CHiP50

BIOMASS-BASED
MICRO CO-GENERATION
SYSTEMS

ESPE
Professione Energia

www.espegroup.com

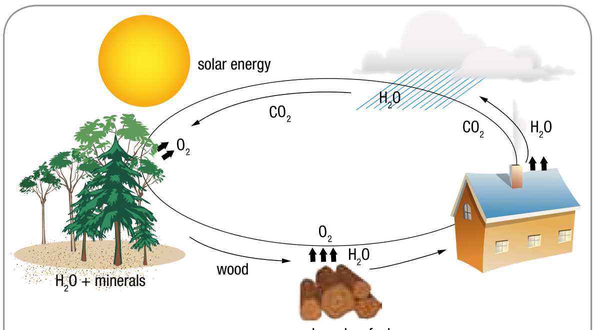
your energy needs: our passion for 40 years.

We believe in offering the future generations a better world. We believe in clean energy and in the fact that consumers themselves might have the option of producing the energy they use.
For 40 years we have been operating in a tough, ever-changing market. Day after day we tackle the continual challenges and broaden our expertise, building on our successful results while overcoming any errors.

This is what the Padua-based ESPE company is all about. Established in 1974, ESPE has registered constant growth since its inception. The company began its operations in the sector of electric power plants and then expanded into the areas of renewable energy, technological systems and automation. ESPE is the number one Energy System Integrator of the Veneto region and one of the top five in Italy. It offers “turnkey” green solutions for residential, business and industrial areas as well as for Public Administration bodies. ESPE designs and builds high performance eco-sustainable power systems: biomass-based micro co-generation systems, mini wind power aerogenerators, photovoltaic solutions, hydroelectric power stations and turbines, and high efficiency energy systems.

What is biomass?

Biomass consists of any animal and vegetable derived biological material in non-fossil form from which energy can be obtained. The European Union considers the energy application of wood biomass one of the most effective systems for reducing greenhouse gas emissions. The combustion of wood in fact releases the same amount of CO_2 that a tree absorbed from the atmosphere during the course of its growth.
The balance regarding CO_2 therefore stays level. What's more, if the wood should not be used and left to rot in the undergrowth the same amount of CO_2 would be released into the atmosphere. Therefore, it makes good sense to exploit energy derived from wood waste.



The biological closed cycle of wood

Biological cycle. Wood is CO_2 neutral. In fact, the same amount of CO_2 that a tree – thanks to photosynthesis – had absorbed from the atmosphere during the course of its growth is released during wood combustion processes. The CO_2 balance therefore stays level. If the wood were not used and left to rot in the forest the same amount of CO_2 would be released into the atmosphere.

Fuel	Calorific value (average)	Calorific value (average)
unit	MJ	kWh
Extra light fuel oil	36.17 MJ/l (42,5 MJ/kg)	10 kWh/l (11,80 kWh/kg)
Light fuel oil	38.60 MJ/l (41,5 MJ/kg)	10.70 kWh/l (11,50 kWh/kg)
Methane*	36.00 MJ/m³	10.00 kWh/m³
LPG**	24.55 MJ/l (46,30 MJ/kg)	6.82 kWh/l (12,87 kWh/kg)
Coal	27.60 MJ/kg	7.67 kWh/kg
Coke 40/60	29.50 MJ/kg	8.20 kWh/kg
Lignite (briquettes)	20.20 MJ/kg	5.60 kWh/kg
1 electric kWh	3.60 MJ	1 kWh
1 kg wood (M = 20%)	14.40 MJ/kg	4.00 kWh/kg

*1 kg = 5.8 l (20 °C, 216 BAR) • ** 1 m³ GPL = 4 l = 2 kg

1 kg fuel oil ≈ 3 kg wood• 1 l fuel oil approx. ≈ 2.5 kg wood

Fuel	Q.ty.	Moist. Cont.	Mass	Calorific value	Energy density*		
unit		M%	kg	MJ/kg	MJ	kWh	fuel oil litres
Cippato							
Beechwood	1 msr	15	295	15.3	4,505	1,251	125
Beechwood	1 msr	30	328	12.1	3,987	1,107	111
Spruce	1 msr	15	194	15.6	3,032	842	84
Spruce	1 msr	30	223	12.4	2,768	769	77
Wood pellets	1 msr	8	650	17.1	11,115	3,088	309

Wood chips

The biomass used by the ESPE CHiP 50 co-generator is virgin wood chippings, i.e. wood chips. These wood chips are generally obtained locally from:

- sawmill processing waste (woodworking industry);
- forest timber production and forest maintenance (management and reforestation).

Specifically, the chips coming directly from forestry waste generally have a moisture content ranging from 40 to 60% and therefore require the following:

a. optimization of the collection process in order to improve the first stage of natural drying;
b. suitable storage that enables proper aeration in order to prevent fermentation that would make the chips deteriorate and lower the calorific value.

The lower calorific value varies from 12 to 18 MJ/kg in function to the moisture content and wood type.

Main quality features of wood chips

The European standard CEN/TS 14961:2005 defines the normative specifications that must be referred to when drawing up supply contracts and relative declarations of quality of the biofuel supplied. The optimal quality features of wood chips currently used to fire a CHiP50 gasifier are as follows:

- Maximum moisture content: M = 10%
- Wood type (composition and LCV):
  - Lower Calorific Value (LCV): 18 MJ/kg.
  - Type of trees: broad leaf or conifer or a combination of broad leaf and conifer (excluding fast-growing woody plants).
  - Particle size: P50 (Main fraction 3.15mm < P < 50mm, min. 80%; fine fraction < 1mm, max 5%; thick fraction > 50mm, max 1%).

INFORMATIVE SPECIFICATIONS	Origine Commercial class	Uncontaminated woody biomass (1.1.1, 1.1.2, 1.1.3, 1.1.4, 1.1.6, 1.2.1.1, 1.2.1.2, 1.2.1.4) WOOD CHIPS	
Particle size			
	Main fraction > 80% (mass)	Fine fraction < 5%	Thick fraction < 1%
P 16	3.15 mm ≤ P ≤ 16 mm	< 1 mm	> 45 mm, < 85 mm
P 45	3.15 mm ≤ P ≤ 45 mm	< 1 mm	> 63 mm
P 63	3.15 mm ≤ P ≤ 63 mm	< 1 mm	> 100 mm
P 100	3.15 mm ≤ P ≤ 100 mm	< 1 mm	> 200 mm
Moisture content (M)			
M20	≤ 20% dried		
M30	≤ 30% seasoned outdoors and suitable for silo storage		
M40	≤ 40% not seasoned and not suitable for silo storage		
M55	≤ 55%		
M65	≤ 65%		
Ash content (%dry matter)			
A0.7	≤ 0.7%		
A1.5	≤ 1.5%		
A3.0	≤ 3.0%		
A6.0	≤ 6.0%		
A10	≤ 10.0%		

ESPE biomass-based micro co-generation systems

Energy plays a crucial role in terms of costs, benefits and investment opportunities in the agricultural, residential, industrial and commercial sectors as well as in the public administration. In fact, the use of fossil fuels is becoming a heavy cost factor especially in areas with high levels of energy consumption (heat and electricity).
This is why in 2010 Espe decided to develop a high-efficiency CHP (combined heat and power) module using virgin wood chips. The research carried out in the past years has resulted in the CHiP50, a high-yield micro co-generation system for biomass-derived syngas. Project precision and choice of materials are just two of the strong points of the ESPE CHiP50 co-generator which, due to ESPE's broad expertise, lets it achieve total energy yields that are among the highest in the market. Specifically, the combination of the fuel (syngas) resulting from a 49 kg wood chips biomass with max. 10% moisture content, P50 size and 18 MJ/Kg Lower Calorific Value allows you to potentially generate in one hour:

- ≅ 49 kWe gross electrical energy (30%)
- ≅ 110 kWt gross heat energy (60%)
- ≅ 20 kW process loss (10%).

The ESPE modular solution with 50 kWe and 110 kWt per unit provides up to 7500 hours of thermal and electrical energy per year, with yearly net electrical productivity of 337.5 MWhe and yearly net thermal productivity of 750 MWht. Virgin wood chips is the renewable biomass resource used. This resource is available in the national territory and its bio-products are readily found locally. The ESPE CHiP50 micro co-generator is also suitable for a trigeneration configuration (heat, power, cooling or CHPC), which provides maximized conversion yields and at the same time ensures access to the subsidized rates as provided by the Ministerial Decree of the MSE (Ministry of Economic Development) dated July 6, 2012.
Said Decree establishes the rates according to the size of the system and the type of biomass used, with the option of obtaining additional subsidies.
Specifically, the systems that use the b type biomass (materials of bio origin) are granted all-inclusive subsidized rates of 257 €/MWh for 20 years (with less 2% reduction up from 2014/01/01 and another 2% reduction up from 2015/01/01). Moreover, registration is not required for systems with less than 200 kW capacity.
This means that if you install an ESPE micro co-generation system you can cover the energy needs of your company (either fully or partly), and at the same time make an intelligent investment in eco sustainable development.
Its forty-year expertise and in-depth specialization and professionalism in the energy sector means that ESPE can supply extremely reliable high performance solutions that include installation, supervision and maintenance services.

Application sectors:

- Agriculture: farming businesses, silviculture or forestry, greenhouses, breeding farms, dairies, processing of agricultural products.
- Industrial: wood chips distribution and production logistics platforms, woodworking, joineries, food industry, paper mills, ceramics, chemical, metalworking and textile industries, and artisan workshop districts.
- Private businesses: shopping centres, hotels, swimming pools, city areas and districts, wellness centres.
- Public administration: municipalities, nursing and retirement homes, public swimming pools, hospitals, schools.
- Energy industry: district heating.

Performance and reliability: the industrial turning point of the biomass-based micro co-generation systems

100% ENERGY INPUT = 170 kW (49 kg/h woodchips, max. 10% moisture content)

CHiP50

TECHNICAL DATASHEET

Technical specifications

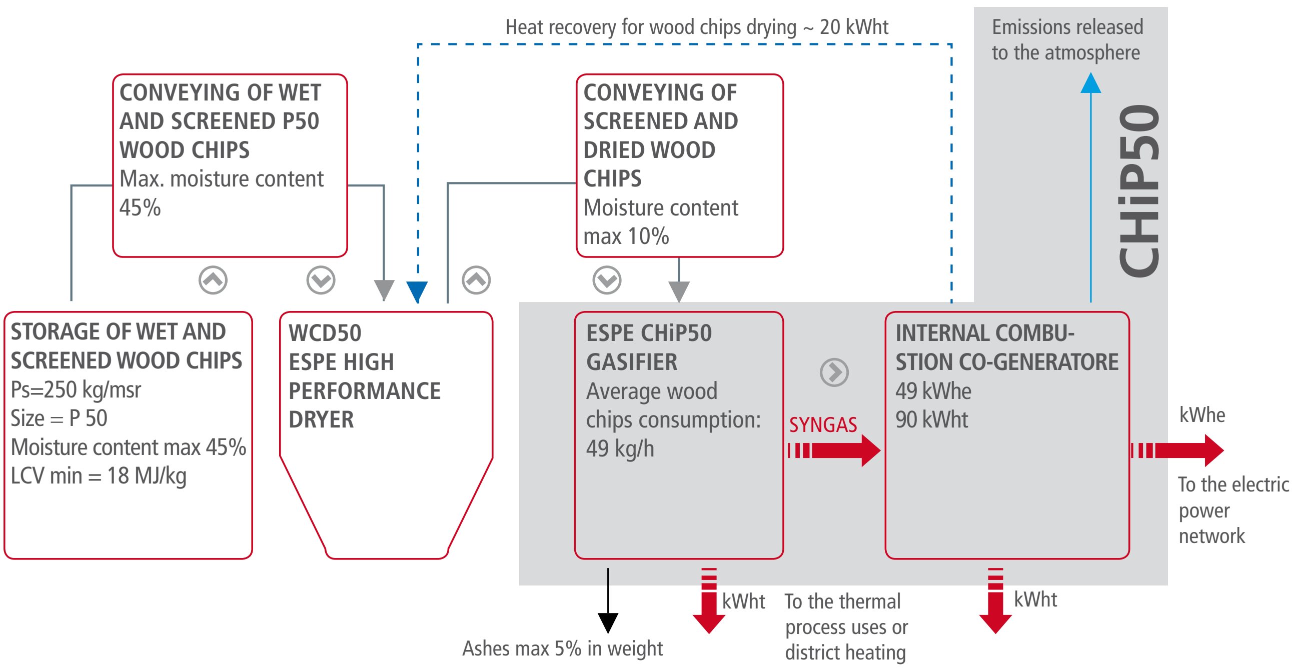
Co-generator*	
Technology	Otto-cycle internal combustion engine with direct drive three-phase alternator
Engine features	Liquid-cooled
Fuel	Syngas from wood chips
Height	1500 mm
Width	1000 mm
Length	2300 mm
Engine capacity	12.000 cm^3
Number of cylinders	n° 6
Number of revolutions	1500 g/min
Gross electric power	49 kWe
Number of phases	4 con accensione a candela
Operating volts	415 V
Output	75 A
cos PHI	0.98
Noise level	90 db
Gross thermal power	110 kWt

Gasifier*	
Type of gasifier	Downdraft
Height	3180 mm
Base width	1214 mm
Length	5800 mm
Weight	2500 kg
Capacity power chips M10	49 kg/h
Average flow Syngas generated	0.036 kg/s
PCI average Syngas (if PCI chips = 18 MJ / kg)	3.5:4 MJ/kg
Average efficiency of gasification	>75%
Ash produced	max 5% by weight of the chips input
Ash removal	Automatic
Wood chips loading	Automatic
Operation temperature	1100 °C

The co-generator is suitable for supplying power networks in compliance with the CEI021 regulations. Emissions in compliance with attachment X of Legislative Decree 152/2006

The data refer to the machines supplied in standard configuration of the frame. However, it is also available in the configuration encasing.
*** All the described data refer to fir wood chips with the following features: Max. Particle size of wood chips: P 50 main fraction 3.15mm < P < 50mm, min 80%; fine fraction < 1mm, max 5%; thick fraction > 50 mm, max 1%.**

Process diagram



SAFETY EQUIPMENT

CHiP50 is equipped with proprietary software for process control both locally and remotely.

Espe CHiP50: operating scheme

The ESPE CHiP 50 co-generator uses virgin wood chips for gasification. The "synthesis gas fuel" produced (syngas) is used to fire the micro co-generation unit. This unit enables combined and concurrent production of electrical and thermal energy in a single integrated system that can integrate or replace heating boilers and fully or partly satisfy electrical energy needs.

Specifically, CHiP50 uses syngas fuel in a co-generator equipped with an Otto cycle engine (CHP "Combined Heat and Power"). With this system the exploitation of the biomass for energy is maximized, enabling a total efficiency (electrical + thermal) that can reach 90%.

The gasification technology used in the CHiP50 is called "downdraft" (DG) or "co-current" because the wood chips and gasification air flow downward of the reactor in co-current configuration. The fixed bed "down draft" system provides cleaner syngas (less pyrolysis oil or TAR). TAR could in fact jeopardize the reliability of the internal combustion engine.

Gasification process stages (see diagram):

1. biomass is dried by the heat produced in the reactor;
2. biomass is pyrolized and produces syngas, TAR and char;
3. part of the pyrolisis products and biomass burn with air to supply the heat required;
4. the gases produced react with the residual char to produce additional CO and H_2;
5. The residual char and ashes fall through the lower grate.

The benefits of a co-current fixed bed gasifier include essential configuration, biomass versatility, good cleanliness level of the gas produced especially if compared with heavy hydrocarbons (such as ketones etc.).

The higher temperatures of the gasifier (compared to counter-current configuration) in fact enable splitting the heavy hydrocarbons via thermal cracking.

The heat power of the syngas depends on the LCV of the wood chips used. On average it is approx. 4.5 MJ/m^3 considering a wood chips LCV of at least 18MJ/Kg. A catalytic converter cleans the exhaust gases of the co-generator and an exchanger cools them before they are released (clean and cool) to the atmosphere in compliance with the current regulations in force regarding emissions (Legislation Decree 152/06 attachment X).

The gasification process for the production of energy has certain advantages over direct combustion, such as overall improved energy yield and fewer emissions. The syngas produced by the high-temperature gasification process is cleansed of elements such as chlorine, sulphur and potassium (that damage the engine during combustion), the ashes are removed and then it is used in the internal combustion engine.

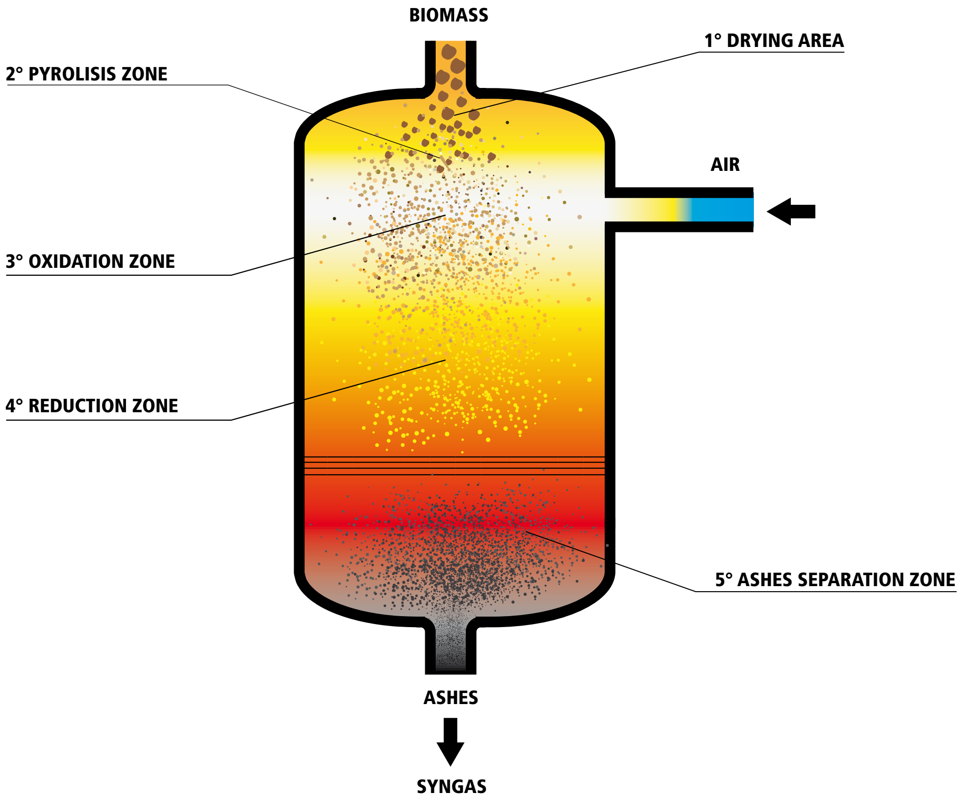
Typical thermochemical reactions in gasification processes:

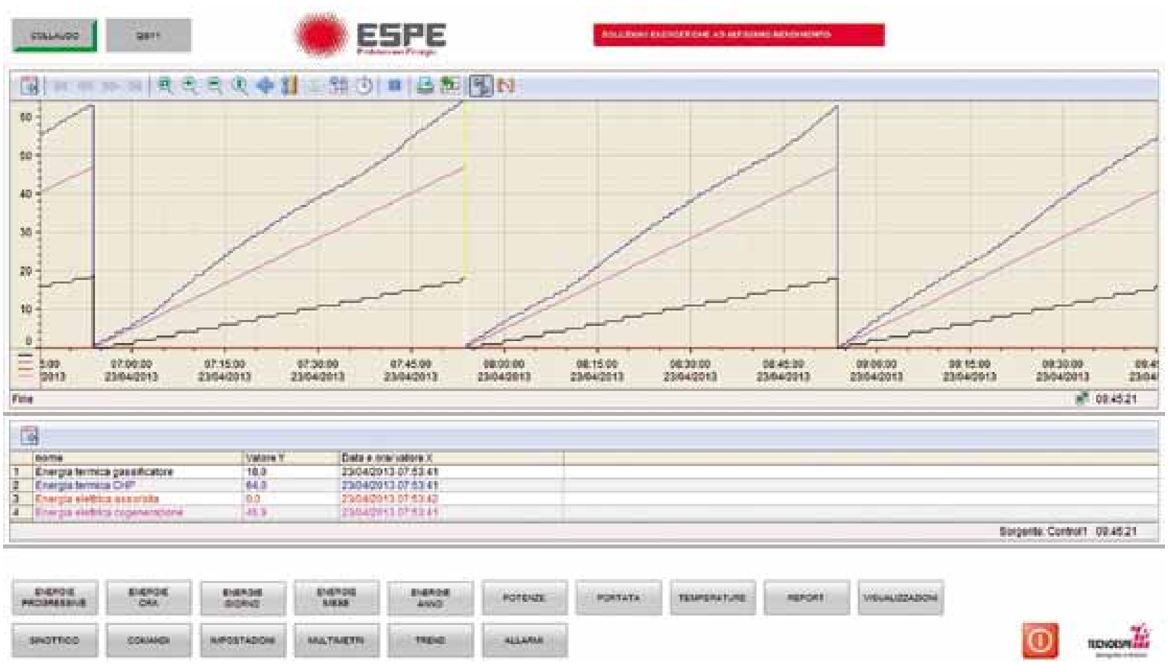
Oxidation zone:	Reduction zone:
$C + O_2 \rightarrow CO_2$	$C + CO_2 \leftrightarrow 2\,CO$ (Boudouard reaction)
$C + \frac{1}{2} O_2 \rightarrow CO$	$C + H_2O \leftrightarrow CO + H_2$ (Hydrogen reaction)
$H_2 + \frac{1}{2} O_2 \rightarrow H_2O$	$C + 2\,H_2 \leftrightarrow CH_4$ (Methane reaction)

Typical syngas composition (ESPE laboratory test data with 8% wood moisture):

CO: 17 - 20 Vol.-%	CnHm: 0.1 - 0.5 Vol.-%
H_2: 13 - 16 Vol.-%	CO_2: 8 - 12 Vol.-%
CH_4: 1 - 4 Vol.-%	N_2: Rest 53.5 Vol.-%

Diagram of Downdraft gasifier





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