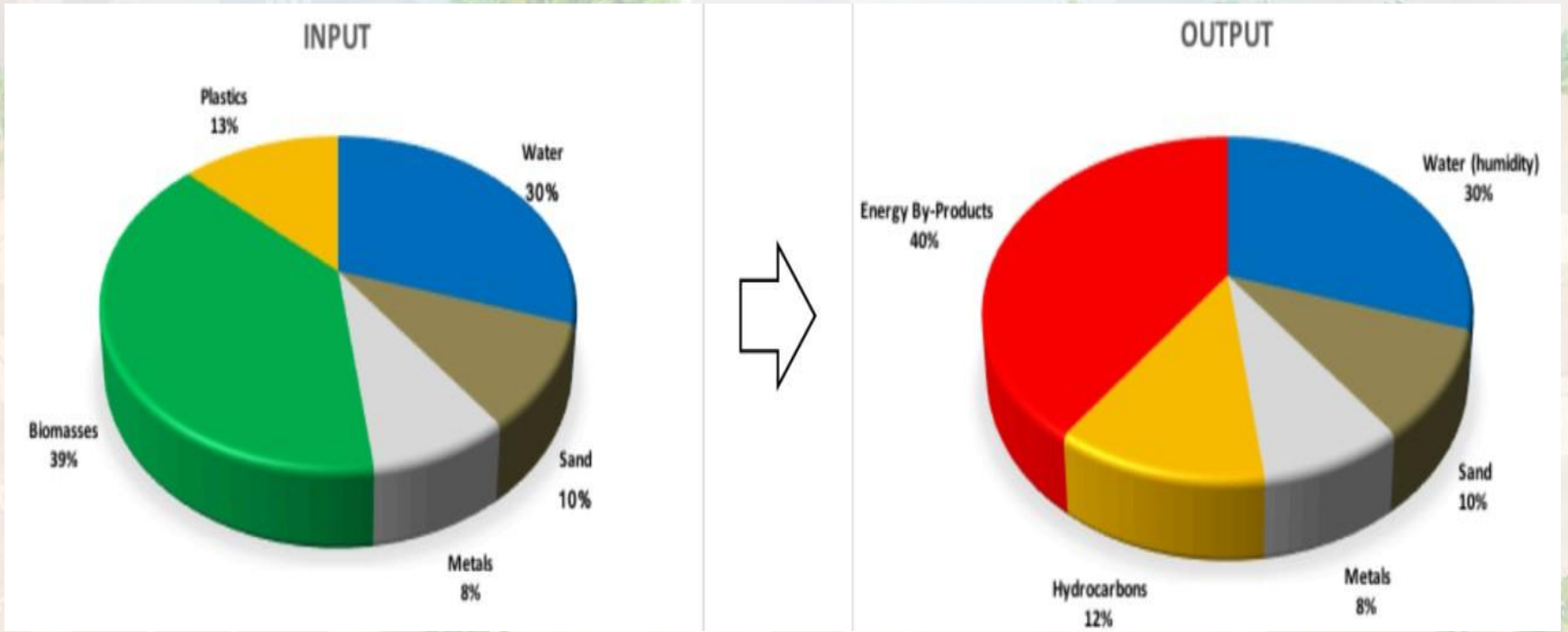
AVERAGE EUROPEAN MUNICIPAL SOLID WASTE COMPOSITION (in weight %)



THE MASS BALANCE

The WASTE RECOVERY plant OUTPUT strongly depends from the material input, generally we can say that the plant
recover:
100% of the metals and of the inert materials, clean from any organic impurity
100% of the water, clean and ready to be use for agricultural porpoise
most of the hydrogen and the carbon content, to produce light hydrocarbons
clean renewable C02 , to be enhanced in carbon fertilization greenhouses

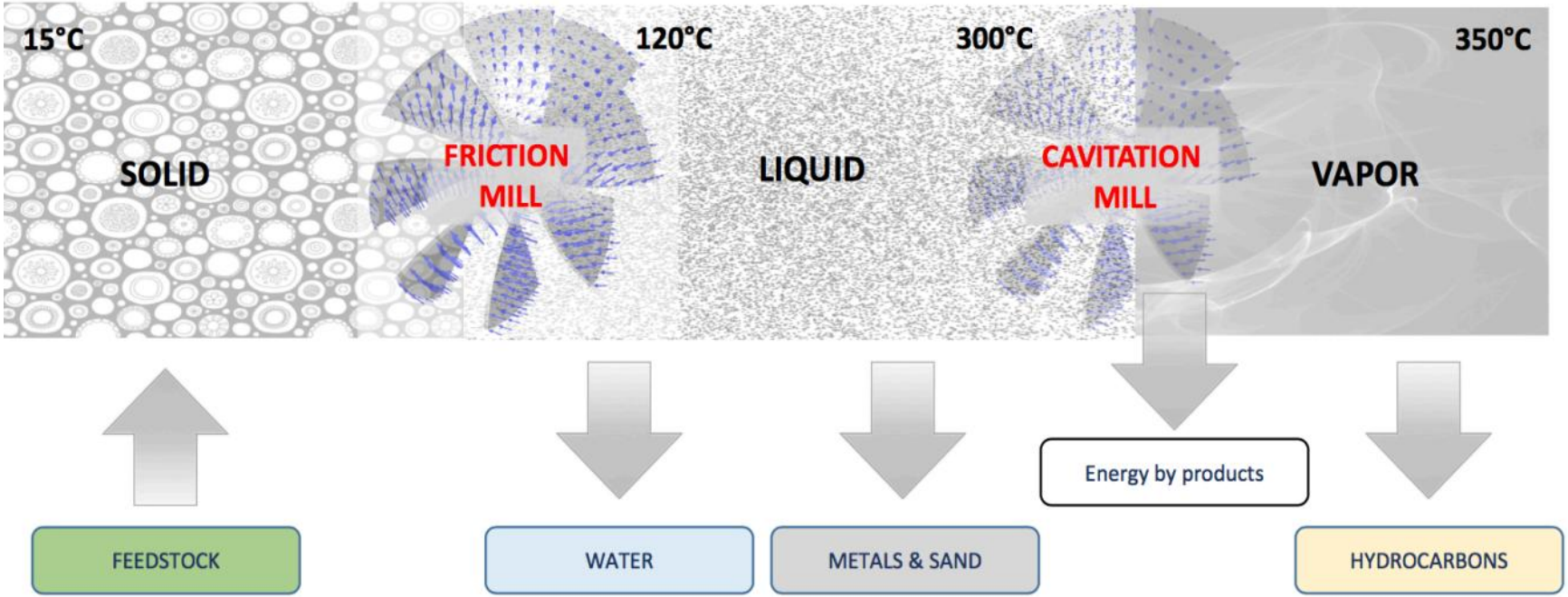
AVERAGE EXPECTED MASS BALANCE FROM MUNICIPAL SOLID WASTE



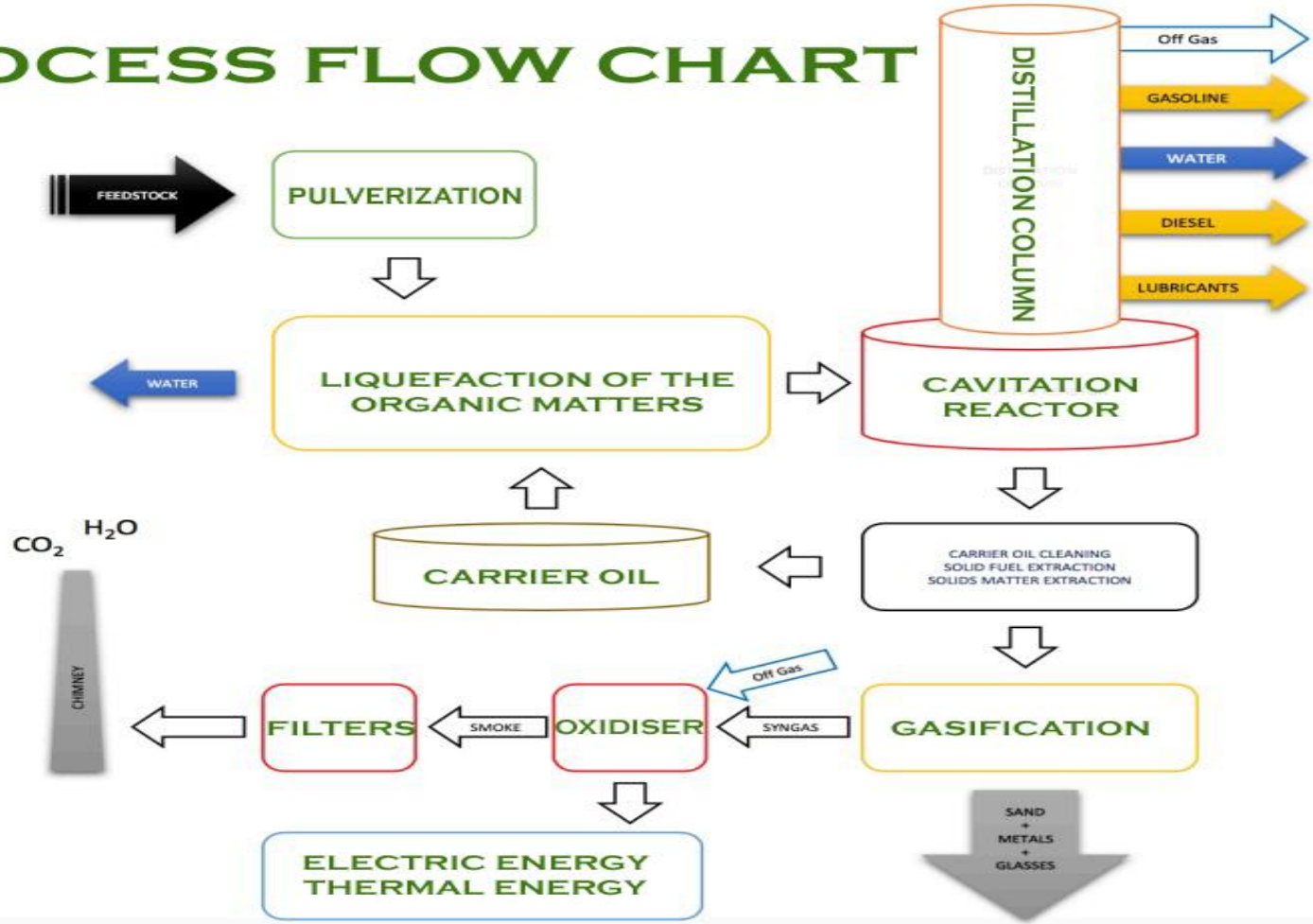
HOW IT WORKS

The WASTE RECOVERY BIOREFINERY plant reduces in size and purifies the waste single components, to obtain commercial
raw materials.
The waste material is processed through mechanical very high speed mills capable to induce thermal and cavitational effects, to
change the materials status from solid to liquid to vapor phase allowing the system to valorize the single raw materials content.
The plant produces 100% of the energy required to transform the waste in a raw material using the process by products

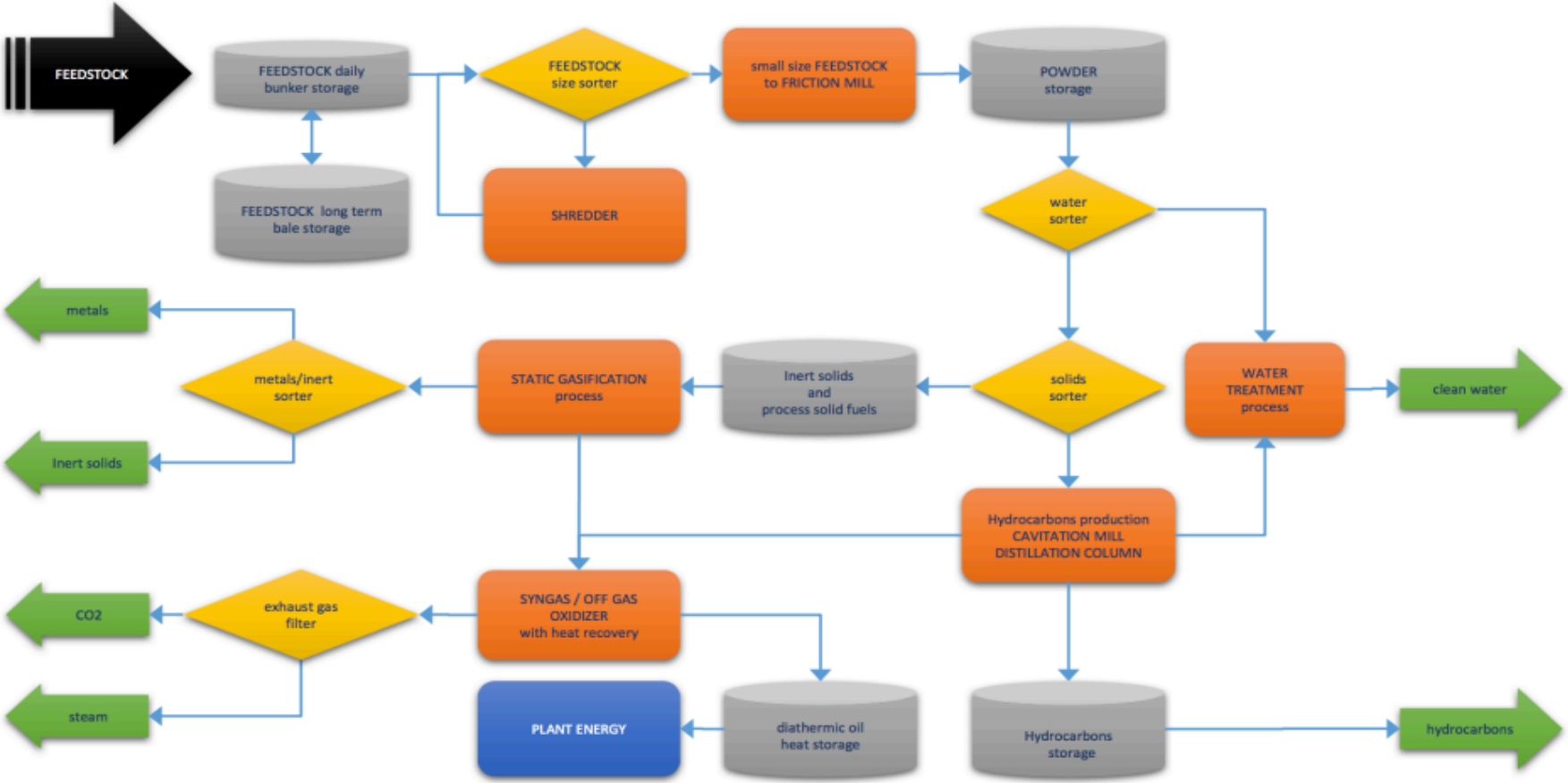
The WASTE RECOVERY BIOREFINERY



PROCESS FLOW CHART



PLANT FLOW CHART



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WASTE RECOVERY BIOREFINERY

Plant Basic Technologies

FRICTION MILL

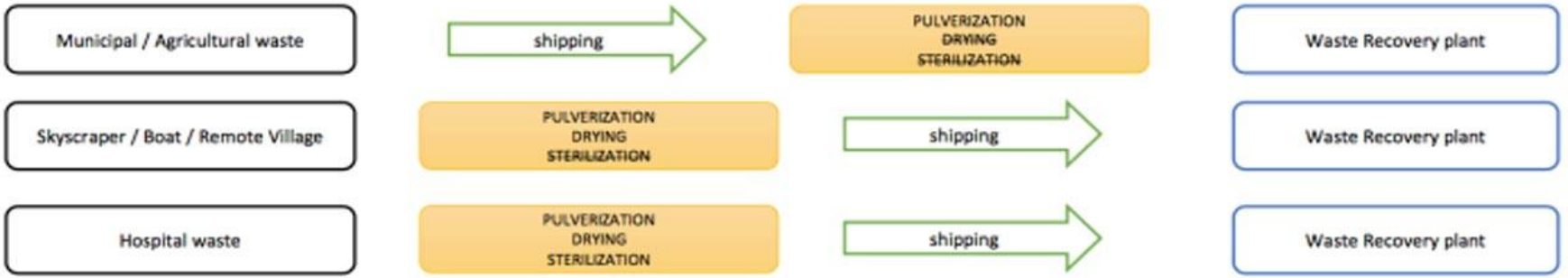
The pulverization step has the aim to mechanically transform the feedstock loaded into the plant, in a homogeneous and
small in size material.

During the step of pulverizing the feedstock:

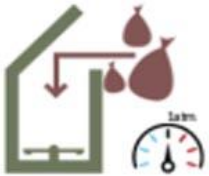
- can be reduced in volume up to 20% of the initial volume;
- can be dehydrated below the 10% of humidity;
- can be sterilized by eliminating its the bacterial load.

The treatment level depends on the nature and by the position of the raw material.
The step of pulverization can in fact be realized both in the site of the plant or close to the place of generation of the
feedstock.

FRICTION MILL



The pulverization is achieved through a closed high-speed mill, maintained below the atmospheric pressure, so as not to impair the surrounding environment during the treatment phase.



LOADING

Pulverization Drying

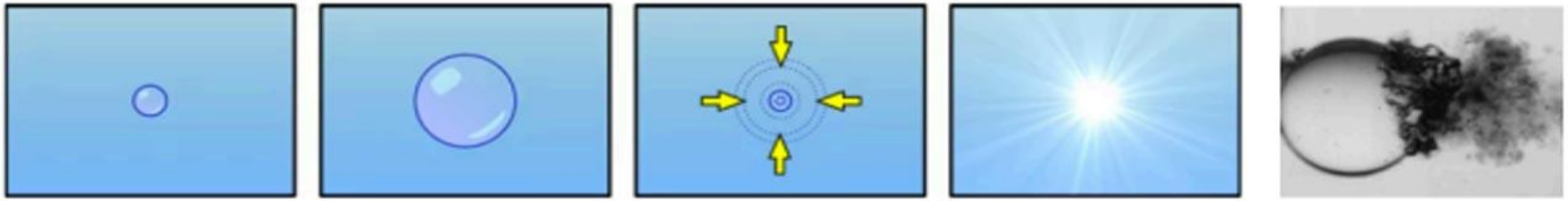
STERILIZATION

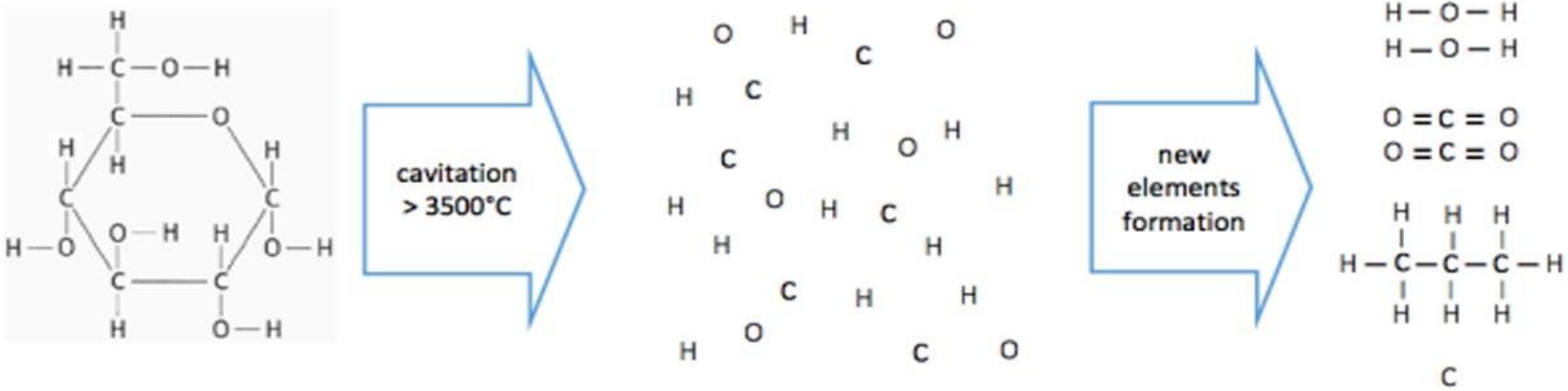
UNLOADING

CAVITATION MILL

The cavitation mill promote the formation of vaporization zones, within a fluid, induced by a mechanical action.
The cavitation process produces a local lowering of the pressure which, when it reaches the vapour pressure of the
surrounding liquid, induces the change of state of the liquid, forming bubbles of gas.
When the cavitation bubbles reach a quiet area, they tend to collapse producing very high pressures and temperatures, such
temperatures promote the breakdown of each type of bond between the molecules.
As soon as the cavitation effect end, the free atoms tend to aggregate again, pursuing the natural tendency that carries the
molecules to aggregate themselves according to the different enthalpies of formation, first the more stable (C02 and H20)
and then the more instable as the hydrocarbons

CAVITATION MILL

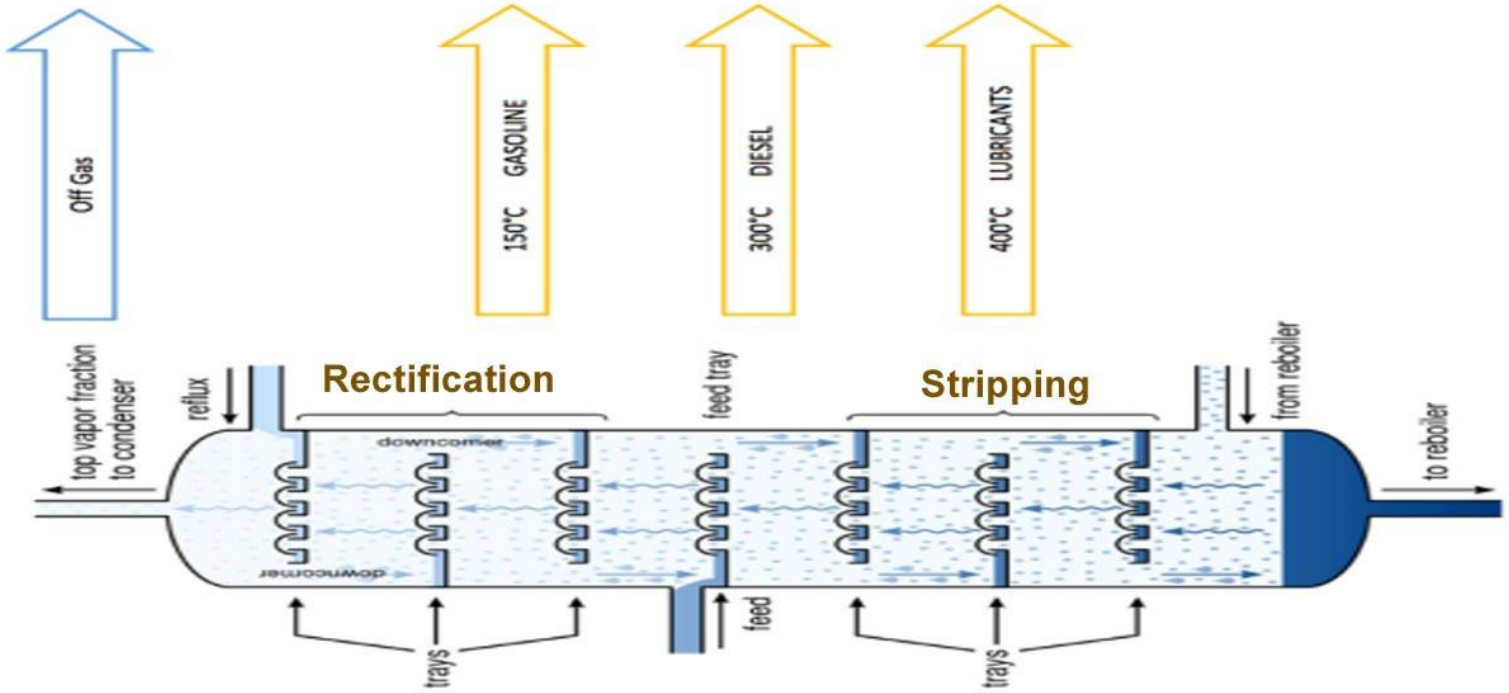




DISTILLATION

The cavitation produces a series of new molecules in the gaseous state.
The distillation phase transforms the gas into liquids, separating them according to their different boiling
points.
The technology used is the fractional distillation.
This technology, through a distillation tower containing a series of "condensing plates", separates the various
hydrocarbons as a function of their boiling point.
The non-condensable gases, essentially consisting of light hydrocarbons (C1 - C5) and carbon dioxide, are
conveyed to an oxidation system where their energy content is used to meet part of the energy requirementsof the plant.
The fraction of heavy hydrocarbons, which is not removed, is fed back into the system for thetransportation of the pulverized feedstock

DISTILLATION



GASIFICATION

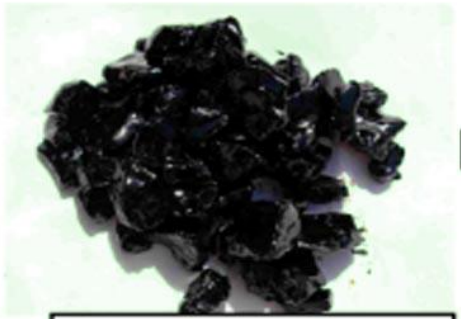
The solid fuel extracted from the system is a mixture of inert materials (silicates, minerals, metal), coal and a fraction of heavy oils.
The solid residue is treated through a low temperature static gasifier.
The gasifier transform the coal and the heavy oil fraction into syngas, maintaining the other elements unchanged.

The low temperature static gasification is a slow process that nevertheless offers several advantages:

- It produces a syngas with a high calorific value;
- It does not develop solid particulate;
- During the process, it forms a hydrogen rich environment that prevents the formation of dioxins;
- It does not modify the structure of most of the minerals;
- **It does not allow the sublimation of the metals.**

The syngas produced during the process is used to meet the energy requirements of the system.

GASIFICATION



PROCESS
SOLID FUEL

STATIC
GASIFIER

syngas

Silicates
Mineral salts
Metals

ENERGY PRODUCTION

The gasifier “syngas” and the distillation column “off gas”, provides the entire energy needs of the system.
The system requires:
- **Electrical energy for the plant auxiliary services; to power the friction and cavitation mills; for the extraction and the handling of the solid residue.**
- **Thermal energy for the evaporation of the water contained in the feedstock; for the thermal process purposes.**

In order to generate the necessary energy, the syngas from the gasifier and the non-condensable hydrocarbons from the head
of the condensation tower, are oxidized in a combustion chamber. The heat produced is subsequently used to produce
electrical energy (turbine) and to meet the thermal needs of the system.
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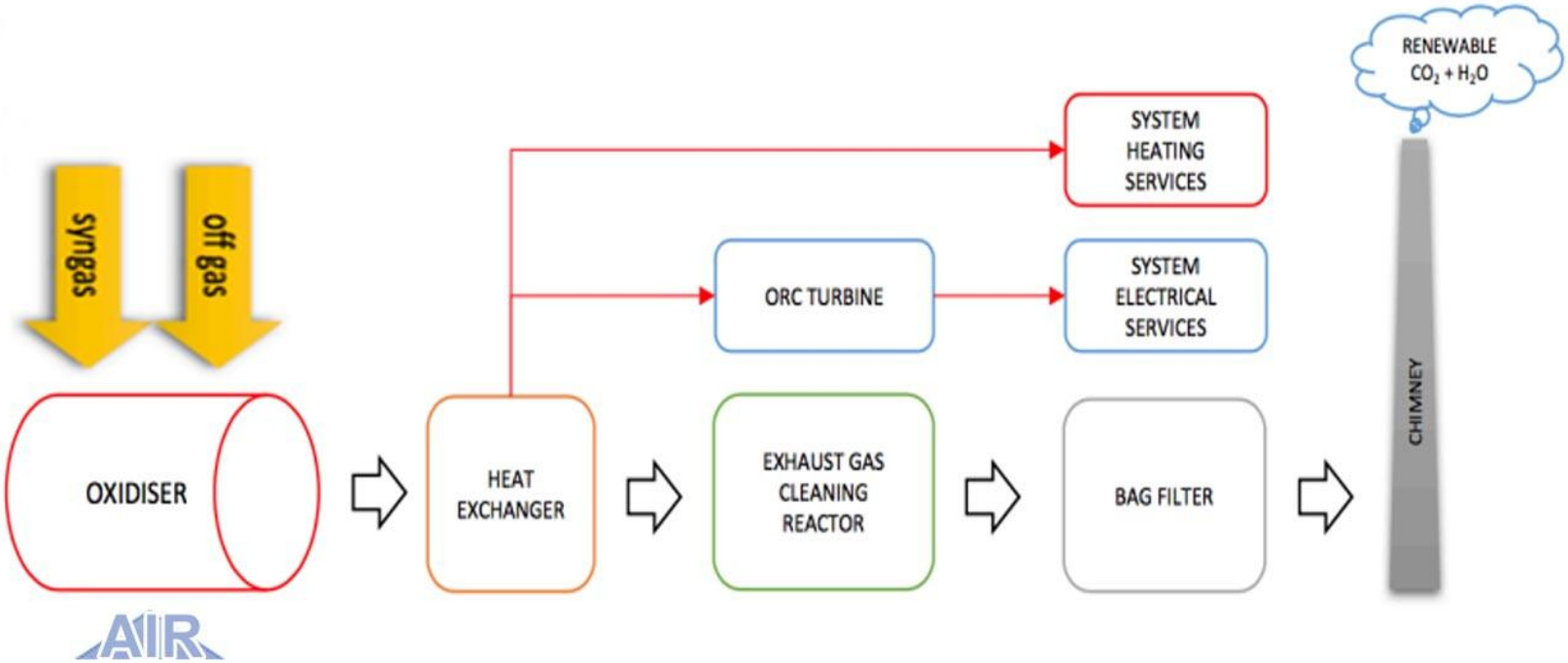
The exhaust gases coming from the combustion chamber, despite not contain solid residue as resulting from the combustion in the homogeneous phase of gases, are purified through a dry cycle that includes a dry reactor and bag filter

GASIFICATION

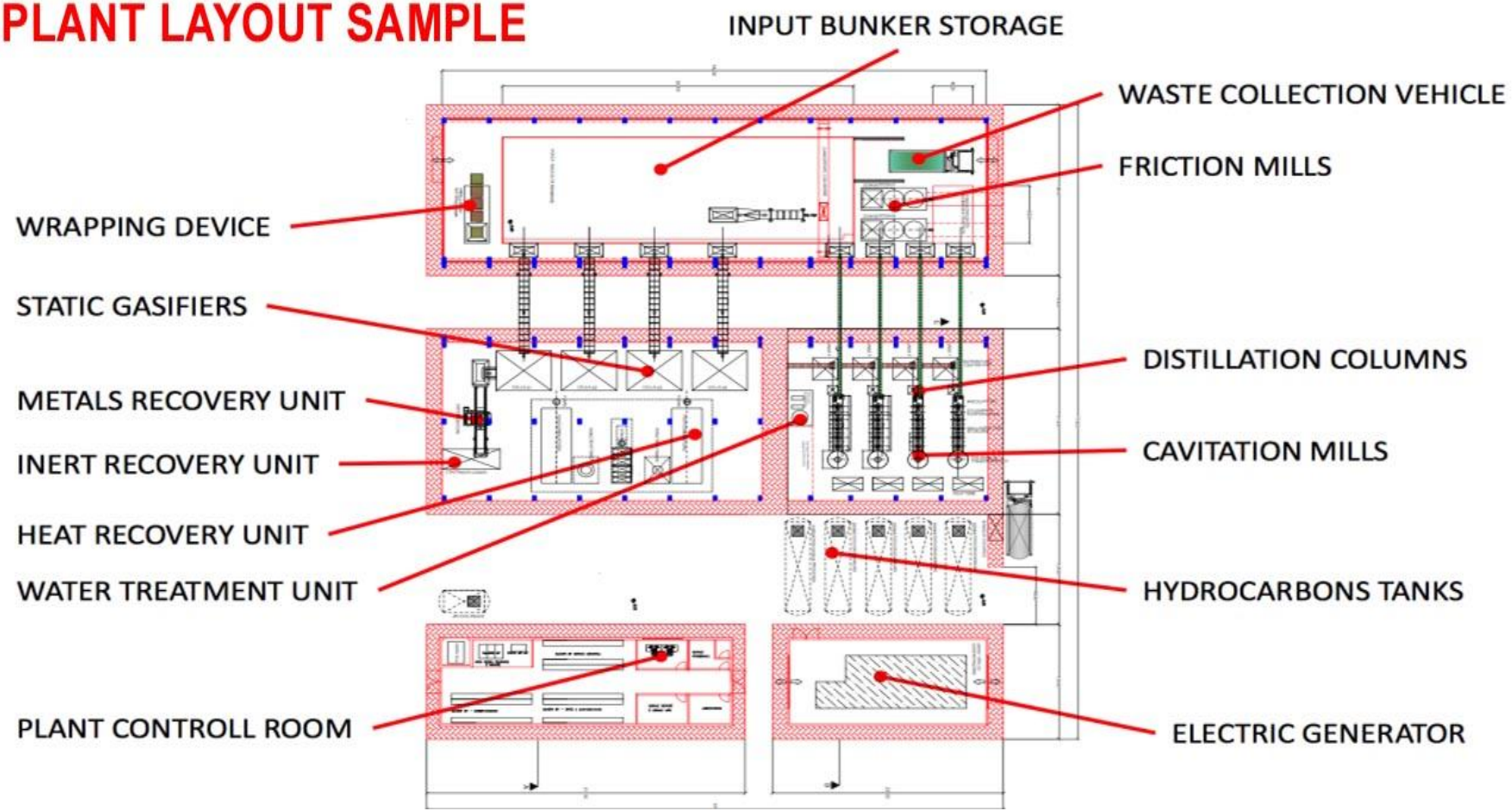


Plant Size Sample

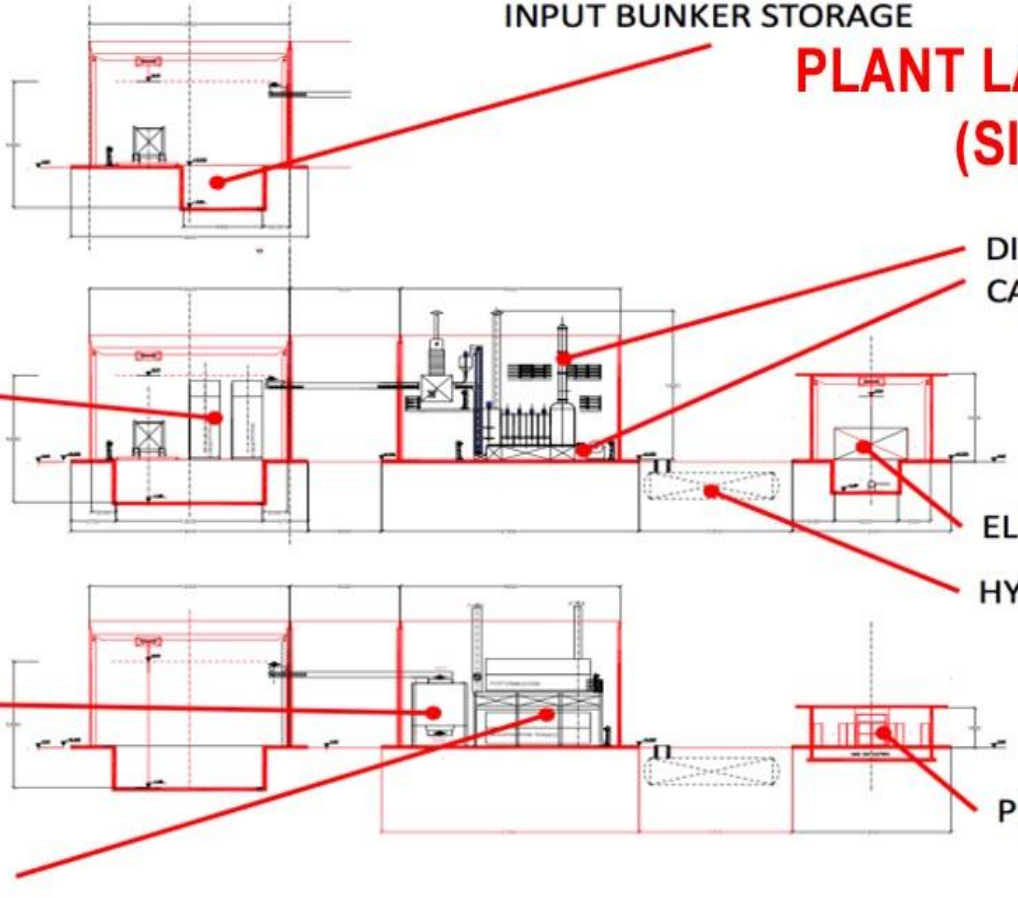
The WASTE RECOVERY PLANTS can be design according to the Customer requirements, nevertheless some sample models has been defined:

MODEL	WR 10	WR 5	WR 2.5	BR 5	BR 2.5
FEEDSTOCK TYPE	WASTE	WASTE	WASTE	BIOMASS	BIOMASS
FEEDSTOCK MAXIMUM INPUT QUANTITY (ton/h)	10.0	5.0	2.5	5.0	2.5
FEEDSTOCK MAXIMUM INPUT QUANTITY (ton/Y)	80'000	40'000	20'000	40'000	20'000
HYDROCARBON MAXIMUM PRODUCTION CAPACITY (liters/h)	1'600	800	400	800	400
METALS RECOVERY DEVICE	YES	YES	YES	NO	NO
TOTAL PLANT TECHNICAL AREA (m^2)	5'000	3'500	2'500	3'500	2'200
BUILDINGS MAXIMUM HEIGHT (m)	12	12	12	12	12
PLANT MAXIMUM HEIGHT (distillation column) (m)	16	16	16	16	16
PLANT MAXIMUM DEPTH (m)	4	4	4	4	4
TECHNICAL PERSONNEL REQUIRED PER SHIFT	6	5	4	2	2

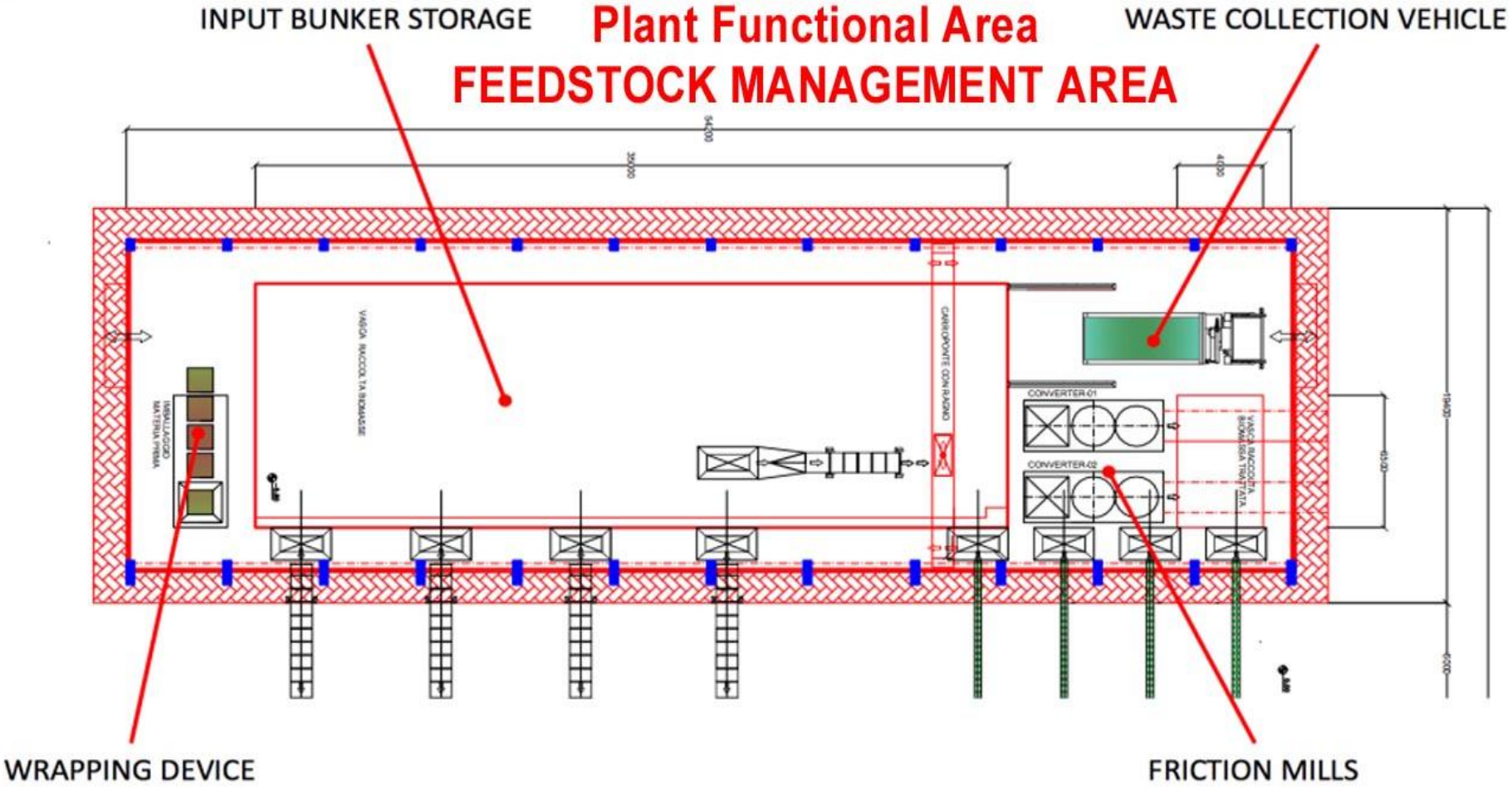
PLANT LAYOUT SAMPLE



PLANT LAYOUT SAMPLE (SIDE VIEW)



Plant Functional Area
FEEDSTOCK MANAGEMENT AREA



FEEDSTOCK MANAGEMENT AREA

The FEEDSTOCK arrives to the Waste Recovery Plant with special collecting vehicles and is loaded into a daily bunker storage.
As soon as the collecting vehicle arrives to the plant, it is identified and the door of the FEEDSTOCK MANAGEMENT AREA is opened.

The vehicle enters into the FEEDSTOCK MANAGEMENT AREA, the door is closed, and the vehicle can start the unloading operations.

The FEEDSTOCK MANAGEMENT AREA is maintained at negative pressure to avoid bad smell. The air, sucked by the area, is burned by the gasification unit.

In case of FEEDSTOCK overload, due to special events, a waste wrapping machine, able to produce more than 10 ton/h of waste bale, allows a long term storage in external areas.

Inside the FEEDSTOCK MANAGEMENT AREA, high speed FRICTION MILLS, convert all the small size FEEDSTOCK stored into powder.

FEEDSTOCK MANAGEMENT AREA

MODEL	WR 10	WR 5	WR 2.5	BR 5	BR 2.5
FEEDSTOCK MANAGEMENT AREA					
BUILDING (m^2)	1'000	1'000	500	1'000	500
FEEDSTOCK STORAGE CAPACITY (m^3)	1'700	1'700	800	1'700	800
EXTRA STORAGE WRAPPING DEVICE	YES	YES	YES	NO	NO
CRANE (4 ton)	2	2	2	1	1
RDF CONVERTER DEVICE	3	2	2	1	1

FEEDSTOCK MANAGEMENT AREA

The input storage bunker receives the waste materials by the collecting vehicles and, through appropriate devices, divide the materials to be treated.

The bunker is contained in a building with a small negative pressure to avoid bad smell.

The waste is manage through a crane that feeds the friction mills, the gasification units and the waste bale wrapping machine

FEEDSTOCK MANAGEMENT AREA- LONG TERM STORAGE STRATEGY

In case of need the plant is provided with a waste wrapping machine able to produce waste bale that can be easily store in any area.
This can be useful both for plant maintenance periods and for temporary waste overproduction connected to special local events.

FEEDSTOCK MANAGEMENT AREA- LONG TERM STORAGE STRATEGY

In case of need the plant is provided with a waste wrapping machine able to produce waste bale that can be easily store in any area.
This can be useful both for plant maintenance periods and for temporary waste overproduction connected to special local events.

FEEDSTOCK MANAGEMENT AREA- CONVERTER FRICTION MILL

The high speed friction mill transform the solid waste into a easy to manage, dry, homogeneous dust.
Through the friction mills, wastes are reduced in volume and humidity together with the elimination of any bacterial load.

LIQUID/SOLID SEPARATOR

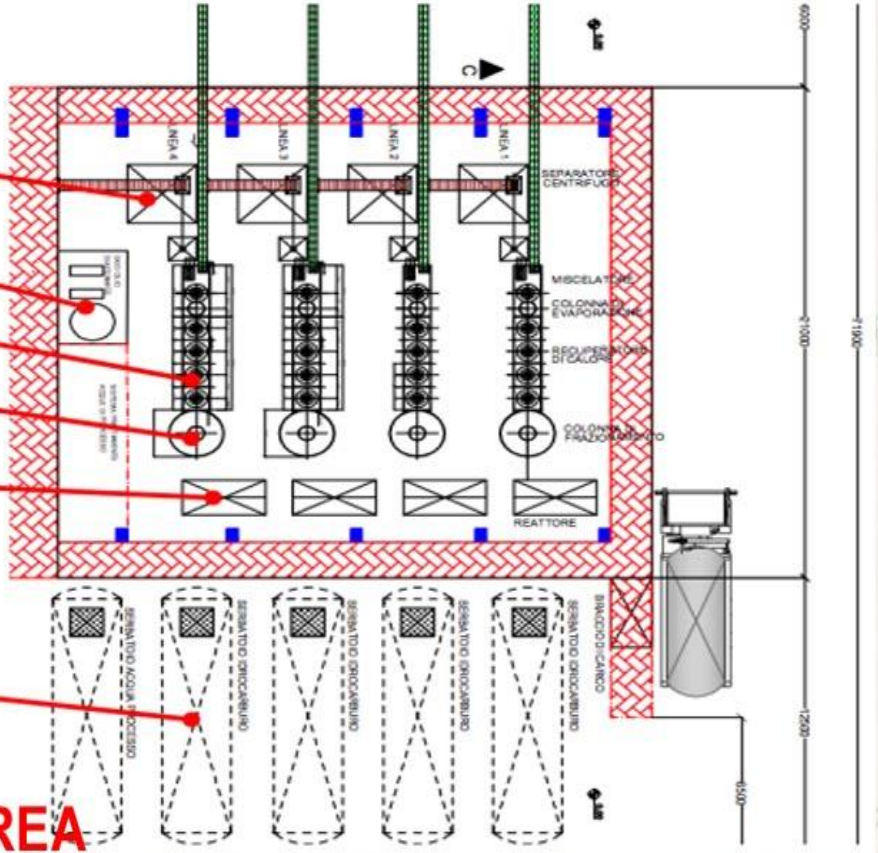
WATER TREATMENT UNIT

PRE-HEATING DEVICES

DISTILLATION COLUMNS

CAVITATION MILLS

HYDROCARBONS TANKS



HYDROCARBON PRODUCTION AREA

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WASTE RECOVERY BIOREFINERY

HYDROCARBON PRODUCTION AREA

Inside the HYDROCARBON PRODUCTION area the CAVITATIONAL MILLS units transform the powder into Hydrocarbons.

The heavy Hydrocarbons produced are recirculated inside the plant, while the light one's are extracted to be sold to the market.

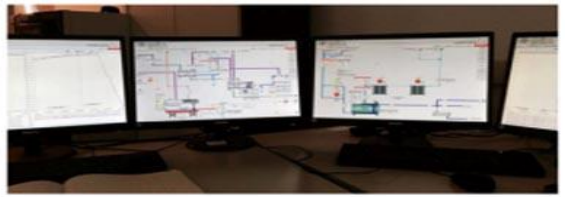
During the process, the water contained into the powder and the one that is formed during the hydrocarbons formation process, is evaporated and then treated to obtain clear water to be use for agricultural needs.

The metals and the other solids contained into the powder are separated through centrifugal devices and, together with the solid fuels formed as byproducts of the cracking process, are sent to the gasification unit to produce the energy required by the plant

HYDROCARBON PRODUCTION AREA

MODEL	WR 10	WR 5	WR 2.5	BR 5	BR 2.5
HYDROCARBON PRODUCTION AREA					
COVERED AREA (m^2)	2'000	1'200	700	1'200	700
HYDROCARBON PRODUCTION LINE	4	2	1	2	1
FUEL TANK (m^3)	400	200	100	200	100
HYDROCARBON TRUCK LOADING ARM	YES	YES	YES	YES	YES
WATER TREATMENT SYSTEM	YES	YES	YES	YES	YES
WATER TANK (m^3)	400	200	100	200	100

HYDROCARBON PRODUCTION AREA



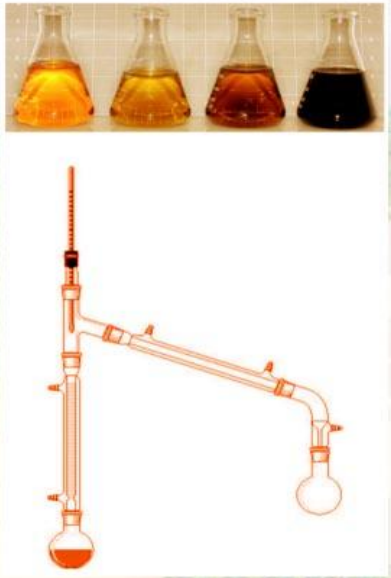
The hydrocarbons are a group of molecules containing exclusively hydrogen and carbon.

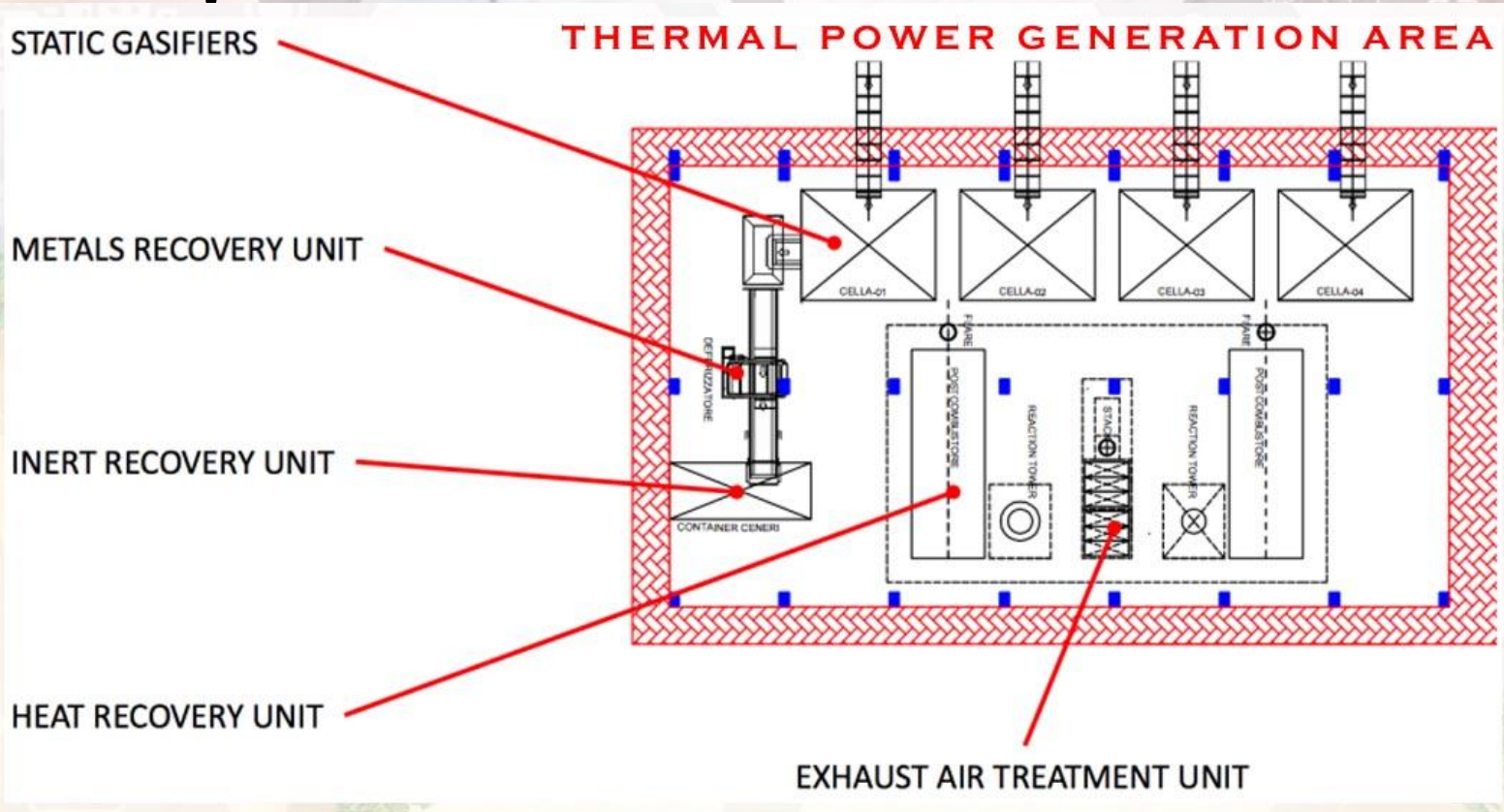
The system produces synthetic hydrocarbons having chemical and physical characteristics similar to the one of fossil origin.

HYDROCARBON PRODUCTION AREA - FUEL CHARACTERISTICS

The hydrocarbons produced by the plant have the following characteristics:

Parameter	Unit	Value
Density @ 15°C	Kg / m^3	830 - 860
Viscosity @ 40°C	mm^2 / s	3 - 11
Water	% v / v	0.01 - 0.1
Carbon residue	% m / m	0.15 - 0.30
Sulfur	% m / m	0.30 - 0.60
Ash	% m / m	< 0.01
FAME content	% v / v	0.25 - 3.50
Metals contamination	mg / kg	< 1
Lubricity	μm	220 - 300
Net specific energy	MJ / kg	42 - 43




THERMAL POWER GENERATION AREA
STATIC GASIFIERS
METALS RECOVERY UNIT
INERT RECOVERY UNIT
HEAT RECOVERY UNIT
EXHAUST AIR TREATMENT UNIT
CELLA-01
CELLA-02
CELLA-03
CELLA-04
DEFANGATORE
CONTAINER CENERI
REACTION TOWER
REACTION TOWER

THERMAL POWER GENERATION AREA

The THERMAL POWER GENERATION AREA through a static gasifier transforms in syngas the solid fuels arriving from the cracking area and the large size portion of the FEEDSTOCK.

The syngas is burned into a gas burner at more than 900°C for more than 2 seconds, and the heat is stored inside a diathermic oil at 350°C.
During the GASIFICATION process, performed at 400°C of temperature for more than 20 hours, the solid components inside the gasification chamber are cleaned and deprived by any organic content.

The metals and the other solids are recovered through an appropriate metals separator.

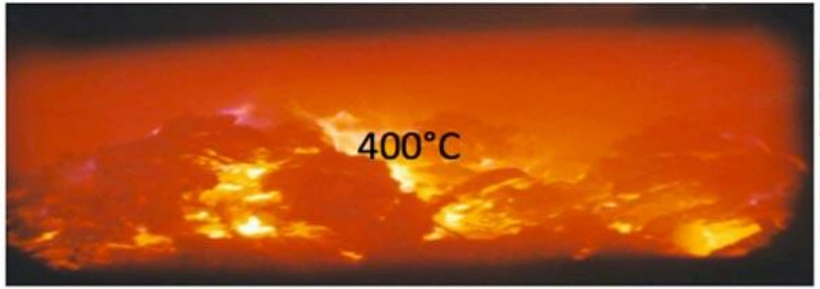
The gasification technology that has been selected is the “static gasification technology”.
This technology doesn’t allow the formation of any dioxins and produce a very clean syngas because the feedstock is managed by the gasifier without moving it, avoiding the production of any particulate

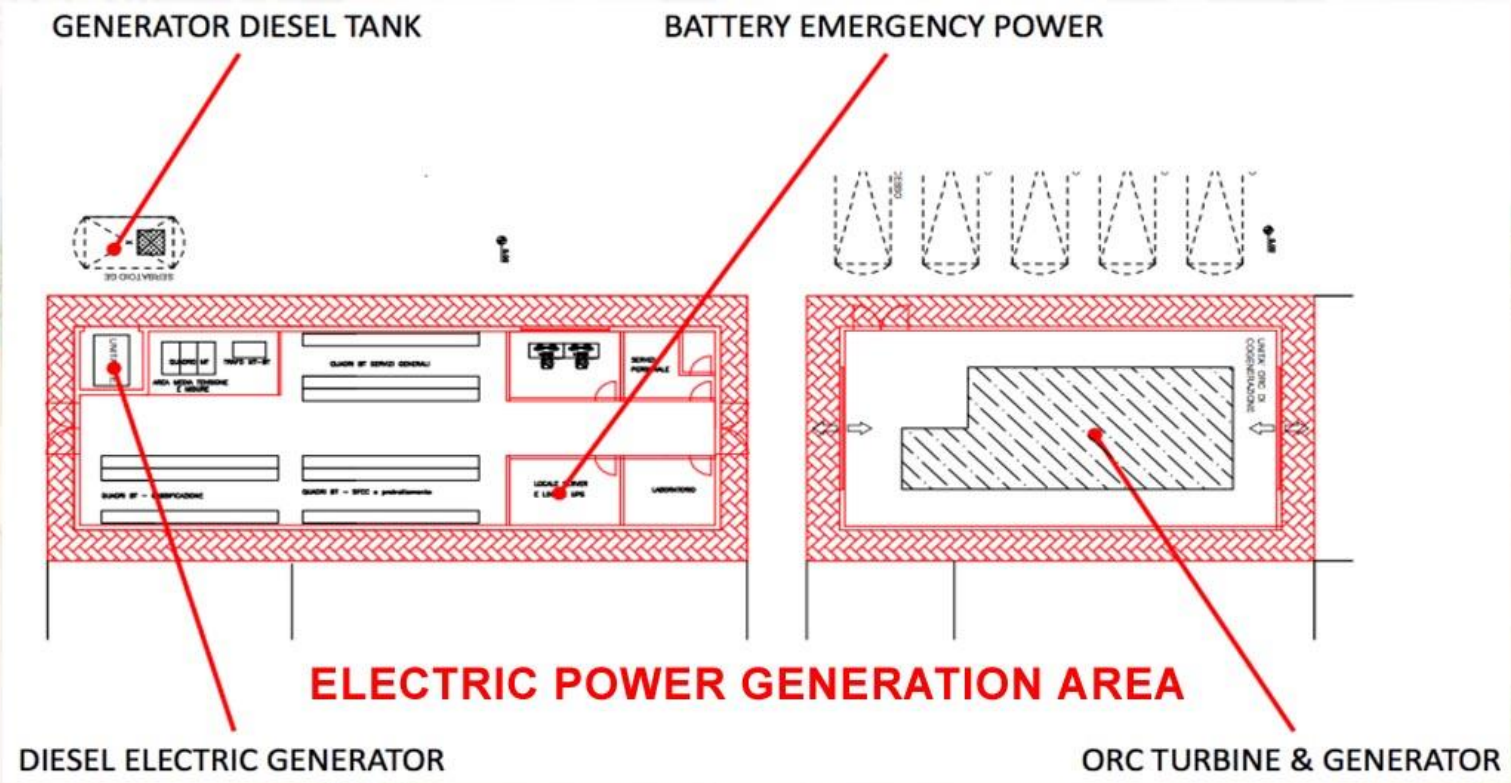
THERMAL POWER GENERATION AREA

MODEL	WR 10	WR 5	WR 2.5	BR 5	BR 2.5
THERMAL POWER GENERATION AREA					
COVERED AREA (m^2)	1'300	700	700	700	500
GASIFICATION CELLS	4	2	2	2	1
HEAT RECOVERY UNIT	2	1	1	1	1
EXHAUST AIR TREATMENT UNIT	YES	YES	YES	YES	YES
RESIDUAL ASH CONTAINER	6	3	3	1	1

THERMAL POWER GENERATION AREA

The gasification is the partial oxidation of organic material at low temperature that converts the processed material to synthetic gas (syngas) and inert ash. The Static Gasification is a valid and cheap system to convert biomass and waste, into thermal energy




GENERATOR DIESEL TANK
BATTERY EMERGENCY POWER
ELECTRIC POWER GENERATION AREA
DIESEL ELECTRIC GENERATOR
ORC TURBINE & GENERATOR

ELECTRIC POWER GENERATION AREA

The ELECTRIC POWER GENERATION AREA recover the heat provided by the combustion of the syngas and supply the plant with the totality of the electric energy required.

The technology used to produce electric energy is the Organic Rankine Cycle Technology.
ORC technology is similar to a traditional steam turbine, but with a single, important difference.
Instead of using water vapor, the ORC system vaporizes a high-molecular-mass organic fluid, resulting in excellent electric performance and several key advantages: slower turbine rotation, lower pressure and no erosion of metallic parts and blades.

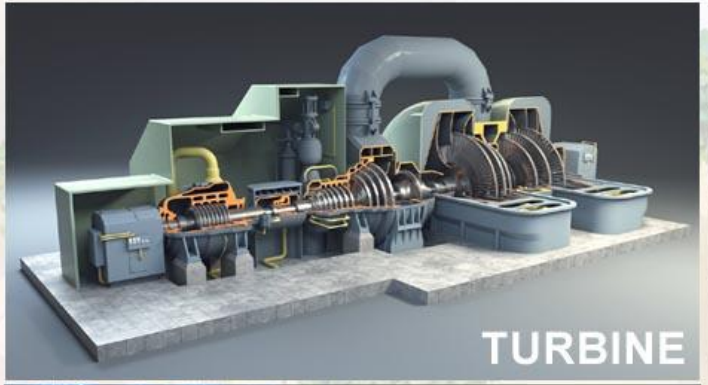
This technology allow the plant to use very low pressure reducing the related risks.
In addition to the power produced by the ORC turbine, the plant is equipped with a standard diesel generator producing enough energy to start up the system from a complete stop condition.

For emergency purpose the plant is equipped with a battery UPS having the required power to place the plant in a safe configuration in case of a lack of the other power sources.

ELECTRIC POWER GENERATION AREA

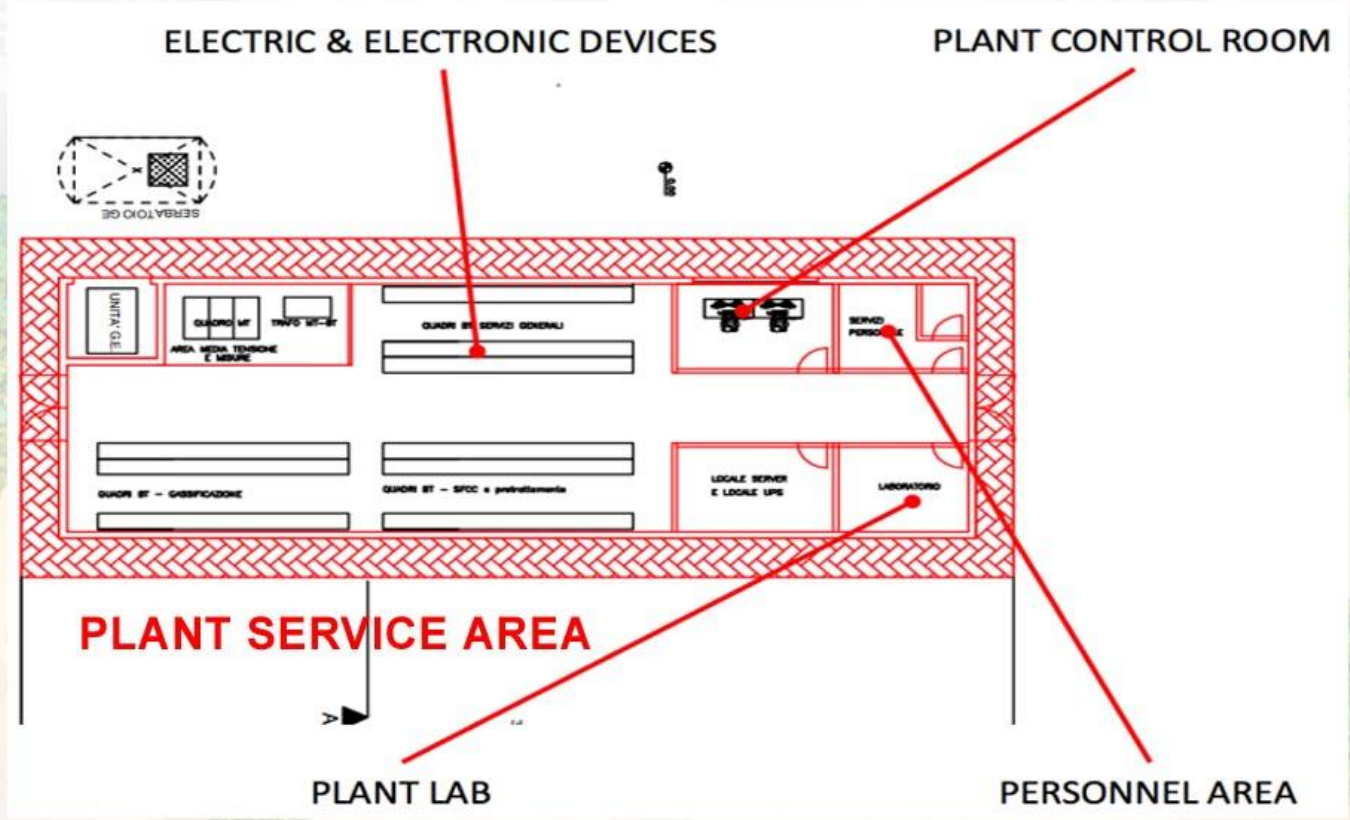
MODEL	WR 10	WR 5	WR 2.5	BR 5	BR 2.5
ELECTRIC POWER GENERATION AREA					
BUILDING (m^2)	200	200	200	200	200
ORGANIC RANKING CYCLE TURBINE & GENERATOR (MW)	1.1	0.6	0.3	0.6	0.3
DIESEL ELECTRIC GENERATOR (kW)	300	300	150	150	150
BATTERY EMERGENCY POWER (UPS)	2	2	1	1	1

ELECTRIC POWER GENERATION AREA



The plant produces 100% of its electric energy needs through:

- a primary ORC turbine generating the plant required power using the plant waste heat
- a diesel generator to provide the plant start up energy
- a battery back up energy UPS for emergency use


ELECTRIC & ELECTRONIC DEVICES
PLANT CONTROL ROOM
PLANT SERVICE AREA
PLANT LAB
PERSONNEL AREA

PLANT SERVICE AREA

The PLANT SERVICE UNITS are mostly positioned close the control room building, nevertheless some devices are positioned in different position inside the plant area.

Among the PLANT SERVICE:

The PLANT CONTROL ROOM, remotely connected, monitors any plant activity.

The PLANT LAB, contain the required devices to analyze both the plant input and output.

The EMERGENCY devices, including the safety tanks for oils, the inert gas generators, the fire protection systems.

The plant personnel private area.

In the larger plants one infirmary shelter

PLANT SERVICE AREA

MODEL	WR 10	WR 5	WR 2.5	BR 5	BR 2.5
PLANT SERVICES					
BUILDING (m^2)	500	400	400	400	300
PLANT CONTROL ROOM	YES	YES	YES	YES	YES
PLANT ELECTRIC & ELECTRONIC DEVICES ROOM	YES	YES	YES	YES	YES
PLANT LAB	YES	YES	YES	YES	YES
PLANT PERSONNEL PRIVATE AREA	YES	YES	YES	YES	YES
EMERGENCY OIL COLLECTION VESSEL	YES	YES	YES	YES	YES
EMERGENCY NITROGEN GENERATOR & STORAGE	YES	YES	YES	YES	YES
EMERGENCY FIRE PROTECTION SYSTEM	YES	YES	YES	YES	YES
INFIRMARY SHELTER	YES	YES	NO	NO	NO

In Addition

- A portable unit (seacan) is a viable option for the waste reduction component of the process.
- The converter is able to go onto ships, hospitals, trucks, and much more!