DELIVERABLE D6.4
ORC USER'S MANUAL INCLUDING INSTALLATION PROCEDURE

WP6: DEMONSTRATION OF ELECTRICITY AND THERMAL POWER GENERATION

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V4	24/04/2019	Final approval	GENTER / ESG

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1 EXECUTIVE SUMMARY

1.1 DESCRIPTION OF THE DELIVERABLE CONTENT AND PURPOSE

The WP6 is intended to demonstrate the feasibility of generating electricity in various geothermal environments. The deliverable 6.4 is an operating manual for ORC modules which are equipment that convert thermal power into electricity. The purpose of this document is to provide to the final user the necessary technical elements for a good use of the different ORC units. This deliverable is complementary to deliverable 6.3 – 3 ORC units ready to be shipped.

1.2 BRIEF DESCRIPTION OF THE STATE OF THE ART AND THE INNOVATION BREAKTHROUGHS

The conversion of heat into electricity on geothermal sites is already very advanced. Today, there are more than 100 ORC installations on geothermal sites. The temperature ranges of valorized geothermal resources are generally in the range of 100-220°C. However, the potential of electricity generation using low temperature geothermal resources (70-100°C) is clearly neglected.
The innovation in this project is to produce electricity from geothermal resources at low temperatures while offering a manufacturing cost to have a competitive ROI.
In addition, the project is also focusing on the heat exchanger material selection. The heat exchanger must deal with a corrosive geothermal environment.

1.3 CORRECTIVE ACTION (IF RELEVANT)

N/A

1.4 IPR ISSUES (IF RELEVANT)

N/A

2 DELIVERABLE REPORT

2.1 DISCLAIMER

READ CAREFULLY AND BE SURE TO THOROUGHLY UNDERSTAND ALL THE INFORMATION PROVIDED IN THESE INSTRUCTIONS BEFORE DESIGNING AND, IN ALL CASES, BEFORE CARRYING OUT ANY HANDLING, UNPACKING, ASSEMBLING, POSITIONING AND COMMISSIONING OPERATION INVOLVING THE UNIT.

The Manufacturer declines any and all liability for injuries to people or damage to property arising from failure to observe the indications in this document.

2.1.1 General warning

The following document is a user manual written in order to give ENOGIA's products, and more specifically 20LT ORC and 40LT ORC, understanding of the basic operations, frequently asked questions and applications related guidelines.

This document is not to be used for calculating the performance or the output of the ORC unit because operating values and ORC unit output can be affected by many variables, including hot water temperature at ORC inlet, heat sink type and temperature, and flow rates.

For a complete project evaluation, please ask ENOGIA staff.

2.1.2 About the safety of operation

The following document is a user manual which depicts the proper use of ENOGIA's products. In case of a non-compliant use of the ORC by the End User, ENOGIA shall not be considered as responsible of any harm or damage caused.

Please respect the integration and utilization instructions described in this document. In case of any doubts, please contact ENOGIA (see § 2.1.3).

2.1.3 Contact information

You can contact ENOGIA commercial and technical teams at the following:

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Tel: +33 4 84 25 60 17

2.2 GENERAL DESCRIPTION OF ORC

Although the principle of Organic Rankine Cycle (ORC) was stated by Mr. Rankine in the 19th century, small operational ORC products are cutting edge technology able to convert low temperature streams of energy into useful energy, namely electricity.

The Organic Rankine Cycle is an alternative to the traditional Rankine Cycle, which uses steam as a working fluid. The ORC can use any organic fluid, but to attain successful low temperature performances, refrigerant fluids are preferred.

2.2.1 Balance of energy flows

The ORC is a thermodynamic power cycle. It is used to convert heat into electricity. The Figure 1 show the balance of the energy outputs of the ORC.

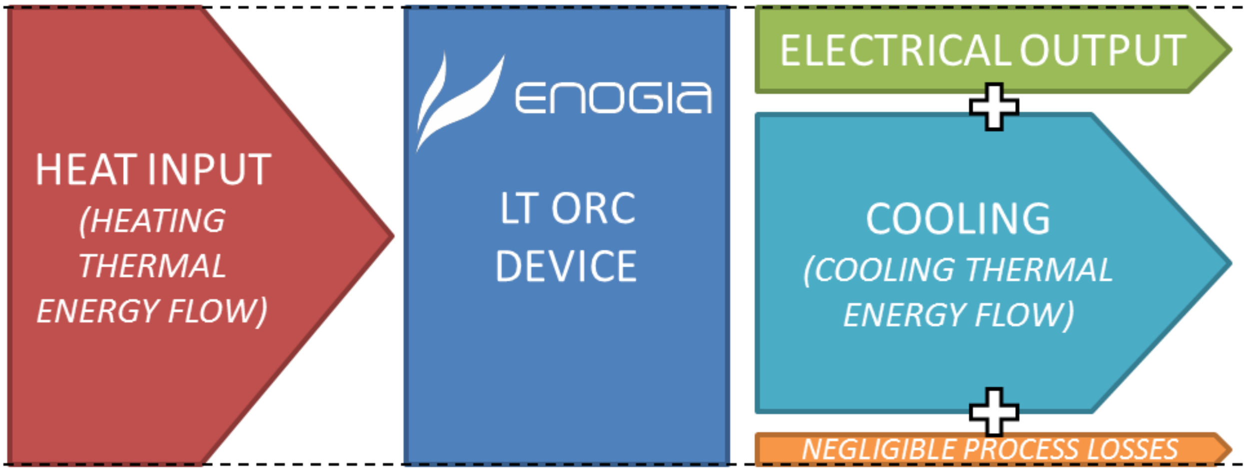


Figure 1 : Balance of Energy flow diagram

All the heat cannot be converted into electricity. The system has a system efficiency, which can be calculated by dividing the electrical output power with the thermal inlet power.

The heat which was not turned into electrical power needs to be removed from the system in order to balance the energy flows. To this end, an ORC always needs a heat sink, which can be provided by cold water or ambient air through a condenser.

The performance of the ORC unit is highly dependent of the quality (temperature, thermal capacity and flowrate) of the cooling source. Therefore, the ORC output can vary with the cooling source parameters (variation of ambient temperature, flow rates, fluid, etc.).

2.2.2 General working principle of ORC

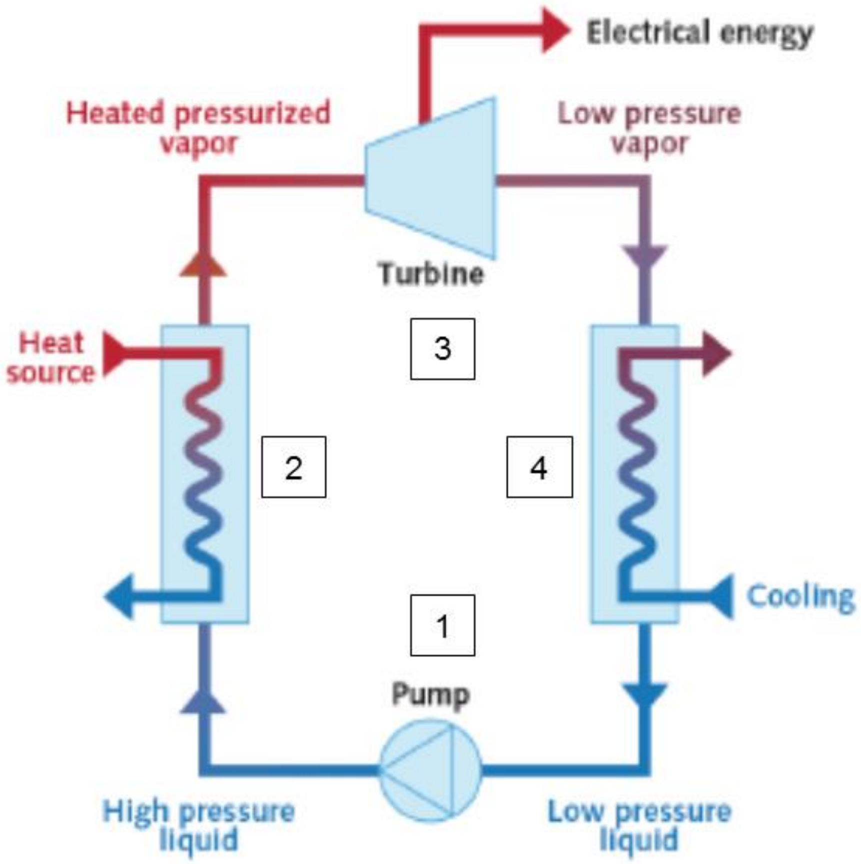


Figure 2: General working principle ORC diagram

Like the commonly used steam Rankine cycle, the Organic Rankine Cycle uses the expansion of high-pressure gas through a turbine expander connected to a generator in order to transform mechanical work into electrical work (3). The turbine needs an adapted pressure ratio to perform efficiently.

To this end, the working fluid is heated in the “boiler” exchanger (2), in order evaporate a liquid and produce high pressure gas.

The “condenser” exchanger (4) uses a cold loop (water, water and glycol…) to condense the gas at low pressure, allowing a high-pressure ratio across the turbine for correct operation.

The pump, also called feed pump (1), is then used to pressurize and feed the fluid in liquid phase coming from the condenser to the boiler.

2.3 ABOUT ENOGIA'S ORC

2.3.1 Evaporator and condenser

The thermal exchange between the heat source and the working fluid and between the working fluid and the cooling source are done through two heat exchangers called the evaporator and the condenser.

The evaporator's main purpose is to transfer the thermal energy from the heat source to the working fluid, in order to warm it up and vaporize it. The evaporator is a plate exchanger specifically designed to fit with the flow rate and temperature conditions of each project.

Regarding the condenser, its role is to evacuate the condensing heat of the working fluid into a cooling loop. Indeed, after being expanded in the turbine, the working fluid still contains thermal power that must be evacuated in order to condense it and fit with the Organic Rankine Cycle.

Thus, using the same technology as the evaporator (plate exchanger), the condenser transfers the heat from the working fluid to the cooling loop at a lower temperature than the hot source.

The way the ORC is cooled down plays a very important role in the conversion cycle performance meaning that the condenser's design needs to be optimized to guarantee the efficiency of the system.

2.3.2 ENOGIA turbo expander and H22 Mavel Powertrain inverter

Each system manufactured by ENOGIA is associated with one or several ENOGIA turbo-expanders and H22 electrical inverter.

The ORC configurations are presented in Table 1. Moreover, the Figure 3 shows the inverter and turbine configuration of the 20 kW ORC module.

ORC model	Turbine model	Inverter model
20 kW ORC module	Enogia 20 kW x1	H22 x1
40 kW ORC module	Enogia 20 kW x2	H22 x2

Table 1: ORC configurations

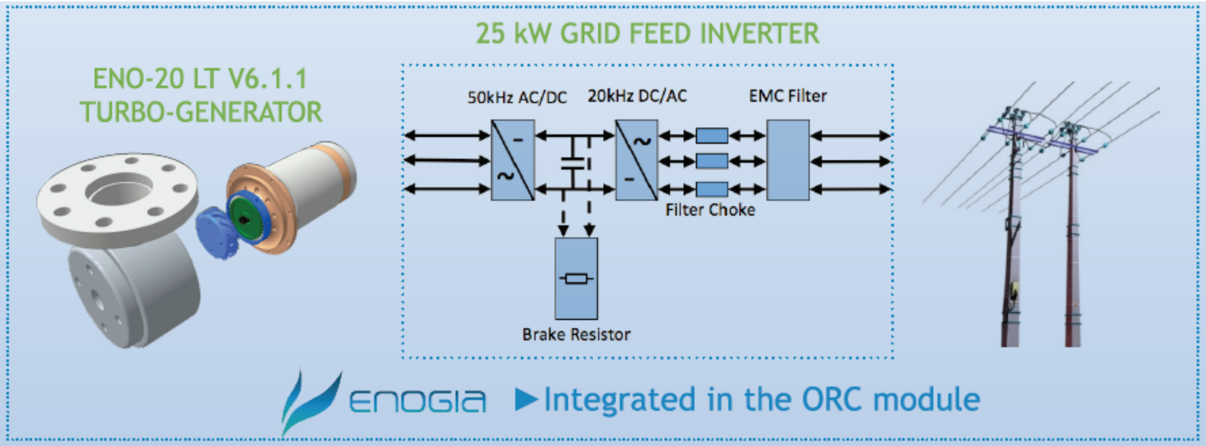


Figure 3: Turbo expander and inverter configuration diagram

The strengths of this combination of elements are listed hereafter:

- **Extremely compact** turbo expander shaft,
- **100 % oil free** running involving less maintenance on the working fluid and on the system itself,
- **Hermetic** and homogeneous turbine + generator block without any mechanical seal, requiring 10 to 100 times less working fluid reloads than the competitors using mechanical seals,
- **Modular** architecture of the blades allowing ENOGIA to adapt and optimize the turbo-expander to each thermal power and temperature of heat sources,
- **Contactless** rotating parts of the turbo expander guaranteeing less wear of the blades of the turbine,
- **Highly efficient**, the Mavel Powertrain H22 inverter offering a turbine to grid current conversion ratio of over 97 %.

2.3.3 Feed pump

To generate power through the expansion of a gas through the turbine, the Organic Rankine Cycle requires the compression of the working fluid upstream.

In the perspective of a long-lasting ORC system, ENOGIA selected the best technology on the market for its pumps such as the Grundfos brand.

More precisely ENOGIA adopted the CRN multistage range of product offering the perfect combination between performance, reliability, compactness and power consumption.

2.3.4 R1233zd working fluid

The organic fluid used in ENOGIA's LTV2 ORC modules is the R1233zd, manufactured by Honeywell.

This fluid has been chosen for its very interesting performance for the low temperature ORC applications.

The use of this working fluid, along with ENOGIA's turbo expander technology, makes possible the "low" temperature heat recovery and conversion even with geothermal water at 80°C.

Moreover, the R1233zd shows safety properties that guarantee the security of the people and the environment around the ORC:

- **Non flammable**
- **No color**
- **Very weak smell**
- **Non toxic**
- **Neutral pH**
- **Low GWP**

2.4 ORC APPLICATIONS

2.4.1 Waste heat on exhaust stack

ENOGIA's ORC can be used on an intermediate waste heat recovery loop using liquid fluid such as water to recover the heat from hot gases. The hot liquid/water can be fed into the ORC to transform the recovered thermal power into electricity. A cooling device such as dry-cooler or cooling tower shall supply cooling water to the ORC. For more details, see § 2.5.

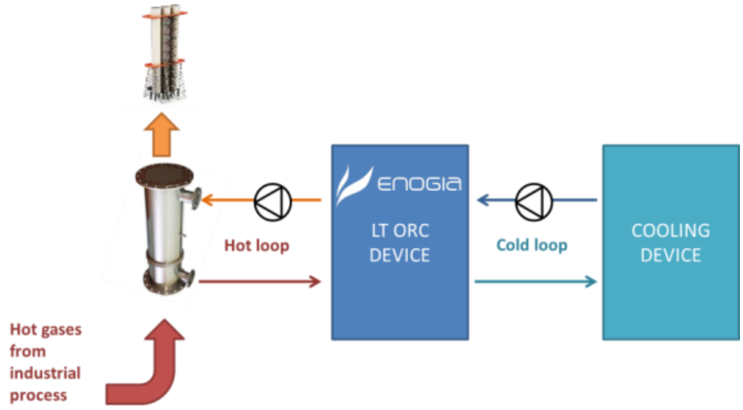


Figure 4: Waste heat on exhaust stack process diagram

2.4.2 Biomass Boiler

ENOGIA's ORC can be used with the hot water from a biomass boiler, either as a prime power device but also as a Combine Heat and Power (CHP) device, where the water from the cooling side of the ORC could be used for low temperature heating purposes, such as floor heating, poultry farming, dryers, swimming pools, algae or shrimp ponds, etc. The biomass boiler could be warm water or superheated water type. Obviously efficiency will be higher with a superheated water boiler.

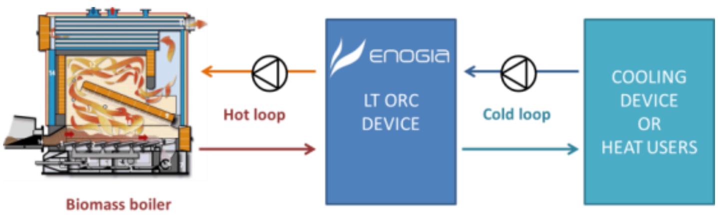


Figure 5: Biomass Boiler process diagram

2.4.3 Solar

ENOGIA's LTV2 ORC can be used with solar collectors, from planar to parabolic troughs, including tube and Fresnel types. The collectors will supply hot water or hot thermal transfer oil to the ORC.

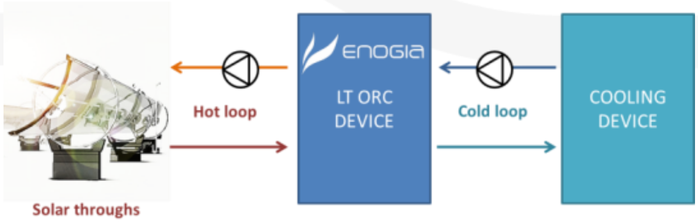


Figure 6: Solar Process diagram

2.4.4 Internal combustion engine jacket water

ENOGIA's LTV2 ORC is the only range of ORC products which can make an efficient use of the 90°C hot water from the jacket of an internal combustion genset engine. Indeed, with many genset manufacturers, the water shall be sent back to the engine at 70°C, and the LTV2 range of product can attain full power using a 90/70°C hot loop.

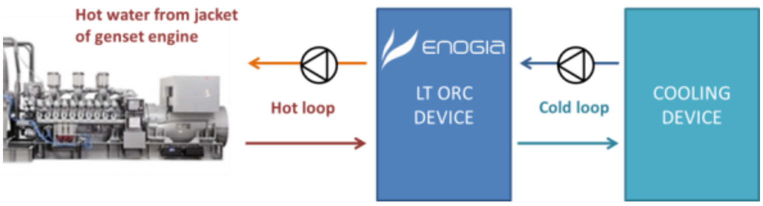


Figure 7: Internal combustion engine jacket water process diagram

2.4.5 Internal combustion engine combined recovery

In some cases, the genset engine is sold as a "CHP unit" meaning it has a loop using the hot gases and the jacket water in order to provide hot water to a user. In those cases, the LTV2 ORC can use the "CHP loop" in order to produce electricity. Again, ENOGIA's LTV2 ORC is the only ORC which can be used at full power using the low temperature 90/70°C loop of a genset CHP.

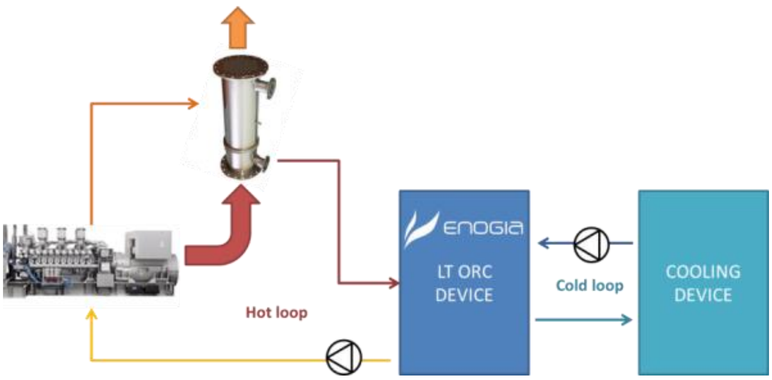


Figure 8: Internal combustion engine combined recovery process diagram

2.4.6 Geothermal

ENOGIA's LTV2 ORC can use either natural, artesian or enhanced geothermal resources. One should be careful to water specifications when considering a geothermal ORC project. Please contact ENOGIA's sales representative for a project evaluation.

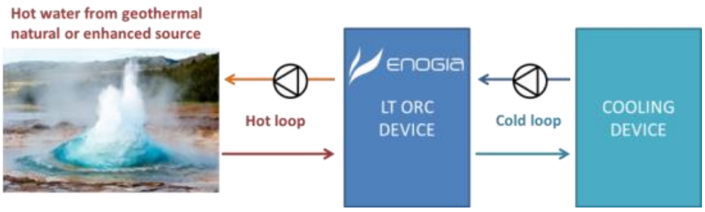


Figure 9: Geothermal process diagram

2.5 COOLING SYSTEM FOR ENOGIA'S ORC

The cooling system is a very important part of a successful ORC project.

It has a great impact on the efficiency of an ORC device as well as a great impact on parasitic consumption levels: indeed, the cooler the water the cooling system can provide to the ORC, the best the efficiency of the ORC will be. But sometimes, this means also parasitic consumption is increased as well.

ENOGIA's sales representatives can help you in the design of the optimal solution for cooling down the ORC.

One could use the following as cooling method for ENOGIA's LTV2 ORC:

Cooling only:

- Dry cooler
- Adiabatic cooler
- Cooling tower
- Cooling pond
- River
- Lake
- District water

Combined Heat and Power:

- Process water
- Floor heating
- Dryer

Other heat uses

2.6 MAIN PARTS PRESENTATION

2.6.1 20 kW ORC MOBILE UNIT

2.6.1.1 Whole assembly

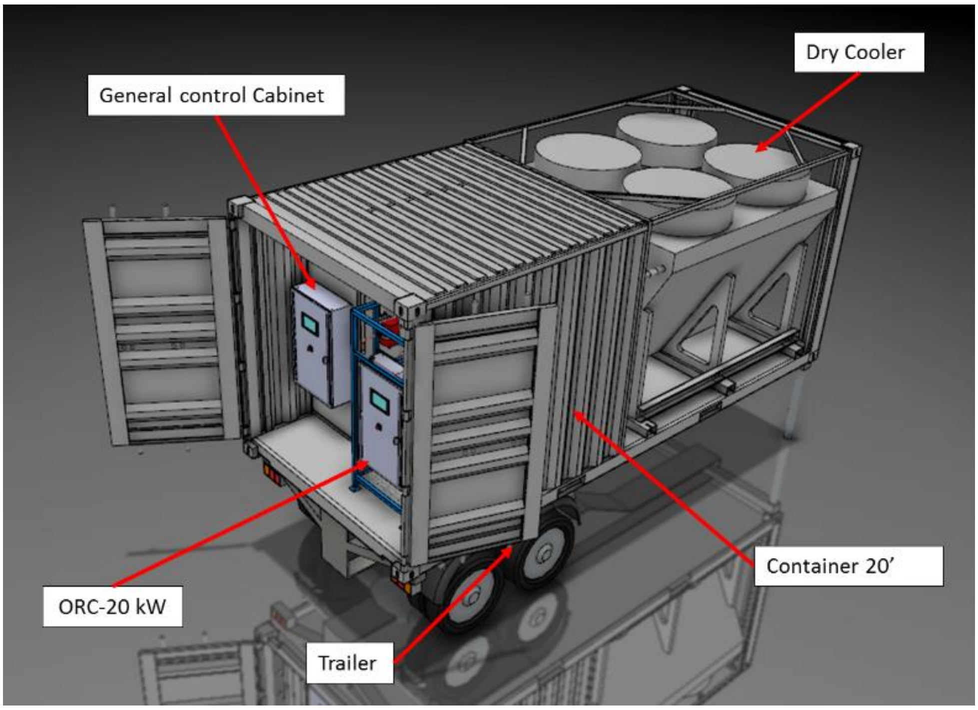


Figure 10: Presentation of 20 kW ORC mobile unit.

The 20 kW ORC mobile unit is made of a 20'' converted container, containing a 20 kW ORC, a dry cooler and a cold loop pump. This module only needs electrical connections and a hydraulic hot loop connection to work.

The module is mounted on a trailer in to offer the possibility to move the system easily between two sites and make its use more flexible.

The general control cabinet manages the ORC and all auxiliaries.

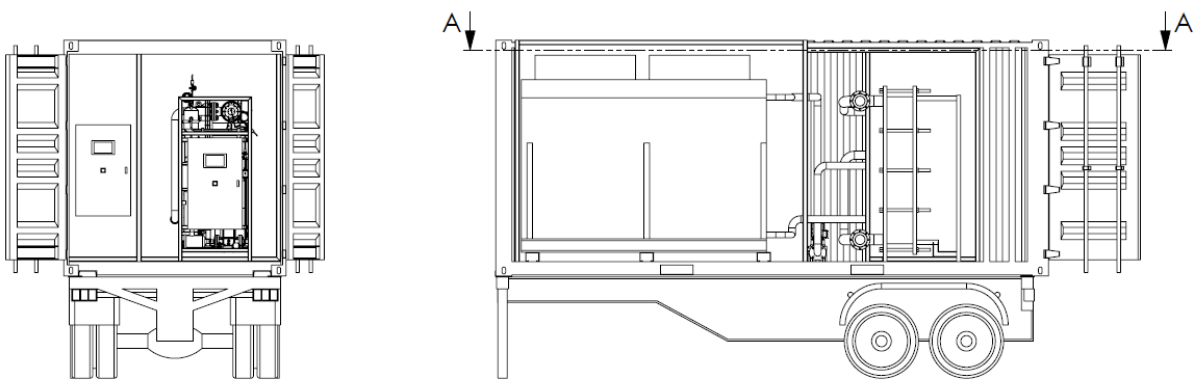


Figure 11: Dimension of the 20 kW ORC mobile unit

2.6.1.2 20 kW ORC

The ORC is composed as it is mentioned in section 2.3, the main components being the feed pump, the evaporator, the condenser, the turbine and the inverter. Other components ensure the proper functioning of the machine. There are two more loop inside the ORC units, the cooling turbine loops and the lubrication loop. The cooling turbine loop cools the generator part of the turbine, It is composed by an air condenser, a flow switch, an expansion tank and a cooling pump. The lubrication loop preserves the duration of the bearings; this loop consists of lubrication pump and pressure switch.

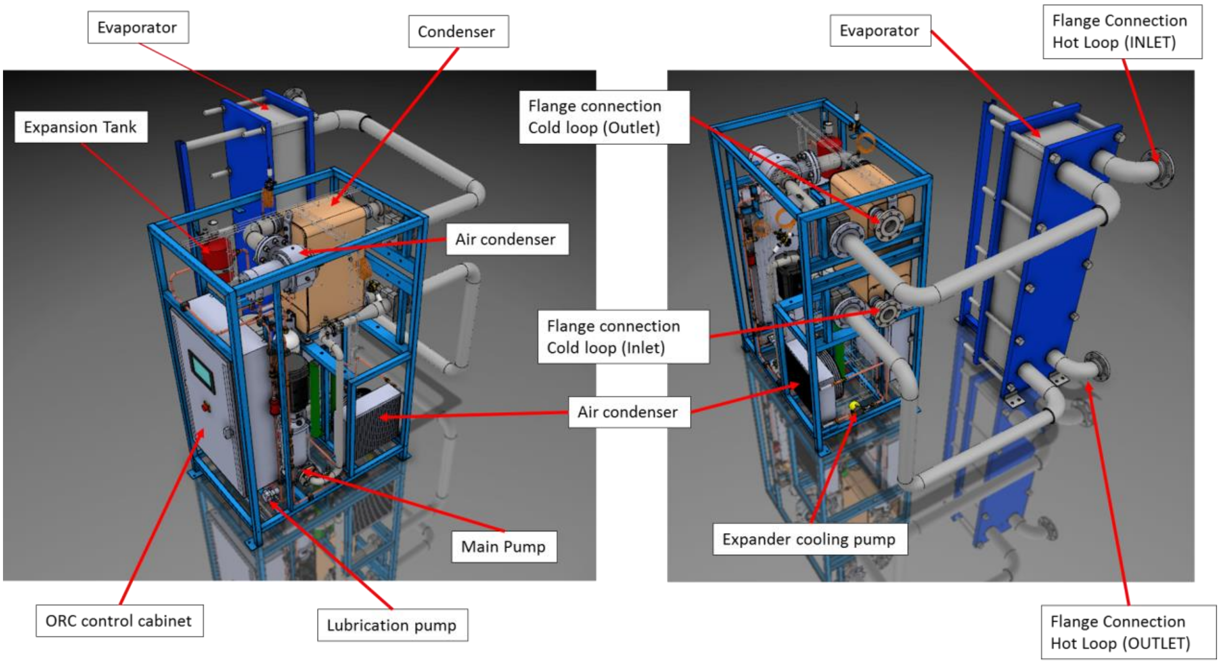


Figure 12: Main components of the 20 kW ORC

2.6.1.3 Piping and Instrumentation Diagram

The Piping and Instrumentation Diagram (P&ID) of Enogia's 20 kW ORC is presented in Figure 13.

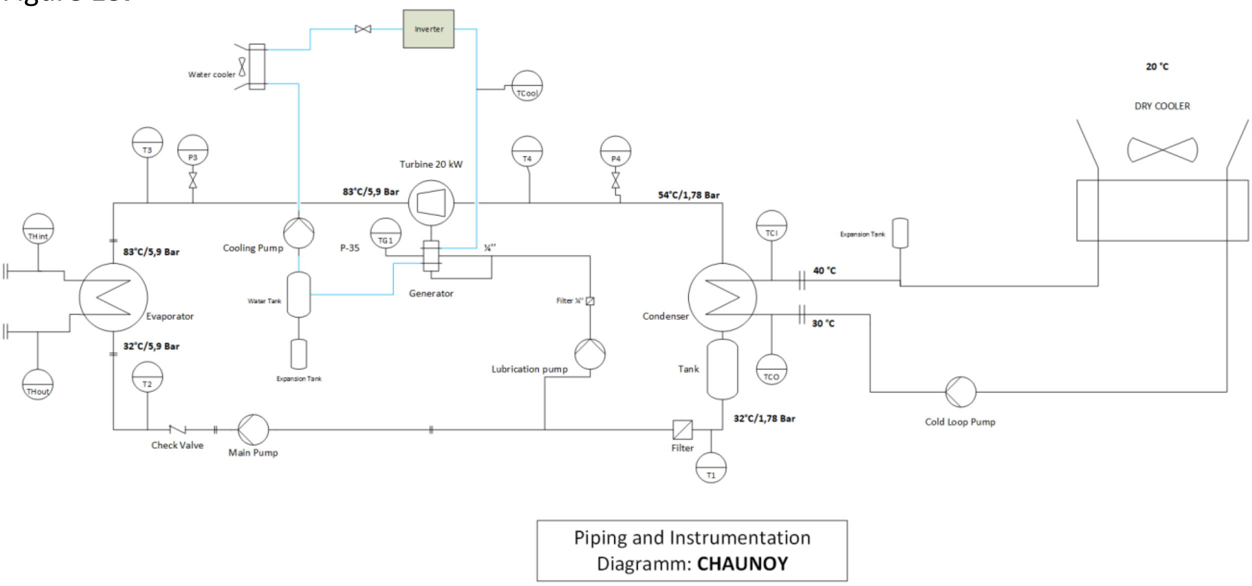


Figure 13: Piping and Instrumentation diagram of the 20 kW ORC mobile unit

2.6.2 40 kW Stationary Unit

2.6.2.1 Whole assembly

Enogia's 40 kW ORC stationary unit is equipped with a larger dry cooler than the 20 kW ORC mobile unit, because it requires to evacuate greater quantities of condensation heat from the condenser. Moreover, it consists of two 20 kW turbines and inverters, taking up more space than the smaller 20 kW mobile unit.

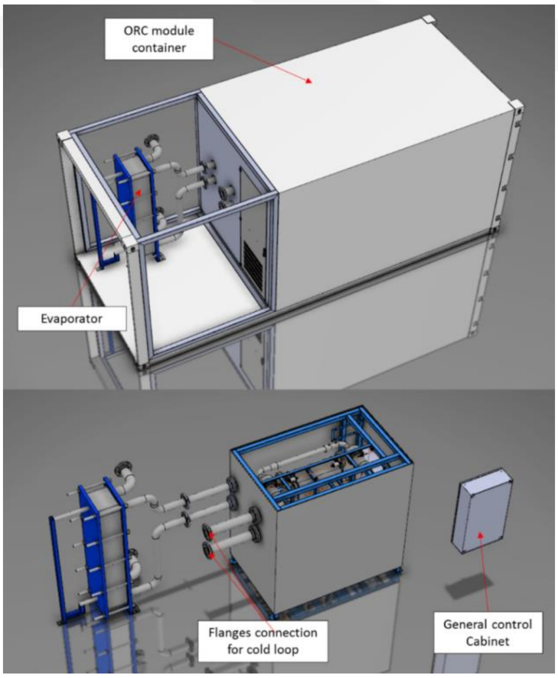


Figure 14: Presentation of 40 kW ORC stationary unit

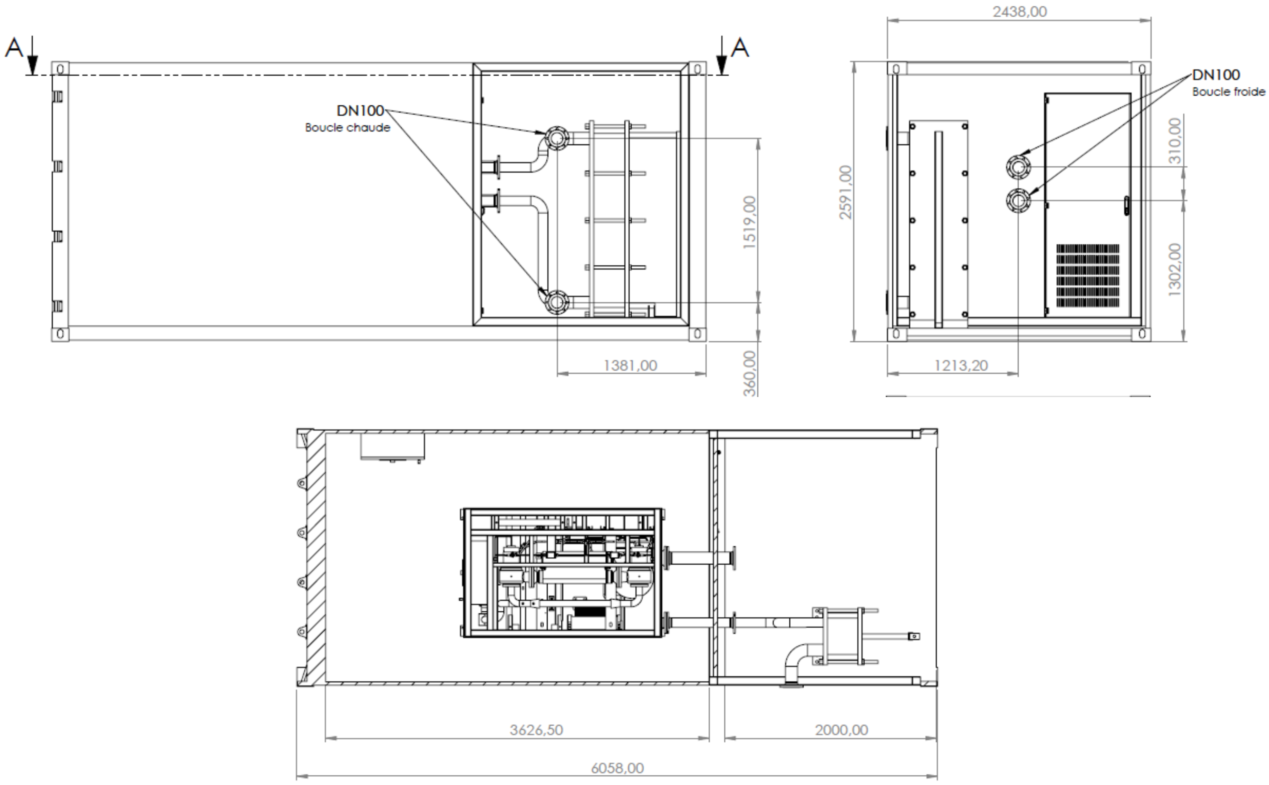


Figure 15: Dimension of the 40 kW ORC stationary unit

2.6.2.2 40 kW ORC

The composition of the 40 kW ORC is similar to that of the 20 kW ORC, though it consists of two 20 kW turbines, as presented on Figure 16**Erreur ! Source du renvoi introuvable.**.

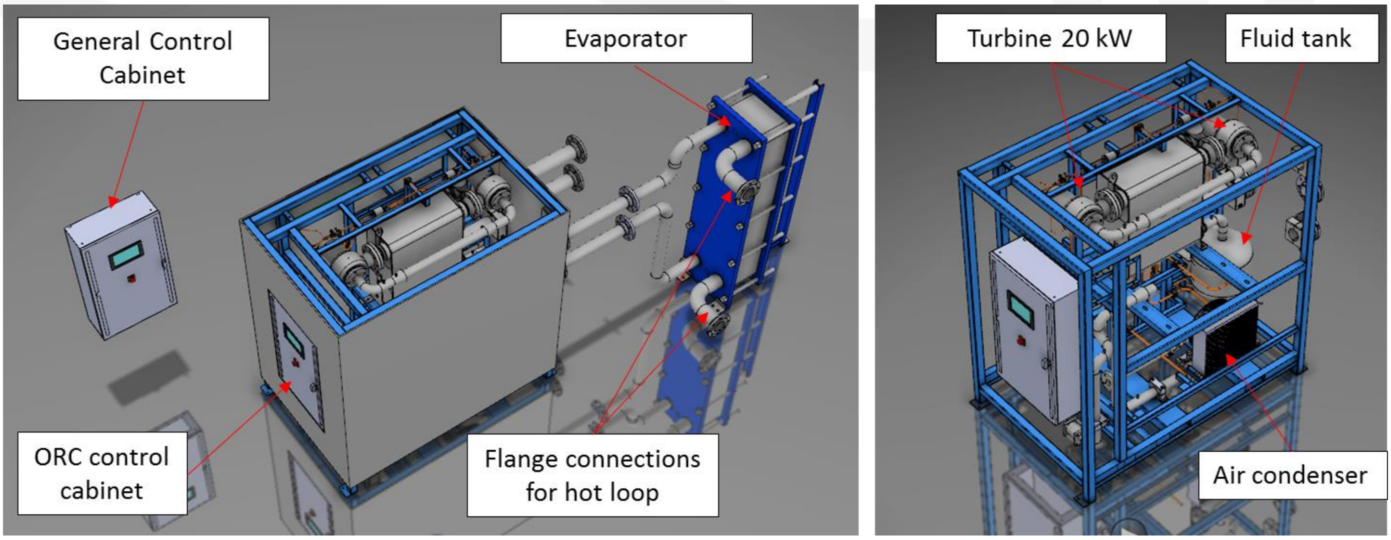


Figure 16: Main components of the 40 kW ORC

2.6.2.3 Piping and Instrumentation Diagram

The Piping and Instrumentation Diagram (P&ID) of Enogia's 20 kW ORC is presented in Figure 17.

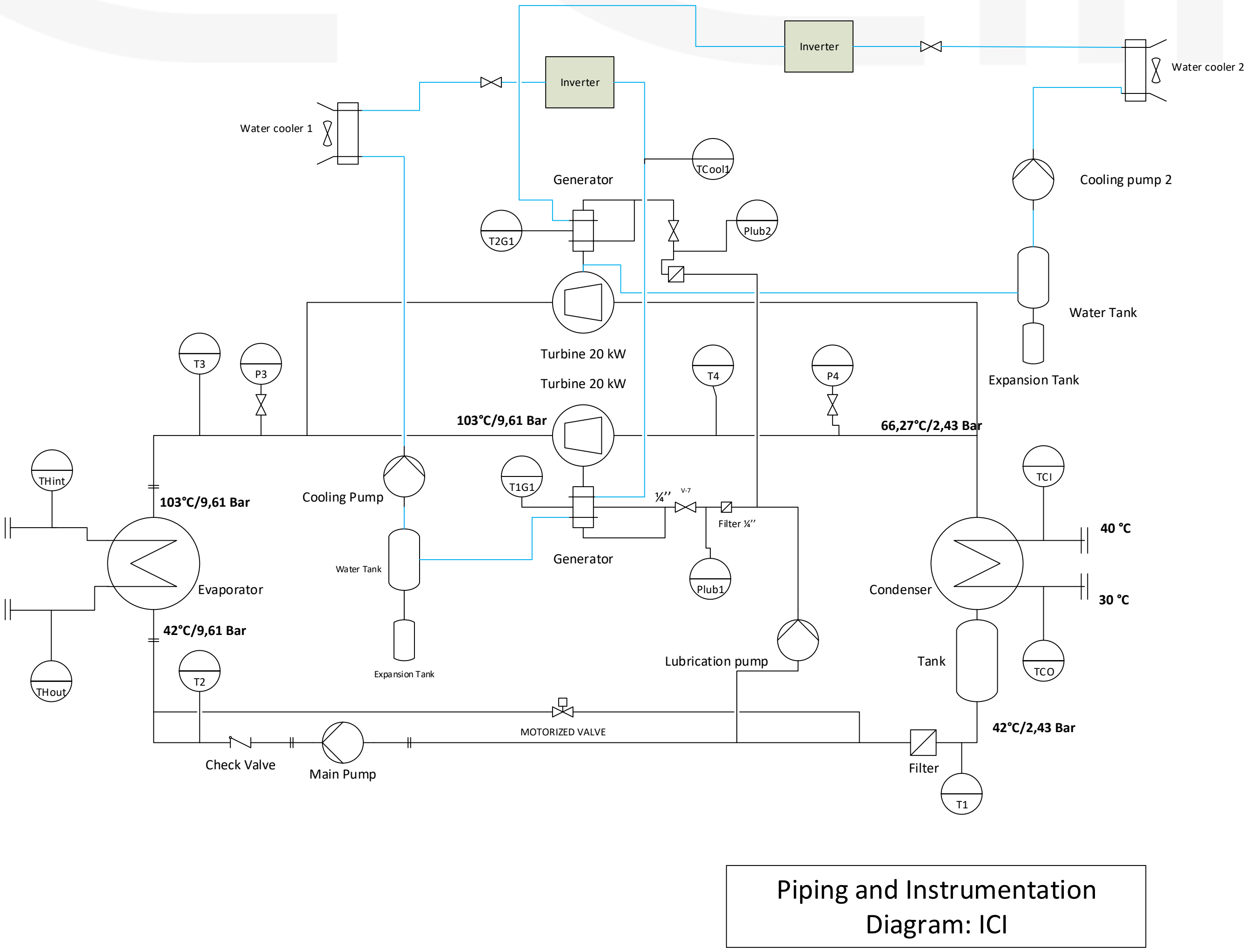
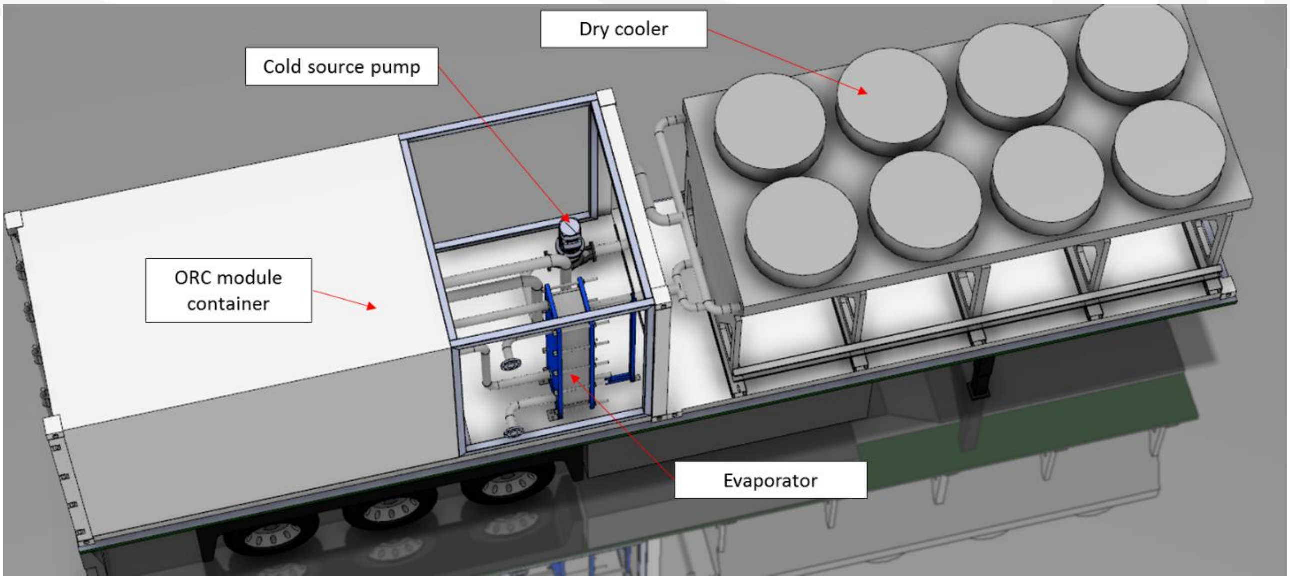


Figure 17: Piping and Instrumentation diagram of the 40 kW ORC unit

2.6.3 40 kW MOBILE UNIT

2.6.3.1 Whole assembly

As shown on Figure 18 and Figure 19, Enogia's 40 kW ORC mobile unit is installed on a larger trailer than the 20 kW ORC mobile unit. The trailer is equipped with the 40 kW ORC stationary unit described in section 2.6.1.1, along with a large dry cooler.



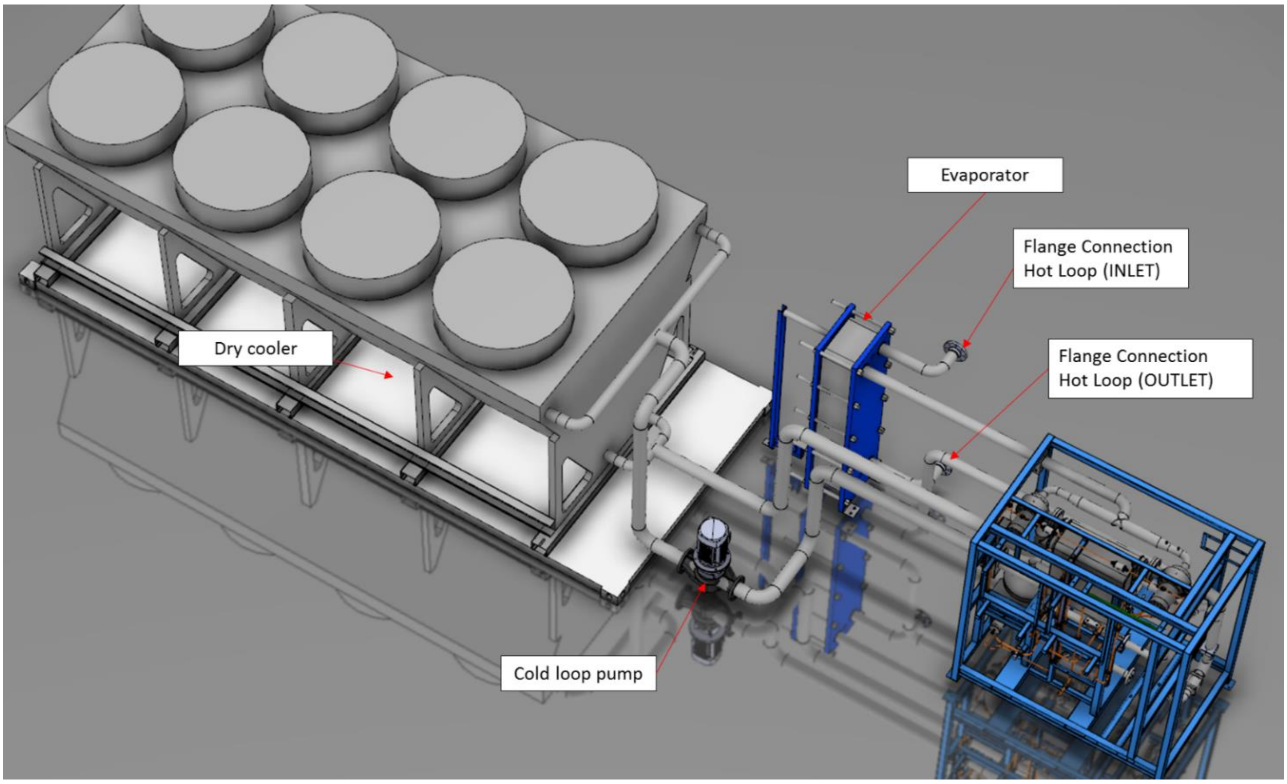


Figure 18: Presentation of 40 kW ORC mobile unit

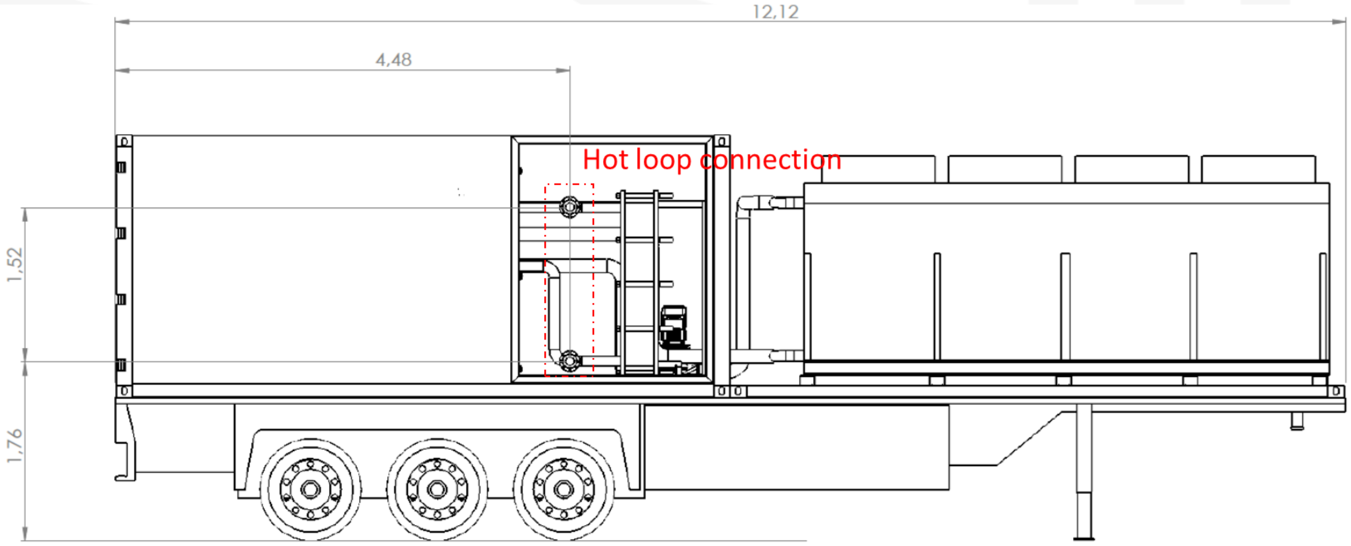


Figure 19: Dimension of the 40 kW ORC mobile unit

2.6.3.2 40 kW ORC

See section 2.6.2.2.

2.6.3.3 Piping and Instrumentation Diagram

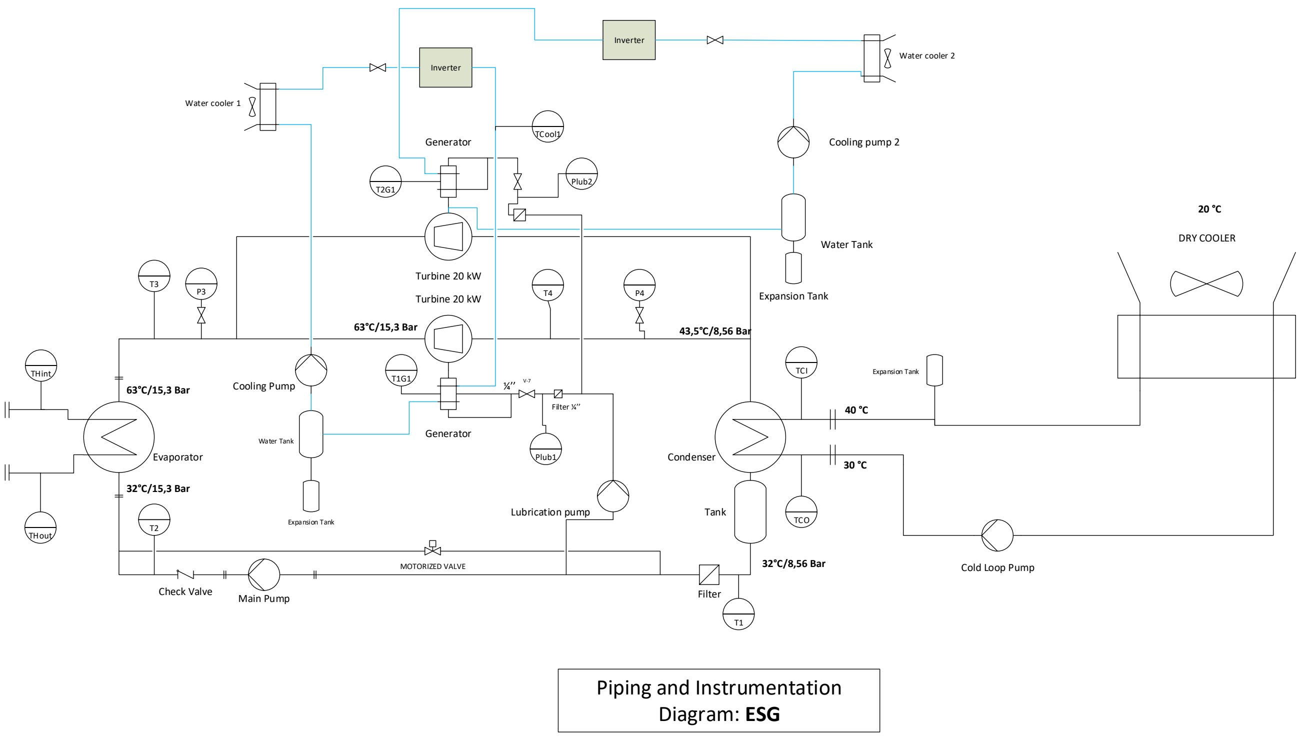


Figure 20: Piping and Instrumentation diagram of the 40 kW ORC mobile unit

2.7 CONNECTIONS TERMINAL

The electrical connection must be carried out by an authorised electrician in accordance with local regulations.

WARNING

Electric shock, Death or serious personal injury - Before starting any work on the product, make sure that the power supply has been switched off, locked out and tagged out.

2.7.1 Mains supply

The three-phase connection for the reinjection and the production of the ORC is made by a 5G electric cable (3 phases, earth and neutral). The section must be 10 mm² for the 20 kW ORC unit and 16 mm² for the 40 kW ORC unit.

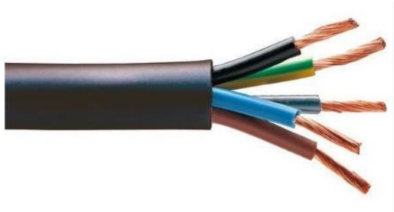


Figure 21: Power supply cable

The three-phase connection is connected to the BNP1 terminal block.

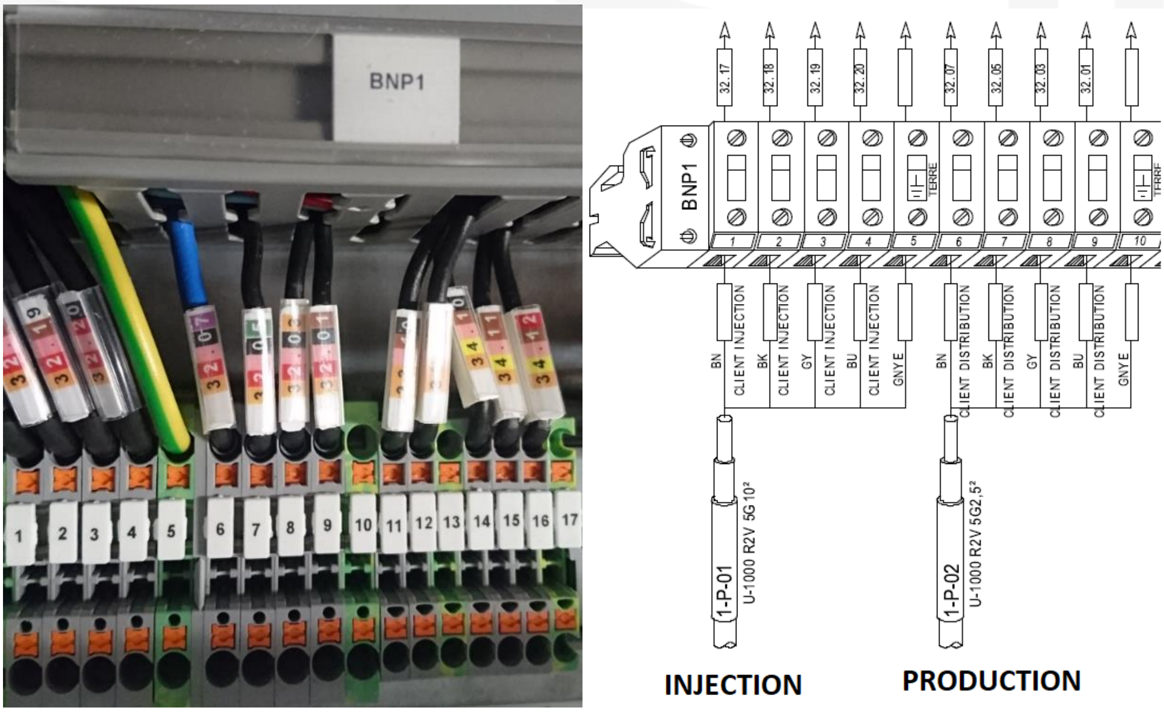


Figure 22: Power supply connection (Injection and production).

It is possible to wire the ORC in two specific cases:

- Case 1: You want to separate power production and power supply ; You must have two 5G cables and respect the following connection
  - Cable 1 – Power supply to the ORC
    Terminal 1 => Neutral
    Terminal 2 => Brown
    Terminal 3 => Black
    Terminal 4 => Grey
    Terminal 5 => GYE: Earth
  - Cable 2 – Production from the ORC
    Terminal 6 => Neutral
    Terminal 7 => Brown
    Terminal 8 => Black
    Terminal 9 => Grey
    Terminal 10 => GYE: Earth
- Case 2: You want to connect the production and the power supply in the same terminal block ; You must have one 5G cable and respect the following connection
  - Cable 1 – Power supply to the ORC
    Terminal 1 => Neutral
    Terminal 2 => Brown
    Terminal 3 => Black
    Terminal 4 => Grey
    Terminal 5 => GYE: Earth

In case 2, ENOGIA will connect the bridges between the production and injection terminals, as shown in Figure 23

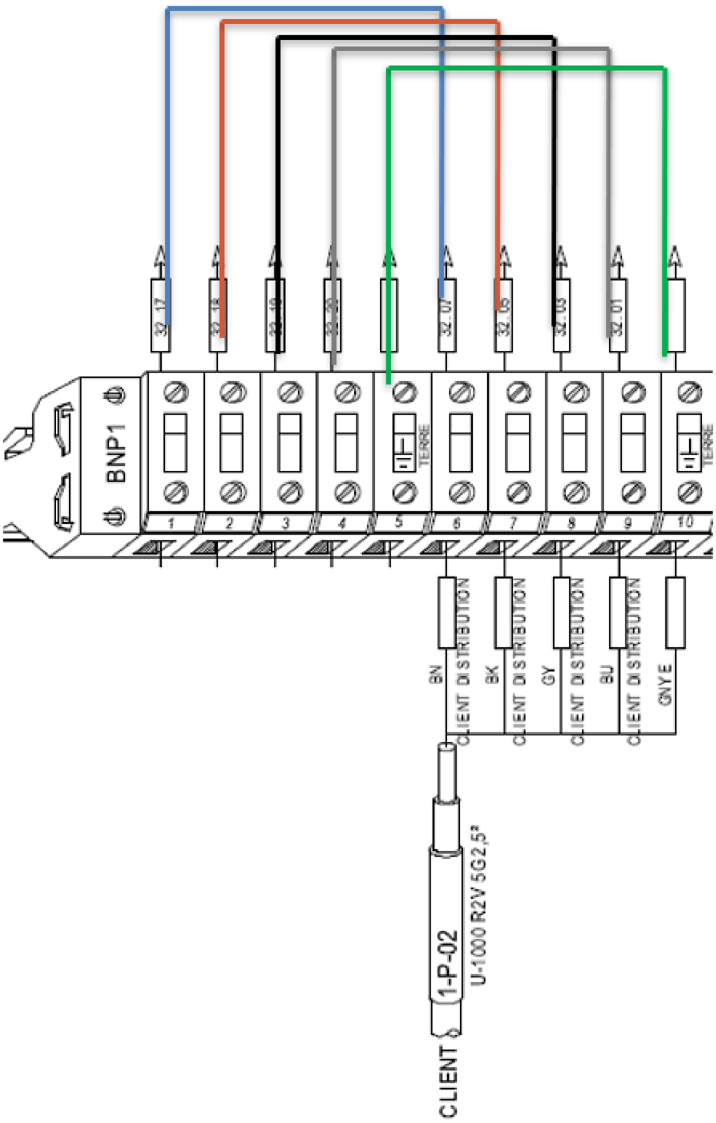


Figure 23: Power supply connection (one cable)

2.7.2 Signal relay

This part is not mandatory for the proper functioning of the ORC. However, some signals can be wired between ENOGIA's ORC unit and an external PLC (client).

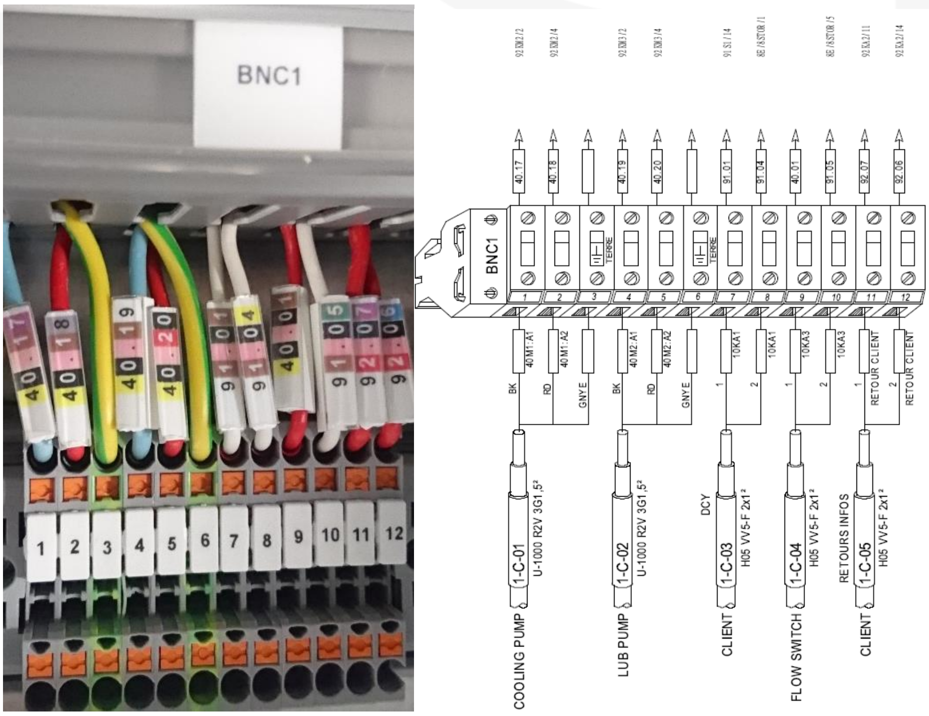


Figure 24: Command junction

The Figure 24 presents the terminal block on which the Client can connect its cables in order to exchange some signals. The **Table 2** presents the input and output signals with the Client PLC implemented in the ORC, to be connected on the terminal block BNC1.

Signal name	Description	Signal type	ON	OFF	Terminal
Start cycle	Client requests the ORC to start	Binary input (24 VDC active)	Initiate the ORC starting procedure	Wait for ON signal	7 - 8
ORC_OK	ORC status	Binary output (24 VDC passive)	ORC in operation	ORC failure	11 - 12

Table 2: ORC input / output signals

2.7.3 General control cabinet

The ORC module can be assembled on the trailer and in the container. It is the case for the GEO 20 LT and GEO 40 LT. For these cases the electrical connection will be made in the general control cabinet. This cabinet supplies power to all the equipment of the ORC module.

The user must connect only the power supply. The cables for power supply must be adapted to the ORC module power and respect the following connection on the terminal block BNP1:

- Cable 1 - Power supply to the ORC

Terminal 1 => Neutral
Terminal 2 => Brown
Terminal 3 => Black
Terminal 4 => Grey
Terminal 5 => GYE: Earth

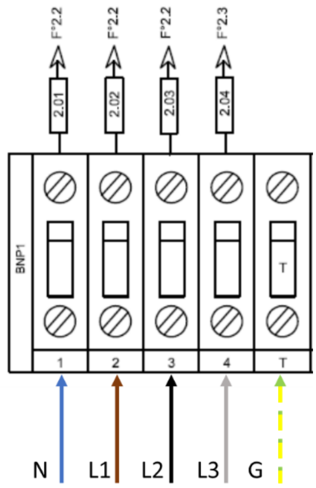


Figure 25: Power supply connection to general control cabinet

The user must install a circuit breaker inside his main cabinet in order to isolate the ORC module. The Table 3 recaps which circuit breaker must be used for the different ORC module.

ORC MODEL	Power (KW)	Circuit breaker rating	Cable Section (mm²)
20 LT	20	40 A	10
40 LT	40	63 A	16

Table 3: ORC feeder circuit breaker sizing

2.8 CONTROL UNIT

2.8.1 Webserver/visualization

The state of the ORC is accessible via a control unit.

As a first step, you must connect an Ethernet cable from your computer to the Ethernet port located under the ORC cabinet.

To access to your visual interface, you must enter the default address ***192.168.1.17:8080/orc.htm*** in the computer's Internet browser, as shown in Figure 26.

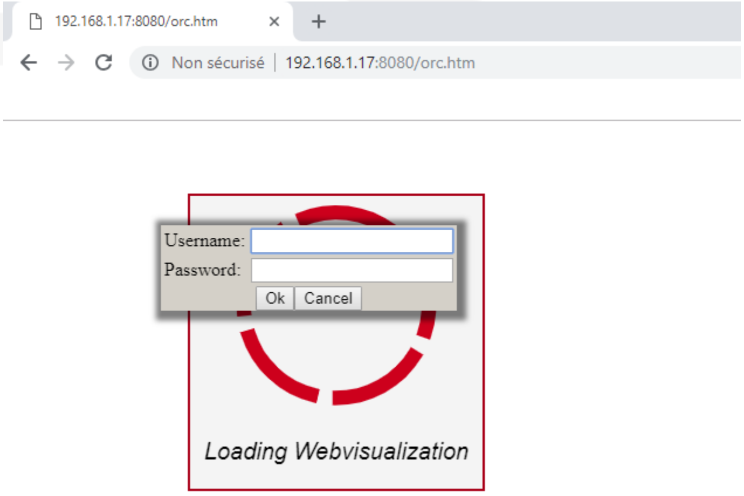


Figure 26: Web visualization connection

The "username" and "password" as well as the IP address will be modified and provided on the day of the unit commissioning.

The control unit HMI (Human Machine Interface) of ENOGIA's ORC is presented in the Figure 27.

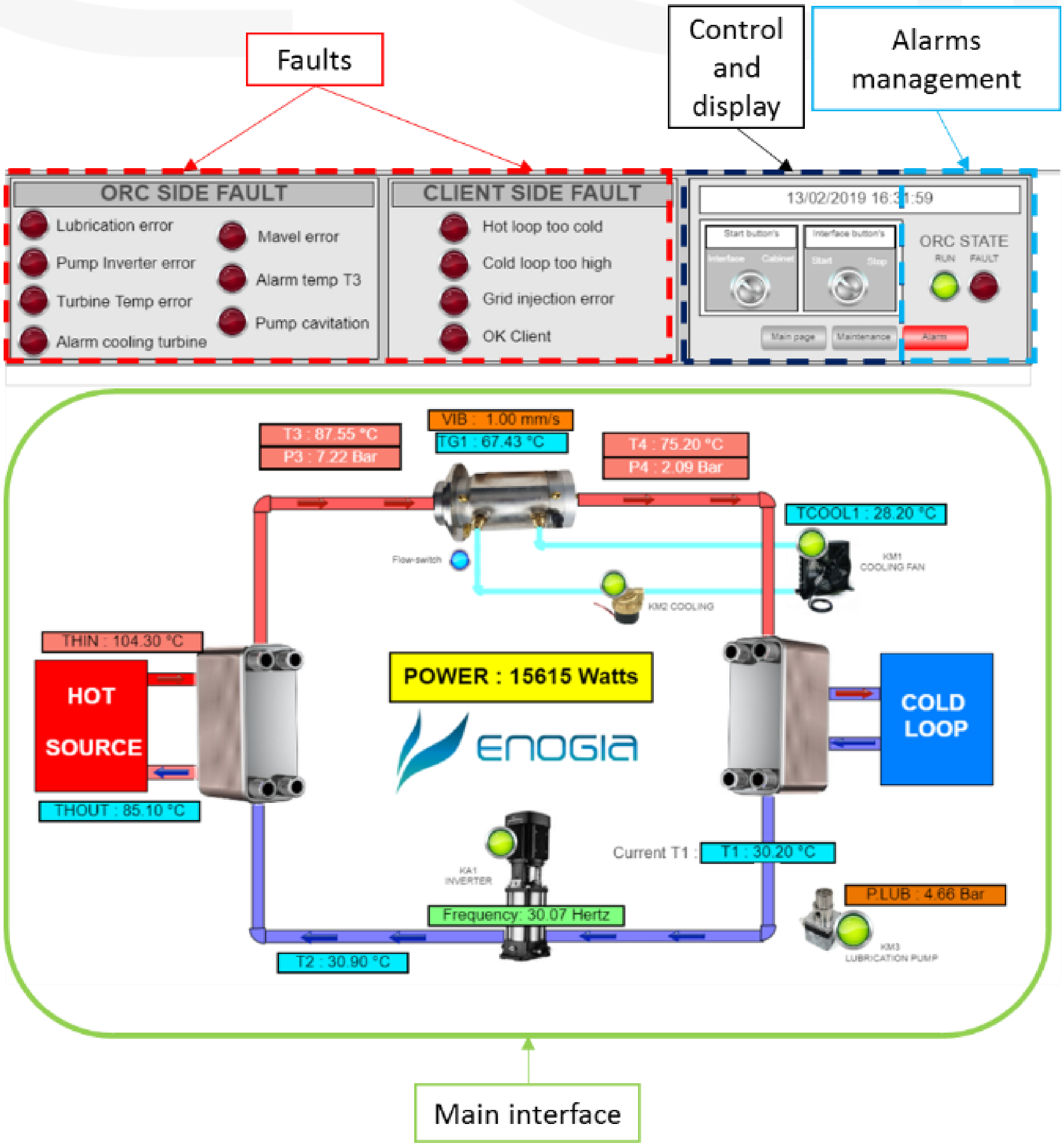
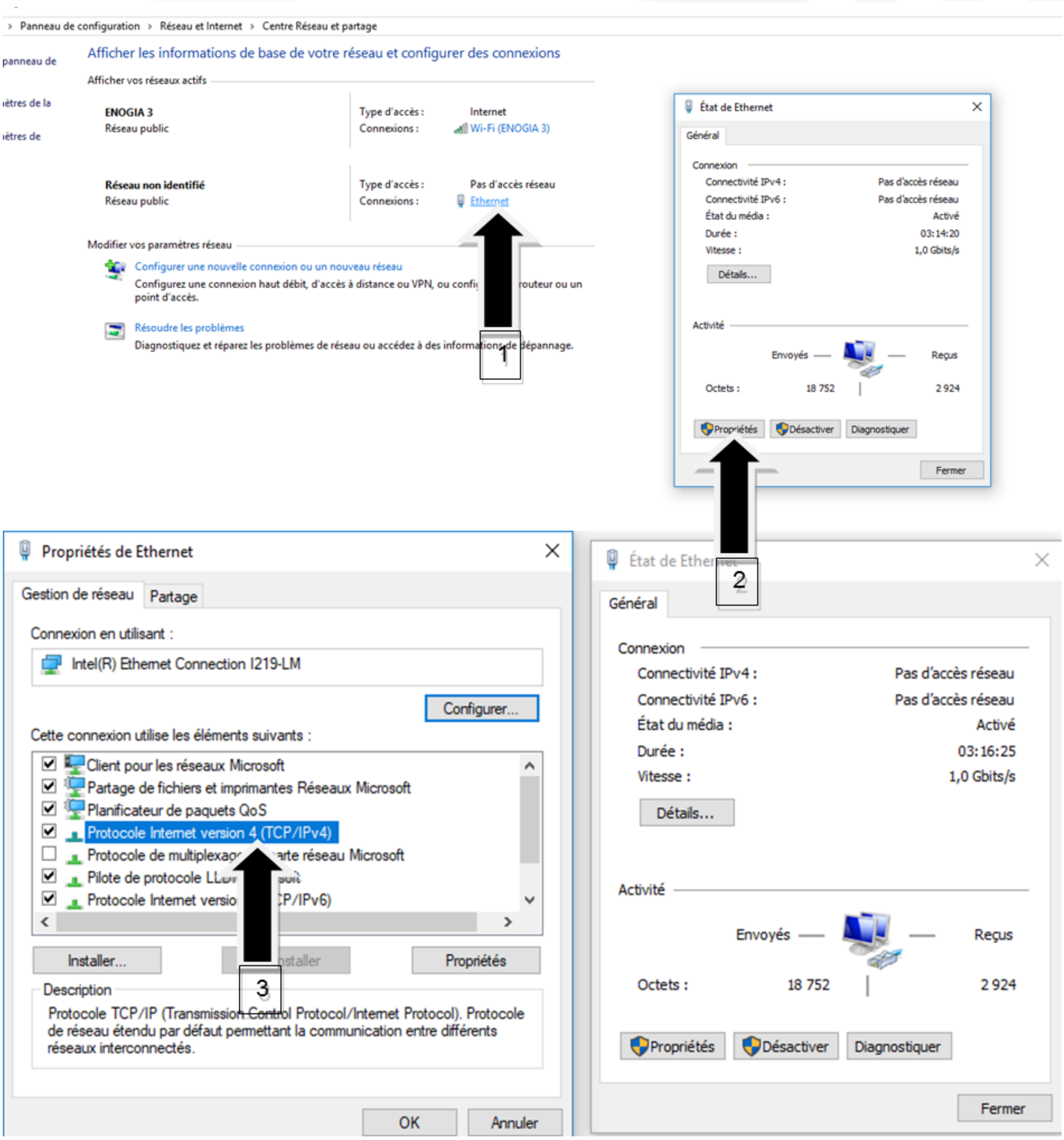


Figure 27: ORC's Web interface

If the page does not load, it probably comes from your computer that is logged on another network. To do this, simply change the IP address of your computer to identify it on the same network as the PLC, following this procedure:

1. Open the control panel on the "network and sharing center" page
2. Go to the properties of your Ethernet card
3. Double click on "internet protocol version 4 (TPC / IPV4)
4. enter the IP address => ***192.168.1.16*** and the subnet mask ***255.255.255.0***
5. Validate the settings
6. Refresh the internet page

The different steps of this procedure are detailed in the Figure 28.



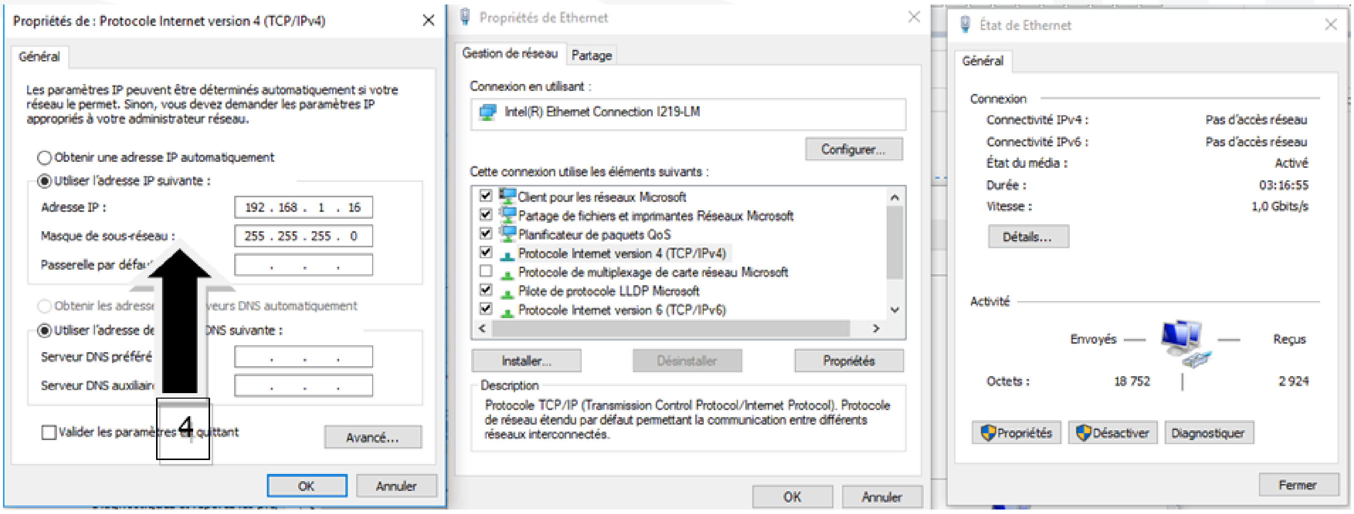


Figure 28: Procedure to modify the Ethernet parameters on your computer

2.8.2 Pannel Description

2.8.2.1 Control and display

You can start your ORC from the HMI described in the section 2.8.1 (remote) or from the electrical cabinet of the ORC unit itself (local).

For this you have to set the selector on "Remote" or "Local" according to your choice of priority:

- Remote => The ORC will start from the supervisory interface with the "start / stop" button shown in **Figure 29**,
- Local => The ORC will start from the button installed in the cabinet facade.

Figure 29: Mode selection

On the picture above you have the example of an ORC being controlled from the electrical cabinet.

If you choose a boot from the interface, remember to put the button of the interface on remote and put on start to start a cycle.

The ORC will take 5 minutes to start once all the temperature and electrical network conditions have been validated.

2.8.2.2 Faults

The faults taken into account by the ORC are listed in the Table 4, and presented on the HMI as shown on the Figure 30.

Figure 30: Faults visualization

Name of the default	Group	Description	Resetable	Action
Lubrification error	Default ORC	The turbine is no longer lubricated.	The pump has a cavity on startup. You have the option to reset this fault to perform another boot	Contact Enogia if the problem persists
Pump inverter error	Default ORC	Internal fault in the drive of the main pump	This defect is not resettable	Contact Enogia if the problem persists
Turbine Temp error	Default ORC	Turbine temperature too high	This defect is not resettable	Contact Enogia if the problem persists
Alarm cooling turbine	Default ORC	Turbine no longer receives cooling	The pump has a cavity on startup. You have the option to reset this fault to perform another boot	Contact Enogia if the problem persists
Mavel Error	Default ORC	The inverter stops on a temperature fault, network or internal fault	You have the option to reset this fault. If this fault appears with another fault contact Enogia	Contact Enogia if the problem persists
Alarm temp T3	Default ORC	ORC input temperature above the safety threshold	This fault is reset when the temperature drops below the threshold	Please reduce your hot spring
Pump cavitation	Default ORC	Form of gas cavities at the main pump inlet	The pump has a cavity on startup. You have the option to reset this fault to perform another boot	Check your cold source. If it works properly, please contact Enogia
Hot loop too cold	Default du site client	Hot inlet temperature still too cold	This fault is reset when the temperature goes above the threshold	Check that your hot source is running
Cold loop too high	Default du site client	Hot inlet temperature still too hot	This fault is reset when the temperature drops below the threshold	Check that your cold source is running
Grid injection error	Default du site client	ORC cannot start	This fault does not reset	Check the connection between the customer site and the ORC cabinet
Ok client	Default du site client	Start / stop button	This fault does not reset	Change the state of the button

Table 4: Faults list

2.8.2.3 Alarms management

Alarm management can be accessed by pressing the alarm button in the HMI, as shown on the Figure 31.

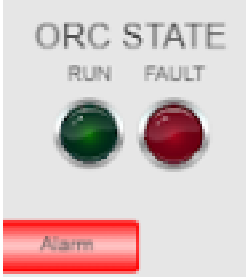


Figure 31: Alarm button

The button is flashing in case a threshold is exceeded.

This page displays the list of alarms and a total history, as shown on the Figure 32.

The alarm table can be cleared via the "ACK selected" key.

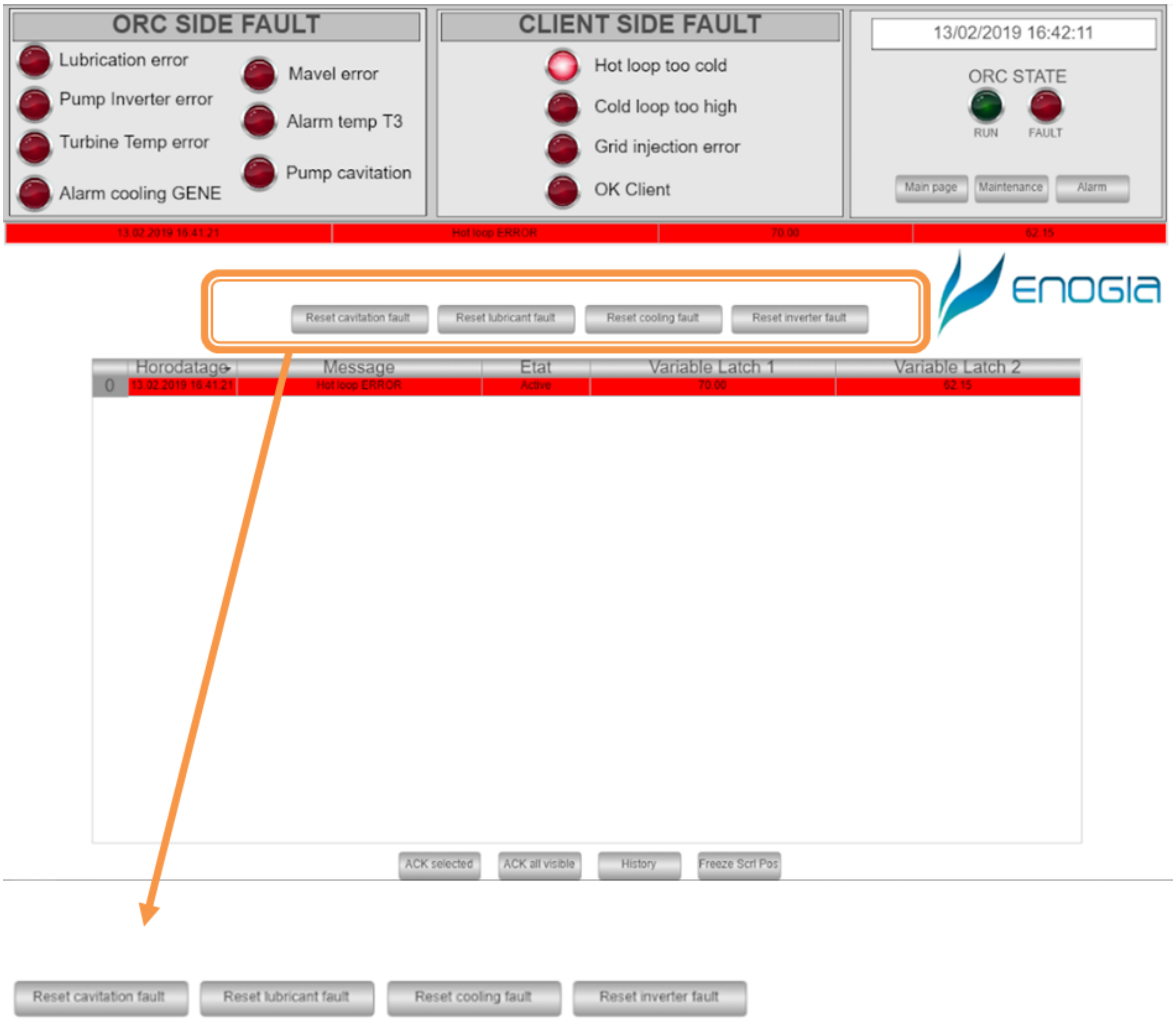


Figure 32: Alarm management interface

The alarm page displays 4 resettable faults:

- Cavitation fault,

- Lubricant fault,
- Cooling fault,
- Inverter fault.

A simple press on the "reset" button removes the alarm. You will have to wait for 5 minutes before the next start.

2.8.2.4 Main interface

The main view of the HMI is shown on the Figure 33, and the description of each sensor visible on this view is detailed in the Table 5.

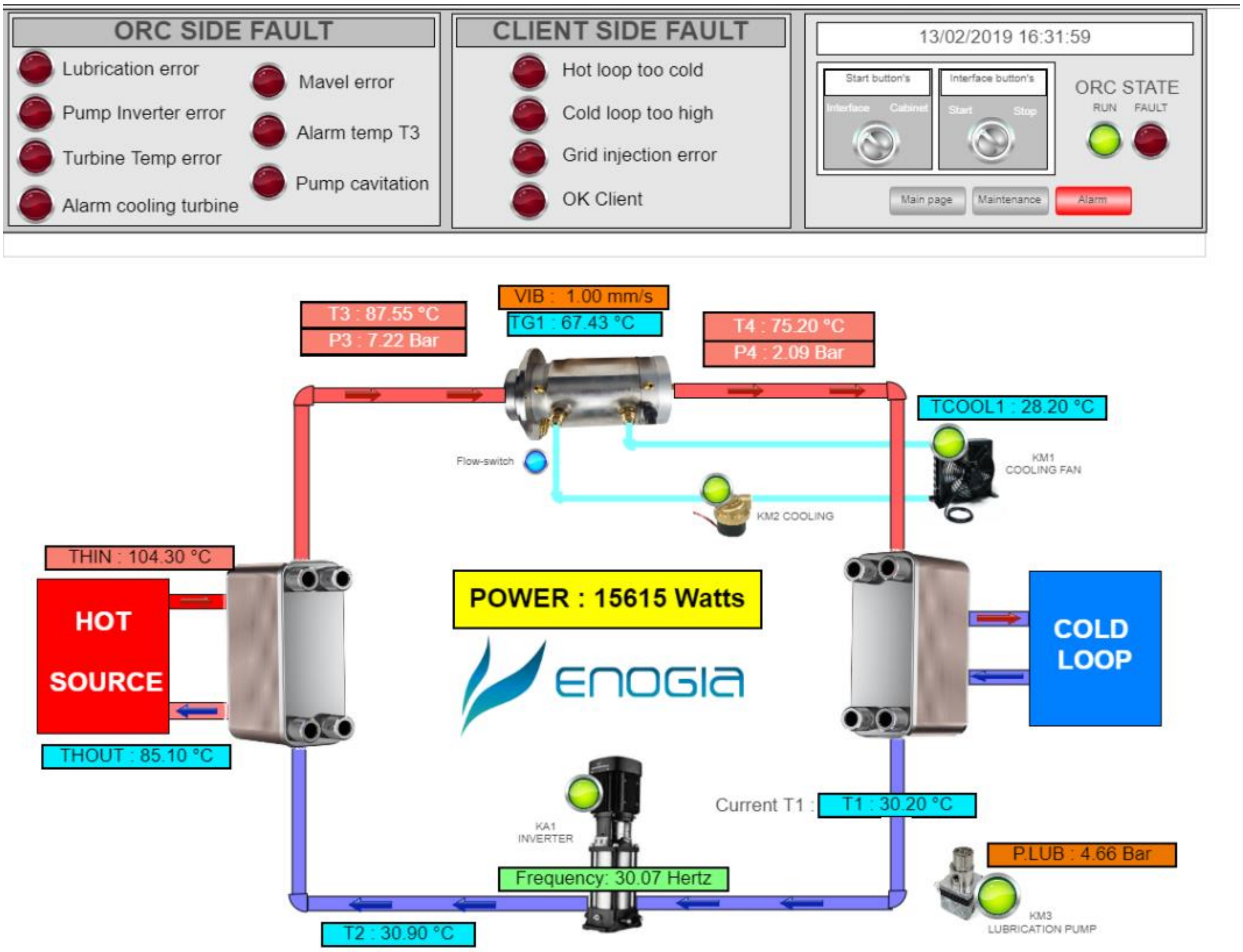


Figure 33: Main interface

Name	Description
T1	Temperature sensor located between the condenser outlet and the pump inlet
P. lub	Lubrication pressure sensor
Frequency	Frequency of the main pump
T2	Temperature sensor located between the pump outlet and the evaporator inlet on the fluid side
Thout	Temperature sensor located between the customer's hot source outlet and the evaporator inlet on the water side
Thin	Temperature sensor located between the customer's hot source inlet and the evaporator outlet on the water side
T3	Temperature sensor located between the evaporator outlet and the turbine inlet

P3	Pressure sensor located between the evaporator outlet and the turbine inlet
VIB	Turbine vibration sensor
TG1	Turbine generator temperature sensor
T4	Temperature sensor located between the turbine outlet and the condenser inlet
P4	Pressure sensor located between the turbine outlet and the condenser inlet
TCOOL1	Temperature sensor for turbine cooling
POWER	Sensor indicating the power produced

Table 5: Sensor list

2.9 DATALOG

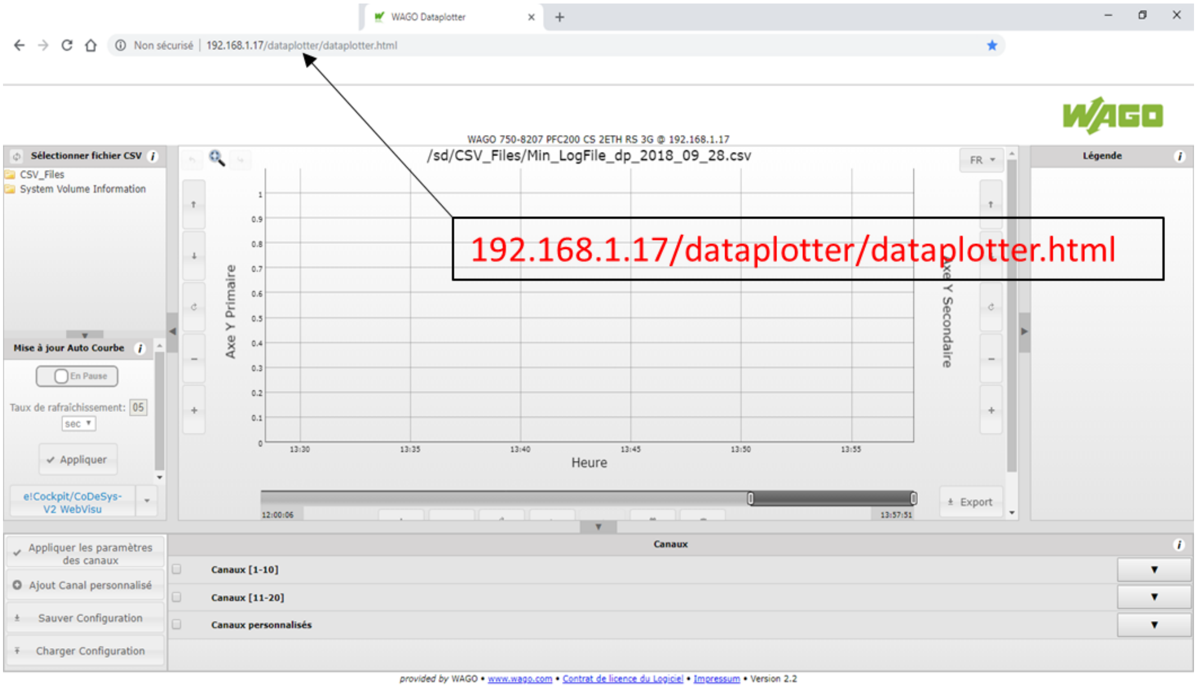
The operating data of the ORC can be retrieved via the web interface or with an SD card.

2.9.1 Datalog via web interface

This method allows you viewing the current operating data from the ORC as well as downloading the data history.

To retrieve operating data please follow the following below:

1. Go to: *192.168.1.17/dataplotter/dataplotter.html*
2. Select the file to analyze
3. Validate
4. Click on "export"
5. Select the format and confirm



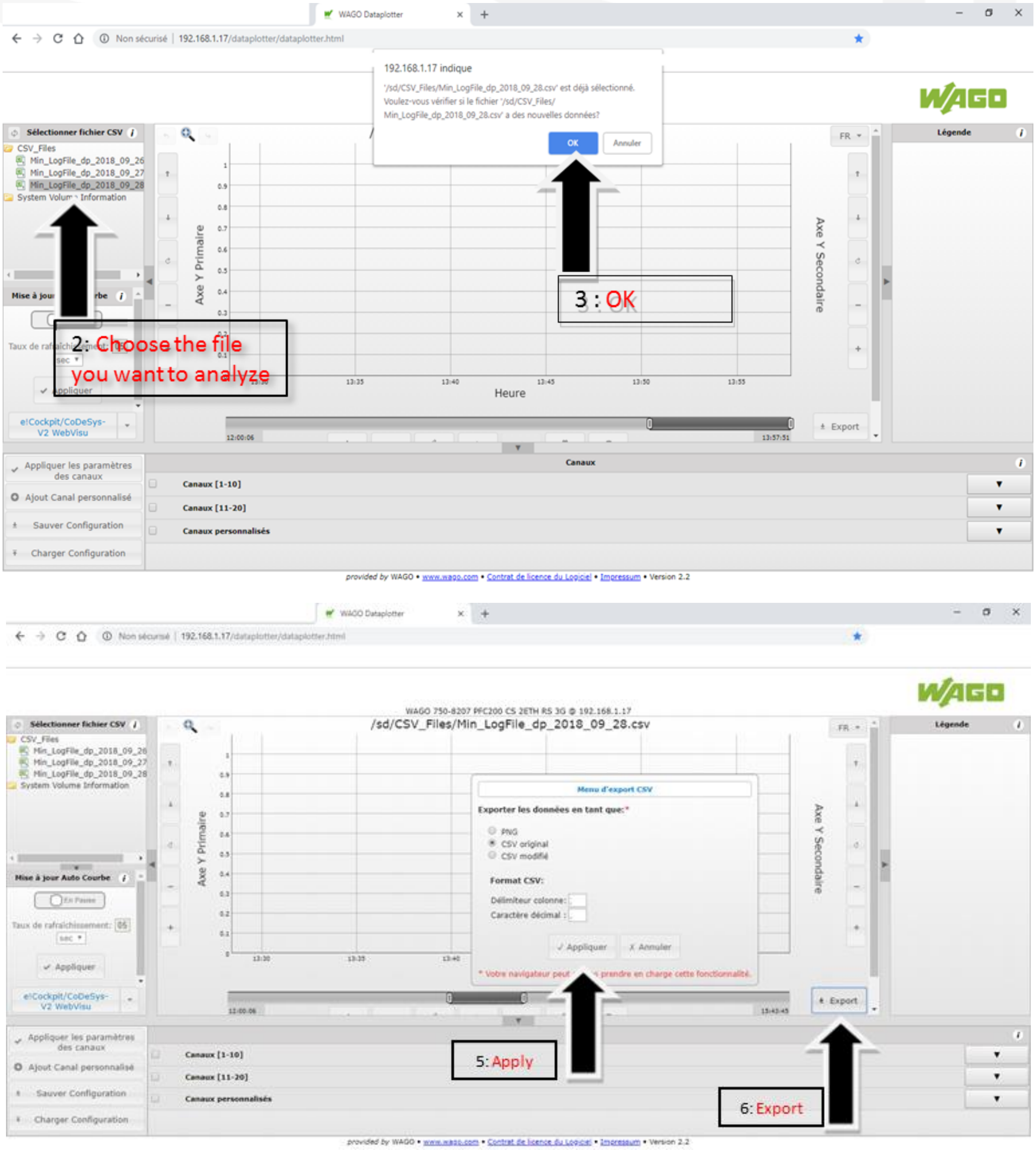


Figure 34: Datalog acquisition procedure

2.9.2 Datalog via SD Card

In order to retrieve ORC data via an SD card, you must check that your hot source and your cold source are shut down. As for the ORC it must be turned off.

Once all these conditions are validated you can remove the SD card.

Figure 35: PLC; SD card localization

Connect the SD card to your PC and select the excel file you wish to analyze.

Do not turn on the ORC again without reconnecting the SD card.

After downloading the data, they will be presented as follow:

1. « *5s_LogFile_dp* » → name of the folder
2. « *20xx_xx_xx* » → date

5s_LogFile_dp_2019_01_25.csv	25/01/2019 18:00	Fichier CSV Micro...	98 Ko
5s_LogFile_dp_2019_01_28.csv	28/01/2019 16:13	Fichier CSV Micro...	131 Ko

The format of the data log file is .CSV, it is common format which can be opened with excel or another spreadsheet software.

2.10 MAINTENANCE

2.10.1 Periodic inspections

2.10.1.1 European regulation

As specified in the European regulation N ° 517/2014 entitled F-Gas, the ORC is subject to a periodic control each semester.

<u>This control is the responsibility of the customer and can be serviced by ENOGIA or any other certified company.</u>

2.10.1.2 ENOGIA recommendation

Frequency	Inspection
Weekly to monthly (depending on site conditions)	Antifreeze liquid level of the cooling system tanks Clean fans Cleanliness of electrical cabinets
bi-annual	ORC loop sealing (according to European regulations)
Annual	Clamping ORC bolts

2.10.2 Level 1 Maintenance

Any maintenance operation described below requires the shutdown of the ORC and its lockout / tagout from all external energy sources.

2.10.2.1 Checking the level of antifreeze fluid in the cooling tanks.

The two cooling tanks are located in heights, close to the condenser.

The first filling procedure is described hereafter:

1. Unscrew the upper cap of the clarifier,
2. The volume capacity of the cooling circuit is 11L,
3. Fill the circuit with 4 liters of antifreeze -18 ° C at +/- 2 ° C,
4. Fill the rest of the circuit with 7 liters of mixture of water and 30% glycol,
5. Replace the cap.

2.10.2.2 Checking the cooling fans

The cooling fans are located under the evaporator.

The cooling fan grating can be clogged with dust as shown in Figure 36, which degrades its effectiveness. Cleaning the grill can be done by gently rubbing a clean cloth.

Figure 36: Cleaning operation of the air condenser

The operation of the cooling fans can be easily detected by the airflow and noise during the ORC operation. If there is no flow or fan noise, please contact ENOGIA.

2.10.2.3 Checking the operation of the cooling pump

The operation of the pump can be detected by a slight vibration of the rear part while the ORC is operating.

In case of no vibration or unpleasant noise, please contact ENOGIA.

2.10.2.4 Fan unit maintenance

Maintenance is essential for both safety and proper functioning of the fan unit.

1. Checking and tests must be carried out by qualified personnel.
2. Servicing the unit is prohibited before wiring off the power supply. Wait until all fans have come to a complete stop.
3. The efficiency of the electrical wiring, earthing system and parts mostly subject to wear (motors, electric heaters, switches, etc.) must be checked at least every six months.
4. Correct functioning of all electrical and mechanical parts must be tested at least every six months by checking the operating temperatures.
5. It is recommended to clean the surfaces of both the finned pack and the fans at least every six months using non aggressive, water-based solutions with compressed air at a maximum pressure of 2 barg and at a distance exceeding 200 mm, perpendicularly to the finned pack. When cleaning the exchanger, wear proper clothing and protections. After cleaning the finned pack, carry out a visual check to find possible traces of dirt residues or damaged fins. For further details refer to the specific technical bulletin.
6. It is advisable to check the finned pack for cleanliness on a monthly basis.
7. In case of prolonged shutdowns in humid atmosphere, it is recommended to run the fan once a month for about two hours in order to evaporate the moisture inside it. In any case, refer to the instructions of the fan manufacturer fitted on the fan unit. If these documents are missing, ask ENOGIA Technical Department for a copy.
8. Walking or placing loads on the casing and headers is forbidden.
9. Placing or leaving any tool on the fan grids is also forbidden.
10. All maintenance and installation work must be carried out only if the weather conditions are such as to prevent risks to the operator's safety (rain, wind, etc.).

2.10.3 Preventive maintenance schedule

The ORC includes wear components, which must be replaced periodically.

The preventive maintenance planning recommended by ENOGIA is presented in Table 6.

Schedule [years]	2	3	5
0. Durations			
0.0 Duration of the operation [days]	3	5	5
1.Fluid			
1.1. Level check	X	X	X
1.2. Partial filling / dehydration		X	
1.3. Total filling			X
2.Turbine			
2.1. Disassembly and verification, sealing kit		X	X
2.2. Bearing replacement		X	X
3.Other			
3.1. ORC filter		X	X
3.2. Lubrication filter			X
3.3. Cooling pump	X	X	X
3.4. Lubrication pump			X

Table 6: Preventive Maintenance planning

2.10.3.1 Description of maintenance operations

<u>All maintenance operations described below require the shutdown of the ORC and its lockout / tagout from all external energy sources.</u>

<u>FLUID</u>

<u>Checking the fluid level</u>: The fluid level check must be performed by a qualified technician to handle the refrigerant. The fluid should be weighed appropriately and compared to the nominal fluid weight for the ORC considered.

<u>Liquid filling:</u> The fluid level must be checked by a qualified technician to handle the refrigerant. The fluid refill consists of a complete ORC emptying, a liquid level check and a liquid refill up to the nominal level. The technician in charge of the operation must ensure the dehydration of the liquid before its injection into the ORC.

<u>TURBINE</u>

The maintenance of the turbine must be carried out by ENOGIA. The turbine is an exclusive knowledge belonging to ENOGIA and cannot be opened or dismantled.

<u>Disassembly and verification, replacement of the seal kit</u>: After draining the ORC fluid, the turbine must be sent to the ENOGIA premises for checking the rotating and fixed parts by ENOGIA qualified personnel. The turbine will then be returned for assembly on the ORC.

Bearing replacement: After draining the ORC liquids, the turbine must be sent to the ENOGIA premises for replacement by qualified ENOGIA personnel. The turbine will then be returned for assembly on the ORC.

OTHER

ORC Filter: In order to ensure the quality of the refrigerant, maintain the operation and electrical performance of the ORC, the ORC filter must be changed after draining the ORC liquid.

Lubrication Filter: In order to ensure the quality of the refrigerant, its dehydration, maintain the operation and electrical performance of the ORC, the lubricating filter must be changed after the ORC liquid drain. At this point and for quick replacement, the filter is located between the isolation valves. The component can be changed after draining the fluid from this part.

Cooling pump: After draining the water from the cooling loop, the cooling pump can be disassembled to ensure the cooling of the electrical components with high reliability.

Lubrication pump: To ensure proper operation of the impeller, the lubrication pump must be replaced. At this point and for quick replacement, the pump is located between the isolation valves. Once the section has been removed from the working fluid, the component can be disassembled.

2.11 MAINTENANCE SERVICES

ENOGIA offers services for preventive and curative maintenance programs, including benefits such as online supervision and timely interventions.

For more information, please contact ENOGIA:

Tel: 0033 (0) 4 84 25 60 17

Email: info@enogia.com