Climate change mitigation in the wine sector: sustainable practices in vineyard and winery

Deliverable D3.2

Heat exchanger prototype

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Authors

Raul Losantos, Luís Valiño.

Executive summary

This deliverable presents the implementation of a geothermal heat exchanger prototype designed to improve the performance of a heat pump system at the winery and vineyard of Bosque de Matasnos, located in a semi-natural area in the region of Burgos, within the Ribera del Duero Denomination of Origin area in Spain.

The system leverages the cold water extracted from the subsurface water layer used for irrigation to enhance the efficiency of the heat pump responsible for cooling the fermentation vats and maintaining moderate temperatures in the winery premises during the summer. By replacing the aerothermal system with a geothermal solution, the project aims to achieve energy savings, reduce operating costs, and provide a more sustainable refrigeration process.

Disclaimer

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List of abbreviations

COP – Coefficient of Performance

EES – Energy Efficiency Ratio

WP – work package

HP – heat pump systems

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1. Introduction

The European wine sector, as part of the broader agricultural industry, is among the most vulnerable to the impacts of climate change, as rising temperatures and changing weather patterns directly affect grape quality and yields. Helping to mitigate the climate change is then of particular interest for this sector.,. However, the adoption of mitigation measures remains slow. This delay is largely attributed to several factors: the limited availability of detailed information on specific adaptation strategies, the variability in the profitability of these measures depending on the circumstances, and the economic challenges faced by wineries of different sizes. Smaller wineries, in particular, often struggle to achieve the economies of scale required to offset the high capital costs of implementing innovative technologies, such as renewable energy systems or advanced cooling solutions. These structural challenges highlight the need for tailored approaches that address the unique financial and operational constraints of wineries across the sector.

Therefore, the LIFE CLIMAWIN project addresses the problem of climate change by involving the wine sector in its mitigation. This is done by means of converting the wineries and vineyards into a compendium of climate change mitigation actions, including also adaptation and circular economy measures. Thus, the main objective of the project is to **show that wineries and vineyards can become a model of sus**tainability.

The demonstrative activities are being performed in the premises of the winery and vineyard of Bosque de Matasnos, located in a semi-natural area of the Denomination of Origin Ribera del Duero. This wine company counts with the ideal conditions in order to implement the prototypes.

One of the activities focuses on improving the performance of the heat pump system at the Bosque de Matasnos winery by utilizing the cold underground water table, already used for irrigation, in the refrigeration process. A heat exchanger system is being implemented taking avantage of the water used for irrigation which is taken from a well to enhance the energy efficiency of refrigeration for fermentation vats and winery premises. This is part of **WP3 – Design, installation, and testing of the heat exchanger prototype**.

WP3 aims to demonstrate sustainable solutions for winery refrigeration needs by utilizing existing resources, to optimize cooling processes in an energy-efficient manner. **Objective B** specifically focuses on improving heat pump performance by leveraging cold underground water for enhanced refrigeration efficiency, reducing energy consumption and reliance on external energy sources.

A performance evaluation will be conducted under normal working conditions. The results will be analyzed from technical, economic, and environmental perspectives, assessing energy savings, , to inform potential replication in other wineries.

This report aims to present the geothermal heat pump system installed at the location, detailing its components, how it operates, the development process, the challenges

encountered during installation, and the potential issues expected during its testing and operation under normal winery conditions.

2. Background

Bosque de Matasnos (Figure 1) is placed in a semi-natural area 4 km north from the town of Peñaranda de Duero (Burgos, Spain). It is located on the edge of Ribera del Duero Denomination of Origin area (Figure 2). In 1960, the previous owners decided to deforest part of the land to allocate hectares to what is now an old vineyard and 149 hectares of rainfed cereal crops. This has been the historical use of the agricultural land for the past 60 years. Until 2019, it was managed using the traditional system of cereal cultivation and fallow. The current owners are respecting and expanding the forested area, replacing cereal with vineyards and introducing extensive livestock and bee colonies for honey production.

Figure 1. Bosque de Matasnos winery and vineyard location in Burgos, Spain

Today, Bosque de Matasnos consists of 123.4 hectares of forest, 53.3 hectares of cereal and 67 hectares of vineyard. The building of the winery, recently built, is also placed there, alongside with other facilities, including a cottage house used by the winery owners to receive visits. The complex also counts with a refuge for sheep and other animals that coexist on the place.

Figure 2. Ribera del Duero Denomination of Origin area. Source: http://www.vinoriberadelduero.com/ribera-del-duero/, modified

The summer months in Spain are characterized by periods of high temperatures (Figure 3), , although the Ribera del Duero region where the winery is located is not among the hottest areas,. Additionally, climate change has caused a significant increase in temperatures in recent years (Figure 4).

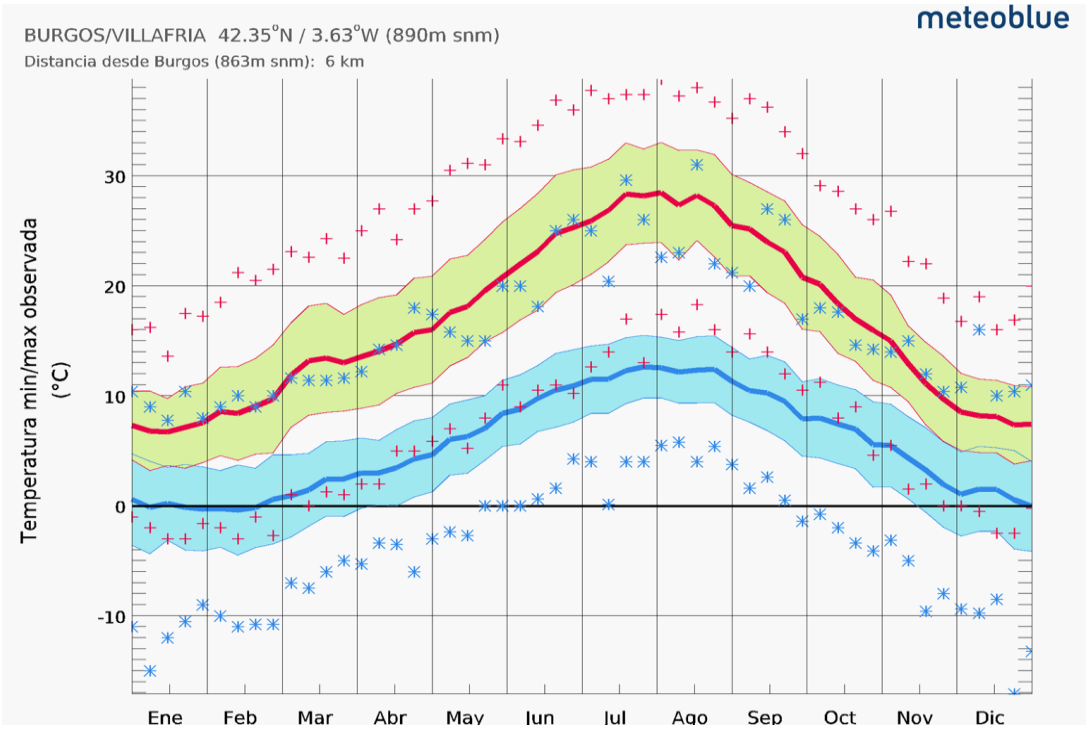


Figure 3. Annual temperature variation in Burgos, with minimum (blue) and maximum (red) values, uncertainty bands, and average climate ranges. Source: https://www.meteoblue.com/es/tiempo/historyclimate/climateobserved/burgos_espa%C3%B1a_3127461

This rise in temperature has a direct impact not only on the vineyards, but also on wine production, as fermentation processes in vats and the ambient temperature of the winery facilities require efficient cooling systems to preserve wine quality. As temperatures continue to climb, the demand for energy-intensive refrigeration during the summer months becomes increasingly critical, placing additional strain on the existing energy systems.

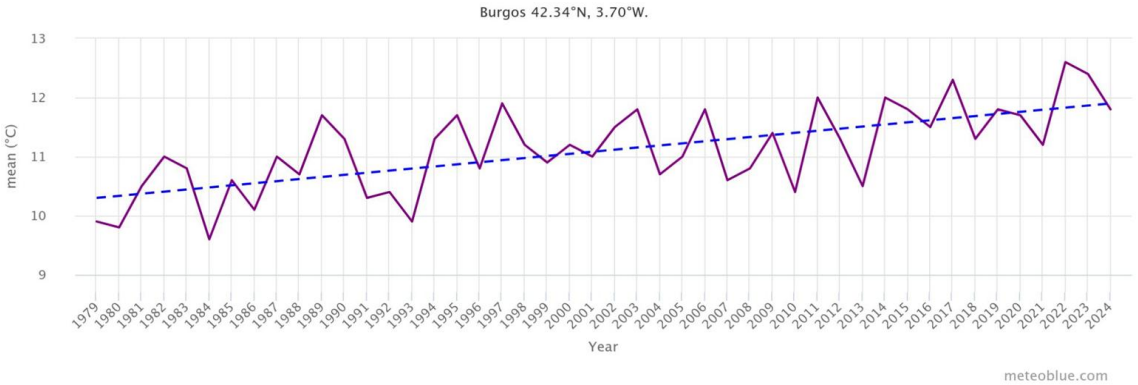


Figure 4. Mean yearly temperature and trend, 1979-2024. Source (modified): https://www.meteoblue.com/es/climate-change/burgos_espa%C3%B1a_3127461

Regarding energy supply, the entire facility is not connected to the electric grid. At the start of the project, energy needs were primarily met through fossil fuels. However, driven by the owners' commitment to sustainability, a stand-alone energy system was designed for the winery's operations, with a focus on expanding and prioritizing the use of photovoltaics combined with battery storage. The installation of solar panels has also been part of a broader initiative included in the *ClimaWin* project.

The various electrical demands, including water pumping for irrigation and climate control systems, are dependent on this isolated network. The system is a hybrid, integrating photovoltaics with a diesel generator. However, as observed based on the region's climatic conditions, the high energy demands during the summer months—when irrigation and refrigeration systems operate simultaneously—pose a challenge to sustainability.

To address these challenges, the *CLIMAWIN* project takes advantage of the availabilityof the cold water from the underground source used for irrigation. The refrigeration system improves cooling efficiency by using the naturally low temperature of the water, which significantly reduces the energy required for refrigeration. Notice that no drilling or other typical actions carried out in geothermal are needed.

3. Definition heat pumps systems

Heat pump systems (HP) are energy-efficient systems used for heating, cooling, and providing hot water in various settings, such as residential, commercial, and industrial environments. These systems transfer heat from one place to another by exploiting a thermodynamic cycle. A heat pump can extract heat from a cooler environment (such as outdoor air, water, or the ground) and deliver it to a warmer space, which makes them useful for both heating and cooling purposes. Their growth is strongly supported by European regulations, such as the Renewable Energy Directive and the Energy Efficiency Directive, which promote their use as energy-efficient solutions to reduce greenhouse gas emissions and energy consumption in heating and cooling systems [1][2].

This widespread adoption is attributed to their high energy performance and their ability to operate using electricity generated from renewable sources like solar, wind, and hydropower. By effectively harnessing environmental thermal energy, heat pumps achieve significant energy savings while aligning with global goals for energy transition and sustainability.

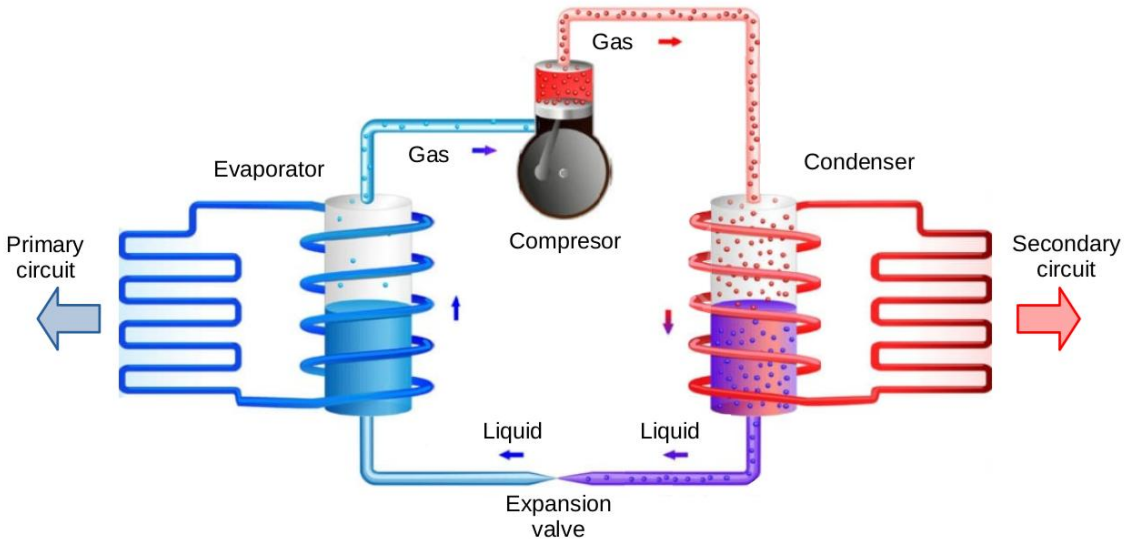


Figure 5. Schematic diagram of a heat pump system operation. Source: modified from https://areatecnologia.com/calefaccion/bomba-de-calor.html.

As shown in Figure A, heat pump systems consist of several essential components that work together in the thermodynamic cycle to transfer heat from a cold source to a hot one. The **evaporator** is responsible for absorbing heat from the source, such as air, water, or soil. In the evaporator, the refrigerant fluid circulates through a coil or heat exchanger, where it evaporates by absorbing heat from the surrounding environment. After this, the refrigerant enters the **compressor**, which increases its pressure and temperature. This process transforms the refrigerant into a high-pressure, hot gas. The hot, high-pressure gas then moves to the **condenser**, where it releases the absorbed heat to the target medium, which

could be air or water. As the refrigerant cools, it condenses back into a liquid at high pressure. Finally, the **expansion valve** reduces the pressure of the refrigerant, causing it to cool further. This cold, low-pressure refrigerant is then ready to absorb more heat in the evaporator, restarting the cycle.

Heat pumps are classified based on their heat exchange source: **traditional heat pumps** that use air, and **geothermal heat pumps** that use water or the ground, which tend to offer higher efficiency. This is to the fact that the heat pump is more efficient when the cold reservoir and the hot reservoir have temperatures that are closer together

Traditional heat pumps rely on outdoor air for heat exchange. While they are more affordable in terms of initial installation costs, their energy efficiency is heavily influenced by extreme climatic conditions. This is because air, as a heat exchange medium, has low thermal inertia and limited heat transfer capacity compared to water. In very low or high outdoor temperatures, the system struggles to maintain consistent performance, as the temperature differences reduce the efficiency of heat transfer, leading to higher energy consumption and diminished overall efficiency.

In contrast, geothermal heat pumps offer higher and more stable efficiency due to their reliance on the constant more temperate temperature of subsurface or groundwater, leading to significant reductions in energy consumption compared to traditional air-source systems [3][4]. Although they involve high initial costs, especially for drilling, using existing water reservoirs, such as irrigation ponds, as the heat exchange medium can provide a more cost-effective solution.

These systems are particularly suited for large-scale projects with high energy demands, such as industrial facilities, due to their efficiency and sustainability. While initial investments may be higher, the long-term operational savings and low maintenance costs often justify the investment [4][5]. Advances in drilling technologies and control systems are also reducing implementation costs [6][7].

A cost-effective alternative to geothermal systems, implemented in this project, is to use existing water reservoirs as the heat exchange medium. The idea is to use the water already extracted from a subterranean aquifer for irrigation purposes and stocked in a tank as the hot reservoir. This approach reduces the need for costly ground drilling and extensive modifications, while also offering several technical and environmental advantages.

- **High Energy Efficiency**: Water's superior thermal properties enable heat exchange systems to achieve higher coefficients of performance (EES/COP) compared to other types of heat pumps, with also a more temperate temperature[5].
- **Thermal Stability**: Groundwater or surface water maintains relatively stable temperatures year-round, ensuring a more efficient performance as cold or heat reservoir, regardless of outdoor climatic conditions [6].

4. Implementation

4.1.1. Work progress and setbacks

During the initial stages, the main equipment was carefully selected, prioritizing efficiency, operational flexibility, and integration with available resources. The sizing of the climate control system for fermentation took into account the energy requirements of the various processes it needs to support within the winery. The climate control system primarily relies on a water-to-water HP, with the air-to-water HP serving as a secondary component. The system is supported by inertia tanks and dedicated circuits tailored to the specific requirements of each process.

The water-to-water HP utilizes underground water stored in an existing 1,000,000-liter tank, thereby taking advantage of an already available resource within the winery. This tank plays a critical role, serving multiple purposes: providing water for vineyard irrigation, supplying treated water for the winery's operational needs, and acting as the primary cooling medium for the heat pump system, which can either provide cooling or heating depending on the mode of operation. The design of the climate control system accounts for these other uses to ensure that temperature variations caused by the refrigeration processes do not interfere with the availability or functionality of water for irrigation or operational supply.

The energy demand for the winery's climate control and fermentation processes was taken into account to size the water-to-water system as the primary unit. This system achieves high efficiencies, with an EER exceeding 5 under optimal conditions and a COP near 4. It is used as a priority HP system, with its functionality limited during colder months due to freezing risks, particularly when the tank water temperature falls below 10°C. Designed to operate at baseline capacity, it minimizes electricity consumption and primarily relies on solar-generated energy.

The air-to-water HP serves as a supplementary system, addressing peak demands or situations where the thermal conditions of the underground water are unsuitable. While not as efficient as the water-to-water HP, this unit can modulate its capacity from 20%, ensuring energy efficiency and meeting the winery's operational needs. Together, both heat pumps offer operational reliability, supporting either simultaneous or independent operation.

To enhance system stability and efficiency, the installation includes three 750-liter inertia tanks in a four-pipe configuration, allowing for simultaneous heating and cooling to meet specific process needs.. This includes maintaining temperatures for fermentation tanks (7-18°C), heats malolactic fermentation tanks (35-40°C), and regulates the ambient climate for barrel and bottle storage. The modular design of the system ensures operational security, enabling either or both units to function simultaneously during peak demands, optimizing energy usage and maintaining consistent control. The system also incorporates a water treatment and pressurization setup to ensure the quality and functionality of the water supply. Safety valves, filters, and bypasses safeguard the operation and minimize risks of leaks or interruptions.

Currently, the facility includes two distinct climate-controlled areas: one dedicated to fermentation tanks and the other for barrel aging and bottle storage. In the fermentation area, cold or hot water lines regulate the temperature of each tank individually through their cooling jackets. Meanwhile, the barrel aging and bottle storage area is maintained using ambient air conditioning. Both systems are functioning efficiently without any issues.

The winery is expected to have an expansion, adding two separate buildings to house barrels and bottle racks. Once operational, these new buildings will take over the climate-controlled storage of barrels and bottles, leaving the area available for the addition of new fermentation tanks. This reorganization will optimize space and support the winery's increased production capacity.

The new buildings are already designed to connect to the existing mechanical room, where the necessary climate control installations will be implemented. Importantly, the initial design of the mechanical systems accounted for the additional demand of these new configuration and capacity.

4.2. Configuration and description of the installation.

The different components of the climate control system are located at the Bosque de Matasnos winery estate, as shown in Figure 6. The 1,000,000-liter tank, which serves as the thermal source for the water-to-water heat pump, is filled with groundwater through a pumping system located in a small adjacent building.

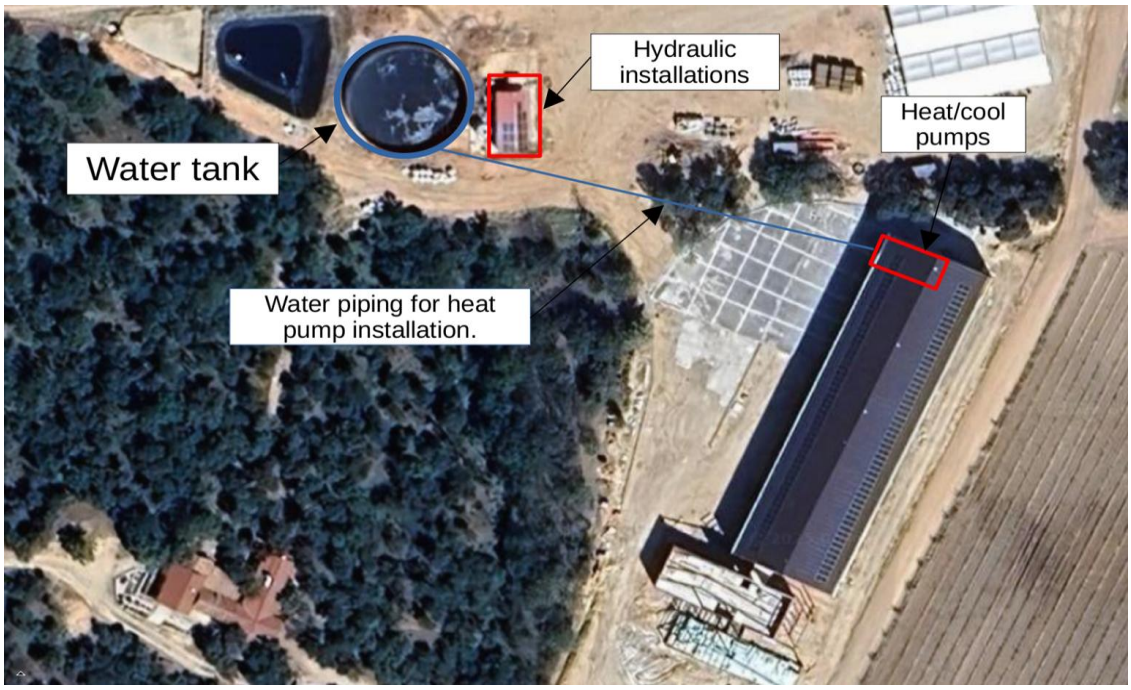


Figure 6. Aerial view of a heat pump installation system. The image highlights key components, including the water tank, hydraulic installations, heat/cool pumps, and the water piping connecting these elements.

Water is pumped from the tank through two PE Ø63 pipes—one for supply and one for return—to the main warehouse, located less than 100 meters away. The tank also has an additional inlet used for filling and supplying water for both irrigation and other winery needs.

The tank water is primarily used for vineyard irrigation but also supplies the winery's offices and internal processes, requiring filtration through a treatment system that includes filters and water softeners. Additionally, **the water serves as a thermal source for the heat pump**, which regulates temperatures in specific winery processes.

Irrigation ensures continuous renewal of the tank water with groundwater, preventing excessive temperature buildup from the HP and maintaining efficient thermal exchange. However, if the HP alters the water temperature too much, it could limit its use for irrigation and other purposes, requiring careful system management. The complete system diagram is provided in Annex I.

As indicated in Figure 6, the climate control system and its various components are located on the side of the main warehouse. From there, water is supplied to meet the heating and cooling needs of the different processes taking place in the winery.

Figure 7 shows the operational scheme of the winery's climate control system, designed to regulate temperature during fermentation, malolactic fermentation, and wine storage. The system ensures optimal conditions by using heat pumps, inertia tanks, and distribution circuits, allowing simultaneous heating and cooling when needed. The main equipment is housed in a dedicated control room to centralize operations, except for the air-to-water heat pump, which must be located outdoors to use ambient air as a thermal source (see Annex III).

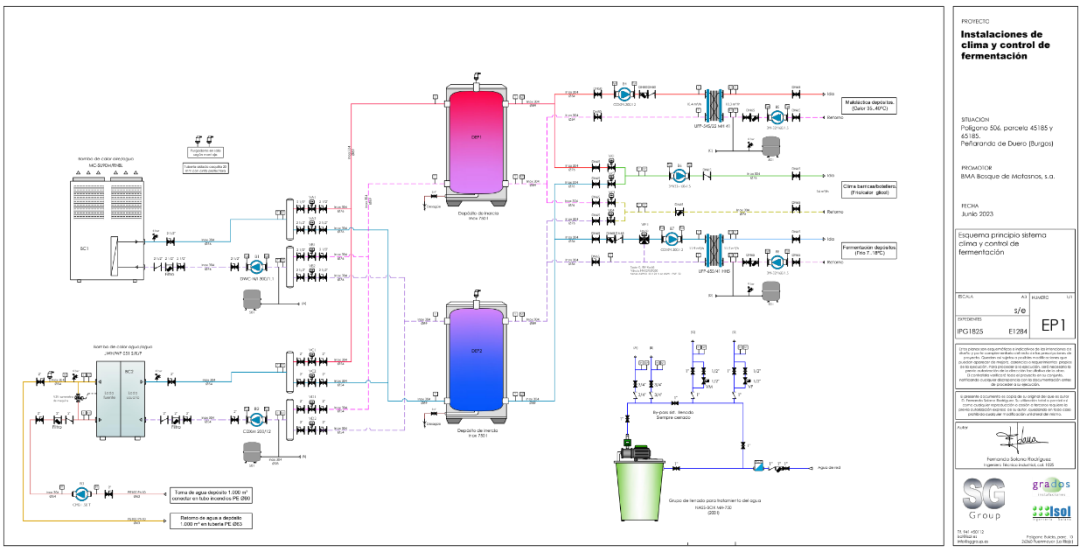


Figure 7. Principle diagram of the climate and fermentation control system. For detailed view, refer to Annex II.

The diagram highlights **three main thermal needs** within the winery. The first is fermentation cooling, which requires maintaining a controlled temperature between 7°C and 18°C to dissipate the heat generated during alcoholic fermentation. The second need is malolactic fermentation heating, where temperatures between 35°C and 40°C are necessary to

facilitate the conversion of malic acid into lactic acid. Finally, the third requirement is barrel and bottling area climate control, ensuring the proper temperature for wine preservation during aging and storage.

To generate both cooling and heating, the system employs two types of heat pumps that extract energy from different sources.

The water-to-water HP is the primary system used for cooling and heating, utilizing underground water stored in a 1,000,000-liter tank as its thermal source. This unit is prioritized for use due to its higher energy efficiency, with an EER exceeding 4. However, during winter, its operation is more limited due to the risk of freezing. This HP plays a critical role in the system, as outlined in the WP3 objective, ensuring the system's efficiency and performance.

In complement, the air-to-water HP uses the outside air as a thermal source. This unit can provide both heating and cooling, modulating its power output from 20% to 100% based on demand. It serves as an auxiliary system, primarily used when the water-to-water HP is unable to operate or when thermal demand is high. This HP is located outside the main building, functioning as a backup when necessary.

Both heat pumps transfer thermal energy to inertia tanks, which act as storage buffers and help stabilize the system's thermal demand. The schematic representation of the system's operation can be found in Figure 7 (ANNEX II).

The system features a four-pipe network that enables the simultaneous transport of hot and cold water based on process requirements. Inertia tanks act as thermal storage interfaces, ensuring stability and efficiency. Each thermal demand is managed through dedicated circuits, regulated by heat exchangers, circulation pumps, and control valves, allowing precise temperature control for different stages of the winemaking process.

The system is designed to maximize energy efficiency and ensure operational redundancy in case of failures. To achieve this, priority is given to the use of the water-to-water HP due to its superior energy efficiency. The air-to-water HP is activated only when water-to-water HP cannot meet the full demand. Additionally, thermal storage in the inertia tanks helps reduce electricity consumption during peak demand periods.

4.3. Description of the components.

The wine fermentation climate control system in the winery, as shown in Annex II, is composed of the main elements described in this chapter. It provides a detailed overview of the key components of the heating and cooling generation system, including their specifications and functions within the installation. A summary table of these components is provided below.

Table 1. Description and quantity of main components for heating and cooling system installation.

Component	Description	Quantity
Water-to-water heat pump (53 kW)	Provides heating and cooling using water as a thermal source; includes essential components for operation.	1 unit
Air-to-water heat pump (90 kW)	Provides heating and cooling using external air as a thermal source; includes essential components for operation. Needs outdoor installation.	1 unit
Water source components	Includes pressurization and heat recovery pumps, mixing valve, and filters;	1 set
Stainless steel DN100 collector	Insulated, with entry and two exits; includes valves, thermometers, and purger; used for heat and cooling distribution.	4 units
750-liter stainless steel buffer tank	Vertical, insulated, with flanged valves and thermometers; provides thermal inertia.	2 units
Piping and components installation	Includes filling system, stainless-steel pipes, antifreeze solution, and electrical wiring; connects circuits in the machine room.	1 set
Heating distribution collector set	Includes distribution pumps, valves, and accessories for heat distribution; used for distributing hot water to the system.	1 set
Cooling distribution collector set	Includes distribution pumps, valves, and accessories for cooling distribution; used for distributing cold water to the system.	1 set
Climate control distribution system	Designed for the barrel and bottling room; includes insulation, valves, and pumps; regulates climate in specific areas.	1 set
Power and control electrical panel	Includes automation, protections, and monitoring; manages the entire machine room control.	1 unit

- Water-to-Water Heat Pump

The JWH/WP 051 water-to-water water-to-water HP is the main climate control component, designed to efficiently utilize the winery's resources—specifically the thermal potential of the irrigation water tank—to climatize the winery's processes. This heat pump provides both heating (70.9 kW) and cooling (53.1 kW) under standard conditions, ensuring optimal thermal management. It features a Scroll compressor with an oil level indicator, thermal protection, and a crankcase heater, all mounted on anti-vibration supports to minimize noise and enhance durability. The pump operates with R410A refrigerant, making it an eco-friendly solution. Its plate heat exchangers (condenser and evaporator) are made of AISI 316 stainless steel, providing excellent corrosion resistance and thermal efficiency. Additional key components include silent blocks, a primary circulation pump, safety valves, expansion vessels, shut-off valves, filters, thermometers, and pressure gauges. The insulated stainless steel interconnection pipes ensure minimal heat loss.

- Water Source Components for the Water-to-Water Heat Pump

To ensure proper functionality of the water-to-water heat pump, several auxiliary components are installed to handle the external water source. These include a pressurization pump for the water line, a heat recovery pump, a mixing valve, inclined filters, and check valves. There are also shut-off valves and a safety valve to ensure the integrity of the system. The system features insulated stainless steel and PVC pressure pipes, which are designed to handle the varying pressures within the system. Thermometers and pressure gauges are included to monitor the water's status.

- Air-to-Water Heat Pump

The air-to-water HP, model MC-SU90-RN8L-B, serves as the auxiliary system to the main climate control component. It has a heating capacity of 90 kW and a cooling capacity of 82 kW, operating with INVERTER scroll compressors that ensure efficiency even at low temperatures. It offers versatile performance for both heating and cooling needs, delivering high efficiency even at a minimum operating capacity of 20%.

This heat pump incorporates several key components, including a primary circulation pump, safety valve, expansion vessel, shut-off valves, filters, thermometers, and pressure gauges. The interconnection pipes are constructed from insulated stainless steel, ensuring durability and optimal heat transfer.

The unit must be installed outdoors on a stable foundation near the machine room.

- 750-Liter Stainless Steel Buffer Tank

A vertical buffer tank with a 750-liter capacity provides thermal inertia, improving the stability of the system. The tank is insulated to prevent thermal losses and includes several valves and thermometers for efficient monitoring and control. This component plays a key role in maintaining temperature stability in the system.

- Piping Installation and Machine Room Components

This section covers the components required for the generation zone and connections within the machine room. The installation includes a filling system with a pressure group, stainless-steel pipes for connections, a PVC drainage line, cable tray for wiring components, and antifreeze solution to prevent freezing. Additionally, wiring for pumps, servovalves, sensors, and control units is part of this setup.

- Heating and Cooling Collectors (DN100 Stainless Steel)

The system includes two insulated DN100 stainless steel collectors for efficient heating and cooling distribution. These collectors are designed to minimize energy loss and ensure effective thermal transfer. They feature multiple exits for distributing hot and cold water and are equipped with shut-off valves, servo-controlled butterfly valves, three-way mixing valves, non-return valves, thermometers, and a high-efficiency air purger. Additionally, distribution pumps are integrated to maintain energy efficiency and optimal system performance.

- Heat, Cooling, and Climate Distribution Systems

The heat and cooling distribution systems consist of stainless-steel pipes, plate heat exchangers, high-efficiency air purge bottles, protection filters, shut-off valves, circulation pumps, expansion vessels, safety valves, thermometers, and assembly accessories. These systems regulate the distribution of thermal energy to various parts of the installation, including storage tanks and climate-controlled spaces.

- Power and Control Electrical Panel

The power and control electrical panel is responsible for managing the entire machine room, providing automation, protections, and monitoring for the system. It includes a dual enclosure for control and power components, various circuit protections (main switch, differential breakers, etc.), and a programmable logic controller (PLC) with a touchscreen for visualization and control. Remote monitoring is possible through an internal/external network connection. The installation does not include the electrical connection to the panel or the power protection for the heat pumps, which must be supplied by the prop

5. Operation and expected results

During operation, the climate system optimizes its performance to meet the thermal demands of the winery's fermentation process, adapting to external conditions and specific cooling and heating needs. To achieve this, the system includes a primary heat pump that uses irrigation tank water as its thermodynamic source and an auxiliary unit that employs external air. Both systems have been sized to ensure they can independently meet the installation's power requirements, even under unfavorable operational conditions related to the temperature of the thermal source (air or water).

The operational control for activating each system must take into account that the **water-to-water HP** should serve as the primary system, as it provides higher performance and thus leads to greater energy savings. However, there are specific conditions under which the auxiliary system (air-to-water) must operate:

- Failure of the primary **water-to-water HP** system.
- Insufficient water in the storage tank to supply the HP.
- Water temperature in the tank falling below the operational range for the **water-to-water HP**.
- Excessive heating of the water or a significant temperature change in the storage tank that prevents its use for other processes.
- Consumption peaks where the **water-to-water HP** cannot meet the required demand.
- Simultaneous heating and cooling requirements in the winery processes.
- Situations where heating or cooling power needs are well below nominal levels, and the **air-to-water HP** offers better efficiency.

The average efficiencies (COP/EER) for the operational conditions at the winery for these two climate control devices, for different modes of operation, are as follows:

- **Cooling Mode:**
    - **Air-to-water HP**: EER ≈ 2.95
    - **Water-to-water HP**: EER ≈ 5.38
- **Heating Mode:**
    - **Air-to-water HP**: COP ≈ 3.2
    - **Water-to-water HP:** COP ≈ 3.95

Operation Scenarios

Based on these efficiency data, we will estimate the energy savings achieved by using a HP that utilizes irrigation tank water as its thermodynamic source compared to a traditional air-to-water HP. To do this, we consider the following operational scenarios for the climate control system, which demonstrate how energy consumption varies with the selected configuration:

- **Scenario 1 (100% air-to-water):** This is the base scenario for calculating energy consumption. In this case, only the air-to-water HP is used to meet the entire cooling and heating demand.
- **Scenario 2 (30% air-to-water, 70% water-to-water):** In this configuration, 30% of the demand is met by the air-to-water heat pump, while 70% is met by the water-to-water HP.
- **Scenario 3 (10% air-to-water, 90% water-to-water):** Here, 10% of the demand is met by the air-to-water HP, with the remaining 90% supplied by the water-to-water HP.

The energy consumption in each scenario is presented below, along with the percentage reductions compared to **Scenario 1 (100% air-to-water)**:

Table 2. Percentage reductions in cooling and heating energy consumption for different operational scenarios compared to the baseline (100% air-to-water).

Scenario	Cooling Savings (%)	Heating Savings (%)
Scenario 2 (30% air-to-water, 70% water-to-water)	46.3%	32.4%
Scenario 3 (10% air-to-water, 90% water-to-water)	55.9%	38.3%

Conclusion

The strategic implementation of the water-to-water HP as the primary system for cooling the fermentation processes at Bosque de Matasnos winery not only enhances operational efficiency and optimizes energy consumption but also plays a crucial role in promoting sustainability. By significantly reducing energy demand and associated emissions, this approach contributes to a greener process while ensuring continuous, reliable operation throughout the year—even under challenging conditions such as low water temperatures in the storage tank.

Moreover, leveraging the higher efficiency of the water-to-water HP, particularly when external conditions are not optimal for the air-to-water system, enables substantial energy savings. The built-in redundancy and operational flexibility—provided by integrating the air-to-water HP as a backup—further ensure that the system can handle peak loads, simultaneous heating and cooling demands, and any operational constraints that may arise. Overall, this integrated solution results in a robust, efficient, and resilient thermal management system tailored to the unique needs of the winery.

References

[1] *European Commission. (2018). Directive 2018/2001/EU on the promotion of the use of energy from renewable sources (RED II).*

[2] European Commission. (2012). Directive 2012/27/EU on energy efficiency.

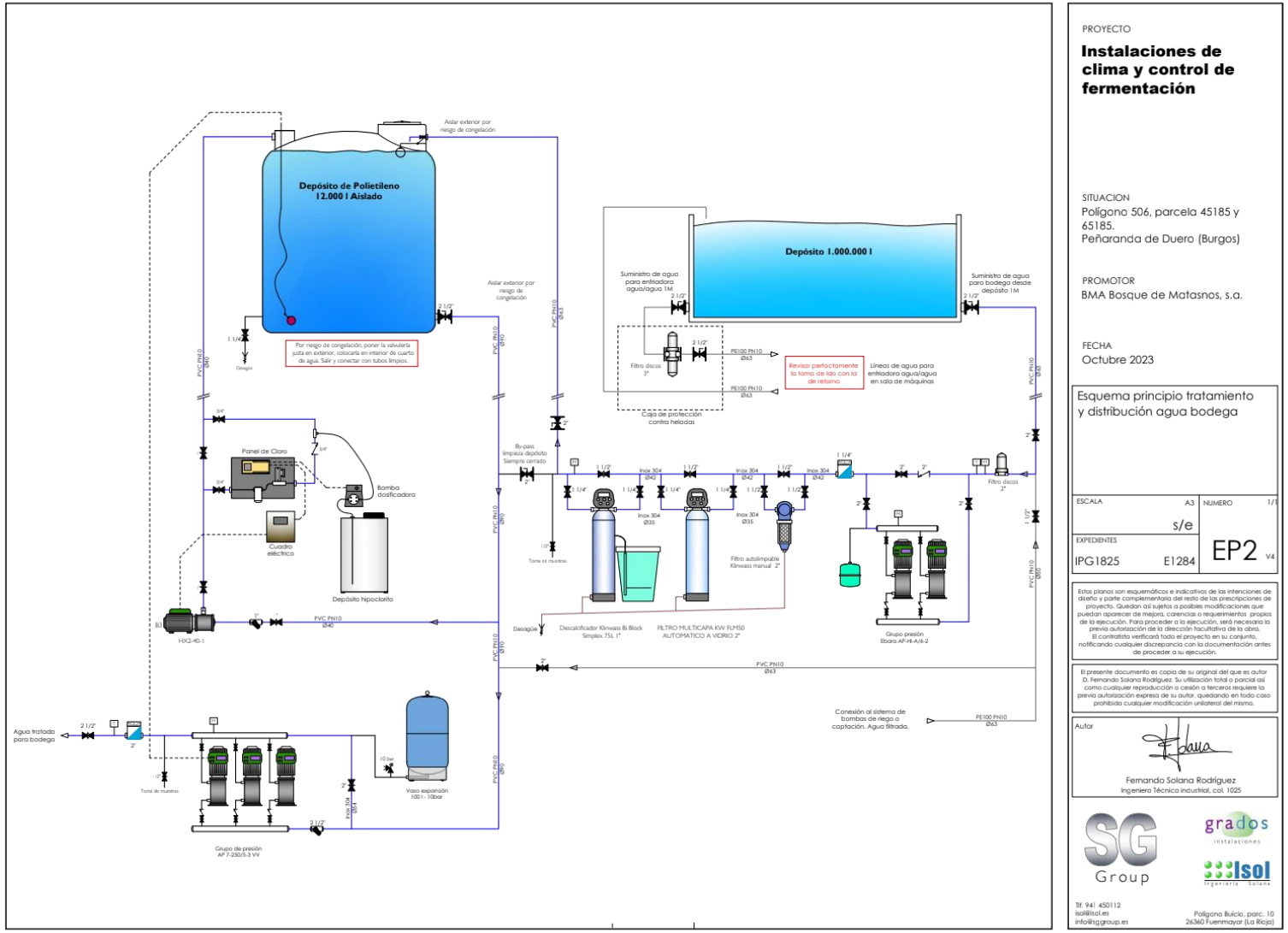
[3] Lund, J., Sanner, B., Rybach, L., Curtis, R., & Hellström, G. (2004). "Geothermal (ground-source) heat pumps: A world overview." *GHC Bulletin*.

[4] Hepbasli, A., & Kalinci, Y. (2009). "A review of heat pump water heating systems." *Renewable and Sustainable Energy Reviews*. DOI: 10.1016/j.rser.2008.06.003

[5] Man, Y., Yang, H., & Wang, J. (2010). "Study on the performance of ground-source heat pumps with groundwater heat exchange." *Energy*. DOI: 10.1016/j.energy.2009.07.050

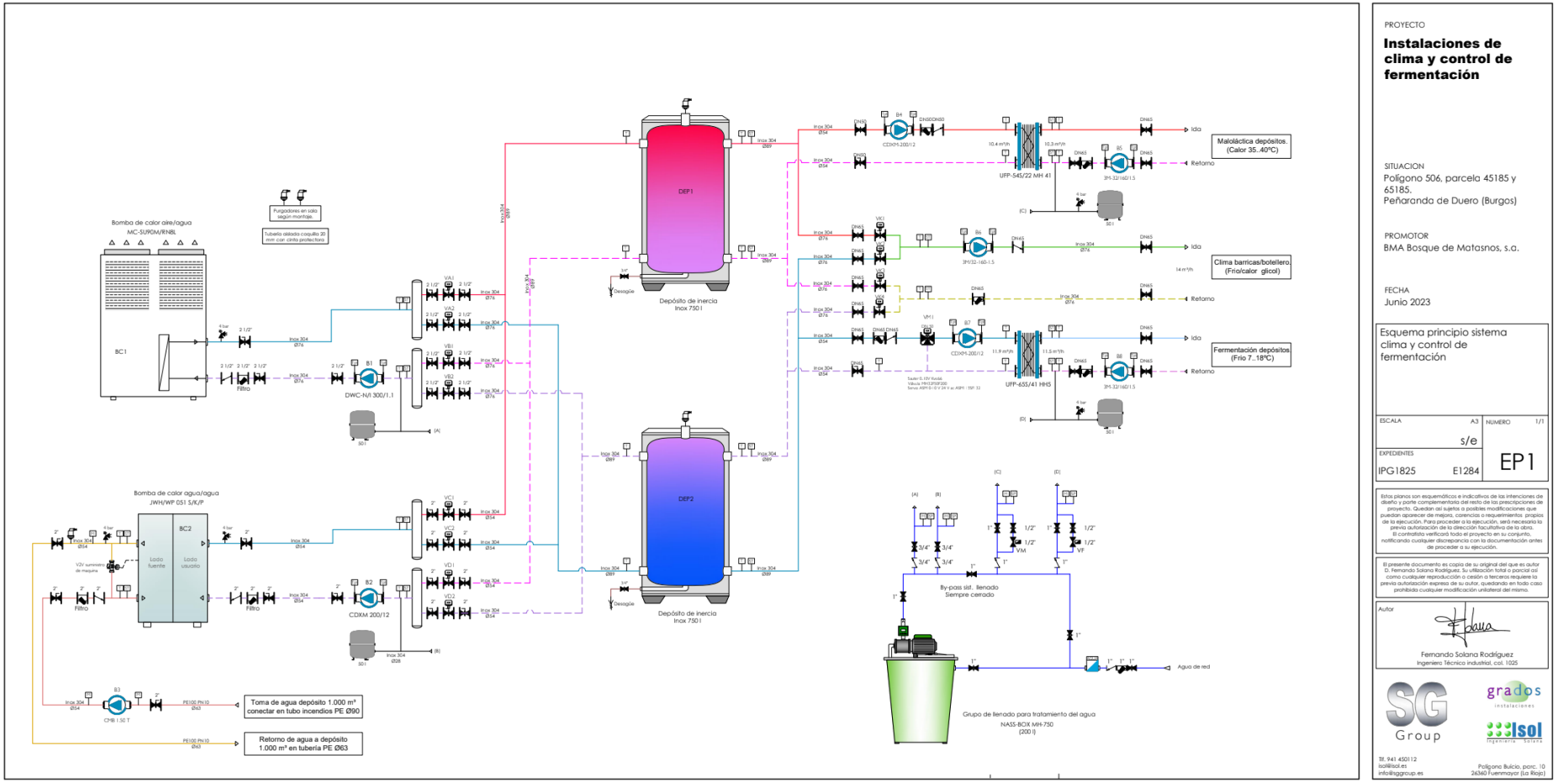
[6] Omer, A. M. (2008). "Ground-source heat pumps systems and applications." *Renewable and Sustainable Energy Reviews*. DOI: 10.1016/j.rser.2007.06.007

Annex I – Technical drawings



Deliverable D3.2 – Heat exchanger prototype

Annex II – Principle diagram of the climate and fermentation control system



PROYECTO

Instalaciones de clima y control de fermentación

SITUACION
Polígono 506, parcela 45185 y 65185.
Peñaranda de Duero (Burgos)

PROMOTOR
BMA Bosque de Matasnos, s.a.

FECHA
Junio 2023

Esquema principio sistema clima y control de fermentación

ESCALA s/e | NÚMERO 1/1

EXPEDIENTES IPG1825 E1284

EP1

Estos planos son esquemáticos e indicativos de las intenciones de diseño y parte complementaria del resto de las prescripciones de proyecto. Quedan así sujetos a posibles modificaciones que puedan aparecer de mejora, carencias o requerimientos propios de la ejecución. Para proceder a la ejecución, será necesaria la previa autorización de la dirección facultativa de la obra. El contratista verificará todo el proyecto en su conjunto, notificando cualquier discrepancia con la documentación antes de proceder a su ejecución.

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Autor
Fernando Solana Rodríguez
Ingeniero Técnico industrial, col. 1025

SG Group
Tlf. 941 450112
isol@isol.es
info@sggroup.es
Polígono Bujicio, parc. 10
26360 Fuenmayor (La Rioja)

Deliverable D3.2 – Heat exchanger prototype

Annex III – Photographs of the climate control system for fermentation

Depósitos BMA
Enfriador sggroup
23.05.2024 13:08
41.72238, -3.46763
Vía sin nombre, 09410 Peñaranda de Duero

Depósitos BMA
Inst.aire
30.05.2024 13:47
41.72228, -3.4677
Vía sin nombre, 09410 Peñaranda de Duero

Life Climawin

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