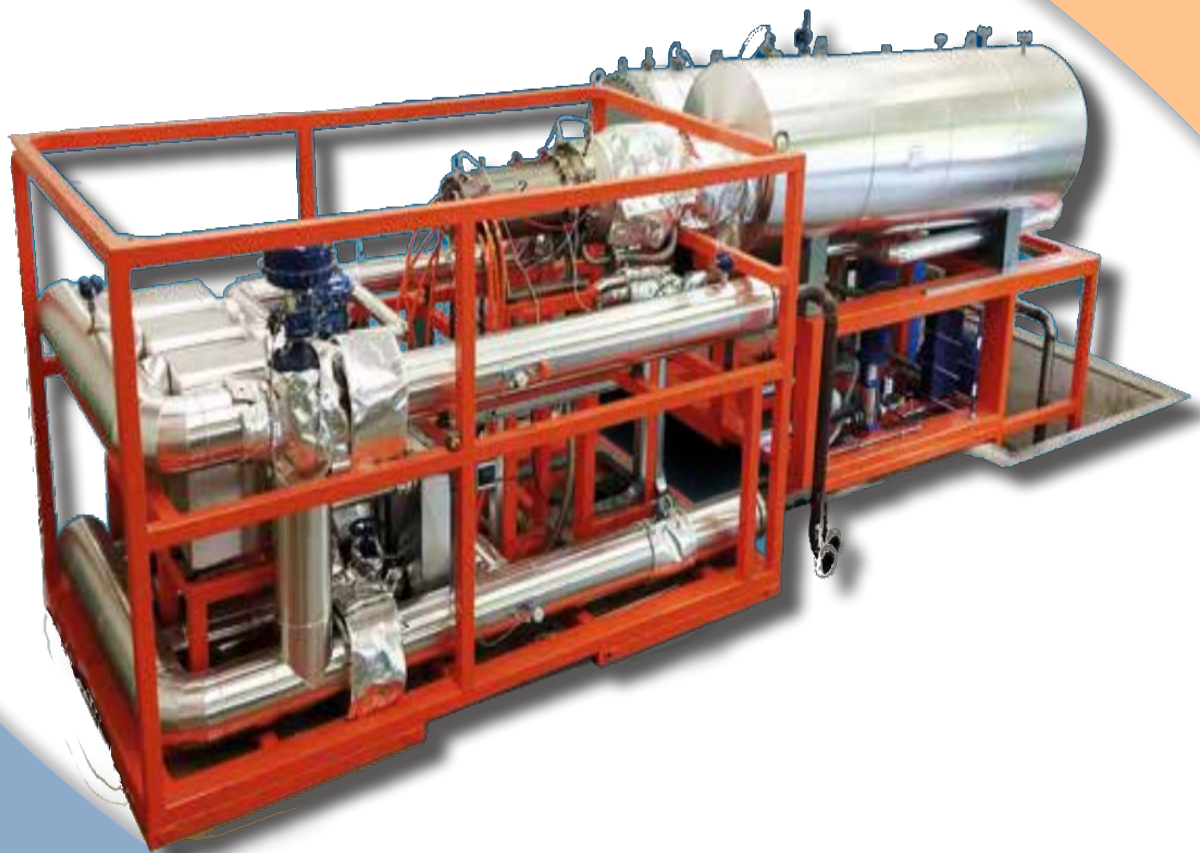


PRODUCT SHEET

ENERGY PRODUCTION



ORC MODULE

ZE - 500 - HT

ze ZUCCATO
ENERGIA

PLANT TECHNOLOGY

The structure of the proposed plant is based on the organic Rankine cycle (LT-ORC), and may be summed up by the diagram in **Figure 1**.

A heat source [1] generates heat, which is conveyed through a **vector fluid** circulating into a closed loop to one or more primary heat exchangers, usually a preheater and an **evaporator** [2], where said heat is transferred from the vector fluid to the **working fluid**.

The working fluid - a low-boiling, biodegradable, low GWP non toxic liquid when at room temperature - boils in the evaporator at a temperature far lower than that of water, becoming a high-pressure dry gas which spins through its expansion the impeller of a specifically designed and sized **turbine** [3].

The turbine shaft with rotational speed of 6500 rev/min spins the rotor of a **generator** which is directly connected to it, thus producing **electric power** [4] which, after being synchronized in frequency, phase and voltage by a **power converter**, may be injected into the national power grid or self-consumed, according to local needs and policies.

Downstream the turbine, the working fluid - still in gas phase - is conveyed to another heat exchanger, called a **condenser** [5], where it is cooled, releasing its excess heat and condensing back into a liquid which is collected in a **condensation tank**, ready to be sent back to the primary heat exchanger by a **recirculation pump**, thus closing the loop.

Excess heat released in the condenser is a low-temperature thermal energy source itself, which may be used for other purposes such as preheating or desiccating biomass fuel (thus increasing its heating value), building heating, hot water production and so on.

In case that is not possible, residual heat may be dissipated by using an **external cooling system** [6] such as an evaporative cooling tower or a **dry cooler**.

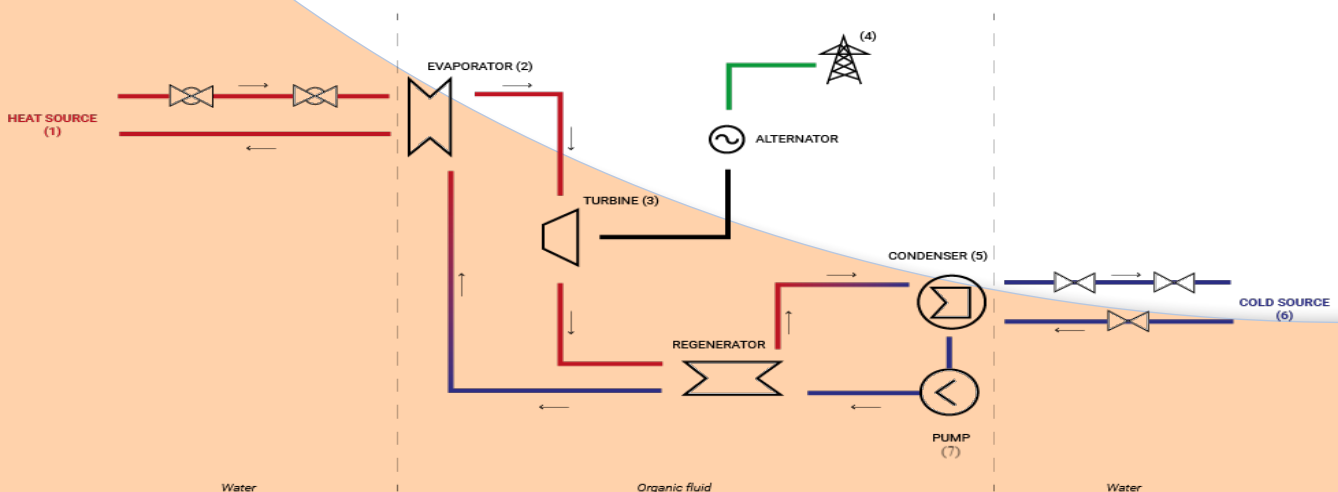


Figure 1 - Funzionamento ORC

INNOVATION

Independently designed and manufactured using the most advanced technologies in finite elements and fluid-dynamics analysis (CFD/CFX), the ZE turbogenerators are designed from scratch to operate in a low-temperature organic Rankine cycle which uses a special working fluid that offers better performances and several advances over traditional steam turbines:

- **Low operational temperature** which allow our systems to tap even low-grade heat sources;
- **High condensation temperature** which may allow the use of simple air-cooled condensers;
- Totally **dry working fluid**, which means no turbine blade erosion, giving the system **high reliability** and reduced maintenance costs as well as fewer controls;
- **No atmospheric emissions** (closed circuit operation);

From an environmental standpoint, ZE systems are reproachless:

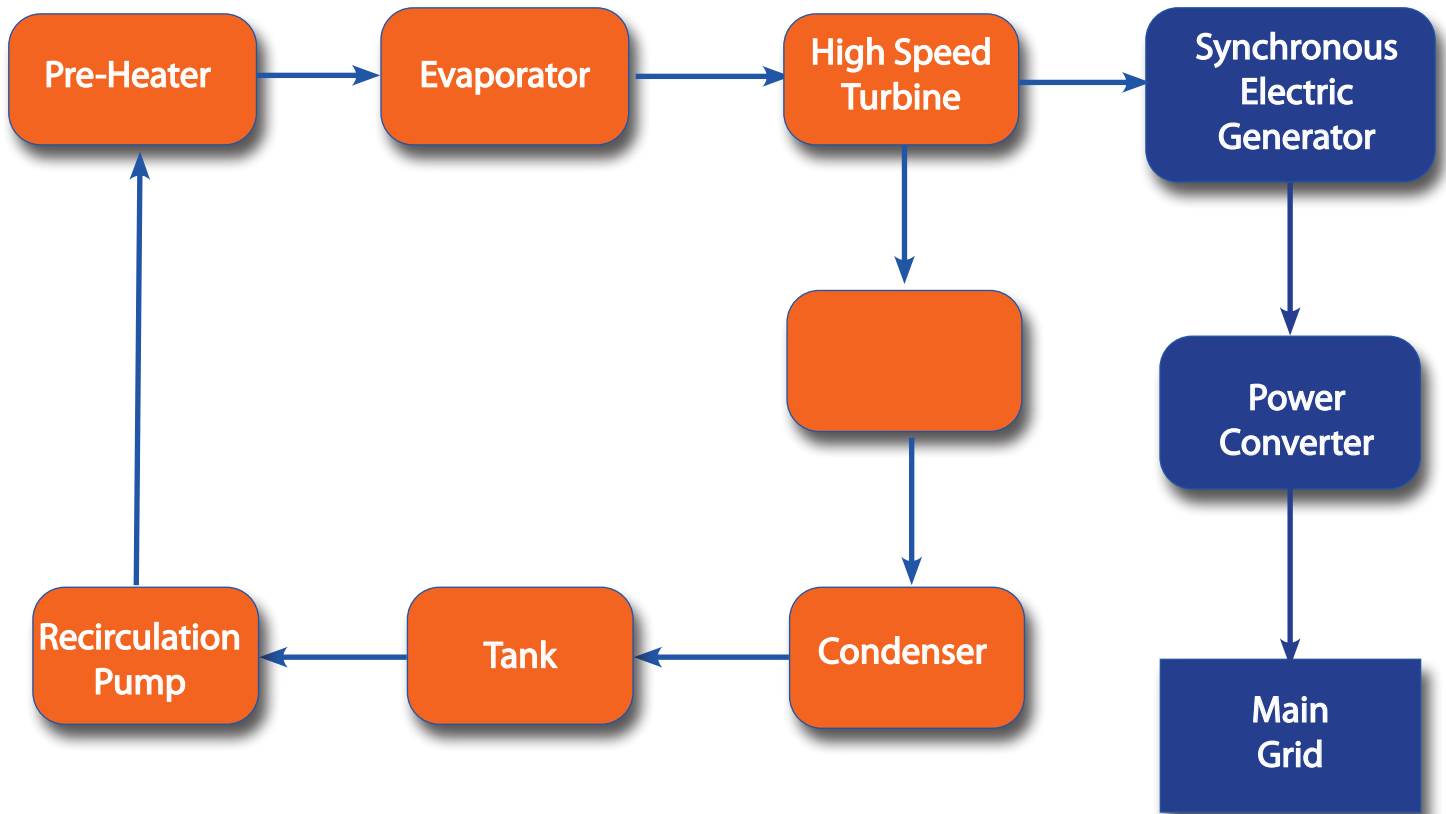
- They **recover of wasted resources** such as waste heat and byproducts or help tapping renewable sources such as solar and geothermal heat;
- They use **plain tap water for thermal energy** transfer instead of environmentally dangerous diathermal oil;
- Their **working fluid is ozone-friendly, non-toxic, non flammable** in liquid form, and 100% biodegradable tha has a Low Global Warming potential (GWP);
- They are made of **recyclable, environmental friendly materials**, use a minimum of plastic parts and employ no toxic substances in their construction.

The ZE turbogenerators have been **custom designed from scratch** for the purpose of being installed in small plants (<1MWe). So, several engineering solutions have been incorporated in their design to enhance their performance:

- **Direct turbine-to-alternator coupling**, to eliminate the attrition losses inherent in gearboxes;
 - **Use of ceramic bearings to prolong operational life** and allow very high-rpm operation;
 - **Custom-designed and sized turbines and power converters** for every plant size to obtain optimal mechanical-to electric energy conversion and performance in energy grid output.
- Our innovative technology has already been widely field-tested with success in dozens of plants throughout Europe, Asia, Africa and America, from biomass and biogas fueled plants in Italy to solar-assisted plants in Africa, from large farms in the USA to Korean power stations.. All systems by Zuccato Energia are equipped with telecontrol and telediagnostic systems that allow constant monitoring and real-time intervention in case of malfunction through the 3G / GPRS / EDGE cellphone network and any Web-savvy device (PC or tablet).

Figure 1 - Funzionamento ORC

CIRCUIT COMPONENTS



PROCESS DATA

WORKING FLUID	
Type	Mixture of environment-friendly, non-toxic, non-flammable HFOs
Working Temperature	60-200°C
Condensation Temperature	~ 33°C (@1 bar)
Working Pressure	PS40

HEAT EXCHANGER	
Type	Brazed plate (evaporators & preheaters) plate and shell (regenerator and condenser)
Operating Pressure	30 bar (Nominal) / 39 bar (Test) / 225 bar (Burst)
Materials	AISI316 S/S & 99,9% copper (evaporator/preheater) Copper (regenerator/condenser)
Max Working Temperature	250°C

PREHEATER + EVAPORATOR

Total Thermal Power Input	2909 kWt
Vector Fluid	Diathermic Oil
Vector Fluid Temperature (input/output)	225/103°C
Vector Fluid Flow Rate	11.28 kg/s
Power Output	505 kWe

CONDENSER

Thermal Dissipation Power	2391 kWt
Condenser Cooling Water Temperature (in/out)	32°C/48°C
Condenser Circuit Flow	35.38 kg/s

TURBINE

Type	Two stage turbine (radial and axial stage), directly coupled to the generator shaft
Operating Temperature (input/output)	180/100°C
Stage Pressure	PS40
Materials	Machined steel (body) / Titanium alloy (impeller)
Speed Control	Feedback loop on the generator current output
Seals and Gaskets	Sealed labyrinth on impeller back and optionally at generator interface. Environmental seal using gaskets and O-rings

GENERATOR

Type	Synchronous, permanent magnet
Power Output	505 kWE
Output Voltage	503-577 VAC @ 500 Hz
Rotational Speed	6500 rev/min
Rectifier /synchronizer	Built-in / Included
Cooling System	Water + glycol mix @ TIN<40°C, 30l/min flow
Cooling Fluid	Working fluid injection

INVERTER

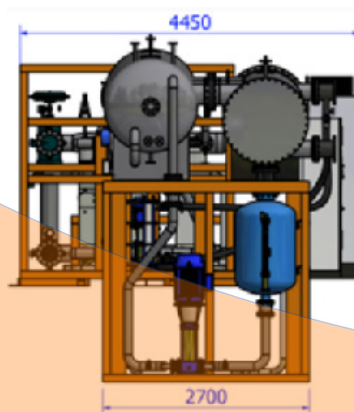
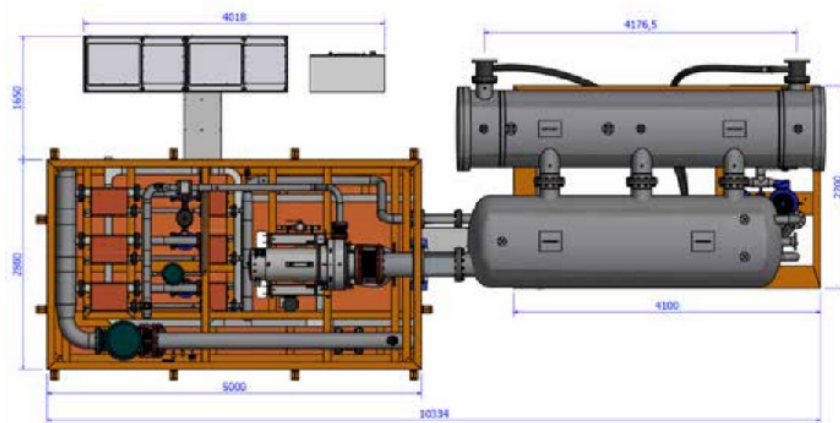
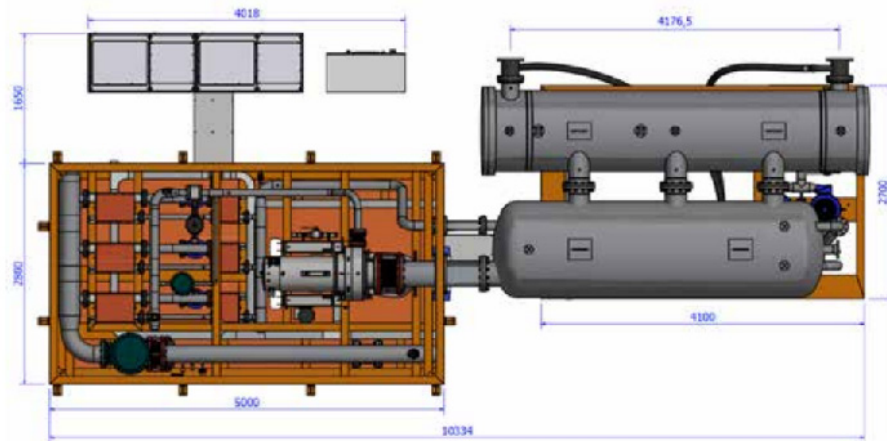
Type	IGBT- mains synchronized modules
Total Output Power	495 kWE / 700 kWE max (2x350 kW modules)
Output Voltage/Frequency	400 V + 5% Tol. @50/60Hz
Temperatura max ambientabile accettabile	40°C
Chopper di frenatura	External, included in the scope of supply

ZE-500-LT SKID DIMENSIONS

The power generation module is supplied mounted on two interconnected self-supporting frames ("skids"), one of which houses the "hot side" components (turbine, evaporators, preheaters...) while the other houses the "cold side" - regenerator, the condenser, the working fluid tank and pump.

The following drawings show the standard, "naked" version of the ZE-500-HT ORC power generation module, is designed for indoor installation.

Paneled and containerized/weatherproof versions for outdoor installation are also available.



Please note that the skid also requires at least 1.5 meters of free space on all sides for easier maintenance access.

Zuccato Energia, being the system developer and manufacturer may also build the skid in nonstandard dimensions different from the above, to tailor the system on the client's needs.