
ZUCCATO
ENERGIA

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Company presentation

ORC Application

ORC Series

ABOUT US

Zuccato Energia Srl is an Italian company, **founded in 2006** and based in **Verona**, Italy, operating in the **renewable energy sector** and having its core business in the design and production of **Organic Rankine Cycle (ORC) electric power generation systems**.
These systems enable efficient **conversion of low-temperature heat into electricity** and have several applications, which will be described further in this brochure.

Zuccato Energia **is not just a systems integrator**, as it **designs** and **manufactures** its ORC modules, testing their performance in their Verona facility.
Always devoted to R&D, it is open to new challenges, creating both **standard** and **custom** ORC systems and prototypes, to efficiently meet the requirements of even the most complex projects.

The firm is proud to have dozens of installations in Italy, Africa, USA, Asia and Latin America, some of which have been operating non-stop since 2011, as a testimonial of their reliability.

SERVICES

MANUFACTURERS, NOT JUST INTEGRATORS

- **Designs** and **manufactures** its own ORC modules, so it can offer **the model range**, "off the shelf" systems as well as custom systems tailored to the user's needs.
- **Containerization** of the system for **outdoor use**, or creation of **soundproofed enclosures** for applications in residential areas;
- Modifications to the **geometry of the module frame** ("skid") to better fit it into available spaces;
- Adaptation of the **working point** of a module to meet particular temperature or thermal power needs;
- Manufacture of **full-custom turbines** and modules perfectly tailored to the available ther mal power and temperature specifications.
- Zuccato Energia **tests each one of its ORC modules** in a purpose-built **test area** on its premises.

COMPREHENSIVE CONSULTANCY SERVICES

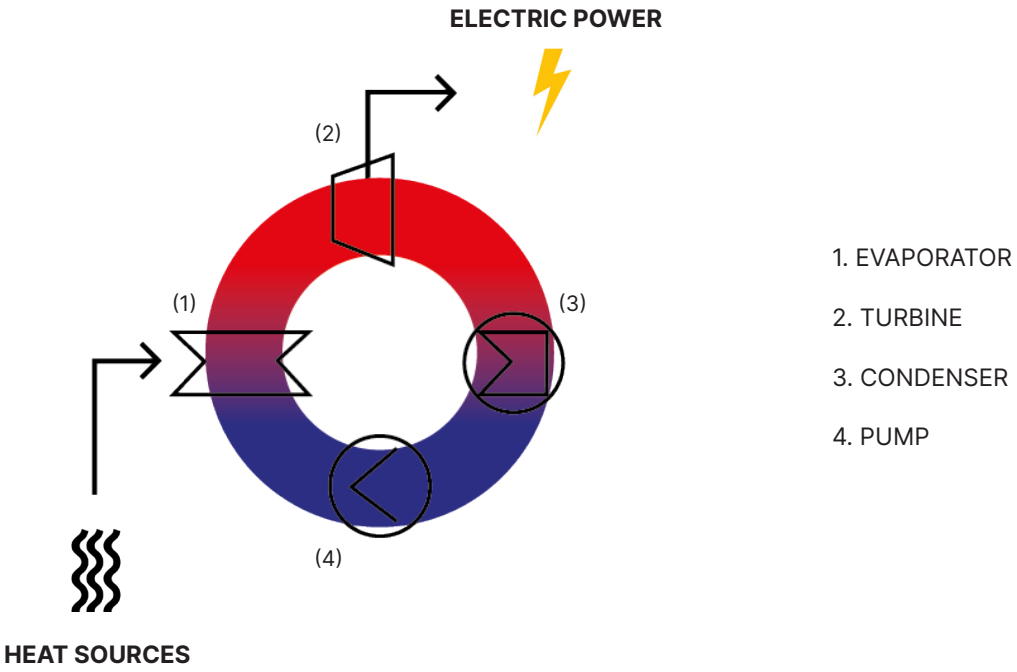
- Carry out **feasibility studies**;
- Correctly **size thermal production / heat recovery systems** (boiler, heat exchangers, heat dissipation systems such as dry coolers and evaporative towers);
- Create **preliminary designs** of the entire plant, based on the most suitable of its ORC system;
- **Integrate** the new system with existing ones, and **size out the project** both from a **techni-cal** and **financial** standpoint, or – if the client so prefers – **assist** the client's preferred system integrators in doing the same;
- Draw up financial amortization estimates (**business plans**).

In short, Zuccato Energia can be seen as an **all-round partner**, able to work side-by-side with the client to make sure that the latter receives an optimal answer to its needs.

OUR TECHNOLOGY
Organic Rankine Cycle

All of Zuccato Energia's systems are based on the **Organic Rankine Cycle (ORC)**, a simple, **high efficiency thermodynamic cycle** that is ideally suited for the **conversion of low- and medium-temperature heat sources (86°C and up) into electrical energy**.

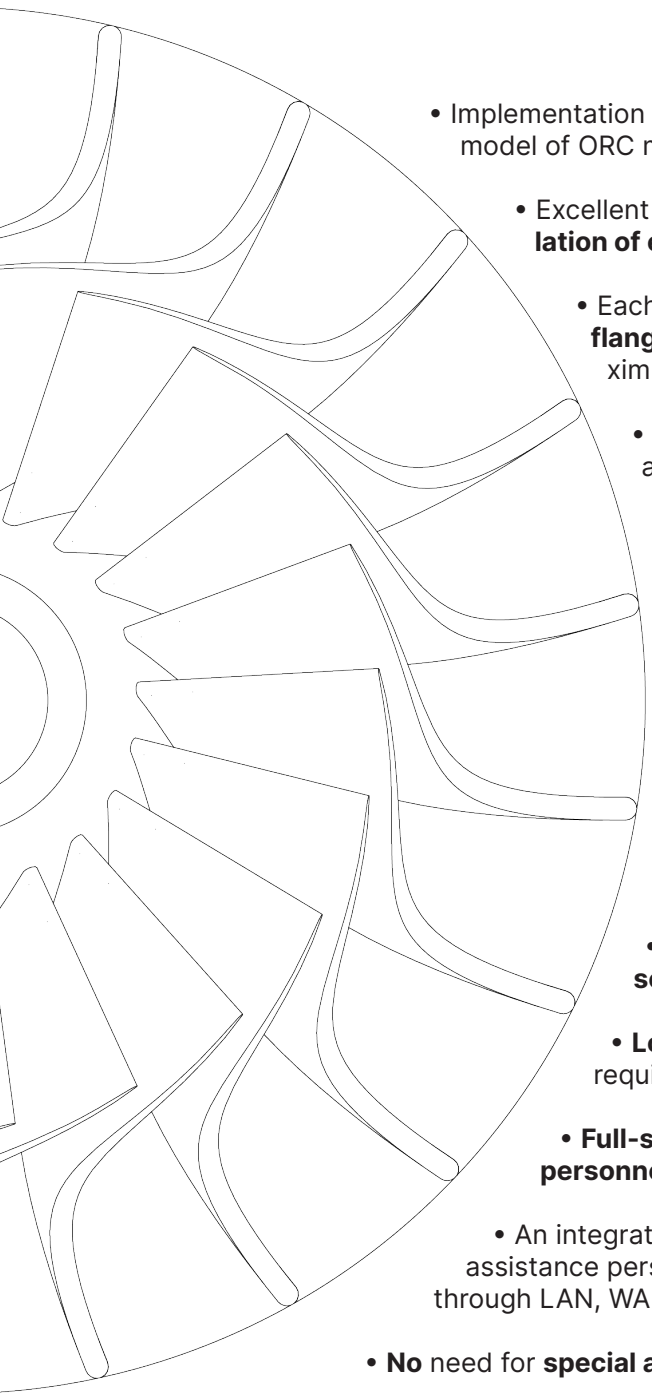
Invented by Scottish physicist **William Rankine** (1820 -1872), one of the fathers of thermodynamics, it operates in an **emission-free, closed loop**, illustrated in the diagram below.



1. EVAPORATOR
2. TURBINE
3. CONDENSER
4. PUMP

Heat from a **heat source evaporates**, through an **evaporator heat exchanger** (1), a low-boiling-point working fluid which expands spinning a **turbine** (2) attached to an **alternator generating electric power**. The **working fluid** is then **condensed** in a condenser **heat exchanger** (3) and **pumped back** (4) to the first exchanger, thus closing the loop. Residual heat from the condenser can also be used as a resource for CHP (Combined Heat & Power generation).

TECHNICAL ADVANTAGES



- Implementation of single-stage turbines **specifically designed in-house** for each model of ORC module guarantee **top efficiency** (up to 90%);
- Excellent operational performances **even under partial load allow modulation of electrical production** according to the available thermal power;
- Each module is mounted on a **self-supporting, self-contained, flange-to-flange frame** ("skid"), which can be **containerized** for maximum **modularity** and **compactness**;
- Extensive use of **ceramic bearings** grants a longer service life and maximum **reliability**;
- The **non-toxic, non-flammable working fluid is full eco-compatibility** as well as being **ozone-friendly**;
- **Direct coupling** of the **generator** to the **turbine shaft eliminates** the need for a gearbox and eliminates the inherent **efficiency losses**;
- **Custom-designed power converters** (inverters) for each model guarantee **maximum efficiency** in energy conversion;
- The **completely dry** working fluid ensures against **turbine blade erosion**;
- An accurate choice of top-quality components grants a **long service life**;
- **Low operational pressures** give better operational **safety** and require far **less bureaucratic red tape** for operation;
- **Full-scale automatization** removes the need to employ **specialized personnel** for operation;
- An integrated remote control system grants the client and technical assistance personnel **full remote monitoring and management capabilities** through LAN, WAN and the Web;
- **No** need for **special authorizations** for installation and operation.

HARNESSING GEOTHERMAL HEAT

Why not exploit a free and inexhaustible energy source ?

Geothermal energy is a form of **renewable, inexhaustible energy** that derives from the **Earth's own internal heat**, which rises proportionally to the depth one penetrates into the Earth's crust.

By placing a **thermal collection system** into an existing **hot spring** or into an ad-hoc **geothermal pit** drilled in an appropriate point of the Earth surface, it is possible to obtain hot water with enough **flowrate** and **temperature** to operate one or more Zuccato Energia ORC modules.

Said modules have **exclusive technical advantages** which make them particularly suitable to **harness energy from "weak", relatively low-temperature sources**, without having to resort to complex and difficult-to-manage systems.

It is thus possible to use Zuccato Energia ORC modules to **exploit geothermal heat sources** or geothermal pits having a **reduced depth** with regard to those required by conventional, steam-based systems.

Among the exploitable sources the following can be counted:

- **Hot springs** having a temperature of 95°C or above;
- **Volcanic heat** sources having temperatures equal or greater than 150°C;
- Purpose-made **geothermal pits**.

COLLECTING SOLAR POWER

Why not use the largest, inexhaustible power source ?

Thanks also to their **excellent performance under partial load** - i.e. when thermal power input is below nominal values - Zuccato Energia ORC modules can easily be used to implement **thermodynamic or hybrid solar plants**.

These ORC-based thermodynamic system can exploit the relatively low-temperature heat obtained by **simple concentration-type solar panels** to produce electric power as long as enough solar power is available.

Hybrid systems can then **automatically switch over** the ORC module to using **alternative heat sources** (such as biomass/biogas boilers, geothermal heat systems...) **when solar heat is insufficient**, such as during night time or in case of inclement weather conditions.

Zuccato Energia **has already built and installed pilot systems of this kind** as part of research and in partnership with prestigious Universities both in Italy and abroad.

MONETIZING BIOMASS

Waste?
No: resources!

ORC modules by Zuccato Energia have found several applications in combination with a wide range of overheated water generation systems based on **biomass combustion**.

A typical system connects one or more ORC modules to a **fixed- or movable-grate boiler** fueled via an **automated feeding system** by wooden chips derived from **woodworking waste** or from **pruning residues** derived from the management of municipal, regional or state parks.

The biomass conversion plants built by Zuccato Energia – several of which **have been operating for years** – are **highly reliable and compact** enough to be employed **even in a small firm**, monetizing its waste, **simplifying waste disposal**, and paying themselves back **in a few years**.

HEAT RECOVERY FROM BIOGAS ENGINES

Why not obtain maximum efficiency?

Many cattle breeders choose to use the manure of their livestock to **generate biogas** through the use of **fermenter digesters**; this biogas is then used as fuel for engines connected to electrical generators (commonly called gensets).

Few of them know, however, that thanks to the Zuccato Energia ORC systems it is also possible to **recover the waste heat** contained in the **exhaust fumes** or carried away by the cooling jackets of said gensets - a **valuable thermal resource** that would otherwise be wasted.

The same heat recovery system can of course be applied to **any genset of sufficient power**, regardless of the fuel it uses - biogas, syngas, vegetable oil, methane or biofuel, thus pushing **the overall system efficiency of said systems to the maximum**.

Zuccato Energia has an **extensive experience** in this field, having installed **several systems of this type** both in Italy and Germany.

HEAT RECOVERY FROM ENGINES

Why burn more fuel ?

Thanks to their **compactness** and **modularity**, ORC-based heat recovery systems by Zuccato Energia are ideal to be **factory-mounted** or applied as a **retrofit** to engines.

In this capacity, ORC modules can in fact excellently replace one or more gensets in the task of producing electric power by using waste thermal energy recovered from the engines **instead of fuel.**

Essentially, **two types** of energy recovery are possible:

- **Medium-temperature** (160°C) heat recovery from exhaust gases and cooling jackets of auxiliary engines or primary engines too small to justify a steam-based recovery system;
- **Low-temperature** (≥ 85°C) heat recovery from the cooling jackets of large engines or multi-engine units already equipped with a steam-based energy recovery system;

ORC modules manufactured by Zuccato Energia are **comparable in size with gensets** of equal electric output, but differently from the latter, they **do not pollute** nor use a **single drop of fuel more.**

HEAT RECOVERY FROM INDUSTRIAL PROCESSES

Petrochimical Industry
Glassworking
Food Industry
Metalworking Industry
Ceramics
Paper Industry

As already said in the previous pages, the ORC systems by Zuccato Energia can **recover energy from most industrial processes** involving heat, such as:

- **Ovens**, **furnaces and kilns** in steel, glass and ceramic industries and cement mills;
- **Boilers and steam generators** in paper mills and naval industry;
- **Ovens, dryers and smokehouses** in the food industries as well as incinerators in animal fat rendering.

As an example, by installing **heat exchangers** in the flue gas circuit of a **glass bottle manufacturing** plant equipped with three ovens, enough thermal energy can be recovered to drive the same number of ZE-150-LT ORC modules , which can **output up to 3 GW/year** of electricity to the power grid.

Even an **end-of life waste disposal site** can become a power generation plant, by using an ORC module to recover the heat from the **combustion of flared-off waste gas** too weak to operate a normal genset.

ULH SERIES

Designed using the most advanced technologies, the in the ULH-series ORC modules from Zuccato Energia are a **compact and efficient solution to exploit low-temperature thermal sources**.

Available in a power range **from 30 to 100 kWe output**, and able to operate efficiently even under partial load conditions (i.e.lower than nominal thermal power input) their ideal fields of application are **waste heat recovery from engines and industrial processes**, harnessing **geothermal power** and **converting solar heat from concentrator-type solar panels into electricity.**

General Specifications	ZE-30-ULH	ZE-40-ULH	ZE-50-ULH	ZE-100-ULH
Thermal power input	350 kWt	450 kWt	550 kWt	1200 kWt
Electric power output	30 kWe	40 kWe	50 kWe	100 kWe
System efficiency	8.50 %	8.90 %	9.10 %	8.30 %
Skid dimensions (L x W x H)	3.3 × 1.4 × 2.1 m		3.5 × 1.4 × 2.1 m	5.6 × 2.3 × 2.7 m
Weight (incl. working fluid)	3100 Kg		4500 Kg	6500 Kg
Vector fluid				
Vector fluid	Hot Water			
Vector fluid input temperature	≥94°C			
Vector fluid output temperature	86°C			
Vector fluid nominal flowrate	10.20 kg/s	13.40 kg/s	16.42 kg/s	28.50 kg/s
Condensation Stage				
Thermal power dissipation	310 kWt	390 kWt	470 kWt	1100 kWt
Cooling water input temperature	26°C			27°C
Cooling water output temperature	31°C			35°C
Cooling water nominal flowrate	14.81 kg/s	18.65 kg/s	22.46 kg/s	32.50 kg/s
Turbine				
Type	Single stage, radial inflow turbine with fixed nozzles, directly coupled to generator			
Working fluid temperature	85°C input / ~60°C output			
Stage pressure	PS4,42 (tested up to 10 bar)			
Materials	CNC Machined steel body / Aluminium alloy impeller			
Working Fluid				
Type	Environmentally friendly, non-flammable HFC mixture			
Operating temperature range	60°C ≤ T ≤ 165°C			
Operating pressure	≤ 20 bar			
Toxicity / Biodegradability / Ozone layer impact	Non-toxic / Full eco-compatibility / Ozone-friendly			

LT SERIES

Designed using the most advanced technologies, the **LT-Series ORC** modules from Zuccato Energia are a **compact and efficient solution for small-scale primary power generation.**

Available in a wide range of models ranging **from 75 to 495 kWe,** and able to operate efficiently even **under partial load conditions** (i.e.lower than nominal thermal power input), these systems and their ideal eld of application in association with **biomass-fueled boilers**, as well as in **waste heat recovery** applications from ovens and industrial processes.

General Specifications	ZE-75-LT	ZE-100-LT	ZE-150-LT	ZE-175-LT	ZE-200-LT	ZE-250-LT	ZE-500-LT
Thermal power input	550 kWt	740 kWt	1100 kWt	1280 kWt	1400 kWt	1560 kWt	2909 kWt
Electric power output	75 kWe	100 kWe	150 kWe	175 kWe	200 kWe	250 kWe	495 kWe
System efficiency	13.60 %	13.50 %	13.60 %	13.60 %	14.30 %	16.00 %	17.00 %
Skid dimensions (L x W x H)	4.1 × 2.0 x 2.7 m	5.6 × 2.3 × 2.7 m					10.3 × 4.5 x2.9 m
Weight (incl. working fluid)	4000 Kg	6500 Kg	6200 Kg				21500 Kg
Vector fluid							
Vector fluid	Presurrized water						Diathermic Oil
Vector fluid input temperature	≥160°C					175°C	225°C
Vector fluid output temperature	145°C		140°C		145°C		103°C
Vector fluid nominal flowrate	8.49 kg/s	11.91 kg/s	13.14 kg/s	14.88 kg/s	21.65 kg/s	12.00 kg/s	11.28 kg/s
Condensation Stage							
Thermal power dissipation	471 kWt	640 kWt	940 kWt	1075 kWt	1180 kWt	1300 kWt	2391kWt
Cooling water input temperature	32°C	26°C				28°C*	32°C
Cooling water output temperature	40°C	36°C				40°C*	48°C
Cooling water nominal flowrate	14.07 kg/s	15.60 kg/s	22.46 kg/s	25.69 kg/s	28.25 kg/s	25.91 kg/s*	35.38 kg/s
Turbine							
Type	Single stage, radial inflow turbine with fixed nozzles, directly coupled to generator						
Working fluid temperature	145°C input / ~ 100°C output						180°C input / ~ 100°C output
Stage pressure	PS16 (tested up to 24 bar)						PS40
Materials	CNC Machined steel body / Aluminium alloy impeller						
Working Fluid							
Type	Environmentally friendly, non-flammable HFC mixture						
Operating temperature range	60°C ≤ T ≤ 165°C						60°C ≤ T ≤ 185°C
Operating pressure	≤ 20 bar						≤ 30 bar
Toxicity / Biodegradability / Ozone layer impact	Non-toxic / Full eco-compatibility / Ozone-friendly						

*Available also with a direct condenser - no cooling circuit is required

CHP SERIES

The CHP-series ORC modules are instead a compact and efficient solution for **small-scale primary power generation when combined heat and power generation is required.**

General Specifications	ZE-105-CHP
Thermal power input	1280 kWt
Electric power output	105 kWe
System efficiency	8.20 %
Skid dimensions (L x W x H)	5.6 × 2.3 × 3.2 m
Weight (incl. working fluid)	6500 Kg
Vector fluid	
Vector fluid	Overheated Water
Vector fluid input temperature	≥160°C
Vector fluid output temperature	140°C
Vector fluid nominal flowrate	14.88 kg/s
Condensation Stage	
Thermal power dissipation	1157 kWt
Cooling water input temperature	60°C
Cooling water output temperature	80°C
Cooling water nominal flowrate	13.82 kg/s
Turbine	
Type	Environmentally friendly, non-flammable HFC mixture
Working fluid temperature	145°C input / ~100°C output
Stage pressure	PS16 (tested up to 24 bar)
Materials	CNC Machined steel body / Aluminium alloy impeller
Working Fluid	
Type	Environmentally friendly, non-flammable HFC mixture
Operating temperature range	60°C ≤ T ≤ 165°C
Operating pressure	≤ 20 bar
Toxicity / Biodegradability / Ozone layer impact	Non-toxic / Full eco-compatibility / Ozone-friendly

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