bio&watt

ENERGY FROM BIOMASS

GASIFICATION PLANTS

"In nature nothing is created, nothing is lost, everything changes."
Antoine-Laurent de Lavoisier

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BIO&WATT ENERGY FROM BIOMASS

We are committed to working for a sustainable development of the Energy Production from Renewable Sources, through the use of an innovative and efficient technology that delivers small size plants and extremely low environmental impacts.
Innovation is our passion, and our mean. We collaborate with universities and research centers, nation-wide and internationally, to evaluate and transfer to our plants state-of-the-art technologies, materials and processes. We work with suppliers/partners with the highest expertise on the market in their respective fields.
In this way, we aspire to enable the development of new models of economic growth based on the exploitation of available biomass. The high efficiency of the process and the small-scale of the plant allow to attain the production of electrical and thermal energy in self-production units of small size located in several points of the territory, where the biomass is present and available. The unique characteristics of the gasification process allow a wide range of applications, ranging from Agro-Energy chains to Biowaste to Energy. Our industrial project aims to develop a small-scale, distributed power generation technology based on the gasification process.

PLANT

Agro-Energy chains

The gasification of virgin biomass from dedicated energy crops can produce renewable energy more efficiently, and therefore with higher profitability than alternative technologies based on combustion.

Other than from energy crops, virgin biomass can be derived from agricultural residues or industrial by-products such as forest service residues or saw mill shaving chips, and nonetheless represent a valuable resource to be exploited through the gasification technology. Our system has been designed focusing on the concept of flexibility with respect to the biomass fed, which may vary significantly in order to its physical and chemical characteristics though continuing to fuel the process effectively. Through our plants different businesses like farming, forest servicing, etc. can provide a stable and additional source of income to their business.

Biowaste to Energy

Beyond being able to use a wide variety of organic materials to produce power and heat, the gasification process has another important characteristic: it performs a strong volume shrinkage of the mass input (the only residue of the thermo-chemical process is the ash contained in the biomass). This suggests the application of the process to waste feedstocks generated by agricultural or industrial activities, that will be transformed into energy rather than disposed to landfill, making such a transformation not only economically viable but also environmentally sustainable.

Our plant's design is suited to gasifying virgin biomass (i.e. wood chips) as well as organic waste fractions like anaerobic digestate, poultry litter, sewage sludge from civil and industrial water treatment processes (i.e. wastewater sludge or paper mill sludge) and still meet all the applicable emissions regulations.

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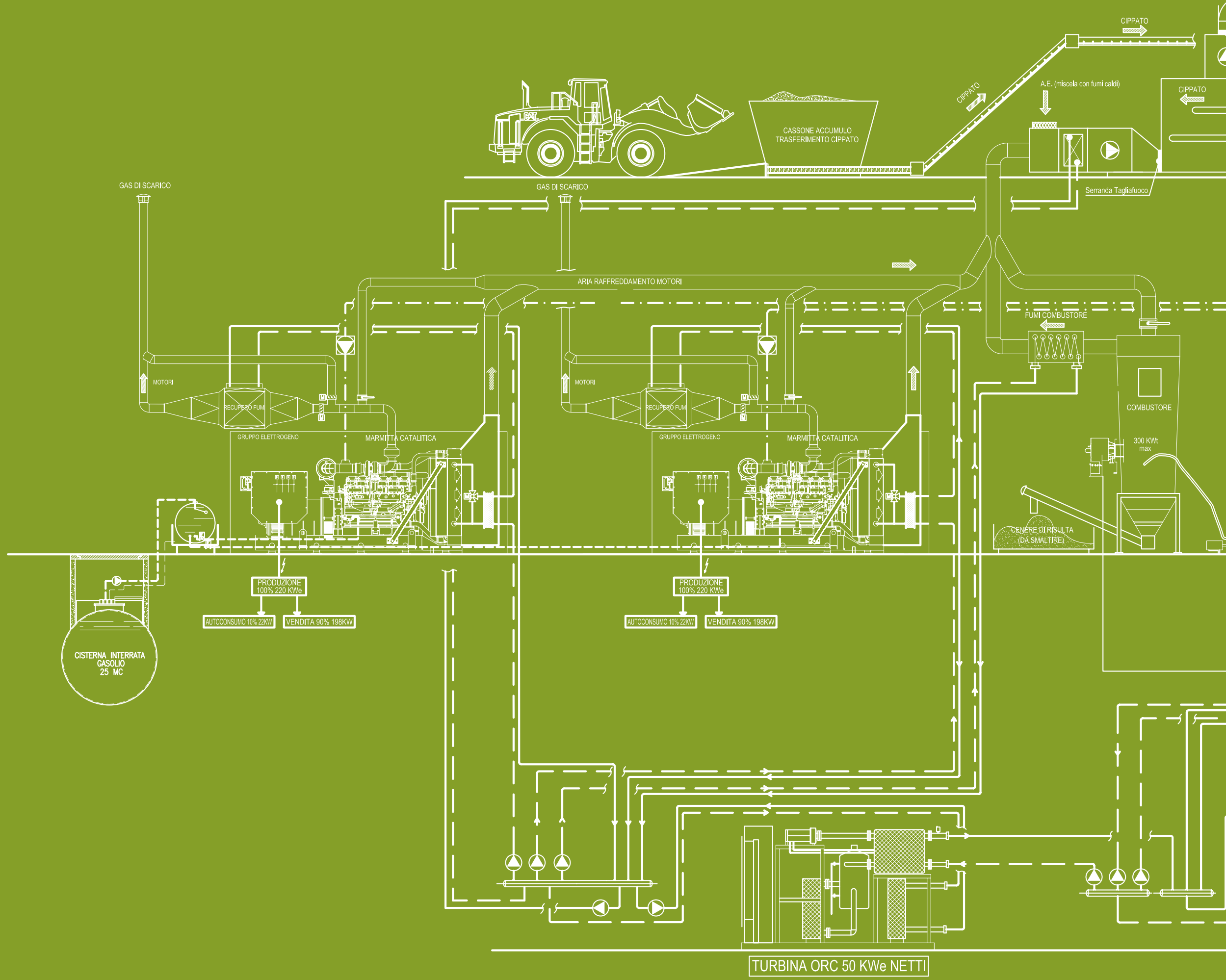
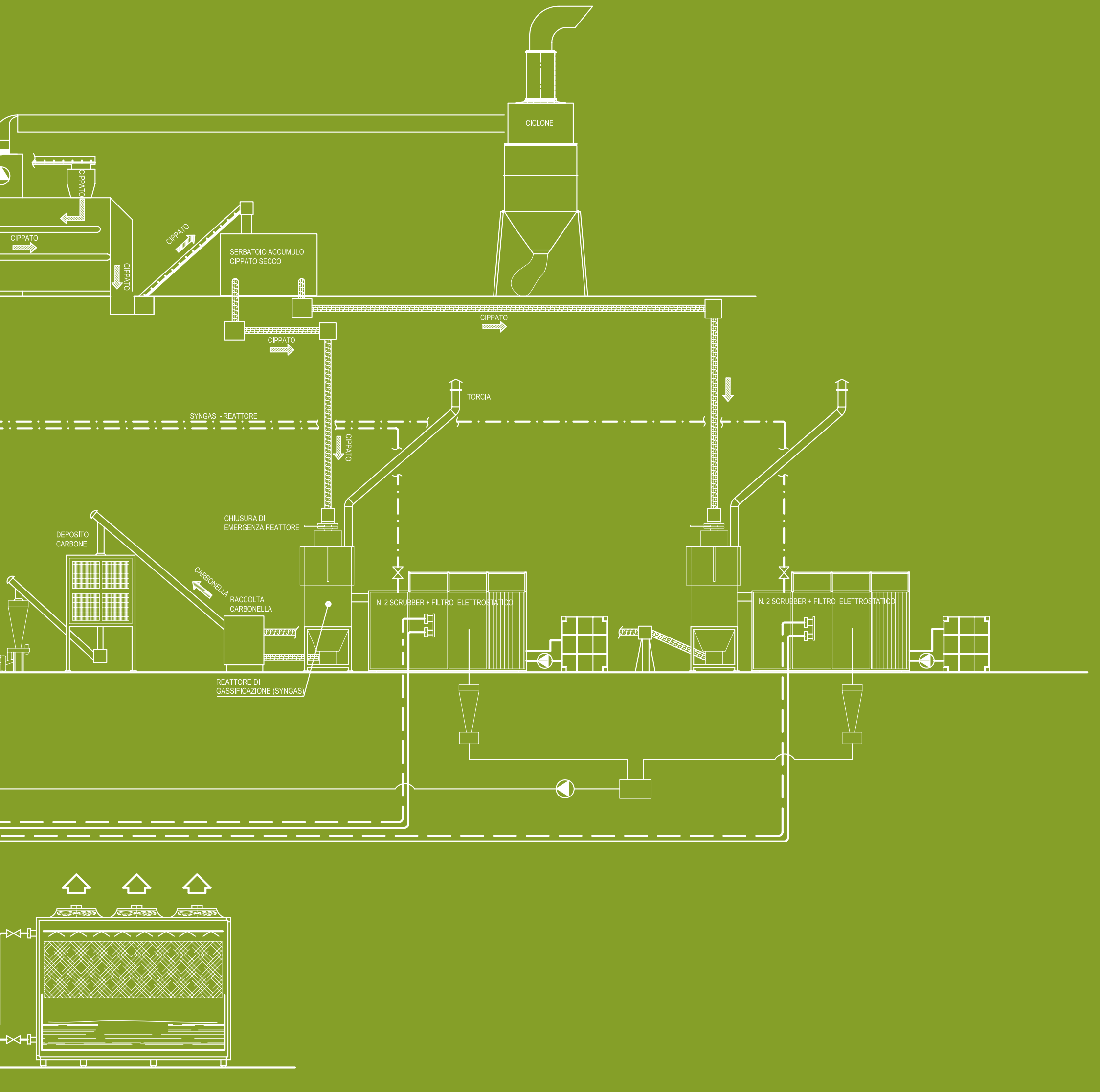
SERVICES TURNKEY ENERGY SOLUTIONS



We assist the client in every phase of the project, from feasibility study to after-sales service, taking advantage of qualified partners when necessary, to ensure the conditions required for the successful completion of the project:

- Feasibility study (technical/financial)
- Assessment of available biomass
- Implementation of a tailor-made solution
- Assistance for authorizations and permitting procedures
- Supply of "turnkey" plants
- Training of customer's personnel for plant management
- Ordinary and extraordinary maintenance



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GASIFICATION PLANT

ADVANTAGES

Our solution offers a number of advantages with respect to alternative technologies of biomass-to-energy conversion:

- Small-scale (the installed capacity of the single module is of 300kWe or less), high efficiency plant thanks to combined heat and power production, allowing decentralized energy generation

- Superior electrical efficiency (50% higher than a conventional conversion process of the same size based on biomass combustion) and, as a consequence, higher return on investment in the plant

- Extremely compact design, allowing the plant to be conveniently located in any agricultural or industrial environment (higher plant efficiency implies reduced logistic requirements in terms of biomass storage, number of transports etc., and the characteristics of the thermochemical conversion process consent to reduce the footprint both in terms of plant height and surface area occupied)

- Scalability through modular approach (by installing multiple modules you get the desired electrical capacity, commensurate with the availability of local biomass)

- Broad range of applicable fuels (virtually any organic material having C-H-O composition can be used in gasification through appropriate pretreatments)

- Very low emissions level (the gasification process itself does not produce any emissions) and substantial amount of CO_2 avoided

- Virtually no waste products (the only by-product of the process is the ash originally contained in the biomass fed to the plant), all the energy potential of the biomass is exploited

- Large variety of possible applications (the process allows the transformation of the energy carrier from solid to gas, increasing ease and ability to use: the syngas can be used to fuel internal combustion engines for power production or fired directly for the production of heat in existing plants such as kilns, boilers or industrial dryers)

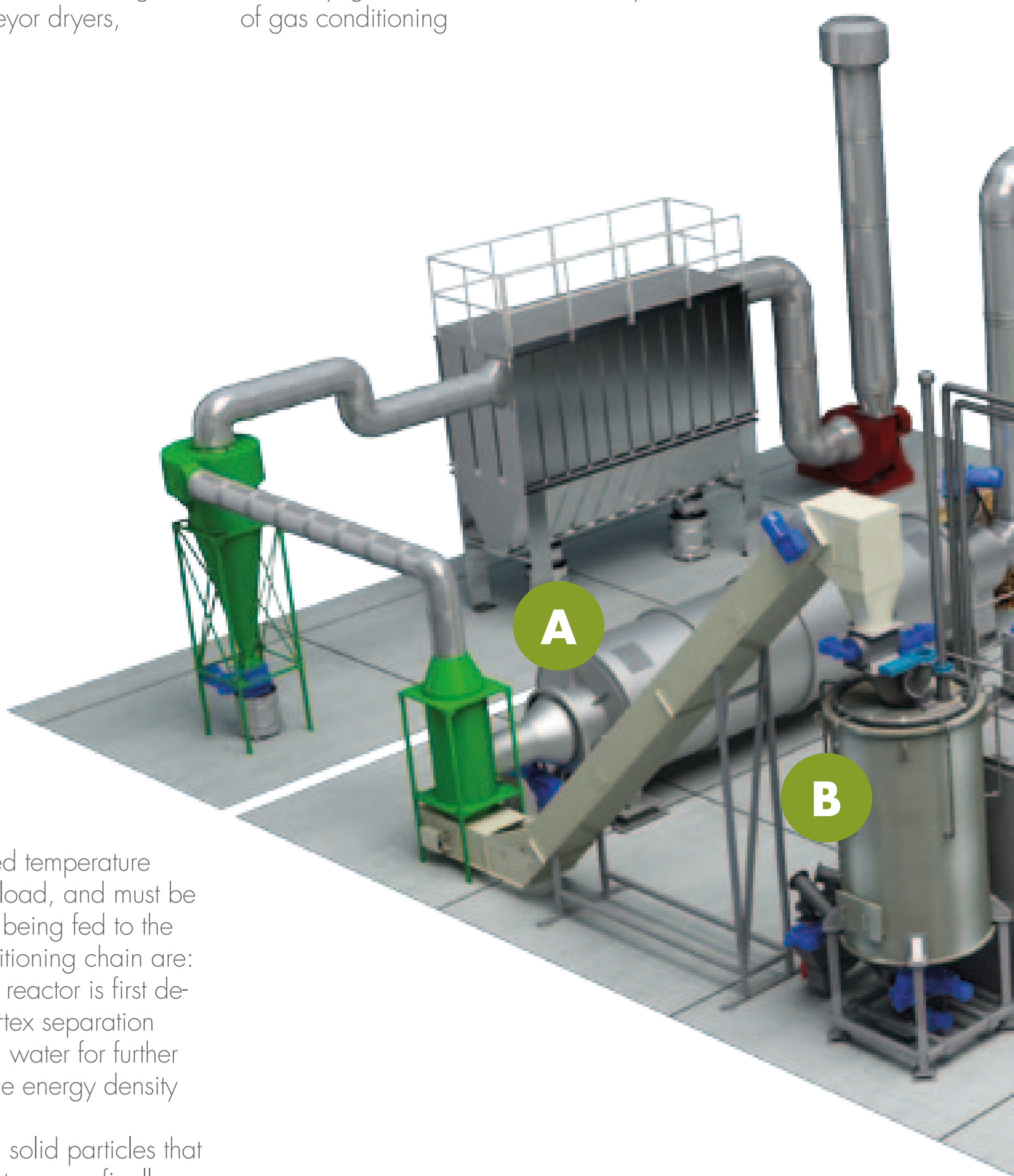
- Complete automation through the use of a PLC based control system. The control system is designed with the purpose of ensuring the necessary availability and reliability along with the maximum safety of the entire system

A. DRYER

- Drying is required when the humidity content of the available biomass is higher than 10%
- Dryer: temperature controlled device where the biomass humidity decreases due to evaporation, until it reaches the value required by the next phase of gasification process
- Biomass is dried using the heat cogenerated by the plant
- The choice of the drying technology is made on the basis of environmental conditions and customer needs (amongst the applicable: rotary drum dryers, belt/conveyor dryers, bed/grate etc.)

B. GASIFIER

- Gasification reactor: inside the reactor the biomass is converted into a combustible gas (syngas, from synthesis gas) through a succession of thermo-chemical reactions which take place at high temperature, without combustion, with a controlled amount of oxygen
- The carbonaceous solid co-product (char) is extracted from the bottom of the reactor and continuously fed to the oxidizer
- The syngas is directed to the next phase of gas conditioning



C. SYNGAS CONDITIONING

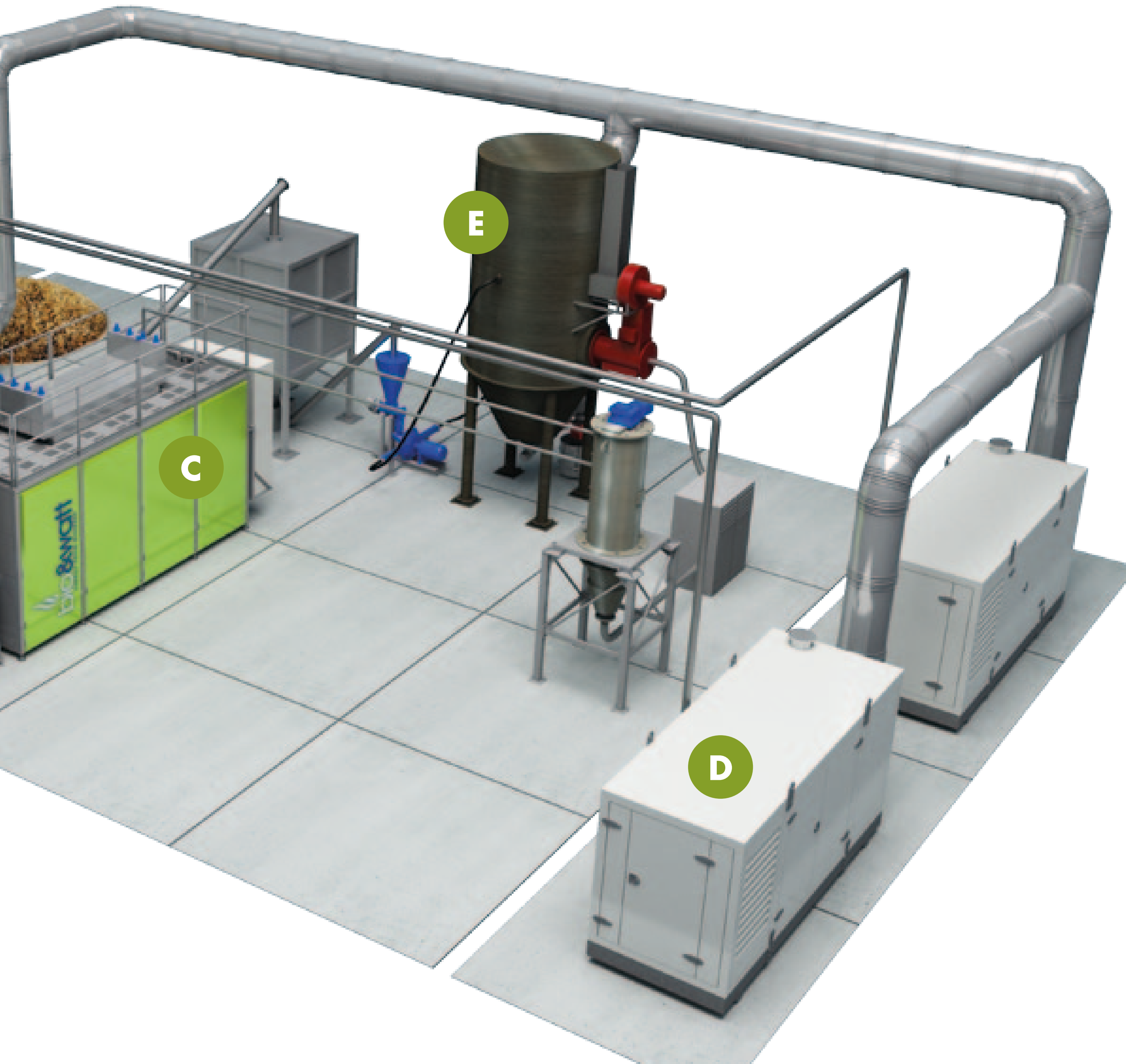
- The syngas leaves the reactor at elevated temperature with a certain heating value and pollutant load, and must be conditioned (cooled and cleaned) prior to being fed to the engine. The main components of the conditioning chain are: Cyclone separator: hot syngas leaving the reactor is first dedusted by removing particulate through vortex separation Wet scrubber: syngas is then sprayed with water for further cleaning and cooling (cooling increases the energy density of the gas) Electrostatic precipitator: condensable and solid particles that may have passed the first two cleaning systems are finally removed from the flowing syngas using the force of an induced electrostatic charge. An extremely clean syngas is now ready to feed the engine
- The liquid fuel which may be produced by condensed vapors (tar or pyrolytic oil) is directly fed to the oxidizer

D. CHP MODULE

- Internal combustion engine fueled with syngas generated from biomass
- Cogeneration: electrical power is produced by an alternator linked to the engine and sent to the grid; heat from engine's cooling circuits and exhaust gases is recovered for thermal needs

E. OXIDIZER

- Oxidizer: a secondary reactor specifically designed in which the liquid and solid components generated simultaneously to the gas inside the gasification reactor are converted to clean flue gas. The recovered heat is conveyed for thermal needs or converted to power through an ORC system



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TECHNOLOGY

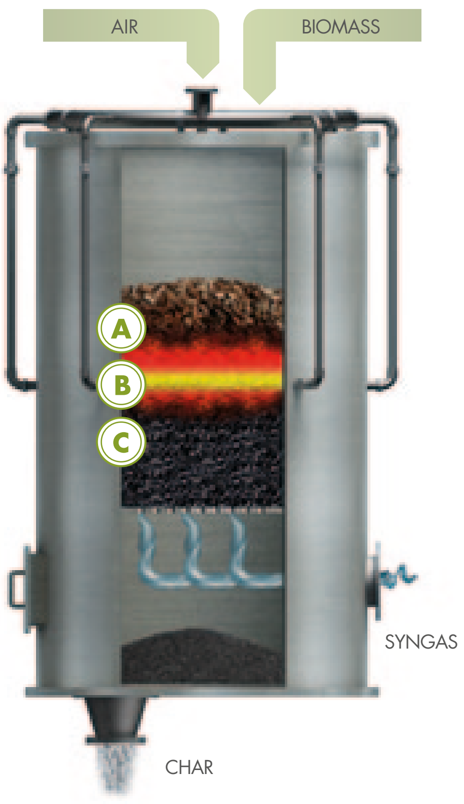
REACTOR DESIGN AND MAIN PROCESS PHASES

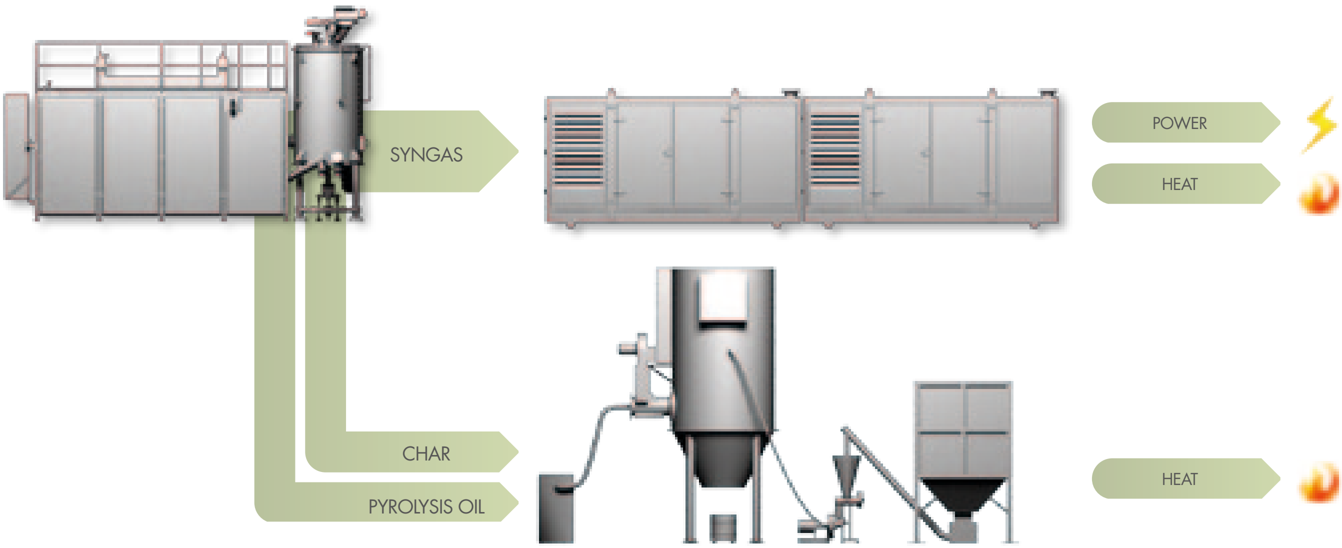
Bio&Watt gasification reactor (proprietary design) can be defined as "stratified - downdraft - twin fire" fixed bed gasifier. Referring to the scheme, the main steps of the process inside the reactor are:

A. Pyrolysis (200°C < T < 600°C)
The volatile components of biomass (cellulose, hemicellulose) vaporize generating the so-called pyrolysis gas, rich in hydrocarbons, whilst non-volatile components (lignin) remain in the solid phase forming charcoal

B. Oxidation (T 800 ÷ 1.000°C)
Part of the biomass is oxidized under non-stoichiometric conditions, producing the heat necessary for the gasification reactions. The pyrolysis gas passes through the high temperature combustion zone where it undergoes a thermal cracking: complex hydrocarbons are decomposed into elementary molecules like CH_4

C. Reduction (T lowers to 600÷700°C)
The charcoal then reacts with the combustion gases absorbing heat and producing CO and H_2





ENERGY CONVERSION

Gasification process converts the biomass, a renewable fuel, into co-products which are themselves fuels. The power derived from gasification and combustion of the resultant products is considered to be a source of renewable energy if the gasified compounds were obtained from biomass.

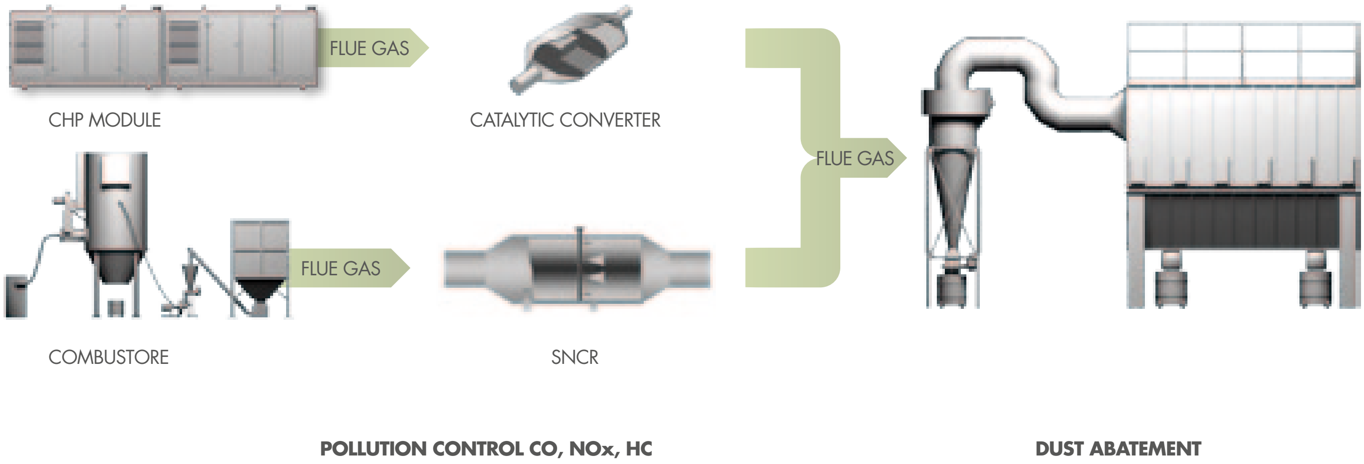
Energy conversion of gasification products is achieved through the use of technological solutions that are best suited to the characteristics of each fuel stream:

- syngas, the most relevant stream, is converted into power and heat through a high-yield cogenerator (internal combustion engine)
- char and pyrolysis oil are converted into thermal energy through a secondary oxidation reactor (oxidizer)

The typical configuration of a Bio&Watt gasification system, in which all streams are converted to produce power and heat, is illustrated below. Gross overall yield of the system in this configuration is around 75÷80%.

The power produced converting biomass can be used on site or poured into the national grid to get the incentives granted for the generation of electricity from renewable sources.

The heat can be transferred to thermal loads (e.g. district heating, biomass drying, industrial drying processes) or converted into additional power through an ORC system.



EMISSIONS CONTROL

In the field of energy production from RES, the strict control of emissions from power generation systems is particularly important, also because of the "environmental value" of this type of installations.

Greenhouse effect

The environmental impact of converting a renewable source such as wood chips into energy is null, because it returns to the atmosphere the same amount of carbon dioxide absorbed by plants through the photosynthesis during their growth.

Air emissions

Bio&Watt gasification plant adopts the state of the art of available technology (BAT - Best Available Techniques) in order to control emissions. In particular:

Gaseous effluents

- gasification process produces no emissions, transforming solid biomass into a gas which is entirely channeled to the CHP module
- the CHP module, depending on size and technological characteristics of the internal combustion engine, is equipped with a catalytic converter or a SCR system for the abatement of pollutants
- the oxidizer is equipped with an SNCR system (with use of a reagent) for NOx control

Dust

- exhaust gases, before exiting to the atmosphere, undergo a further treatment aimed at controlling particulate material through the use of a de-dusting cyclone and a baghouse filter

Plant waste

The only effluent produced by the plant is the ash initially contained in the biomass. This bio-ash is rich in nutrients (such as potassium and phosphorus) and could be effectively utilized by the farming industry.

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PERFORMANCE

PLANT PERFORMANCE

The following table shows the main performance parameters of our gasification module:

Fuel consumption	
Reference biomass	Wood chips (LHV ≈ 4÷5 kWh/kg DM)
Syngas production	2,2÷2,5 Nm3/kg DM
Syngas max flow rate	720 Nm3/h
LHV Syngas	1,3÷1,5 kWh/Nm3
Biomass specific consumption rate	0,8÷1,2 kg DM/kWhe

Nominal capacity	
Single module installed capacity[1]	200÷300 kWe
Annual operation hours	+7.000 h/y
Gross electricity generation	1,4÷2,1 GWh/y

Gross thermal power[2]	
CHP exhaust gas (@400°C)	170÷250 kWth
Hot air from engine cooling system (@65°C)	170÷250 kWth
Oxidizer flue gas (@900°C)	250÷350 kWth

[1]Depending on the size of the installed CHP module
[2]Depending on the installed capacity

Higher installed capacity can be obtained by scaling-up the system through a modular approach (2 or more gasification modules in parallel).

The available thermal power can be used for:
- drying biomass
- supplying heat
- producing additional electricity (e.g. through an ORC system)

ENVIRONMENTAL PERFORMANCE

The two most important environmental parameters qualifying energy production from renewable sources are the amount of CO2 avoided and the Primary Energy Savings (PES). In the table below the values of the parameters have been estimated for a single gasification module (based on 7.000 hours of operation per year) under the hypothesis of exploiting all the power and heat available:

Cogeneration from RES	
CO2 avoided	ca 2.500 ton/y
Primary energy saving	ca 1.100 tep/y

The concentration values of gaseous pollutants and particulate are largely kept within the limits established by Legislative Decree no. 152, 3 April 2006. For systems with installed capacity ranging from 0.15 MW and 3 MW and fed with solid fuels, the emission limits are set as follows (with 11% oxygen content in effluent gases):

Emissions	
Dust	100 mg/Nm3
Carbon Monoxide (CO)	350 mg/Nm3
Nitrogen oxides (as NO2)	500 mg/Nm3
Sulfur Oxides (as S02)	200 mg/Nm3

The plant consumes a small amount of water necessary for the operation of the cooling tower. No process residues are produced, with the exception of mineral ashes originally contained in the biomass fed to the plant. The system does not generate significant noise emissions, which are largely kept within the limits prescribed by law.

Other	
Water consumption	600-700 m3/y
Biomass ashes	40-50 ton/y
Noise emissions	within the limits prescribed by law

CONTACTS

BIO&WATT Gasification s.r.l.
Legal Head Office: Via Pietro Maroncelli 17 - 20154 Milano
T. +39 02 873 66 873 - F. +39 02 873 66 860
info@bioewatt.com - www.bioewatt.com

www.bioewatt.com

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