Municipality of Kirkuk

SOCRAM MECCANICA
ATTREZZATURE E VEICOLI PER L'IGIENE URBANA

Proposal planning for 800 tons/day WASTE (1.000.000 inhabitants) in order to provide an Integrated System as Waste Life Cycle Assessment

Index

Summary

1. **Additional waste sorting**
2. **Production of biogas from anaerobic composting plant**
3. **Gasification or pyrolysis of the dry part for Syngas production**
4. **Conversion of gas to energy**

The data reported in this presentation are calculated on the basis of our European experience (CSS class I and II) and will only be confirmed following a thorough check and study on site.

As a result of this it can also be varied some processes and prices in order to obtain finally the maximum of electricity production.

Introduction

The present study describes in detail the operation made on solid waste treatment that the Administration is looking to realize on his own island territory in order to adjust his own waste treatment on line with the European standard.

The plant is designed as an integrated waste system treatment in a way to permit to manage more garbage fractions with the following processes:

a) Mechanical selection is realized in order to produce underscreen selection with a predominant organic matrix, and overscreener selection to recover plastic containers, in order to produce RDF size < 40 mm;

b) dry anaerobic digestion of the predominantly organic matrix fraction by mechanical selection (primary underscreen) and MSW; with biogas production;

c) bio-stabilization and biodrying of the anaerobic treatment residue called “digestate”;

d) refinering FOS and compost.

The complete size of the project is able to treat **260.000. tons per year.**

Technically the system is characterized by compliance with EU directives on the treatment of organic waste and reducing the volume and hazard of the materials should be disposed of in landfills.

Project Data

About the design size by proposed system we have been taken as reference data the foreseen Plan on the forecast trend growth as maximum production by the municipal waste production and sewage sludge over a period of 20 years.

In following there are the operating system terms:

- Working days for year n. 312
- Working days for week n. 6
- Mechanical shift for day n. 2
- Operational biological treatment shift for day n. 1
- Hours per shift day n. 7

Waste delivered:

- Municipal Waste ton / year 260.000

Full lines of treatment:

By the project the foreseen waste quantity amount able to be treated by the plant has the following details of the lines of treatment:

- Nominal capacity of the mechanical section: ton / year 260.000
- Nominal capacity of the biological section: ton / year 120.000
- Ton capacity compost refining ton / year 40.000

Process Description

The treatment plant covers a **total area of 90.000 square meters**, completely fenced and it is accessible through doors either located on side of the property, linked by internal roads.

The lay-out of the various sections of the system within the area were studied in accordance with the general criteria of safety in order to obtain the best exploitable space in relation also to the flows of material to be handled.

In this way we realize safe circuit for vehicle and materials.

In the central area, means a total area of 90.000 square meters, are located the buildings which accommodate the functional sections of the system as they are summarized below.

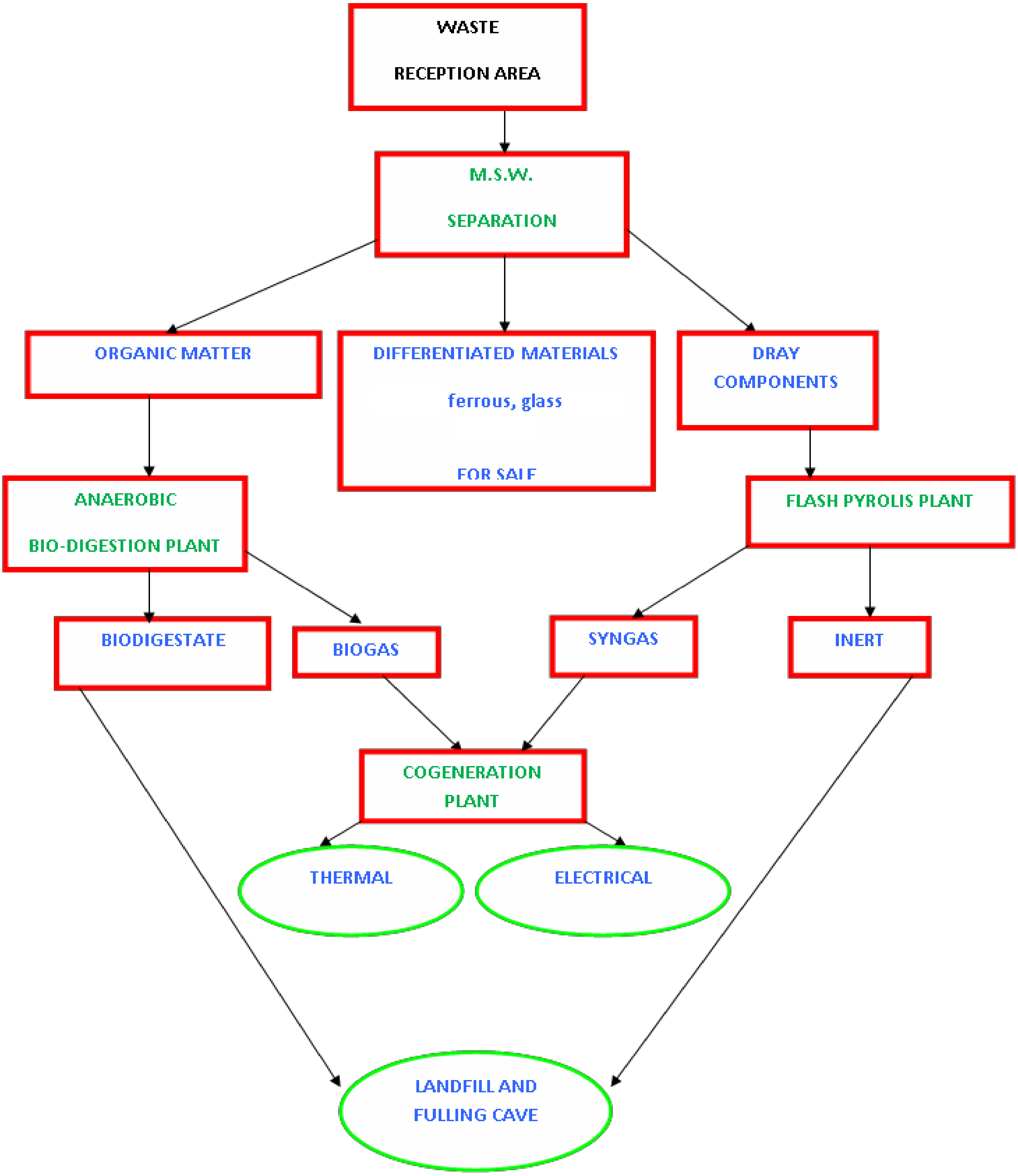
Treatable Materials

The materials can be treated by our plants are numerous both organic kind and inorganic kind such as:

- Municipality solid waste
- Toxic waste, dangerous waste and hospital waste
- Plastic waste
- OPSUW (Organic Portion Solid Urban Waste)
- Tires and rubber
- Agricultural organic and inorganic rejects, industrial organic and inorganic rejects



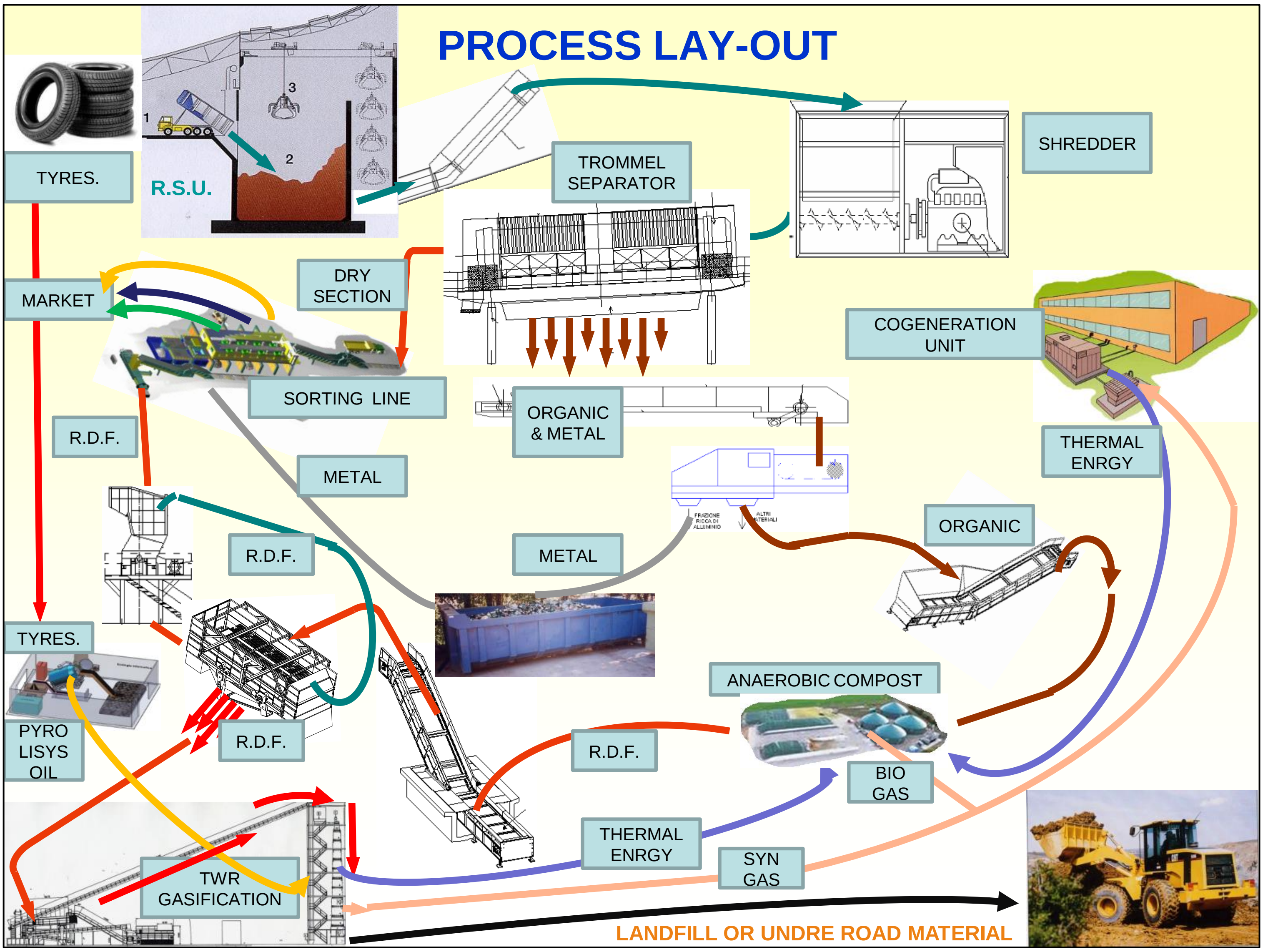
BIOMEDICAL WASTE
KEEP CLEAR
CAUTION
BIOMEDICAL WASTE


WASTE
RECEPTION AREA
M.S.W.
SEPARATION
ORGANIC MATTER
DIFFERENTIATED MATERIALS
ferrous, glass
FOR SALE
DRAY
COMPONENTS
ANAEROBIC
BIO-DIGESTION PLANT
FLASH PYROLIS PLANT
BIODIGESTATE
BIOGAS
SYNGAS
INERT
COGENERATION
PLANT
THERMAL
ELECTRICAL
LANDFILL AND
FULLING CAVE

Technical description of the global process

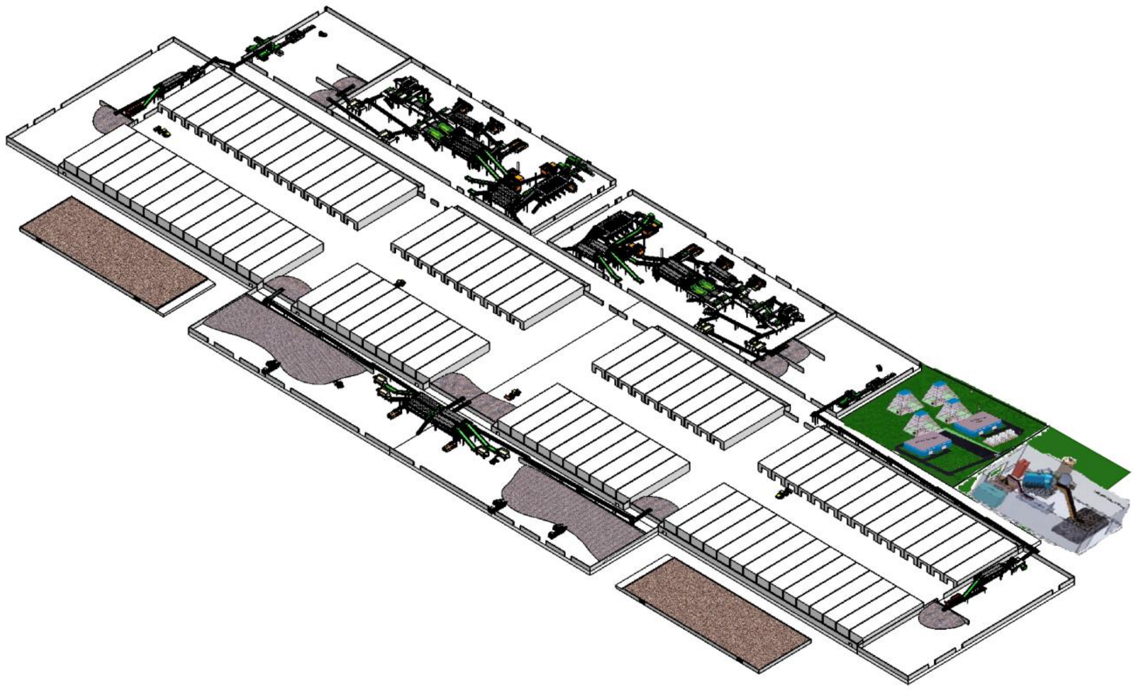
The plant, after the entrance gate, starts with a large square for the movement of the means of collection and of disposal of waste.

If these wastes are collected "as they are" without selective collection, they, by the means of collection, are downloaded directly into special pits. While, if it is already done a recycling collection, the sack of the undifferentiated follows the road of the previous point in the pits. The differentiated waste collection, such as wet, plastics, iron, glass and paper will have their very precise and specific collection points. As well as for any collections of special materials such as tires, refrigerators, electrical appliances in general, used oil, electric batteries, etc. ...

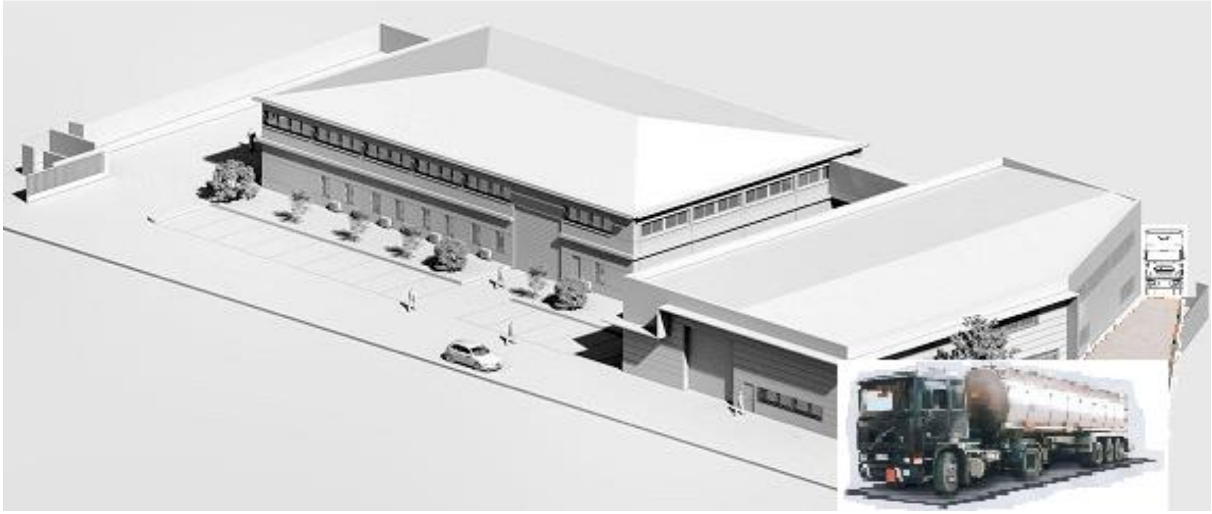


Waste road map in the plant:

1) Reception building with weight bridge office and workers area
2) Loading cell stoking area
3) Pretreatment area open sac and primary shredder
4) Sorting line
5) Compost plant
6) Gasification plant
7) Cogeneration Plant
8) Bailer unit for raw materials or in order to stock material waiting gasification process

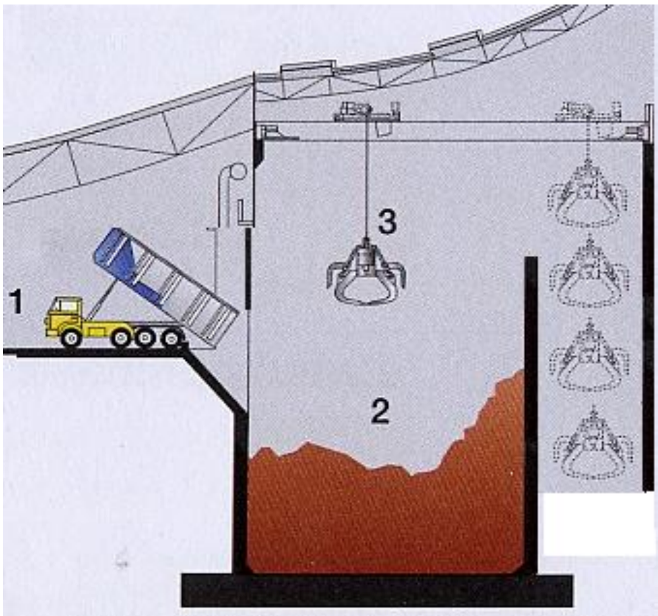


1) Reception building with weight bridge office and workers area

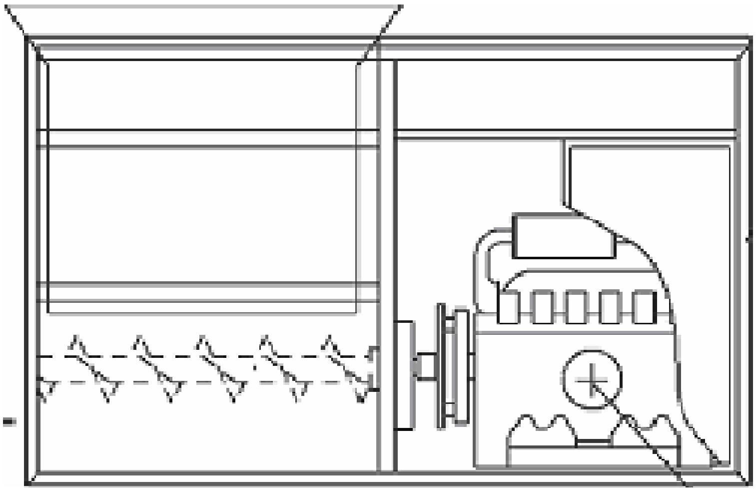


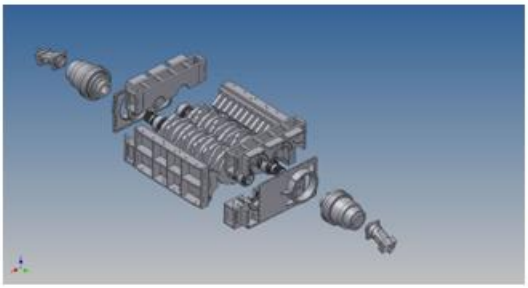
ANALYSIS LABORATORY To VERIFY INPUT MATERIALS AND COMPOS TQUALITY

2) Loading cell stoking area



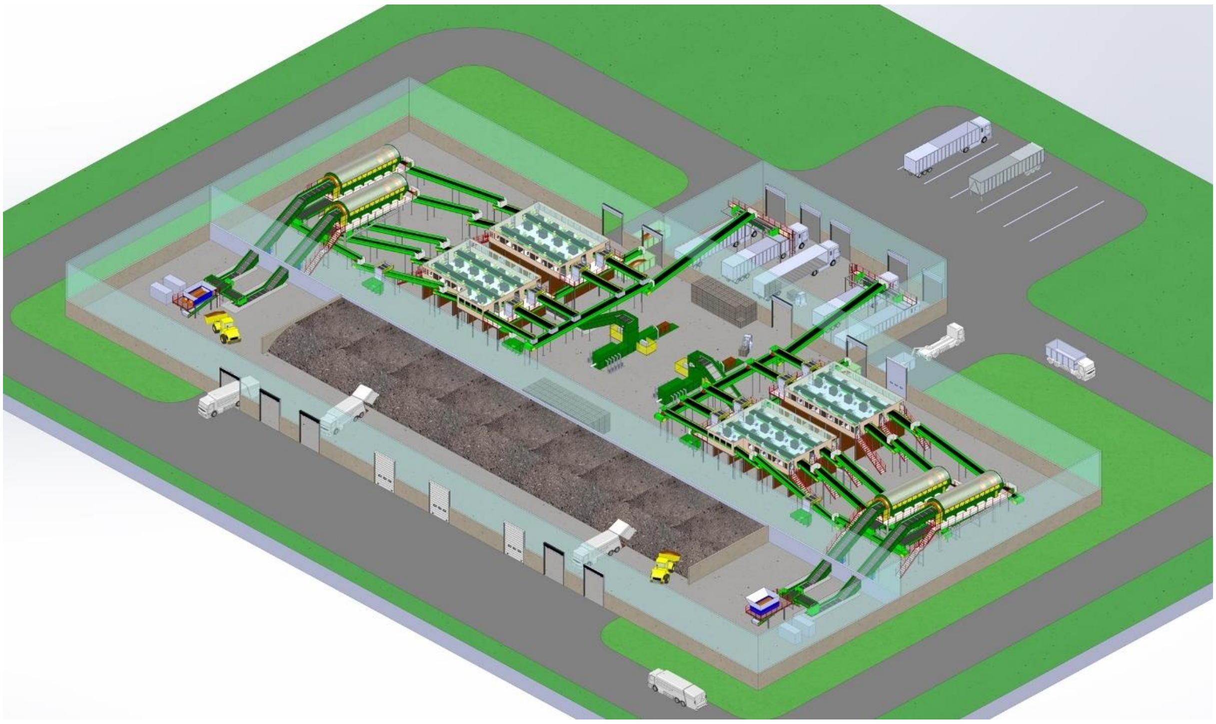
3) Pretreatment area open sac and primary shredder

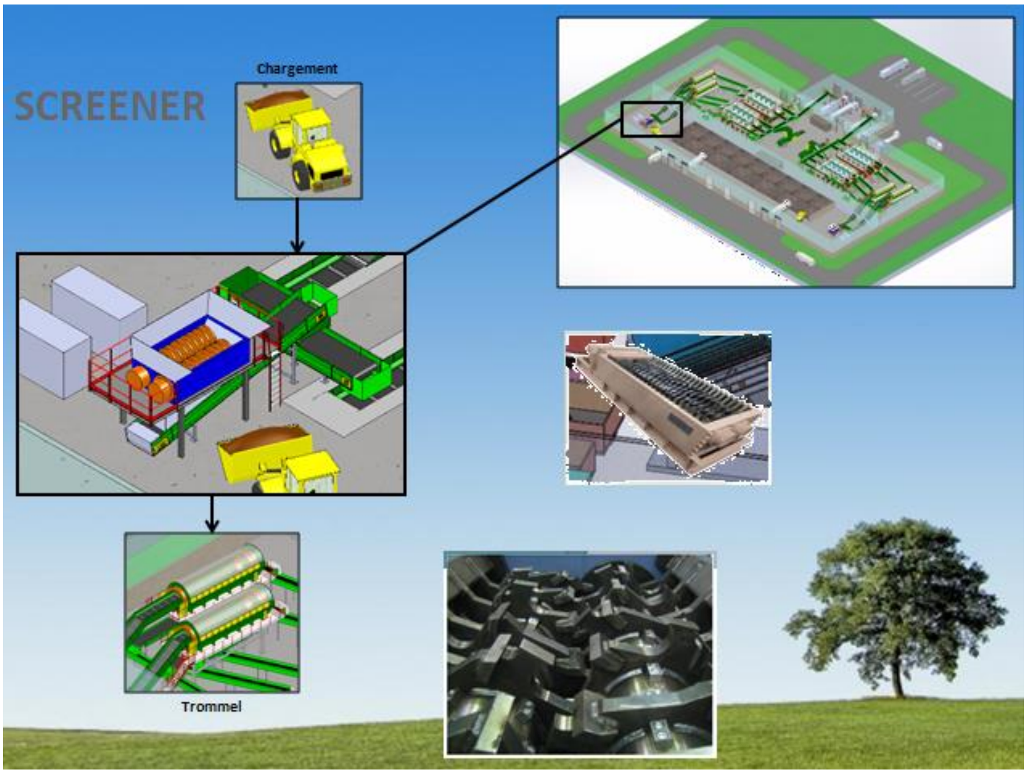



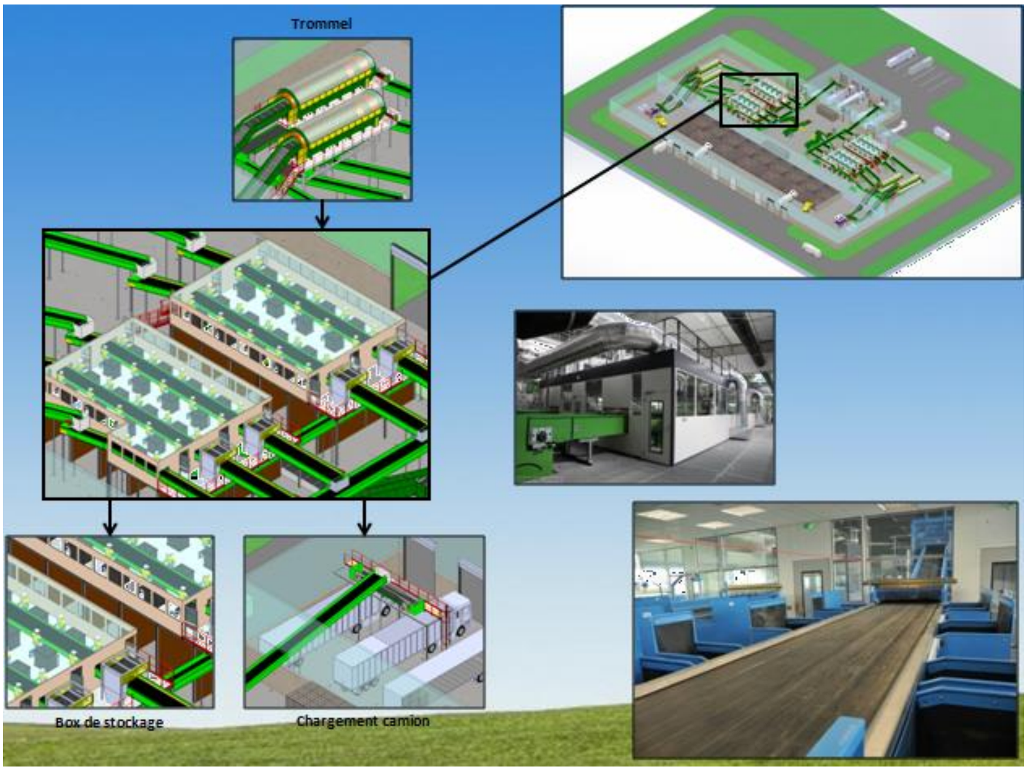

PRIMARY SHREDDER

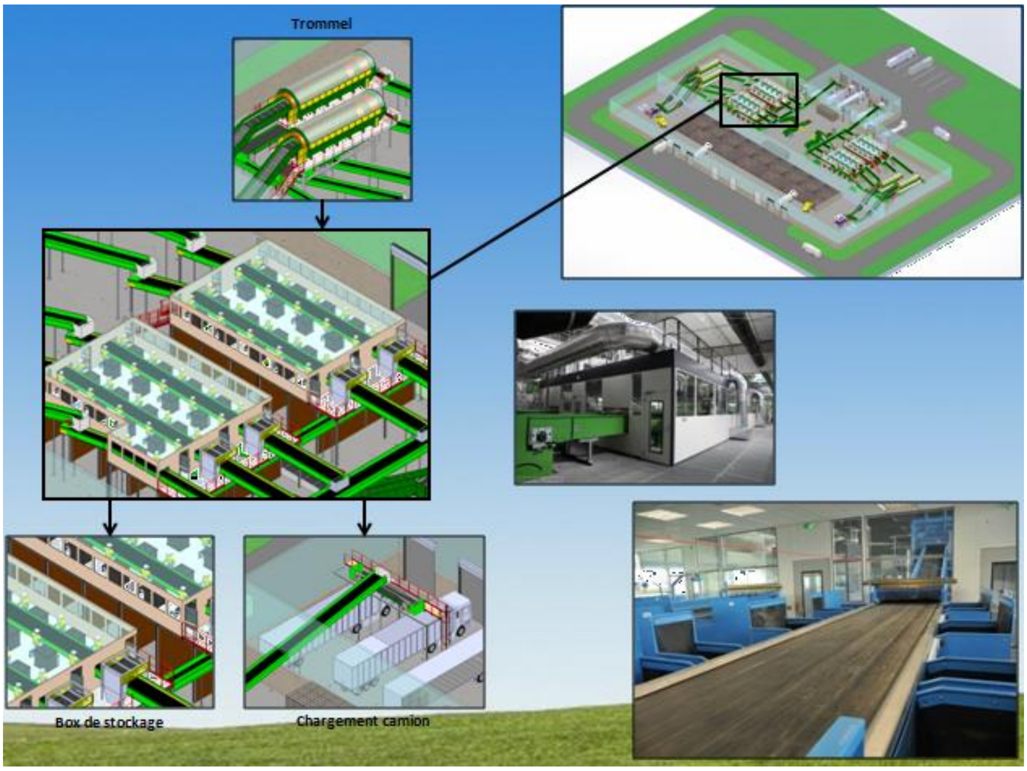
4) Sorting line

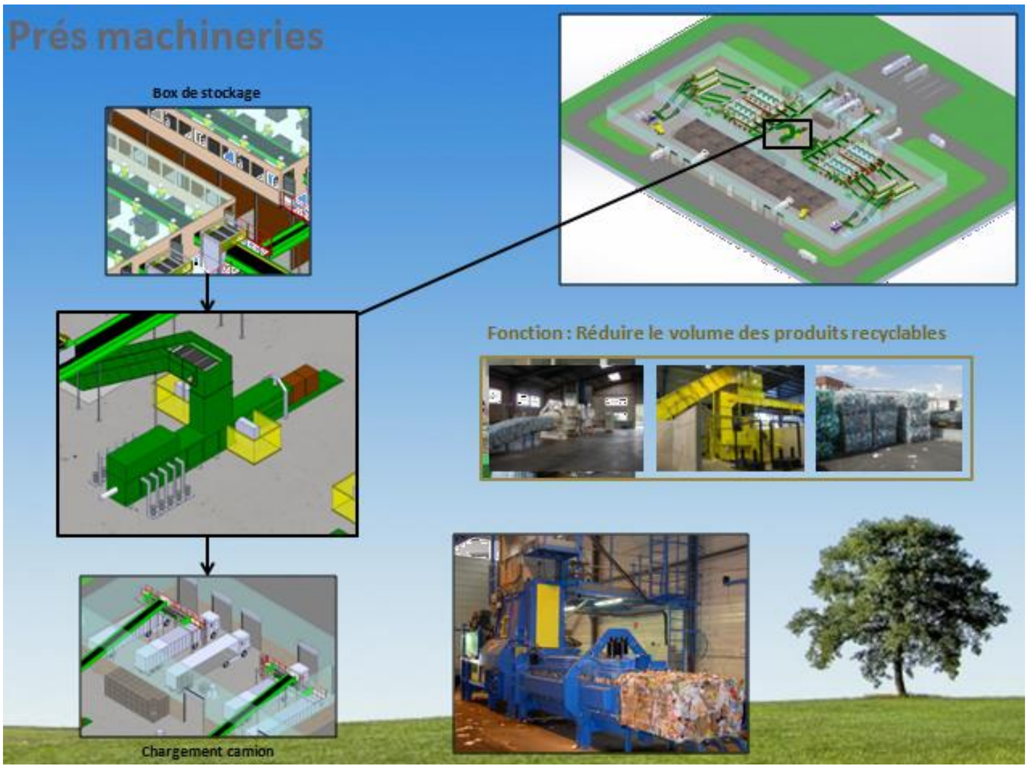


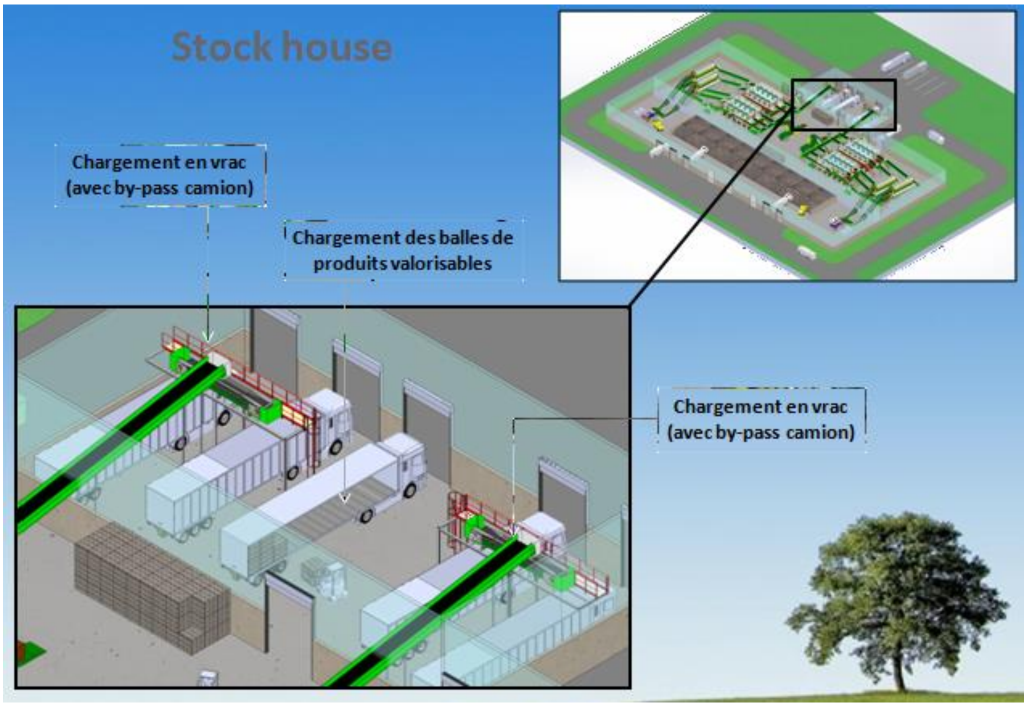

SCREENER
Chargement
Trommel

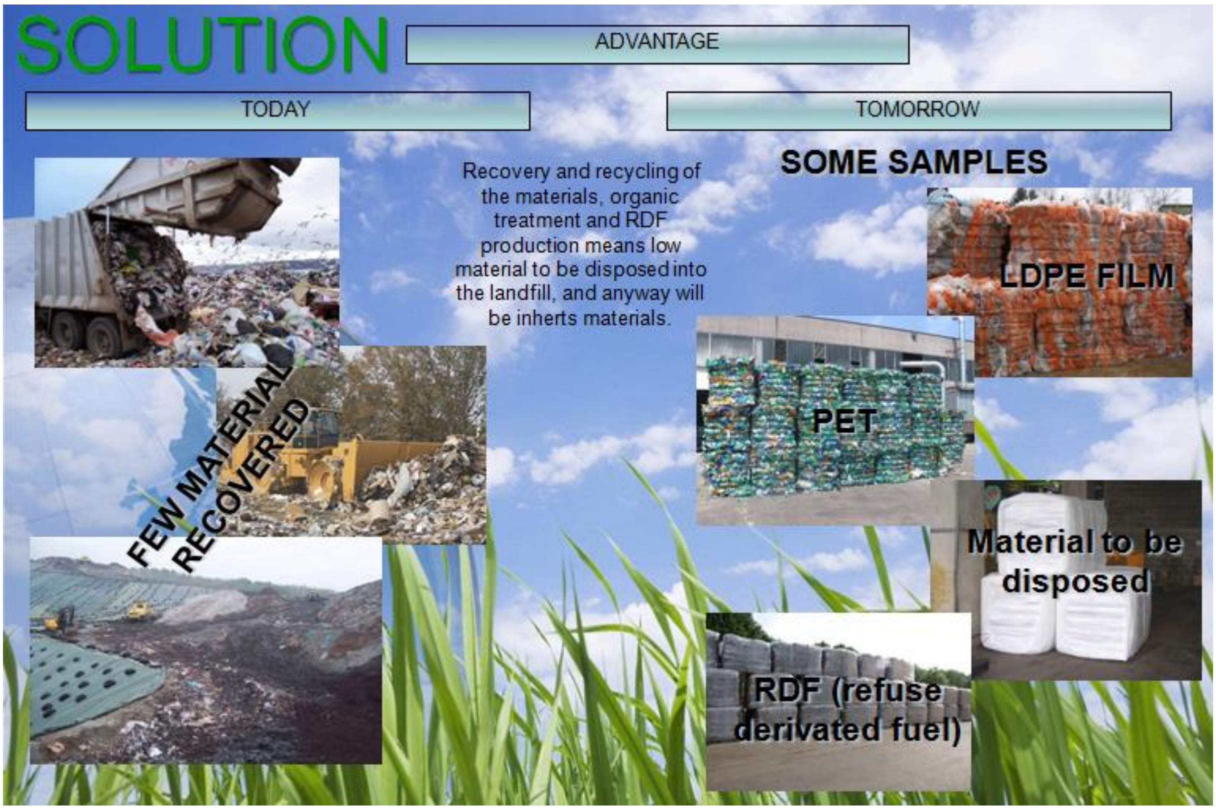

Trommel
Broyeur
Dimensions Ø2500 x 10 m de criblage
Fonction : Séparation granulométrique en 3 fractions
- 0/100 mm (Fraction organique)
- 100/200 mm
- >200 mm
Tri manuel


Trommel
Box de stockage
Chargement camion


Trommel
Box de stockage
Chargement camion


Prés machineries
Box de stockage
Fonction : Réduire le volume des produits recyclables
Chargement camion


Stock house
Chargement en vrac
(avec by-pass camion)
Chargement des balles de
produits valorisables
Chargement en vrac
(avec by-pass camion)


SOLUTION
ADVANTAGE
TODAY
TOMORROW
SOME SAMPLES
Recovery and recycling of the materials, organic treatment and RDF production means low material to be disposed into the landfill, and anyway will be inherts materials.
FEW MATERIAL RECOVERED
LDPE FILM
PET
Material to be disposed
RDF (refuse derivated fuel)

5) Compost plant

Waste Treatment Plant integrated system for anaerobic digestion – biostabilization biodrying with R.D.F. production

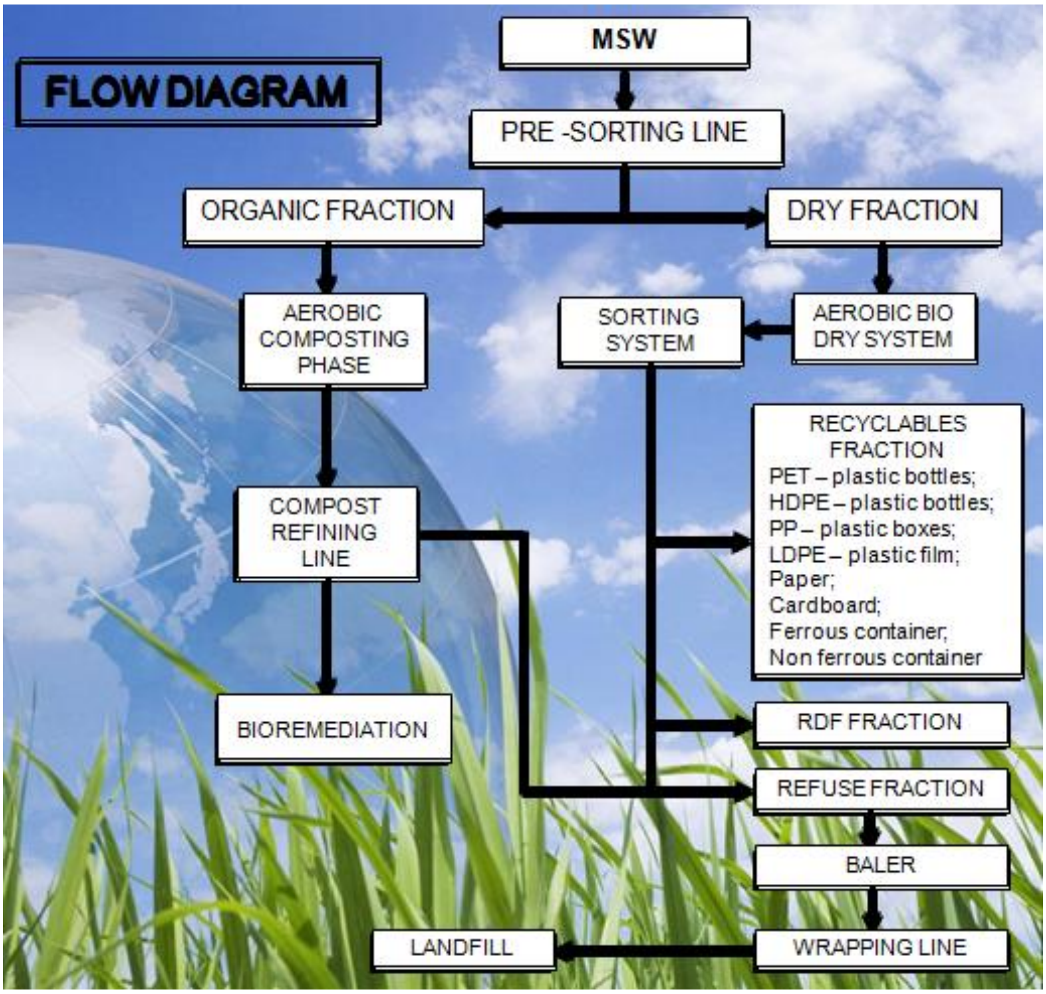
After the discharge hopper there is the separation system which separates, in a first phase, the organic (food, plant and animal waste, etc. ...) which, together with any OFMSW (Organic Fraction of Municipal Solid Waste) if there is a possible separate wet collection, which ends, suitably treated, in a system of multi-stage anaerobic bio-digestion that as products at the end of the process has: the biogas, which we will see later as it will be used, and the bio digestion, that is the part of material that microorganisms are not able to dissociate up to the level of gas.

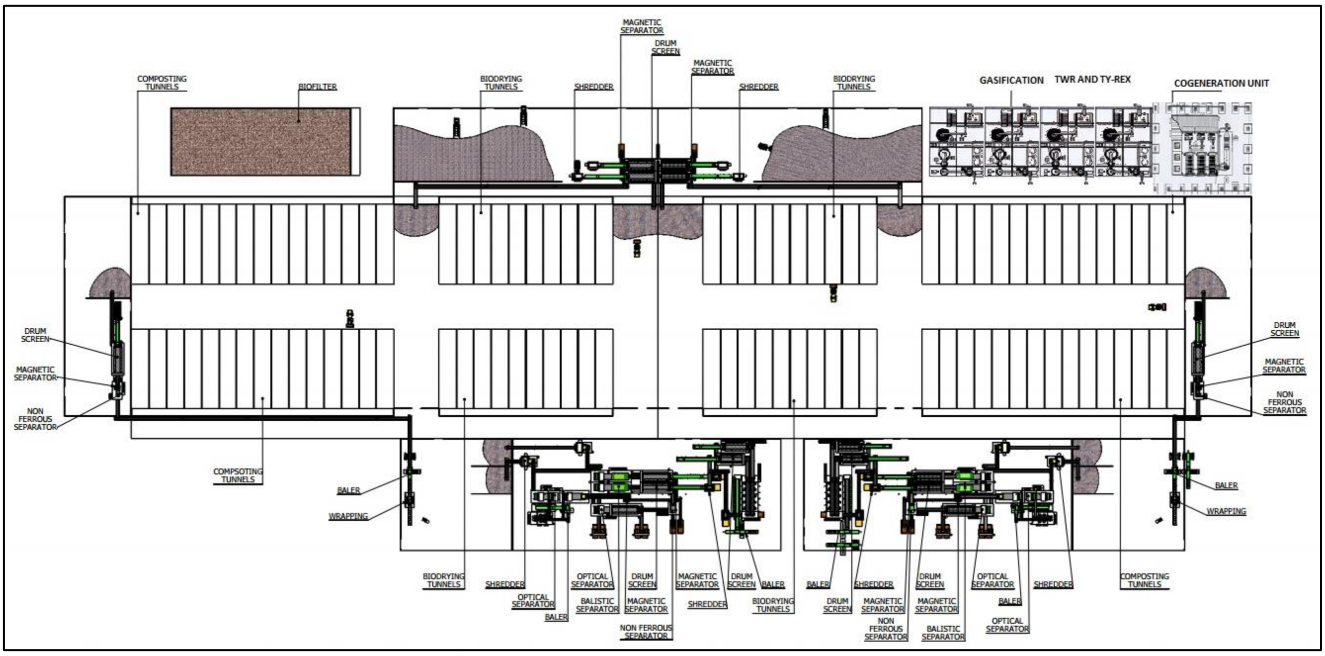
In a traditional system of bio-digestion, biogas is used as fuel of internal combustion engines of the automotive type, that produce electricity and heat but emit fumes which, although lower comparing to those of common passenger cars, are otherwise polluting.

We will see later how it is used this biogas in our integrated system.

Lay-Out of Compost Plant

a) Section for dry anaerobic digestion of MSW by primary underscreen and FORSU;
b) Section biostabilisation biodrying of digestate;
c) Section refining of organic biostabilized (compost);
d) Section temporary storage RDF;
e) Biofilter;
f) Fermenter;
g) Cogeneration unit.


FLOW DIAGRAM
MSW
PRE -SORTING LINE
ORGANIC FRACTION
DRY FRACTION
AEROBIC COMPOSTING PHASE
SORTING SYSTEM
AEROBIC BIO DRY SYSTEM
RECYCLABLES FRACTION
PET – plastic bottles;
HDPE – plastic bottles;
PP – plastic boxes;
LDPE – plastic film;
Paper;
Cardboard;
Ferrous container;
Non ferrous container
COMPOST REFINING LINE
BIOREMEDIATION
RDF FRACTION
REFUSE FRACTION
BALER
LANDFILL
WRAPPING LINE



The “*a)÷g) process steps*” are done inside closed buildings that are maintained in constant depression by a vacuum air system.

Part of this air is used in the biological processes and then sent through a purification system by treatment consists in chemical scrubbers (for the control of ammonia), by humidifiers (to control the dust and to be ensure to obtain an adequate supply of humidity to the biofilter material) and, finally, it is treated by biofilters in the H Plant section.

PROJECT DATA		
TOTAL PLANT CAPACITY	260.000	Tons / Year
DAY CAPACITY	800	Tons / Day
TOTAL WORKING DAYS	312	Days / Year
TOTAL SHIFT PER DAY	2	
MSW TREAT PER HOUR	50	Tons / Hour

MSW composition		
Organic fraction	%	35,0
Paper	%	15,0
Plastic	%	10,0
Metal	%	3,5
Glass	%	3,0
Diapers	%	2,5
Stones	%	4,0
Fine fraction (0÷ 20 mm)	%	10,0
Bulky waste	%	5,0
Wood	%	3,0
Others	%	9,0
TOTAL	**%**	**100,00**

All the intensive phases of biological treatment SEZ. D & E (digestion, bio-stabilization and biodrying) happen inside proof modular reactors (bio-cells or tunnels).

This allows a perfect control of the process and limiting the volume of exhausted air producing with a good benefits on pollutants load reducing by the environ emissions that normally have to be destroyed by the odorous treatment system.

The biofilters - SEZ. H - are divided into several sections to allow the air handling system to remain active even partially in the replacement phases by the biofilter bed.

Section A MSW Receiving and pre-treatment (primary shredding).

The vehicle entering the plant are registered and weighed and, subsequently, are send to the – SECT. A - reception building to be unloaded.

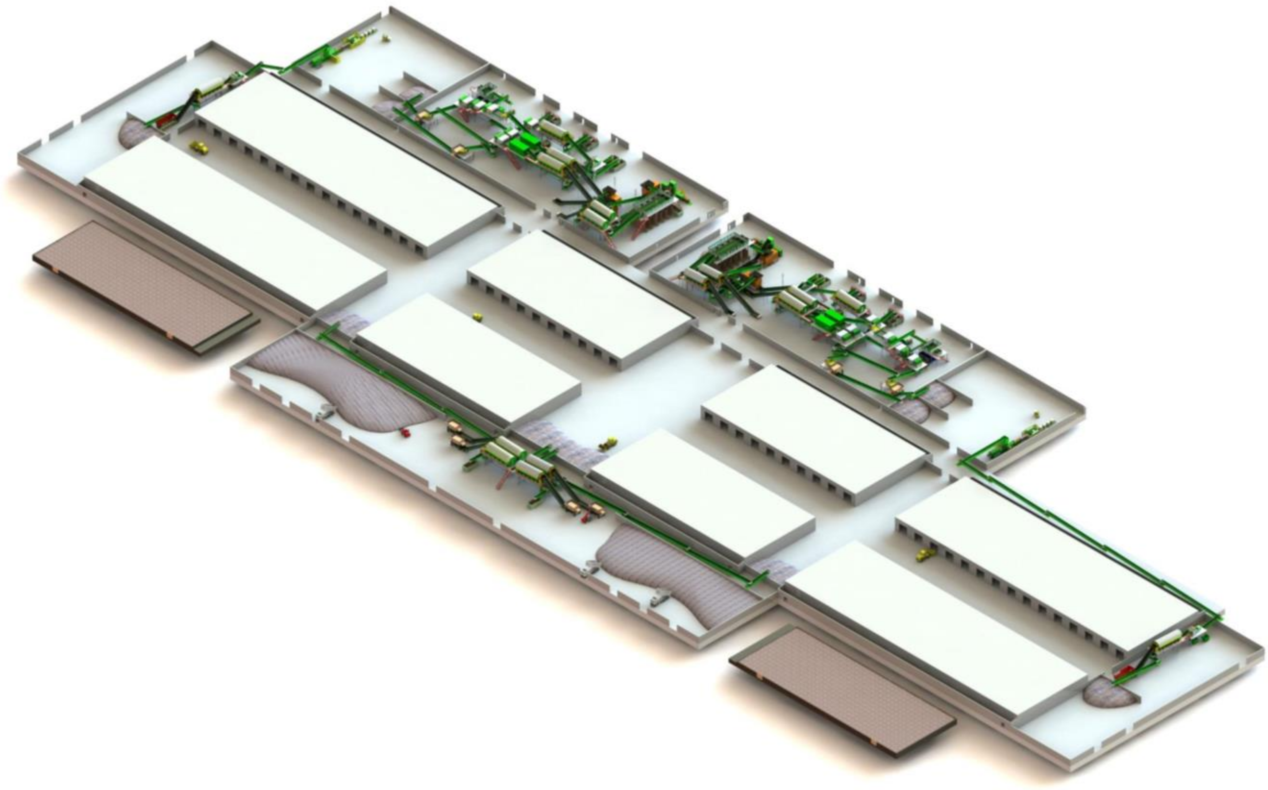
The reception sock building is a prefabricated building (24 meters length 22 meters wide and15 meters high), it is closed on the sides part and equipped on front with speed doors allowing the trucks to entry and exit even with several vehicles operating at the same time.

The unloading and temporary storage of the waste takes place inside a pit sized to hold two placing days and totally it is based on an annual quantity of municipal input waste estimate around 260.000 tons to be treated on 312 working days per year.

The material awaited is based on products indicated in the tender data.

Given the above, the waste daily average flow will be 800 tons, on 312 working days/year, the quantity will have variations related the tourism season which will be managed through a possible increase in working hours during this period (second shift).

Assuming the waste density in pile of 350 kg/m³ every day are conferred in the stock-house about 2.000 cubic meters of waste that will be stored and processed simultaneously. The waste flow lines have to be design in order to support this amount of waste treatment.



The receiving pit is 20 meters long, 15 meters deep and 10 meters large corresponding to a theoretical storage capacity of 3.000 cubic meters, equivalent to 1 day for calculation of the maximum storage capacity of the system.

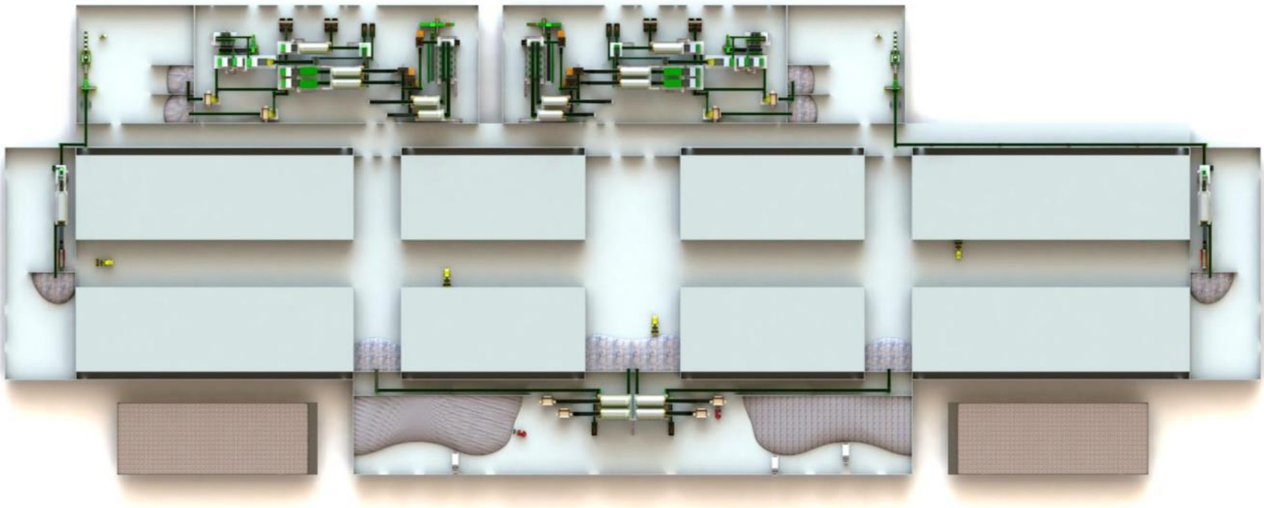
The Vehicles coming to unload they enter in reverse shift and then stop close the pit border line where they execute the download operation then they out the building, running forward, coming from the same gate which they entered.

The doors used to in/out the reception building are equipped with traffic light control to avoid interference during the input/output operation by the trucks.

Even, the area in front the discharge zone is organize in a way to allow rapid manoeuvres in complete safety.

The waste control and handling starting the pit is made by cranes-bridge with grapple-polyp able to select-out unprocessed bulky waste may be resent and feeding primary crushers that constitute the beginning of treatment lines. The cranes-bridge is maneuvered by a crane operator located inside the command room.

The reception area (with the pit) is physically separated from the treatment section by a prefabricated concrete wall in which there are holes for the feed belts passage (running carpet) direct to the primary screens, in a way that the discharge area is isolated and is maintained under negative pressure through a generalized extraction system which avoids the escape of dust and odours.

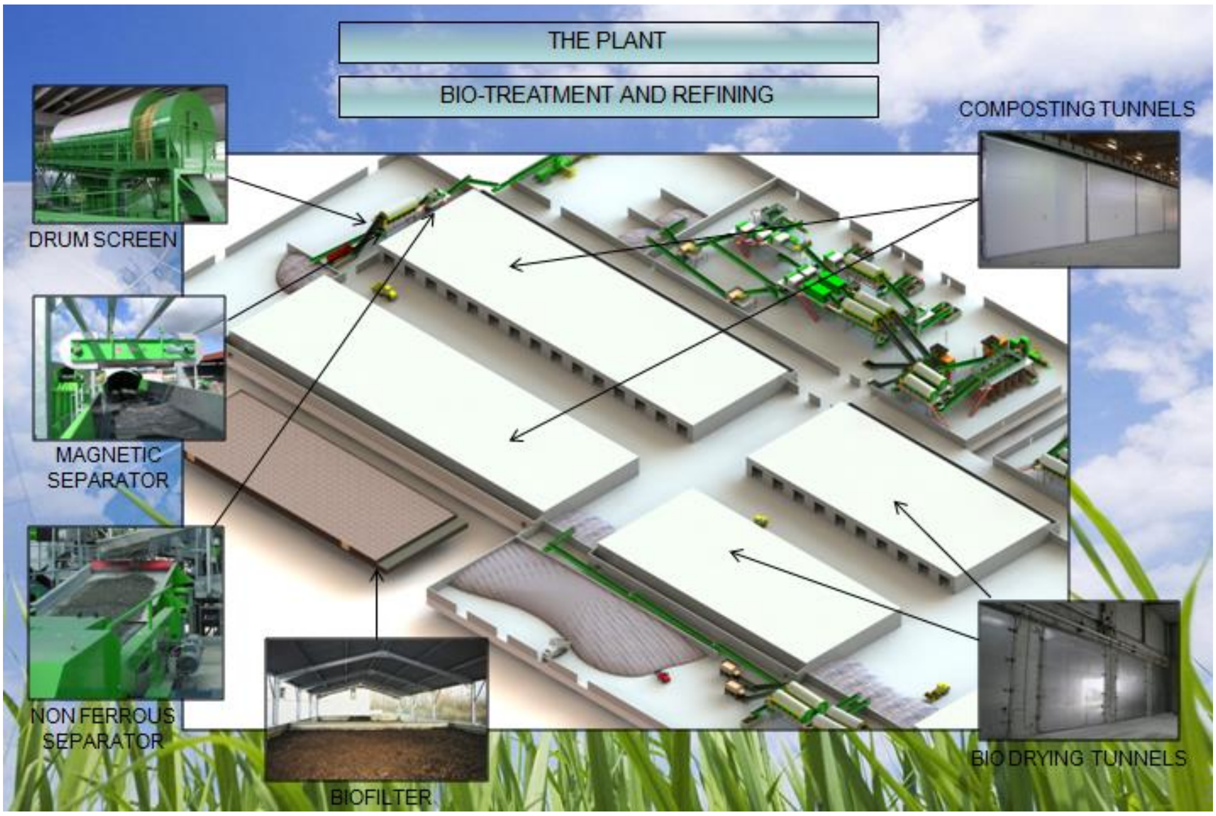


When it is verify the material compliance, the workers, transfer the material from the receiving pit with the crane bridge into the hopper equipped with walking floor.

The particular movement of this floor directs the waste in the charge hopper of the primary shredders, which realize the opening of bags and a coarse grinding of materials intended to bring the size of the subsequent mechanical treatments down of the shredder facility.

Section B of mechanical selection and RDF preparation

The effluent flow coming from the primary shredder item101 and item 201 is transferred to the mechanical treatment section through the conveyor belts of recovery that connect the two sections of the plant, to section B of the plant dedicated to waste selection.



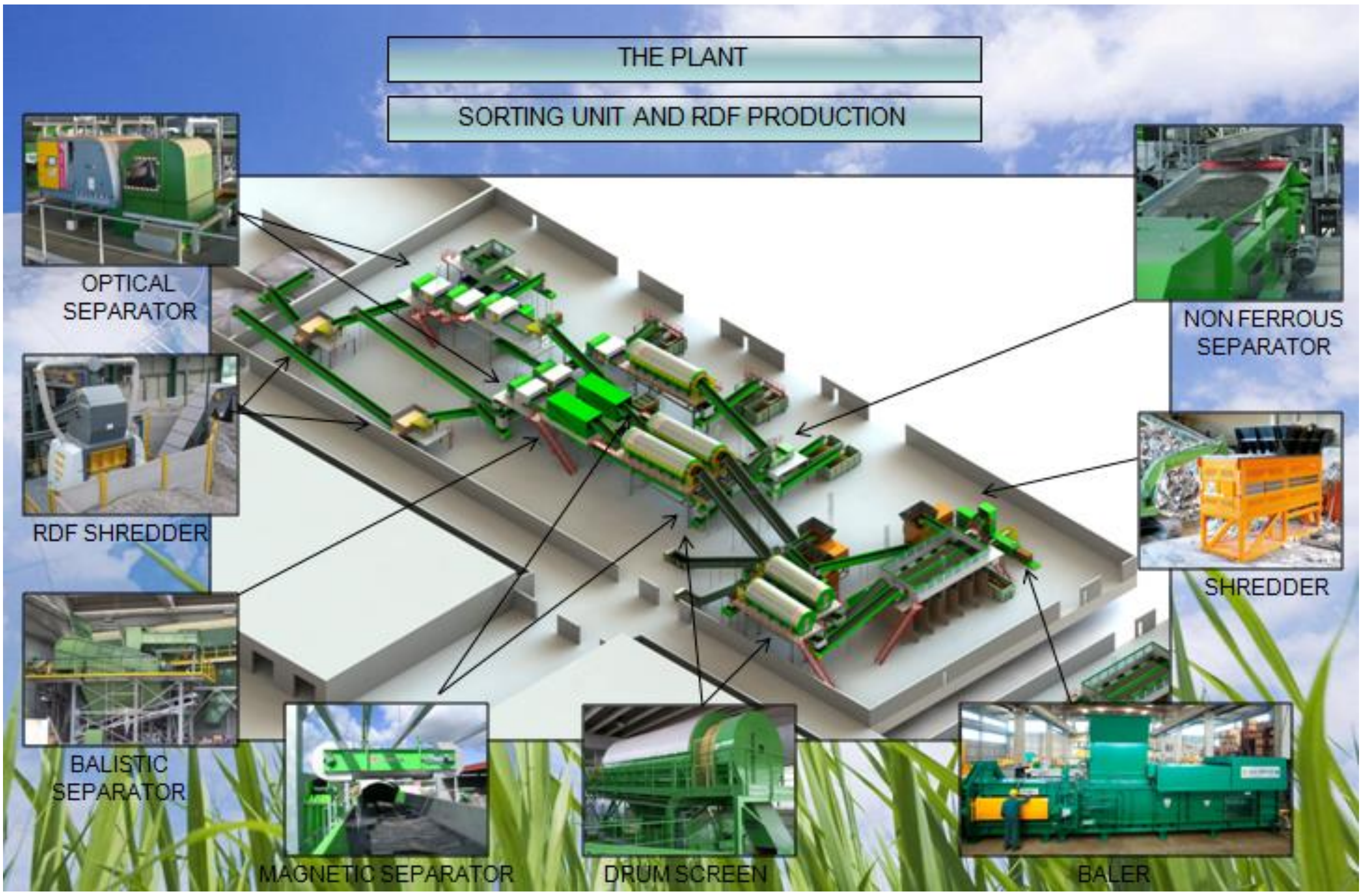
The section B is housed in a completely enclosed building, 200 to 75 meters variable wide, 75 meters long and 15 meters high, which is an extension of the building of section A.

The access to the interior takes place through doors placed in an outer side of the building, because the inner side is the perimeter to the other buildings that constitute the biological treatment and refining compost sections.

Inside the building it develops the system formed by two lines of mechanical specular selection, perfectly split, with a capacity of 40.0 tons / h each in order to ensure the treatment capacity of the incoming daily waste also through the increase hours of use of a line in case of technical arrest of the other and / or an increase in contributions due to the tourist season.

Each line of treatment is composed by two phases of screening arranged in sequence and aimed to obtain under screened homogeneous flows and by phases of optical selection in order to recovery the fraction of fuel and plastic containers. Ferrous metal containers are recovered through magnetic separators located at the confluence of the conveyor belts.

The lines of treatment are encoded with the item100 and item 200 , while the belts and the common service machineries to the lines of screening are encoded with item300. This coding is shown below in the description of the production process in order to identify the machinery involved and restricted to item100 in the early phases of the plant lines because of the specular lines.



The extractor belt which receives the material from the primary shredder feeds the primary screen composed of a rotating octagonal drum, leaning on rollers coated with rubber, on which is fixed a grid of coating made of panels of sheet metal, easily replaceable and provided with holes of suitable diameter depending on the underscreen flow which is intended to be obtained.

The effect of the rotation of the drum and the contact of the material with the coating grid realizes the separation of fractions having size less than the diameter of the holes, by subdividing the set, in the specific process, into two streams known as:

- primary underscreen, having a size less than 100 mm.
- primary overscreen, having a size exceeding 100 mm.

Primary underscreen

The primary underscreen, of sizes ranging from 0 to 100 mm, represents approximately the 55% of the total and is composed predominantly of organic matrices, powders and aggregates, glass, paper, plastics, metals of small dimensions.

The through-flow is driven by the bottom discharge hopper of the primary screen on the tape of receipt item104 disposed below the drum which transfers it to the magnetic separators item 105 and item 106 for the separation of ferrous metal from those non ferrous. The metals are evacuated to the respective bins of accumulation by the belts of recovery item301and item302 and constitute about 7.5% of weight of the fed stream.

The undersize residual flow, approximately the 48.0% of the incoming waste with a 75% organic matter content, effluent from the magnetic separators ends on the tape of centralization and evacuation of the organic fraction item300.

This belt transfers the undersize section to the dry anaerobic digestion and precisely in the intermediate storage, that is located in SEZ C from which it will be taken up and transferred to the process cells following described in the report.

Primary overscreen

The primary overscreen flow, its size ranging from 100 and 500 mm, represents about the 45% of total fed and consists mainly of paper and paperboard, rigid plastics and films, textiles, leather, organic wastes and residues, to be dragged on, remain entangled in the mixture of fractions.

The effluent fraction from the primary screen is taken from the tape of reception of the overscreen item110 that, through the tape recovery item111, transfers it to the secondary screening item112.

Of similar construction to the primary screen, the secondary one has four sections of sifting to divide the overscreen into multiple streams so as to make them suitable in size and flow rate to the optical separation section located downstream of the sieve itself.

Specifically the secondary screen generates the following flows of underscreen:

1) secondary underscreen with sizes between 100/150 mm;
2) secondary underscreen with sizes between 150/200 mm;
3) Secondary underscreen with sizes between 200/250 mm;

The major fraction of 250 mm is the flow of secondary overscreen, that is destined for disposal in landfill which comes through recovery belts described below.

The flows of the secondary underscreen - 100/150 mm - 150/200 mm - and 200/250mm - are transferred through the tapes of recovery item310, item320, and item330 to the automatic selection line that is the most technological part of the plant as it is prepared, through optical readers, for the separation of the polymers in plastic and cellulose present in the flow itself.

The purpose of this section is to produce a flow of value such as RDF of high quality and, in the meanwhile, to select a fraction of plastic containers to be enhanced as the recovery and recycling part.

The readers are positioned on feed belts arranged in sequence on the platform in metal structural work item703 which also supports the hoppers of unloading of the readers themselves, of the belts of evacuation of the selected flows and of the residual flow of selection.

Form the fed material, the sub-fractions recognized by the readers are removed through the air jets from adjustable nozzles (expulsion upwards or downwards) placed on a bar installed in the discharge point of the feed belt-discharge, while on the not recognized flow, the machine behaves like an ordinary belt.

Specifically the fractions present on the feed belts of the separator are subjected to screening by a high-definition spectrometer connected to a management computer which, based on the program set and the information that receives from the material processed, controls a jet air at the point of the tape where it is present the object to be removed, simultaneously with the step of unloading of the speed feeding tape of the separator.

The efficiency of the process of separators is approximately 90% which means that 90% of the interested fractions are selected with a purity closed to 90%.

The optical separators item312, item322 and item332 constitute the first stage of separation and are positioned, with the respective feed belts item311, item321, and item331, at the top floor of the metal support structure item703. In this phase from the secondary underscreen flows, harmonized in size, it is separated the fraction to be valorized as RDF.

The selected flow is taken from the evacuation tape item390 which centralizes the combustible fraction coming from the separators and conveys it to the phase of secondary shredding, described later.

The optical separators item315, item325 and item335 constitute the second stage of separation and are positioned, with the respective feed belts item314, item324 and item334, at the second floor of the metal support structure item703. In this phase from the flow of the secondary underscreen, residual of the first stage of separation, the plastic polymers are selected in PET/PE, mainly consisting of containers for liquids of different shape and size and by the plastic film of the same polymer.

The selected flow is centralized on the evacuation conveyor belt item350 which feeds the air separator item351 for a further phase of selection aimed for the separation of plastic film (PET/PE) from the containers. The selection is done through a blade of air, generated by a fan, which, crossing the material from the bottom upwards in the fall of these between the tape and the tape of centralization item350 and of recovery item352, realizes the separation of the light flow to more sail area by plastic containers.

The films picked up through a pneumatic conduit reach an inside cyclone in which air / film are separated; the air is recirculated to the fan for two-thirds and one third is sent to the centralized line of treatment of process air, while the films finish on the centralization tape of the combustible fraction item380 for its use as components of RDF fraction.

The refined fraction of containers ends on the recovery tape item352, that feeds the final phase of enhancement of plastic containers made of optical separators item355 and item360, installed in sequence, and from the cab of quality control item374.

The flow of containers refined by the belt item352 is transferred to the power supply vibrating item353 that dispenses them to the separator through the tape fast optical item355 item354. The separator selects the flow of PET containers by directing it onto the quality control belt item356 while the flow, when it is not recognized, ends, by gravity, on the conveyor belt item358, installed downstream, which feeds the second optical separator item359 for the selection of the containers from the PE stream of end line. The fraction of containers in PE is then transferred from the recovery belts item361 and item362 to the quality control belt item363, while the fraction of end line is fed from the recovery belt item364to the sorting belt item365.

The sorting belts are installed inside the cab of sorting item371 which, in turn, is supported by the platform in metal structural work item370 in which, among the distances of the support beams, are installed temporary storage bunker of the selected containers item366 and item367.

At the sides of the sorting belts that pass through the cabin , there are the manual sorting stations in which the operators pick up, from the respective belts, the fractions of waste and/or fractions of interest that allocate in the temporary storage bunker through the hoppers of sorting item365 and/or to the production RDF line through the recovery waste belt under the platform item373.

Reached the limit of capacity of the storage bunker item366and item367, one at a time, are emptied and their contents are transferred to the pressing line constituted by the feed belt item374 and the continue hydraulic press item375 for the compaction of the material into bales bound with wire. The bales are taken out from the press by the operator with a suitable self-propelled vehicle and stored in the temporary storage area located in front of the press itself, waiting to be sent to the recycling plants.

The secondary underscreened fraction is not valued as a fuel material and as a recovery of containers from the optical readers it ends on the tape of centralized waste item340.

Through the tape item340 the residual fraction is conveyed to the belt of recovery item380 which centralizes also the fraction of overscreen of secondary screens for the transfer of the same line to the evacuation of non-reusable fractions across the tape recovery item381 and item 382, which, in fact, goes out from the selection building and conveys the waste stream selection directly in the body landfill.

The phase of selecting and processing is completed with the reduction in size of the flow of fuel materials – RDF - selected by the optical readers and centralized on the recovery belt item390. Two single-shaft shredder with opposed grid item393 are mounted in parallel and fed, alternately, from the reversible belt item392 that receives the material from the recovery belt item391.

To prevent that the metallic parts reach the secondary shredders, the magnetic separator item391 is installed at the confluence of the centralization belt item392and the reversible tape item391. The intercepted ferrous materials are downloaded in a small body of accumulation, through the discharge hopper of the separator itself, while the light flow ends in the hopper of the shredder.

From this one, the material is pressed on the rotor by an internal pusher to the shredder, which moves on the horizontal axis of the machine, thus optimizing the hourly capacity of the machine itself. On the rotor there are mounted interchangeable teeth acting on the integral counter-blade with the structure of the shredder, that tear the material and transport it, due to the rotation, on the grid of contrast that, in this specific case, has holes of 35 mm.

The minor fraction of 35 mm is then separated, while the fraction of major size recirculates again on the counter-blade to undergo a further reduction in size and a new screening until the size reduction does not allow the material to pass through the holes of the grid.

The passing flow instead ends by gravity on the extractor belt item394 placed under the shredders which conveys the recovery belt item395 and item396 , through them it reaches SEZ F that is dedicated to the storage of the RDF.

The storage area of the RDF - SECT. F - is derived from the partitioning of the building with a partition wall treatment - SECT. B - to create an area of 50 meters wide, 75 long and 15 meters high.

Inside the area, in order to optimize the storage volumes, it is made a pit of temporary storage 60 meters long, 10 meters wide and 10 meters deep for a useful volume of storage of 4.000 cubic meters.

Considering a density of the RDF in fluff of 150 kg / m³ the storage capacity of the pit is equal to 800 tons which corresponds to approximately six days of production of the selection plant, always considering the maximum capacity of the plant of 260.000 tons per year.

The handling of the material in fluff takes place through a bridge crane that provides to load the means of transport and to pile the material inside the pit.

Section C of receipt and processing SSOW.

With reference to the development plans of the separate collection according to European standards a special reception area - SECT. C - has been prepared to the receive and pre-treat the Source Separated Organic Waste (SSOW) coming from the separate collection.

Flexibility of digestion system of the wet part of waste.

By the project data analysis it is clear as the Food waste (putrescible) selective collection is now equal to zero, but it is in the Administration's aim to activate this collection in the next future.

The national government regulations as well as the European ones, require to activate the sorting collection as soon as possible.

The regulation and the experience gained in Europe exalt more and more the necessity to increase the food waste separation by the other dry refuse portion to allow an adequate recycling treatment.

This leads the necessity to activate the wet (Food Waste) separated garbage collection in order to create two different material flows of organic matrix: the MSW and the mechanical treatment wet waste. These two different kind of definitions depend on the origin of the organic putrescible material, that coincide with a distinction generated by a technical consideration and from a rule consideration:

a) The wet fraction coming from selective collection, because it isn't in contact with pollutant elements, metals, etc., may, suitably treated, generate quality compost (type A);
b) The legislation, following the above reasoning, imposes an obligation for the production of quality compost (type A), that is that the organic matrix is the result of separate collection;

Because of the reason shown above the new plant, we are looking for, in this project, must have the possibility and capacity to manage the two different streams of organic matter (MSW by mechanical separation and wet separated collection (food waste)) in a completely separate way, the two flows never must come in contact.

Starting from the total waste quantity data and from the analysis of municipal waste in Kirkuk, about 260.000 t/y has a percentage of moisture of around 38.5%, it is evident that the amount of organic matrix is approx 140.000 t/y.

That is because today, in the absence of separate collection of wet, we should treat approximately 140,000 t/y.

With the start up of separate food waste collection will be generate two distinct flows of organic matrices to be treated compulsorily in a completely separate way.

The plant in the project is structured with 20 anaerobic treatment cells. The cells are then equipped with a sprinkler irrigation system, that recirculates the liquid contained in 4 separate fermentation tanks. In this way the cells are managed two by two and completely isolated one from the others. The irrigation system is used to start up the anaerobic process in order to inoculate the fresh material with the bacterial flora present in the fermenter.

The aerobic composting, which is also structured with 18 cells completely independent, is in condition to complete the process managing the 2 streams separately.

The technical-legal necessity to manage the flows (food waste, wet from underscreen) produces, during the time, a inversely proportional trend; in fact when the second matrix increases the first one decreases.

The separate FW collection allows, in practice, to have a flow, declining tendency of poor compost, that is destined to landfill because it is not in accordance with the law (type B), while, obviously it grows (as a result of the decrease of the other flow), the compost of quality (type A), utilizable as agriculture fertilizer.

Here under we propose some calculation tables pointing out the evolution of the 2 organic matrix flows when the separate FW collection increases.

The building is large 50 meters, 75 meters long, 10 meters high and is obtained between the SEZ. A receipt of municipal solid waste and SEZ. D dedicated to the anaerobic composting to which it is directly connected through the central corridor of loading/unloading of the tunnels.

The area is sized to receive 120.000 tons/year of SSOW.

The total quantity of 120.000 tons/year of SSOW has been derived by the project data analysis through which we suppose to intercept, through the development of the organic matter selective collection in the commercial establishments (restaurants, hotels, bars), the 40% of total waste production as, foreseen by the collection plans already approved.

The SSOW fraction is unloaded on a concrete waterproofed floor by the transporter trucks, that, in reverse, enter in the section and begin to discharge in the dedicated area bounded by perimetral concrete walls.

Close to this area is located the shredder/mixer used to pre-treat the fraction before the transfer to the intensive biological treatment. The operator, assigned to the transfer of SSOW to the composting tunnels, also provides to move the fraction within the area and to feed the ready material to the shredder/mixer.

An underground tank with 100 cubic meters of volume is also foreseen for the temporary storage of the biological sludge, and due to their semi-liquid nature, they require a drying intermediate treatment before their biostabilization in the intensive biological treatment sections.

Section D of dry anaerobic digestion of material coming by primary underscreen, of the FW and of the sludge.

The primary underscreen, in size 0/100 mm, is transferred, by the conveyor belt, item300, to the intensive biological treatment section constituted, in this first phase by the dry anaerobic digestion section - SECT. D – in which it is delivered in a temporary storage zone bounded by containment walls.

The anaerobic digestion section consists of 20 cells in cement, 39 meters long, 7 meters wide, and 6.0 meters high, with a storage volume capacity for the process about of 700 cubic meters for each cell.

The cell is supplied and discharged by an operator equipped with a wheel loader.

The residence period of the organic fraction inside the anaerobic tunnels is set at about 21 days.

Every digestion cell is constituted by a concrete water proof structure equipped with a pressure proof rubber sealed door. The floor houses a series of parallel PVC tubes which are incorporated in the original casting.

These pipes are equipped with nozzles in plastic material (spigot) and connected by two ventilation systems:

- a high prevalence fan is used to recirculate the gas through the material during the digestion process and to flush the gas at the end of the process;
- another fan with lower prevalence is used in the first stage of the process to increase the temperature of the material by a short aerobic process that also has the purpose of consuming the oxygen in the cell before starting the anaerobiosis phase. The same fan is also used to keep the nozzles, spigot, free during loading and unloading operation.

The tunnel is then equipped with a pneumatic valves series used for:

- Open/close the flow of gas to the gas tank and then into groups of cogeneration;
- Open/close the flow of exhaust air sent to the biofilter;
- Open/close the recirculation loop to the spigot through the fan at high prevalence.

The cell are then equipped with an irrigation sprinkler system that recirculates the contained liquid in a fermentation tank. The irrigation system is used in a massive way at the beginning of the anaerobic process in order to inoculate the fresh material with the bacterial flora present in the fermenter.

In the anaerobic cells it is maintained a slight overpressure to prevent the entry of air that would stop the anaerobic process.

The cells are also equipped with a mechanical protection against over/depressions which discharge into the atmosphere.

During the initial process phase, the present air above the material pile in the tunnel is recirculated through the ventilated floor in order to facilitate the raising of the temperature of the material (for mesophilic process).

In the next phase it begins the bleed gas from the tunnel, but because methane concentration is not yet enough, the gas is further diluted (to be ensured that its concentration remains always lower the explosive level - LEL) and expelled in a torch or through the biofilter.

As soon as the CH4 concentration is enough, the gas is diverted to the gasometer to be subsequently used by the cogeneration units. In any case recirculating phases of the gas in the tunnel are also foreseen, always through the floor, to facilitate during the process the biogas production and to maintain the porous mass.

At the end of the process, when the gas production decreases, it starts the flushing air through the floor.

Only when the gas concentration inside the cell drops below the LEL, the safe door interlock starts free and the tunnel can be opened.

The material is then extracted, with the wheel loader, and transferred to the treatment aerobic cells. The system is equipped with a multiplex analyzer which analyzes the gas quality in each tunnel and in the gasometer.

The anaerobic digestion process of organic waste fractions coming from various input is able to generate an electrical power of approximately 700 kW and a roughly equivalent thermal power.

The generated electric power will be internally used or sold in parallel to the electric grid system. The thermal power is instead used in part in the digestion unit, but even in more substantial quantity in the heat exchange unit for the sewage drying and in the sludge section of biostabilisation-biodrying.

This precaution is necessary because the organic digested fraction has already suffered a significant organic degradation during the anaerobic process and it has no longer the enough "organic" energy required for its self drying.

This condition is even more evident from the fact that the output digestate has a very high humidity and therefore requires a lot of energy in order to lower the moisture level below the right limit required by the successive phases of the processing of the material. The advantages of the proposed system can be resumed as follows:

- The anaerobic tunnels are equipped with ventilated floor for the following reasons:
  a. to permit an aerobic start-up able to bring quickly the temperature in the mesophilic stage before starting the anaerobic treatment;
  b. to allow the recirculation of biogas in the anaerobic phase to optimize the process;
  c. to allow the complete biogas flushing at the end of the process not only in the upper part of the tunnel but in the entire mass of material, avoiding the forming of dangerous biogas boll;
  d. to allow the use of anaerobic tunnel even for an aerobic treatment where necessary.
- The anaerobic process is inoculated through the liquid phase: substantially it is not necessary to recirculate material to the tunnels. In fact the system is equipped with four fermentation tanks in which there are conveyed the leachate coming from anaerobic cells divided into separate couples able to process the organic fraction from TM or from differentiated collection. The fermentation sewage stocked in the tanks is copiously sprayed on the material at the beginning of anaerobic process in order to supply the necessary bacterial families to start the process in order to avoid the mixture of the material with the digestate material.

This involves, compared with a same potential system, a substantial reduction of the required volumes in tunnels as well as a reduced and easier handling of the materials.

The fermenter allow an effective recovery of biogas also from the liquid phase.

The time process in the tunnels is optimized in order to reduce the required volumes/spaces. This condition means a lower biogas production per waste ton treated but at the same time, compared to equal volumes, allows to treat more waste and therefore to have a greater production of biogas per unit of time.

Section E biostabilisation and biodrying of digestate.

At the end of anaerobic treatment, the digestate is extracted from the cells and transferred to the aerobic biocells where it completes the biostabilization process and at the same time it is bio-dried. – SEZ. E -.

This section consists of 18 concrete cells: 39 meters long, 7 meters wide and 6.0 meters high, closed at the sides except where there is a front door entrance. The storage volume useful for the purposes of the process is 700 cubic meters each cell. The material is fed and taken by an operator equipped with a wheel loader.

The residence is set in about 3 weeks. After this phase of intensive aerobic treatment, the stabilization of the material stands at the required level (IRD<1,000 mgO2 / kg SVH).

The dedicated cells for the biodrying of the material are equipped with a system of heat exchange air/water that allows to recover the heat from the cogeneration group that uses the biogas produced in the section of anaerobic digestion.

This arrangement, together with the process "closed" in biocell, allows to optimize the final stage of biodrying of the material which, therefore, can achieve a high level of stabilization and a low humidity (less than the expected 35%) in a limited period of time.

Once the filling of the tunnel is completed, the front door is closed and begins the process controlled by the automation system.

The tunnel is formed by a reinforced concrete structure with a door in the front and in the back, provided with a rubber gasket.

It is therefore a sealed structure within which the process can be controlled very precisely for each of the units and therefore for each "batch - batch - batch" of waste. The floor of each cell is constituted by a jet of concrete block that houses inside it a series of PVC pipes parallel to the long side.

These pipes are provided with conical nozzles in plastic material (spigot).

Each cell is equipped with its own centrifugal fan with high prevalence that blows air into a plenum made of concrete at the rear of the cell.

From this plenum the air is distributed in the pipes "spigot" above mentioned which provide to distribute it in an uniform way below the treated mass.

The "top" of the spigot is very narrow (about 30-35 cm) which allows a perfect distribution of air to the treated material.

The blown air is constituted by a mixture of "fresh" air process, sucked from the buildings of treatment, and by recirculating air that is continuously withdrawn from the cell at the top. The control of the mixture of blown air takes place automatically according to the process control and is implemented through pneumatic dampers. Also the quantity of blown air is regulated by the process computer through the inverter that drives the fan continuously adjusting the speed of rotation.

The adjustment of the process takes place fully automatically according to parameters set in the process computer and based on parameters detected by sensors in the field.

In fact the temperature of the material, the temperature of the various flows of air, the oxygen content in the blown air to the cells, the pressure in the plenum to the tunnels, the pressure-depression in the different sections of the air system, the recirculated water flow, etc. are continuously measured.

The process control in the tunnels is based on a software package that also includes a control type "Fuzzy" on some of the process parameters.

Fuzzy logic is based on rules that influence the process through a control "weighed" of the various parameters.

Compared with a linear control, which generally is used in simple biological systems, fuzzy logic is well suited to nonlinear processes and to varying conditions that are the norm in this type of plant (waste characteristics, environmental conditions, etc.).

Each tunnel is connected to two central air systems:

- a "fresh air" system;
- a system of "exhaust air".

The first draws air from the process buildings and moves it towards the biocells.

The required air in the different phases of the process is withdrawn from here, while the remaining part, sucked to keep in constant depression the buildings, is directly transferred to the treatment plant where the air "exhausted" emitted by the biocells is conveyed.

A big advantage of a "closed" system is exactly what the volumes of exhaust air to be treated are very limited compared to an "open" system where all the large volume of air in the buildings above the mounds is intensively treated.

This brings undoubted benefits in the load of pollutants that must be destroyed by air handling system. The connection for the discharge of the exhausted air from the cells is equipped with a motorized damper which ensures that, even in the event of excess pressure within the centralized system of suction, there is no entry of false air in the cells.

All cells are maintained in constant depression at all phases of the process in order to avoid that air with high odorous concentrations uncontrolled escape.

The cells are also equipped with a damper counterweight that protects against excessive depression.

At the end of the process the material is extracted from the cells and fed to their fining phase.

Auxiliary systems - air and water treatment

All buildings in the process (receiving, sorting, front-tunnels, etc..) are kept in constant depression by dedicated vacuum systems.

The aspirated air is partially used in the process and then treated in a unit of humidification and discharged into the atmosphere through a biofiltering bed – SECT. H -. The biofilter is divided into two compartments in order to ensure a continuity also in the early phases of substitution of the material.

The leachate collected in the tunnels, in the pits, in the biofilter, etc.. are collected in an underground tank sedimentation. The slurry then touches another tank where a submersible pump raises it up and transfer it in the fermentation tanks, named fermenter that constitute SECT. I of the process phases

This unit has enough capacity to ensure the storage of the amount of liquid necessary for the process (remember to regard that the triggering of the process takes place precisely through the liquid phase recirculating in the tunnels he liquid contained in the fermenter).

Fermenter are placed on the top of the double membrane gasometer that collect the biogas produced by the various cells and they distribute it to the cogeneration unit.

The same gasometer also collects the gas produced by the liquid in the fermenter.

The fermentation tanks are also equipped with a recirculation system of the liquid which allows to maintain the same in continuous mixing.

The liquid ,contained in the fermenter, is drawn by a pump that provides to transfer it to the irrigation system which is fitted to each tunnel.

The tunnels and the fermenter are equipped with heat tracing to allow the maintenance of the system in mesophilic temperature (35-38 ° C).

The collection point of all process water are the fermentation tanks

Section F of refining compost .

At the end of the biostabilisation-biodrying phase the organic fraction deposited in the aerobic cells, now transformed into FOS and/or compost, in function of the fed mixture, is transferred to the line of refining in order to remove from the main flow of the inert materials, metals, and the films of plastic that are mixed to the organic substance of the first stage of sieving.

The line is located in the dedicated building - SECT.F - that develops close to the anaerobic cells to which is connected by a passage that allows the passage of the feeding blade of the line.

The organic material at the end of the vesting period is extracted from the cell aerobic by the operator, using a wheel loader, and fed directly to the metering hopper item 500.

This hopper is constituted of a extractor bottom made of aluminium profiles, referred to as "walking floor" and connected by welding to the walls of steel sheet of the banks of containment. On the front of the unloading of the hopper are installed two bolt shafts that have the function of lump-breaking.

Through the alternating movement of the movable floor the material is conveyed on the conveyor belt of recovery item 501 that feeds the rotating drum sieve item 502.

This machine consists of a rotating drum formed by a zone of a charge and a discharge in calendered sheet interconnected by welded. The structure is based on rollers, rubber coated and fixed through bearing supports,to the structural support of the drum. The load side rollers are driven , while the exhaust side rollers are idle.

On the rotating drum is fixed a coating grid made of panels of metal sheet, easily replaceable, with holes of suitable diameter depending on the purpose of the underscreen flow, which is intended to be obtained.

The passage inside the drum screen achieves the separation, in the specific case, of the main flow into two flows known as:

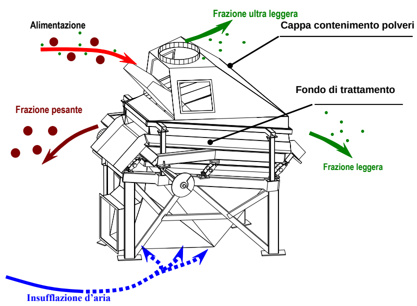
- underscreen, of size less than 20 mm;
- overscreen of size greater than 20 mm.

The underscreen ends on the tape item503 and, in function of the matrix of source, may be fed to the densimetric table item505 through the recovery belts item504 and the reversible belt item504.

The purpose of the treatment on the densimetric table is, in fact, that of selecting from the underscreen the inert fraction and the plastic film for reusing it as forestry fertilizer; treatment which, evidently, does not require the biostabilzed FOS that is used as ground to cover the landfill.

The densimetric table combines multiple effects of screening (see also the graphical representation) and is composed of the following parts:

a) a fan of fluidization;
b) a vibrating screen;
c) a hood for light material ;



The refining of the material, fed to the table, takes place for an aeraulic effect coupled to the vibration and the sieving effect of the vibrating screen which has a grid of sieve with holes of 4 mm.

In practice, the flow of underscreen, fed through the hopper, ends on the vibrating floor of the vibrating screen, which makes a first separation of the ultrafine parts, less than 4mm, which fall into the containment bin at the bottom of the machine and are discharged through a recovery screw.

At the same time the bottom of drilled treatment is crossed by a flow of air generated by the fan of fluidization which keeps the light material suspended and drags with it the ultra light parts till the upper body of the machine where they are intercepted by the vacuum created by suction fan which transports them to the cyclone item506.

The light parts, non-volatile, remain in suspension on the vibrating bottom and for effect of the air and of the vibration receive a downward thrust in the direction of the bottom discharge hopper while the heavy parts, glass and inert, remain in contact with the bottom that through the vibration brings them up to the upper discharge hopper.

The densimetric table realizes in this way the refining of the flow of compost in which they are generated in several points of the flows of waste that are centralized on the evacuation conveyors item508 and item509, while the refined compost goes to the conveyor item507 in a temporary dedicated storage box.

The flow of overscreen of the drum sieve item502 is taken from the bidirectional conveyor item510 that feeds the magnetic separator item513 for the recovery of the section of the ferrous metals, the residual fraction is conveyed on the feeding conveyer belt item512 of the air separator item513.

The selected light flow through a pneumatic conduit reaches a cyclone within which occurs the separation air/film; the air is recirculated for two-thirds to the fan and,for a third, sent to the centralized air process treatment line of, while the film end on the secondary shredder conveyer belt item 390 in order to produce RDF.

The heavy material flow falls down onto the centralization belt conveyer of waste that conveys all the screening residue on the evacuation belt item382 in the SECT. B for the transport to the landfill.

Since this is a line that operates inside a sealed area and subjected to ventilation is not provided with suction points on the conveyor belts. The air filtration unit is connected to the air separator and the sieve with a rotating drum.

Supervision section of mechanical treatment

The proposed system is designed to supervise and control the functional areas from the control room through computerized operator interface stations.

The management system is fully automated and the manual intervention, in the field, is confined to the activities of start up and stop of the plant.

System Automation (PLC) is designed to control and supervise from the control room the following process areas:

- Power supply;
- Screening;
- Automatic selection of containers;
- Production and storage RDF;
- Packing non-reusable fractions of screening;
- Line of refining compost

The architecture of the automation system has been designed to meet the needs of high reliability of the system, providing maximum operational safety and minimize the incidence of failures and the possible downtime of the system.

These considerations have made it possible, in common practice, to minimize the conventional instrumentation framework reserved for individual packages or local control panels, giving the overall PLC control system operator stations via video-keyboard.

The high reliability of the system is also guaranteed by the source CPU and related signals in the central control room cabinets.

The exchange of data between individual units is via bus.

The PLC will also be interfaced with control systems dedicated through RS-232 serial links if the microprocessor or the wired for conventional systems.

The main signals of supervision and summary alarm will be acquired by these systems.

The contacts in the field will be read by the PLC with a voltage generated by the system itself.

Codes and standards

Design, materials, configuration and testing of control equipment will be according to the following standards:

- ISO: International Organization for Standardization
- IEC: International Electromechanical Commission
- CEI: Italian Electro technical Committee
- UNI: National Unification in the Industry

Supervisory system.

The main objective of the system is to enable a modern management of the selection, in order to immediately detect faults for a ready maintenance and/or repair; to improve the quality of services, the cost of management and security.

In particular in the supervision system is based on an architecture that provides for the use of:

- a programmable controller (hereinafter PLC), to which is assigned the task of command and control of all the loads present in the system;
- the Operator Station consists of a personal computer, to perform the functions of man/machine interface and to arrange for viewing or historicization of events. The station operator can perform both functions of the Control/Command that Supervision.

Description of the functional system.

The PLC constitutes the interface both towards the field, both towards the station operator with which it exchanges data input, reads the status of the plant and the activation signals of the motorized users.

Data exchange between the PLC and the Supervisor is on a line of communication.

The PLC will activate the sequences for motorized users independently on the order of the Station Operator, the PLC is also entrusted with the activation of the alarms that are showed to the supervisor through the synoptic pages.

The supervisor will have essentially the tasks of data presentation of state utilities and the display of process variables and will send the commands of on/off, etc. ...

Manual and Automatic function

In general, all the electric utilities can be started through manually or automatically sequences, if enabled by local or remote consensus on arranged panels or on push button in the field.

The preparation of the manual or automatic operation is delegated to authorized personnel who can operate in the plant, which will organize, through a proper switch on each panel or the local context, the functioning of the single electric user.

The users, arranged for manual operation, will be started and stopped only by local control through local control panels; instead in automatic operation the command of starting and stopping will be conducted from the keyboard of the Station Operator.

All signals having lock functions, provided for protection of electric users, are arranged to act directly on the respective contactors so as to prevent starting of the users in both manual and automatic.

With the intervention of any protective device we will have the block of the interested user, with relative optical and acoustic signal the restoration of the block will be performed by the operator after having removed the cause of the block and silenced the alarm.

Black-out and restoration of the plant.

In the event of power failure, the system must be able to maintain its functionality and the restoration of the mains voltage must be able to return the plant to the previous condition and in any case in conditions of safety.

When the mains voltage returns, the utilities will be restarted with due delays, to avoid excessive absorption peaks of the network and will restart in a logical sequence defined by the system operator.

With the restoration of energy, the supervisor must scan each of the inputs to detect the status and regain control of the system, alerts the operator in the utilities selected for manual operation and provide for starting locally.

Operator's station

When starting the plant every single user, if designed to operate automatically, will wait for the start command by the operator using the keyboard or mouse using synoptic pages.

All operations performed from the keyboard or mouse will be easy and quick insight on the part of the personnel proposed to operate the plant.

The command execution is allowed only in the presence of words (password) that the operator would type at the beginning of the session management.

All pages of historical events, alarms and operator messages will be feasible using the appropriate menu command window or by selecting the appropriate icon on the background screen.

All analog signals arising from the variables of process will be displayed in the form of dynamic graphics in order to perform analysis of comparison between the various and variables analog sizes of the plant.

All calibration values of the thresholds and/or set-point of acquired analog signals , the various timings, counts for maintenance, etc. are freely selectable and editable from the keyboard of the supervisor.

Synoptic pages

The display of the status of the plant will be made on synoptic video pages to show the graphic and dynamic layout of the plant.

Each synoptic page will display the overview section of the respective production process through graphic symbols and allow the activation and/or execute of the command directly from the video.

For each synoptic page will be displayed the conditions of operation of each device in the following ways:

- the object representing the electrical/pneumatic user changes its color FLICKERING according to the state of start/stop – open/closed or damaged;
- near the object representing the instrumentation of process the actual value with engineering unit will be shown;

In general on each synoptic page will be present strategic areas that will let, through a window or selecting the interested object with the mouse, to activate or execute commands by the operator.

The process areas will be displayed on special pages in a synoptic way to plot the layout of the plant.

The operator station, through password, can be specialized to show the area of plant, you want.

The operator station will be able to take charge of the complete management of all I/O (Tags) of the plant.

Each synoptic page should display in graphical and dynamic way according to the respective section of the process stages.

Features of the Automation System and Supervision

The system of control and supervision will ensure the following services:

- keyboard commands (ON/OFF - START/STOP);
- update data on the display (Digital Signal);
- update data on the display (analog signals);
- page turn Synoptic Dynamic Video;
- scan times (Digital Signal);
- scan times (Analog signal);
- Ability to program all the network users on the same PC with continuity of supervision of data acquisition and control system;
- single database/tags between PLC and SCADA software;
- one drive to the proprietary network and Ethernet.

Software

The operating software of the process will be realized starting from the functional description of the process and by patterns of sequence that will be developed in the engineering phase of the plant and will be sized for the type of the proposed process.

Programmable controller (PLC)

The PLC will be contained within one or more cabinets that will be adjacent to the auxiliary cabinets for the interface with the field and with the MCC.

The PLC will be able, at each stage of the process, to alert the operator, through the supervisor, any hardware or software failure that can be engendered during normal operation.

The system has high availability and reliability.

You can expand the system by adding , in the future, new functions (up to a maximum of 25% of the potential size of the current one) and then reprogram it on the spot.

In case of failure or malfunction of the hardware it will be replaced safely directly by maintenance personnel of the plant without the aid of the supplier or of the manufacturer.

All field signals and MCC will be wired to the cabinets with multiple cable terminals.

The signals from/to MCC will be resting on the cable terminals with regard to the digital inputs, while the digital outputs will be connected with an interface relays.

Supervision Line of biological treatment

Central system of automation and supervision

The entire electrical system and automation components consist of leading suppliers in Europe on the basis of local availability of spare parts.

A process computer communicates with a PLC decentralized. Communication occurs through a "bus" system. The PLC, which is positioned in a separate panel, receives the process functions from the computer.

A display computer transfers to the process computer the data for the regulation and control. For this reason it is not necessary to intervene operatively on the process computer.

The data are exchanged via data bank that resides on the display computer. Both computers of "visualization" and "process" are connected to the Windows net work. The computer display is equipped with modem and communications software for fast remote support in case of problems.

The processor operating system is Windows NT. This is a high performance operating system and multi-user that maintains a simple user platform.

The architecture of the video pages is the same for all the pages of the system.

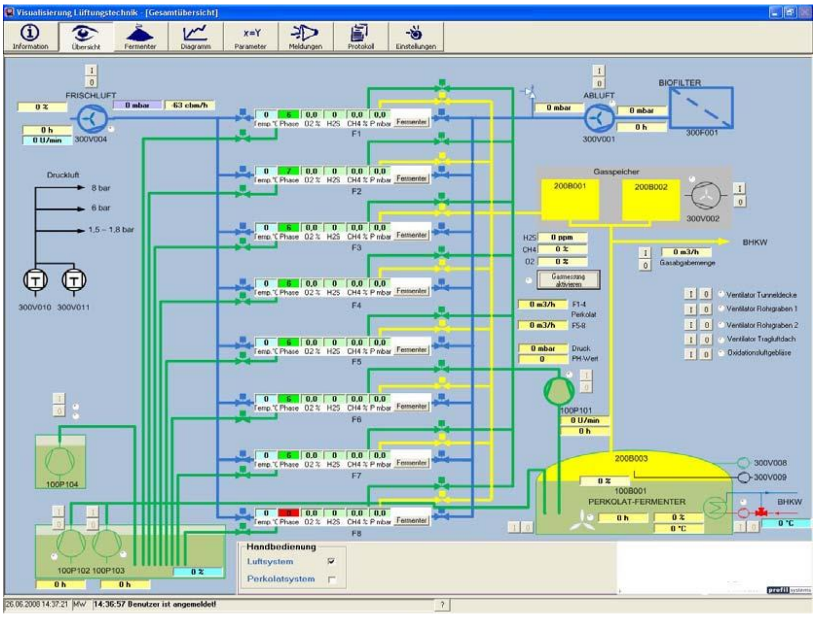
At the top of the screen there is a list that contains keys for the selection of the area involved. In addition to a summary screen, there are screens on the tunnels ,humidification, air flows, diagrams, cogeneration system, etc..

When the mouse moves over one of the buttons, it appears a description of the page that will be opened. At the bottom of the page, as well as date and time, the processor displays status and fault messages will be shown.

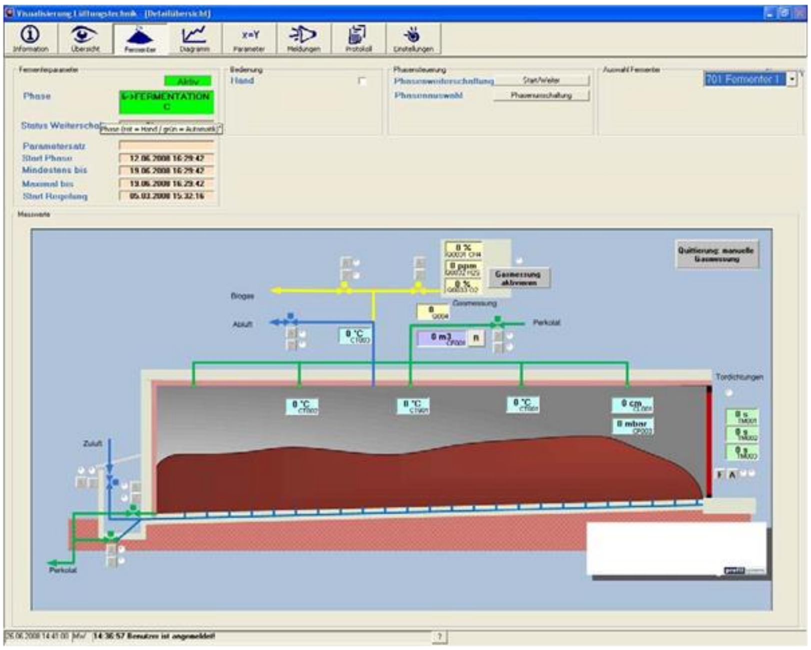
Below there are some typical video pages. Note that the control system is divided into two parts of which one direct at proof of a failure (FAIL-SAFE) which works without the PLC and the PC of automation.

In case of interruption of the electricity must be activated an emergency generator to ensure that the essential components of the system remain operational.

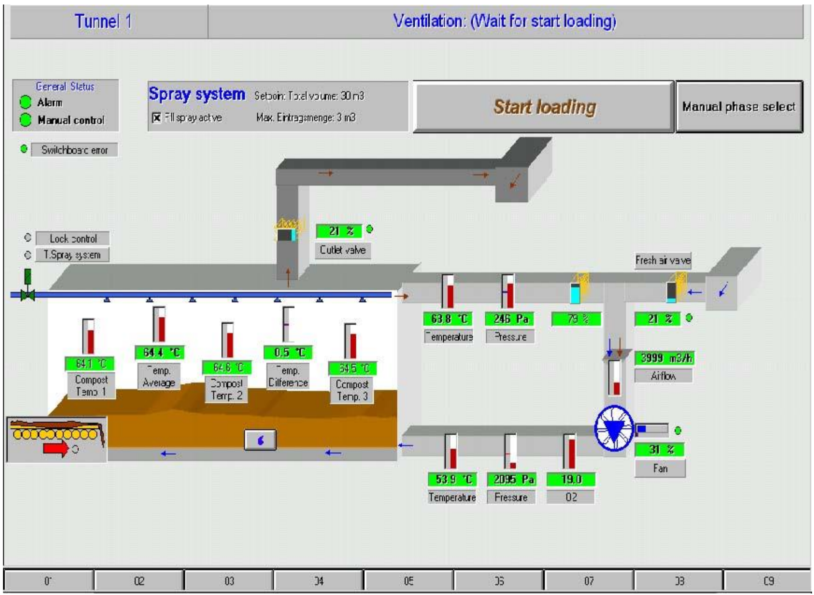
General screen of anaerobic process



Screenshot of the single anaerobic tunnel



Screenshot of the single aerobic tunnel



Sizing

Quantities and characteristics of the incoming waste MSW:

- Quantity 260.000 t/year

Waste-Composition

- Organics 38,75 %
- Paper, Cardboard 23,50 %

- Plastic 13,10 %
- Metals 8,10 %
- Glass 3,45 %
- Leather, wood, textile 5,80 %
- Inert 7,30 %

Pre-treatment

- Total Quantity incoming waste 260.000 t/year
- Incoming waste quantities per day 800 t/day
- Number lines of selection 1 unit
- Design flow of each line 35.0 t/h
- Design flow of the plant 60.0 t/h
- Days of work per year 312 d/year
- Working shift per day 2
- Hours of work per shift 8 h/day
- Real Hours worked 7 h/shift

Anaerobic digestion of underscreen fraction with 0% of separated source of organic waste

- Input Quantity 140.000 t/year
- Gas Production 11.500.000 m³/year
- Content-methane biogas average 52.5%
- Calorific natural gas 3.2 kWh
- Total energy in gas 60.000. MWh/year
- Average Yield 37.5% of the generator
- Electricity-theoretical 26.000 MW/year
- Generator Operation 8,000 h/year
- Project-density material 0.60 t/m³
- Input-annual total volume 170.000,00 m³/year
- Input-weekly 3.610 m³
- Number of tunnels filled by week 1 unit
- Required per unit-volume 710 m³
- Width-net tunnel 7 m
- Net-length inside the tunnel 35 m (33.5 useful)
- Technical back corridor 3.0 m
- Filling height 3,5 m
- Residence in the tunnels 3 weeks
- Total number of tunnels 20 units

Cogeneration Group

- Power- rated supply
- Content-methane mixture in biogas 45-55%
- Manufacturer Deutz, Jenbacher, Guascor or equivalent
- Power input
- Power output
- Thermal power output
- Electrical efficiency-average 37.5%
- Thermal efficiency-average 41%

Bio-Stabilization and Bio-Drying underscreen digestate

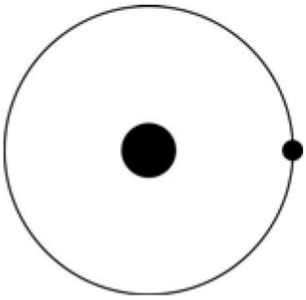
- Input-annual 140.000 t/year
- Project-density material 0.55 t/m³
- Input-annual volume approx. 220.000 m³/year
- Input-weekly 3.500 m³
- Number of tunnels filled by week 1 unit
- Unit volume required 635m³
- Width-net tunnel 7 m
- Net-length inside the tunnel 35 m (28 useful)
- Technical back corridor 3.0 m
- Filling height 3.0 m
- Residence in Tunnels 3.0 weeks
- Total number of tunnels 18 units

Air Handling System

- Capacity-demand receipt, sorting, processing 140,000 m/h
- Specific load on the biofilter 400 m³/h/m²
- Area biofiltering 2.000 m²

7) Gasification plant

Editorial



HYDROGEN: WHAT FUTURE?

The energy industry, from now on and more and more in the future, in particular in the next 50 years, will have to reconcile two contrasting demands: the growth of energy request at worldwide level and the correlative increase of environmental impact both at global level, such as the greenhouse effect and the change of the climate, and at local level for the air quality.

The developing countries, with particular regard to China and India, will try to carry out their natural aspiration to reach economic growth and life good quality levels like the industrialized countries with the consequent increase of energy needs.

Such increase will assume significant values in relationship both to the swiftness of the predictable development and the growth of the pro-capite consumption of energy (the only China grows more than 10 millions people every year). Furthermore, if the rest of the world reached a pro-capite consumption of energy equal to the half of the average of the OCSE Countries, the worldwide energy needs would double and in proportion, without substantial structural changes in the energy system, would increase the emissions by tragically worsening the quality of life with irreparable damages both to health and ecosystem.

These simple considerations give an indication how the necessary energy production is important and difficult for the "tolerable development" which should allow to provide an adequate quality of energy to the worldwide population, in consideration of its growth, reducing the difference between rich and poor countries, it should allow to use the exhaustible energy resources with respect of the inter generation equity, ensuring an adequate availability also to the next generations and to produce and use the energy with reversible environmental impact or however tolerable by the ecosystem.

The recent Kyoto international conference discussed these problems coming to an agreement which takes up the developed countries and the economies in transition phase to reduce, in 2010 the greenhouse gas emissions of about 5% in comparison with those of 1999. This agreement, which has not however been ratified yet by most signatory countries, has had the merit to promote concrete initiatives to start interventions on a big scale for the restriction and the reduction of greenhouse gas.

The interventions regarded and concern the most rational use of the energy, the eficiency improvement of both the energy processes and the production technologies and use of energy, which have quickly given interesting results, which in perspective, also in short time (about 10 years), will run out the waited benefits, dramatically reproposing the problem of the socio-economic development and total pollution.

There is a solution, and it is just one: to introduce the hydrogen as energy vector! Hydrogen is, in fact, besides the electric energy, the only not polluting, accumulative, easily supplying energy vector and which can be produced by several energy sources, the renewable ones included. The hydrogen represents the key component of a new tolerable energy system: it can be produced by the fossil fuels, subject to conversion of the same ones with mature technologies (steam reforming, partial oxidation, gasification) and advanced technologies (membranes reforming, pyrolysis processes with carbon separations, without carbon dioxide production) and CO2 separation allowing he cleanest way to use these fuels. Furthermore it can be produced by other sources (renewable, nuclear) without CO2 emissions and during its use it does not generate either CO2 nor other types of pollutants, satisfying other fields which go from the generation of electric energy, to transports, to the most disparate uses in the civilian and industrial sector.

In perspective, in accordance with the more credited forecasts (OECD, DoE, Iaasa and the most important oil companies) the energetic market will be dominated, within 2020, by the natural gas which assures the lowest enviromental impact (lower CO2 production) in all the energy conversion processes thanks to the optimum hydrogen/carbon ratio (4:1). Despite this forecast, the growth of the energy consumptions at worldwide level and however the necessity of the developing countries to use the plentiful coal reserves for their growth, makes the stabilization of CO2 at a middle level of 550 pmm within 2050 necessary. The evaluation and the economic advantage is fundamentally based on the "avoided" CO2 cost and on the awaited benefits from significant savings in all the sectors, which nowadays require interventions of "environmental improvement". A study of the U.S. Department of Energy assumes a cost of about 15-25$/t for the CO2 seized by the hydrogen production process and one of about 300$/t for the separable one from the smokes of the current works and energy production processes. Therefore it is possible to tolerate the background in which the hydrogen, however produced, can be distributed by a suitable pipe-line, accumulated and used for all the energy applications, the transports area included.

When the hydrogen is produced by fossil fuels, the separate CO2 is bordered in stable way in the subsoil of the saline waters at about 800/1000 meters depth or in methane or petroleum worked-out deposits (a confinement below sea level, beyond 1000 meters, in particular streams and thermal gradient conditions, is also assumable) The optimum use of hydrogen is since today insured by the technology of the fuel batteries which guarantee high conversion efficiency (60% in electric energy, and up to 75% with the thermal recovery through a turbine).

The fuel batteries usually called fuel cells, which have reached a good development level, are fit also for all the applications both for the centralized and the distributed generation, by keeping a high conversion efficiency without being penalized either by the size of the power or the change of the work charge, and for the use in the electric transports without environmental impact.

A national program is in advanced arrangement phase by Enea (National Council for Research and Development of Nuclear and Alternative Energies) and by Eni (National Hydrocarbon Agency) through a combined study.

Even if the main interest of Eni is turned to the hydrogen production from fossil fuels, Enea will extend the program to the renewable sources applications and to the ecosystem behaviour evaluations as well as to the research and the development of advanced technologies and processes (hydrogen store, in carbon nanostructures, solid membranes for CO2 separation and the purification of the hydrogen for polymeric membranes fuel cells, application to the transport means, etc.) and to the solution of the problems of safety and standardization concerning the hydrogen use.

Written by:

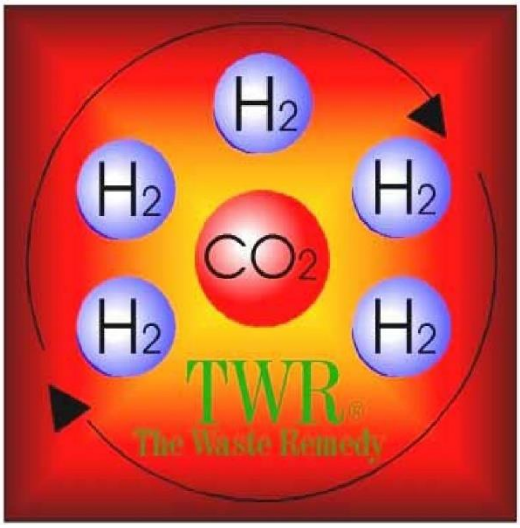
Carlo Rubbia and Raffaele Vellone

Prof. Carlo Rubbia, Nobel prize winner for the Physics and Chairman of Enea

Dr. Raffaele Vellone, director of the Department and Advanced Energy Technologies of Enea and responsible for the Enea-Eni Hydrogen National Project

From "La Termotecnica" - October 2000

TWR: The Waste Remedy



A SERIES OF HIGH TECHNOLOGY PROCESS AIMING TO THE ENERGY PRODUCTION WITHOUT EMISSIONS

The never well definite frontiers of the so-called "**tolerable development**" clash every day with the growing need of clean energy and with the necessity of removing all substances not reusable in processes they were produced from, too much generically called wastes and treated in processes using more or less polluting technologies.

"A tolerable development strategy requires a stronger increase in value of that big resource which is knowledge.

The nature itself is the primary source of knowledge. Mankind learned the knowledge to use up to unsustainable levels from nature itself. Now mankind can learn how to progress respecting the limits. However how not to see the high potentialities of the technological innovation, the possibilities of multiplying the ecoefficiency, to develop renewable and clean energy and sources, to stop pollution, to drastically reduce the consumption of natural resources, to live better and with more and reasonable wealth, in peace with nature?

Knowledge, opportunely oriented and spread, can become the principal engine of the tolerable development: a clean engine fed by a renewable energy" (From "Uno sviluppo capace di futuro", Edo Ronchi, Il Mulino).

TWR suggests as objective to realize a process that allows, starting from raw materials coming from wastes, and usable in any industrial or civil activity without further atmospheric pollution production, to produce hydrogen (H2), recovering carbon dioxide (Co2).

Incinerators: the technology for the future?

It rises spontaneous the question why in the high technology era the problem of the correct treatment of waste, both of civil or industrial origin, has not found the right solution yet.

The costs of waste disposal are very high, the treatment plants which are installed require big investments without definitively solving the initial problem: **POLLUTION**.

In the last few years the most important evolution of the incinerators, pointed out in the specialized congresses or in specific sector reviews seems to be stopped at the fact that now they are called "thermal evaluators".

Anyway they are incinerators even if they can boast some more per cent point as energy performance and a few additional equipment, which limits from one side the emission of dioxins and other polluting gases, creating perhaps other problems from the other one.

Incinerator in Brescia - Italy

The first answer to the initial question emerges in a very clear way:

When the initial concept is "WASTE DISPOSAL" all the initiatives followed up to today find a justification. The principal aim is to destroy, the secondary aim is to limit the damages of this destruction, the third aim is to decrease the destruction costs, by recovering energy.

And this is a progress in comparison with the burial in dumps, a method which was very used in is the past and unfortunately too much used in the present. It must be remembered that attempts have been done and are trying to solve the problem, also through different systems, but unfortunately the dominating "WASTE DISPOSAL" concept conditions and determines the adoption and the results of the applied alternative technologies.

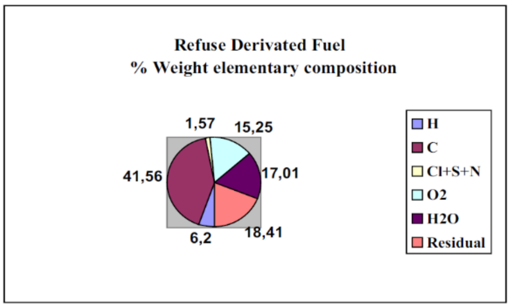
TWR: a new "waste disposal" concept

TWR starts from a different concept: The aim is to produce.

The choice of the product is determined by four factors:

- the market request
- the availability of the starting raw materials
- the economic costs-returns production budget
- the production social cost bound to the "sustainable development"

The first question finds an easy answer in the editorial proposed in the first pages of this presentation: aim "**HYDROGEN PRODUCTION**".



The second question inevitably takes to the rediscovery of all presenting everything, in part at least, hydrogen and carbon contents, simply called. This is for TWR a precious and indispensable raw material, whose availability is very high.

Any productive activity, being nowadays undertaken, cannot leave the economic costs-returns evaluation out of consideration. In a few cases, above all when the worldwide ecosystem future could be involved, this evaluation should be subordinate to many others, but actually nations are driven by economic laws at first and then by all the rest, where ecology is not either pre-eminent.

For this, TWR's aim is to provide a product that, on the basis of the current values of conferment of the raw materials and the return value from the use of hydrogen, can guarantee an acceptable return of the investment (8-10 years) and, can reach, with the scale optimizations, also the reduction of the value of conferment and consequently of the economic and also environmental benefit for the citizen.

It would be inconceivable and it could not be proposed that the realization of a plant which, having as purpose the solution of a social problem, creates in the same time some other problems with worse consequences than the starting problem.

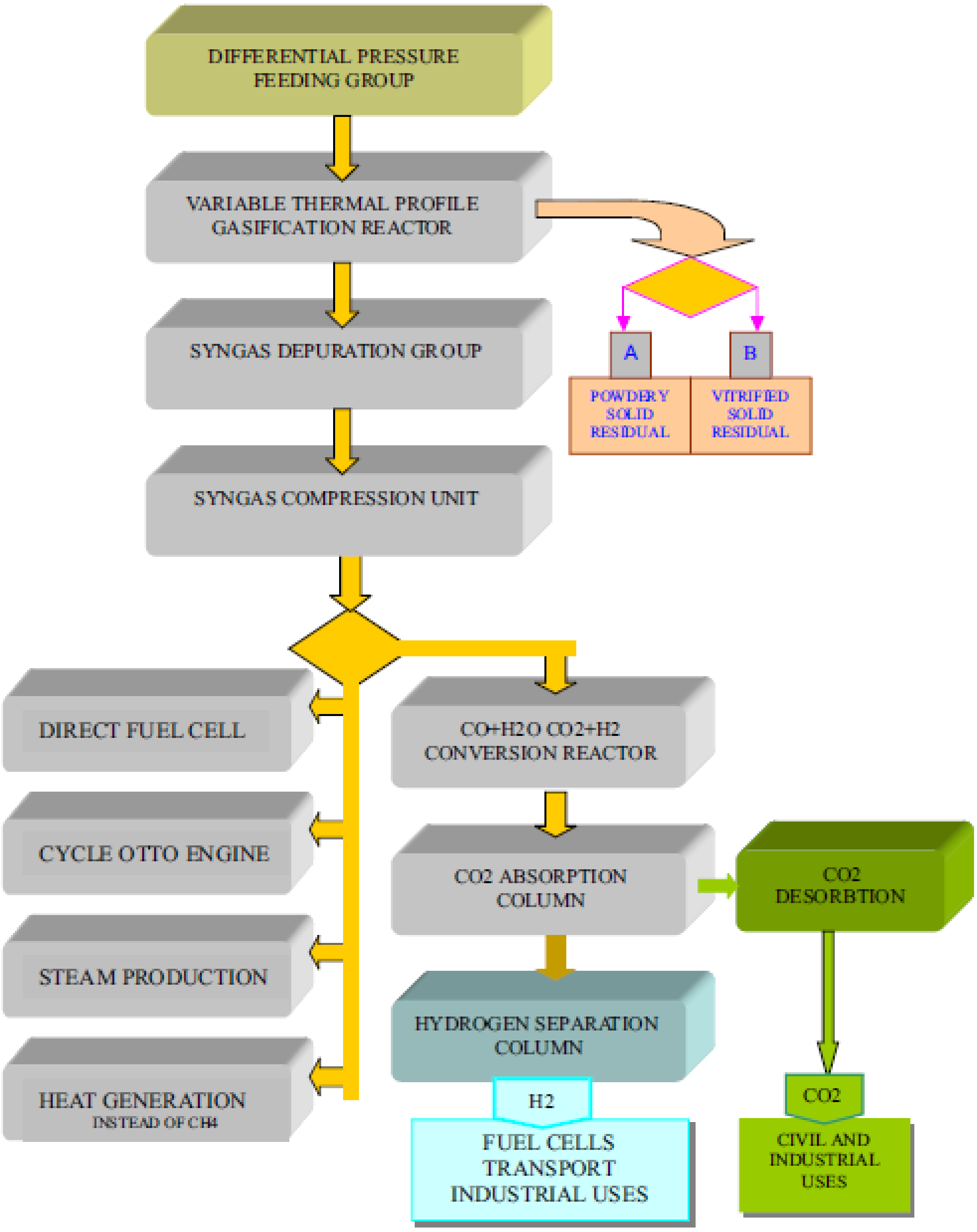
We could decide to stop the progress in the name of the "SUSTAINABLE DEVELOPMENT".

TWR proposes the remedy and the wastes problem solution through the realization of a transformation process which does not produce emissions: **NO POLLUTION.**

<u>TWR: the technological solution</u>

AIM: hydrogen production starting from raw materials (at present called wastes) without producing pollution.

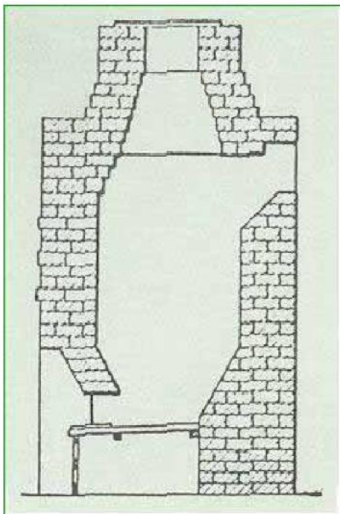
SOLUTION: gasification of raw materials with purified syngas production (at high hydrogen concentration), final reaction and hydrogen separation, with carbon dioxide recovery.

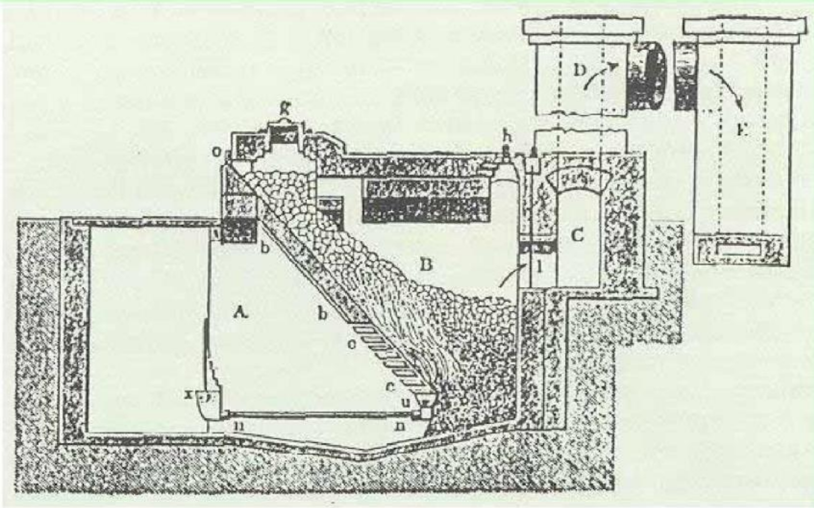


TWR: the gasification

The pyrolysis or gasification process is a chemical decomposition process exclusively produced by the thermal energy intervention. In absence of air (and oxygen in excess), and so in reducing ambient, the gasification causes the organic thermochemical decomposition of the organic material. The process, endothermic for its nature, causes the resolution of the complex molecules which constitute the fed raw materials, turning it into a gaseous uncondensable (syngas) phase principally composed of hydrogen, carbon monoxide, nitrogen, carbon dioxide and secondarily, in very low percentages, of chlorine, sulphur, fluorine and metals, which are possibly contained in the fed raw materials.

The gasification has been a well-known technology for a long time, the first known applicatory examples date back about two centuries ago. (See pictures1 and 2).


Picture 1 - Gas-producer of Bischoff (1839)


Picture 2 - Gas-producer Siemens (Prussian patent 1856)

Since then of course steps ahead were taken and this technology has found, and still finds, many applications with excellent results in the chemical and petrochemical industry, that is where for usual procedure the reactions are led and managed with the specific aim at producing this or that molecule.

The results obtained with the gasification of wastes are different, generally quite unsatisfactory and only in few cases acceptable.

The use of this technology with the principal purpose of "waste disposal", by using equipment more like huge "pans" than specific reactors, could not help but reaching these results even calling into question the possibility of application of the gasification itself.

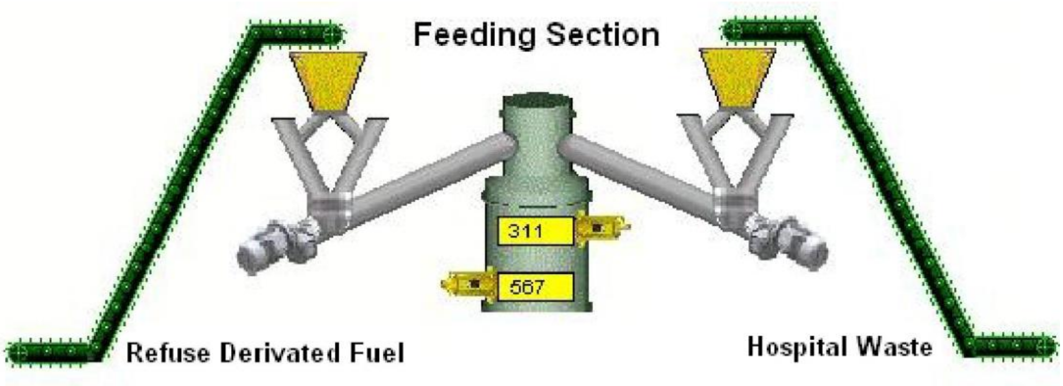
1. TWR: the fast gasification reactor

The reactor for the fast gasification is composed of three sections which are an integral part of the same one.

- **The first section is constituted by a raw materials differential pressure feeding system;**
- **The second section is constituted by the variable thermal profile fast gasification zone;**
- **The third section is constituted by the system of extraction of the gasification solid residual.**

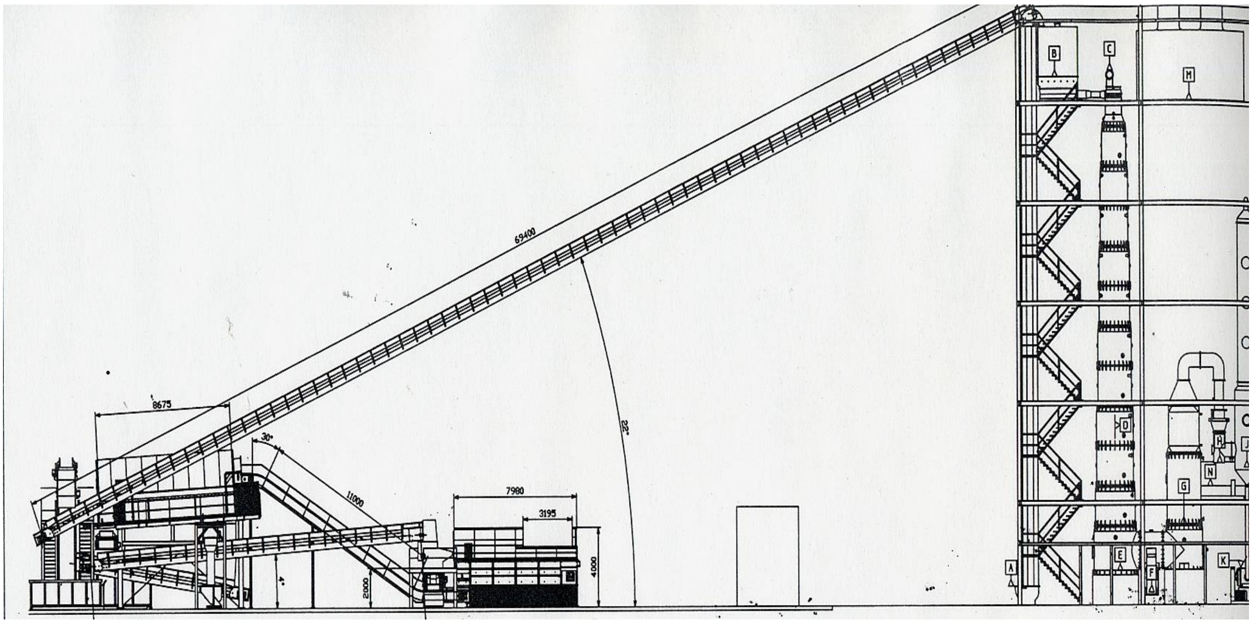
1.1 Raw materials feeding section

The feeding and the dosage of the raw materials has fundamental importance for the realization of the fast gasification process. In fact, the continuity of feeding, the size of the fed solid material and the realization of the feeding differential pressure turn out to be very important as blockage system to avoid the penetration of the ambient air inside the gasification reactor.

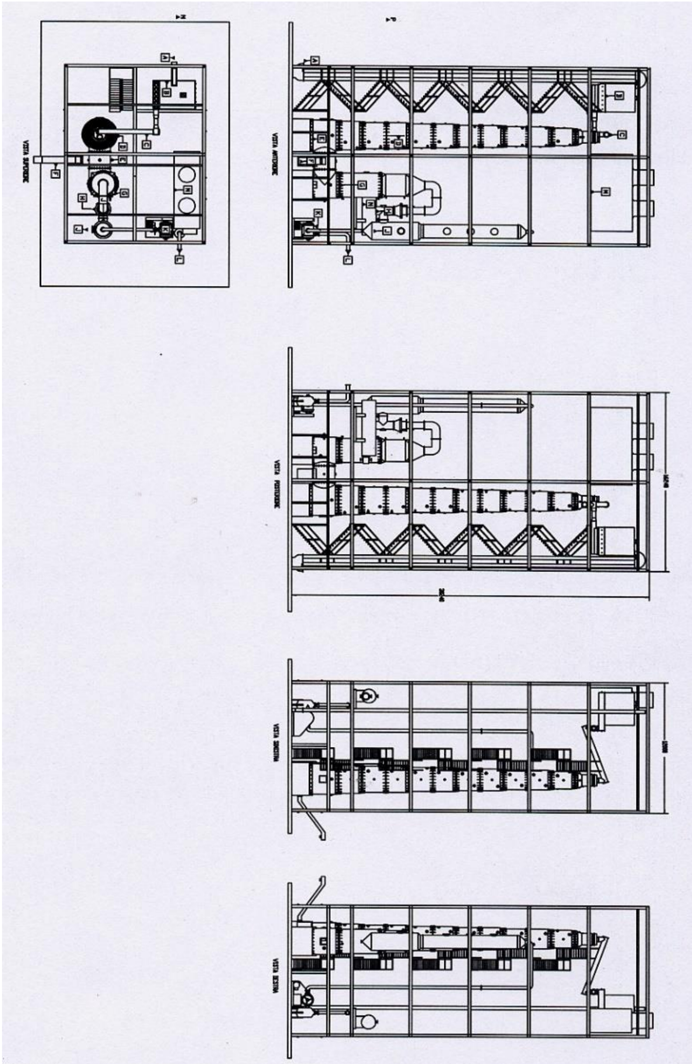


The feeding is developed in four different phases:

- compression for mass loaded raw materials
- introduction and dosage through pressure push pistons
- controlled size grinding
- fluidification and feeding to the gasification section with possibility of preheating

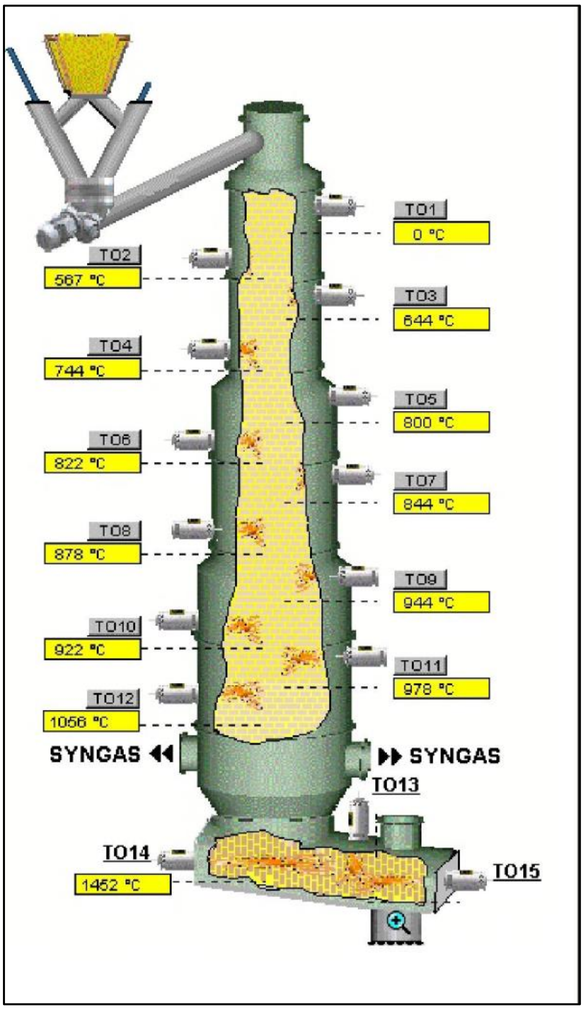


The conveyor means (trucks) will have the inside access through a principal door located on the long side of the area directly to the service building and after the checking and weighting operations, they will direct towards the other buildings following a road with double cart way, that links all the operative areas, the entrance and exit of the plant. The exit will be done through a second door on the same side of entrance.



2 Fast gasification section

It is a vertical development monotubular reactor with descending current.



This reactor section is designed to realize the fast gasification reaction in continuos. It is composed of a series of cylindrical sections with different diameters put one on the other (on every section a couple of torches is positioned at least, set at about 1 meter one from the other) with its thermometric survey: the number of the couples of torches depends on the diameter and length of the section and on the capability of the plant. The torches are fed with oxygen, as comburent, and with the available gaseous fuel (methane), dosed at stoichiometric ratio.

The realization of the monotubular reactor in cylindrical sections equipped with the opportune frustum-conic tapers, which enable them to be one on the other also in presence of various sections, allows a building modular structure and the possibility of making them transportable also with the refractory covering being already installed.

This characteristic materially allows to reduce considerably the assembly time at the yard also for the reactors with the

maximum admissible flow rate (10t/h), because all the parts of the plant can be assembled in workshop and then transported and, definitively assembled, at the final destination place.

The advantage of this solution is due to the fact that by completely making the various building phases in workshop (mechanical framings, refractory linings), and not bindingly at the yard, the quality of the work turns out considerably improved, the building costs decrease, the time of realization is much shorter.

Besides the building modular structure makes possible the availability of spare sections in the workshop, making possible and convenient the replacement of a damaged section with the spare section, reducing the time of plant stop with a great advantage for the productivity.

In the first cylindrical section, placed to the top of this gasification area, on one side the opening is made for the connection to the screw which transports the ground raw materials coming from the feeding section.

The reactor can be equipped with one or more feeding sections in order to gasificate, simultaneously, various raw materials which are physically different, and for security or process reasons, not mixable among them.

2.1 Reaction temperature

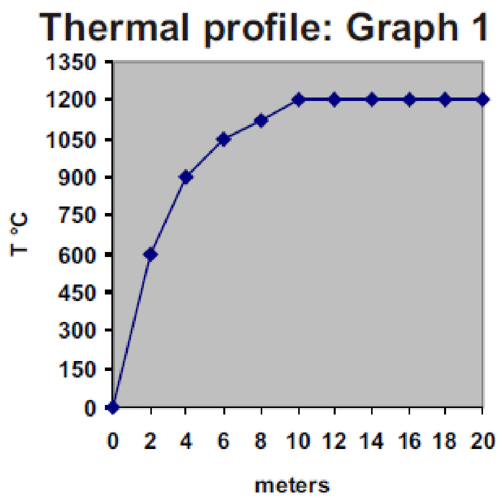
The reaction temperature is variable according to the single zone of the reactor and the typology of the fed raw materials. The admitted temperature range, in the gasification section, starts from a minimum of 350°C, to a maximum of 1200°C.

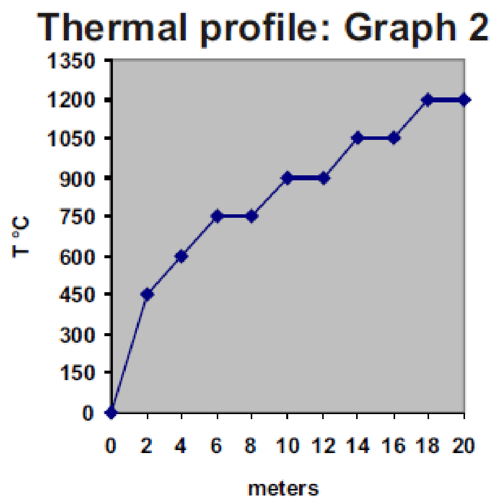
The exercise temperature in the various zones of this section is determined through a settable VARIABLE THERMAL PROFILE in the admitted temperature range.

The trend of the thermal profile is determined by the typology of the fed raw materials or possibly by the mix of the same ones according to the amount of the present water, of the amount and typology of inorganics which are present, of the granulometry and in consequence of the fed raw materials reactivity.

In a few cases it can be necessary to set up a thermal profile tending to reach the maximum temperature in the minimum possible time (see graph 1), while, in other cases, it can be more convenient to reach the maximum temperature only in the final part of the gasification section (see graph 2).

The two thermal profile examples for the gasification section, assumed with a length of 20 meters, are the following ones:





The thermal profile of the gasification reactor is reached and kept through the series of torches installed in the suitable section of the reactor. Each torch has electronic gauges and proportional control regulation valve for combustible and comburent gas.

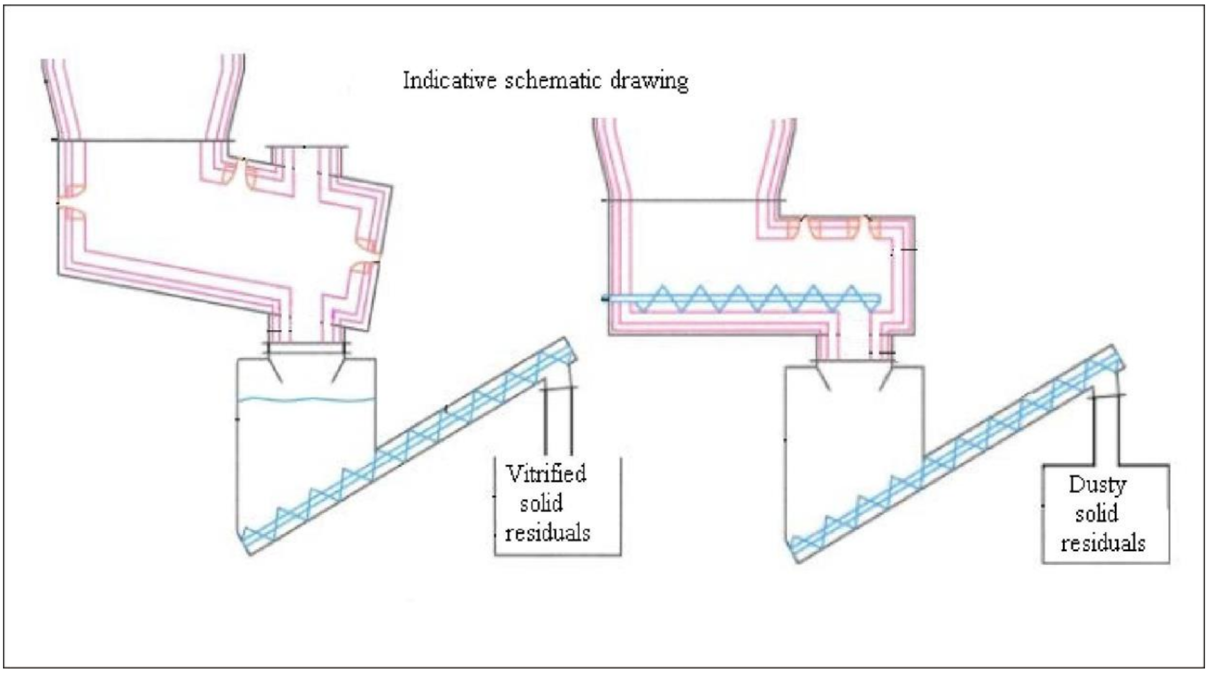
The flow rate values of each gas are set in the plant control room; they will be automatically maintained.

The fuel gas flow rate regulation of every torch is automatically determined by the temperature, which is sensed by the suitable thermo element located close to the torch itself. In this way it is possible to set up the temperature value of the thermal profile established for that reactor or that specific application in the various areas of the reactor itself.

3 Gasification solid residuals evacuation system

The section of the gasification solid residuals extraction, obtained in the lower part of the reactor, is foreseen with two working systems and consequently through two different solutions. Another characteristic of the TWR system is the double possibility of extraction form of the solid residuals.

It can be provided with this thanks to the variable thermal profile that allows to present these residuals, entering this section, at the most suitable temperature in function of the final treatment which they must undergo.



TWR reactor: treatment alternative system and gasification residual evacuation

3.1 Extraction of dusty residuals

The first solution foresees the evacuation of the residuals in dusty solid form. This solution is adopted when, because of the typology and the homogeneity of the raw materials fed to the gasification reactor, it is possible to characterize the quality of the residual inorganic substances, so that they can be used in the same process which has produced them or as raw materials in other processes.

This section consists in a horizontal cylindrical chamber hooked under the gasification section, into which a screw is set .

In this zone one or more torches are installed which are fed with comburent lightly in excess, allowing the possible residual carbon oxidation contained into the dusts.

The exercise temperature in this section is about 700-800°C and however it is determined by the fusion point of the residuals, that has never to be reached.

The residual dusts, pushed by the screw, are discharged through an exit placed in the lower part at the bottom of the cylinder.

3.2. Residuals extraction in vitrified form

The second solution, concerning the system of evacuation of the solid gasifications, foresees the vitrification of the same ones.

This solution is adopted in the cases in which, for the typology and the heterogeneity of the raw materials fed to the gasification reactor it is impossible to foresee the reuse of these solid residuals in other industrial processes, or due to the analytical characteristics these solid residuals can constitute an environmental risk.

In this case by taking the residuals to fusion, followed by the sharp cooling in water, the vitrification of the same is obtained, by making them completely inert as the process turns out irreversible.

This inertization process is obtained by the realization of a residuals evacuation section, hooked, through the connection area, under the gasification section.

The evacuation section consists of a parallelepiped chamber horizontally set with slope towards the discharge point placed in the lower side.

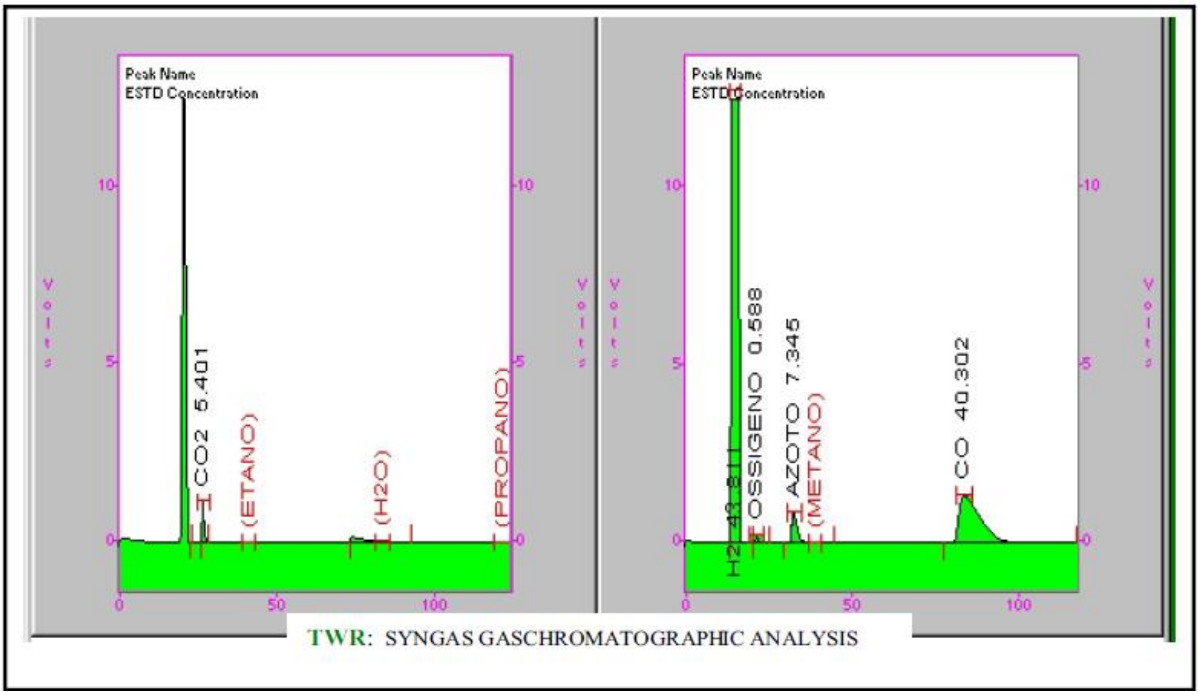
The exercise temperature, determinated by the necessary overcoming of the point of fusion of the residuals is of 1500°C.

This thermal regime is obtained through at least 2 or more torches fed with comburent dosed with a partial excess, according to the stoichiometry, to guarantee a lightly oxidizing atmosphere which allows the oxidation of the carbon eventually contained in the solid residuals.

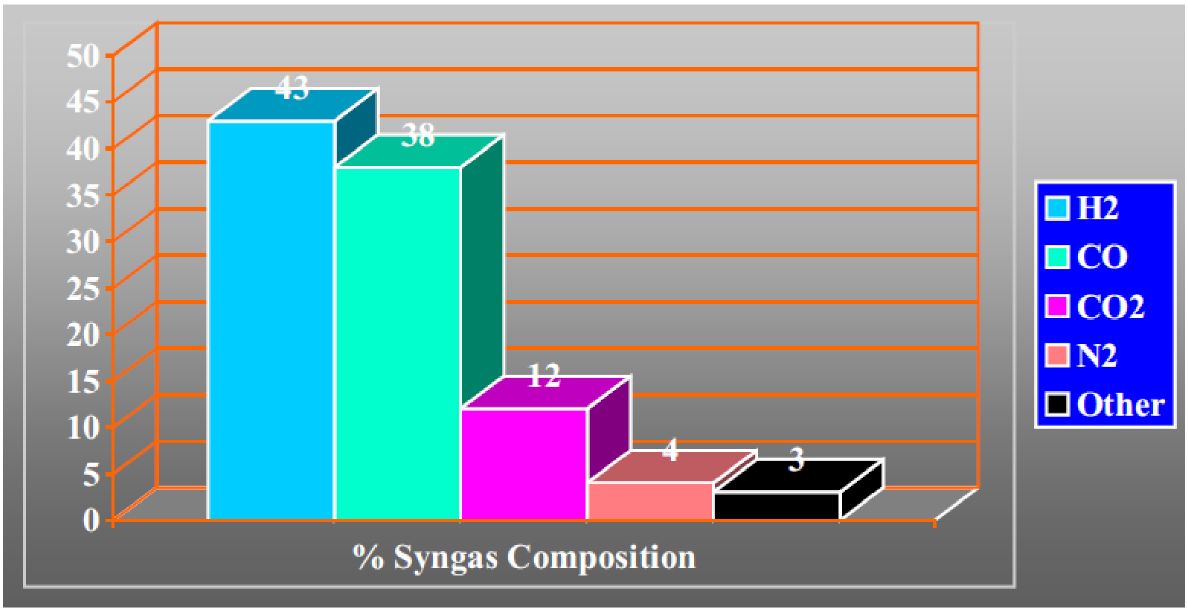
4. TWR: production of hydrogen and CO2 from SYNGAS

The TWR process, the characteristics of the gasification reactor, the specific management and the process control, allow to obtain a syngas with concentration of H2 from 38% to 45% and CO from 35% to 40%.

The chromatographic in the figure here below highlights also the percentage concerning CO2, O2, N2.



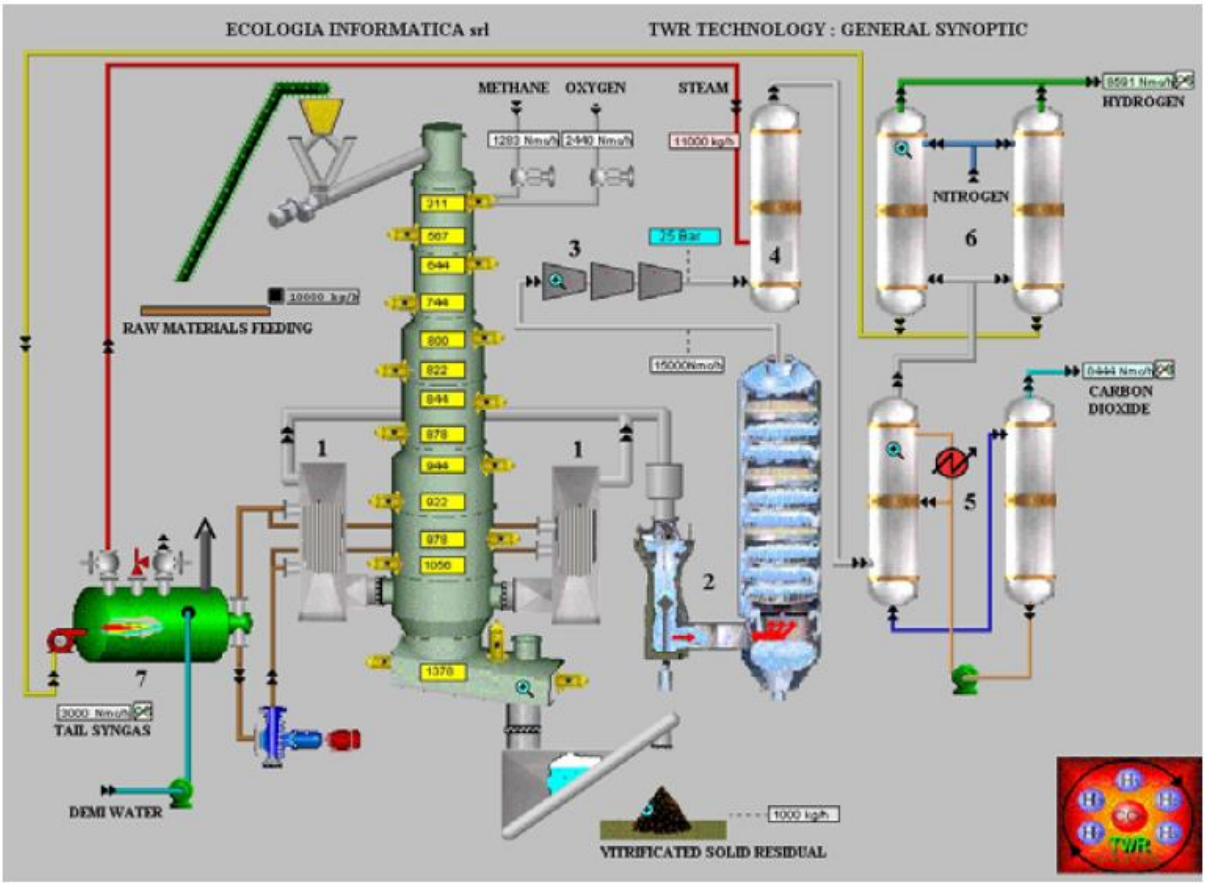
TWR: SYNGAS GASCHROMATOGRAPHIC ANALYSIS



If the plant uses syngas for hydrogen and Co2 production, it is supplied with a particular equipment aiming at the maximization of such molecules production.

The syngas is separated from substances and impurities, witch depend on the fed waste ("other" into the graphic), which are contained in the syngas itself.

Separate collection of molecules

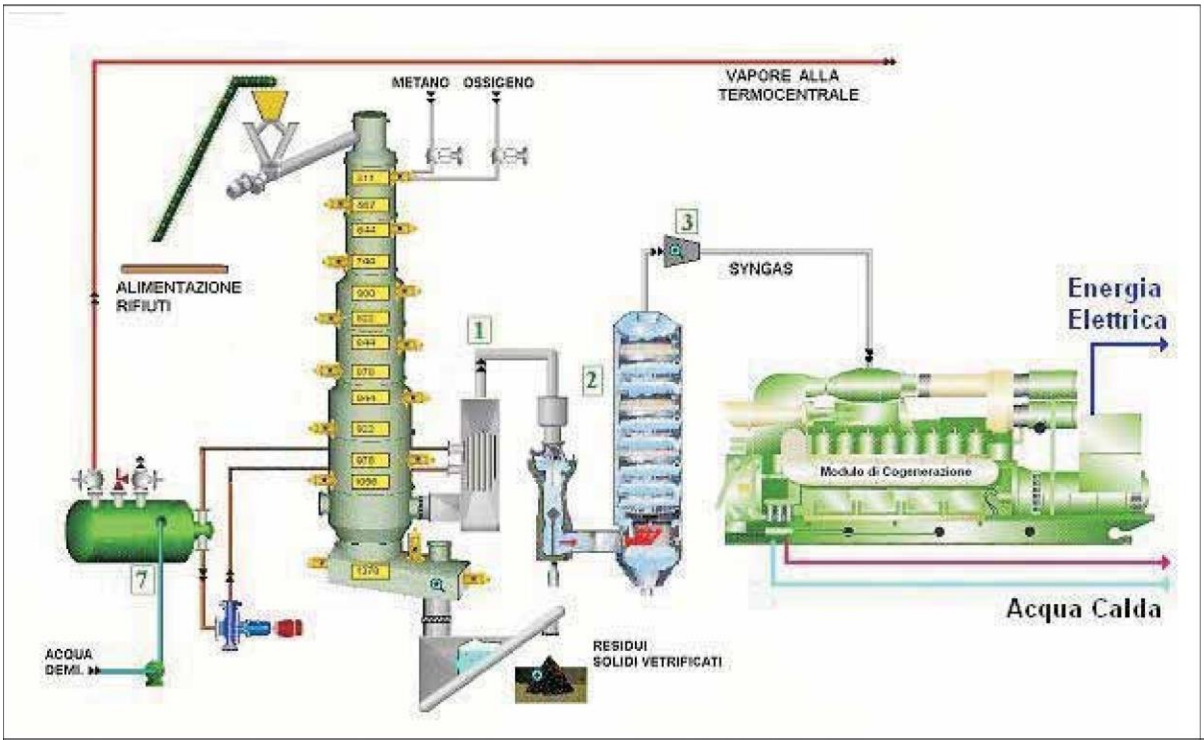


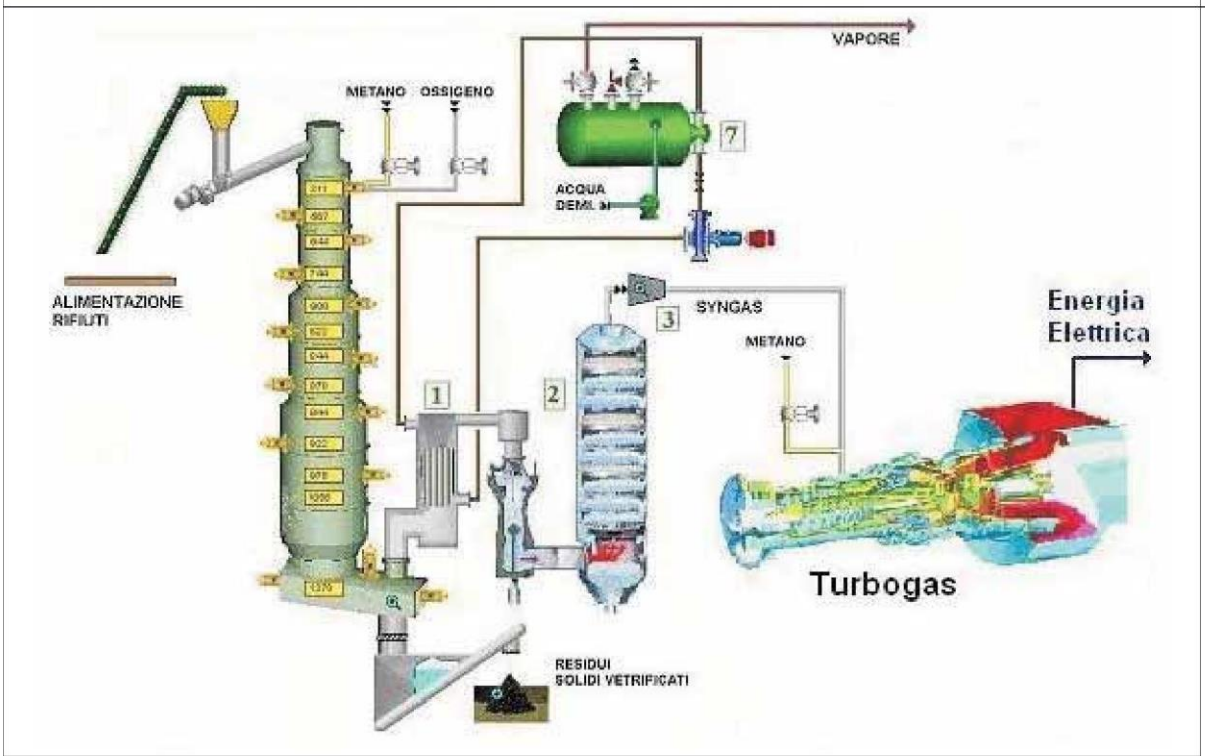
H2 AND O2 FOR WASTES PLANT PRODUCTION

The technologies and the equipment included in the TWR process to complete the plant, already widely tested in similar processes, are the following ones:

1. Heat recuperator
2. Syngas neutralization and purification
3. Syngas compression unity
4. CO in H2 conversion reactor
5. CO2 recovery
6. H2 separation from the residual syngas
7. Steam production boiler

TWR Plant possible configuration





4.1 Heat recuperator

The syngas produced in the gasification chamber comes out through flanged little sections set at 180° one from the other.

Connected to each of these little sections two heat exchangers are installed to cool the syngas from 1200°C to 250°C, recovering the heat for the production of steam.

The heat exchange takes place between the syngas, flowing outside the pipes, and the diathermy oil which comes inside the pipes.

The diathermy oil is made circulate, in a closed circuit connected to a steam generator, where the enthalpy contained in the syngas is recovered.

The produced steam is used in the reaction of conversion of the CO in H_2+CO_2.

4.2 Syngas neutralization and purification

The neutralization and purification of the syngas is made in a high performance multistage system so that the outgoing syngas does not present incompatibility characteristics with the following reaction phases.

The syngas can eventually contain mainly carbon black, metals, acid substances according to the typology of the fed raw materials.

The multistage system foresees some specific intervention sections for every present pollutant typology.

For this reason every treatment section is provided with a suitable circuit, for the absorption of one specific pollutant or a specific pollutant family, which enables the separation and the possible recovery of the absorbed substance.

The first unity is constituted by a quencher for the cooling and the saturation in water of the syngas.

The temperature of the syngas is taken from 250°C to 90°C and the saturation in water allows a better efficiency in the following treatment phase.

The second unity is constituted by a variable Venturi throat. The "must have" characteristic of this section of plant is the high efficiency of separation of the carbon black, (disguised as micronic dusts) possibly contained in the syngas.

The throat of the Venturi is one off adjustable type.

The central bob, it is equipped with, can vertically move in order to change the passage area through the throat. In such a way the gas ideal speed can be kept, through the throat, within a very wide gaseous flow rate range, always remaining in the optimum of pressure drop and equipment efficiency.

The liquid process, kept in recycle by a suitable pump, is continuously filtered to separate the particles being in it.

These particles, essentially constituted by coal dust, are refereed to the gasificator.

The third unity is constituted by a multistage scrubber. This equipment is constituted by a column inside which three hydraulically separated zones exist at least.

In the first one, destined to the absorption of the neo metals possibly contained into the syngas, a series of trays is inserted, suitable to the purpose, on which, the absorbing solution kept to ph acid is made circulate by a suitable pump.

The circuit of this solution is equipped with a suitable treatment section where the metals contained in it are made filter and separate, and the solution is put again in cycle precipitate.

In the second zone, destined to the neutralization of the acid substances, another series of trays suitable to the purpose is inserted, on which it is made circulate the neutralizing solution kept at basic ph by suitable pumps.

The circuit of this solution is equipped with a suitable treatment section where the obtained, filtered and separated salts are made precipitate, and the solution put in cycle again.

The third zone is composed of a high efficiency demister for the separation of the micro drops dragged through the purified syngas.

No discharge of liquid substances is foreseen from the syngas purification plant.

4.3 Syngas compression units

The purified and neutralized syngas is sucked by a multistage compression unit which has the task to overcome the pressure drops, produced by the equipment placed on the top, and compress, the same syngas, to the pressure of 25 bar, necessary to the following reaction phases.

The exercise pressure difference between the equipment at the top and the equipment at the bottom being high, it is necessary to use a compressor with at least three compression phases in series to reach the established working pressure.

The compressor is equipped with a flow rate regulation system connected to an electronic pressure transmitter, positioned on the gasification chamber.

4.4 CO in H2 conversion reactor

In this reactor the syngas stream and steam are fed at the pressure of 25 bar at the temperature of 280 ° C.

Due to these conditions, in the presence of the catalyst, the $CO+H_2O$ in CO_2+H_2 conversion reaction takes place with a conversion performance equal to 84%.

The reaction is exothermic and the produced heat is recovered, through a heat exchanger using, the gaseous stream coming out from the reactor to heat the stream entering the conversion reactor.

4.5 CO2 recovery

This section is composed of a couple of columns, destined to the separation of the CO_2 contained into the fed syngas.

In the columns a solution circulates, having 30% potassium carbonate in water, at the temperature of 80°C, and in order to increase the absorption speed, suitable activators are used.

In this condition, in the first column kept at a pressure of 22 bar, the (exothermic) reaction $K_2CO_3+H_2O+CO_2$ to $2KHCO_3$ takes place.

At this tower exit the syngas mixture contains about 2% CO_2 residual.

In the second tower the desorption of CO_2 from the potassium carbonate solution is made by simple expansion and in steam stream stripping of the water solution which is so reproduced and sent again to the first tower.

The produced CO_2 at 99.5% purity is cryogenically cooled and liquefied and then sent to the suitable storage container and to the final use.

4.6 Separation of hydrogen from the syngas

The third section is composed of two columns destined to the separation of the hydrogen, (with purity of 99.9%), contained in the fed syngas.

The columns work at 21 bar pressure, and at 40°C temperature, and they are filled with molecular sieves.

To have a continuous hydrogen production, the two columns must work in an alternated way.

The syngas is fed in the first column, where the molecular sieves keep only the hydrogen.

When the molecular sieves reach the saturation, the first column is closed and the syngas is fed in the second column, while the first one is put in regeneration with a nitrogen stream and it is prepared for the following cycle.

The recovered hydrogen separation performance, in comparison with the fed one, is equal to 81%.

The tail gases of this section, obtained in the regeneration phase with nitrogen and composed of H_2, CO_2, CO, N_2, are given back at a pressure of 1.5 bar and used as fuel gas in the boiler for the steam.

4.7 Steam production boiler

The boiler for the steam production foreseen for this application uses a double energy source.

The first one consists of the heat recovered by the exchangers installed for the cooling of the syngas going out from the gasification section.

The second source consists of the enthalpy contained in the tail gases (2000 Kcal/Nm3), which is used as fuel in the burner of the boiler itself.

5. TWR: the ecological aspect

The Waste Remedy must be analysed, evaluated and judged, above all, as regards the ECOLOGICAL APPEARANCE. In fact every other evaluation must be considered as secondary, even if the right importance is given at each.

If **TWR** wants to be "**the solution**" of the problem, ecological-environmental type direct consequences must not and can't be tolerated. This concept is better clarified by analysing the most important aspects of the subject at issue.

Raw materials in feeding

The **TWR** process, whose aim is to produce, needs the fed raw materials to correspond to determinate characteristics, (for instance Refuse Derivate Fuel of Municipal Solid Wastes) with qualitative ratio, which are well-known in the vastness of the admitted typologies.

This means that the careful selection of the treated wastes becomes compulsory. This selection takes to the recovery of all those substances which can have a direct value of market, or other arrangements, forming the most suitable composition of the raw materials in feeding. It must be remembered that the gasification reactor is not equipped with a "big door" where everything can be introduced in an indiscriminate way just because it must be burnt and that the remedy to the consequences of this action is in other parts of the plant.

This characteristic could seem a limitation, but by analysing all the aspects of the problem it is clear that it constitutes the correctness of the approach and the guarantee for the achievement of the result.

Gasification residuals vitrification

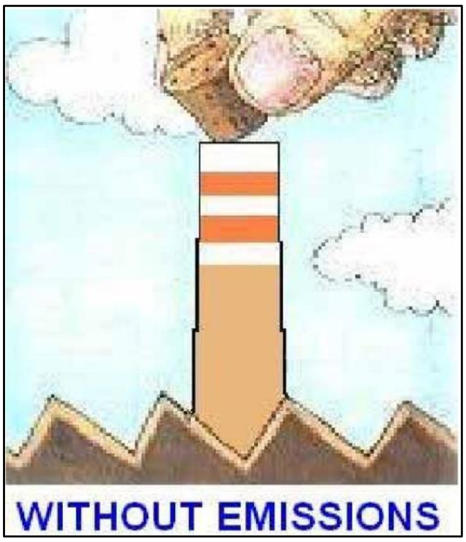
The solid gasification residuals coming from the **TWR** process are vitrified.

This guarantees the total inertia towards the environment and allows also the reuse, if possible, in other utilization (such as road foundations, pre-shaped blocks etc.). In the case of homogeneous raw materials feeding and consequently to the obtaining of residuals from the well-known composition, it is possible not to proceed to the vitrification just limiting to the thermo-oxidation by unloading the dusty form residuals and allowing their reuse in other processes.

The gasification

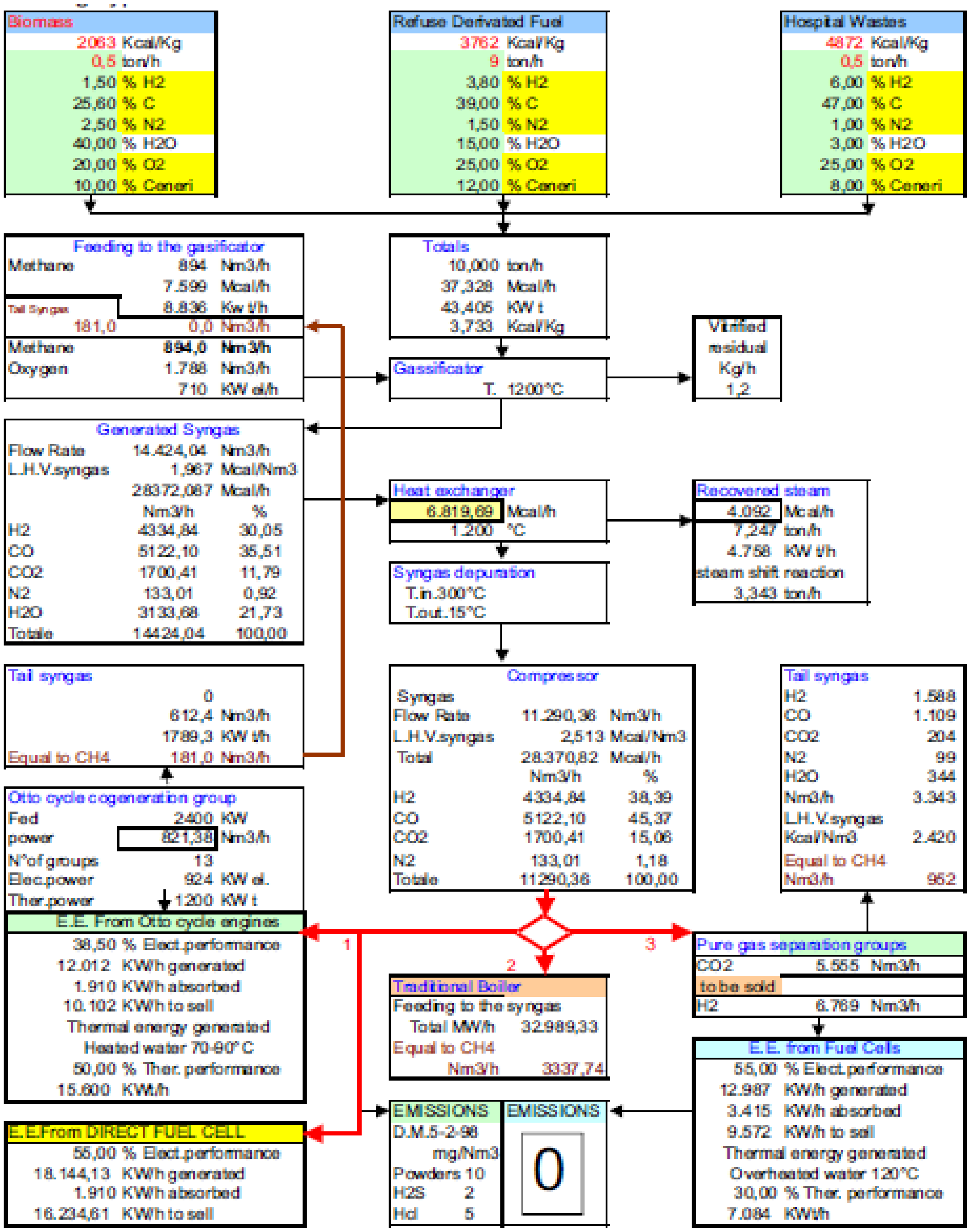
The gasification is the only process, without emissions, which enables "to burn" the wastes, using them as raw materials.

The **TWR** process, realizing the fast gasification with variable thermal profile, optimizes the gasification, allowing the hydrogen production and the recovery of the carbon dioxide by the syngas produced.



6. TWR: the energetic aspect

The generation of energy by renewable sources is one of the fundamental concepts of the **TWR** process. For this reason technologies, guaranteeing the highest performance, have been adopted also for the electric energy generation systems. In the flow chart, here below, the various energy performances are shown according to a feeding hypothesis.



7. TWR: the safety aspect

The typology of the reactions carried out and the produced gas (hydrogen) impose a due attention with respect to the way of realization of the plant and to the management of the process.

The design of the plant adopts all the precautions normally used in the chemical or petrochemical plants, because some sections of the plant are alike.

Particular attention is paid to the active security that is principally realized by the following solutions.

- **Modular reactor**

  The dimension of the gasification reactor is intentionally limited to contain the volumes of the flammable gases. For this reason the maximum capability range of every gasificator is fixed from 8 to 10 Ton/h.

  The installation of several gasification modules always allows to reach the wished project flow rate.

- **Fast gasification**

  The adoption of the **TWR** process enables the realization of the fast gasification.

  This means that inside the reactor there is no accumulation of substances to be gasifed and the reaction inertias are very low, allowing the stop of the production of flammable gases in a very short time.

- **Computerized management**

  The management of the whole plant is totally computerized. A complete series of analysis and control instrumentation, in a few cases installed in double, connected to a powerful elaboration and calculation system, allows the management in real time of all the process variables and consequently the optimum regulation of the reaction parameters.

  The whole equipment is provided with its diagnostic which enables to detect any malfunction of each instrument or plant part.

-Adequate plant engineering

A suitable plant lay-out study, the observance of the distances of security among the various equipment, the reliable instrumentation adoption, the working logic sequence, the intrinsic security electric plants, the quality of the materials used, constitute an indicative and not exhaustive list of the choices also aiming at the safety of the plant.

8. TWR: the economic aspect

"A strong sustainable development is able to promote also the necessary changes in the economy. The aims and the priorities of these changes are clear and identified.

The environmental goods are worth to be included in a real and complete evaluation of costs and benefits.

The market must conform to the environmental aims actually to become a really efficient tool of allocation of the resources.

In the relationship between international commerce and environment, the priority is the sustainability, not the liberalization. When the liberalization, avoiding protectionisms damaging the environment, is useful to the sustainability, it must be promoted; when on the contrary it brings to the unsustainable exploitation it must be limited.

When the market economy obstructs the start of new sustainable technologies, defending consolidated and unsustainable technologies, it must be regulated with laws and oriented with economic and fiscal incentives."

The **TWR** process, under the economic aspect must be analysed according to the double use of the produced syngas.

Through the direct use of the syngas in the Otto cycle engines, ensuring a drastically lower environmental impact and a higher energy performance than the traditional technologies of wastes disposal, the value of the investment and its amortization are perfectly comparable to the best alternative technologies.

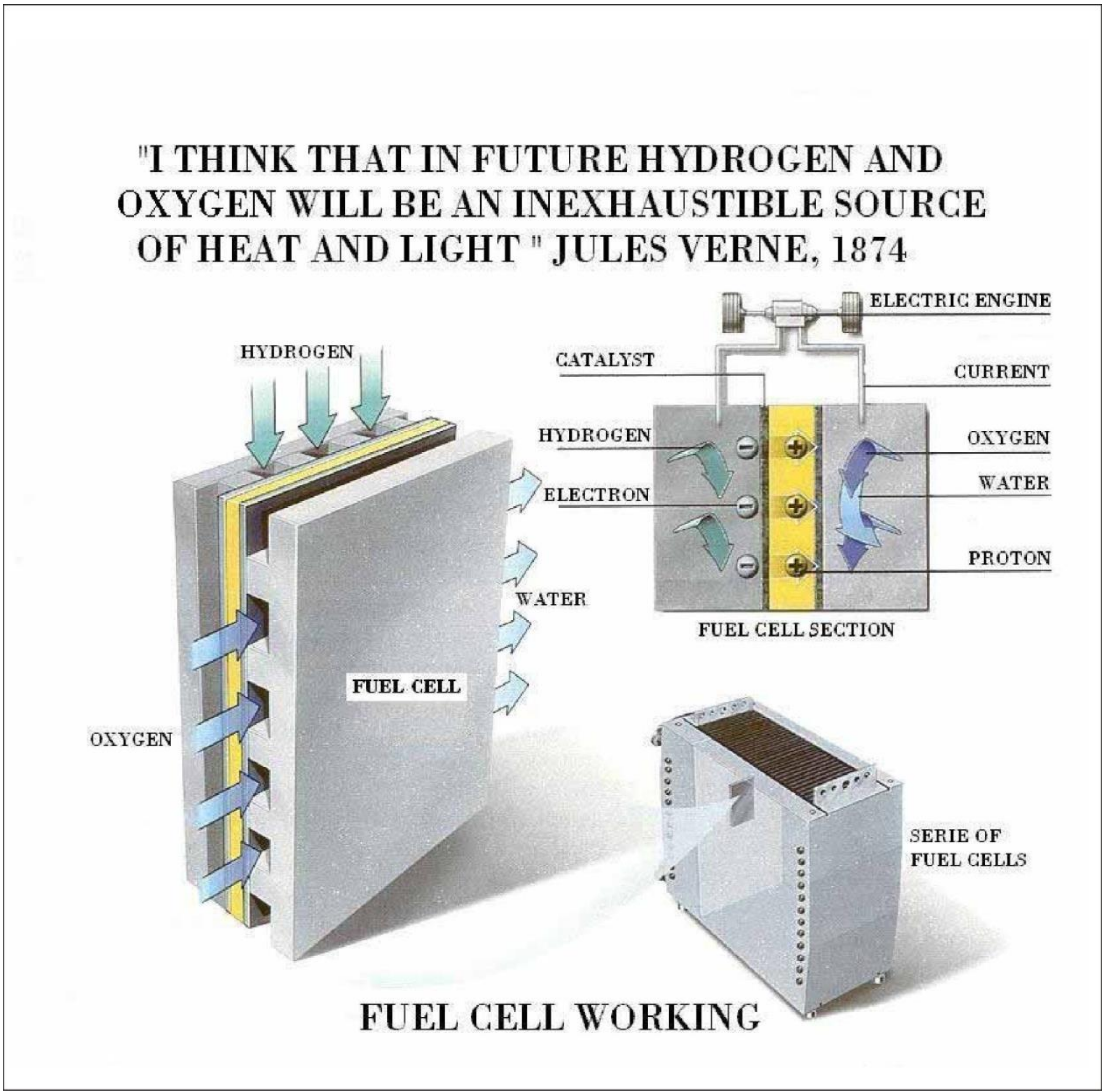
In case of use of the syngas for the hydrogen production, recovering the CO2 and by destining it to the marketing, it becomes possible to set at zero emissions

Using the hydrogen to produce electric energy in the fuel cells, the management costs become very competitive for the high electric performance guaranteed by the cells, but the value of the investment rises a lot because of the high cost of the cells.

But in this case if:

“the environmental goods are worth and they must therefore be included in a real and complete evaluation of costs and benefits"

<u>what is the value of no emissions?</u>

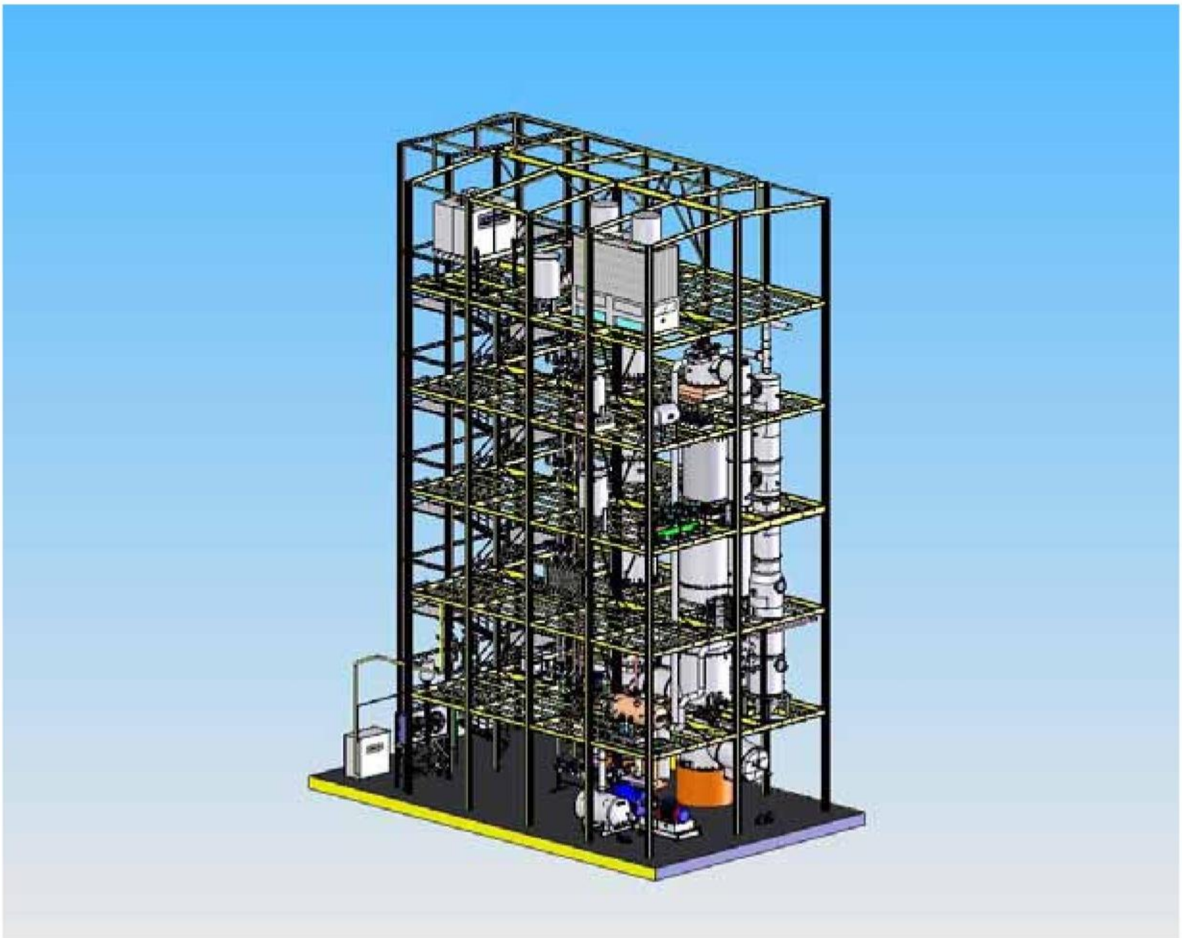


9. TWR: lay-out of the plant

The equipment of the **TWR** need a specific installation lay-out according to the working and security distances characteristics adopted for the typology of the treated gaseous streams.

The occupied area is determined by the capability of the plant and by the adopted technological solutions. Indicatively a 10Ton/h gasification reactor of Refuse Derivated Fuel, that constitutes the main section, occupies an area of 100 m2, with a height of 35 meters.

The other sections of the plant do not present particular dimension because they contain enough "normal" equipment and therefore the occupied area can vary very much just according to the dimension and the capability of the storages which constitute the strategic reserve of the plant working capability.



11. TWR: the experiences

The **TWR** process is based on a series of technologies which have already been widely tested in the chemical and petrochemical industry.

In fact, the gasification, the syngas neutralization , the $CO+H_2O$ in H_2+CO_2 reaction conversion, the recovery of the CO_2, the H_2 separation with molecular sieves, are all reactions having development mode without uncertainties and having certain performances.

The news of the **TWR** process is constituted by the assembly of these technologies and by the constructive and functional characteristics of the gasification reactor applied to the "disposal" of the wastes, which come from a recently deposited patent request.

The great number of experiences acquired in plants with the same characteristics and problems concerning the **TWR** process allowed the planners, starting from these already tested industrial plants, the dimensioning and complete design realization of plants according to the **TWR** process.

LEK D.D. Plant -Lendava (SLO)

CLARIANT L.S.M Plant - Origgio VA (I)

Gasification pilot plant (400 kg/h)

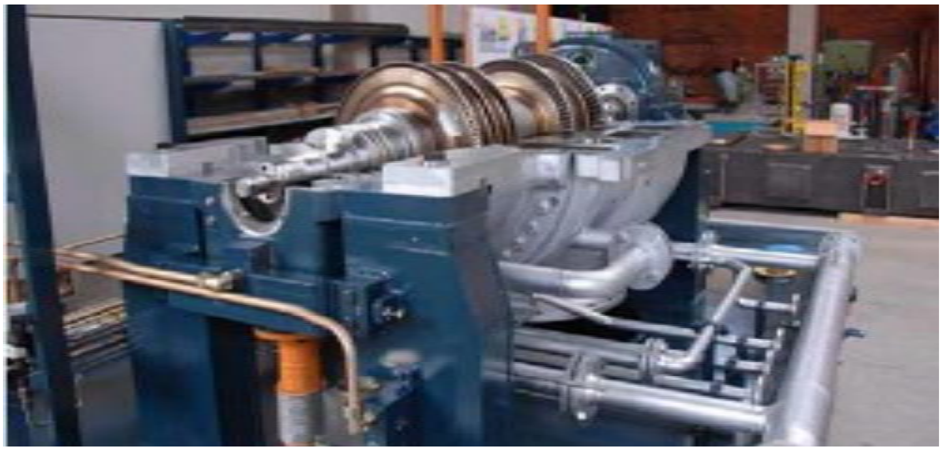
ACS DOBFAR Plant -Albano S.A. BG (I)

8) Cogeneration Plant

Conversion gas in energy

All the outlet heat is picked up, in a heat exchanger, by the water, which thus reaches values of temperature and pressure such as to make possible a Rankine cycle that through a turbine and an coupled alternator produces electricity and heat that can be used for district heating.

Alternatively, if the heating is not required or convenient, with this heat at low temperature we can still produce electricity with another Rankine cycle with a different fluid and retrieve another 15% of electric energy.



9) Bailer unit for raw materials or in order to stock material waiting gasification process or to landfill destination