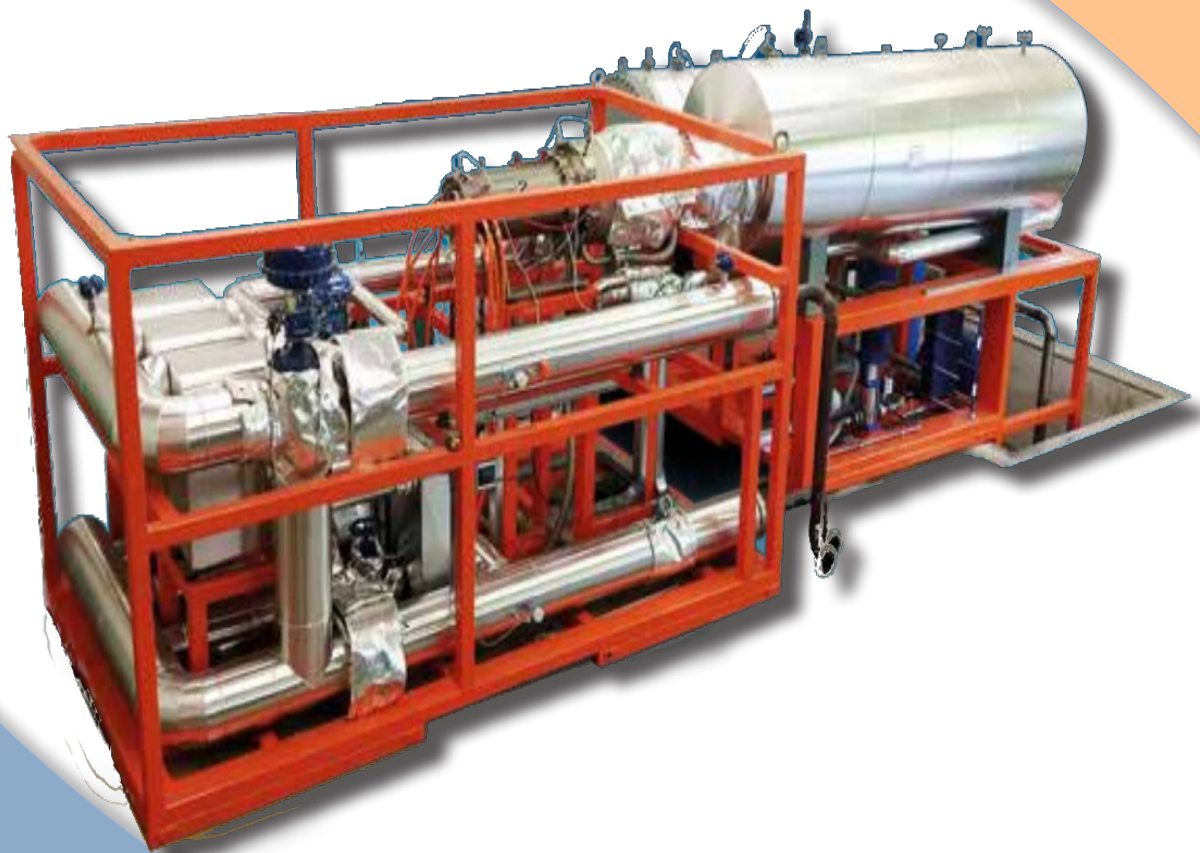


# PRODUCT SHEET

## ENERGY PRODUCTION



**ORC MODULE**  
**ZE - 400 - LT**

# PLANT TECHNOLOGY

The structure of the proposed plant is based on the so-called low-temperature 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, 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 high-speed rotation (12.000÷18.000 Rpm) of the turbine shaft 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 **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** such as an evaporative cooling tower or a **dry cooler [6]**.

The **ZE-400-LT is one of the largest power generation modules** offered by Zuccato Energia, designed to operate in conjunction with boilers in power generation applications but equally well suitable for industrial heat recovery systems where large enough quantities of medium temperature ( $\geq 160^{\circ}\text{C}$ ) waste heat are available. If required, this modular unit is also capable to be coupled with other similar or smaller units to take advantage of all available thermal power.

The use of **shell-and tube heat exchangers** for the cold side instead of the usual brazed plate units gives the system the highest efficiency (16%) of all the Zuccato Energia range of products.

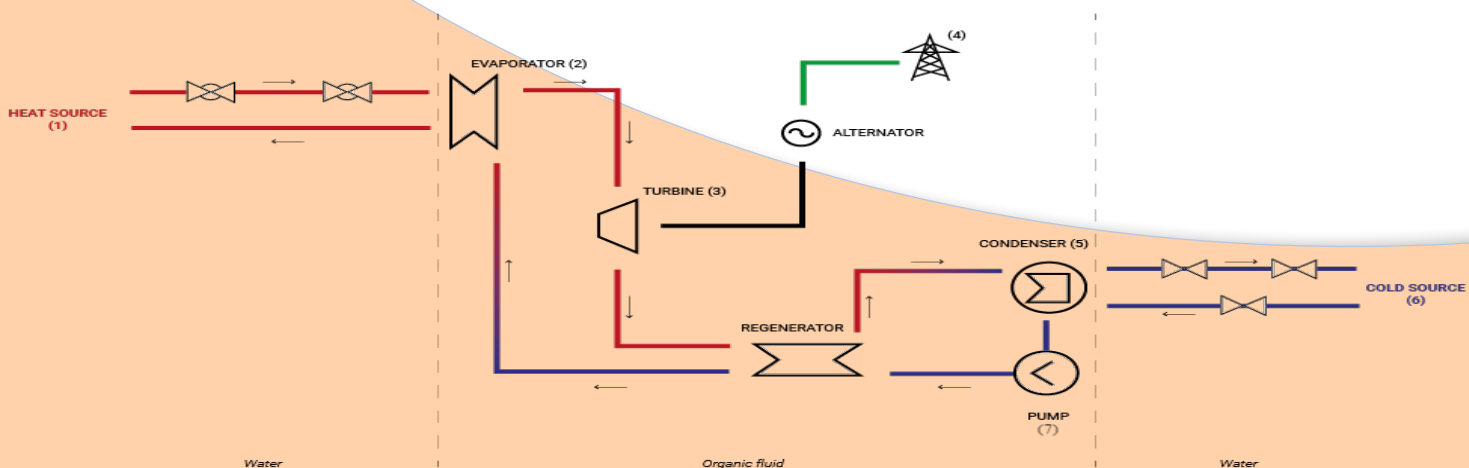


Figure 1 - Funzionamento ORC

# 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;
- **Lower operational pressures** (20 bar max), which mean safer operation, less bureaucratic problems and reduced plant costs;
- **No atmospheric emissions** (closed circuit operation);

From an environmental standpoint, ZE systems are reproachless:

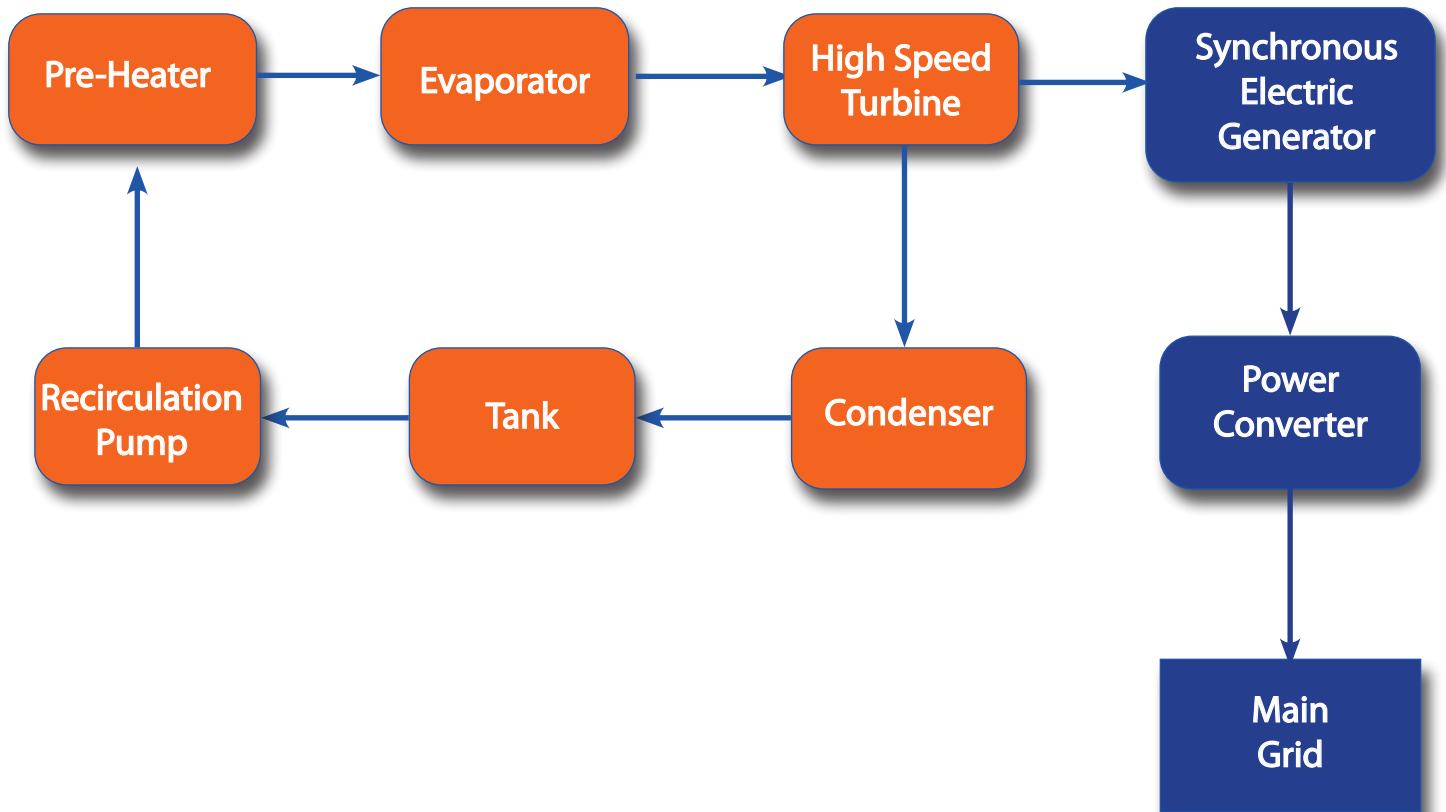
- They **recover otherwise wasted resources** such as waste heat and byproducts or help tapping renewable sources such as solar and geothermal heat;
- They **use plain tap water for thermal energy transfer** instead of environmentally dangerous diathermal oil;
- Their **working fluid is ozone-friendly, non-toxic, non flammable** in liquid form, and 100% biodegradable;
- 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

# ORC CIRCUIT COMPONENTS



## PROCESS DATA

Working Fluid	
Type	Mixture of environment-friendly, non-toxic, non-flammable HFCs
Operational range (temperature/pressure)	60-165°C, max. 20 bar
Condensation temperature	~ 33°C
Condenser output pressure	1,17 bar
Organic vapor mass flow	~ 6 kg/s (145/40°C)

Heat Exchanger	
Type	Brazed plate
Operating pressure	30 bar (Nominal) / 39 bar (Test) / 225 bar (Burst)
Materials	AISI316 S/S & 99,9% copper
Max working temperature	195°C

## PREHEATER + EVAPORATOR

Total Thermal power input	2630 kWt
Vector Fluid	Presurized Water
Vector Fluid Temperature (input/output)	≥ 160°C / 145°C
Vector fluid flow rate	40.63 kg/s
Power Output	420 kWe

## CONDENSER

Thermal dissipation po	2186 kWt
Condenser cooling water temperature (in/out)	28°C / 38°C
Condenser circuit flow	52.16 kg/s

## TURBINE

Type	Single-stage radial inflow turbine w/fixed nozzles, directly coupled to the generator shaft
Operating temperatur (input/output)	145°C/~100°C
Stage pressure	PS 16 (tested to 24 bar)
Materials	Machined steel (body) / Aluminium alloy (impeller)
Speed controll	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	420 kWE
Output voltage	503-577 VAC @ 500 Hz
Rotational speed	9500 Rpm (9...10 kRpm)
Rectifier /synchronizer	Built-in / Included
Cooling system	Water jacket, 15 KWT heat dissipation
Cooling fluid	Water + glycol (antifreeze) mix @ TIN<40°C

## INVERTER

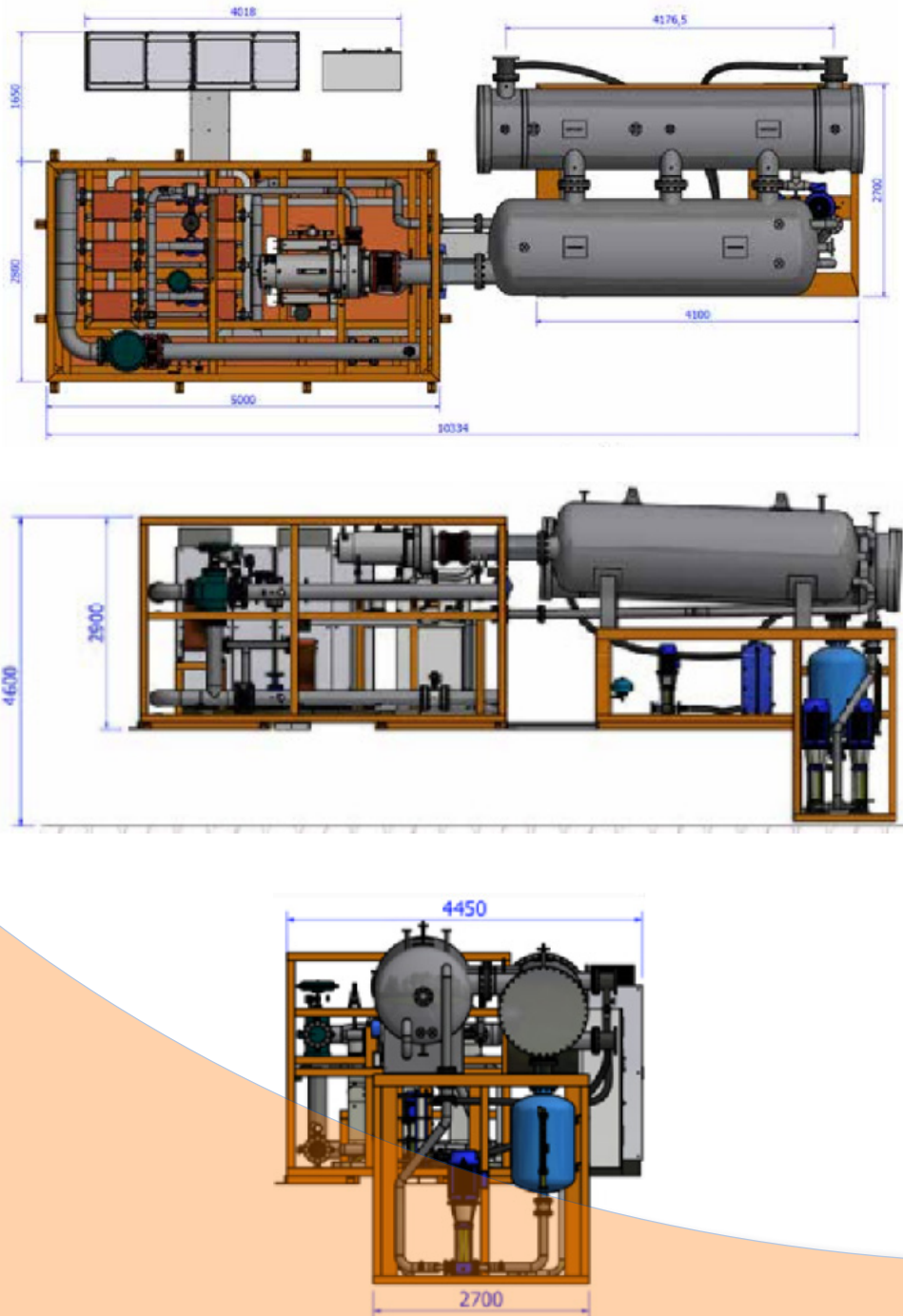
Type	2 x IGBT- mains synchronized modules
Total output power	420 kWE / 500 kWE max (2x250 kW modules)
Output voltage/frequency	400 V + 5% Tol. @ 50 Hz +0,5% Tol.
Max operational environmental temperature	40°C
Breaking chopper	Built-in, 200 kJ on external resistor bank

## ZE-400-LT DIMENSIONI SKID

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-400-LT ORC** power generation module, which weighs about 10 tons and 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.