ZUCCATO ENERGIA®
WE TRANSFORM ENERGY

Our Carnet of Selected References

Updated as of May,2023

Arranged in reverse chronological order (newest to oldest)

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The Zuccato Energia premises in Verona, Italy

Veneto 05

Manager: *Private firm* • ***Location:*** *Province of Padua, Veneto, Italy*
Plant: *1 x ZE-200-LT Organic Rankine Cycle (ORC) module*
Application: *Waste heat recovery from furnace fumes*

This installation was made in a **steel mill** which produces up to 2.000.000 tonnes/year of steel and is located near Padua, in the region of Veneto, in northern Italy.

The management decided to install a Zuccato Energia ORC system to **recover the heat contained in the fumes exiting from the billets pre-heating furnace**, thus avoiding its release in the atmosphere and using it instead to produce electricity.

As billet production requires **careful avoidance of pressure spikes** the fumes line is regulated by automatic electro-regulated shutters.

This **helped in retro tting our ORC system to the existing plant**, which was done by installing a fumes/water exchanger on a bypass line connected to the pre-existing ˜ue gas e xhaust.

This fumes/water exchanger **recovers ue gas heat** to obtain **overheated water at 160°C** which is then used to feed, through a **closed loop**, a secondary heat exchanger where its heat vaporizes the **low-boiling-point organic working ˜uid** used in the Rankine cycle, the expansion of which **spins the turbogenerator** at the core of the ORC power generation module.

The installed module is a **Zuccato Energia ZE-200-LT system**, installed outdoors in a **custom, containerized weatherproof enclosure**. This system has a nominal electrical power output of 200 kWE which it produces by absorbing about 1400 kWT of waste heat .

Cooling for the condensation stage of the ORC is e¸ ected by **cold water** coming from the same **cooling tower** owned by the client which is used in their own production process.

Below and on the opposite page you can find a photo gallery related to this plant.

The ORC ZE-200-LT container open for easy maintenance

The heat exchanger (blue) installed on the ˜ue g as line

An overview of the ORC ZE-200-LT from the side

Access area to the ORC control panel and electronics

Veneto 05 / Padua : *The ORC ZE-200-LT module is located near to the smokestack*

Veneto 05 / Padua : *Overview of the ZE-200-LT ORC module enclosed in its weatherproof container*

Mexico 01 a,b,c

Manager: *Private firm* • ***Location:*** *State of Veracruz, Mexico, Central America*
Plant: *3 x ZE-200-LT Organic Rankine Cycle (ORC) modules in separate locations*
Application: *Waste heat recovery from from oil extraction gas flaring*

This installation is composed of **three plants in separate locations** in the Mexican federated state of Veracruz, a few kilometers distant from each other. Each of these three plants – **almost identical to each other** – is applied to an on-ground modular combustor system for the disposal of gaseous byproducts from crude oil extraction. These reactors **oxidise combustible gaseous hydrocarbons** at the base of a cylindrical chamber where the hot gases remain **far longer than in a traditional free-air combustion torch**, with the twofold advantage of **destroying 99.5% of harmful combustion byproducts** while creating a favorable environment for waste-heat recovery.

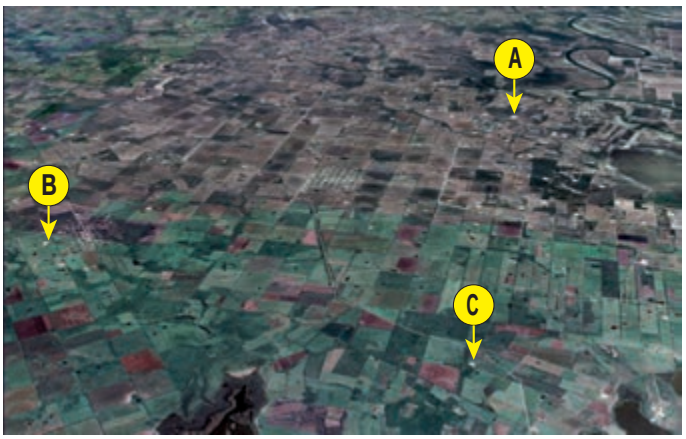
Zuccato Energia was contacted by the supplier of these combustors - a primary ÿrm of the Oil & Gas sector - to **integrate our ORC system into their existing plants**. This was done by conveying the hot ˜ue gases to a primary fumes/water exchanger, which **recovers ue gas heat** to obtain **overheated water at 160°C** .

This water is then used as a vector ˜uid to feed, through a **closed loop**, a secondary heat exchanger where its heat vaporizes the **low-boiling-point organic working ˜uid** used in the Rankine cycle, the expansion of which **spins the turbogenerator** at the core of each ZE-200-LT ORC system, which produces 200kW of electricity, which is then used locally to reduce the energy consumption of oil extraction machinery.

Each ORC system is **skid-mounted** and installed inside the same **weatherproof container** hosting part of the control systems for the combustor. An **evaporative cooling tower** fed by a local tank supplies cold water to cool **the condensation stage** of the ORC.

Given the rural nature of the locations where the plants are installed, the **full automation** of the Zuccato Energia ORC systems and its **remote monitoring and control capability** are paramount - during installation our technicians in Italy were able to monitor and control the plant and assist their on-site colleagues in troubleshooting the startup process via the Web.

Below and on the opposite page you can find a photo gallery related to these plants.



Satellite overview of the rural area where the plants are located. The plants are located ~10 km from each other.

The ZE-200-LT ORC module inside its enclosure during installation. On the right, the large cylindrical combustor.

A detail of the primary heat exchanger. Hot gases are drawn from the combustor on the left and pass thru the exchanger

The evaporative cooling tower of plant B. The black vertical tanks on the right contain the cooling water supply.

Mexico 01b / Veracruz : *Front view of Plant B. The container in the center hosts the ORC sytem.*

Mexico 01c / Veracruz : *Plant C, seen from the rear . The yellow cabinet hosts the start-up generator.*

Sardinia 01

Manager: *Private firm* • ***Location:*** *Province of Cagliari, Sardinia, Italy*
Plant: *1 x ZE-200-LT Organic Rankine Cycle (ORC) module*
Application: *Waste heat recovery from special waste incineration kiln*

The client who commissioned this plant is a ÿrm specializing in **hospital waste disposal** and has decided to make their incineration plant, based on a thermodistiller furnace, even more **energy e cient** by recovering the thermal energy (waste heat) contained in its high-temperature ˜ ue gases using a Zuccato Energia ZE-200-LT Organic Rankine Cycle (ORC) system.

Solid waste is transported to the plant and fed to a **rotary kiln**, in which the waste undergoes a **mixing and pyrolisis process**, producing a ˜ ammable gas (**syngas**) which is then burned in a boiler.

Waste heat from the pyrolitic reaction (~ 1400kWt @1050°C) is **recovered from the ue gases** to produce overheated water through a fume/water exchanger. This overheated, pressurized water conveys heat, via a closed loop, to a secondary heat exchanger, where the heat is transferred to the **working uid of the ORC**, which **evaporates** and **expands** powering the turbogenerator of the ORC system.

The ORC module system, like all Zuccato Energia ORC systems, is mounted on a **self-supporting frame** (skid) that includes **exchangers, turbogenerator, and control panel.** The skid is housed indoors in a small purpose-built room and **operated in full automation**, without the need for an operator as it is fully **capable to be monitored and opearted by remote** via the Web.

Cooling of the "cold side" (condensation phase) of the ORC system is e¸e cted using a custom **adiabatic cooler**, under which a space has been found to locate the skid. This cooling technology is best suited for e¸e ctive operation when ambient temperature is high.

The plant was built using the **project nancing formula**. With the collaboration of Zuccato Energia, the client was put in contact with an E.S.CO. that fully ÿnanced the plant, receiving as consideration its ownership and the amount of incentives for the ÿrst years of its life. After that, plant ownership will be passed back to the client, who will thus have obtained it at **virtually zero cost.**

Below and on the opposite page you can find a photo gallery related to this plant.

An overall view of rotary kiln (green), syngas boiler (gray), ˜ue g as ÿlter (silver) and waste loading hopper (yellow)

The ZE-200-LT skid in its place below the cooling system. The cabinets hosts electronics and local control panel

A detail of the heat exchangers aboard the skid and the blue 3-way valve that regulates the incoming heat ˜o w

The single stage, radial in˜o w turbine directly coupled to the 200kWe generator at the heart of the ORC module

Sardinia 01 / Cagliari : *General view of the plant, with the cooling system at far right.*

Sardinia 01 / Cagliari : *The syngas burner & exhaust system. Silver cylinder (L) is the primary heat exchanger.*

Marine 01

Manager: *Private firm* • ***Location:*** *On board a Bahamas-registered luxury cruise ship*
Plant: *1 x ZE-100-LT Organic Rankine Cycle (ORC) module in custom configuration*
Application: *Waste heat recovery from exhaust gases of marine engines*

This installation **is the rst made by Zuccato Energia onboard a seagoing vessel,** namely a large (28.000+ tons) luxury cruise ship specialized in long-term cruises. This ship is powered by four large marine engines, two of which dedicated to electric power generation. The owner decided to install one of Zuccato Energia ORC units to **recover heat from the exhaust gases** of one of these latter engines.

Onboard ship space is at a premium, so the skid hosting the ORC module was redesigned to be **as compact as possible** while being able to be easily **separated in half a dozen compact sub-assemblies** that could be moved through the narrow technical access corridors to the engine room before being reassembled there. This spared the client the **costly operation of cutting open the ships' side to insert the plant**, that is often necessary to perform to install other system retroÿts.

Installation on the Bahamas-registered ship was made amidst the operations of a **programmed refurbishing stop in Marseille** and required little more than one week.

The installed ORC module **took the place of a secondary genset**, drawing 740 kW_T of heat from the exhaust gas conduit via a primary fumes/water exchanger, which **uses the heat contained in exhaust gases heat** to obtain **overheated water at 160°C** . This water is then used as a vector ˜uid to feed, through a **closed loop**, a secondary heat exchanger where its heat vaporizes the **low-boiling-point organic working ˜uid** used in the Rankine cycle, the expansion of which **spins the turbogenerator** at the core of the **ZE-100-LT ORC** system, which produces an additional 100kW of electricity **without burning a single drop more fuel** than what is already used .

Cooling is done using **sea water** – always available both at sea and when berthed – through an **intermediate clean water loop** and an **inspectable plate-type heat exchanger**.

Below and on the opposite page you can find a photo gallery related to this plant.

A general view of the engine room. The skid was installed in a small technical space behind the yellow cabinet

The narrow technical space where the skid is going to be hosted and its I-beam support frame, welded to the ˜o or

The ZE-100-LT skid in place. L to R: the blue 3-way valve, the main heat exchanger and the turbogenerator (far right)

The inspectable heat exchanger used to exchange heat between the cold side condenser of the plant and the sea

Marine 01 / Marseille : *General view of the ship in its maintenance berth at Marseille, France*

Marine 01 / Marseille : *The skid in place. seen from the side facing the electrical panels.*

Emilia-Romagna 01

Manager: *Private firm* • ***Location:*** *Province of Piacenza, Emilia-Romagna, Italy*
Plant: *1 modulo a ciclo Rankine Organico (ORC) ZE-200-LT*
Application: *Electricity generation by thermal recovery from glassware manufacture*

The client who commissioned this installation is a **large glassware factory** producing up to 45,000 tonnes of glass per year located near Piacenza, in the region of Emilia-Romagna, in northern Italy. The basic idea for this installation was recovering at least part of the **thermal content of the ue gas** in order to **decrease their temperature and to produce electricity.**

By installing this heat recovery system, based on the Zuccato Energia ZE-200-LT ORC system, the customer **avoided wasting heat while improving fume management** by removing the need to cool the ˜ue gas after the ÿlter (which would be mandatory to avoid damages to the ventilation system) with the added bonus of a **lower electrical consumption** of the fans that would be used for the introduction of cool "false air" in the ˜ue gas .

To control and manage heat recovery, a **bypass valve** with adjustable shutters directs ˜ue gas ˜o w in real time according to the client's needs for Rimini heat recovery. The latter is carried out by a heat exchanger **intercepting the heat of the ue gases** and feeding it to an overheated water loop, **lowering ue gas temperature from 450° C to 200°C** while heating the pressurized water in the loop up to **160°C**. This heat is fed to the **ORC module vaporizer**, making the low-boiling-point organic working ˜uid become a dry gas, the expansion of which powers the **ORC turbogenerator**.

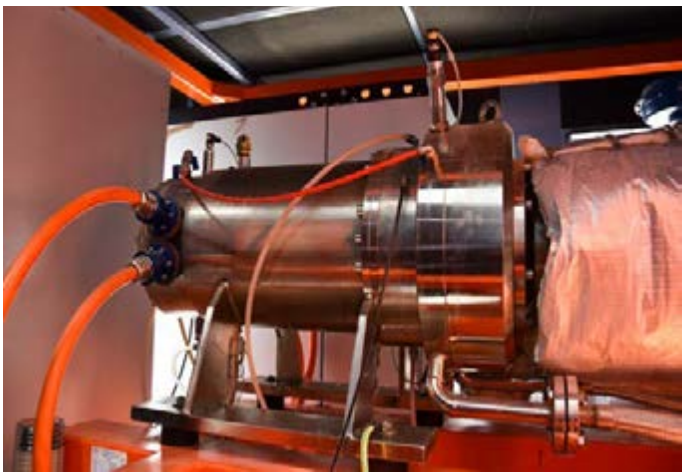
An **adiabatic cooler** is used for cooling, to allow normal operation **even in case of high ambient temperature**; system output is **very constant** thanks to the low variability of production and furnace operation characteristics of glass factories.

The system is mounted on a **self-supporting frame (skid)** including all ORC machinery and control electronics. This, in turn, is housed inside a **weatherproof containerized enclosure** located outdoors, near to a smokestack. As operation is **fully automatic and remotely managed**, the system **doesn't require a technical operator on site**.

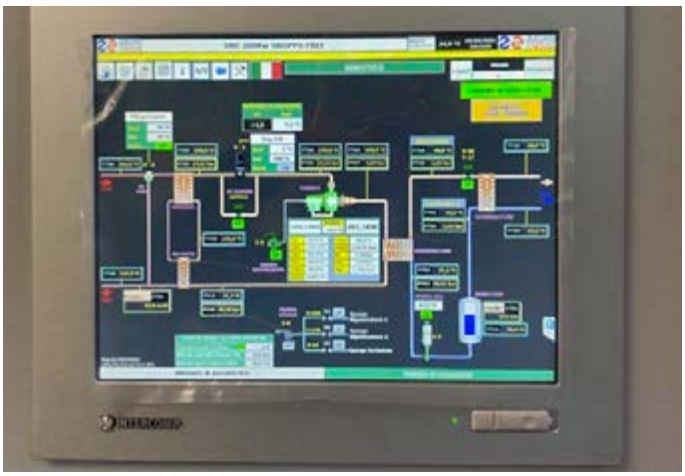
Below and on the opposite page you can find a photo gallery related to this plant.

Electrical Panel

Three-way Diverter Valve



ORC system turbine



ORC ZE-200-LT Module Control Panel

Emilia-Romagna 01 / Piacenza : *The ZE-200-LT ORC module before installation*

Emilia-Romagna 01 / Piacenza : *The ORC module in its weatherproof containerized enclosure.*

United Kingdom 01

Manager: *Private Firm* • ***Location:*** *South Gloucestershire, England, United Kingdom*
Plant: *1 x ZE-105-CHP Rankine Cycle (ORC) combined heat & power generation module*
Application: *Power generation in combination with a biomass-fed boiler (pruning residues)*

The owner of this plant is **one of the largest producers of potatoes and onions in England**, and uses its 4 warehouses to store its freshly harvested products until the distribution trucks arrive.

The idea behind the plant was to have a **power plant working 24/7 to dispose of the waste biomass** (mainly residues from mowing and pruning) produced by local landowners and industries while **producing electrical and thermal energy** to be used for product storage and to power the thermal utilities used by the sta¸ on sit e.

The client, therefore, decided to equip itself with a system capable of exploiting the biomass, feeding it to a 1.2 MWT + boiler and conveying the heat thus produced to a **Zuccato Energia ZE-105-CHP Organic Rankine Cycle module.**

This combined heat and power (CHP) module, beside producing **105 KwE of electricity**, outputs **hot water at 60/80°C** which is used to supply the heating systems on the site and, above all, to keep the **ideal storage conditions** in the temperature- and humidity-controlled warehouses for the vegetables.

This hot water leaving the ORC module goes into **water-air heat exchangers** where it heats ambient air which is conveyed to the warehouses by fans.

The system, like all Zuccato Energia systems, is mounted on a **self-supporting frame (skid)** which includes heat exchangers, turbogenerator and control panel. It is **housed indoors** near the boiler to which it is connected. **Operation is fully automatic** and doesn't require an operator on site, as it entirely **remote-controlled**.

Before installing Zuccato Energia's ORC system, the customer had to burn **diesel oil** to heat the deposits and the working spaces, with all the consequent **high fuel purchase costs and the high rate of pollution** resulting from combustion; now instead, as the fuel used to power the boiler (pruning cuttings) is an environmentally friendly and renewable resource, **the environmental footprint of the plant has been drastically reduced** with the added bonus of a **pro table reduction in heating costs**.

Below and on the opposite page you can find a photo gallery related to this plant.

The warehouse that also houses the ORC system

The biomass loading hopper

The boiler preheating system and part of the water loop.

One of the plant's dry coolers

United Kingdom 01 : *The Entire plant - chipper, loading hopper, boiler and ORC module*

United Kingdom 01 : *The ZE-105-CHP module in place*

Tunisia 01

Manager: *State University* • ***Location:*** *Tunis (Tunisie)*
Plant: *1 x ZE-60-DSG LT-ORC power generation module*
Application: *Didactic hybrid plant (thermal solar power + biogas boiler)*

This plant - the ÿrst Zuccato Energia plant in Africa - is located in near Tunis, Tunisia. It is an **experimental hybrid plant**, built in collaboration with several european academic and industrial entities within the frame of the EU-ÿnanced RE.EL.COOP project.

This plant shows some parallels with our previous Sicily 02 installation. In both plants the goal in not as much energy production as the **demostration of various engineering principles**, and in both plants **concentration-type thermal solar panels work side-by-side with a gas boiler** as an alternate power source.

The Tunis plant, however, shows several di¸ erences with the Sicily one, the main being - for the ÿrst time in a Zuccato Energia plant - the use of **160°C saturated steam** as vector ˜uid in **direct heat exchange** with the working ˜uid without the use of an intermediate steam/water heat exchanger. This new working point required a **full turbine blade redesign**, and several modiÿcations were made to the "hot side" of the ORC module, adding various devices to better handle and exploit this new vector ˜uid .

From the thermal source viewpoint, the plant relies on a **small solar eld** made of Soltigua parabolic concentrators, using – as an alternate heat source – a boiler fueled by the **biogas** produced in a fermenter fed by the food residues of the local universitary dining hall. Residual heat from the condensation stage of the ORC is dissipated by a battery of **dry coolers**.

While the plant as a whole is the concerted e¸ ort of a dozen ÿrms, the heart of the whole plant – The **ZE-60-DSG Organic Rankine Cycle power module** – has been **entirely designed and developed in-house by us**. It is a **compact, skid-mounted system**, which is now hosted – together with the boiler – in a small building adjacent to the main campus building.

The **compact size** of the ORC module has **simpli ed shipping** while its capacity to **interface through secure protocols with the web for control, monitoring and diagnostics** (a common characteristic of all our ORC modules) has allowed our company's technicians to supply **real-time assistance** to their colleagues commissioning the plant in Tunis.

Below and on the opposite page you can find a photo gallery related to this plant.

A general overview of the plant

The solar ÿeld seen from another angle

The white building protecting the skid (L).

The ZE-60-DSG skid seen from the door

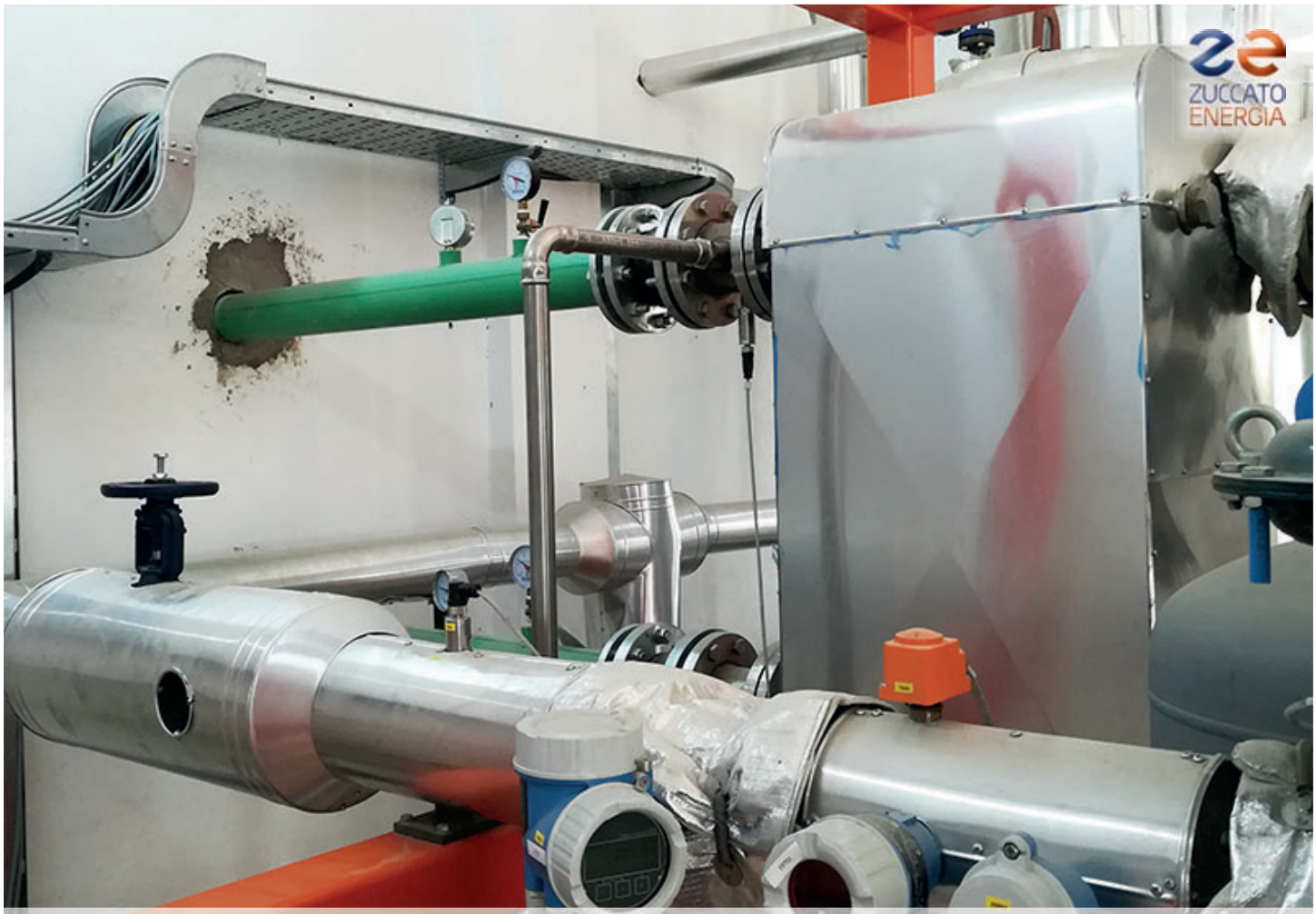
The biogas boiler (R) and the ORC module skid (L)

The ZE-60-DSG ORC Module during commissioning

A detail of the plant's custom turbine

The dry coolers with the main campus building in the background

The dry coolers from the opposite side



Tunisia 01: *The heat exchangers. This was the rst plant by ZE using live saturated steam as a vector uid.*

Tunisia 01: *The solar eld at sunset, taken from the canopy adjacent to the building housing the skid.*

Korea 01

Manager: *Private Korean Firm* • **Location:** *Yellow Sea islands, South Korea*
Plant: *1 x ZE-40-ULH LT-ORC module in custom configuration*
Application: *Heat recovery from engines (Heavy fuel diesel gensets)*

This plant – **our rst installation in the Far East** – is located in the main hamlet of a small island located in the Yellow Sea o the southeast ern shore of South Korea.

This small island, occupying less than 20 km², is home to about 3000 persons, and relies for its electricity on **a local power station based on eight large diesel gensets**.

A Korean private ÿrm received from the state-owned plant owner and manager the task to **increase the e ciency** of the plant.

This ÿrm turned to us via our US representative at the time and asked us to manufacture for them a **custom - con gurated Low-Temperature Organic Rankine Cycle Module** according to their speciÿcations, i.e. 30-kWE nominal output and a 40-kWE peak output power with a maximum e cienc y of 9% , designed to operate by recovering the heat from the exhaust gases of the 1-MW diesel engine operating one of the plant gensets.

The ORC module, built as all of our system on a self-contained frame (skid), was mounted in open-frame, non-containerized conÿguration under a little awning o the main entrance to the generator room, and was interfaced with generator #8 through a heat exchanger placed in the exhaust chimney, recovering waste heat from the engine fumes.

The compact size of the plant has simpliÿed shipping, while its remote interface with the Internet for control, monitoring and diagnostics has made it possible for our technicians to give real-time assistance to their colleagues performing plant start-up nearly 9000 km away.

Below and on the opposite page you can find a photo gallery related to this plant.

Satellite view. The plant is in the SW corner of the large white buiding in the center.

The entrance to the power plant.

The generators building. The skid is on the right, below a small awning

The ZE-40-ULH module during installation

The large diesel genset from which waste heat is recovered

A general view of our skid installation and the cooling tower

The hot-side piping conveying heat to the ORC. The heat exchanger is on the platform at the top

A front view of the turbine

A back view of the turbine

Korea 01 : *The cooling tower and the awning hosting the ZE-40-ULH ORC power generation module*

Korea 01 : *A detail of the ORC skid - the steel cylinder in the middle is the turbogenerator*

Umbria 01

Manager: *Private Italian Firm* • ***Location:*** *Province of Perugia, Umbria, Italy*
Plant*: 2 x ZE-100-LT Module*
Application: *Power generation in combination with a boiler burning biomass (pruning residues)*

The client who commissioned us this plant is a large **holiday farm** located in the Umbria countryside near the border with Tuscany, that includes several restructured historical buildings, as well as a **60-hectares park** including woods and ÿelds.

They decided to monetize the waste biomass their park produces (i.e.pruning residues) by using its combustion to generate electricity taking advantage of the existing **state incentives**.

The biomass is used to fuel a Herz-Binder moving grate boiler, which channels the **1.6MW of thermal power** thus generated to feed two ZE-100-LT ORC modules supplied by Zuccato Energia.

These modules are housed in a purpose-built thermal power plant, each mounted on its own skid including turbine, exchangers and control system but operating in parallel.

The total output of 200 kWE is fed into the grid via a nearby electrical substation.

The plant was built under the **project ÿnancing** formula by an Energy Service Company or ESCO, which fully ÿnanced the plant by receiving as consideration its ownership and the amount of incentives for the ÿrst years of its life, during which the developer will provide the biomass necessary for its operation at an agreed cost.

After that period, the plant will become wholly owned by the developer, who will thus have obtained it at virtually zero cost.

Like all biomass, pruning clippings are an **environmentally friendly,** renewable and incentive-neutral energy resource with respect to CO2 production-that released in combustion is the same as that captured in due course by plants as they grow.

Below and on the opposite page you can find a photo gallery related to this plant.

The power station entrance gate.

The power station building. Large door opens on bolier room, small one on ORC room.

The ORC modules through the open ORC room door.

The front of the power station building with the biomass storage area in foreground.

The rear of the power station with (L to R) biomass storage, fuel hopper and control room door.

The fuel loading hopper, with feeding rakes on the bottom.

A peek inside the operating boiler.

One of the two ZE-100-LT modules in its seat.

The boiler (R) and the ash ÿlter (L).

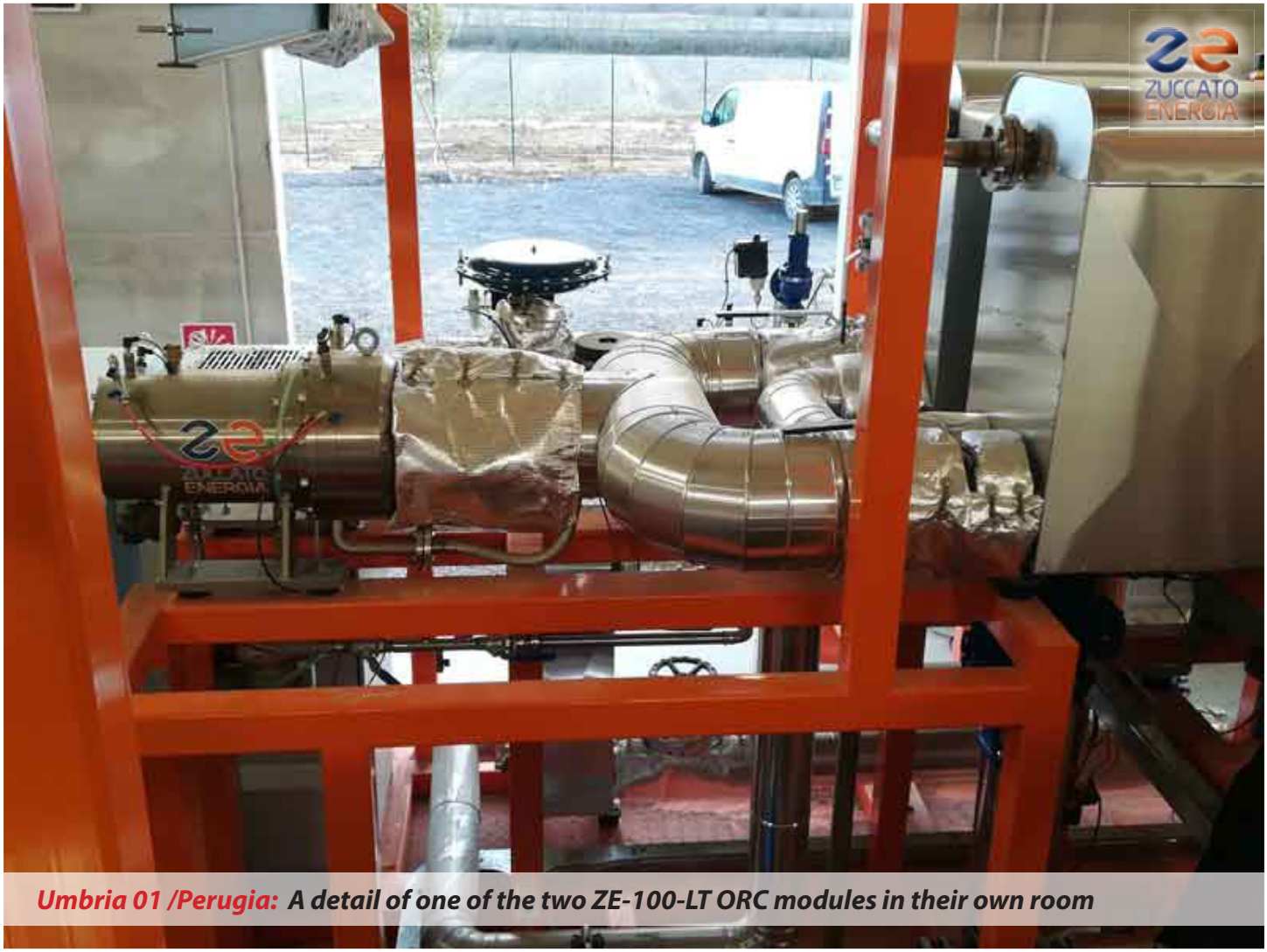
Flue gas treatment system and chimney.
On the right, the dry cooler.

A detail of the dry cooler control panels.

The nearby electrical cabin.

Umbria 01 / Perugia : A detail of the heat exchangers

Umbria 01 / Perugia : The ˜ue gas e xhaust chimney



Umbria 01 /Perugia: *A detail of one of the two ZE-100-LT ORC modules in their own room*

Lombardy 03

Manager: *Private Italian Firm* • ***Location:*** *Province of Brescia, Lombardy, Italy*
Plant: *1 x ZE-150-LT ORC module*
Application: *Primary energy production in conjunction with a biomass-fueled boiler*

Located in a large Lombardy town in the province of Brescia, this plant is operated by a company that is in the trucking pallet business and has all the permits for **transport, storage, and disposal of wood waste**. In order to valorize the waste wood biomass it comes in possession of (pallets that can no longer be used), it has equipped itself with a 1 MWT Herz moving grate boiler, most of whose heat goes to feed an ORC ZE-150-LT unit supplied by Zuccato Energia.

The versatility of our systems, which can provide excellent performance even at part load, is exploited in this plant whose generating system has been **depowered to 135 kW** electrical from the nominal 150 kWE to meet customer requirements. In addition, **an economizer** located on the boiler ˜ue gas line recovers some of its waste heat to dry and preheat the woody biomass.

The system, like all ZE systems, is mounted on a self-supporting frame (skid) that includes exchangers, turbogenerator, and control panel. The skid, in indoor conÿguration, is housed indoors in a small purpose-built room and operated in **full automation, without the need for an operator** as it is operated entirely remotely. Waste heat produced by the condensing stage of the ORC is disposed of through a special closed evaporative tower located outside.

The plant was built using the project **ÿnancing formula**: in fact, with the collaboration of Zuccato Energia, the developer was put in contact with an ESCO that fully ÿnanced the plant, receiving as consideration its ownership and the amount of incentives for the ÿrst years of its life, during which the developer will supply biomass at zero cost. After that period, the plant will become fully owned by the developer, who will thus have obtained it at virtually zero cost.

Woody biomass is **environmentally friendly and renewable**, and has **zero ecological impact** with respect to CO2 production because as it burns it releases the same amount of CO2 captured in due course from the plants themselves into the atmosphere.

Below and on the opposite page you can find a photo gallery related to this plant.

A general view of the building housing the plant.

The biomass hopper, with a rake-style feeding system.

The boiler seen from the right side.

The ZE-150-LT ORC module in place, seen from the control panel side.

The turbogenerator (silver cylinder) inside the skid frame.

The skid seen from the hydraulic connections side.

The shredder which reduces the unusable pallets into wooden chips.

The water treatment system feeding the evaporative cooling tower.

L to R: the bag ÿlter for ˜ue g ases, the chimney and the cooling tower.

Lombardy 03 / Brescia: *The ZE-150-LT ORC power generation module, seen from the control panel side*

Lombardy 03 / Brescia : *A detail of the ORC skid - the steel cylinder in the middle is the turbogenerator*

Veneto 04

Manager: *Private Italian firm* • ***Location:*** *Province of Padua, Veneto, Italy*
Plant: *2 x ZE-100-LT ORC modules*
Application: *Primary energy production in connection with a boiler fueled (wood prunings)*

This plant is operated within a **large agritourism facility** located in a small town in the Venetian countryside in the province of Padua, which decided to equip itself with a system capable of **valorizing waste biomass** produced as part of its agricultural activities.

The biomass (consisting mainly of **pruning clippings**) is used to fuel an Ahena Boilers **mobile grate boiler** with a total capacity of 1.6 MWT,.

The heat generated by the above boiler is used both to power t**wo ZE-100-LT organic Rankine cycle modules** supplied by Zuccato Energia and, in smaller quantities, to generate hot water for plumbing uses.

These two ORC modules, mounted - as all Zuccato Energia systems - on **self-contained frames (skids) including all ORC machinery and and control system**, are housed indoors, in a dedicated power plant building.

Operating in parallel, the two ZE-100-LTs modules produce a total of **200 kWE of electricity**, fed to the national power grid according to Italian law, thus **contributing signi cantly to the company's energy balance**.

Cooling for the condensing stage of the ORC module is provided by a simple **evaporative tower** located outside the thermal power plant building. The ORC system is, as always, a closed-loop system and produces no emissions by itself.

As mentioned above, the boiler uses **chipped pruning residues and other woody waste** from the facility as fuel, which are environmentally friendly and renewable resources made competitive for energy production by state and regional incentives.

Like all biomass, such fuel has **zero ecological impact** with respect to CO2 production because as it burns it releases into the atmosphere the same amount of CO2 captured in due course by plants as they grow.

Below and on the opposite page you can find a photo gallery related to this plant.

A general view of the agritourism.

The boiler building hosting the ORCs and the boiler.

The evaporative cooling tower.

The biomass loading hopper.

The boiler in its room behind the ORC modules.

The control panels for the ORCs

The mains grid interface panels.

A detail of the boiler and its ash ÿlter.

The ˜ue g as treatment system and the boiler room

Veneto 04 / Padua: *The two skid-mounted ZE-100-LT Organic Rankine Cycle modules in their room*

Veneto 04 / Padua: *A detail of the ORC skids - the silver cylinder (middle) is one of the turbogenerators*

Calabria 01

Manager: *Private Italian Firm* • ***Location:*** *Province of Cosenza, Calabria, Italy*
Plant: *1 x ZE-175-LT ORC module in indoor configuration*
Application: *Primary energy production in connection with a bolier fed by biomass (prunings)*

The client of this plant is a **licensed waste manager**, which started its activity in the septic purging sector and later evolved to the waste transport and treatment sector, where it now operates on behalf of numerous institutional clients.

The company decided to equip itself with a waste-to-energy system to valorize the **woody biomass** (branches and pruning clippings from state forests) it collects as part of its work in order to eliminate the **economic and environmental costs** of transporting such biomass to a landÿll.

Instead of being transported and disposed of in a landÿll as before, the material is now brought to the company premises, where it is **shredded and burnt in a 1300 kWT moving grate boiler**.

The heat produced by this combustion, captured by a heat exchanger, is then conveyed to a **Zuccato Energia ZE-175-LT Organic Rankine Cycle (ORC) power generation module,** where it vaporizes a special low-boiling organic working ˜uid , which expands spinning the blades of the **turbogenerator** at the core of the ORC, producing up to **175 kWE of electricity**.

This system **is housed indoors** and, like all Zuccato Energia systems, is supplied installed within a **self-supporting frame (skid)** that also includes all ORC machinery, the control panel and the parallel switchboard.

In contrast, components that require more ventilation (e.g., the **cooling tower** for the condensing stage) are located externally.

Untreated virgin wood is an **environmentally friendly and renewable energy source** made competitive for energy production by state and regional incentives, and it has a **minimal environmental footprint** because the CO2 released during combustion is the same as that captured in due course by the plants from which it is derived.

There is also the added environmental beneÿt of **fossil fuel savings and reduced pollution** resulting from on-site processing.

Below and on the opposite page you can find a photo gallery related to this plant.

A bird's-eye view of the client's premises

The biomass storage area

The ORC module skid seen through the shack doors

A detail of the ORC module control panel

The ORC Module; in background, the braking resistors cabinet

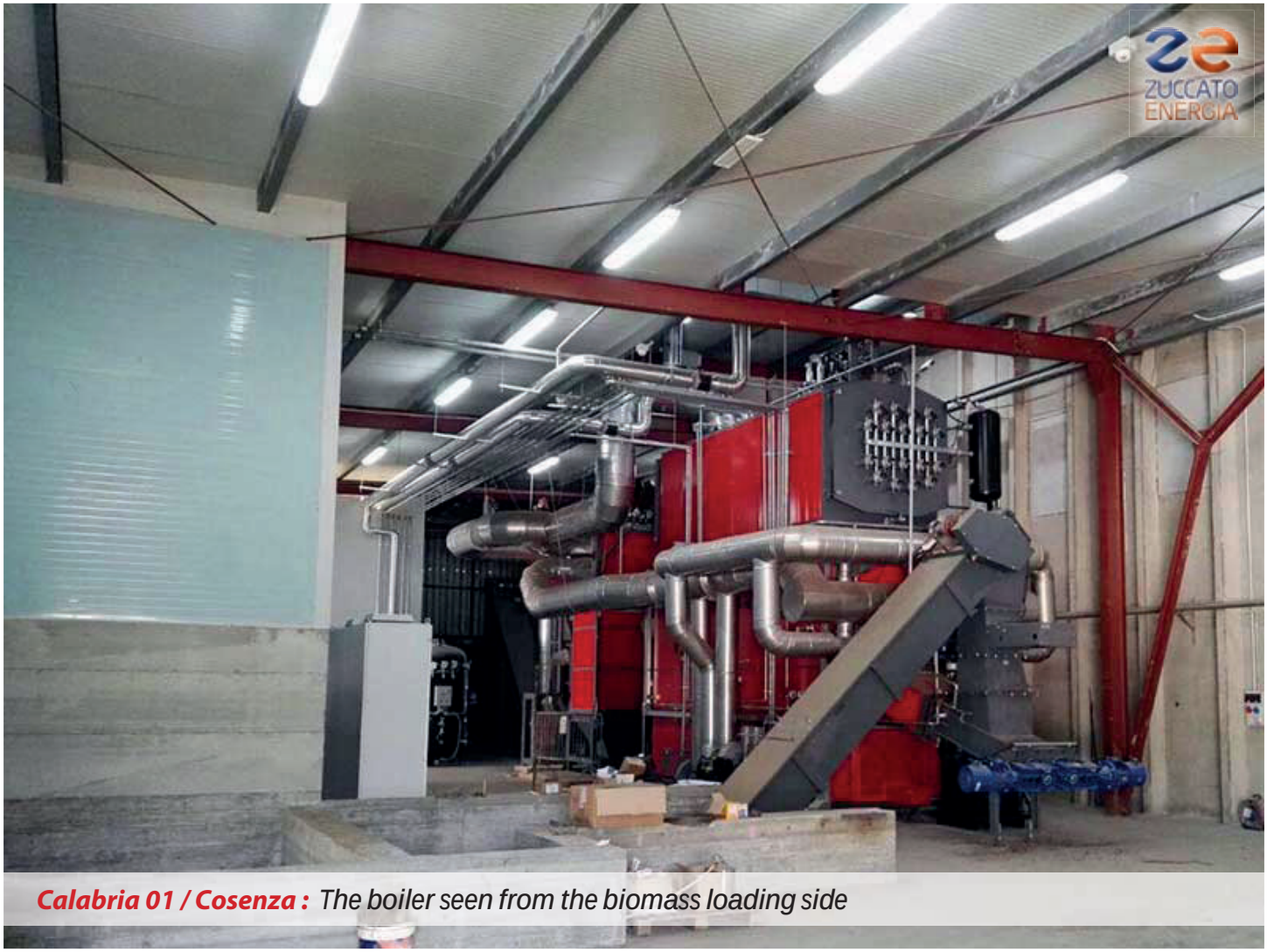
The boiler seen fron the ˜ue g as processing side

The vector ˜uid e xpansion vessel

The cooling tower

The tower base hosts the cooling water treatment system

Calabria 01 / Cosenza : *The ZE-175-LT ORC module in its place, seen from the control panel side*



Calabria 01 / Cosenza : *The boiler seen from the biomass loading side*

Germany 02

Manager: *Private germany Firm* • ***Location:*** *Lower Saxony, Germany*
Plant: *1x ZE-40-ULH LT-ORC energy module in indoor configuration*
Application: *Waste heat recovery from a MAN genset fueled by biogas*

Located in a small town in Germany's Lower Saxony state about 60 kilometers from Bremen, this plant stems from the operator's desire to **increase the e ciency of a thermoelectric micro power plant** based on a biogas-fueled MAN motogenerator in order to take full advantage of **German federal incentives** provided for microgeneration systems powered by renewable sources.

The system supplied by Zuccato Energia consists of a **ZE-40-ULH ORC module, having a nominal power output of 40 kWE**, and operates by **recovering heat from the cooling jackets and fumes of the micro power plant engine**, thus making a signiÿcant contribution to the overall productivity of the plant.

This system **is housed indoors** in a shed in the countryside and, like all Zuccato Energia systems, is supplied installed within a **self-supporting frame (skid)** that also includes all ORC machinery, the control panel and the parallel switchboard. The system is **fully automated and remotely managed**, thus requiring no operator on site.

The above mentioned shed hosts the entire system, including the **motogenerator** and the **ORC skid** with its enclosed machinery and control electronics.

Cooling for the condensing phase is provided by **dry coolers** located - of course - outdoors, just outside the shed.

The **biogas** used to fuel the motogenerator is an **environmentally friendly and renewable energy source** made competitive for energy production by state and regional **incentives**. It has **zero ecological impact with respect to CO2 production** because as it burns it releases into the atmosphere the same amount of CO2 captured in due course by the plants on which the animals fed.

Below and on the opposite page you can find a photo gallery related to this plant.

An overview of the village

The shed where the plant is housed

The entrance door to the shed and the dry coolers serving the condensation stage

The ZE-40-ULH ORC module in place, seen from the control panel side

Germania 02 / Lower Saxony: *The ORC Module seen from the hydraulic connections side*

Germania 02 / Lower Saxony: *The container hosting the biogas-fueled MAN genset*

Sicily 02

Manager: *Private university institution* • ***Location:*** *Province of Enna, Sicily, Italy*
Plant: *1x ZE-50-ULH LT-ORC energy module in outdoor installation*
Application: *Didactic hybrid plant (gas boiler + thermic solar power)*

The young **private university** that commissioned this plant did so in order to equip itself, as part of its engineering faculty, with what is described as an "*experimental prototype subsystem with a modular, di use solar thermodynamic system*" operating as part of a **national research project**.

This plant – the purpose of which is not so much energy production *per se* as the **demonstration of various engineering principles** – combines as a thermal source a series of **solar thermal panels** of the concentrating type with a backup **methane boiler** and was built on a small plot not far from the university.

Zuccato Energia won the contract for the construction of the **entire energy system**, including the hot line (i.e., boiler and heat conveyance systems), cold line (evaporative cooling systems), and energy production module.

The latter is a **Zuccato Energia ZE-50-ULH Low-Temperature Organic Rankine Cycle (LT-ORC)** module mounted, as all of our ORC systems, on a **self-supporting frame (skid)** including **all ORC machinery** and **control electronics**.

In this installation the skid was housed **inside a weatherproof containerized enclosure** and located outdoors, adjacent to the solar panels ÿeld and the boiler.

The thermal energy required to run the plant is **90% supplied by the high-e ciency, low-emission natural gas boiler** produced by ICI Caldaie.

The **solar panels** - PTMx parabolic systems made by Soltigua, already a partner of Zuccato Energia in the RE.EL.COOP European project for the realization of a hybrid (biomass+solar) plant in Tunis - **provide a thermal contribution of about 10%** under peak conditions.

Below and on the opposite page you can find a photo gallery related to this plant.

A satellite view of the faculty, with our plant in the lower right corner.

The solar concentrators; behind them, the cooling tower

A detail of the solar panels, supplied by Soltigua

An overview of the solar concentrators area

Behind the cooling tower, the ORC module, in its weatherproof containerized enclosure

The rear of the tower; in background, the boiler, protected by gridfences, and located under a lean-to

The ICI boiler which supplies most of the thermal energy for the plant.

The pumps which manage the hybrid heating system

The plant commissioning plaque.

Sicily 02 / Enna : *The area housing the concentration-type solar panels*

Sicily 02 / Enna : *Front to back: cooling tower, containerized ZE-50-ULH ORC module, boiler housing*

Sicily 01

Manager: *Private Italian Firm* • **Location:** *Province of Ragusa, Sicily, southern Italy*
Plant: *ZE-175-LT ORC power generation module in indoor installation*
Application: *Power generation from biomass (wood scraps from production of wooden horticultural*

The client of this plant is a major company specializing in the production of wooden packaging for agricultural use (mainly fruit and vegetable crates and pallets), which has decided to monetize its production waste by burning it in a special boiler after reducing it to chips for easier handling and combustion.

The heat thus produced is used to generate electricity through a ZE-175-LT organic Rankine cycle power generation module, supplied by Zuccato Energia and housed inside a small, purpose-built building.

This micropower plant uses a 1300 kWT mobile grate boiler, equipped with a dust suppression system and connected to an ORC system housed, like all Zuccato Energia systems, within a self-supporting frame (skid) that also includes the control panel and parallel switchboard. The braking resistor panel, which needs more ventilation, in this installation is separate and placed near a dedicated ventilation opening.

Cooling for the condensing phase uses an externally located EvapCo evaporative tower.

The fuel used as mentioned above is untreated virgin wood, an environmentally friendly and renewable energy source made competitive for energy production by state and regional incentives. It has zero ecological impact with respect to CO2 production because as it burns it releases into the atmosphere the same amount of CO2 captured in due course by the plants from which it is derived.

Below and on the next pages you can find a photo gallery related to this plant.

An aerial overview of the site.

The ZE-175-LT skid being tested before shipping in Zuccato Energia's test area

The skid being loaded on the truck for shipping to Sicily

A general view of Ortoimballaggi's wide loading area.

Part of the warehouse. The client is a leader ÿrm in the production of agricultural packaging

Part of the production line. Only quality, untreated virgin wood is used.

The wooden scraps destined to become fuel for the boiler

The chipping machine reduces the scraps in fast-burning small wooden chips

IWood chips being taken for loading in the boiler's fuel hopper.

The building which hosts the ORC module. Behind, a glimpse of cooling tower and chimney.

A detail of the ORC building. The skid may be glimpsed through the open door

The ZE-175-LT Organic Rankine Cycle energy module, seen from the right side.

The ZE-175-LT ORC module in its skid, seen from the left side.

The 1300-kWT movable grate boiler, fueled by wooden chips.

R to L: boiler, dust trap and and ˜ue gas treatment system

The dust trap. Wood burns cleanly, requiring only minimal ˜ue g as treatment

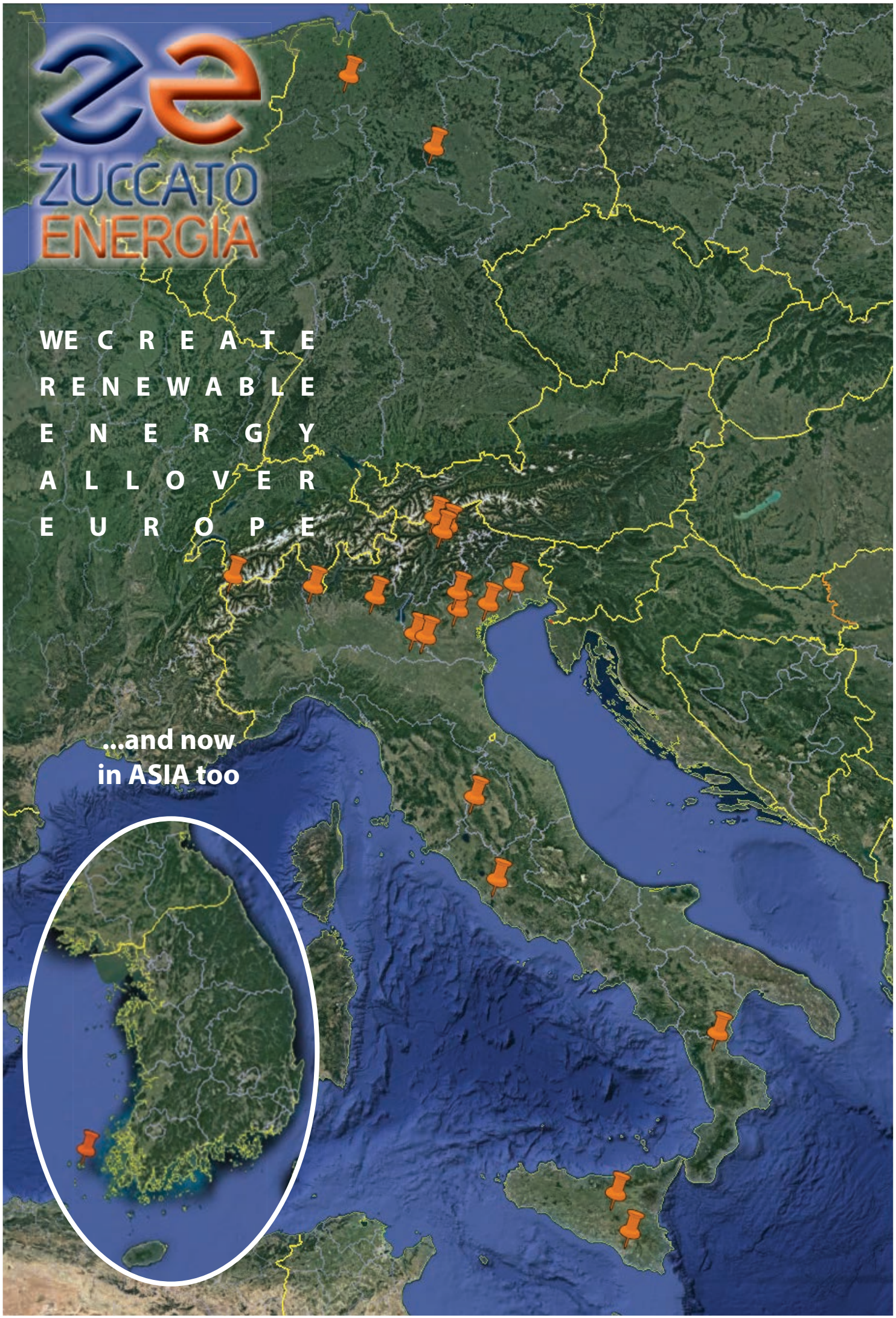
The wood chips loading screw which brings fuel to the boiler

The cooling tower which dissipates the excess heat of the ORC condensation stage

Sicilia 01 / Ragusa : *The ORC system being tested in Zuccato Energia's Test Area*

Sicilia 01 / Ragusa : *The ORC ZE-175 LT module on site at the customer's premises, viewed from the right side.*

Sicilia 01 / Ragusa : *The 1.3MWt moving grate boiler , fed with wood chips (fruit crate production waste)*


ZUCCATO
ENERGIA
WE CREATE
RENEWABLE
ENERGY
ALL OVER
EUROPE
...and now
in ASIA too

Lombardy 01

Manager: *Private Firm* • **Location:** *Province of Varese, Lombardy, Italy*
Plant: *1 organic Rankine cycle (ORC) module mod. ZE-100-LT, power 100 kWE (nom.).*
Application: *Electricity generation from biomass-ÿred boiler (Waste from sawmill activity)*

A sawmill in the Varese area, the client of this plant, decided to convert its processing waste, consisting of wood fragments and bark, into energy by shredding it in a special machine to make it more easily handled and combustible and then burning it in a moving grate boiler that provides a continuous flow of superheated water to an Organic Rankine Cycle (ORC) module for energy production supplied by Zuccato Energia.

The system provided by Zuccato Energia is an ORC module model ZE-100-LT that operates by taking thermal energy directly from the boiler via a superheated water loop.

The 'use of such an environmentally friendly carrier liquid significantly increases the safety of the system compared to systems that use diathermic oil for this function, which in the face of fractionally better efficiency has the drawback of environmental toxicity and flammability.

Mounted-as in all Zuccato Energia systems-on a self-supporting frame (skid), the ORC module is housed outdoors under a large canopy. A peculiarity of this installation is that given the system's location in a semi-residential area, it has been enclosed in a sound-absorbing enclosure to virtually zero its already low noise emissions.

A further special feature of the system is the reuse of waste heat dissipated in the condensation phase to dry the wood chips destined for the boiler so as to increase their calorific value. The electricity produced is, as usual, fed into the national distribution grid.

The wood chips used as fuel in this installation-because they are derived from untreated virgin wood that has undergone purely mechanical processing-are considered biomass for all intents and purposes and therefore constitute a renewable energy source.

Below and on the opposite page you can find a photo gallery related to this installation.

Aerial view of the farm; right, the canopy under which the plant is housed

The ZE-100-LT skid as it is being loaded for shipment

The skid during installation in the soundproof enclosure.

The sound-absorbing enclosure when completed.

From left to right: the wood chip storage (green), the waste hopper (red),

Detail of the conveyor between the chipper and the woodchip yard

Detail of the wood chip conveyor to the boiler. On the bottom the skid.

Detail of thermal connections to the boiler, fully insulated

The cooling tower: some of the waste heat is used to dry the wood chips.

Lombardy 02 / Varese : *Plant overview: ORC module (white), boiler (red) , wood chip storage and loading (green)*

Lombardy 02 / Varese: *The ORC module in its sound-absorbing enclosure (L) and the moving grate boiler (R)*

Germany 01

Manager: *Private Firm* • ***Location:*** *Harz District, Saxony-Anhalt, Germany*
Plant: *1 organic Rankine cycle (ORC) module mod. ZE-50-ULH, power 50 kWE (nom.).*
Application: *Heat recovery from engine (Genset powered by biogas)*

This plant is located in the **Harz district of the state of Saxony-Anhalt**, in Germany.

Its purpose is to **upgrade the efficiency of a thermoelectric micro power plant** based on a **biogas-fueled MAN genset**, which benefits from federal incentives provided for microgeneration systems powered by renewable sources.

The system supplied by Zuccato Energia consists of a **ZE-50-ULH ORC module** with a **nominal electric output of 50 kWE** and operates by carrying out **heat recovery from the cooling jackets and fumes** of the micro power plant engine, thus making a significant contribution to the overall productivity of the plant.

The ORC system used in this installation is **entirely housed inside a small freestanding precast concrete building** located by the side of a road in a craft area.

Plant operation is fully automated and remotely managed, without the need for an on-site operator.

The small prefabricated building houses **the whole thermoelectric plant**, including the **genset**, the ORC module in its **self-supporting frame (skid)** incorporating all of the ORC machinery and control electronics, as well as an **air-conditioning system** for the switchboard and electronics part.

Cooling for the condensation phase is provided by a **dry cooler** placed on the roof of the building.

The **biogas** which fuels the motogenerator is produced by fermentation of manure and as such is an **environmentally friendly and renewable energy source** made competitive for energy production by state and regional incentives. It also has **zero ecological impact with respect to CO2 production** because as it burns it releases into the atmosphere the same amount of CO2 captured in due course by the plants on which the animals fed.

Below and on the opposite page you can find a photo gallery related to this installation.

The plant in a satellite photo.

The plant as seen from the main road

The east side of the prefab.
On the roof, the dry cooler of the condensation stage.

The west side of the facility with the access doorand

The skid seen from the access door

The ORC ZE-50-ULH skid in place inside the building.

The same skid during shipment from the Zuccato Energia plant

The back (south) side of the plant

A detail of the dry cooler placed on the roof

Germany 01 / Saxony-Anhalt: *The west side of the plant with the access door*

Germany 01 / Saxony-Anhalt : *The ORC ZE-50-ULH skid in place inside the building.*

Friuli 01

Manager: *Private Firm* • ***Location:*** *Province of Pordenone, Friuli-Venezia Giulia, Italy*
Plant: *1x ZE-150-LT Organic Rankine cycle (ORC) power generation module.*
Application: *Primary production of electricity from poultry-fired boiler*

Raising broiler chickens is the core business of the **large poultry company** that commissioned Zuccato Energia to build this plant.

This ÿrm had the problem – common to many poultry farms – of **disposing of the so-called "pollina" (poultry manure)** produced by the raised animals, as that material has a nitrogen content so high as to impose **legal limitations** to the amount which can be used as a fertilizer.

They managed to solve that quandary thanks to a **specially designed boiler** that serves as a heat source for a **Low-Temperature Organic Rankine Cycle (LT-ORC) system** supplied by Zuccato Energia.

The ORC module **converts that heat into electricity**, which is then fed into the national power grid at the advantageous **all-inclusive tari** provided by the Italian state for newly built energy systems powered by renewable sources.

The ORC module is a ZE-150-LT system, with a **nominal power output of 150 kWE** (depowered to 140 kWE at the customer's request) and operates by **taking thermal energy directly from the boiler** via a superheated water loop. As usual, the module was supplied mounted on a **self-supporting frame (skid)** incorporating all of the ORC machinery and control electronics. Housed in a dedicated room, its operation is **fully automated and remotely controlled, requiring no operator on site**.

Due to the customer's need for a low-voltage connection, **the inverter panels were not installed on board the skid** as in the standard model, but housed in external cabinets. An additional peculiarity of the system is the use of an **air cooling system (dry cooler)** instead of the traditional water evaporative tower for cooling in the condensing phase.

"Pollina" (a mix of poultry droppings, feathers, feed and bedding) **is considered as biomass** by Italian law and therefore can be used a **renewable energy source**, giving access to the incentive mechanisms for renewable electricity provided by law.

Below and on the following pages you can ÿnd a photo gallery related to this plant.

Company overview

The storage of fuel (poultry manure)

The boiler (left) and the ˜ue g as treatment plant

The ˜ue g as treatment plant with the cover removed To show the ÿlter cyclones

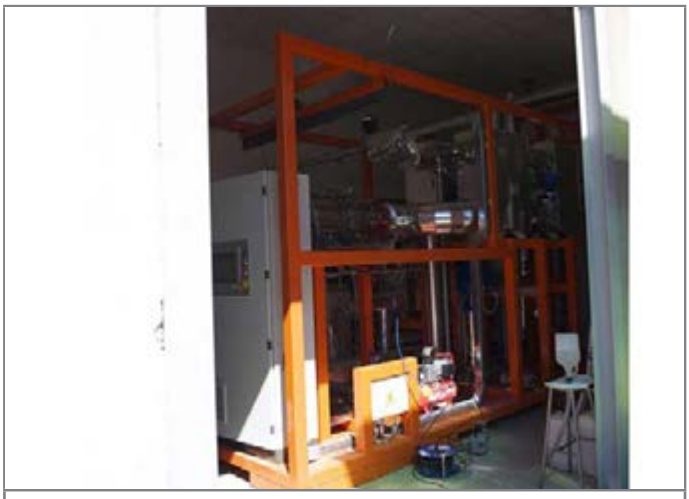
Fuel loading hopper and chimney

General view of the fuel loading auger

A detail of the loading auger and burner

General view of the dry cooler

A detail of the dry cooler



General view of the ZE-150-LT module in its shelter

The ORC ZE-150-LT system in detail with the turbine in the foreground

The 150 kWE turbine of the ZE-150-LT system.

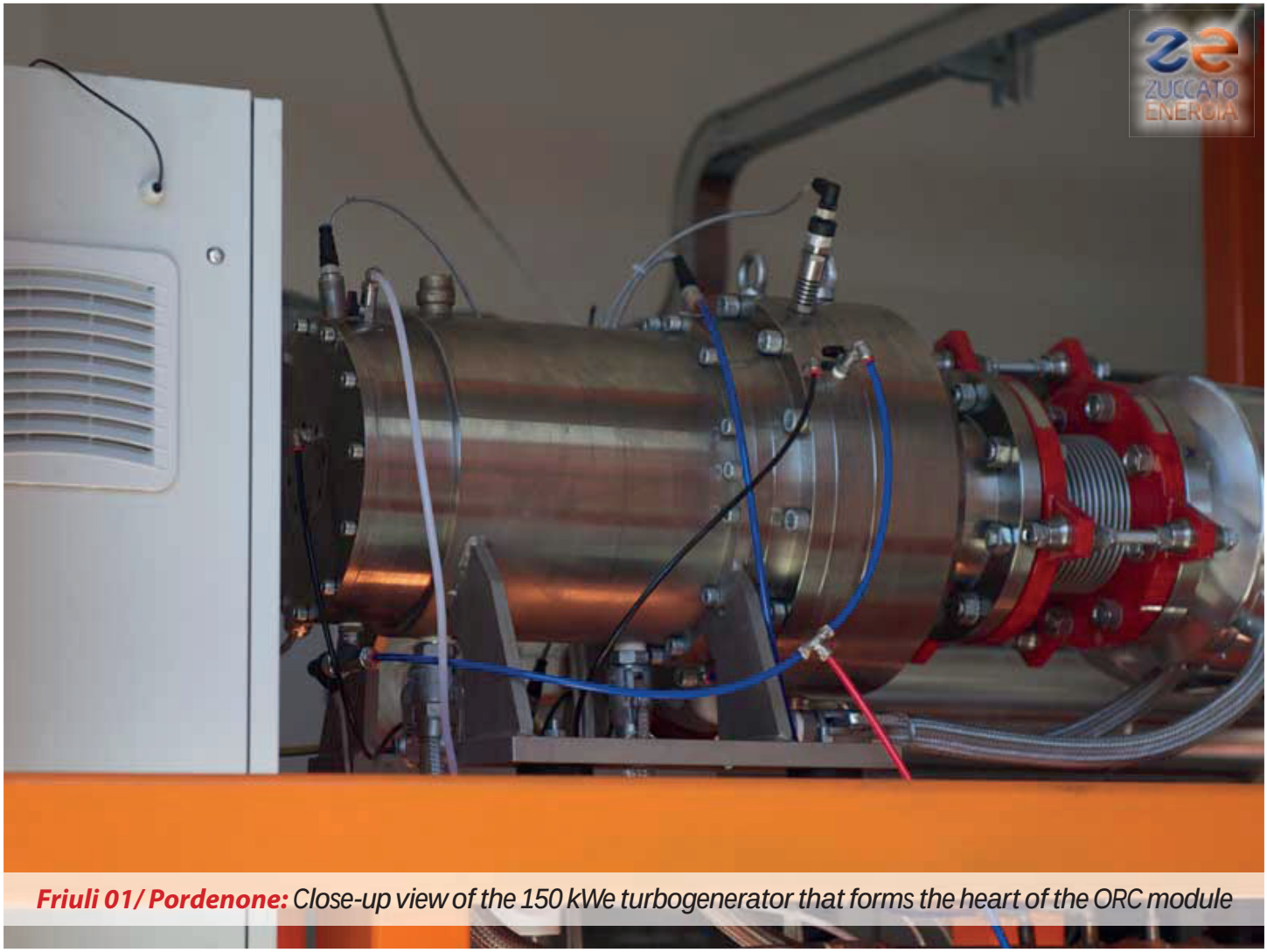
The ORC skid control panel

Friuli 01 / Pordenone: *The fuel loading hopper (right) and the chimney with its ue gas treatment system.*

Friuli 01 / Pordenone: *The manure- red moving grate boiler(left) and the ue gas treatment system.*

Friuli 01 / Pordenone: *General view of the dry cooler dissipating condensing heat from the ORC module*

Friuli 01 / Pordenone: *A detail of the turbine and heat exchangers of the ORC module*



Friuli 01/ Pordenone: *Close-up view of the 150 kWe turbogenerator that forms the heart of the ORC module*

Aosta 01

Manager: *Private Firm* • ***Location:*** *Valle d'Aosta, Italy*
Plant: *1 x ZE-50-ULH Organic Rankine cycle (ORC) power generation module*
Application: *Thermal recovery from engine (vegetable oil-fueled Daewoo genset)*

The client of this plant is a **hotel** located in the mountains of Val d'Aosta, on the road from Aosta to Courmayeur.

The plant is a **thermoelectric micropower plant** that was born from the desire to take advantage of the **incentives** provided by the Italian state for newly built energy plants powered by biomass or renewable sources.

The ORC system provided by Zuccato Energia for such a micro power plant consists of **a ZE-40-ULH Organic Rankine Cycle (ORC) module** - that is, a normal ZE-50 ULH depowered from 50 to 40 kWE to take advantage of the reduced thermal power available.

The system **recovers heat** from the **cooling jackets and exhaust fumes** of a **420 kWE genset** based on a single Doosan Daewoo engine modiÿed to run on **vegetable oil or animal fats.**

Zuccato Energia, as a manufacturer, has been able **to modify the frame (skid)** on which this system is mounted, **reducing its size** thus allowing the system to be installed in a **small underground space** that otherwise would have been insufficient to accommodate either standard Zuccato Energia or other manufacturers' ORC systems.

The **biofuel** used to fuel the genset (EU-sourced **rapeseed oil** from a certified and tracked supply chain) is an **environmentally friendly and renewable energy source** made highly competitive for energy production by state and regional incentives.

All produced electricity is fed into the **national distribution grid**; the installation, like all biomass installations, has **zero-impact as far as CO2 is concerned** since the one released by combustion is the one captured by the plants during growth.

Below and on the opposite page you can find a photo gallery related to this installation.

The hotel façade

Hotel back with the thermal power plant under construction

Interior view of the thermal power plant

Overview of the vegetable oil engine

The vegetable oil engine in more detail

The thermal storage tank and the ORC module

General view of the ORC ZE-40-ULH module from the control panel side

The ORC ZE-40-ULH module in greater detail

The cooling tower, housed in an underground room with a grid ceiling

Aosta 01 / Aosta: *General view of the boiler room - motor (green), thermal bu er (red) and ORC module (white)*

Aosta 01/ Aosta: *The ORC ZE-40-ULH module in greater detail.*

South Tyrol 04

Manager: *Private Firm* • ***Location:*** *Province of Bolzano / Bozen, South-Tyrol,Italy*
Plant: *2 x ZE-50-ULH Organic Rankine cycle (ORC) power generation modules*
Application: *Thermal recovery from engine (MAN 420 genset powered by vegetable oil)*

The owner of this plant is a **well-known construction company** based in a small town in the mountains behind Bolzano.

Like others in the area, the plant is **a thermoelectric micropower plant fueled by vegetable oil**, created to exploit government incentives for microgeneration based on biomass and renewable sources.

The system supplied by Zuccato Energia – consisting of **two ZE-50-ULH Organic Rankine Cycle (ORC)** power generation modules with a capacity of **50 kWE each** – **recovers heat from the cooling jackets and ue gases of two MAN 420 gensets** of 420 kWE each, fueled by rapeseed oil.

The addition of the ORC module **has increased overall plant productivity by more than 10 percent**, raising it from 840 to 940kWE.

An interesting detail of this ORC plant is that **the skids on which it is mounted have been customized** by making them narrower and longer than traditional skids to make better use of the reduced space available.

The electricity produced is fed into the national distribution grid while the **residual thermal energy** from the condensing stage is used to **heat the farm facility**, water and concrete plant or **given to the district heating system** when needed.

The **biofuel** used (EU-sourced **rapeseed oil** from a certiÿed supply chain) is an **environmentally friendly and renewable energy source**, made competitive by state and regional incentives, and is also **CO2-neutral** as the carbon dioxide released by its combustion is the same that was in due time captured by the rapeseed plants during growth.

Below and on the opposite page you can find a photo gallery related to this installation.

The company's main entrance

Overview from the company yard

One of the two customized ZE-50-ULH modules is unloaded from the truck

The cooling towers, located at the back of the building.

South Tyrol 04 / Bozen: *The first of the two ZE-50-ULH ORC modules on its custom skid during installation.*

South Tyrol 04 / Bozen: *The complete ORC installation modules flanked by the motors it recovers heat from.*

Lazio 01

Manager: *Private Firm* • ***Location:*** *Province of Rome, Lazio, Italy*
Plant: *1 x ZE-50-ULH Organic Rankine cycle (ORC) module*
Application: *Heat recovery from processes (wood pyrogasification) and engines (syngas-fired)*

A **large multiplex cinema** with adjoining shopping arcade located in the province of Rome is the site of this plant.

There, two **Burkhardt gasi ers produce fuel gas (syngas)** through the pyrolysis of wood pellets; **that syngas is then used to fuel two 180kWE gensets based on specially modi ed MAN engines** connected to electric generators having a total output of 360kWE.

The ORC module we supplied draws thermal power from both the **gasi ers**, (**heat produced by the pyrolysis process**, otherwise lost in the outgoing gases), and the **gensets** (**cooling jackets** and **waste heat** contained in the **ue gases**).

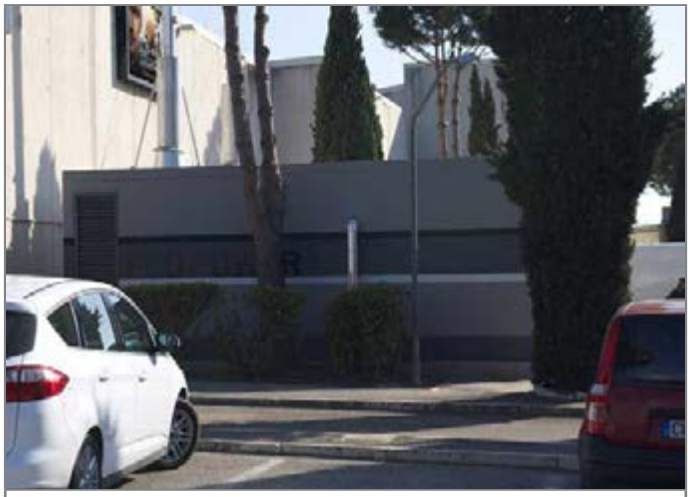
The plant supplied by Zuccato Energia - consisting of **a standard ZE-50-ULH module** - adds an additional 45 kWE to the 360kWE fed into the grid by the above-mentioned plant, **bringing the total power fed into the grid to 405 kWE** and realizing a **performance increase of about 9 percent** over the "naked" system.

The ORC module skid used in this installation **is a standard, "off-the-shelf" model**, mounted as usual on a **self-supporting frame (skid)** incorporating all of the ORC machinery and control electronics. Due to its **compactness**, relative **quietness, and** its **fully automated operation and remote management requiring no operator on site**, it was possible to install it in a technical space located **under the cinema itself**, while gasifiers, motors and cooling tower were located outside.

The gasifiers transform **biomass**, in this case **locally produced wood pellets**. So, like all biomass-fueled plants, this installation is **carbon-neutral** as the CO2 released from combustion is equal to that captured by the plants as they grow.

Below and on the opposite page you can find a photo gallery related to this installation.

General aerial view of the complex



Side detail of Burkhardt cogenerators

The cogenerators and the cooling tower (blue, right)

The gasiÿer room with ash discharge in the foreground

Lazio 01 / Roma: *The ORC module in its underground room located under one of the movie theaters.*

Lazio 01 / Roma: *The ZE-50-ULH ORC module viewed from the heat exchanger side*

South Tyrol 03

Manager: *Private Firm* • ***Location:*** *South Tyrol, Italy*
Plant: *1 x ZE-50-ULH Organic Rankine cycle (ORC) power generation module*
Application: *Heat recovery from processes (wood pyrogasification) and engines (syngas-fueled)*

The client who commissioned this plant is a **special-purpose company** based near Merano, dedicated to the production of electricity from renewable sources, established as a **technology demonstrator** of Burkhardt gasiÿcation technology in association with an ORC system.

In fact, the plant to which our ORC system is connected consists of **two Burkhardt gasi ers** that produce combustible gas (syngas) through the gasiÿcation of wood pellets; the syngas thus produced goes to feed two **specially modi ed MAN engines** connected to electric generators for a total output of **360kWE**.

The Organic Rankine Cycle system **draws thermal power from both the gasi ers** (heat from the gasiÿcation process otherwise lost in the outgoing gases) **and the motogenerators** (heat otherwise lost from the cooling jackets and ˜ue gas).

The system supplied by Zuccato Energia consists of a standard **ZE-50-ULH** module and **adds an additional 45 kWE to the 360 kWE already fed into the grid** by the aforementioned installation, bringing the total power fed into the grid to 405 kWE and realizing **a performance increase of about 9 percent** over the "bare" system. The skid used in this installation is a **standard model**, and due to its **compactness** it was possible to install it in the same technical space used for the gasiÿers and engines.

The fuel used by the gasiÿers (locally produced **wood pellets**) has a **zero carbon footprint** as the carbon dioxide released by combustion is the same that was in due time captured by plants during growth.

Below and on the opposite page you can find a photo gallery related to this installation.

A general view of the complex

The skid seen from the hydraulic connections side

An overview of the Burkhardt gasiÿers

Internal perspective of the plant

South Tyrol 03 / Meran: *The ZE-50-ULH ORC module at the customer's site, viewed from the side.*

South Tyrol 03 / Meran: *One of the gasi ers from which the ORC module recovers thermal waste.*

Veneto 03

Manager: *Local municipal corporation* • ***Località:*** *Province of Venice, Veneto, Italy*
Plant: *1 x ZE-50-ULH Organic Rankine Cycle (ORC) power generation module.*
Applicazione: *Thermal rec. from engines (hot air turbines) / Prod. from biomass (pruning clippings)*

The developer of this plant is **one of the largest multi-utility municipal companies** in Italy. It is a wholly publicly owned company, owned by a consortium consisting of about ÿfty municipalities in the Veneto region, whose main activity is to provide **environmental, water and energy services** to its entire catchment area.

The system is installed at that entity's management and operations center in the province of Venice, on the Venetian mainland.

The thermal source of the system consists of **two biomass boilers** capable of generating a total thermal output of about 1.3 MWT. This thermal energy, in addition to being used for ambient heating and domestic hot water production, can be used in **two alternative modes**:

In the rst mode, the heat produced by the boilers goes to drive two Turbec hot-air turbogenerators capable, under optimal conditions, of feeding a total electrical power of about 160 kWE into the grid. In this mode, the ORC module we supplied – a standard **ZE-50-ULH** module – r**ecovers heat from the cooling jackets of the turbines**, adding an additional 50 kWE to the power fed into the grid by the plant, **realizing a performance increase of more than 30 percent** over the "bare" system.

In the second mode – which is activated when there are no conditions to put the turbines into operation – the **thermal energy from the boilers is instead piped directly to the ORC system**, which feeds its nominal **50 kWE** into the grid.

The skid used in this installation is a **standard model for indoor installation**, and because of its **compactness** it was possible to install it in a pre-existing technical space (a steel grating mezzanine) within the same building that houses boilers and turbines.

The electricity produced by the system in both modes is fed into the grid and helps make the complex energy self-su˝cien t along with an existing photovoltaic system.

The **thermal energy** from the system, as mentioned above, is used to **heat the various buildings** that make up the management and operations center itself via a small local district heating network.

The boilers burn **biomass** – **virgin wood chips** from local environmental activities and **forestry pruning** collected by the municipal utility itself as part of its institutional public green management activities. This fuel, as all biomass, has **zero environmental impact** since the CO2 released from combustion is equal to that captured by plants as they grow.

Below and on the opposite page you can ÿnd a photo gallery related to this installation.

Entrance to the facility

The building housing the system

The mezzanine hosting the ZE-50-ULH system

The ORC system from above

A side view of the ORC system

A detail of one of the Turbec hot air turbines

Veneto 03 / Venice ***The ORC ZE-50-ULH module on site at the customer's premises, seen from above.***

Veneto 03 / Venice: ***A detail of the heat exchangers of the ZE-50-ULH organic Rankine cycle module.***

South Tyrol 02

Manager: *Società privata* • ***Location:*** *Province of Bolzano/Bozen, South Tyrol, Italy*
Plant: *1 x ZE-50-ULH Organic Rankine cycle (ORC) power generation module*
Application: *Thermal recovery from engines (MAN genset powered by vegetable oil).*

The client of this plant, a company specializing in the **rental of special vehicles** based in the province of Bolzano, has equipped itself with a **thermoelectric micro power plant** capable of taking advantage of the favorable all-inclusive tari¸ provided by the Italian state for newly built energy plants powered by biomass or renewable sources.

The system supplied by Zuccato Energia consists of a **ZE-50-ULH Organic Rankine Cycle (ORC) module** with a nominal electrical power output of **50kWE** that performs **heat recovery from the cooling jackets and exhaust fumes of a motogenerator** (genset) consisting of a MAN 420 model 2842 LE 211 engine powered by vegetable oil connected to a 420 kWe generator.

The connection of the ORC module **increases the overall productivity of the plant by more than 10 percent.**

The MAN engine used in the genset is, as in many other projects of this kind, a **marine engine** normally fueled by heavy oil specially **modi ed to burn vegetable oil**, typically rapeseed oil, an EU-sourced fuel from certiÿed environmentally friendly and renewable supply chain made highly competitive for energy production by state and regional incentives.

Like all biomass-derived fuels, **vegetable oil is "CO2-neutral"** in that the CO2 released from its combustion is that at its time captured by plants as they grow.

Below and on the opposite page you can ÿnd a short photo gallery related to the installation.

A view of the ÿrm from the main gate

The plant control panels

The ORC module at the headquarters

The vegetable oil tanks during installation.

South Tyrol 02 / Bozen: *The plant control room as seen from inside.*

South Tyrol 02 / Bozen: *The ZE-50-ULH module in its housing.*

Veneto 02

Manager: *Private Firm* • ***Location:*** *Province of Padua,Veneto, Italy*
Plant: *1 x ZE-50-ULH Organic Rankine Cycle (ORC) power generatiom module*
Application: *Heat recovery from engines (2 x Genset MAN powered by biogas from fermentation)*

Raising cattle is the core business of this ÿrm, which commissioned this plant after deciding to equip itself with **a biogas production system** fueled by the fermentation of the slurry produced by their numerous heads of cattle.

The biogas produced by the fermenters goes to feed a **thermoelectric micro power plant** based on **two motogenerators** (gensets) powered by MAN engines, which beneÿts from the favorable **all-inclusive tari** provided by the Italian state for newly built energy plants powered by renewable sources.

The system provided by Zuccato Energia, consisting of a **ZE-50-ULH module** with a nominal power output of **50 kWE**, **recovers the heat otherwise lost from the cooling jackets and fumes of the micro power plant's motors**, thus making a signiÿcant contribution to the overall productivity of the 'plant.

In this installation, our skid-mounted ORC module i**s housed outdoors under a canopy**. At the customer's request, the control panel, was mounted **inside an existing container** that also houses the control panels for the motogenerators and fermentation system instead of on board the skid as usual.

This installation uses an **ingenious solution for cooling**. In fact, **the cooling water** - potable but extremely cold as it comes from a local well - after passing through the exchangers is simply **fed as drinking water to the livestock**, thus preventing the latter from the gastrointestinal problems resulting from ingesting water that is too cold. All this is done in **complete safety**, as the **food-grade stainless steel** walls of our condenser exchangers **do not give rise to any contamination.**

The fuel used (biogas) is an e**nvironmentally friendly and renewable, incentivized and "CO2-neutral" energy source** since as it burns it releases the same amount of CO2 captured in due course by the plants on which the animals have been feeding.

Below and on the opposite page you can ÿnd a photo gallery related to the installation.

Aerial view of the company

The ORC skid being unloaded at the site

Side view of the plant

The container housing the control panels

Detail of the 50 kWE turbogenerator

The cooling towers for the condensing stage.

The ORC system under its awning

An overview of the plant from the North side

Panorama of the plant from the South side

Veneto 02 / Padua: *The ORC module (orange) with its terminal block (white) and the containerized control room*

Veneto 02 / Padoua: *The ZE-50-ULH Organic Rankine Cycle module seen from the front.*

Lombardy 01

Manager: *Private Firm* • ***Location:*** *Province of Mantua, Lombardy, Italy*
Plant: *1 x ZE-50-ULH Organic Rankine cycle (ORC) power generation module*
Application: *Heat recovery from engines (1 x Jenbacher genset fueled by fermentation biogas)*

The operator of this plant is a **livestock company** that specializes in **raising pigs,** and has decided to equip itself with a **biogas production system** fueled by fermentation of the slurry produced by the numerous animals they raise.

The biogas produced by the fermenters goes to feed a **thermoelectric micro power plant** based on a 637 kW Jenbacher engine, which benefits from the favorable **all-inclusive tariff** provided by the Italian state for newly built energy plants powered by renewable sources.

The system supplied by Zuccato Energia, consisting of a **ZE-50-ULH** module with a nominal power output of **50kWE**, operates by carrying out heat recovery from the cooling jackets and fumes of the micro power plant engines, thus making a significant contribution to the overall productivity of the plant.

The ORC system used in this installation is **entirely housed in an ad hoc container placed outdoors**. That container, **compact** in size (4.2 x 1.5 x h 3.1m), is **entirely weatherproof and houses the entire system**, including turbine, secondary exchangers, and control panel, as well as an automatic air conditioning system to prevent overheating of the electronics part in the summer months. Cooling for the condensation phase is provided by an EvapCo **evaporative tower** located alongside the container.

The fuel used by the motogenerator (**biogas**) is an **environmentally friendly and renewable energy source** made competitive for energy production by state and regional incentives. **It is CO2-neutral** in that as it burns it releases into the atmosphere the **same amount of carbon dioxide** captured in due course by the plants on which the animals fed.

Below and on the opposite page you can ÿnd a photo gallery related to the installation.

General view of fermentation tanks

The slurry loading auger

A glimpse of the container housing the ORC system

The right side of the containerized ORC module.

Lombardy 01 / Mantua: *Overview of fermenters, motors and containerized ORC ZE-50-ULH module.*

Lombardy 01 / Mantua: *The weatherproof containerized ORC module and, behind it, the cooling tower.*

Veneto 01

Manager: *Private Firm* • ***Location:*** *Province of Venice, Veneto, Italy*
Plant: *1 x ZE-50-ULH Organic Rankine cycle (ORC) power generation module*
Application: *Heat recovery from engines (1 x Jenbacher genset fueled by fermentation biogas)*

The farm responsible for the management of this plant, located in the Venetian region of Italy, is a **livestock farm** specializing in cattle breeding, and has decided to equip itself with a **biogas production system** fed by the fermentation of the slurry produced by the numerous animals raised.

The biogas produced by the fermenters goes to feed a **thermoelectric micro power plant** based on a 637 kW Jenbacher engine, which benefits from the favorable **all-inclusive tariff** provided by the Italian state for newly built energy plants powered by renewable sources.

The system supplied by Zuccato Energia, consisting of a **ZE-50-ULH Organic Rankine Cycle module** having a nominal power output of 50 kWE, generates electricity through **heat recovery from the cooling jackets and fumes of the micro power plant's engines**, thus making a significant contribution to the overall productivity of the plant.

The ORC system used in this installation is **entirely housed in an ad hoc container placed outdoors.** That container, compact in size (4.2 x 1.5 x h 3.1m), is entirely **weatherproof** and **houses the entire system**, including turbine, secondary exchangers, and control panel, as well as an **automatic climate control system** for the electronic part. Cooling for the condensation phase is provided by an EvapCo **evaporative tower** located near the container housing the ORC module.

The fuel used by the motogenerator (biogas) is an **environmentally friendly and renewable energy source** made competitive for energy production by state and regional incentives. **It is "carbon-neutral"** in that as it burns it releases into the atmosphere the same amount of CO2 captured in due course by the plants on which the animals fed.

Below and on the opposite page you can ÿnd a photo gallery related to the installation.

Overview of the plant and one of the stables

The plant as seen from one of the stables

One of the fermenters with its loading auger

The container housing the biogas engine

The ORC module from the control panel side

The ORC module from the control panel side

The ORC module from the control panel side

The cooling tower of the condensing stage

The entire plant as seen from the back

Veneto 01 / Venice: *The ORC module in its weatherproof container (left) and the cooling tower (right)*

Veneto 01 / Venice: *An overview of the entire facility from the rear side.*

South Tyrol 01

Manager: *Private Firm* • ***Location:*** *South Tyrol, Italy*
Plant: *1 x ZE-50-ULH Organic Rankine cycle (ORC) power generation module*
Application: *Thermal recovery from engines (1 x MAN genset powered by vegetable oil)*

The operator of this plant, located in a small municipality south of Bolzano, is a **small-to-medium enterprise that has equipped itself with a thermoelectric micropower plan**t in order to take advantage of the favorable **all-inclusive tariff** provided by the Italian state for newly built energy plants powered by biomass or renewable sources.

The system provided by Zuccato Energia consists of a single **ZE-50-ULH Organic Rankine Cycle module** with a nominal power output of 50 kWE mounted as usual, on a **self-supporting frame** (skid) that houses all the main components of the module itself.

In this installation, the ORC module works by performing **heat recovery from the cooling jackets and flue gas** of the 420 kWE genset based on a MAN 420 model 2842 LE 211 engine **fueled by vegetable oil** on which the micro power plant is based, **increasing the overall productivity of the plant by more than 10%.**

The **biofuel** used (EU-sourced rapeseed oil from certified supply chain) is an **environmentally friendly and renewable energy source** made highly competitive for energy production by state and regional incentives. The oil is burned in **heavy oil marine engines** converted to use the new fuel and use the mechanical energy produced to drive electric generators.

Like all biomass, such fuel is **CO2-neutra**l because the CO2 released from combustion is the same that was in due time **captured by plants** during growth.

Below and on the opposite page you can ÿnd a photo gallery related to the installation.

The ZE-50-ULH skid is unloaded.

The ZE-50-ULH skid being unloaded

The ZE-50-ULH skid being unloaded

The structure that houses the skid

South Tyrol 01 / Bozen: *The vegetable oil engine (L) and the ZE-50-ULH module (R) in their concrete shelter.*

South Tyrol 01 / Bozen: *A detail of the ZE-50-ULH Organic Rankine Cycle module in its room.*

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