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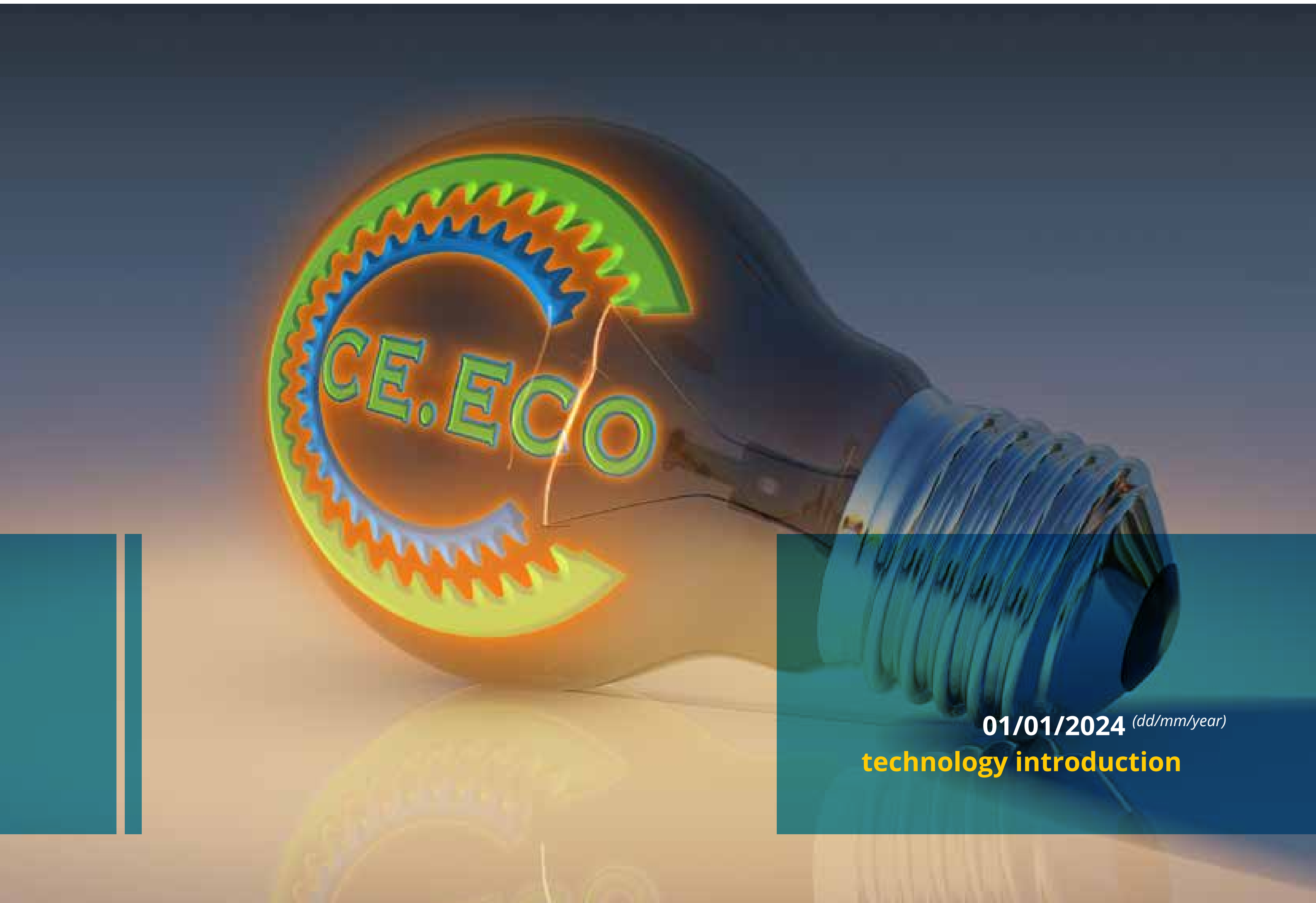
Zero Impact Multi-Matrix Inertizer

BIOZIMMI

How to turn an expensive problem, in an environmentally, socially and economically sustainable solution



01/01/2024 *(dd/mm/year)*

technology introduction

something about us

We study and develop, on industrial-scale, systems capable of transforming the causes of pollution into a source of wealth.
Our patents range from the denaturation of asbestos to the treatment of almost every type of waste, from water purification to the production of aluminum without waste.
What's the point of devastating the environment around us to collect a few crumbs of resources when we can use our technologies to live great and achieve anything in a sustainable way?

Our goal

Since we don't have a second home were to go, we need to make our planet more livable without stopping technological development!
Our goal is to make our planet more livable without stopping development.
For this reason we have developed industrial systems that transform the causes of pollution into an immediately usable source of opportunities: low-priced raw materials ready to be reused through further sustainable processes.
Let's protect nature without stopping progress!

Smartly sustainability

Mission:

- Social progress
- Clean environment
- Wealth production
- Sustainable Development

introduction

In nature there are no “waste”: everything is recovered and put back into circulation in a virtuous cycle.
Therefore, any waste sent to landfills does not represent a solution but an impoverishment of the present generation and a subsequent problem to be managed for future generations.
Nothing is created and nothing is destroyed but everything is transformed: it is our precise duty to apply technological innovations for progress and for the preservation of our planet endowed with abundant but limited resources.
Today we know that plastics can be produced in many different ways, even without the use of oil and biodegradable, but many, too many, consider it unacceptable to eliminate them to produce energy while persisting in recycling with the waste of enormous resources. In this way, they reintroduce into the environment a substance that causes irreparable damage.
The same goes for the paper: the US **EPA** claims that there is a hypothetical 35% water saving in its recycling but does not take into account the economic and environmental cost of the chemical products that will have to be used. Today, with cavitation, the separation of cellulose from lignin can cost only a fraction compared to the past and, therefore, it becomes decidedly more advantageous to proceed with planting new forests, extremely useful also for stabilizing climate change.
This is how our products are born: improving the environment, solving previous problems and delivering to our children an increasingly beautiful and hospitable planet.

who we are...

We born close to the COVID pandemic. We immediately became a meeting point for numerous professionals, research institutions and production companies. All this started in Italy and is now spreading to other countries.

Often our projects precede the times of several years.

Our proprietary technology is totally innovative **but consolidated** and is essentially based on: cavitation, gasification and Coanda effect.

After having implemented and made the above more effective, we have adapted it to everyday life by creating complete processes whose application increases both the quantity and quality of the products obtained, decreasing energy requirements but paying great attention to the creation of a greater number of jobs compared to those eliminated by mechanization.

In addition to the real innovations, we are specialized in engineering and then applying improvements of technologies, mature in their field, to other areas often obtaining, this way, several real technological leaps simply because we had the courage to do what was before under everyone's eyes but no one dared to put it into practice.

We develop technology both independently and in collaboration with Universities (Sassari, Perugia, Amsterdam, Algarve, etc.) or with other public institutions (for example the National Research Center - CNR, Fundación Circe etc.).

We boast a vast proprietary product portfolio with several pilots viewable, by appointment, and several completely innovative process lines.

Some of our products have been defined extremely innovative and promising at international events by panels composed of scientists from all over the world. Our technology and our demo site have been deemed valid and usable in several Horizon Europe projects.

Our patents and innovations have made us immediately designate as members of technology suppliers within the Italian Biogas Consortium.

We have a framework agreement with RINA Consulting - Centro Sviluppo Materiali S.p.A. which allows us to request their supervision and therefore also to certify the production and engineering phase of our products wherever we choose to produce them. Therefore, choosing us also gives access to all the wealth of experience and technology gained in over 70 years by Centro Sviluppo Materiali which, I remember to everyone, was since its establishing the research and development department of IRI (Institute for Italian Industrial Reconstruction, among the top 10 companies in the world by turnover up to 1992).

Numerous specialized industrial plants, centres of excellence on their specific sectors, have made the production slots we need available to us; we are equipping ourselves with proprietary factories to carry out final assembly and to start specific productions.

We are present with companies in numerous European countries. We are opening companies in several African countries and in Asia. We have projects underway in various European, African and Asian countries. Our international staff represents our essence: motivated people with a wealth of personal experience who believe in what they are doing and who come from many different countries. In every nation in which we appear we respect local customs and traditions, bringing a bit of Italianness to the place and "*stealing*" part of their culture to ensure that no one is a ***Stranger in a Strange Land***.

Dr. Bruno Vaccari

... and what we do

- BIOZIMMI
- EMPOWERING DEVICE
- ZEB
- BIODIGESTERS
- FROM HEAT TO ENERGY
- THERMOELECTRIC PANELS
- ASBESTOS DENATURATION
- GASIFICATION & PLASMA
- INERTIFICATION
- WEEE
- UREA & AMMONIA
- FOOD PROCESSES
- HOSPITAL EQUIPMENT
- SOIL WASHING
- WATER TREATMENT
- WTE & WTC
- DESALINIZATION

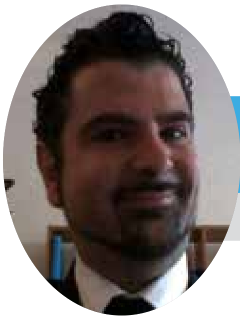
OUR MAIN GOAL: environment and workers' conditions respect

our core team

Bruno Vaccari
CEO

Sabrina Saccomanni
Lawyer

Fabrizio Di Gennaro
CMO



Antonio Demarcus
CTO

Paolo Guastalvino
Civil works

Gianni Deveronico
Lead electrical engineers

Jennifer Martinel
Accounting

Massimiliano Magni
Engineering

Antonio Piserchia
Communications Expert

Barbara Spelta
Lab

Papa Ndiamé Sylla

COO Senegal

Noel Sciberras

COO Malta

Appiah Fofie Kwasi

COO Ghana

Eugen Raducanu

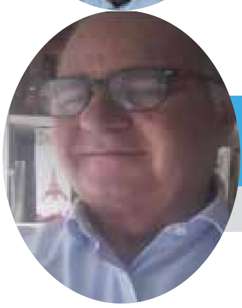
COO Romania

Awa Khady Ndiaye Grenier

COO Guiné-Bissau

Giorgio Masserini

Marketing

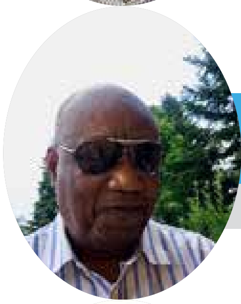


Pantaleo Pedone

Italian energy-intensive

Gianluca Baroni

Hospital Stuff



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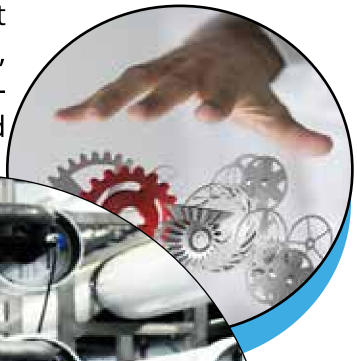
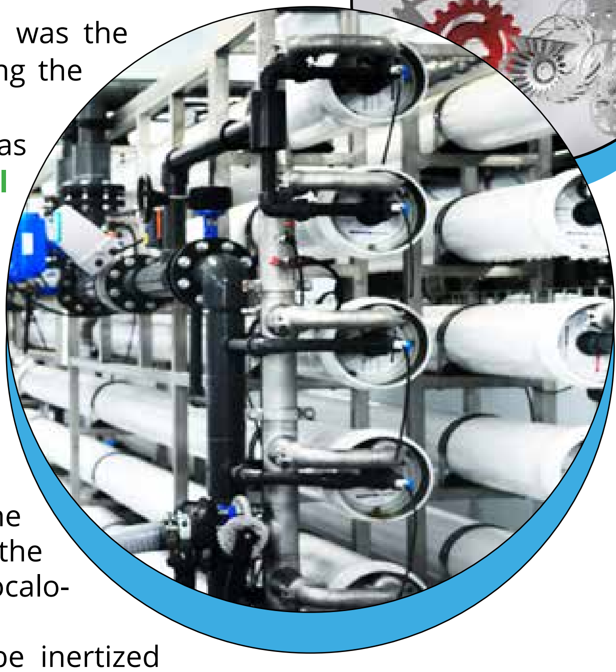
BIOZIMMI

BIOZIMMI is a **modular system** designed and created for the treatment of sewage sludge, industrial sludge, MSW, hospital / sanitary waste, plastics, slaughter waste and any other kind of carbon based waste with their consequent energy recovery through application of a pyro gasification process and subsequent inertization by plasma.





The main focus pursued developing this system was the elimination of waste in AS IS format thus reducing the problems related to their disposal.

The secondary target is the utilization of the syngas and heat to produce **electrical energy, thermal energy and methanol**.

We transform every possible "trimmering" into a useful brick for a further process: they correspond to **zero** waste & **zero** emissions = environmental protection and greater revenues.

The **water** contained in the treated matrices will, for the most part, be recovered and can be either purified or used for agricultural purposes.

The heat treatment allow the exploitation of the energy content in the input matrix (for example, the sludge shall have normally from 2,500 to 4,000 kilocalories / kilograms).

The hospital / sanitary waste will immediately be inertized through plasma.

ZERO EMISSION

By combining the versatility of the gasifiers with the power of plasma, a large number of different matrices can be treated in our system simultaneously without ever completely stopping the abduction lines. Furthermore, our process accelerator, the notorious **EMPOWERING DEVICE**, and the **ZEB** combined with our unique engineering will completely block any emission into the atmosphere.

BENEFITS USING OUR SYSTEM:

- cutting disposal costs
- reduction of process times
- total use flexibility
- farewell to furans and dioxins

With **BIOZIMMI** there are no dangers of furans or dioxins: each gas molecule will be used to produce energy, chemical or other useful by-products.

With the **BIOZIMMI** the landfills will no longer be filled, they will be able to continue operating for a really very long time.

Plasma+Gasification+Cavitation+Advanced Chemistry = BIOZIMMI

BIOZIMMI combines the gasifiers' cost-effectiveness with the disposal total efficiency of a plasma torch. Our gasifiers have been developed in collaboration with the **RINA Consulting - Centro Sviluppo Materiali spa**, a subsidiary of RINA Group. Within the plasma torch we apply the American-made hybrid electrodes that have been used for over 50 years everywhere in the world. Or we can use an Italian-made electrode at the end of the gasifiers to complete the inertization of the ash.

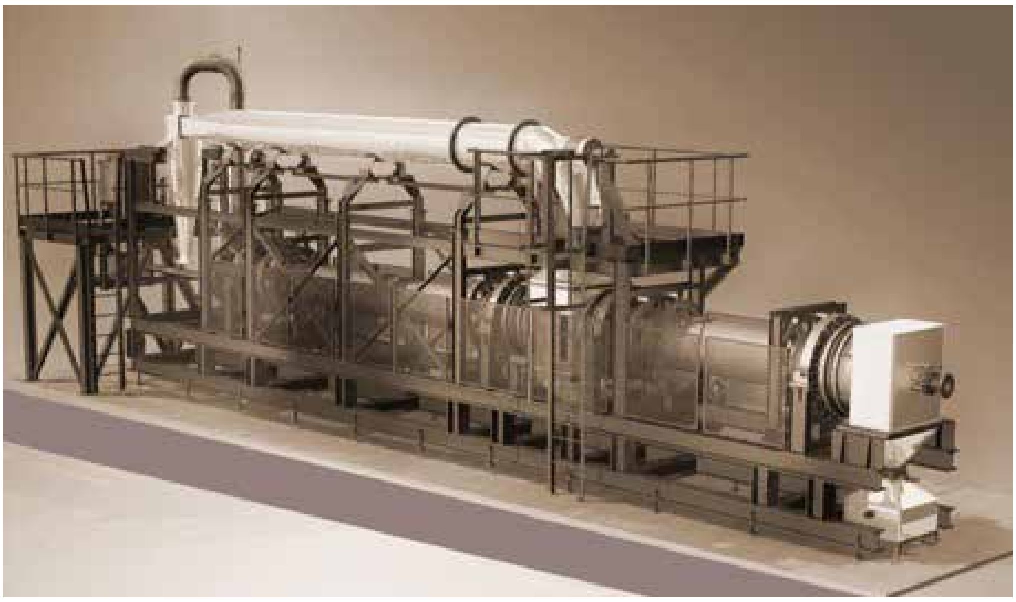
Sustainable and successful treatment of MSW must be safe, effective, and environmentally friendly. **BIOZIMMI** was thought to solve the two main drawbacks of traditional landfills: surrounding areas of are often heavily polluted since it is difficult to keep dangerous chemicals from leaching out into the surrounding land and that any landfill can increase chances of global warming by releasing CH_4, which is 20 times more dangerous as a greenhouse gas than CO_2. Therefore, we find a more environmentally friendly alternative to treat MSW.

The gasifiers take advantage of the molecular dissociation, called pyrolysis, used to directly convert the organic materials present in the waste into gas, by heating, in the presence of small quantities of oxygen.

The processed materials are completely destroyed because their molecules are dissociated. The synthesis gas, even when of a low calorific value, once filtered and purified, can be used for the feeding of a cogenerator, thus enhancing the calorific value of the organic matrix used and can be contain costs simultaneously producing electrical and thermal energy, or it can be used for the production of reusable chemicals.

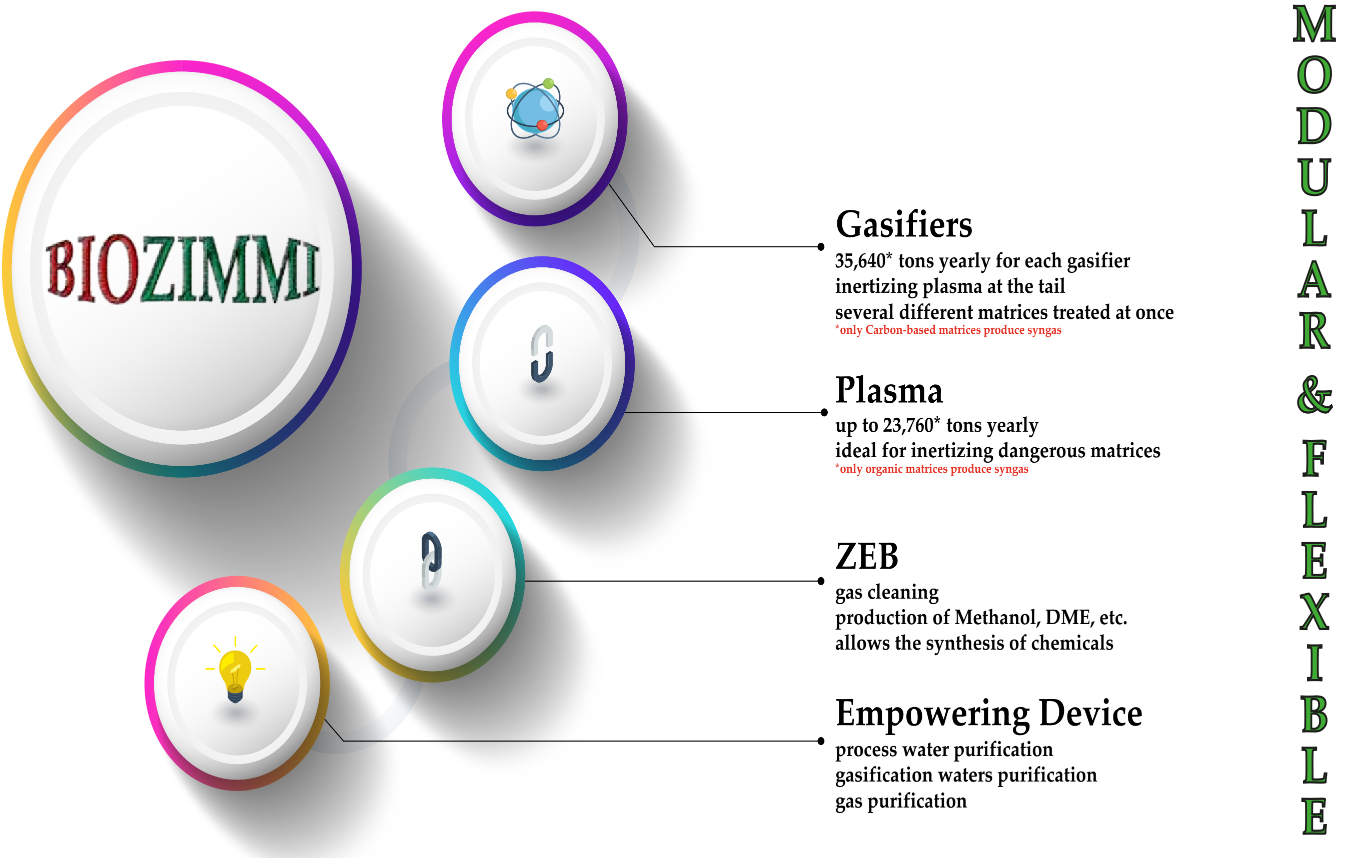
Moreover, it is possible to get practically pure water, thermal energy, methanol and DME.

Our system is modular and each gasifier can operate according to need either as a waste-to-energy plant, combustor or pyrolyzer. This is therefore an extremely flexible system, **modular**, capable of treating different matrices simultaneously and can be implemented, as needed, with further ancillary systems, able to maximize the efficiency of energy recovery.



Our gasification system involves the use of drying systems for pre-treating the incoming material or matrix. The dryer is fed through the process' heat and allows to bring the input humidity of the matrix by the value of the conferral (normally value between 70% and 30%) to, approximately, 10%.

The matrix is dried in this way, is transported



inside the reactor, where it is raised to temperatures ranging from 400 to 650 ° C, through the recovery of heat generated by the same syngas and by the same process of gasification that happens in the last part of the reactor. The waste is so subjected, quickly, to the total drying, pyrolysis and gasification. The gas produced (syngas) is sent, after being washed and purified, to a turbine and / or endothermic engines and / or advanced ORC systems (**EXAMPLE: From Heat to Energy**) in which thermal kW and / or electric kW will be produced or methanol / DME can be obtained with **ZEB**. Part of the electricity will be used for self-sufficiency (about 15%), the other will be used to reduce the costs of other energy-intensive processes within the plant or sent into the national grid. If available, the heat can be used for drying or to power a district heating network or to produce cold thanks to inverters..

Once the gasification process has taken place, the only resulting waste product is ash, on average about 5-10% of the matrix entering the gasifiers. The part of the ash treated with the plasma will turn into a material that can be used for useful purposes without environmental risks.

In **RINA Consulting - Centro Sviluppo Materiali spa**, there is a pilot that can be visited, fully equipped with a plasma torch.

We plan to finish setting up our demo system in Italy in 2024 given the impossibility of showing existing working systems.

Reading key

RED: negative AND/OR harmful to the environment

BLUE: neutral AND/OR no effect on the environment

GREEN: positive AND/OR zero environmental impact

	INCINERATOR	WASTE TO ENERGY PLANT	GASIFICATION	PLASMA	COMBINED GASIFICATION & PLASMA	BIOZIMMI (COMBINED GASIFICATION & PLASMA)
MSW from differenziated collection	Yes	Yes	Yes	Yes	Yes	Yes
MSW from undifferentiated collection	it depends on the facility					Yes
Manual preselection	it depends on the facility					No
Automated preselection	it depends on the facility					Yes
Multiple matrices' simultaneous processing	it depends on the facility					Yes
Immediate recovery of raw materials	No	No	No	No	No	Yes
Special waste treatment	partial	No	No	Yes	Yes	Yes
Hazardous Waste Treatment	partial	No	No	Yes	Yes	Yes
Toxic Waste Treatment	partial	No	No	Yes	Yes	Yes
Nuclear waste treatment *(low radioactivity)*	No	No	No	Yes	Yes	Yes
Hospital waste treatment	partial	Yes	No	Yes	Yes	Yes
Military waste treatment	partial	Yes	No	Yes	Yes	Yes
Treatment in oxygen environment	Yes	Yes	Yes	No	partial	partial
Treatment in argon environment	No	No	No	Yes	partial	partial
Slag to be disposed of in landfills	Yes	Yes	-	No	No	No
Ashes to be disposed of in landfills	Yes	Yes	Yes	-	No	No
Inertization of slag and ash	No	No	Yes	Yes	Yes	Yes
Furan production	Yes	Yes	Yes	No	No	No
Dioxin production	Yes	Yes	Yes	No	No	No
NOx production	Yes	Yes	Yes	No	No	No
Matrices water's reuse	No	No	No	No	No	Yes
Hazardous filters to be disposed in landfills	Yes	Yes	Yes	Yes	Yes	No
Matrices are in contact with the flame	Yes	Yes	No	No	No	No
Matrices are the fuel	Yes	Yes	No	No	No	No
Syngas is the only used fuel	No	No	Yes	Yes	Yes	Yes
Leakage of odors	Yes	Yes	it depends on the facility			No
Electricity production	No	Yes	Yes	Yes	Yes	Yes
Thermal Energy Production	Yes	Yes	Yes	Yes	Yes	Yes
High energy yield	No	No	it depends on the facility			Yes
Methanol and Avio Fuel production	No	No	No	it depends on the facility		
Avio fuel production	No	No	No	it depends on the facility		
Bio Fuel Production	No	No	it depends on the facility			
Compact system footprint	No	No	it depends on the facility			Yes
System modularity	No	No	No	No	No	Yes
System flexibility	No	No	No	No	No	Yes
Rapid plant design	low	low	high	low	low	high
Plant construction speed	low	low	medium	low	low	medium
Plant commisioning speed	low	low	medium	low	medium	high

Synoptic table of technologies for the treatment of so-called "Waste" and / or "secondary materials"

achievable productions

BIOZIMMI is a completely modular system and, therefore, according to the customer's needs, it can be configured and equipped to cope with different productions: everything will depend on the modules chosen during the Feasibility Study and / or the Basic Design.
Inside **BIOZIMMI** are integrated technologies capable of treating matrices at **high temperatures**. With **high temperatures**, any type of matrix can be treated, extracting the syngas which will then be transformed into chemicals and / or energy.
With **low temperatures**, only organic matrices can be treated with biodigestion by breaking them down into natural gas and high quality compost.
Each **BIOZIMMI** module is designed and built to obtain maximum performance from matrices with a very high level of specialization in order to maximize yields.
To obtain high temperatures, gasification or plasma will be used.

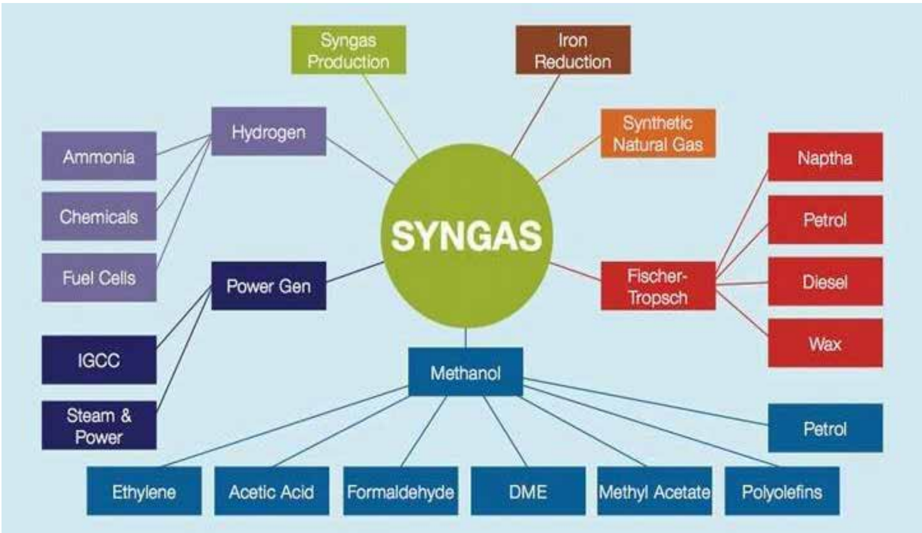
high temperatures

gasification & plasma

syngas, ash and lava

methanol

electricity, thermal energy, chemicals, fuels



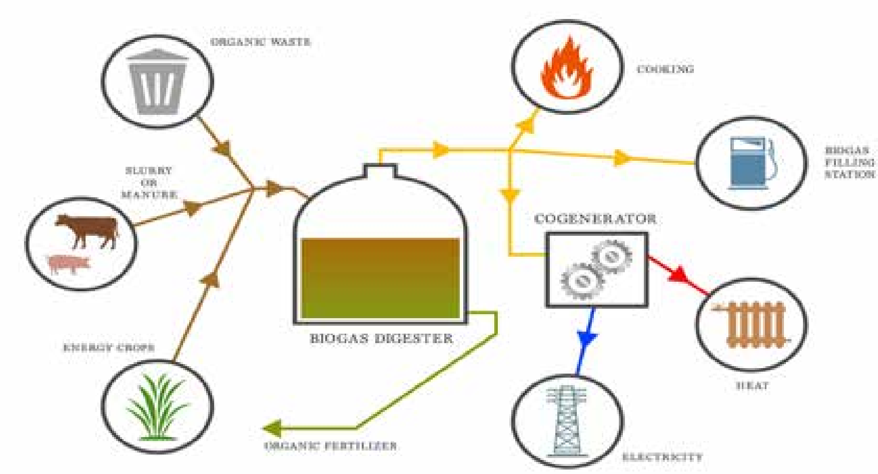
low temperatures

biodigestion

natural gas, quality compost

methane

biomethane, electricity, chemicals, fuels



productions examples

It being understood that could be possible opt for a mix of productions, in BIOZIMMI electricity is the simplest production to obtain; the system will be schematically composed as follows:

Waste reception -> Gasification-> plasma inertization-> electricity generation

Even thermal energy can be transformed into electricity through the **From Heat to Energy** system:

Waste reception -> Gasification-> plasma inertization-> thermal energy production -> from heat to energy

From organic matrices it is possible to obtain methane gas; the system will be schematically composed as follows:

Waste reception -> Gasification-> Plasma inertization-> ZEB -> Liquefaction System -> Gas packing

The syngas produced is purified by the ZEB which eliminates any other gas bringing the percentage of carbon dioxide present below 50 parts per million. It can be wrapped up or placed on the network. By way of example, one ton of matrix can produce up to 1,200kg of syngas; once purified, about 650kg of syngas remain that can be packed and used commercially. From the organic matrices a syngas is also obtained which, washed and treated, can lead to the synthesis of methanol using the ZEB; the system will be schematically composed as follows:

Waste reception -> Gasification-> plasma inertization-> ZEB -> methanol

Starting from methanol, shall be possible to produce biodiesel; the system will be schematically composed as follows:

Waste reception -> Gasification-> Plasma inertization-> ZEB -> Biodiesel

Therefore, syngas is obtained from waste (gasifiers and plasma torches), methanol is obtained from syngas using the ZEB, transesterification starts from a module of this subsystem, leading to the production of biodiesel by adding exhausted vegetable oils to methanol.
Biodiesel can be used 100% pure (B100) or mixed with diesel in varying percentages.
Avio fuel or DME production can also be obtained from methanol; the system will be schematically composed as follows:

Waste reception -> Gasifier -> plasma inertization-> ZEB -> DME/Avio fuel

The syngas produced is polymerized taking the form of fuels with characteristics of avio fuel. The yield in this case will be lower (from 1/7 to 1/10 of the hypothesized production for methanol) but aviation gasoline can be sold at an extremely attractive price.

methanol

It is the simplest of alcohols, it is capable of transporting energy efficiently, it is liquid at room temperature, soluble in water and, last but not least, it is biodegradable.
Methanol is the quintessential intermediate of the chemical industry as an alternative energy vector to hydrogen, therefore, it offers great opportunities for the energy industry and for chemistry, causing a marked increase in its demand.
Unlike an energy source already available in nature as is, a vector is “created” by accumulating energy between its chemical bonds in order to be able to transport it more easily and release it during use.
It can be obtained from syngas (CO + H_2) and semi-pure methane and is easier to handle than gases that require important infrastructures such as gas pipelines, tankers and liquefaction plants, for transport and for regasification. Methanol can be used directly as a fuel for road vehicles, as a fuel for marine engines or for electricity generation, with a clear reduction of pollutants such as NO_x, SO_x and particulate matter. Further advantages come from being able to be used in production cycles of the chemical industry.

Within **BIOZIMMI**, using a mathematical model of our own conception, methanol is “synthesized” within the chemical subsystem **ZEB**. In fluid bed dynamic molecular sieves, methanol is absorbed by the surface of the molecular sieve itself as it becomes liquid using a lowering of temperature and starting from syngas containing an adequate mixture of reagents involved in the reaction.
An inert gas is used for the handling of methanol inside the **ZEB**, thus reducing the risk of accidental explosions.

$$CO + CO_2 + 5\,H_2 \longrightarrow 2\,CH_3OH + H_2O \quad \Delta H298 = -140 kJ.mol\text{-}1$$

Methanol, the building block par excellence of basic chemistry, is the basis from which numerous complex chemicals and polymeric materials can be obtained as well as fuels suitable both for thermal engines, thanks to the high octane number, and for fuel cells, in DMFC, which indirectly, after its transformation into hydrogen by reforming.
Chemically, it can be transformed by dehydration into dimethyl ether, cetane number of 55, which can in turn be used in jet fuels and diesel, as well as a solvent and coolant. Or, through the “methanol to olefin” (MTO) process in ethylene and propylene, it can be transformed into synthetic hydrocarbons of greater molecular weight and other derivatives thereof, which are normally obtained from oil and natural gas.
It is also sometimes used as a denitrifying agent as it accelerates the anaerobic activity of bacteria that “break” the nitrates, releasing atmospheric nitrogen.
In 2005, Nobel laureate George A. Olah advocated the creation of a methanol economy in his essay Beyond Oil and Gas: The Methanol Economy.

DME

Dimethyl ether is a compound that belongs to the ether group: it is an isomer of ethyl alcohol. It represents the simplest aliphatic ether, it is a colorless gas with a faint ethereal odor, extremely flammable. It is readily chosen by consumers in different industrial sectors for a number of advantages such as: easy liquefaction, high compatibility with other propellants or good solubility for many substances. It is used for example in the automotive industry, household chemicals and the tanning industry.
Dimethyl ether is an organic compound with the chemical formula CH_3OCH_3. It is produced in the dehydration reaction of methanol or via synthesis from natural gas, coal or biomass.

2 CH3OH —> CH3OCH3 + H2O

Dimethyl ether is a raw material with numerous advantages. The main advantages deriving from the use of DME certainly include the possibility of using different raw materials in its production: if biogas or biomass are used, we obtain a much more ecological product, which respects the principles of green chemistry. Furthermore, dimethyl ether is an easily liquefiable gas. This determines broad directions of its applications (chemical synthesis, fuels, aerosols); furthermore, gas generates relatively low logistics costs. As a motor fuel, it also guarantees high energy efficiency. Furthermore, burning DME emits negligibly low levels of dust and other pollutants.
The use of dimethyl ether in the **cosmetics industry** is based on its gaseous properties. It is used as a propellant gas in aerosol sprays. It is effectively used by doctors to remove warts with the cryogenic method. As a gas, dimethyl ether can be liquefied under specific conditions; once liquefied it acts as a solvent for numerous substances. It also shows the ability to reduce the viscosity of cosmetic formulations.
The specific properties of dimethyl ether make it an alternative to **conventional diesel fuel**. DME has good flammability and lower viscosity than diesel fuel. It has no corrosive effect on the metal parts of an engine. Furthermore, only minor modifications are required to convert a Diesel engine to one capable of burning dimethyl ether. As a fuel, it does not emit harmful sulfur oxides or solid particles. Since environmentally friendly feedstocks such as biogas or biomass are used to produce dimethyl ether, DME becomes a biofuel.
The popularity of DME as a **propellant** drives its use in the production of polyurethane foams for caulking. The propellant and solvent are pumped simultaneously in this process. As a result, the process is shortened and facilitated. Dimethyl ether is also suitable for the production of expanded polystyrene, which is subsequently used to produce polystyrene sheets.
In the **leather tanning process**, dimethyl ether acts as a solvent. It is used in the tanning of bovine, pig, sheep and goat skins. In particular, it is used in processes that require degreasing and/or drying in one or more solvents. DME is an effective tanning solvent, which improves the ecological safety of the process.
When mixed with ammonia, dimethyl ether is used in refrigeration equipment. When using mixtures of these two compounds (40:60 weight ratio), the refrigeration capacity of a machine increases.

“zero emissions” target

With our technology that combines plasma torches, gasifiers, cavitators and advanced gas management systems, every molecule that escapes from the process represents a loss of profit. Applying the transitive property, therefore, a damage to the planet is equivalent to an economic damage caused to our customer.

Therefore, even beyond any ecological sensitivity we may have, we cannot allow any emissions into atmosphere because gas leaks would not allow us to maintain the contractual performance levels.

Even the same carbon dioxide produced, once “cleaned” and made food grade, is sealed to be sold to the vast market of beverage producers.

With regard to the liquid component, everything whose level of pollution cannot be reduced by using our cavitator will be directly sent to the plasma torch to be inerted.

With regard to the solid component, the ash produced during the gasification and the lava produced with the plasma torch are completely different from the waste products with incineration: in both cases, they are not any more a waste to be conferred to landfill but a new raw material useful for a new process. The ash will be analyzed on a sample basis and continuously to verify its effective inerting; if the parameters are not adequate, the batch in question would be sent to the plasma torch to be transformed into vitrified lava.

It is a well-known and incontrovertible fact that vitrified lava leaking from any plasma torch does not leaks anything, even less than glass, and it was precisely this fact that pushed French legislators to authorize the asbestos supply chain to be interrupted only in cases of plasma treatment. In the presence of biodigestors, the compost deprived by the bacterial loads thanks to the passage in our cavitator, after an adequate period of stoppage in the open air also necessary for the natural evaporation of excess nitrogen, becomes one of the agricultural fertilizers par excellence. Metals and glass will instead be isolated and sent to the appropriate external industries for a complete recovery as raw materials.

As for the emissions into the atmosphere, the reducing environments do not allow the formation of nitrogen oxides (NOx) but simply of N_2 which cannot be considered an emission since nitrogen in this form represents almost 80% of the Earth’s atmosphere.

The CO_2 that is recomposed at the outlet after cooling can either be “clean”, made food-grade and sealed or directly reduced (therefore reduced below 50 parts per million residual) thanks to our special engineering developed for biomethane and considered so innovative to be co-opted as technology suppliers by the Italian Biogas Consortium. In the same way we can easily break down any sulfur residue present in the syngas.

These are all technologies developed by our researchers improving and simplifying procedures that have been used for decades in the extraction and natural gas processing.

Lastly, our controlled cavitation system will allow to recover the residual abatement chemicals and to prepare any, negligible, residual particles to be placed for final inertization inside the plasma torch. Also the emissions from internal combustion engines and turbines will also be conveyed to the cavitation system and, from here, to the plasma torch.

The plant will be built in depression, in such a way all the internal air, including the annoying odor molecules, will be directed to the gasifiers or plasma torches.

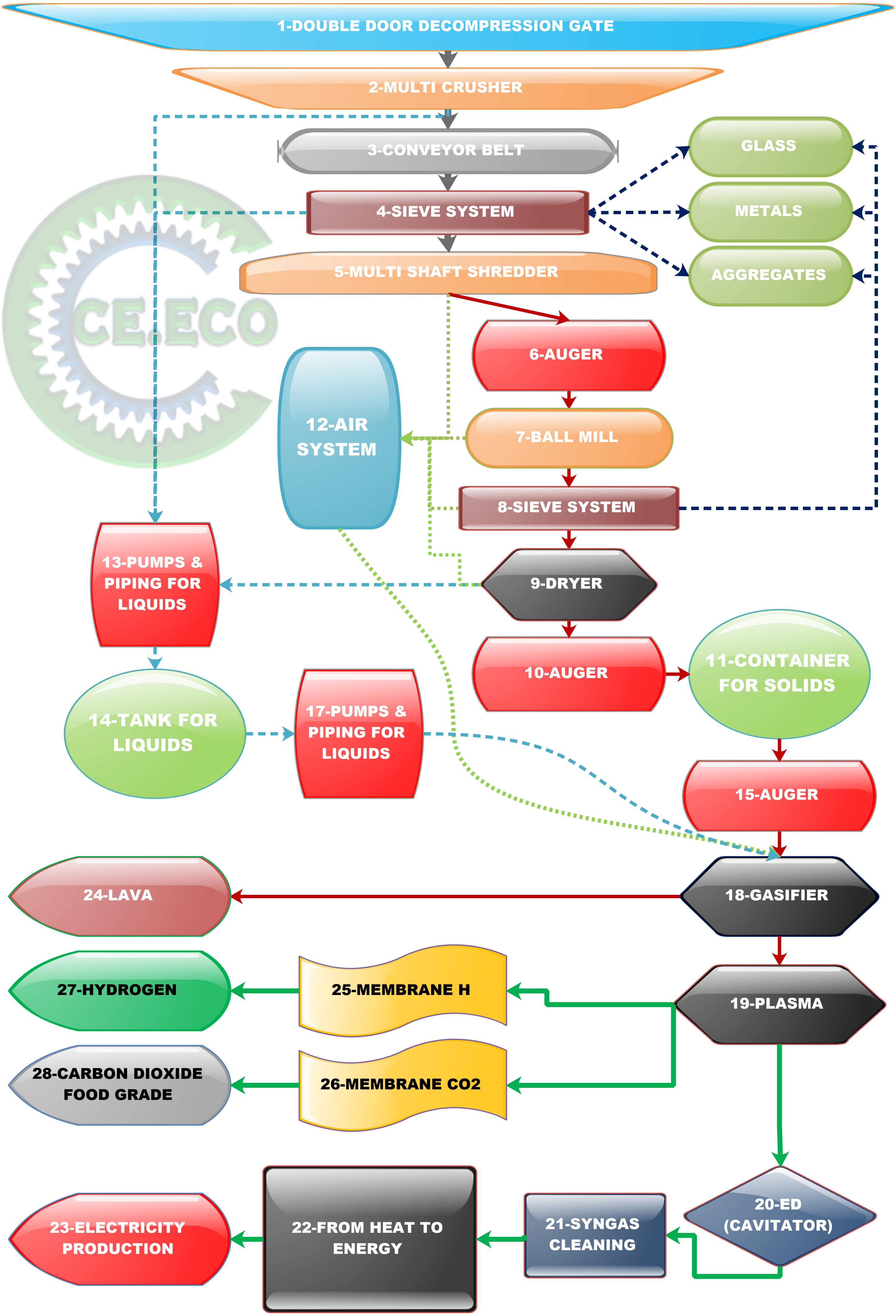
energy production

The energy production generated in our plant is expressed with conservative values. As is obvious, each of our technologies has peculiar strengths: gasification maximizes energy yield while plasma torch maximizes inerting. Some matrices obviously perform better than others.
Our partner **RINA Consulting - Centro Sviluppo Materiali S.p.A.** conservatively provides the parameter of 0,8% gross as the energy coefficient obtainable from gasification. Value obtained by using the syngas in a normal internal combustion engine with an efficiency oscillating between 27% and 32%. As a rule, for each ton of matrix, using an internal combustion engine, a yield of approximately 30% is considered, net of self-consumption.
Therefore, through gasification, a ton of organic matrices can produce about 800kWh which, conservatively, we reduce net of self-consumption, which affects between 10% and 15%, to 700kWh.
With regard to a combined cycle of gas turbine and steam turbine (or ORC or advanced thermodynamic) General Electric, today Aero - joint venture between GE Power and Baker Hughes, conservatively certifies it, at 52.1%. An easy mathematical proportion shows that:

700kWh : 30% = X : 52,1%. — X = 1.215,66kWh

Therefore, by adopting a combined cycle, net of self-consumption, a gasifier with good quality organic matrices can easily exceed 1,200 kWh for each ton treated.
Professor Louis J. Circeo of Georgia Tech University, the greatest living expert in plasma torch technology, claims that a ton of MSW entered in a plasma torch provides over 800kWh using an internal combustion engine. We conservatively reduce this value to 550kWh.
As we are not manufacturer of technology linked to the production of electricity, we will choose each suppliers' products on a case by case basis depending on the size of the plant and on the quality of the syngas produced. Each technology that will be adopted will have different yield parameters.
To date, these yields are only possible by adopting such cutting-edge technologies; moreover, the mounting ecological sensitivity pushes to the margins of legality some technologies, once considered also promising, such as the transformation of plastics into fuel oil by autoclave treatment, a technology now banned by almost the whole European Community due to the very high pollution associated with this technology that does not present any applicable improvement margin.

We are talking about an atypical industrial plant which, instead of polluting, will proceed to remove pollution and improve people's lives. Each component of the system uses mature, consolidated and well-known technologies present on the market. The deep experience of our technicians in the Oil & Gas, plasma and cavitation field made the difference, on the one hand it allowed us to obtain certainly interesting plant performances and on the other hand it gave us a unique perspective regarding the interpretation of the atmospheric emissions, going from "unwanted problems to be eliminated" to a "production loss" to be avoided, so representing an economic damage for the plant itself.



1-DOUBLE DOOR DECOMPRESSION GATE
2-MULTI CRUSHER
3-CONVEYOR BELT
4-SIEVE SYSTEM
5-MULTI SHAFT SHREDDER
GLASS
METALS
AGGREGATES
6-AUGER
7-BALL MILL
8-SIEVE SYSTEM
9-DRYER
10-AUGER
11-CONTAINER FOR SOLIDS
12-AIR SYSTEM
13-PUMPS & PIPING FOR LIQUIDS
14-TANK FOR LIQUIDS
15-AUGER
17-PUMPS & PIPING FOR LIQUIDS
18-GASIFIER
19-PLASMA
20-ED (CAVITATOR)
21-SYNGAS CLEANING
22-FROM HEAT TO ENERGY
23-ELECTRICITY PRODUCTION
24-LAVA
25-MEMBRANE H
26-MEMBRANE CO2
27-HYDROGEN
28-CARBON DIOXIDE FOOD GRADE

the process

The numbering indicated below recalls the flow chart of the previous page.
The entire system is housed in an environment with a depressed atmosphere where all the air, as new air is introduced **(12)**, is pushed and conveyed inside the gasifiers (or plasma torches) also for the purpose of its complete and definitive sterilization.
The material to be treated enters through a double door system **(1)** of sufficient size to house a truck and its trailer. The waste is discharged either into a centralized accumulation system or directly into the mouth of the **(2)** multi-tearing machine. After a first screening process **(4)** matrices are further crushed **(5)** and grinded **(7)** while any liquid contained in them is collected and sent to a special silo **(14)** for liquids.
The matrices are then subjected to a second screening process **(8)** and dried **(9)**.
Reduced to uniform size, glass, metals and aggregates removed as well as dried, the matrices are stored in special containers to better dose them and always keep constant the supply to inerting gasifiers **(18)** equipped with plasma in the tail **(19)**.
The liquids **(14)** collected in the process and the air **(12)** of the areas in depression are also conveyed and treated here. Otherwise the water can be recovered for other uses through an **EMPOWERING DEVICE (20)**.
Once treated, according to the process adopted, from the matrices will remain lava **(24)** and syngas. From the latter, once cleaned, electricity **(23)** and / or chemical products can be obtained by applying the **ZEB** sybsystem. Through membranes it is possible to preventively separate hydrogen **(27)** and food grade carbon dioxide **(28)**.
The applied temperatures are extremely high and the process lasts a very quick time, “fast pyrolysis”, producing a lot of gas and a few oils which will be conveyed back to the mouth of the gasifier. Neither dioxins, nor NOx nor furans are produced. The only gases accidentally loses and released into the atmosphere will be well below the maximum levels permitted by law.

01

02

03

04

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07

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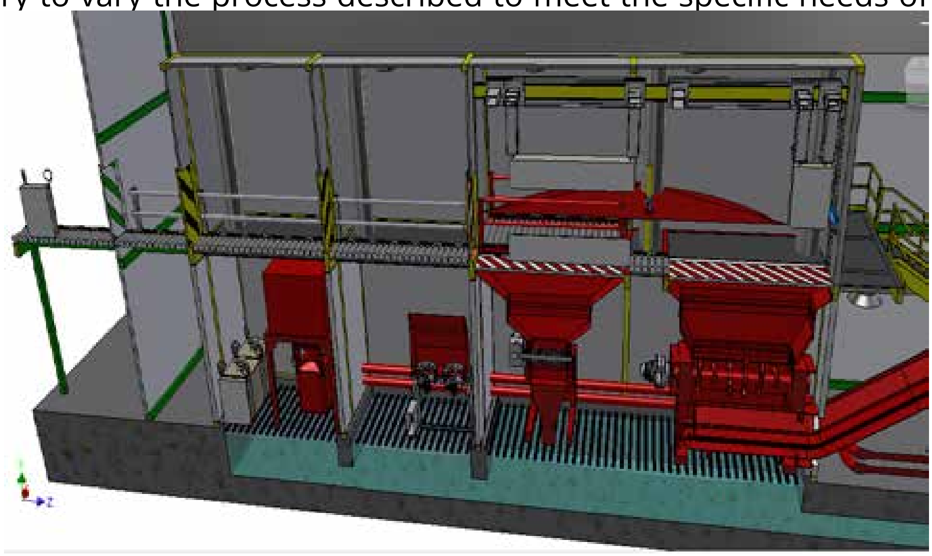
18

The plant is suitable for the continuous treatment of waste 24 hours a day for about 330 days per year of operation.
The maximum capacity of inlet matrices at full capacity is approximately 108 tons / day for each gasifier (humidity 30%), approximately 72 tons / day for each plasma torch and approximately 6 tons / day for each plasma furnace.
The plant is not designed to be completely stopped and started up and, at each total switch-on cycle, it will be necessary to bring the gasifier reactors back to temperature. The plant is designed to work in a continuous cycle with 2 maintenance stops a year.
The automatic greasing of the elements will be controlled by PLC.
In the first year, 2 interventions by Chemical Empowering technicians are planned at the customer's site to verify the correct functioning of the plant.
The plant will be monitored, for the first year, by remote control directly by Chemical Empowering personnel; this service, if deemed necessary by the customer, will be extended from year to year upon payment of a subscription.
Ordinary maintenance usually affects a few euros per ton treated.
Extraordinary maintenance cannot be calculated or prevented in advance.
The plant detail will be final only upon delivery of the detailed engineering as, following a feasibility study, it may be necessary to vary the process described to meet the specific needs of the client and emerged during the design itself. Any modification to the pre-feasibility study must be authorized by the client.
The plant is intended, in any case, as a single system supplied turnkey at the customer's premises and, therefore, are includes all the equipment, devices, piping, carpentry and electrical systems necessary for operation as well as the design of any necessary civil works.

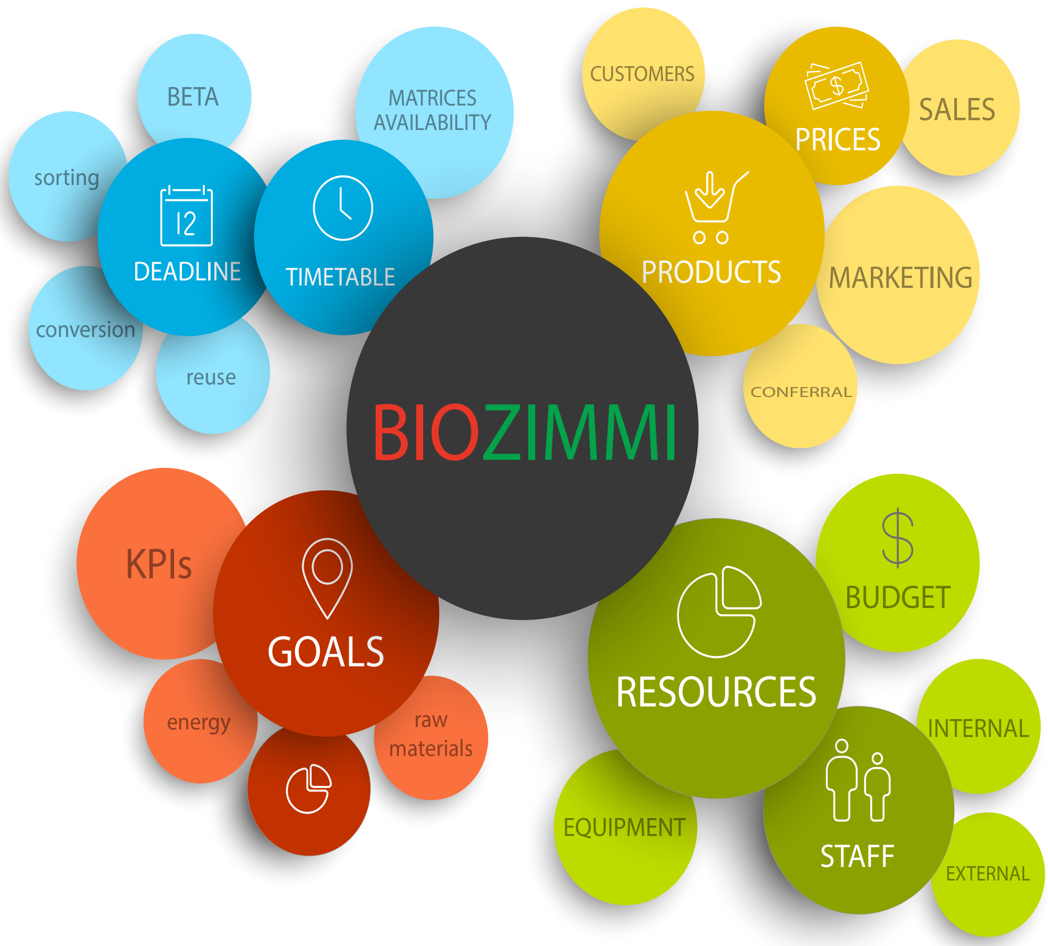


plant size

The process we designed is completely modular. Based on the needs found at the customer site, we can choose to combine the gasification technology with the plasma one and also take advantage of the less performing biodigestion always treating the gases with technologies derived from the oil & gas field and taking advantage, wherever possible, of the controlled cavitation's power; energy production can be obtained from time to time with endothermic engines, gas or steam turbines and, sometimes, with thermo-dynamic systems. The abduction systems are modulated by the extractive industry while the management of safety devices is also the result of experience gained in the oil & gas sector.

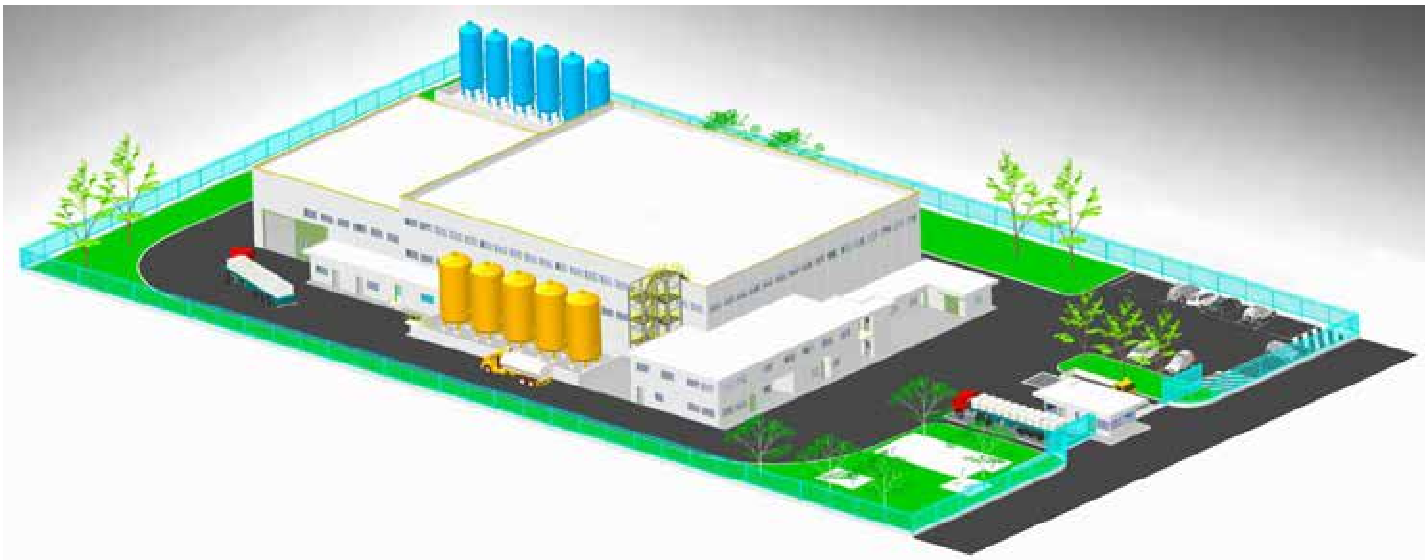
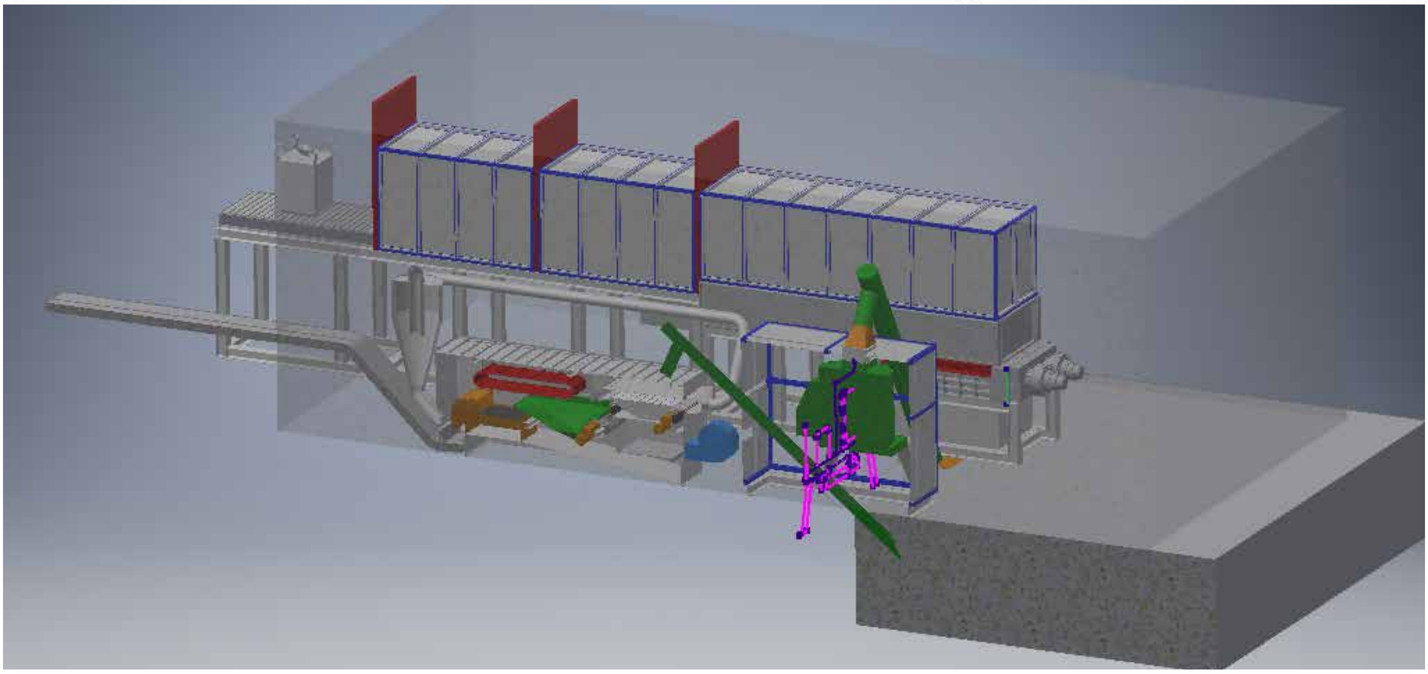
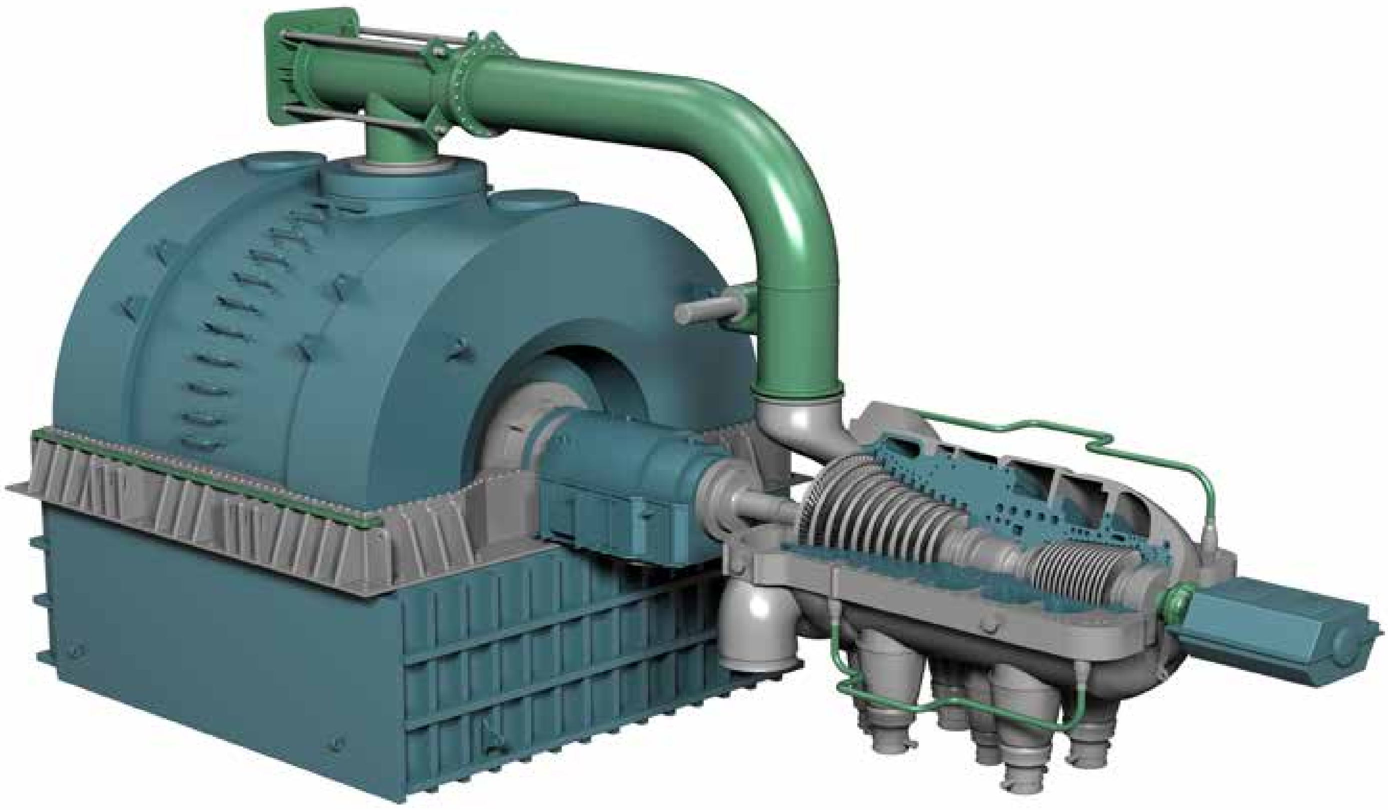
By way of example, each gasifier will be able to treat around 4.5 tons of matrices per hour while each torch will be able to treat up to 3 tons per hour. There is no limit in the number of systems that can be placed in parallel: the heart of the system (gasification, plasma and biodigestion) will be sized and any required ancillary systems will be provided both at the input and output.

Obviously, as in any other industrial plant, the larger the installation, the more economies of scale can be developed. The larger the implant, the more the abduction systems, especially their starting energy consumption, can be spread and absorbed. The larger the energy efficiency, the greater the kWh fed into the grid.



Therefore, the maximum dimensions are dictated by the capacity of the national grid in the country where the client decides to position the plant or, if it points to other productions other than electricity, the quantities of matrices that can be supplied.

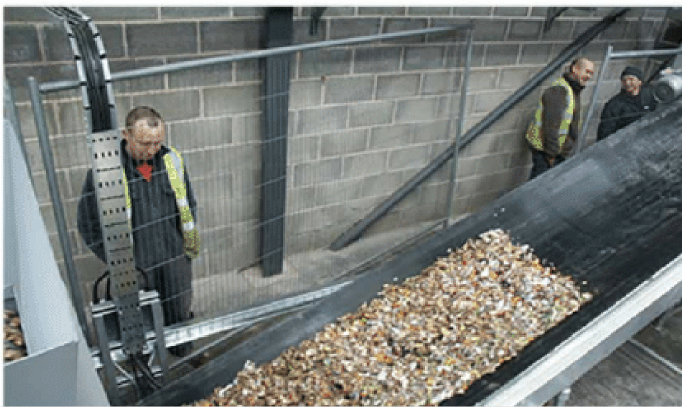
We think to an annual operating cycle of around 330 days. Every value we provide is to be considered conservative as are the values provided by our supplier partners.

The single shaft grinder is configured to obtain high energy savings, to let fast maintenance and to reduce downtime. The single shaft grinder is equipped with a special safety system that prevents damage by blocking, if necessary, the machine in case of introduction of non-compliant materials.

The multi-shaft shredder is characterized by strength, reliability and control of the size of the output material: the ideal solution in case of intensive processing. Is is equipped with a system of interchangeable shafts and grids with anti-wear treatments, in order to optimize management costs and maintenance interventions.

Ball mills are precise and flexible tools, suitable for grinding and granulometric reduction of hard, brittle or fibrous materials. The multiple grinding modes, the different usable volumes and the available materials make ball mills the perfect solution for a wide range of applications.



process with RDF

In **BIOZIMMI**, by gasifying the matrices, the so-called synthesis gas (syngas) is obtained. This is a mixture of hydrogen and carbon monoxide with more or less consistent traces of methane, nitrogen and oxygen.
The composition of the syngas essentially depends on the characteristics of the matrix.
All the more reason it is extremely difficult to predict the exact composition over time of RDF syngas, as this is a heterogeneous waste that also changes with seasonality, as it is linked to the production of municipal waste.
With the process on which the **BIOZIMMI** technology is based, the actual composition of the syngas is not of decisive importance: what is found will be maximized and based on the desired result.
Each result sought will include the adoption of a specific module. It will therefore be possible to have more or less modules for the production of **electricity**, it will be possible to install the specific module for **methanol** or dimethyl-ether (**DME**) or even the subsystem for the production of **calcium carbonate** or a **greenhouse** if it is considered this route is cheaper than selling **food-grade** carbon dioxide.
Hydrogen can be used immediately or special safety and storage modules will be implemented.
Once the syngas has been produced using specific membranes, if required, both hydrogen and carbon dioxide can be separated from the rest of the syngas and then sent the remaining gases to produce energy.
The CO_2 separated by membranes can be packed with a purity over 99%.
The hydrogen contained in syngas is a “clean” fuel / chemical product and is potentially the main fuel for the production of electricity produced without polluting emissions, since the sulfur and nitrogen compounds it contains, in ppb (parts per billion), they can be easily removed.
Hydrogen is a gas that reacts in contact with air according to the reaction:

$$\mathbf{2H_2 + O_2 \longrightarrow 2\,H_2O \quad \Delta H^\circ_{298} = -286\ KJ/mol}$$

thus giving pure water as the only reaction product, it can be produced from fossil sources, from renewable sources, from nuclear power and be easily distributed on the network, compatibly with end uses and with the development of transport and storage technologies. Furthermore, it can be used in various applications (centralized or distributed electricity production, heat generation, traction) with zero or extremely low local impact.

The average composition of the syngas obtainable from the CDR is the following:

		kg/mc	PCI kWh/kg	PCI kWh
H_2	56%	0.084	33.60305556	1.58
CO	31%	1.165	2.805555556	1.02
CO_2	5%	1.83	0	0
CH_4	2%	0.671	13.89722222	0.18
N_2	6%	1.25	0	0
O_2	1%	1.331	0	0
		0.591953989		**2.78**

The matrix has a calorific value from the literature equal to about 18 Mj / kg, equal to 5 kWh / kg. A ton of RDF with **BIOZIMMI** can **theoretically** produce 2,925 electrical kWh and 1,350 thermal kWh. Values from which self-consumption, internal consumption of other machinery, losses, etc. must be subtracted.
The amount of energy recovered is higher than that of the syngas alone since our system allows us to recover the various waste heat and transform them into energy.
In the production of syngas from RDF, there is a breakdown of the chemical bonds of the organic substances present in the material, the autothermal process exploits gaseous hydrocarbons or light liquids and is based on the reaction:

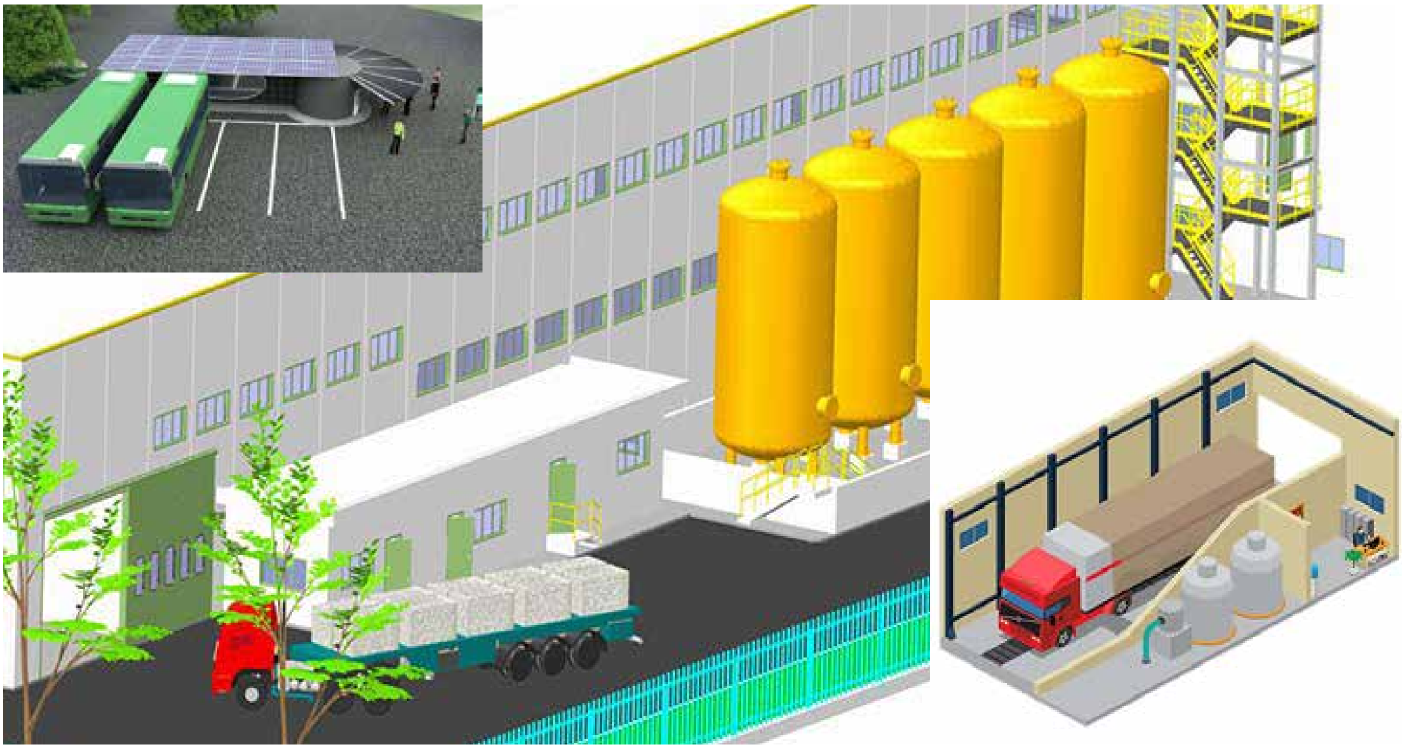
$$CH_4 + ½\ O_2 \longrightarrow CO + 2H_2$$

In reality the reactions that could occur are the following:

$$CH_4 + 2O_2 \longrightarrow CO_2 + H_2O$$
$$CH_4 + H_2O \longrightarrow CO + 3H_2$$
$$CH_4 + CO_2 \longrightarrow 2CO + 2H_2$$
$$C + H_2O \longrightarrow CO + 2H$$

If will be choosen to proceed with the separation of hydrogen from the rest of the syngas produced, we will therefore use specific membranes.
First of all, the CO_2 present will be removed: for each ton of RDF we could separate up to about 104 kg or 57 Smc. The cleaned gas will be treated by means of another specific membrane to absorb hydrogen: with this system we could recover between 50% and 60% of the hydrogen present.
The remaining gases with calorific value, mostly carbon monoxide CO and methane CH_4, will be used for the production of both electrical and thermal energy.


CE.ECO
CHEMICAL
EMPOWERING



scraps and their use

Once the **gasification process** has taken place, in addition to the synthesis gas, we obtain ash in an amount equal to 5-10% of the treated original matrix (approximately 20% from sludges). Based on the analyzes that will be conduct over them even several times a day, the ashes will be destined as:

- **soil fertilizer;**
- **beach nourishment material;**
- **sand for construction;**
- **a soil improver - binder for compost**

If the analyzes show that the ash is not inert, therefore harmful to the environment, the single lot analyzed will be sent to a landfill or to a plasma torch where it will be transformed into a plasmable vitrified lava material and therefore totally free from environmental risks.

The higher the temperature inside the gasifier, the lower the risk of incurring in non-inerted lot. Atmospheric emissions do not occur due the application of our systems.

We will obtain synthesys gas treating the organic fraction in a **plasma torch**. The inorganic fraction becomes completely inert and forms a vitrified material. Then, pouring from the reactor in molten form (lava), it cools down solidifying in a material that can be shaped and used for useful purposes without environmental risks such as:

- **road or rail surface;**
- **floor tiles;**
- **common objects (souvenirs, statues, etc.).**

The extremely fast thermal reaction and the treatment at extremely high temperatures allow the total destruction of toxic organic compounds and the overall vitrification and encapsulation of any compound. Atmospheric emissions do not occur due the application of our systems.

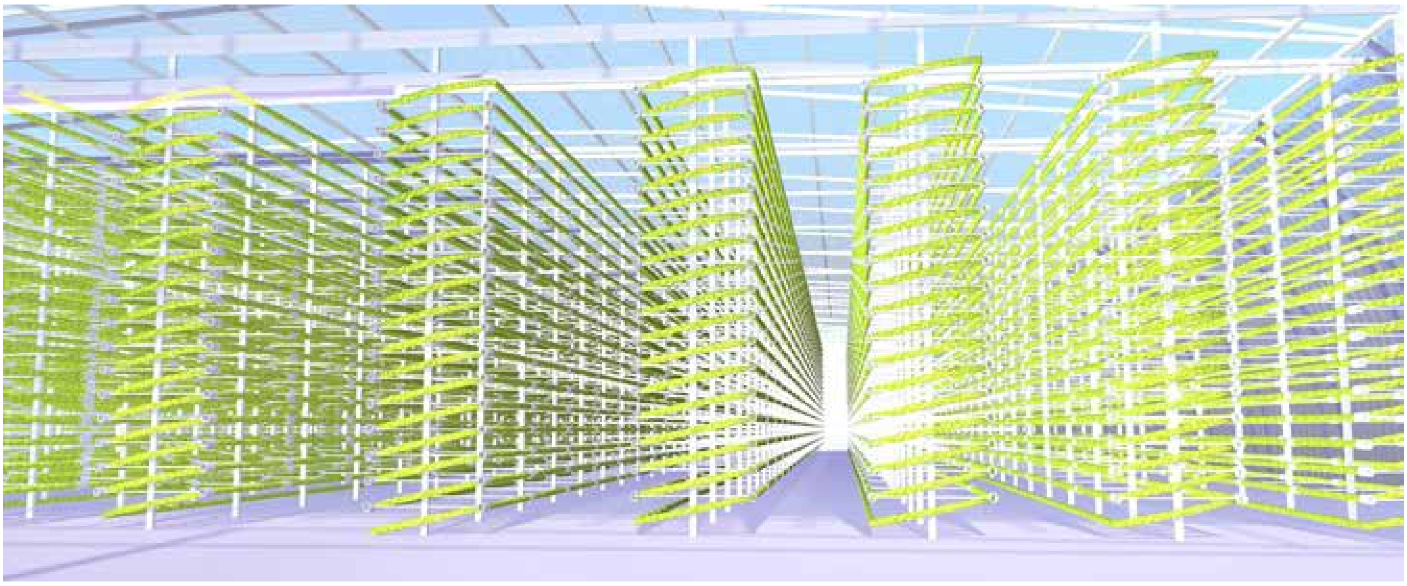
After ad adeguate staying in the **biodigester**, we will obtain a gaseous mixture consisting mainly of methane and carbon dioxide, containing small quantities of hydrogen, and a very liquid sludge, with a solid fraction around 5%, not fully stabilized (the organic matter is not completely degraded).

The gas produces energy or, after the separation of its components, energy and methane. After the separation of the water using a phytopress, this is recovered while the dry fraction is used as biological fertilizer. Any excess nitrate can evaporate in the form of harmless nitrogen, making the quality compost rest. It can be added with gasification ash used as a soil improver.

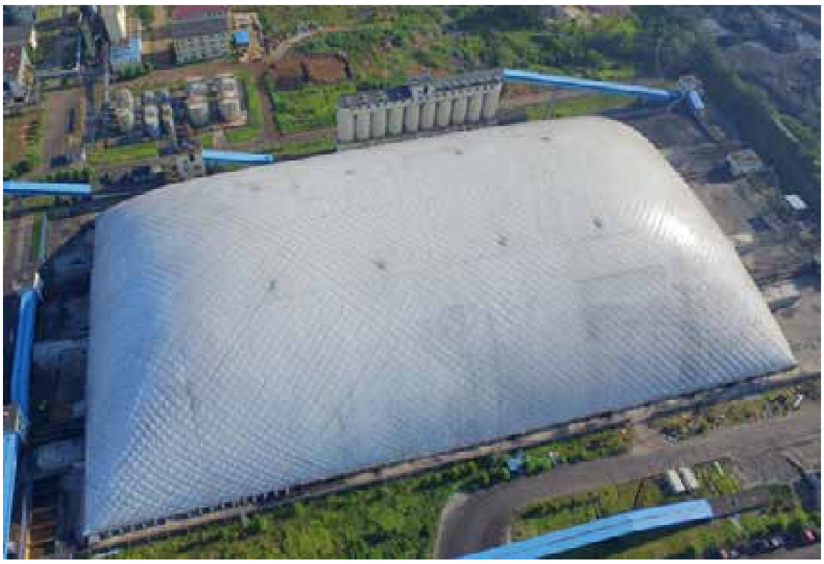
carbon dioxide

Carbon dioxide is the result of the combustion of an organic compound in the presence of sufficient oxygen to complete its oxidation. It can also be produced by reacting a carbonate or bicarbonate with an acid. In nature, it is also produced by aerobic bacteria during the alcoholic fermentation process and is the byproduct of respiration. Plants use it for photosynthesis which, by combining it with water and by the action of sunlight and chlorophyll, transforms it into glucose, releasing oxygen as a by-product.
Therefore, it goes without saying that if on the one hand it is the greenhouse gas par excellence, on the other, without it the life on earth would been extremely different from how we know.
The balance in the atmosphere must be maintained and, therefore, activities that release large quantities of it should be avoided.
To do this literally the humans should abandon modern civilization.
However, there are other viable ways, also more exciting!
Carbon dioxide, if food grade, can be **packaged** and has a large number of applications including sparkling beverages. In **BIOZIMMI** it is possible to make it food grade applying the appropriate moduls.
We have developed modules to use it for the production of **urea** or **calcium carbonate**.
Or it can be immediately **conveyed to greenhouses** to be built nearby, especially if of **spirulina algae** which make it an average consumption enormously greater than the average of other crops: they are able to absorb the CO_2 present in the atmosphere even 400 times faster than a common tree.
Microalgae, microscopic plants that usually grow in aquatic, marine, brackish or freshwater environments, are generally able to reproduce very quickly, often doubling their mass within a day or even a few hours as they can operate closer to the maximum potential of photosynthesis and, therefore, their intensive crops are usually more productive than those of higher plants.
The **greenhouse**, fully automated and optimized for algae cultivation, provides for the complete recovery of the water used through **EMPOWERING DEVICE** and cultivation through closed-cycle photobioreactors in an aseptic bioclimatized area that develop in length but on overlapping levels to exploit the entire internal volume of the greenhouse.

The photobioreactors work continuously powered by solar energy while the microalgae, grown intensively, reproduce in the water flow stimulated by a precise radiation of the electromagnetic spectrum also generated by artificial lighting.
Through the natural process of photosynthesis, the CO_2 molecules are then biofixed by the microscopic algae.
The collection of microalgae is also automated and takes place through filtration with sheets.



The vegetable biomass produced, collected and dried, is an algal flour that can be used as a product or component for agro-industrial, food and / or nutraceutical markets; or it can be transformed into bio-oil suitable, in turn, for transformation into biodiesel.
Greenhouses are usually inflatable, UV-resistant, transparent, insulated structures such as Etfe and Nilon pillow, without invasiveness and damage to the host soil, removable, movable, modular.
The spans can develop up to 180 meters, able to withstand winds up to 70m / s, holding 250 Kg / m^2 of snow, operating life up to 35 years. They require almost no maintenance and are totally recyclable at the end of their life.
Spirulina Arthrospira platensis lived on our planet for more than 3 and a half billion years and is a blue-green spiral-shaped microalgae that reproduces thanks to photosynthesis, like plants. Compared to meat, fish and cheeses which contain 20% of proteins, legumes and eggs which contain 13%, spirulina boasts 70% of proteins, already transformed into amino acid.



It is a 100% vegetable nutraceutical food among the most complete and balanced in nature, already defined by the UN as the best alternative food source of the future.
Algal flour is a source of wealth for its precious use in the food economy and phytocyanin, the pigment molecule, is to be used as a dye or for food supplements due to its antioxidant effect.

the technology

The first experiments on **gasification** were conducted in 1699 by Dean Clayton. In 1840 the first commercial gasifier was built in France and in 1861 the introduction of an innovative model of gasifier consecrated Siemens as a brand related to energy. In the 1930s, various European countries also exploited gasification for the automotive market, and it was not unusual to see vehicles that used gas systems instead of a normal engine.

In 1939 Sweden even boasted 90% of the circulating car fleet operated by gas-fired gas. After the Second World War the technology was set aside given the abundance of oil knowing a new "gold" period during the 70's. In recent decades, several new technologies have been developed regarding biomass and waste gasification, usually for plants of large size.

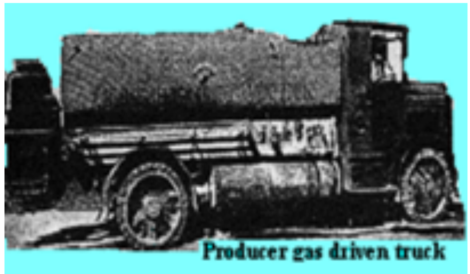
It is an endothermic chemical process thanks to which solid carbon-rich fuels are converted into a synthesis gas. Therefore, low value organic substances can be converted into a versatile product with a higher calorific value and cleaner.

The gas produced is a mixture whose main components are carbon monoxide (CO), carbon dioxide (CO_2) and hydrogen (H_2) with traces of methane (CH_4) more or less consistent depending on the raw material used.

In our plants we have opted to adopt a rotating fluidized bed counter current oven: ideal for the most different kind of matrices.

The purpose of gasification is the transformation of a solid material of little economic and energy value into synthesis gas: the partial combustion that occurs during gasifica-

tion develops only 20-30% of the heat actually obtainable through complete oxidation. This means that syngas has 70 - 80% of the calorific value of the original fuel.



Producer gas driven truck

The gas produced has different compositions according to both the treated matrices and the technology used for its production, as well as the different gasifying current used (air, oxygen, steam). There are also numerous pollutants. Their content must necessarily be reduced both for environmental reasons and to avoid influencing or damaging the subsequent processes to which the gas is subjected. We break them down using mainly cavitation and sending the non-breakable contaminants directly to the plasma torch.

Plasma technology has existed since the 1960s. The first 2 commercial plants capable of treating MSW were both built in Japan. From the pilot plant (30 tons per day) commissioned by Hitachi Metals in Yoshii, given the enormous potential, the plant was immediately built in the zero emission Mihama-Mikata industrial park. The Utashinai plasma gasification plant, whose original project had a capacity of around 170 tons per day of MSW and residues of car shredders (ASR), after initial problems that delayed the opening of a few years, is It has been completely revised to evolve into a plant capable of processing around 300 tons per day: the plant generates up to 7.9 megawatt-hours (MWh) of electricity, selling approximately 4.3 MWh to the electricity grid net of self-consumption.

In France, plasma gasification is used to melt asbestos making it inert, but still in the Bordeaux area another Plasma Torch has been processing organic waste for years with the production of syngas and therefore of energy. Today these are followed by numerous systems, also mounted on cruise and military ships, including the USS Gerald R. Ford (CVN 78) Supercarrier - US Navy.

Another very interesting case of application of plasma to the MSW is the Brasov plant in Romania capable of no less than 12 tons per hour and the first in the world to have exceeded the gross production of 1,200 kWh per ton using a plasma torch.

A 72-ton per day waste-to-energy plant located in Pune, India, was commissioned in 2008. The plant is the world's largest plasma gasification WTE plant that treats hazardous waste. The gas produced burned in a steam boiler that drives a flow turbine that produces up to 1.6 MW (net) of electricity.

system's peculiarities

Our plant is completely innovative in its design while relying on proven, mature technologies and, individually, commercially used for decades in different parts of the world.
It is impossible to doubt the gasification and plasma torch technologies as they exist and are applied daily to treat MSW all over the world, the first since post-World War II and the second since 1980.
Gas treatment technologies are refinements and adaptations from the world of oil & gas.
The main innovation lies in being an industrial plant which instead of creating pollution feeds on it to produce basic needs (electricity for example) or to produce other elements useful for harmonious progress and not in contrast with nature. We were the first who thought of combining different technologies, all complementary to each other.
In addition, being designed in a modular way, allows us to adapt it to almost all uses and needs.
Finally, the adoption of consolidated third-party energy production technologies as well as third-party abduction systems normally adopted in other production chains allows a sensible and significant containment of both purchase and management costs as well as being able to select from time to time on the market the most performing technology for the size and type of syngas to be used.
Controlled cavitation, the long and fruitful experimentation of which has led us to obtain rewarding results, including certified ones, such as the reduction of **COD** (Chemical Oxygen Demand) by more than 90% in just a few minutes, is a powerful new technology that is rarely used in other sectors.
Similarly, the plasma chamber designed by us is the first in the world to be able to use different types of electrodes, thus safeguarding the investment from obsolescence, just as our gas-

The sheds where the matrices are first sorted and then prepared to be treat in our devices are all in depression. A double-door system allows the trucks to enter and unload directly into the "mouth" of the abduction systems but, at the same time, inhibit from leaving, thus preventing the dispersion of nasty odors outside. All the internal air, also in order to keep the depression constant, is sent via pumps to the gasifiers and / or plasma torches.
In the case of treatment in the sewage sludge plant, biological deodorization technology will be adopted by means of a biotrickling filter owned by one of our commercial partners. Thanks to this system, the qualities of the counter-current washing are combined with those of a biological filtering system. The operation is similar to that of a percolating filter in which, however, the percolating agent is not the substance to be purified but the purifying agent. In fact, this is an aqueous solution activated with special microbial strains which metabolize the odorous molecules by setting up on the large surface of the special support. Biotrickling filters have the advantage of being able to treat high concentrations of pollutants and allow the application of high specific loads with consequent reduction of the volume of the filter bed and of the surface used

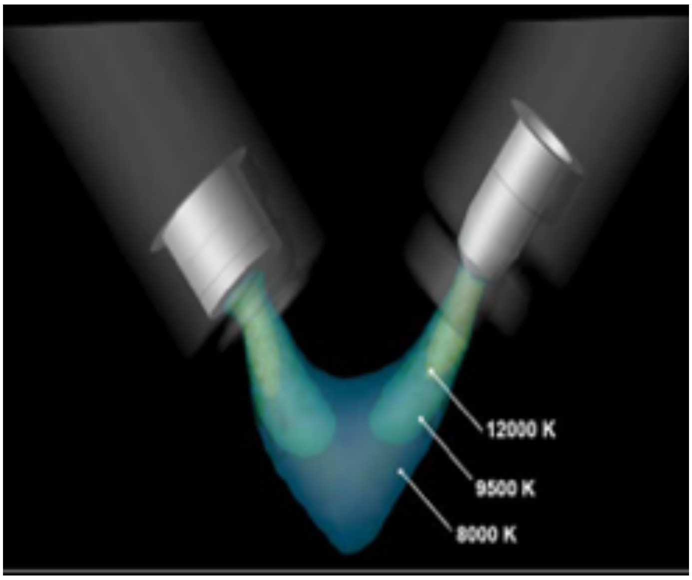
The whole processing area is in depression.
The air is introduced into the area by means of special pumps while other pumps maintain a constant flow by conveying it directly to the plasma torch.
Furthermore, by using specific devices, there will be a lower quantity of gas as a peak flow rate in case of emergency depressurization, and this serves to better guarantee the safety of the system (for example, for the same quantity of gas processed, in emergency case for a standard size of the Plant Unit, 33,500 kg / h were recorded against 134,000 kg / h of the peak depressurization flow rates, always sized according to the API Directives - American Petroleum Institute - 521 latest edition); consequently the spaces needed for the safety torch (Flare) are drastically reduced and the flare itself is much lower.
Moreover, by using specific devices, even near the base of the emergency torch, the thermal radiation produced never reaches dangerous levels for humans (irreversible injuries 5.0 kW / m^2 or reversible injuries 3.0 kW / m^2).

ifiers, in addition to being three-way, do not require continuous changes of refractory or the perceived external temperature is such as to not burn your hands in case of accidental contact.
Our technology is completely different from the one on which are based any incinerators. Both in the gasifiers and in the plasma torches the matrices (waste) are used to produce synthesis gas and, therefore, do not represent the “fuel” of the machinery as in the case of incinerators: the matrices are therefore a raw material used for a process high temperature chemical conversion where the matter is broken down into simple molecules.
The syngas that is formed from the simple molecules mentioned above will then also be used to produce energy or can easily be transformed into high value commercial products (methanol, biodiesel, chemicals, aviation fuel, etc.).
It is precisely the high temperature that is released during the gasification or with the plasma treatment that allows to definitively decompose the larger molecules such as tar, plastics, etc.
The syngas obtained can also be further “cleaned” and “washed”, an operation that is most necessary if it is chosen to use it in an internal combustion engine whose exhaust gases will also end up in the plasma torch cycle.
The lack or absence of oxygen combined with high temperatures and the absence of combustion inhibits the creation of toxic dioxins, furans or nitrogen oxides or even ammonia while the high temperature of the torch destroys the dioxins already present.
The abrupt cooling of process temperatures prevents the reformation of dioxins and furans.
Even the ash produced during the gasification and the lava produced with the plasma torch are completely different from any waste products created with an incineration process: in both cases, the waste to be sent to landfills is the raw material useful for a new process.
From all this it is evident that both the gasification technology and, even more so, the plasma torch technology are significantly different and cleaner than incineration.

plasma torches

Opposed to what happens in other systems used for waste disposal, since the dissociation of the products subjected to treatment takes place in the absence of oxygen, the application of plasma technology does not involve the emission of volatile substances such as combustion gases or harmful substances such as furans and dioxins.
With this process it is possible to treat - mixed or singularly - all solid and liquid waste of toxic-harmful nature. There is no need for a preventive selection of the waste but a Feasibility Study must be carried out beforehand for the system to be adopted to convey the products to be treated hermetically to the torch.
A system that uses this plasma technology is composed by a reactor including a plasma torch, the equipment required for its operation and the cleaning system for the fuel gas produced. This gas will be used for the combined production of electricity and thermal energy in cogeneration plants, or to produce chemicals including methanol.
The system is essentially constituted by a reactor to which the plasma torch is connected. In the upper part of the reactor occurs mainly the thermal transformation of the organic component of the waste generating a combustible gas: the syngas. In the lower part of the reactor there is both a thermal transformation and a kinetic transformation due to the plasma particles with energy higher than the thermal. The non-dissociated organic component, together with the inorganic component falls by gravity into the plasma area.
Here the organic part is completely dissociated generating other syngas, while the inorganic part is mixed in a molten bath possibly enriched with a fluidifier to improve its castability.
The molten slag is extracted from the bottom of the reactor while the gases produced exit from the top of the reactor: the formation of dioxins and furans and other toxic compounds resulting from the dissociation and molecular recombination is practically canceled and, in any case, if were to be present, they falls broadly within

the limits of the law.
The heavy metals in the reactor and those from the felling sections of the syngas are inerted forming a vitrified material. Even the non-combusted fraction of the waste, after its removal from the reactor in molten form (slag), is cooled by solidifying into a material that can be used for useful purposes without environmental risks (road and / or railway ballast, objects, nourishment of sandy shores etc.).
In general, the extremely fast thermal reaction and the treatment at extremely high temperatures allow the total destruction of toxic organic compounds and the vitrification and encapsulation of inorganic compounds.



For Plasma refers to a conductive gas, highly ionized. The torch or the non-transferred arc electrodes are capable of producing plasma at very high temperatures (the highest achieved in controlled industrial processes) and such as to cause thermochemical dissociation of what is being treated. Unlike other incineration systems, since the dissociation of waste occurs in the absence of oxygen, the application of plasma technology does not result in emissions of volatile substances such as combustion gases or harmful substances such as furans and dioxins.

The main reactions that occur during the process within our plasma torch are:

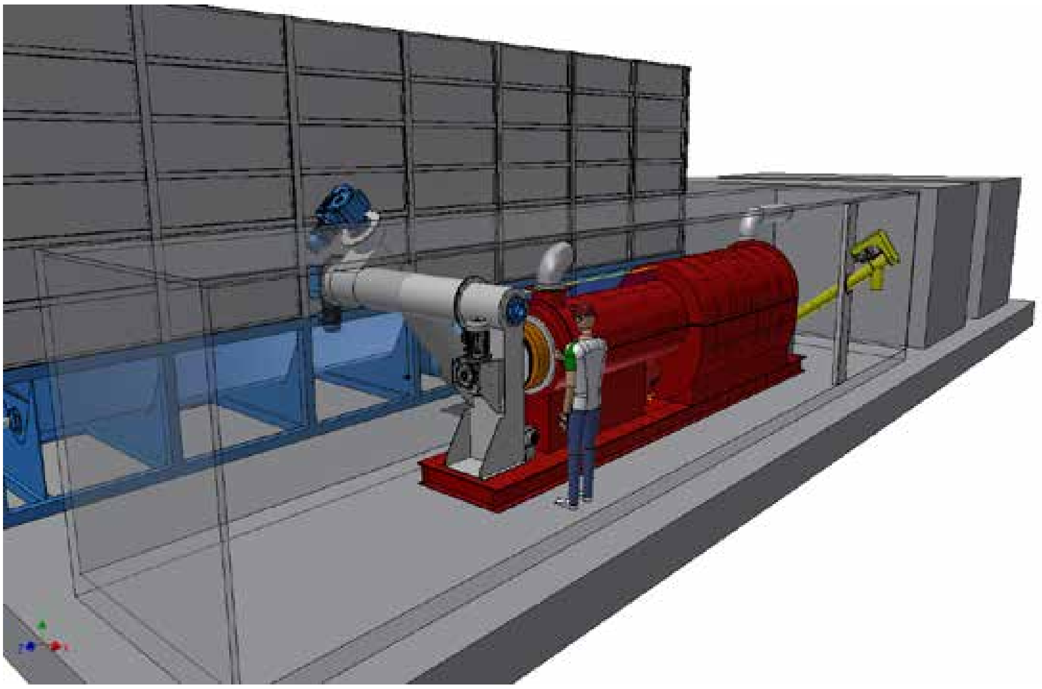
1. disintegration of the components: it allows the dissociation of the organic components that are transformed into synthesis gas. All the hydrocarbons present in the treated waste are gasified and form a synthesis gas composed essentially of hydrogen and carbon monoxide.
This mixture is highly energetic and is reacted to produce electricity or distilled to produce methanol and ethanol. Moreover, the high temperatures reached avoid the formation of toxic compounds such as dioxins and furans.

2. fusion: it involves the fusion of all inorganic compounds and the formation of an inert and non-leachable material (slag). All the toxic elements contained in the treated waste are subject to physical-chemical transformations that allow their total inertization.

gasifiers

Our system consists of a fluidized bed rotary furnace combined with a plasma placed in the queue for the vitrification of the aggregates. Schematically the rotating tube can be divided into three zones: in these three different reactions can take place. Furthermore, the system that supplies the oxidant for the reactions can be installed at will in one area or another allowing the differentiation of application mentioned above. The type of oxidizer can be air, oxygen or water vapor and the entire tube can be brought to operating temperature using gas torches.
If a process based on **combustion** was necessary, we would place the system that provides the oxidant for the reactions in the first part of the tube thus providing an excess quantity of air and thus favoring the combustion of the organic material - understood as a substance carbon base. Depending on the needs, the system that supplies the oxidant for the reactions could instead be placed in the final part of the tube: by heating the tube it allows pyrolysis to be obtained in the first part, reduction in the central part and combustion in the final part. The resulting products of the entire process are ashes which will be vitrified and then inertized using a plasma placed at the end. The heat generated can be used for the production of electricity. If the air is supplied in the first part, all the heat is supplied by the material to be treated.
If a process based on **pyrolysis** is necessary, the tube will be heated using gas torches and brought to a temperature of 500-600°C depending on the material to be treated. The resulting products are bio-oil (similar to diesel produced with the Fisher-Tropsch reaction), coal and gas, the latter can be used to heat the system. In this case there is no oxidizing agent and the organic molecules are split thermally.
If a process based on **gasification** is necessary, the system that supplies the oxidant for the reactions will be positioned in the central part, the quantity of oxidant will be stoichiometric, the tube will be heated to the reaction temperature, i.e. above 900°C.
With this treatment process the main product obtainable is syngas.
The degree of purity of the gas depends on the oxidizer used. By using air, the gas that will form will have a high percentage of nitrogen which will lower its calorific value; using steam, the gas that will be formed will have both high calorific value and purity, allowing easy use of the gas for the synthesis of chemicals; using oxygen instead, the gas formed will have median values.
In the first part of the tube we will have pyrolysis of the material, in the central part there will be partial oxidation and in the final part there

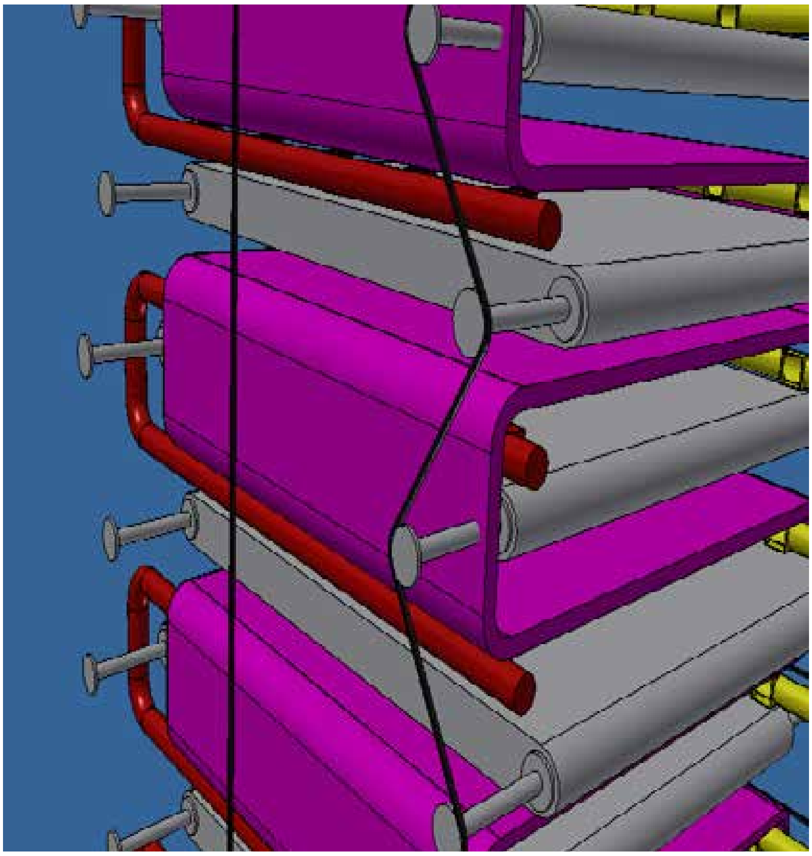
will be a reduction of the gas produced.
The system is particularly flexible, this allows it to treat multiple materials and the ashes produced are vitrified and inertized through a plasma which transforms them into lava. In addition to eliminating the ash problem, this purifies the syngas and increases the percentage of hydrogen present through dry reforming of the methane present in the mixture.
The bed is fluidized by the rotation of the cylinder and by the particular geometry of the system which provides the oxidant for the reactions which, exploiting the Coanda affection, creates a vortex which in addition to pushing the gas forward, offers a more intimate contact with the oxidant itself and, therefore, better efficiency of the system. The rotating drum and the dispenser guarantee the fluidity of the system, ensuring temperature homogeneity; in fact, temperature gradients could create serious problems such as the creation of harmful substances such as, for example, dioxins and furans.
Unlike other systems that can be used for treatments, these are systems of decidedly small dimensions but with very high energy efficiency: in fact the combination of various jumps and the use of high efficiency turbines, as well as the use of our thermoelectric system for the recovery of waste heat allows obtaining an electrical efficiency of up to 65%.
The small dimensions, far from representing a limitation of the rotary kiln, are one of its strong points: since the systems are modular, only the equipment necessary for the treatment will be used.
The system developed by us, when compared with other systems, has numerous advantages. First of all, each plant is containerized and therefore modular and expandable according to treatment needs; at the same time, however, it can be used for small quantities of material, maintaining high efficiency from both an energy and environmental point of view. During chemical reactions we have a very high control which guarantees the formation of unwanted molecules.
The gasifiers take advantage of the molecular dissociation, called pyrolysis, used to directly convert the organic materials present in the waste into gas, by heating, in the presence of small quantities of oxygen.
The processed materials are completely destroyed because their molecules are dissociated. This process allows, if compared with the direct burning, a number of significant

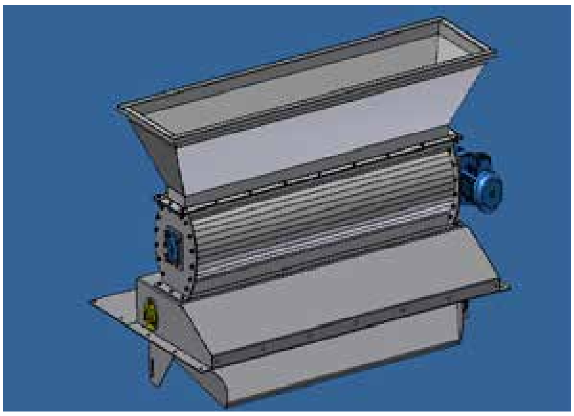


advantages:

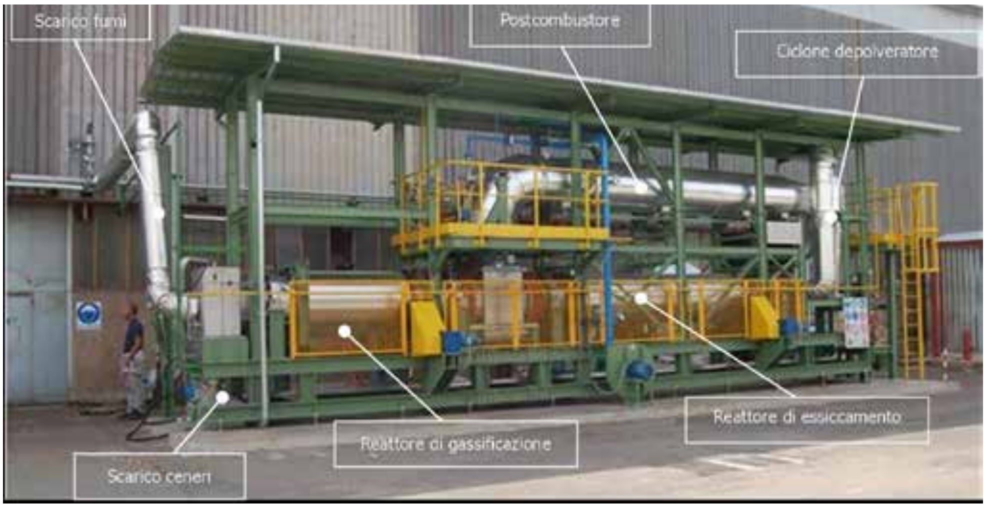
- increased fuel usability;
- use of relatively simple and tested technological solutions;
- higher energy efficiency;
- definitive Destruction of such waste;
- No contributions in special landfills;
- No harmful emissions;
- Production of steam and then of demineralized water from its condensation, with easy addition of saline charge additives for water purification;
- Possible production of Chemicals, primarily methanol, usable in automotive engines or sold on the market;
- Low visual impact.

The synthesis gas, even when of a low calorific value, once filtered and purified, can be used for the feeding of a cogenerator, thus enhancing the calorific value of the organic matrix used and can be contain costs simultaneously producing electrical and thermal energy, or it can be used for the production of reusable chemicals.
We also have **small size gasifiers**, with a lower system capacity than the one of a single standard reactor. These represent the ideal size for the needs of the so-called **circular economy**.
Our gasifiers have been developed in collaboration with the **RINA Consulting - Centro Sviluppo Materiali spa**, a subsidiary of RINA Group, also on the basis of their previous studies. In their industrial area in Rome - Italy -, there is a pilot that can be visited, fully equipped also with a plasma torch.
Our gasification system involves the use of drying systems for pre-treating the incoming material or matrix. The dryer is fed through the process' heat and allows to bring the input humidity of the matrix by the value of the conferral (normally value between 70% and 30%) to, approximately, 10%. The matrix is dried in this way, is transported inside the reactor, where it is raised to temperatures ranging from 400 to 650° C, by recovering the heat generated by the same syngas and by the same gasification process that takes place in the last part of the reactor where the temperature rises up to 1,200° C. The matrix / waste is thus subjected, rapidly, to total drying, pyrolysis and consequent gasification.
Said produced gas (syngas) will be sent, after having been properly washed and purified, to the turbine. In the absence of a plasma torch it is not possible to reach the zero emissions level but, in any case, these will be below the levels allowed by the various national regulations.
The use of syngas will produce thermal kW and electric kW. Part of the produced electricity will be used for the process.
Thermal energy can in turn be partially transformed into electricity.
Once the gasification process has taken place, the only resulting waste product is the ash, on average about 5-10% of the matrix entering the gasifiers.





sludges pyrolysis test



Report of the tests carried in November 2011 on the pilot gasifier at the **CSM** of Rome - IT in order to determine the self-sustenance of the drying process / pyrolysis and gasification of sludge.

The wastewater sludge, residential or industrial whatever their origin, are generally considered as waste and are disposed of in landfill. The increased quantities produced as a result of the increasing number of sewage treatment plants, civil and / or industrial, and the more restrictive regulations regarding the disposal, force to consider with greater care alternative methods to the mere landfill.

Moreover, these materials, once dried to reduce their volumes and costs of transport, acquire a calorific value such as to make them incompatible with the eligibility criteria in landfills. For example, in Italy the PCI limit> 13 MJ / kilograms was introduced by Legislative Decree 36/2003. The sludge, from waste to landfill, become something which must be take advantage of residual heat, keeping them for an extra step in the production cycle and ensuring respect for the environment. Finally, volumes, after the energy yield, are reduced by more than 80%.

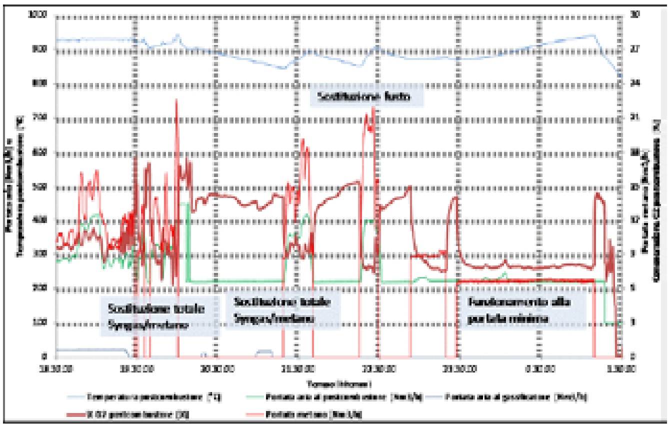
During this experimentation conducted on the pilot in 2011, it has been verified the efficiency of the gasifier quantifying the expected tendency to self-sustenance (reached after 8 hours of charging system operation) and checking that the composition of the syngas produced by the two areas (drying / pyrolysis and gasification) proves suitable to characterize the process' energy carrier.

The tests were carried out with an hourly flow rate of 50 kilograms / h, providing 8 hours of operation at processing temperature (350 ° C for drying, 800 ° C for gasification and 850 ° C for the post-combustion). The 4 hours initially budgeted NOT allowed to reach the conditions for self-sustenance given that, one of the process parameters obtainable with prolonged tests is that related to thermal dispersions, dispersions that are normally specific to a plant that goes to the thermal regime conditions. Such dispersions towards the environment tend to decrease until at a constant value, with increasing time of operation.

So, to make sure to have an operation as long as possible, the sludge gasification tests were organized in 3 shifts.

After the first heating phase, the system has been loaded to the maximum: 390 kilograms. In conjunction with the first part of the process, some oscillations in the measurement of the air flow have been noted, probably due to a compressed air absorption by the **CSM** network.

This phase of oscillation has been stabilized autonomously after about one hour of operation, during which it has been noted the lowering of the flow rate of methane due to the production and combustion of the syngas from the pyrolysis process in the first part of the gasification reactor.



In the side picture the partial replacement of natural gas with the syngas produced keeping constant the temperature at the after-burner is visible.

Added the second material cask, the tendency to self-sustenance has become evident so much so that the temperature of the combustor tended to rise even with very low values of methane flow rates to the burner (9 Nm^3 / h). Loading lasted a total of about 7 hours 30 minutes (from 12:30PM to 19:00PM); the total loaded material was found to be 387 kilograms.

In such operating conditions, to maintain the temperatures of the post-combustor in the programmed limits, have been required cooling air's flow greater than the maximum allowable flow rate (450 Nm^3 / h). Therefore, it was decided to turn off the burner and run the process control manually.

After 11PM, in close proximity of the need to begin the shutdown's proces and in the need to follow such process according to the scheduled procedure, the burner was switched on again bringing it to the minimum possible flow rate (about 6 Nm^3 / h).

In this conditions, the temperature at the post-combustor is returned to rise for about 2 hours, up to reach such a temperature (> 950 ° C) as to make decide for the reactor shutdown (01:15AM). The total duration of the TAS + BIO mixture loading, was then about 6 hours and 10 minutes (from 19:05PM to 01:15AM); the total loaded material was found to be 376 kilograms.

These gasification tests described above have allowed, among other things, to verify the adequacy of the syngas generated to self-support the process of the entire sludge treatment (drying / pyrolysis / gasification), within the limits defined by the experimentation carried out. The syngas for the adopted measures showed a significantly lower content of powders to that recorded for similar technologies (normally equal to 50 mg / Nm^3), having found in the cyclonic dust collection system less than 1000 mg for the duration of long-term experimentation (0.1 mg / Nm^3).

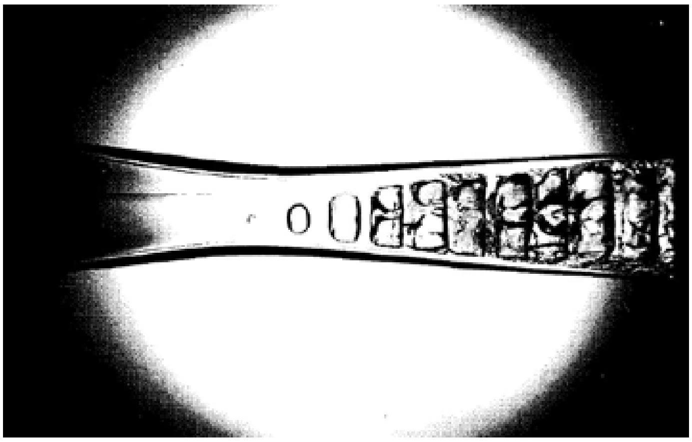
EMPOWERING DEVICE

EMPOWERING DEVICE has been fully conceived, developed and implemented by our team and is able to simultaneously manage different types of controlled cavitation, of which 5 of a different nature but which coexist harmoniously to the point that no significant vibrations are detected.
The summation of the effects produced by each cavitation further implements the efficiency of the chemical, physical and biological processes that take place within the apparatus, resulting in a subsequent cut in the already low energy consumption as well as a sharp reduction in processing times.
A prototype with a special set-up, prepared for experimentation and of 1:1 size, has been used by us since the beginning of 2017 to conduct the required tests on the samples of materials brought by our customers.
Our machinery is equipped with test certificates and international operating certifications with different types of liquids on different chemical, physical and biological processes.
What makes our system, today, unique compared to what the market offers in the field of controlled cavitation is the fact that although it is already extremely difficult to control a cavitation, in our system there are controlled cavitation's numerous and of different kinds, at least one of which is sonic.
The machine body has an element, with the functions of a static mixer, called by us "Il Cedro" (the Cedar) for the peculiar conformation of the "leaves" that make up its design.
This special monobloc mixer, in the presence of processes that involve the formation of crystalline chemical elements, has the ability to favor the formation of Crystallization Germs, with further acceleration of chemical reactions.
Another significant improvement compared to what has existed so far is represented by the evident lower pressure drops compared to machines equipped with motors of similar installed power, with a sensible and consequent energy savings during operation: the **EMPOWERING DEVICE** requires only a fraction of the electrical energy used by the other cavitators.
This is due to the fact that the machine body of the **EMPOWERING DEVICE** is structured to form a true "diffuser", with the consequent recovery of a percentage of the outlet

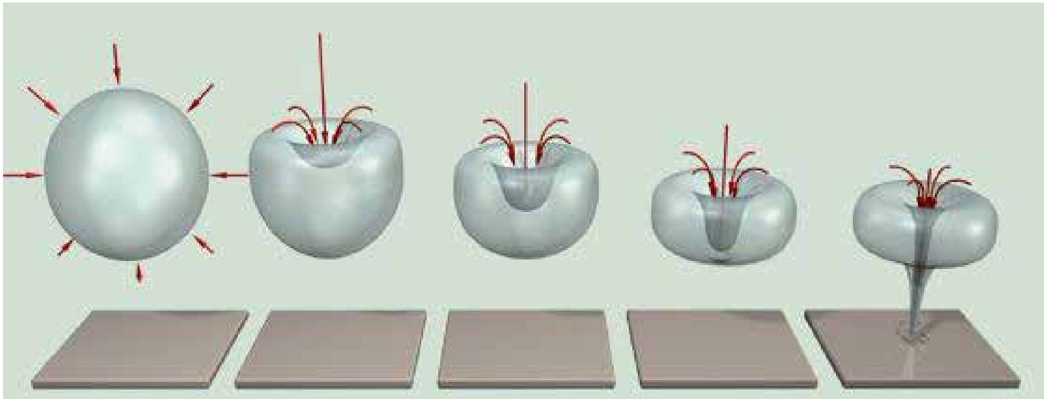
pressure.
Furthermore, it has been designed to be easily and quickly reconfigured according to the use: some of its parts can be removed if very dense and / or viscous liquids have to be treated and / or with extensive granularity or they can be added, inlet or outlet, accessory elements suitable for almost any use.
Moreover, in the presence of organic matter, cavitation leads to the consequent partial physical destructuring, a lysis of the cell walls and the consequent release of the intracellular content.
This action translates into a greater availability of cellular juices, an acceleration of hydrolysis processes and, consequently, an acceleration of the anaerobic digestion process as a whole.
In our cavitator, based on experiments conducted and certified by third parties, the rate of bacterial degradation can accelerate from 4/5 times to over 10 times compared to conventional treatments.
The certifications performed by the Rina Group show that the COD of the waste water from a gasifier is reduced by 90% in just 15 minutes.
By using the supplied inverter system, at the start, consumption is less than the 25kWh of rated installed power, similarly during full use; in the absence of an inverter, at least 36kWh would be required to start.
The standard version can treat up to 60 cubic meters of fluid per hour.
Compactness, simplicity of installation and use, are undoubtedly some of the peculiarities of our cavitation apparatus but it is the total flexibility of use that makes it unique.

SAMPLE	COD mg/L
AS IS material	15.380
after cavitation material	1.508
COD reduction percentuage	90,2%

cavitation

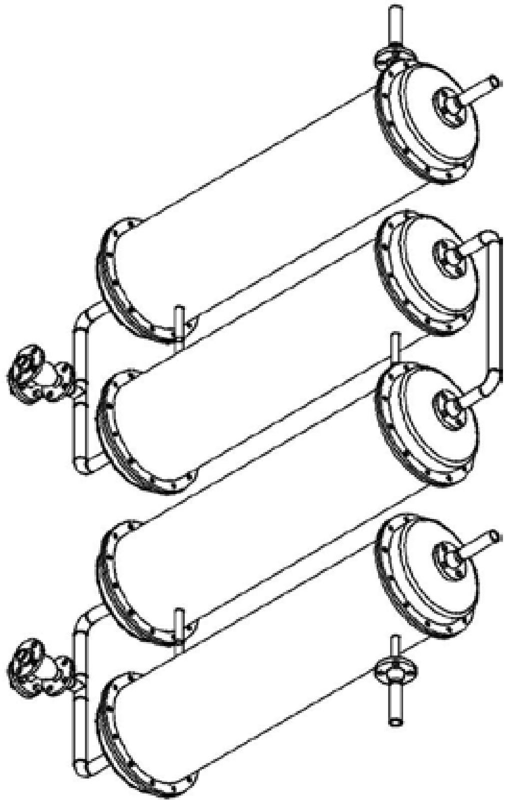


Water has the ability to convey many substances thanks to its particular chemical and physical properties: very high solvent power, high chemical reactivity and considerable specific heat. Moreover, its molecular capacity, two hydrogen atoms bound to an oxygen atom, allows it to behave like a crystal: not only in the solid state (ice) but also in the liquid state.
Cavitation applied to water acts mainly on this characteristic.
Through the violent implosion of the bubbles, it causes the release of nascent oxygen, allows the elimination of viruses and bacteria present; furthermore, it supports the magnetic conversion of calcite (responsible for the formation of scale) insoluble in soluble aragonite and not able to aggregate in the formation of limestone.
Finally, since the molecular structure of water is not uniform, the distance between the molecules is never the same, nor is the reciprocal attraction force; there are therefore areas or points of emptiness or pockets of gas (oxygen, nitrogen) and foreign bodies, sometimes not totally wet.

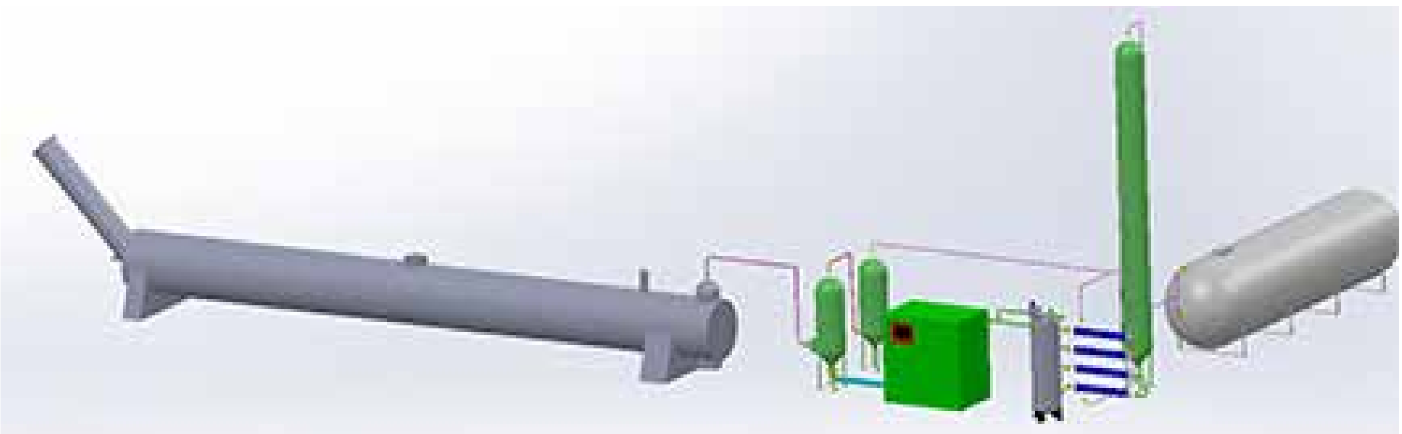


As the pressure decreases, the air pockets expand, the liquid evaporates and the steam fills them. The subsequent phase of implosion violates the oxygen, which can thus exert all its oxidative action on the surrounding organic substrate, mimicking the action of hydrogen peroxide.
Another fundamental aspect of cavitation with respect to all other water purification and filtering treatments consists in the fact that with cavitation they are the same water molecules that, after the implosion phase, assume a homogeneous crystalline configuration, which gives the water the original characteristics of the formation from the source.
Therefore, unlike the other treatments applicable to water, nothing is added or removed, such as ion exchange resins for inserting and subtracting ions or magnetic filtering to subtract iron, but on the contrary it is amplified and enhances the natural ability of water to biodegrade and break down pathogens by oxidation.
Furthermore, our equipment also includes an ozonator that further enhances the oxidation of any pollutants present.

the ZEB



Thanks to a Horizon project (**Project ID: 101058540 - Project name: PLASTICE**), we have developed a process capable of obtaining the synthesis of DME in a single step: starting from syngas to the formation of methanol and up to its dehydration to DME. Process which must be environmentally sustainable and which must reduce processing waste to a minimum, with a tendency towards elimination.
For this specific purpose, the ZEB was therefore designed and built: a modular membrane reactor that requires minimal maintenance. It can process syngas continuously without downtime and works in line with our plasma-equipped gasifier and other gas purification systems.
The plasma at the end of the gasifier improved the quality and purity of the syngas as well as obtaining the fusion of the ash into a useful inert lava, thus solving two of the main problems of the transformation process.
The direct hydrogenation of CO for the formation of methanol and its dehydration leading to the formation of DME is developed in a membrane reactor designed for the optimization and improvement of the conversion efficiency, otherwise limited by the thermodynamic equilibrium and the temperature gradients. The co-current circulation of a sweep gas through the permeation zone promotes the removal of both water and heat from the reaction zone, thus increasing the overall DME yield.
Among the available membrane materials, it has been preferred to adopt porous membranes, in particular SOD membranes, since they satisfy important prerequisites regarding hydrophilicity, thermal and mechanical stability and high selectivity. The process conditions adopted are those that guarantee maximum DME yields as well as the applicability of the ZEB reactor to other reactions that are particularly sensitive to reaction water, such as the hydrogenation of CO_2.



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