D6.1 Validation site scenarios

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Disclaimer

Executive Summary

This report includes the specific analysis of the district cooling test sites to be considered within INDIGO project, as well as the validation scenarios based on them.

In the first section of the document, a description of the test sites is presented. Those test sites are located in Bilbao (Basurto Site) and Barcelona (La Marina Site and Zona Franca Site), both in Spain. Detailed information about generation, distribution and consumption sides is introduced, including the description of the operation and control of the district cooling installations.

The proper analysis of INDIGO characteristics requires different validation scenarios, which are based on the test sites presented in the first section. In the second section of the document, these validation scenarios are defined. Some scenarios are based on the test sites as nowadays are and some others are defined including components that currently do not belong to the sites, but which contribute to the proper validation of the INDIGO toolkit.

The third section of the document includes the description of the test plans related to the validation scenarios. Those test plans will defined how the validation will be performed in practice.

Finally, the annex section contents interesting technical information of the sites, such as P&ID diagrams for the three installations and a list of the HVAC equipment installed in buildings belonging to Basurto Site.

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Nomenclature

DH&C	District Heating and Cooling System
DH	District Heating
DC	District Cooling
CHP	Combined Heat and Power
HVAC	Heating Ventilation and Air Conditioning
DHW	Domestic Hot Water
COP	Coefficient of Performance
EER	Energy Efficiency Ratio
BMS	Building Management System
AHU	Air Handling Unit
RES	Renewable Energy Sources
PLC	Programmable Logic Controller
PI	Proportional Integral

1. INTRODUCTION

This document represents the first step into the validation of the developments that will be performed along the project. This first step consist on the detailed description of the already selected validation sites for the project and the definition of the corresponding validation scenarios as well as the initial description of the related test plans.

2. DETAILED DESCRIPTION OF THE VALIDATION SITES

2.1. BASURTO SITE

2.1.1. General description

Basurto hospital was erected during the first decade of the 20th century in the city of Bilbao (north Spain) and currently comprises more than 15 buildings most of them maintaining their original architectural special features.

Figure 1. Basurto hospital

The hospital belongs to Osakidetza, the public health service of the Basque Country. Heating and cooling demand of the hospital is satisfied thanks to a DH&C installation connected to a trigeneration plant (the generation plant that feeds the DH&C grid includes a CHP based on a pair of gas engines).

The CHP and DH&C systems were erected inside the hospital area in 2003 by VEOLIA and extended in 2011. This company currently operates the complete DH&C system and also the HVAC in the buildings.

Nowadays the trigeneration plant consists of two natural gas internal combustion engines of 2 MW_e (each), two natural gas backup boilers, two absorption chillers and four conventional chillers.

The gas engines generates electricity that is sold by VEOLIA to the Electric Grid. This way VEOLIA can offer cheaper electricity prices to the Hospital than those ones that can be found in the market.

Heat from the CHP is employed for DH supply as well as for feeding absorption chillers for DC supply. Apart from the heat coming from gas engines there are some gas boilers and conventional chillers for DH and DC supply, respectively.

DH temperature level is 80ºC in supply and 65/70 ºC in return while DC temperature level is 7ºC in supply and 10/12ºC in return.

After this brief presentation the document will focus in the DC which is the topic of the project.

2.1.2. Generation plant

The generation plant is located inside the hospital limits and includes chillers, storage, pumping and control. In the next figure the main layout of the DC can be seen where the generation plant is marked with a dark blue arrow and the connected buildings with white arrows.

Figure 2. Basurto Hospital DC main layout

2.1.2.1. *Chilled water production*

Figure 3 shows a simple diagram of the main elements inside the generation plant. As it can be seen all the chillers are installed in parallel and connected to supply and return manifolds.

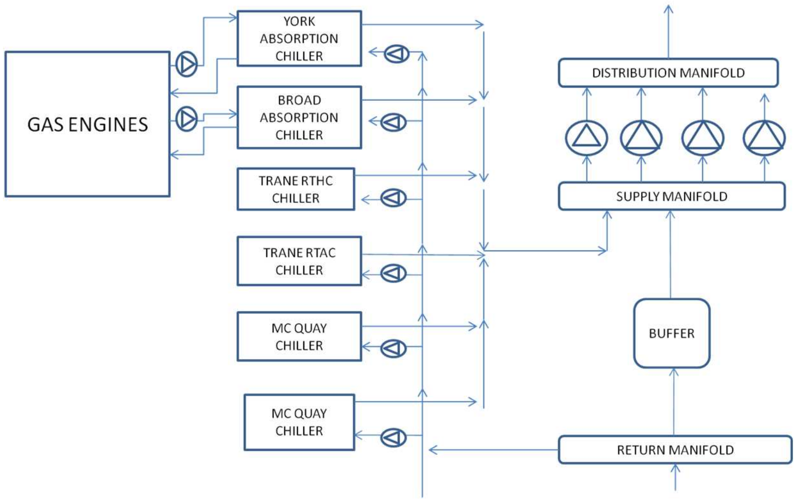


Figure 3. Generation plant simplified layout

The main characteristics of the six chillers are:

Table 1. Main characteristics of the chillers

CHILLER TYPE (MANUFACTURER)	COOLING CAPACITY	HEAT REJECTION
Single stage absorption chiller (YORK)	650 kW_t	Water cooled
Single stage absorption chiller (BROAD)	1 MW_t	Water cooled
Electrical chiller (TRANE)	1,5 MW_t	Water cooled
Electrical chiller (TRANE)	730 kW_t	Air cooled
2 x Electrical chiller (McQUAY)	974 kW_t	Air cooled

Water cooled chillers are connected to cooling towers from EVAPCO. There are five cooling towers connected to three chillers. BROAD absorption chiller is connected to a twin open cooling tower while YORK absorption chiller and TRANE conventional chiller (heat rejection circuit in series) are connected to three closed cooling towers connected in parallel.

Absorption chillers are thermally driven chillers that employed a heat source (hot water, steam, direct combustion, exhaust gas) for producing cold water. Commonly employed absorption chillers, like those installed in this DC, are based on a Lithium Bromide (LiBr)-Water working pair where the water acts as a refrigerant (chilled water above 5ºC). Apart from that, these chillers are single stage which means lower temperature for running (hot water as heat source) and lower performance (COP) in comparison with multi stage absorption chillers.

Nominal ratings of the installed absorption chillers are:

Table 2. Main characteristics of the absorption chillers

MODEL	HOT WATER IN/OUT	CHILLED WATER IN/OUT	HEAT REJECTION WATER IN /OUT	COOLING CAPACITY	COP
BROAD BDH86X	39.7m^3/h 102.5ºC/72.5ºC	172 m^3/h 12ºC/7ºC	333 m^3/h 35ºC/29ºC	1000 kW$_t$	0.75
YORK YIA-HW-3B2	26 m^3/h 105ºC/65ºC	149 m^3/h 12ºC/7ºC	222.6 m^3/h 35ºC/29ºC	650 kW$_t$	0.69

Commonly maximum driven temperature during operation for these chillers in the installation is 105ºC.

Figure 4. BROAD absorption chiller at its location in the generation plant

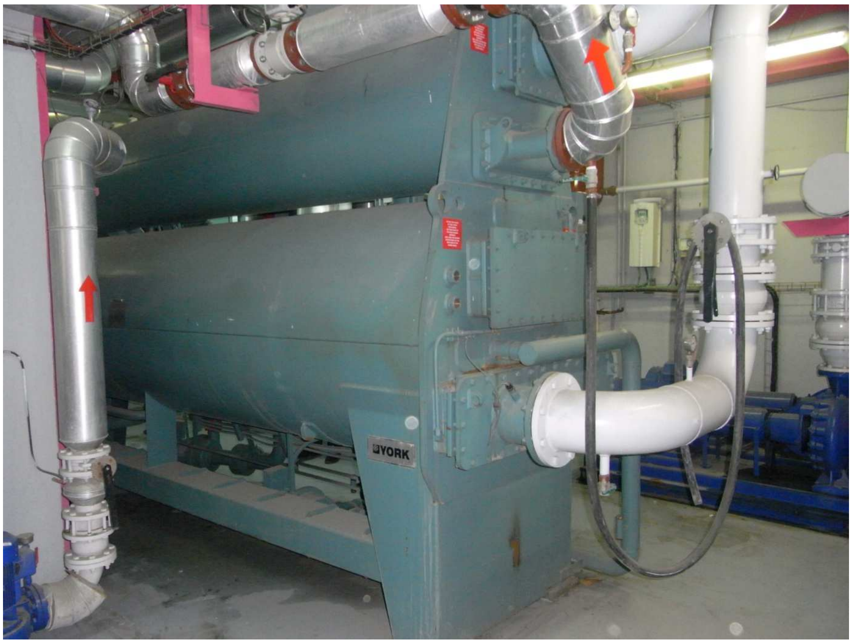


Figure 5. YORK absorption chiller at its location in the generation plant

Regarding conventional chillers there are four chillers that work with R134a as refrigerant. One of them is water cooled and the other three are air cooled (a safer option from possible health risk caused by legionella bacteria than water cooled ones). Two air cooled McQUAY chillers were installed in 2011 while TRANE chillers are operating from the beginning in the district.

In the next table rated conditions of the conventional chillers are shown:

Table 3. Main characteristics of the conventional chillers

MODEL	CHILLED WATER IN/OUT	CONDENSER INLET AIR TEMPERATURE	COOLING CAPACITY	COP or EER
McQUAY AWS-XE-280.2	12ºC/7ºC	35ºC	974 kW	3.15
TRANE RTAC-200 (Low noise and High Eff. version)	12ºC/7ºC	35ºC	730 kW	2.85
MODEL	**CHILLED WATER IN/OUT**	**HEAT REJECTION WATER IN/OUT**	**COOLING CAPACITY**	**COP or EER**
TRANE RTHC-E3	12ºC/7ºC	29ºC/35ºC	1360-1560 kW	5.6-7

Figure 6. McQUAY conventional chiller at its location in the roof of the generation plant

Figure 7. TRANE air cooled conventional chiller at its location in the roof of the generation plant

Figure 8. TRANE water cooled conventional chiller at its location in the generation plant

The cold energy produced by each chiller is recorded by an energy meter installed in the corresponding cold water circuit. In the same way the total cold energy produced by the plant is also recorded in another energy meter connected to the main pipes of the district cooling network.

2.1.2.2. Cold water storage

Outside the generation plant building there is a buffer tank for cold water that is connected between the return and supply manifolds as it can be seen in the Figure 3. The buffer tank has a volume of 26 m^3 (diameter 2.5 m, height 5.38 m) and it is employed for absorbing the flow variations between the flow from chillers and the flow sent to the buildings.

Figure 9. Buffer tank sitting outside the generation plant building

2.1.3. Distribution

The cold water produced in the generation plant is distributed to the consumers (buildings) through a pumping station and a piping layout that can be seen in Figures 2 and 3. From the pumping station installed inside the generation plant, the pipes extends to the different buildings through the underground galleries available to interconnect buildings. The length of the piping is about 2 km (supply + return) split in two branches. The DC network sends cold water to nine buildings where substations are installed. The total number of substation is eleven because in two of the buildings there are two substations.

Figure 10. One of the underground galleries of the Hospital with the pipes of DC and DH installed in the ceiling (upper left corner)

2.1.3.1. Distribution layout

Next figure represents the distribution layout of the installation where the two branches and the different substations can be distinguished

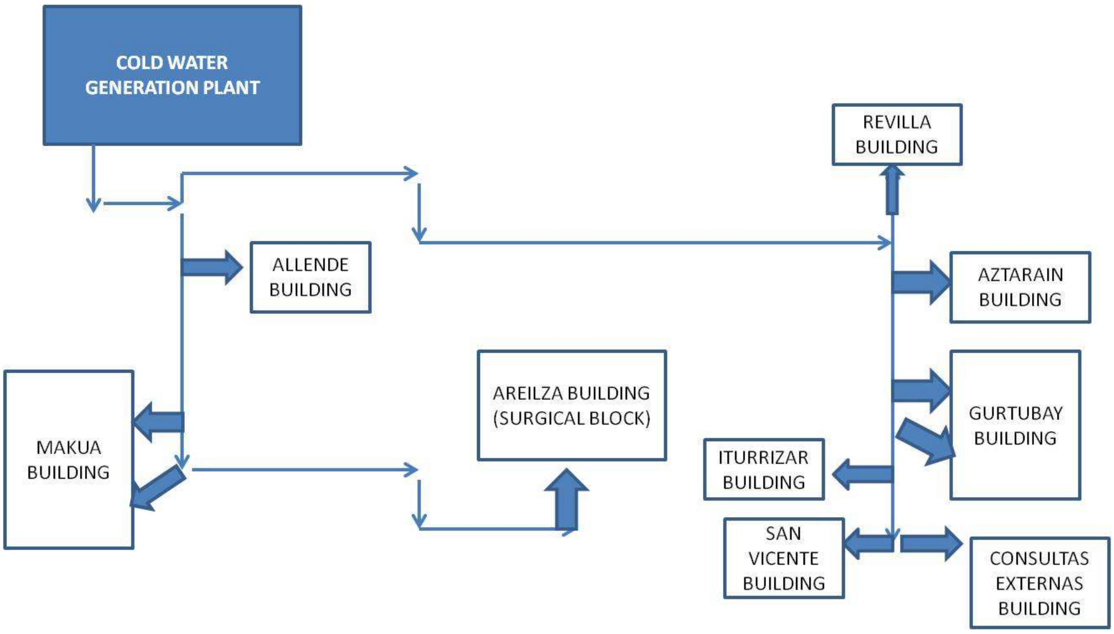


Figure 11. Layout of the distribution of the DC

2.1.3.2. Piping

All the pipes employed in the grid are made of black steel DIN 2448 and DIN 2440. The size of the pipes for distribution ranges from DN 14" (main supply and return pipes) to DN 6" (pipes connecting the last building in the longest branch).

The pipes are insulated with flexible elastomeric nitrile rubber foam (ARMAFLEX type or similar) with a thermal conductivity of 0.040 [W/m K] at 10°C. The thickness of the insulation for the piping is in compliance with IT 1.2.4.2.1 Spanish regulation. Taking this regulation into account and that the pipes are installed indoor (galleries), the thickness is 40mm for all the distribution piping.

The facility is equipped with all elements necessary for compliance with the Spanish RITE normative for thermal installations in buildings:

- Shut-off valves to isolate elements of the system
- Filters for pumps and motorized valves protection
- Check valves to prevent unwanted reverse flow
- Hydraulic balancing valves in each substation circuit

2.1.3.3. Pumping station

The pumping station is installed in the Generation plant and consist of four centrifugal pumps that connects the supply manifold (suction) with the distribution manifold (discharge). These pumps are connected to a frequency converter giving the possibility of controlling the speed of the pump (performance curves).

The power of absorption chiller has not been taken into account in the calculation of the production capacity of the facilities, since its operation is subject to established schedules for operation of cogeneration engines. So the pumping is dimensioned to deliver 4 MW_c (conventional chillers) but the power installed is more than 5 MW_c (including absorption chillers).

Figure 12. Distribution pumps

2.1.3.4. Substations

The substations are the connecting point between the DC and the consumer. In the case of this DC there are not conventional heat exchangers separating both sides, instead of that there are hydraulic separators or decouplers. The separator is a kind of slim tank where two pipes from distribution side and two pipes from building side are connected.

Figure 13. Hydraulic decoupler in one of the substations

The substation includes one (or more in parallel) regulating valve(s) and one static balancing valve in the distribution side. Three temperature sensors are available (supply and return in the building side, return in the distribution side) and connected to the BMS. Apart from that an energy meter is installed in the building side of the substation. Those meters (Ista Sensonic II in most of the cases) calculate the energy (cold) consumed by the building. The consumption of the building is regularly collected via direct readout since remote reading accessories are not installed nor connected to the BMS.

A typical substation for this installation is represented in the next figure:

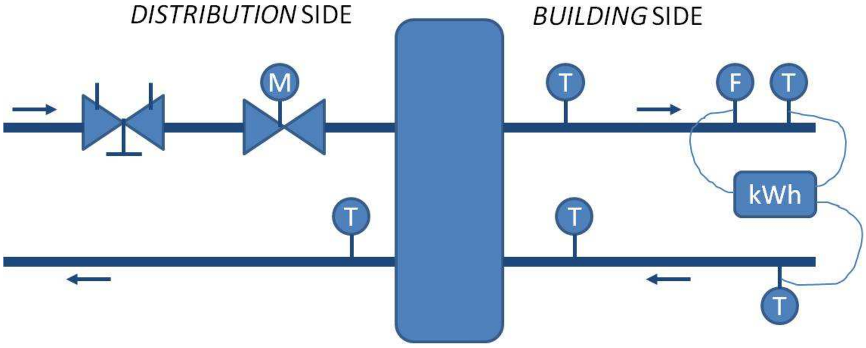


Figure 14. Simple diagram of a substation

There are eleven substations and nine buildings (as it can be seen in Figure 11 Makua and Gurtubay buildings have two substations each) in all the DC network, normally located in the lowest floor under the buildings (underground) although there are a pair of them located in the highest floor under the roof (Aztarain and Makua buildings).

The regulating valve is a two way flanged globe valve with a linear actuator from Siemens (SKC 62) while the static balancing valve is a casting body flanged valve from Tour and Andersson (STAF).

2.1.4. Consumption

The district is connected to eleven different consumers and the main demand corresponds to air conditioning (temperature and moisture) of different areas of the different buildings. The cooling demand is very stochastic since it depends on the number of programmed surgeries (surgical theatres usage), rooms occupancy level, etc.

At the moment the number of running surgical theatres are twenty two split in different buildings. In the case of the Areilza (Surgical Block) building, not working at full capacity, it is possible to put six on service along next year.

Table 4. Number of surgical theatres running in the hospital

BUILDING	NUMBER OF SURGICAL THEATRES
Allende	2
Areilza (Surgical Block)	8
Consultas Externas	1
Iturrizar	5
Makua	6

Anyway there are specific medical equipment connected to the DC. The major example is the linear accelerator placed in San Vicente building.

In the next subsections specific info regarding the consumption side of the DC is given.

2.1.4.1. Building and cooling demands

Most of the buildings that comprehend the hospital are more than one hundred years old (1908). Although different retrofitting works have taken place along the years in facades and roofs, buildings maintain their original outward appearance. Two of the buildings (Areilza and

Aztarain) were rebuilt from scratch in the period 2007-2010 with the same spirit but with modern techniques and materials. A detailed info regarding envelope characteristics for thermal behaviour determination is only available for these two buildings.

As it was said before the energy consumed by the buildings from the district is collected by energy meters. Next table shows the energy consumed by each building during the year 2011.

Table 5. Energy consumption (cold water) in the different buildings connected to the DC

BUILDING	ENERGY [MWh/year] (2011)
Allende	145.206 (3%)
Areilza (Surgical Block)	1333.284 (28.5%)
Aztarain	237.981 (5%)
Consultas Externas	43.737 (0.9%)
Gurtubay	926.484 (20%)
Iturrizar	120.403 (2.6%)
Makua	957.757 (20.5%)
Revilla	829.881 (17.7%)
San Vicente	82.827 (1.8%)
Total	***4677.560 (100%)***

2.1.4.2. HVAC equipment connected to the substations

The equipment connected to the substation of each building is mainly composed of Air Handling Units (AHU) and Fan coils. In these equipments the respective cooling coil is the element connected to the DC through the distribution piping of the building connected to the substation.

The regulation for HVAC in Hospitals, does not allow recirculation indoor air, therefore all the recirculation must be made using outdoor air. This means an important energy consumption in the conditioning of the outdoor air so an energy recovery equipment is commonly installed in AHU to save as much waste energy as possible.

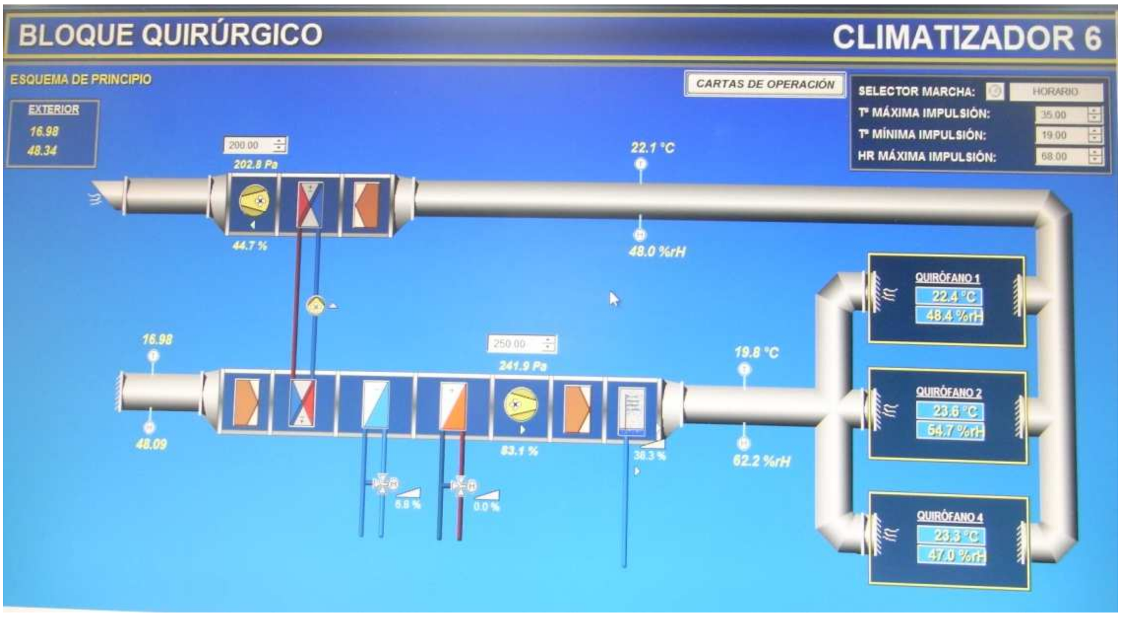


Figure 15. Screenshot from the BMS interface where one of the AHUs (with energy recovery) installed in Areilza (Surgical Block) building can be seen in detail

Figure 16. Screenshot from the BMS interface where two Fan coils installed in Areilza (Surgical Block) building can be seen in detail

Next table shows the installed number of AHU and Fan coils connected to the DC in the different buildings:

Table 6. Number of main HVAC equipment inside the different buildings connected to the DC

BUILDINGS	Number of AHU	Number of Fan coils
Allende	2	-
Areilza (Surgical Block)	28	16
Aztarain	9	-
Consultas Externas	20	7
Gurtubay	3	2
Iturrizar	2	-
Makua	18	31
Revilla	-	52
San Vicente	2	-

A list of the HVAC equipment of different buildings can be found in the annexes of this deliverable.

2.1.4.3. Distribution from substations to buildings HVAC equipment

The distribution from substation to buildings starts in the building side of the hydraulic decoupler. In this point a distribution piping connects several HVAC equipment with the flow and return manifold of the building.

The next figure shows a typical distribution for one building:

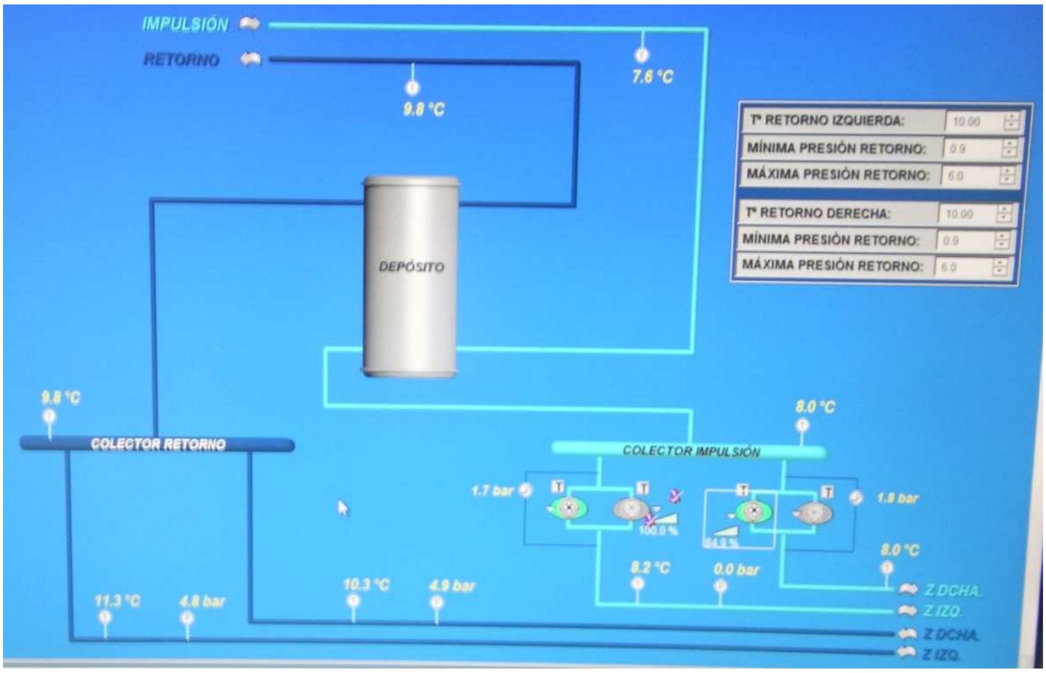


Figure 17. Screenshot from the BMS interface where the distribution to the HVAC equipment can be seen in the Areilza (Surgical Block) building substation

All the pipes employed are made of black steel DIN 2448 and DIN 2440. The pipes are insulated with flexible elastomeric nitrile rubber foam (ARMAFLEX type or similar) with a thermal conductivity of 0.040 [W/m K] at 10°C. The thickness of the insulation for the piping is in compliance with IT 1.2.4.2.1 Spanish regulation. The pumping is commonly done by twin pumps (alternative operation) with speed control for adapting the flow to the demand. The number of twin pumps depends on the number of main branches in the building (in Figure 17 two main branches can be identified).

2.1.5. Operation and control of the installation

Related to the generation system strategy, the trigeneration plant schedule is worked out according to the electricity price. The internal combustion engines are operated daily (manual or automatic start) during high electricity prices, thus prioritizing electricity generation.

During this period heat from cogeneration is stored (hot water) and used for hospital demand and for cooling generation (absorption chillers) and the difference with respect to the cooling demand is covered by a pre-established electrical chillers start sequence management. For the rest of the time (no electric energy generation) another electrical chillers start sequence and cold water storage (buffer for internal chillers management) is automated.

The operation of the DC system is based on a management control that interacts just with the controllers of each chiller. It controls distribution pumps (differential pressure control between impulse and return), but not the temperature set point at substations.

2.1.5.1. System structure and Monitoring&Control

In terms of Monitoring and Control, the Basurto Hospital DC network is divided, as explained, in Generation (and water distribution) and Consumption (Buildings).

The system commanding these two sides are different.

The Monitoring and Control installed in the generation side (comprehending the gas engines, chillers, etc.) is made of scada modules programmed by Veolia and Genelek (local company with expertise in automation), following this architecture:

Generation side

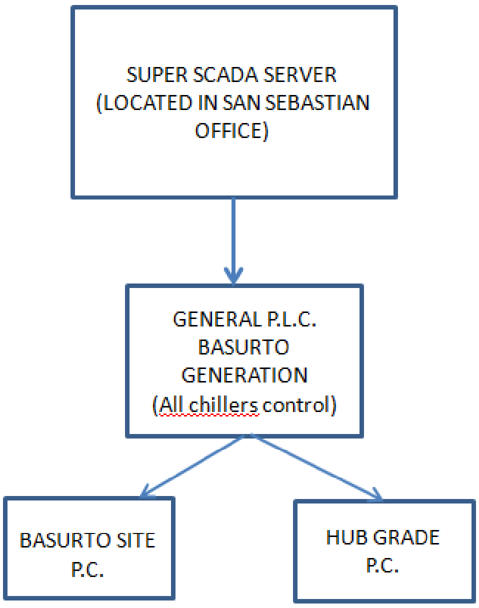


Figure 18. Genelek customized PLC topology

Consumption side

In the next figure the installed Desigo Insight BMS from Siemens is represented

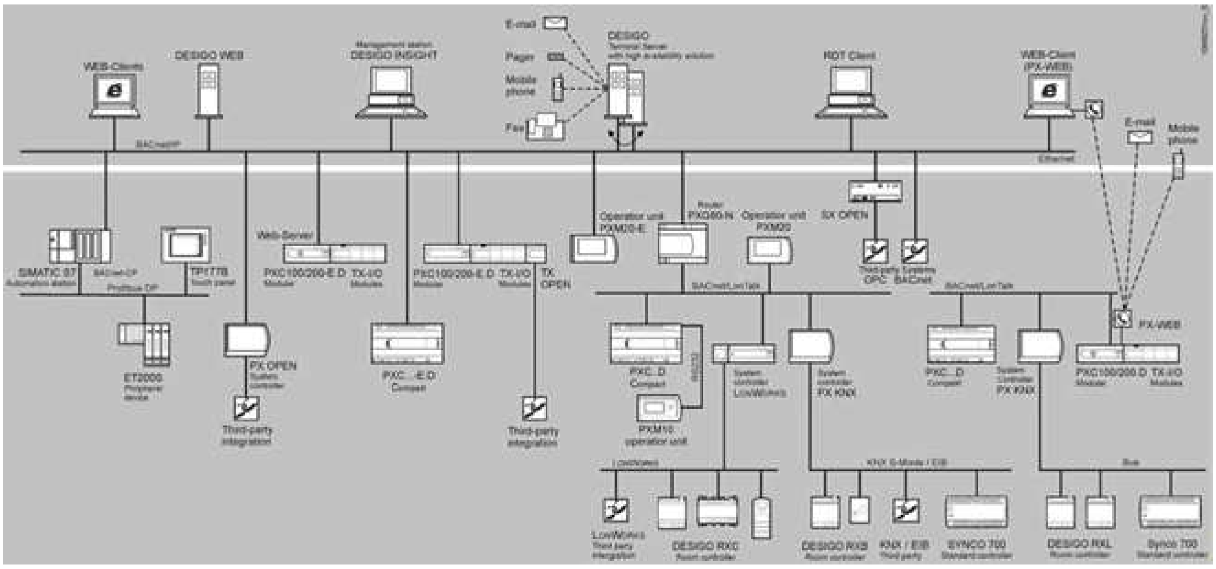


Figure 19. SIEMENS Desigo Insight topology

2.1.5.2. Operation philosophy

Generation

Absorption chillers and cogeneration engines

There is a Schedule already programmed for the start/stop of the cogeneration engines, depending on electricity prices, there are two different general schedules for the cogeneration engines, winter time and summer time:

In winter time, one engine normally works from 7:00 to 24:00 and the other can vary, working in between 12:00 to 17:00. This is important because of feeding the absorption chillers with hot water coming from the cogeneration engines.

The general heat control PLC at generation calculates the difference between the flow of hot water produced by the cogeneration engines and the flow of hot water consumed by the Hospital (comfort heat and sanitary water). The difference corresponds to the flow available to be accumulated in the storage tanks and / or consumed by the absorption machines . The value of this flow available will be sent to the general cold control PLC and it will be used to decide whether or not start absorption machines and to regulate them .

As a matter of fact, absorption chillers have always priority at time of producing cold water for the DC.

Anyway, in winter season, the York absorption chiller is out of run due to low cold demand.

Normally, in winter time, when the cogeneration engines start at 7:00 they feed the 6 x 25 m3 storage tanks with the hot water generated, absorption chillers don't run and the hot water is used for heating.

At 12:00, if cold is needed, the BROAD absorption chiller starts working. If cold water is needed before, a Mc Quay electric chiller will help.

In summer season (between May and November) the two absorption chillers will work .

Normally, as there is not such a need for hot water in the hospital during summer time, the BROAD chiller starts working at the same time that cogeneration engines, using directly part of the hot water generated. YORK chiller will follow it and some hot water will still be storage in the tanks.

Chillers cascade control

Depending on cold demand from the hospital, the regulation will be starting machines in cascade so that the driving flow temperature never rises the established maximum temperature the (ideally 12ºC for maximum performance).

The logic control is:
Cold water theoretically is always sent to the hospital at 7 ºC and returns at 10/12 ºC, so the only variable is the flow that is sent to the hospital. When cold demand in the buildings rises, the regulation will increase the supply flow and inversely, when the demand goes down, it is a lower flow distribution.

The six chillers work always between 7-12ºC, it is understood that at all times the number of running chillers must be such that the sum of the flows from the active chillers is greater than or equal to the flow rate is sent to the hospital.

Again, we can differentiate between two different ways of working:

<u>Winter stage (December-April)</u>

As said before, Cogeneration engines are key in cold water production through the absorption chillers, so when they start, they fill up the hot storage tanks.
In the meanwhile, in the first hours of the morning, if cold water is needed and absorption chillers are not ready, the Mc Quay electric chillers will supply water to the network.
At 12:00, the BROAD absorption chiller will start, stopping the first Mc Quay that will run again if needed. After, the second electric McQuay will start and finally, the air TRANE RTAC air condensed.
Neither TRANE RTHC water condensed nor YORK absorber chiller water condensed are programmed to work in winter stage.

<u>Summer stage (May-November)</u>

In summer stage, as there is no need of much hot water for the hospital (no heating needed) hot water provided by cogenerators can be fully used for the absorption chillers.
So, at 7:00 the BROAD will start, followed by the YORK, followed by the two Mc Quay (2 x 1000 kW) and if more cold is needed the TRANE RTHC (1.400 kW) stopping then one Mc Quay.
Should more cold water is needed, this Mc Quay will start again, being the last one in use the TRANE RTAC due to be the oldest machine in place with the worse COP.

Distribution (pumping)

The operation of the pumping station that sends chilled water to the buildings is controlled by a pressure setpoint between the supply and distribution manifold (see Figure 3). A differential pressure transducer and a PI control loop drives the pumps (speed) to assure the setpoint. Pumps operate in a consecutive way, that is, the second pump does not start until the first pump is at maximum speed and so on.
The differential pressure setpoint is not constant but dependent on the ambient temperature according to the next figure:

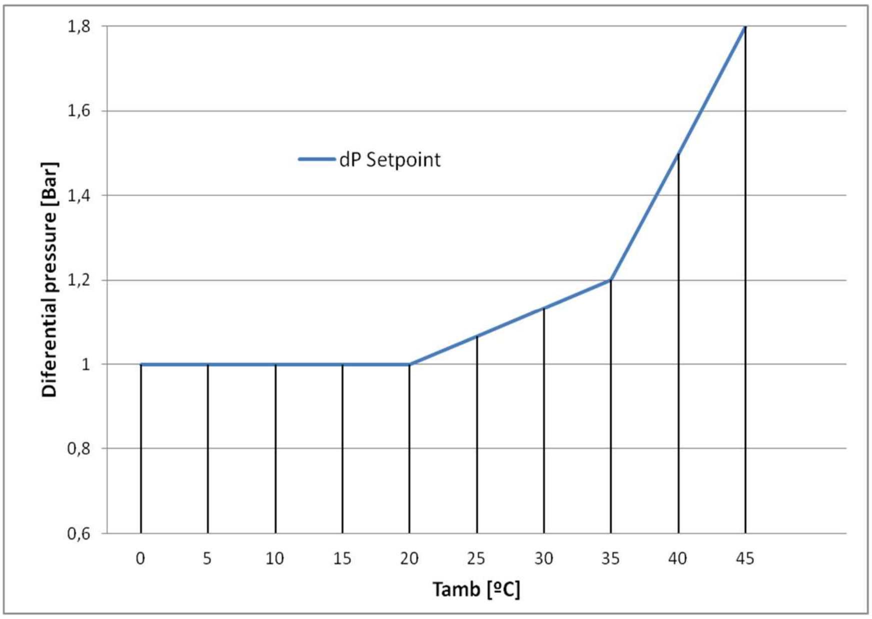


Figure 20. Differential pressure setpoint relation with ambient temperature

Consumption (substations)

According to the Figure 14 the elements that participate in the control of the substations are:

- One (or more in parallel) two-way motorized valve(s).
  For example in the case of Surgical Block building there are five valves arranged in parallel due to the large flow rate. These five valves are divided in two groups: one group of two valves and another one of three valves. Regulation starts opening progressively the first group (both valves together at the same time) until valves are completely open. If more flow is needed, then the second group starts opening (the three valves at the same time). In the case that a flow reduction is needed, the procedure is exactly the other way around.

- One temperature sensor in the building supply
- One temperature sensor in the distribution return

The control of the regulating valve(s) need to assure that the distribution side return temperature is always above a setpoint that is commonly fixed in 10ºC (is not possible to reach the ideal return temperature of 12ºC in most of the substations).

2.1.6. Available monitoring data

2.1.6.1. Generation

Regarding the generation plant, available data correspond to every minute measurements of the next magnitudes since August 2011:

- Cold water produced in each chiller (energy meter)
- Hot water employed for feeding each absorption chiller (energy meter)
- Electric consumption in each chiller
- Gas consumption of cogeneration engines
- Supply and return temperature of the cold water circuit produced by each chiller
- Supply and return temperature of the driving hot water circuit of each absorption chiller
- Supply and return temperature of heat rejection water circuits (cooling towers)
- Water temperature in the supply and return manifolds
- Water pressure in supply and return of cooling ring (DC)
- Water temperatures at the top and the bottom of the buffer tank
- Outdoor temperature (surroundings of the generation plant building)

2.1.6.2. Distribution

Regarding the cold water distribution, the monitoring data can be obtained only at substation level through the Siemens Desigo Insight BMS. This system allows reading next magnitudes (for each substation of the DC) according to the Figure 14:

- Distribution side: Return water temperature
- Distribution side: Position/s of the regulating valve/s (% opening)
- Building side: Supply and return water temperature

Currently the BMS has not included the features for automatic record of measurements (Historical data) and it is only possible to create small record files with limited capabilities called "Trends". Each Trend can store up to nine measurements with an user defined sample time and a fixed maximum file size. These Trends can be defined and download only in the PC installed in the Areilza building (Surgical Block).

It is planned to upgrade the collecting of consumption data installing some new meters at each substation. These meters shall be bus-connected in order to have monitor iced readings. All this info will be included in the first version of the Deliverable D6.3.

2.1.6.3. Consumption

As in the case of the Distribution, the data come from the Siemens Desigo Insight BMS. These data are limited to only one building, Areilza building (Surgical Block) where the different components of the installation inside the building are monitored (see Figures 15, 16 and 17).

As it is mentioned in the above section, Historical data are not available but some trends have been created for different elements of the installation in order to help the Maintenance crew locating source of performance problems of the building installations.

2.2. LA MARINA SITE

2.2.1. General description

La Marina DH&C network is placed in L'Hospitalet de Llobregat a city next to Barcelona, Spain. This installation is going to be part of a bigger deployment with the aim of servicing Barcelona urban area. Ecoenergies Barcelona (VEOLIA) is the company name that was created for the construction, management, operation and exploitation of the complete installation.

The installation is running since 2013 and currently the generation plant of the installation is composed of three water condensed electric chillers and three gas boilers. The plant is placed inside Fira 2000, the new trade fair of Barcelona, and gives service to different costumers in the area: A Hotel, a shopping center, two office buildings and two pavilions of the trade fair. The distribution has a total length of 12 km (supply and return) and is divided in three branches.

The DC temperature level is 5ºC in flow and 14ºC in return while the DH temperature is 90ºC in flow and 60ºC in return.

In the next picture the main layout of La Marina DC network can be seen. The dark blue arrow points to the generation plant while the white arrows point to the consumers. The three main branches of the network can be identified (solid blue lines).

Figure 21. La Marina DC main layout

After this brief introduction the document will focus in the DC part of the installation.

2.2.2. Generation plant

The generation plant is located at underground level in Barcelona trade fair and there, chillers, pumping station and control can be found (Figure 21).

2.2.2.1. Chilled water production

The Figure 22 shows a simple diagram of the main elements inside the generation plant. As it can be seen the chillers are connected in parallel between the supply and return manifolds.

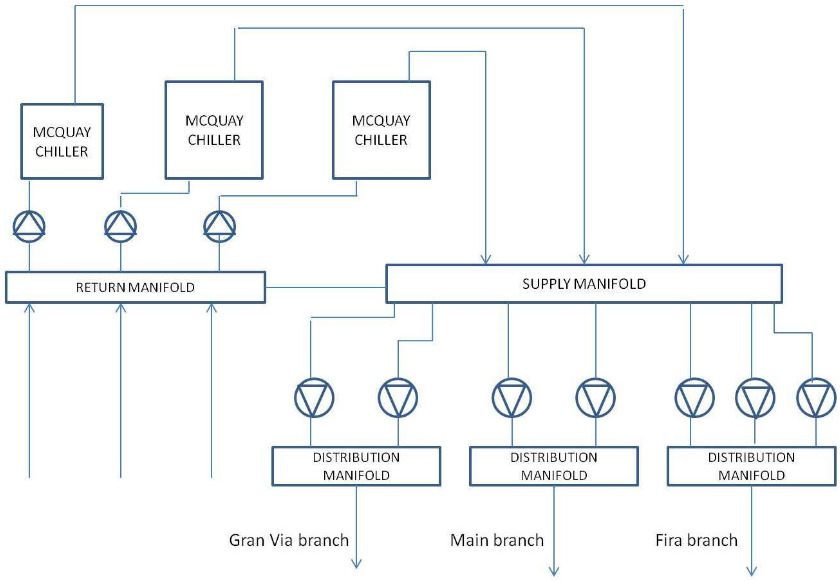


Figure 22. Generation plant simplified layout

The chillers work with R-134a as refrigerant and the main characteristics of the two different chiller models are shown in the next table:

Table 7. Main characteristics of the chillers

MODEL	CHILLED WATER IN/OUT	HEAT REJECTION WATER IN/OUT	COOLING CAPACITY	COP or EER
2 x McQUAY WDC126MB	194 l/s 14ºC/5ºC	410 l/s 30/35ºC	7.33 MW_t	5.51
McQUAY WSC087MA	53 l/s 14ºC/5ºC	113 l/s 30/35ºC	2 MW_t	5.45

The cooling water circuit of each chiller is driven by a pump with a speed control (frequency converter) assuring a constant temperature and variable flow production.

The installation has five cooling towers (with variable speed fan) connected in parallel for heat rejection from chillers. Each rejection circuit is connected to a small supply and return manifold where cooling towers are connected. These chiller rejection circuits have a variable speed pump.

2.2.2.2. Cold water storage

The installation does not include any cold water storage or buffer tank.

2.2.3. Distribution

2.2.3.1. Distribution layout

The next figure represents the distribution layout of the installation where the three branches and the different consumers can be distinguished:

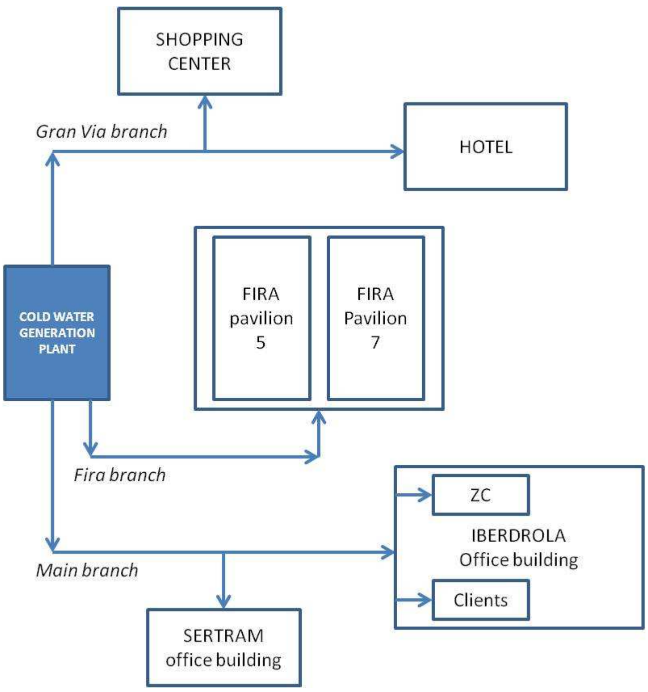


Figure 23. Distribution simplified layout

The Fira branch is currently the less demanding part of the installation due to its direct relation with the scheduled expositions. The SERTRAM office building and the Clients part of the IBERDROLA building has been connected to the network on 2016.

2.2.3.2. Piping

Pipes employed in the generation plant are made of ,on site insulated, black steel DIN 2453 pipes while for the pipes out of the plant (buried) pre-insulated pipes of the same material (black steel) are employed. The size of the pipes for distribution ranges from DN600/DN400 in the outlet of the distribution manifolds to DN50 in certain substations.

2.2.3.3. Pumping station

The pumping station is installed in the generation plant and consist of three groups of pumps (one per branch) as it can be seen in Figure 22. These pumps are connected to frequency converters so their speed (performance) is controlled. As it can be seen an small pipe connects supply and return manifolds. In this pipe a flow detector is installed with the aim of balancing production pumping (chillers) with distribution pumping. Depending on the flow fixed in the distribution (defined for assuring contracted service, 5.5 ºC distribution side supply, to the last consumer) the flow in the chillers is defined looking for a *no flow* condition in the manifolds connecting pipe.

2.2.3.4. Substations

The substations are the interface between the DC and the consumer (building). In this installation a flat plate heat exchanger is installed in each substation for assuring the thermal energy transfer between production side and demand side. Next figure shows a typical substation diagram with the main components.

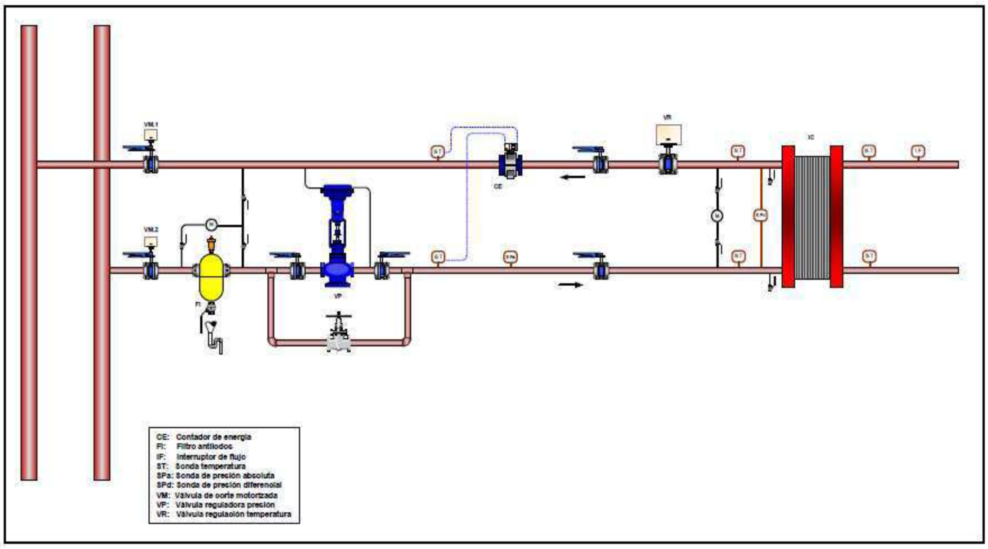


Figure 24. Diagram of a substation

Main elements of the substation are:

Distribution side

- Differential pressure valve
- Regulating valve (temperature control)
- Supply and return water temperature
- Energy meter

Building side

- Supply and return water temperature
- Flow switch

All the components that conform the substation belongs to the client (starting from the pipes that connect the heat exchanger with the distribution branch). For that reason the components are not exactly the same for all the clients. The substations that were built at the same time as the network was, employed the same components but clients that were connected afterwards usually employed equivalent components that performed the same function but that belongs to different manufacturers. The only condition fixed by the operator is to employ components certified for DH&C installations.

2.2.4. Consumption

The district is connected to six different consumers and the main demand corresponds to air conditioning.

2.2.4.1. Cooling demands

Next table shows the power installed and the energy consumed by each building along three consecutive years (2013, 2014 and 2015) and an estimation for 2016. The energy consumed data come from the energy meters installed in each substation.

Table 8. Installed power and annual energy consumed by clients connected to the DC

BUILDING	POWER INSTALLED [kW]	ENERGY CONSUMED [MWh/year] (2013)	ENERGY CONSUMED [MWh/year] (2014)	ENERGY CONSUMED [MWh/year] (2015)	ENERGY CONSUMED [MWh/year] (2016)*
Fira Pavilions 5&7	8350	161.3 (3.5%)	581.5 (8.1%)	304.32 (5.4%)	407.01 (5%)
Gran Via 2 Shopping Centre	3000	3973 (87%)	5204.4 (72.6%)	4152.6 (73.7%)	4878.95 (60.3%)
Hotel SB	850	61 (1.3%)	858.1 (12%)	923.6 (16.4%)	891.65 (11%)
Sertram office building	400	0	0	0	1076.85 (13.3%)
Iberdrola office building, ZC	310	361.4 (8.2%)	523.9 (7.3%)	249.83 (4.5%)	395.57 (5%)
Iberdrola office building, Clients	262.5	0	0	0	435.29 (5.4%)
Total	***13172.5***	***4556.7***	***7167.9***	***5630.35***	***8085.32***

* Estimated

2.2.4.2. HVAC equipment connected to the substations

The equipment connected to the heat exchanger in the buildings is composed of AHU and fan coils in all the cases.

2.2.4.3. Distribution from substations to buildings HVAC equipment

The distribution from substation to buildings starts in the building side of the heat exchanger. In this point a distribution piping connects several HVAC equipment with the flow and return manifold of the building.

The regulation of all terminal equipment inside the building is performed with variable flow (constant temperture) employing two-way control valves and thus, avoiding any water mixture circuit with the return.

2.2.5. Operation and control of the installation

2.2.5.1. System structure and Monitoring&Control

Here is the architectural scheme of the system structure:

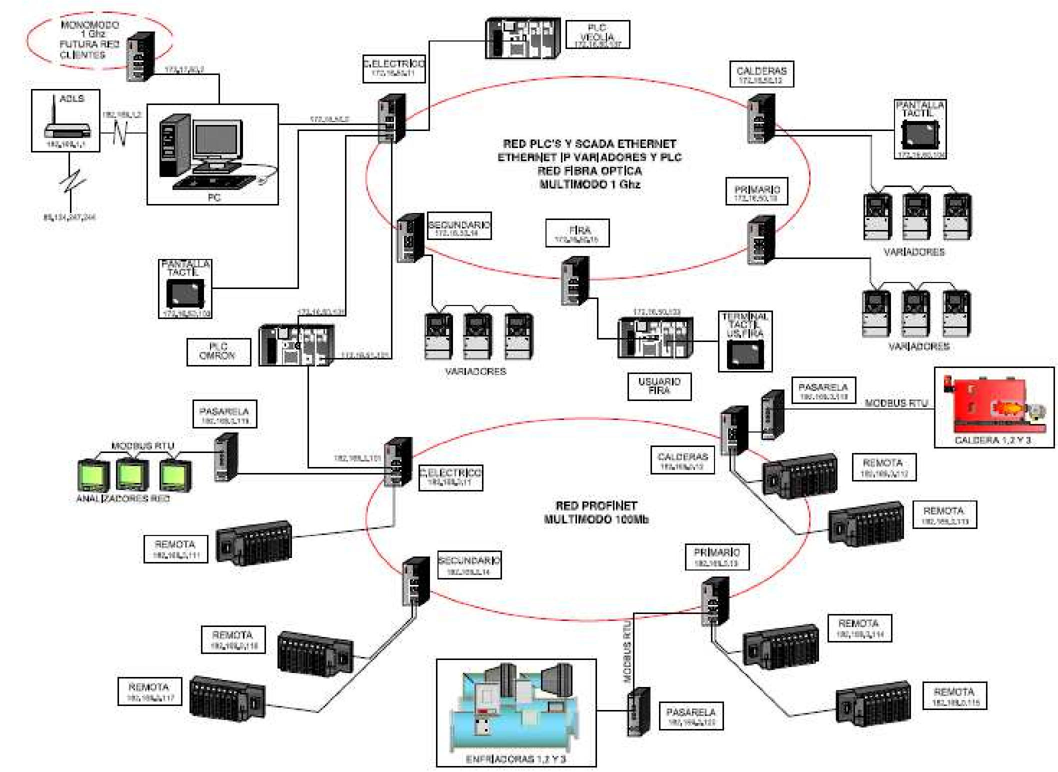


Figure 25. Topology of the system

2.2.5.2. *Operation philosophy*

Generation

The operation of the DC system is based on a management control that interacts just with the controllers of each chiller. The pumps associated to each chiller are controlled to assure constant temperature in the outlet (5ºC) according to the demand. The flow through the chiller is determined to fit the flow in the distribution as it has been explained before.

Distribution (pumping)

The operation of the pumping station that sends chilled water to the buildings is controlled by a setpoint of pressure between the supply and distribution manifold . A differential pressure transducer and a PI control loop drives the pumps (speed) to assure the setpoint. The differential pressure setpoint is variable and is fixed by the operator (manually) assuring supply in terms of the contract (5.5ºC on the distribution side supply) to the farthest client of the network**.**
Each group of pumps (one group for each branch) operate in a consecutive way, that is, the second pump does not start until the first pump is at maximum speed.

Consumption (substations)

In each substation it is installed a control system comprising:

- One motorized two-way valve for flow controlling
- One temperature sensor in the supply to the building
- One temperature sensor in the return from the building
- One temperature sensor in the supply from the distribution
- One temperature sensor in the return to the distribution
- An energy meter in the distribution side

There are two different possibilities of control in the substation and the selection criteria depends on the temperature difference that the building (client) works with during normal operation. Commonly, already existing buildings that are connected to the network work with a low temperature difference while new buildings, with newer installations, work with higher temperature difference. For the first case (low difference) the type of control has as setpoint the flow temperature to the building (depends on the client and the season) while for the second one the control is based on the design return temperature to the distribution (14ºC).

The setpoint for both cases is remotely fixed by the operator of the DC with the permission of the client.

2.2.6. Available monitoring data

2.2.6.1. Generation

Regarding cold water production, the data that is obtained from the installation is the following one:

- Energy meters (kWh cold water) in every chiller
- Electric consumption in every chiller, every pump, every cooling tower
- Water temperature sensors in supply and return of all chillers
- Water temperature sensors in supply and return of cooling towers circuit
- Water temperature sensors in distribution manifold and return manifold
- Water pressure sensors in supply and return manifolds
- Environmental temperature sensors (surroundings of the generation plant)

Historical data is available since 2013 for these magnitudes:

- Cold water produced in each chiller (kWh and m3)
- Electric consumption in each chiller (kWh)
- Temperatures:
    - Cold water supply from each chiller (ºC)
    - Cold water return to each chiller (ºC)
    - Cold water supply from each cooling tower (ºC)
    - Cold water return to each cooling tower (ºC)

  - Cold water supply in main manifold
  - Cold water to general return manifold
- Outside plant temperature.

Readings can be obtained every second if needed. These data is collected in a .csv file that is automatically generated by the system.

2.2.6.2. Distribution

Regarding cold water distribution, the data obtained from the system is:

- Energy sent to the substation (kWh cold water) for a period
- Volume of cold water passed through the substation for a period
- Instantaneous power sent to the substation
- Instantaneous water flow in the distribution side
- Supply temperature from the heat exchanger
- Return temperature from the heat exchanger
- % opening of the motorized two-way control valve

Historical data is available since 2013. Readings can be obtained every second if needed. These data is collected in a *.csv* file that is automatically generated by the system.

2.2.6.3. Consumption

Regarding cold water distribution, the data obtained from the system is :

- Supply temperature to the building
- Return temperature from the building

Historical data is available since 2013. Readings can be obtained every second if needed. These data is collected in a *.csv* file that is automatically generated by the system.

2.3. ZONA FRANCA SITE

2.3.1. General description

La Zona Franca DH&C network is placed in Barcelona, close to the harbour, an strategical point regarding logistics. As in the case of La Marina, Zona Franca, is going to be part of a bigger installation with the aim of servicing Barcelona urban area. Ecoenergies Barcelona (VEOLIA) is the company name that was created for the construction, management, operation and exploitation of the complete installation.

In the next picture it can be seen a layout of the big DHC project of Barcelona

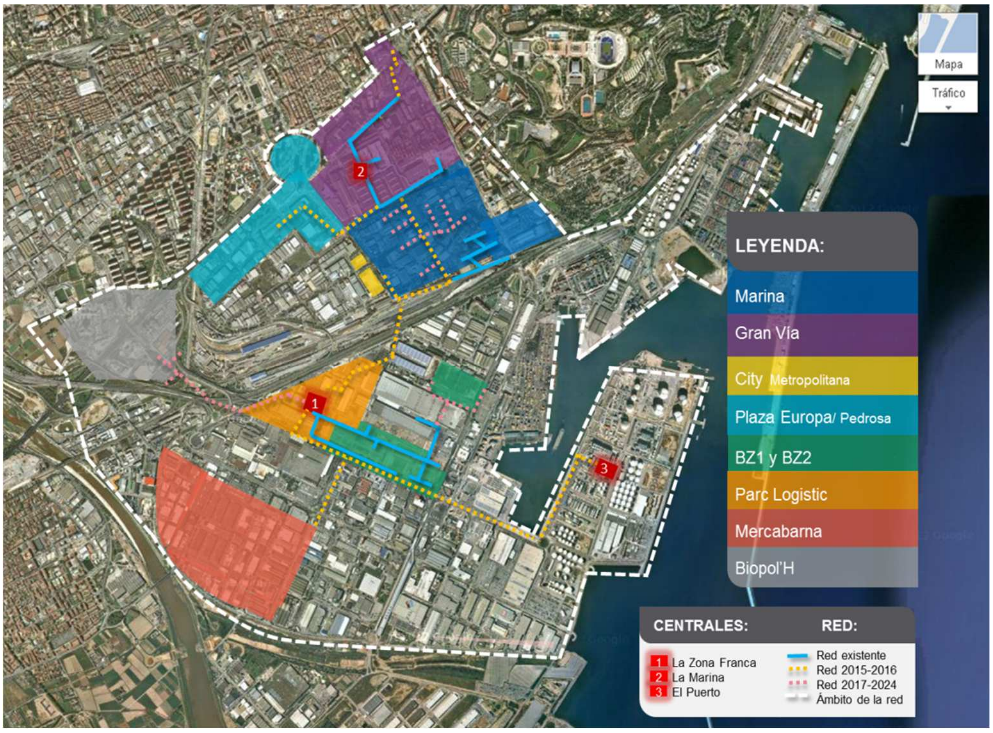


Figure 26. Layout of the Barcelona DH&C project

La Marina installation is identified in the picture with number 2 while Zona Franca installation is identified with number 1. The installation identified with the number 3 represents a future installation that will act as a free cooling source coming from the phase change (gasification) of LNG discharged in the harbour by big LNG carriers.

The installation is running since 2013 and currently the generation plant of the is composed of two water condensed electric chillers and one boiler. The plant is placed close to the Barcelona Port and gives service to only two consumers at the moment, both related to food industry (storage and process).

The DC is splitted in two different networks for two different temperature levels: -10ºC flow (-4ºC in return) and 5ºC flow (14ºC return). The DC for 5ºC cooling supply is currently a quite small installation and only serves to one of the already mentioned costumers with a reduced power (50kW$_t$). Due to that, only the DC for -10ºC cooling supply will be consider in this project.

The distribution network has a total length of around 1.4 km (supply and return) that belongs to the first part of the main branch of the projected installation in Zona Franca.

In the next picture the main layout of the Zona Franca DC network can be seen. The dark blue arrow points to the generation plant while the white arrows point to the consumers. As it can be seen the branch continues to the right but there is no flow due to the lack of clients at the moment.

Figure 27. Zona Franca main layout

2.3.2. Generation plant

The generation plant is located in a specific building constructed as the main building of the big DH&C project of Barcelona. There, chillers, pumping station and control can be found (apart from DH related equipment and other installations).

2.3.2.1. Chilled water production

Figure 28 shows a reduced diagram of the main elements inside the generation plant. The cold water production is done with the same compressors independently of the temperature level. This is done thanks to a little bit complex installation composed of three different temperature level manifolds, condensers, vessels, an economizer and two separators (one per temperature level). Each separator is connected to a flat plate heat exchanger where the supply and return manifolds of each temperature level DC are connected. For simplicity, in the installation layout the cold production is limited to the already mentioned heat exchanger.

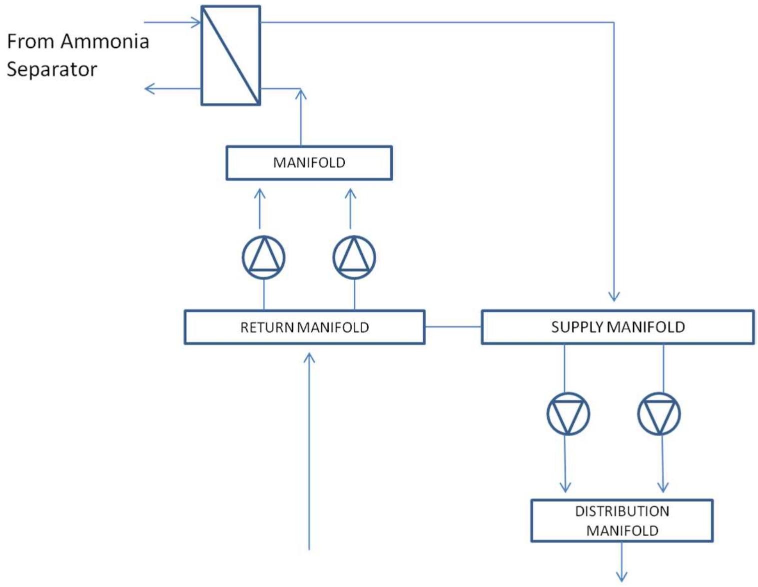


Figure 28. Generation plant reduced layout

The cooling liquid that flows in the installation is a water-propylenglycol mixture with a 30% to 40% by mass ratio of propylenglycol.

The chillers work with Ammonia (R-717) as refrigerant and the main characteristics of the two different chiller models are shown in the next table:

Table 9. Main characteristics of the chillers

MODEL	EVAPORATION TEMPERATURE	CONDENSATION TEMPERATURE	COOLING CAPACITY	COP
MYCON NV250 VMDD-ME	-15ºC	35ºC	1.197 MW	3.7
MYCON N170 JL-L	-15ºC	35ºC	0.509 MW	3.86

The plant works in a variable flow - constant temperature configuration scheme as the rest of the sites.

The main equipment of the installation is:

- Two ammonia compressors
- Two evaporative cooling towers
- Two liquid-gas separators
- Two flat plate heat exchangers
- One Economizer

Figure 29. MYCON NV250 ammonia compressor

Figure 30. Flat plate heat exchanger for ammonia and water-propylenglycol mixture

2.3.2.2. Cold water storage

There is not a cold water storage neither in the generation plant, nor in the distribution network.

2.3.3. Distribution

2.3.3.1. Distribution layout

In the following figure it is shown the distribution lay out for Zona Franca DC.

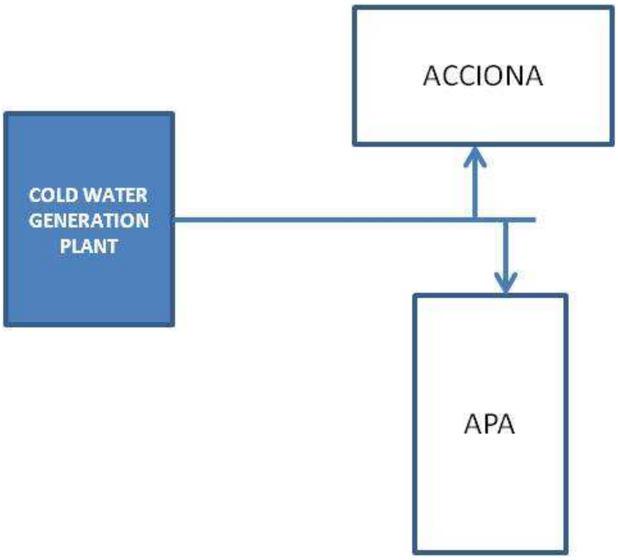


Figure 31. Distribution simplified layout

At the moment there are only two clients: Acciona with a cold demand only for storing food (-7ºC) and APA with a cold demand for storing (-7ºC) and feeding of equipment for food processing (-5ºC).

2.3.3.2. Piping

All the pipes inside the generation plant employed for the -10ºC supply temperature are black steel DIN 2440 of different nominal diameters and adequate insulation thickness to avoid energy losses and condensation. For the distribution part pre-insulated pipes of the same material are employed.

Installation is completed with a series of elements such as shut-off valves (butterfly , ball ..), balancing valves, check valves, control valves, two and three-way valves, safety valves, filling and emptying valves, air vents, Y shaped filters, pressure gauges, thermometers, flow detectors, etc.

2.3.3.3. Pumping station

The pumping station is installed in the generation plant and consist of two pumps for supplying consumers and two pumps for extracting the cold from the heat exchanger as it can be seen in Figure 28. All these pumps are connected to frequency converters so their speed (performance) is controlled. In the same figure pipe connects supply and return manifolds and in this pipe a flow detector is installed with the aim of balancing production pumping (heat exchanger) with distribution pumping. Depending on the flow fixed in the distribution (defined for assuring contracted service, -10 ºC distribution side supply, to the last consumer) the flow in the heat exchanger (water-propylenglycol mixture side) is defined looking for a *no flow* condition in the pipe connecting manifolds.

2.3.3.4. Substations

Next figure shows a typical substation:

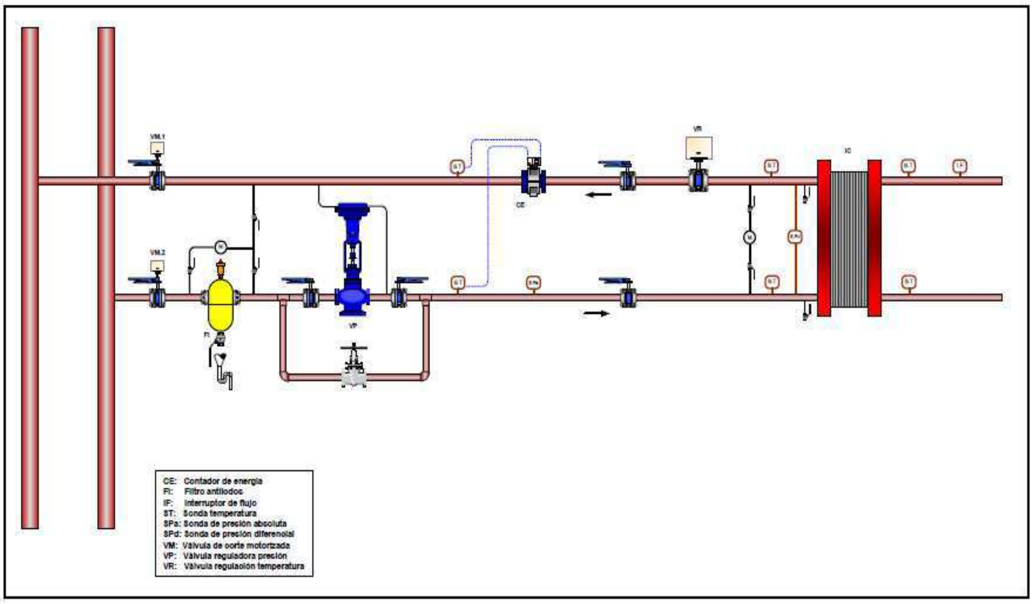


Figure 32. Diagram of a typical substation

Main elements of the substation are:

Distribution side:

- Differential pressure valve
- Regulating valve (temperature control)
- Supply and return water temperature
- Energy meter

Client side:

- Supply and return water temperature
- Flow switch

All the components that conform the substation belongs to the client (starting from the pipes that connect the heat exchanger with the distribution branch). For that reason the components are not exactly the same for all the clients. The substations that were built at the same time as the network was, employed the same components but clients that were connected afterwards usually employed equivalent components that performed the same function but that belongs to different manufacturers. The only condition fixed by the operator is to employ components certified for DH&C installations.

2.3.4. Consumption

2.3.4.1. Cooling demands

Next table shows the power installed and the energy consumed by each client along three consecutive years (2013, 2014 and 2015). The energy consumed data come from the energy meters installed in each substation.

Table 10. Energy consumption of the two clients connected to the DC

BUILDING	POWER INSTALLED [kW]	ENERGY CONSUMED [MWh/year] (2013)	ENERGY CONSUMED [MWh/year] (2014)	ENERGY CONSUMED [MWh/year] (2015)
APA	424	511.5	532.69	510.9
ACC	489	1066.55	1185.44	1216.56

2.3.4.2. Equipment connected to the substations

In the case of this installation, the costumers employed the DC supply to feed their equipment for food storing and processing so the type of elements are evaporators (for storing) and heat exchangers (for processing).

2.3.5. Operation and control of the installation

2.3.5.1. System structure and Monitoring&Control

The Monitoring and Control installed was made from OMROM modules programmed by Veolia. Next figure shows the structure of the installation:

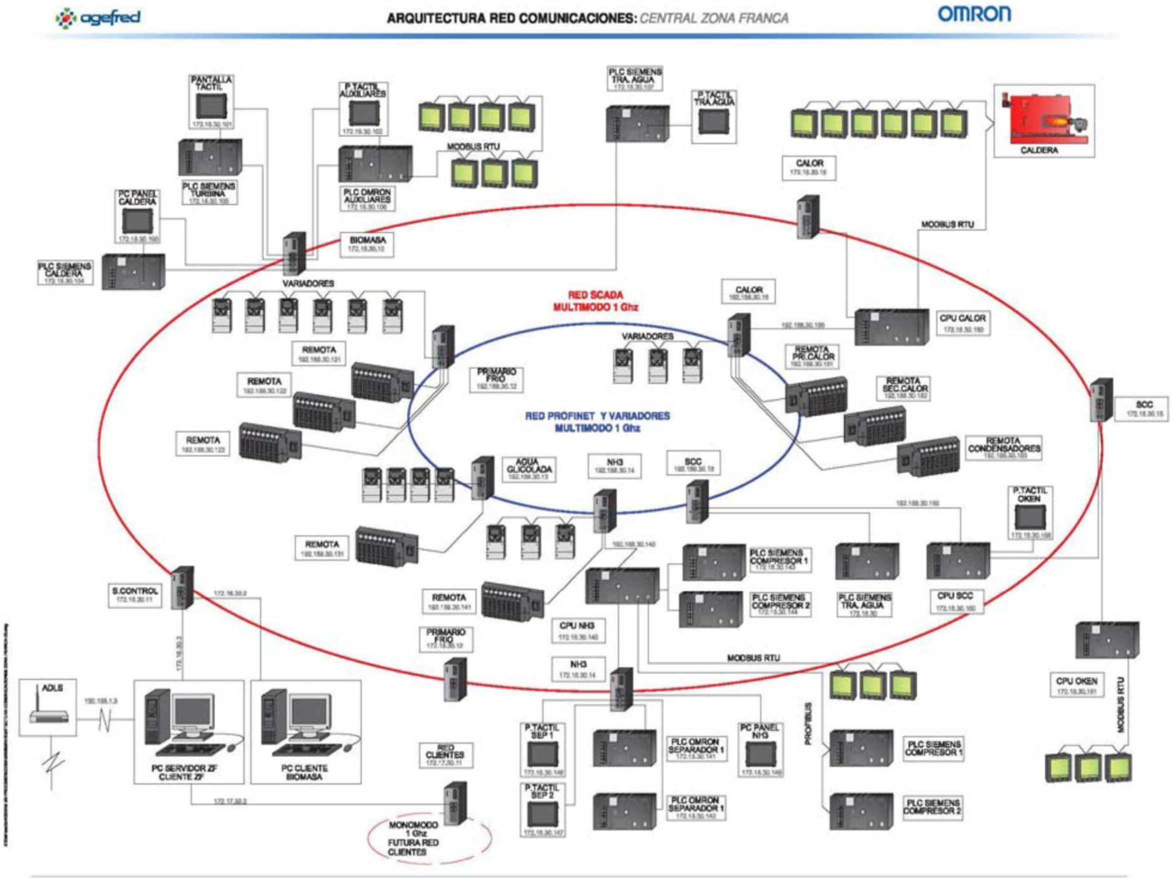


Figure 33. Topology of the system

2.3.5.2. Operation philosophy

Generation

The generation is based on two ammonia screw compressors, one of them with approximately 0.5MW$_t$ cold power output and the other one with approximately 1 MW$_t$.

Due to lack of clients, the production strategy follows a simple philosophy where the smaller compressor works during winter time while the bigger one works during summer time.

Distribution (pumping)

The operation of the pumping station that sends chilled water to the client is controlled by a setpoint of pressure between the distribution manifold and return manifold (see figure 28). A differential pressure transducer and a PI control loop drives the pumps (speed) to assure the setpoint. The differential pressure setpoint is variable and is fixed by the operator (manually) assuring supply in terms of the contract (-10ºC supply on the distribution side) to the farthest client of the network. Each pump operate in a consecutive way, that is, the second pump does not start until the first pump is at maximum speed and so on.

Consumption (substations)

In each substation the installed control system comprises:

- One motorized two-way valve for flow controlling
- One temperature sensor in the supply to the client
- One temperature sensor in the return from the client
- One temperature sensor in the supply from the distribution
- One temperature sensor in the return to the distribution
- An energy meter in the distribution side

The regulating valve in each substation is connected to a controller that assures that the temperature of the water in the supply to the clients (cold water employed in their installation) fits the setpoint temperature (-5ºC for storing food and -7ºC for processing).

2.3.6. Available monitoring data

2.3.6.1. Generation

The data obtained from the installations is the following one:

- Energy meter (kWh cold water) in the ammonia-water propylenglycol mixture heat exchanger
- Electric consumption in every chiller, every pump and every cooling tower
- Water temperature sensors in supply and return of all chilled water production
- Water temperature sensors in supply and return of cooling towers circuit
- Water temperature sensors in supply and return of cooling ring (DC)
- Water pressure sensors in supply and return of cooling ring (DC)
- Outdoor temperature sensor (outside of Generation plant)

Historical data since 2013 are stored:

- Cold water produced in each chiller (kWh and m3)
- Electric consumption in each chiller (kWh)
- Temperatures:
    - Cold water supply from each chiller (ºC)
    - Cold water return to each chiller (ºC)
    - Cold water supply from each cooling tower (ºC)

- Cold water return to each cooling tower (ºC)
- Cold water supply in main manifold
- Cold water to general return manifold
- Outside plant temperature

Readings can be obtained every second if needed. These data is collected in a *.csv* file that is automatically generated by the system.

2.3.6.2. Distribution

Regarding cold water distribution, the data that can be obtained from the system is :

- Supply temperature to the substation (heat exchanger)
- Return temperature from the substation
- Instantaneous thermal power send to the substation
- Energy consumed by the client in a certain period
- Volume of cold water sent to the client in a certain period
- % opening control valve

Historical data is available since 2013. Readings can be obtained every second if needed. These data is collected in a *.csv* file that is automatically generated by the system.

2.3.6.3. Consumption

Regarding cold water distribution, the data obtained from the system is :

- Supply temperature to the building
- Return temperature from the building

Historical data are available since 2013. Readings can be obtained every second if needed. These data is collected in a *.csv* file that is automatically generated by the system.

3. VALIDATION SCENARIOS AND ASSOCIATED TEST PLAN

3.1. INTRODUCTION

INDIGO involves the development of highly efficient and intelligent DC systems based on the development of an **innovative and optimized DC system Management Strategy**.

One of the main characteristics of this strategy is the predictive management: The INDIGO DC system manager will consider predicted values for the consumers' demand, the meteorological conditions, and the price of energy to establish the DC system components appropriated set-points for an optimized operation (energy efficiency maximization with economic cost minimization).

The developed management system will also address other challenges such as:

- Integration of Renewable Energy Sources (RES), which involves additional difficulty since they are non-manageable energies
- Dealing with different types of cooling sources (different dynamic behavior) at the same time
- Combining the cooling capacity coming from the generation, storage, and even distribution (piping storage capacity) and buildings (thermal mass management) in an optimized way.
- Dealing with different types of thermal storage systems: sensible heat (cold water storage) and latent heat (ice storage)

These characteristics must be checked through some validation scenarios, which are based on the test sites previously described.

Nevertheless, in some cases, the tests sites does not contribute to the proper analysis of INDIGO characteristics, since some of the components required are not currently present in the test site, such as RES (the case for all of the sites) or storage systems. Therefore, some of the validation scenarios proposed will be tested virtually.

3.2. VALIDATION SCENARIOS

The first validation scenario, scenario 0, is the most basic one and is entirely based on the sites as they are today. The rest of scenarios, based on scenario 0, include components that currently do not belong to the site, but which contribute to the proper validation of the INDIGO toolkit.

Therefore, two type of scenarios will be proposed apart from the reference one (scenario 0):

- Experimental validation scenario (Basurto Site): INDIGO solution will be physically implemented and ran
- Virtual (or laboratory) validation scenario (La Marina, Zona Franca and Basurto Site): INDIGO solution will be virtually deployed

Next tables define the validation scenarios proposed for the project:

VS-0	
Objectives	In this basic validation scenario, the evaluation of the Sites with the INDIGO predictive management strategy will be performed. The current generation, distribution and consumption system will be only considered, as well as the predictive control according to INDIGO. Energy efficiency maximization with economic cost minimization is the main goal. This goal will be achieved based on the predictive control, considering available information with INDIGO approach: • Boundary conditions (including weather, demand profile, energy price, etc.) • Recorded signals (inputs, outputs and relevant data for validation metrics) In the case of experimental test, it is not possible to get the same boundary conditions and data from site with and without INDIGO, since both control strategies are not possible simultaneously. Therefore, to properly analyze the “before and after” of INDIGO in Basurto site minimizing the uncertainties in the process, two possibilities will be carefully considered: • Maximizing the period of time in which experimental and historical data are taken with the aim of softening the differences • Getting an accurate model of Basurto DC system in order to simulate what would have been the energy consumption (or the cost) operating the system with the previous controller (before INDIGO) with the same initial conditions/disturbances (weather, demand due to hospital operations etc) The reference case for VS0 will be the historical data from its site.
Test Site	***Basurto Site*** will be tested both virtually and on-site. Considering the generation and storage systems in Basurto the prior objective will be achieved based on the predictive control and focusing mainly on the electricity consumption reduction during on-peak electricity prize periods: • Prioritizing the use of absorption chillers • Prioritizing the use of storage as generation source during on-peak electricity prize periods • Prioritizing the use of storage as consumer during out-peak electricity prize periods
	La Marina Site will be virtually tested. ***La Marina Site*** is composed of electrical chillers but there is no storage systems. Therefore, in this case the prior objective will be achieved based just on the predictive control, considering available information with INDIGO approach.
	Zona Franca Site will be left out of this validation scenario due to its constant demand (cold has to be provided to the industries 24h/day, 365 days/year), which does not allow much flexibility to obtain energy savings thanks to the control strategy.

	VS-1 (virtual scenario)
Objectives	In this scenario, the INDIGO predictive management strategy will be performed (VS-0) but considering a non-manageable solar energy system which currently does not exist. With this validation scenario, the adaptability of INDIGO in the dealing with non-manageable energy sources will be analysed Energy efficiency maximization with economic cost minimization is the main goal, focusing on: • Maximizing the use of RES, since it is a free energy • Reduction of the electricity consumption during on-peak electricity prize periods The reference case for VS1 will be the simulation data from the site, operating as currently is done but considering the solar installation. In this case, the operator of the site must decide how the installation would be operated with this new component.
Test Site	None of the test sites includes a renewable energy source, so this is only possible virtually. The ***Basurto Site*** with the INDIGO Management Strategy will be taken into account but considering a solar thermal energy system (with corresponding storage), which feeds up the absorption chillers currently located in Basurto

	VS-2 (virtual scenario)
Objectives	One of the key systems for INDIGO approach is the use of a storage system, which gives flexibility to obtain energy savings thanks to the control strategy (thanks to MPC and production shifting). In this validation scenario, the evaluation of the benefits of using storage will be analysed through the versatility of INDIGO in the suitable coupling between generation, storage and demand Energy efficiency maximization with economic cost minimization is the main goal, focusing on: • Prioritizing the use of storage as consumer during out-peak electricity prize periods • Prioritizing the use of storage as generation source during on-peak electricity prize periods The reference case for VS2 will be the simulation data from the site operating as currently is done but considering an storage system. In this case, the operator of the site must decide how the installation would be operated with this new component.
Test Site	This virtual scenario will be considered for ***La Marina Site*** and ***Zona Franca Site***. The aim in both sites is the same but in this way the flexibility of INDIGO Management Strategy will be analysed at two different temperature levels. In the same way, the INDIGO management with different types of storage will be analyzed, since two different storage will be considered, depending on the water temperature level of the site: • Cold water storage in ***La Marina Site*** • Ice storages in ***Zona Franca Site***

3.3. TEST PLANS DESCRIPTION

Once validation scenarios are defined for the different sites, associated test plans need to be constructed to define how the validation will be performed in practice.

Next tables describes the different test plans needed for the defined validation scenarios. The selected naming for the test plan is based on the previously defined naming for the validation scenarios. As in the case of validation scenarios the test plans are divided in experimental and virtual (laboratory) level.

The aim of this section is to have an initial description of the test plans according to the defined validation scenarios. Taking this into account, figures employed for the different indicators defined as part of the test acceptance criteria of each plan, must be taken as indicative. In the next phase of the project test plans will be developed and completed including detailed definition of the indicators (according to international standards) as well as the figures for targets.

Index of scenarios and corresponding test plans:

- VS0
    - EXP_VS0_Basurto_01
    - VIRTUAL_VS0_Basurto_01
    - VIRTUAL_VS0_Basurto_02
    - VIRTUAL_VS0_Basurto_03
    - VIRTUAL_VS0_Marina_01
    - VIRTUAL_VS0_Marina_02

- VS1 (non-manageable solar energy system)
    - VIRTUAL_VS1_Basurto_01
- VS2 (using storage)
    - VIRTUAL_VS2_Marina_01
    - VIRTUAL_VS2_Franca_01

3.3.1. Test plans at experimental level

Test Name	EXP_VS0_Basurto_01 (INDIGO experimental vs. STANDARD experimental)
Description	• **Test aim and details:** the goal of this test is to compare at experimental level the **overall performance of the INDIGO controller** with respect to current (STANDARD) control implementations. The boundary conditions (demand, weather) will be fixed (no possibility to change them at will: at a given time the consumer demand and weather will be whatever measured). As it is not possible to have both controllers (INDIGO and STANDARD) operating at the same time, only possibility for comparison is to acquire data in each case with similar boundary conditions (e.g. perform experimental tests with INDIGO and STANDARD controllers during time periods with similar climate and demand). • **Test scenario:** Basurto VS-0 • **Benchmark:** normal operation with STANDARD controller. Data collected during 2017-2018 (possibility to make use of previous historical data also). • **Test description:** normal operation (respond to regular cooling demand) with INDIGO controller during 2018-2019. Testing period may include: parallelization with WP3 development for bug detection and fine tuning prior to data acquisition with INDIGO for several months.
Test Variables	• **Operation goal:** cost minimization or efficiency maximization. As boundary conditions are fixed at experimental level, the only degree of freedom for varying the tests is changing the cost-function employed by the INDIGO controller, i.e. putting more weight on minimizing cost (2-3 months INDIGO testing with this goal) or putting more weight on maximizing efficiency (2-3 months INDIGO testing with this goal).
Signals to be Measured or Calculated	*Measured Magnitudes*: • **Demand profile:** cool water demand at each consumer point. While this can be expressed in simple terms by providing cooling power values [kW], for evaluation and comparison purposes it is better to have more detailed information with temperature [ºC] and flow data [m^3/s]. Sampling time: 1-15 minutes • **Weather:** outdoor temperature [ºC] and humidity [%]. Sampling time: 1-15 minutes • **Energy price:** electricity cost [€/kWh] at demonstration site (electricity prices are known one day in advance). Sampling time: 1 hour • **Cooling supply:** cool water supply at each consumer point. While this can be expressed in simple terms by providing cooling power values [kW], for evaluation and comparison purposes it is better to have more detailed information with temperature [ºC] and flow data [m^3/s]. Sampling time: 1-15 minutes • **Power consumption:** power consumption measurement on cool water generators (e.g. chillers) [kW]. Sampling time: 1-15 minutes *Calculated Magnitudes*: • **Employed energy cost:** calculation of employed energy cost [€]. Sampling time: 1-15 minutes • **Efficiency of power consumption at cool water generators:** calculation of energy efficiency at each generation point; ratio between cooling energy produced and energy consumed (electrical or gas) [%]. Sampling time: 1-15 minutes
Test Acceptance Criteria	Key performance indicators (KPI): • **Employed energy cost:** INDIGO controller cost less than STANDARD controller cost. Indicative target cost saving 20%; acceptable saving 10% (targets to be further defined). • **Efficiency of power consumption at cool water generators:** INDIGO controller efficiency more than STANDARD controller efficiency. Indicative target efficiency increase 10% (targets to be further defined).

	Other indicators: • **Building temperature outside of comfort boundaries:** <5% (targets to be further defined). • **Use of renewable energy vs. total energy consumption:** not applicable in Basurto VS-0.
Notes	Challenge for a "fair" comparison with benchmark: cannot exactly match boundary conditions (weather, demand profile, etc.). One boundary condition that could be forced to be exactly the same is Energy Price (e.g. use energy price during operation of STANDARD controller and consider it to be the price in force during operation of INDIGO controller.

3.3.2. Test plans at virtual level

Test Name	VIRTUAL_VS0_Basurto_01 (STANDARD experimental vs. STANDARD virtual) & (INDIGO experimental vs. INDIGO virtual)
Description	• **Test aim and details:** compare the **experimental results with virtual simulations**. The aim is to compare experimental data with simulated data to check whether they "match" and thus the simulation environment can be considered to be robust and realistic to draw conclusions out of virtual tests. The boundary conditions (demand, weather) will be fixed (whatever values were operating during experimental tests). Comparisons include analysis of how well the simulations resemble the performance of the STANDARD controller (STANDARD experimental vs. STANDARD virtual) and the performance of the INDIGO controller (INDIGO experimental vs. INDIGO virtual). • **Test scenario:** Basurto VS-0 • **Benchmark:** experimental measurements with STANDARD controller during 2017-2018 (possibility to make use of previous historical data also) and with INDIGO controller (data collected during 2018-2019). • **Test description:** normal operation (respond to regular cooling demand) with STANDARD controller and with INDIGO controller subject to benchmark boundary conditions.
Test Variables	• **Operation goal:** cost minimization or efficiency maximization No flexibility as tests are stick to experimentally measured boundary conditions. Only degree of freedom is INDIGO controller's goal: more or less enhancement on cost and/or efficiency.
Signals to be Measured or Calculated	*Measured Magnitudes*: • **Demand profile:** cool water demand at each consumer point. While this can be expressed in simple terms by providing cooling power values [kW], for evaluation and comparison purposes it is better to have more detailed information with temperature [ºC] and flow data [m^3/s]. Sampling time: 1-15 minutes • **Weather:** outdoor temperature [ºC] and humidity [%]. Sampling time: 15 minutes • **Energy price:** electricity cost [€/kWh] at demonstration site (electricity prices are known one day in advance). Sampling time: 1 hour • **Cooling supply:** cool water supply at each consumer point. While this can be expressed in simple terms by providing cooling power values [kW], for evaluation and comparison purposes it is better to have more detailed information with temperature [ºC] and flow data [m^3/s]. Sampling time: 1-15 minutes • **Power consumption:** power consumption measurement on cool water generators (e.g. chillers) [KW]. Sampling time: 1-15 minutes *Calculated Magnitudes*: • **Employed energy cost:** calculation of employed energy cost [€]. Sampling time: 1-15 minutes • **Efficiency of power consumption at cool water generators:** calculation of energy efficiency at each generation point; ratio between cooling energy produced and energy consumed (electrical or gas) [%]. Sampling time: 1-15 minutes
Test Acceptance Criteria	Comparison of variables at experimental and virtual level: • **Cooling supply:** difference <10% • **Employed energy cost:** difference <10% • **Efficiency of power consumption at cool water generators:** difference <10%
Notes	

Test Name	VIRTUAL_VS0_Basurto_02 (INDIGO virtual vs. STANDARD experimental)
Description	• **Test aim and details:** the goal of this test is to compare at simulation level the **overall performance of the INDIGO controller** with respect to experimentally measured STANDARD control implementations. The boundary conditions (demand, weather) will be fixed (no possibility to change them at will: at a given time the consumer demand and weather will be whatever measured). • **Test scenario:** Basurto VS-0 • **Benchmark:** normal operation with STANDARD controller. Data collected during 2017-2018 (possibility to make use of previous historical data also). • **Test description:** normal operation (respond to regular cooling demand) with INDIGO controller subject to benchmark boundary conditions.
Test Variables	• **Operation goal:** cost minimization or efficiency maximization No flexibility as tests are stick to experimentally measured boundary conditions. Only degree of freedom is INDIGO controller's goal: more or less enhancement on cost and/or efficiency.
Signals to be Measured or Calculated	*Measured Magnitudes*: • **Demand profile:** cool water demand at each consumer point. While this can be expressed in simple terms by providing cooling power values [kW], for evaluation and comparison purposes it is better to have more detailed information with temperature [ºC] and flow data [m^3/s]. Sampling time: 1-15 minutes • **Weather:** outdoor temperature [ºC] and humidity [%]. Sampling time: 15 minutes • **Energy price:** electricity cost [€/kWh] at demonstration site (electricity prices are known one day in advance). Sampling time: 1 hour • **Cooling supply:** cool water supply at each consumer point. While this can be expressed in simple terms by providing cooling power values [kW], for evaluation and comparison purposes it is better to have more detailed information with temperature [ºC] and flow data [m^3/s]. Sampling time: 1-15 minutes • **Power consumption:** power consumption measurement on cool water generators (e.g. chillers) [kW]. Sampling time: 1-15 minutes *Calculated Magnitudes*: • **Employed energy cost:** calculation of employed energy cost [€]. Sampling time: 1-15 minutes • **Efficiency of power consumption at cool water generators:** calculation of energy efficiency at each generation point; ratio between cooling energy produced and energy consumed (electrical or gas) [%]. Sampling time: 1-15 minutes
Test Acceptance Criteria	Key performance indicators (KPI): • **Employed energy cost:** INDIGO controller cost less than STANDARD controller cost. Indicative target cost saving 20%; acceptable saving 10% (targets to be further defined). • **Efficiency of power consumption at cool water generators:** INDIGO controller efficiency more than STANDARD controller efficiency. Indicative target efficiency increase 10% (targets to be further defined). Other indicators: • **Building temperature outside of comfort boundaries:** <5% (targets to be further defined). • **Use of renewable energy vs. total energy consumption:** not applicable in Basurto VS-0.
Notes	The measured boundary conditions will be used as inputs for the simulations.

Test Name	VIRTUAL_VS0_Basurto_03 (INDIGO virtual vs. STANDARD virtual)
Description	• **Test aim:** compare at virtual level the **overall performance of the INDIGO controller** respect to current control implementations. • **Test aim and details:** the goal of this test is to compare at simulation level the **overall performance of the INDIGO controller** with respect to STANDARD control implementations. As all tests take place at simulation level, arbitrary boundary conditions can be applied. • The boundary conditions (demand, weather) will be fixed (no possibility to change them at will: at a given time the consumer demand and weather will be whatever measured). • **Test scenario:** Basurto VS-0 • **Benchmark:** normal operation with STANDARD controller. • **Test description:** normal operation (respond to regular cooling demand) with INDIGO controller subject to benchmark boundary conditions.

Test Variables	• **Operation goal:** cost minimization or efficiency maximization
	• **Self-learning capabilities:** activated and deactivated
	• **Management level:** operation with High Management Level (HML) only (optimization process; predict most efficient set-points) or with Low Management Level (LML) included (grid control system; accommodate supply to sudden demand variations/disturbances)
	• **Boundary conditions:**
	  o Electricity price profiles: flat and variable
	  o Demand profile: flat and variable
	  o Disturbances and real demand/prediction differences: none and variable
	  o Weather profiles: cold and warm scenarios

Signals to be Measured or Calculated	• **Demand profile:** cool water demand at each consumer point. While this can be expressed in simple terms by providing cooling power values [kW], for evaluation and comparison purposes it is better to have more detailed information with temperature [ºC] and flow data [m^3/s]. Sampling time: 1-15 minutes • **Weather:** outdoor temperature [ºC] and humidity [%]. Sampling time: 15 minutes • **Energy price:** electricity cost [€/kWh] at demonstration site (electricity prices are known one day in advance). Sampling time: 1 hour • **Cooling supply:** cool water supply at each consumer point. While this can be expressed in simple terms by providing cooling power values [kW], for evaluation and comparison purposes it is better to have more detailed information with temperature [ºC] and flow data [m^3/s]. Sampling time: 1-15 minutes • **Power consumption:** power consumption measurement on cool water generators (e.g. chillers) [kW]. Sampling time: 1-15 minutes • **Employed energy cost:** calculation of employed energy cost [€]. Sampling time: 1-15 minutes • **Efficiency of power consumption at cool water generators:** calculation of energy efficiency at each generation point; ratio between cooling energy produced and energy consumed (electrical or gas) [%]. Sampling time: 1-15 minutes
Test Acceptance Criteria	Key performance indicators (KPI): • **Employed energy cost:** INDIGO controller cost less than STANDARD controller cost. Indicative target cost saving 20%; acceptable saving 10% (targets to be further defined). • **Efficiency of power consumption at cool water generators:** INDIGO controller efficiency more than STANDARD controller efficiency. Indicative target efficiency increase 10% (targets to be further defined). Other indicators: • **Building temperature outside of comfort boundaries:** <5% (targets to be further defined). • **Use of renewable energy vs. total energy consumption:** not applicable in Basurto

	VS-0. Self-learning performance: • **Prediction accuracy in short and long prediction horizons:** difference between predicted values and "real" values <20%; target gains with improved prediction methods with respect to the sole reduced model prediction: 50% RMSE reduction.
Notes	

Test Name	VIRTUAL_VS0_Marina_01 (INDIGO virtual vs. STANDARD experimental)
Description	• **Test aim and details:** the goal of this test is to compare at simulation level the **overall performance of the INDIGO controller** with respect to experimentally measured STANDARD control implementations. The boundary conditions (demand, weather) will be fixed (no possibility to change them at will: at a given time the consumer demand and weather will be whatever measured). • **Test scenario:** La Marina VS-0 • **Benchmark:** normal operation with STANDARD controller. Use of previous historical data . • **Test description:** normal operation (respond to regular cooling demand) with INDIGO controller subject to benchmark boundary conditions.
Test Variables	• **Operation goal:** cost minimization or efficiency maximization No flexibility as tests are stick to experimentally measured boundary conditions. Only degree of freedom is INDIGO controller's goal: more or less enhancement on cost and/or efficiency.
Signals to be Measured or Calculated	*Measured Magnitudes*: • **Demand profile:** cool water demand at each consumer point. While this can be expressed in simple terms by providing cooling power values [kW], for evaluation and comparison purposes it is better to have more detailed information with temperature [ºC] and flow data [m^3/s]. Sampling time: 1-15 minutes • **Weather:** outdoor temperature [ºC] and humidity [%]. Sampling time: 15 minutes • **Energy price:** electricity cost [€/kWh] at demonstration site (electricity prices are known one day in advance). Sampling time: 1 hour • **Cooling supply:** cool water supply at each consumer point. While this can be expressed in simple terms by providing cooling power values [kW], for evaluation and comparison purposes it is better to have more detailed information with temperature [ºC] and flow data [m^3/s]. Sampling time: 1-15 minutes • **Power consumption:** power consumption measurement on cool water generators (e.g. chillers) [kW]. Sampling time: 1-15 minutes *Calculated Magnitudes*: • **Employed energy cost:** calculation of employed energy cost [€]. Sampling time: 1-15 minutes • **Efficiency of power consumption at cool water generators:** calculation of energy efficiency at each generation point; ratio between cooling energy produced and energy consumed (electrical or gas) [%]. Sampling time: 1-15 minutes • **Greenhouse gas emissions:** calculation of emitted GHG [t-$CO_{2\text{-eq}}$]. Sampling time: 1-15 minutes
Test Acceptance Criteria	Key performance indicators (KPI): • **Employed energy cost:** INDIGO controller cost less than STANDARD controller cost. Indicative target cost saving 20%; acceptable saving 10% (targets to be further defined). • **Efficiency of power consumption at cool water generators:** INDIGO controller efficiency more than STANDARD controller efficiency. Indicative target efficiency increase 10% (targets to be further defined). • **Greenhouse gas emission:** INDIGO controller emissions less than STANDARD controller emissions. Indicative target emission reduction: 20% (targets to be further defined). Other indicators: • **Building temperature outside of comfort boundaries:** <5% (targets to be further defined). • **Use of renewable energy vs. total energy consumption:** >30%

Notes	The measured boundary conditions will be used as inputs for the simulations.

Test Name	VIRTUAL_VS0_Marina_02 (INDIGO virtual vs. STANDARD virtual)
Description	• **Test aim:** compare at virtual level the **overall performance of the INDIGO controller** respect to current control implementations. • **Test aim and details:** the goal of this test is to compare at simulation level the **overall performance of the INDIGO controller** with respect to STANDARD control implementations. As all tests take place at simulation level, arbitrary boundary conditions can be applied. • The boundary conditions (demand, weather) will be fixed (no possibility to change them at will: at a given time the consumer demand and weather will be whatever measured). • **Test scenario:** La Marina VS-0 • **Benchmark:** normal operation with STANDARD controller. • **Test description:** normal operation (respond to regular cooling demand) with INDIGO controller subject to benchmark boundary conditions.
Test Variables	• **Operation goal:** cost minimization or efficiency maximization • **Self-learning capabilities:** activated and deactivated • **Management level:** operation with High Management Level (HML) only (optimization process; predict most efficient set-points) or with Low Management Level (LML) included (grid control system; accommodate supply to sudden demand variations/disturbances) • **Boundary conditions:** o Electricity price profiles: flat and variable o Demand profile: flat and variable o Disturbances and real demand/prediction differences: none and variable o Weather profiles: cold and warm scenarios
Signals to be Measured or Calculated	• **Demand profile:** cool water demand at each consumer point. While this can be expressed in simple terms by providing cooling power values [kW], for evaluation and comparison purposes it is better to have more detailed information with temperature [ºC] and flow data [m^3/s]. Sampling time: 1-15 minutes • **Weather:** outdoor temperature [ºC] and humidity [%]. Sampling time: 15 minutes • **Energy price:** electricity cost [€/kWh] at demonstration site (electricity prices are known one day in advance). Sampling time: 1 hour • **Cooling supply:** cool water supply at each consumer point. While this can be expressed in simple terms by providing cooling power values [kW], for evaluation and comparison purposes it is better to have more detailed information with temperature [ºC] and flow data [m^3/s]. Sampling time: 1-15 minutes • **Power consumption:** power consumption measurement on cool water generators (e.g. chillers) [KW]. Sampling time: 1-15 minutes • **Employed energy cost:** calculation of employed energy cost [€]. Sampling time: 1-15 minutes • **Efficiency of power consumption at cool water generators:** calculation of energy efficiency at each generation point; ratio between cooling energy produced and energy consumed (electrical or gas) [%]. Sampling time: 1-15 minutes • **Greenhouse gas emissions:** calculation of emitted GHG [t-$CO_{2\text{-}eq}$]. Sampling time: 1-15 minutes
Test Acceptance Criteria	Key performance indicators (KPI): • **Employed energy cost:** INDIGO controller cost less than STANDARD controller cost. Indicative target cost saving 20%; acceptable saving 10% (targets to be further defined). • **Efficiency of power consumption at cool water generators:** INDIGO controller efficiency more than STANDARD controller efficiency. Indicative target efficiency increase 10% (targets to be further defined). • **Greenhouse gas emission:** INDIGO controller emissions less than STANDARD controller emissions. Indicative target emission reduction: 20% (targets to be further defined).

	Other indicators: • **Building temperature outside of comfort boundaries:** <5% (targets to be further defined). • **Use of renewable energy vs. total energy consumption:** >30% Self-learning performance: • **Prediction accuracy in short and long prediction horizons:** difference between predicted values and "real" values <20%; target gains with improved prediction methods with respect to the sole reduced model prediction: 50% RMSE reduction.
Notes	

Test Name	VIRTUAL_VS1_Basurto_01 (INDIGO at VS-1 virtual vs. STANDARD at VS-1 virtual)
Description	• **Test aim:** compare at virtual level the **overall performance of the INDIGO controller** respect to STANDARD control implementations when some improvements are introduced on the test-site (from Basurto VS-0 to Basurto VS-1 where renewable energy sources are integrated). • **Test scenario:** Basurto VS-1 • **Benchmark:** normal operation with STANDARD controller on Basurto VS-1. • **Test description:** normal operation (respond to regular cooling demand) with INDIGO controller subject to benchmark boundary conditions.

Test Variables	• **Operation goal:** cost minimization, efficiency maximization and greenhouse gas emission reduction
	• **Self-learning capabilities:** activated and deactivated
	• **Management level:** operation with High Management Level (HML) only (optimization process; predict most efficient set-points) or with Low Management Level (LML) included (grid control system; accommodate supply to sudden demand variations/disturbances)
	• **Components efficiency re-calculation:** model self-learning ON and OFF
	• **Operation in restricted conditions:** operation in restricted conditions and transition from normal to restricted/failure mode (component disconnect due to failure/alarm)
	• **Boundary conditions:**
	  ○ Electricity price profiles: flat and variable
	  ○ Demand profile: flat and variable
	  ○ Disturbances and real demand/prediction differences: none and variable
	  ○ Weather profiles: cold and warm scenarios

Signals to be Measured or Calculated	• **Demand profile:** cool water demand at each consumer point. While this can be expressed in simple terms by providing cooling power values [kW], for evaluation and comparison purposes it is better to have more detailed information with temperature [ºC] and flow data [m^3/s]. Sampling time: 1-15 minutes • **Weather:** outdoor temperature [ºC] and humidity [%]. Sampling time: 15 minutes • **Energy price:** electricity cost [€/kWh] at demonstration site (electricity prices are known one day in advance). Sampling time: 1 hour • **Cooling supply:** cool water supply at each consumer point. While this can be expressed in simple terms by providing cooling power values [kW], for evaluation and comparison purposes it is better to have more detailed information with temperature [ºC] and flow data [m^3/s]. Sampling time: 1-15 minutes • **Power consumption:** power consumption measurement on cool water generators (e.g. chillers) [kW]. Sampling time: 1-15 minutes • **Employed energy cost:** calculation of employed energy cost [€]. Sampling time: 1-15 minutes • **Efficiency of power consumption at cool water generators:** calculation of energy efficiency at each generation point; ratio between cooling energy produced and energy consumed (electrical or gas) [%]. Sampling time: 1-15 minutes • **Greenhouse gas emissions:** calculation of emitted GHG [t-$CO_{2\text{-}eq}$]. Sampling time: 1-15 minutes
Test Acceptance Criteria	Key performance indicators (KPI): • **Employed energy cost:** INDIGO controller cost less than STANDARD controller cost. Indicative target cost saving 20%; acceptable saving 10% (targets to be further defined). • **Efficiency of power consumption at cool water generators:** INDIGO controller efficiency more than STANDARD controller efficiency. Indicative target efficiency increase 10% (targets to be further defined). • **Greenhouse gas emission:** INDIGO controller emissions less than STANDARD controller emissions. Indicative target emission reduction: 20% (targets to be further defined).

	Other indicators: • **Building temperature outside of comfort boundaries:** <5% (targets to be further defined). • **Use of renewable energy vs. total energy consumption:** >30% • **System payback time:** estimation of investment recovery for newly included components Self-learning performance: • **Prediction accuracy in short and long prediction horizons:** difference between predicted values and "real" values <20%; target gains with improved prediction methods with respect to the sole reduced model prediction: 50% RMSE reduction.
Notes	

Test Name	VIRTUAL_VS2_Marina_01 (INDIGO at VS-2 virtual vs. INDIGO at VS-0 virtual)
Description	• **Test aim:** compare at virtual level the **overall performance of the INDIGO controller** when some improvements are introduced on the test-site (from La Marina VS-0 to La Marina VS-2 where storage systems are integrated for coupling between generation, storage and demand) respect to the same INDIGO controller in the original VS-0 scenario. • **Test scenario:** La Marina VS-2 • **Benchmark:** normal operation with INDIGO controller on La Marina VS-0. • **Test description:** normal operation (respond to regular cooling demand) with INDIGO controller subject to benchmark boundary conditions.

Test Variables	• **Operation goal:** cost minimization, efficiency maximization and greenhouse gas emission reduction
	• **Self-learning capabilities:** activated and deactivated
	• **Management level:** operation with High Management Level (HML) only (optimization process; predict most efficient set-points) or with Low Management Level (LML) included (grid control system; accommodate supply to sudden demand variations/disturbances). Consider or not also cooling capacity from generation, storage, distribution systems (piping storage)
	• **Components efficiency re-calculation:** model self-learning ON and OFF
	• **Operation in restricted conditions:** operation in restricted conditions and transition from normal to restricted/failure mode (component disconnect due to failure/alarm)
	• **Boundary conditions:**
	  ○ Electricity price profiles: flat and variable
	  ○ Demand profile: flat and variable
	  ○ Disturbances and real demand/prediction differences: none and variable
	  ○ Weather profiles: cold and warm scenarios

Signals to be Measured or Calculated	• **Demand profile:** cool water demand at each consumer point. While this can be expressed in simple terms by providing cooling power values [kW], for evaluation and comparison purposes it is better to have more detailed information with temperature [ºC] and flow data [m^3/s]. Sampling time: 1-15 minutes • **Weather:** outdoor temperature [ºC] and humidity [%]. Sampling time: 15 minutes • **Energy price:** electricity cost [€/kWh] at demonstration site (electricity prices are known one day in advance). Sampling time: 1 hour • **Cooling supply:** cool water supply at each consumer point. While this can be expressed in simple terms by providing cooling power values [KW], for evaluation and comparison purposes it is better to have more detailed information with temperature [ºC] and flow data [m^3/s]. Sampling time: 1-15 minutes • **Power consumption:** power consumption measurement on cool water generators (e.g. chillers) [kW]. Sampling time: 1-15 minutes • **Employed energy cost:** calculation of employed energy cost [€]. Sampling time: 1-15 minutes • **Efficiency of power consumption at cool water generators:** calculation of energy efficiency at each generation point; ratio between cooling energy produced and energy consumed (electrical or gas) [%]. Sampling time: 1-15 minutes • **Greenhouse gas emissions:** calculation of emitted GHG [t-$CO_{2\text{-eq}}$]. Sampling time: 1-15 minutes
Test Acceptance Criteria	Key performance indicators (KPI): • **Employed energy cost:** INDIGO at VS-2 controller cost less than INDIGO at VS-0 controller cost. Indicative target cost saving 20%; acceptable saving 10% (targets to be further defined). • **Efficiency of power consumption at cool water generators:** INDIGO at VS-2 controller efficiency more than INDIGO at VS-0 controller efficiency. Indicative target efficiency increase 10% (targets to be further defined). • **Greenhouse gas emission:** INDIGO at VS-2 controller emissions less than INDIGO at VS-0 controller emissions. Indicative target emission reduction: 20% (targets to be

	further defined). Other indicators: • **Building temperature outside of comfort boundaries:** <5% (targets to be further defined). • **Use of renewable energy vs. total energy consumption:** >30% • **System payback time:** estimation of investment recovery for newly included components Self-learning performance: • **Prediction accuracy in short and long prediction horizons:** difference between predicted values and "real" values <20%; target gains with improved prediction methods with respect to the sole reduced model prediction: 50% RMSE reduction.
Notes	

Test Name	VIRTUAL_VS2_Franca_01 (INDIGO at VS-2 virtual vs. INDIGO at VS-0 virtual)
Description	• **Test scenario:** Zona Franca VS-2 (different types of thermal storage systems) • **Test aim:** compare at virtual level the **overall performance of the INDIGO controller** when some improvements are introduced on the test-site (from Zona Franca VS-0 to Zona Franca VS-2 where different types of thermal storage systems are integrated) respect to the same INDIGO controller in the original VS-0 scenario. • **Test scenario:** Zona Franca VS-2 • **Benchmark:** normal operation with INDIGO controller on Zona Franca VS-0. • **Test description:** normal operation (respond to regular cooling demand) with INDIGO controller subject to benchmark boundary conditions.

Test Variables	• **Operation goal:** cost minimization, efficiency maximization and greenhouse gas emission reduction
	• **Self-learning capabilities:** activated and deactivated
	• **Management level:** operation with High Management Level (HML) only (optimization process; predict most efficient set-points) or with Low Management Level (LML) included (grid control system; accommodate supply to sudden demand variations/disturbances). Consider or not also cooling capacity from generation, storage, distribution systems (piping storage)
	• **Components efficiency re-calculation:** model self-learning ON and OFF
	• **Operation in restricted conditions:** operation in restricted conditions and transition from normal to restricted/failure mode (component disconnect due to failure/alarm)
	• **Boundary conditions:**
	  o Electricity price profiles: flat and variable
	  o Demand profile: flat and variable
	  o Disturbances and real demand/prediction differences: none and variable
	  o Weather profiles: cold and warm scenarios

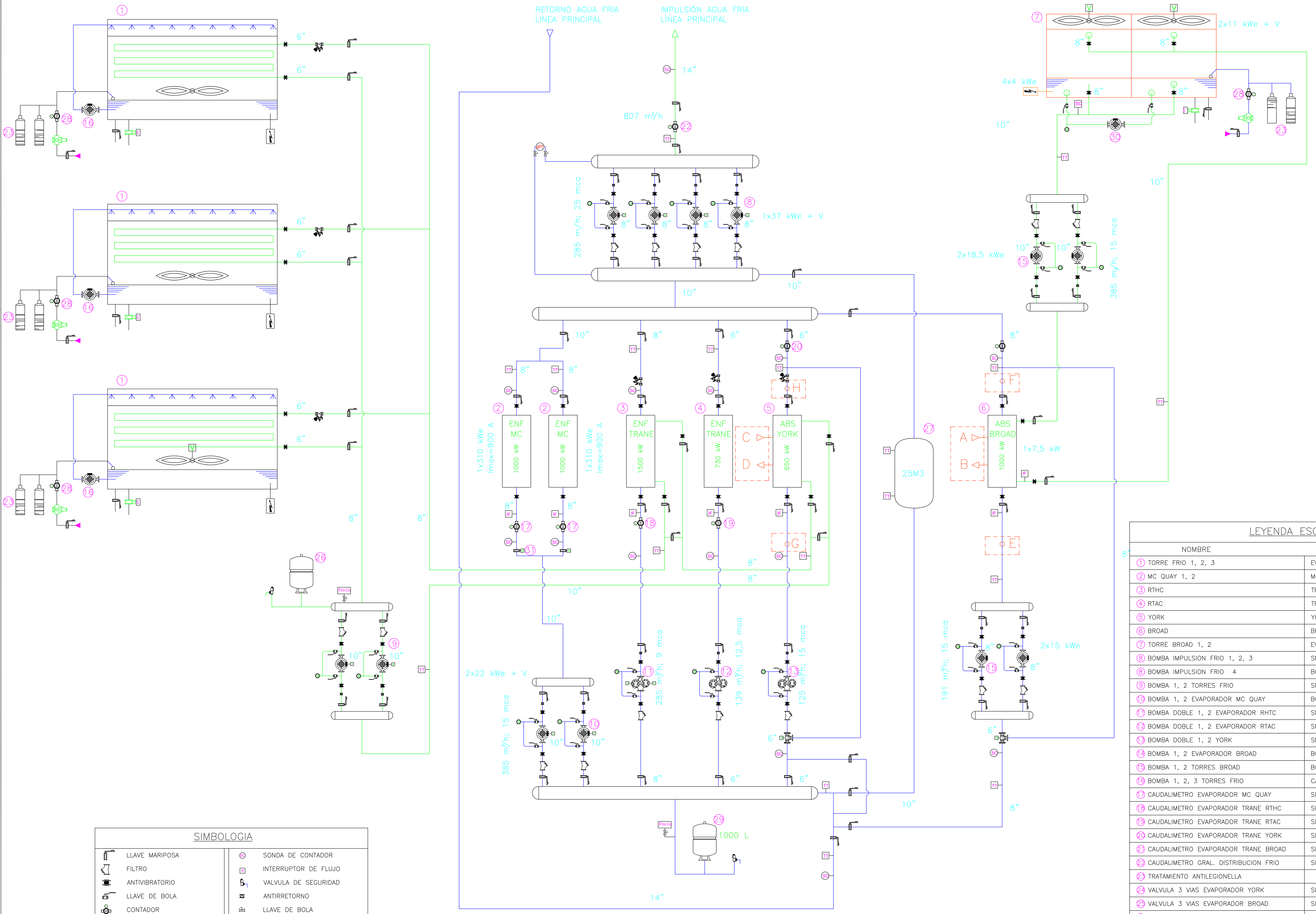
Signals to be Measured or Calculated	• **Demand profile:** cool water demand at each consumer point. While this can be expressed in simple terms by providing cooling power values [kW], for evaluation and comparison purposes it is better to have more detailed information with temperature [ºC] and flow data [m^3/s]. Sampling time: 1-15 minutes • **Weather:** outdoor temperature [ºC] and humidity [%]. Sampling time: 15 minutes • **Energy price:** electricity cost [€/kWh] at demonstration site (electricity prices are known one day in advance). Sampling time: 1 hour • **Cooling supply:** cool water supply at each consumer point. While this can be expressed in simple terms by providing cooling power values [kW], for evaluation and comparison purposes it is better to have more detailed information with temperature [ºC] and flow data [m^3/s]. Sampling time: 1-15 minutes • **Power consumption:** power consumption measurement on cool water generators (e.g. chillers) [kW]. Sampling time: 1-15 minutes • **Employed energy cost:** calculation of employed energy cost [€]. Sampling time: 1-15 minutes • **Efficiency of power consumption at cool water generators:** calculation of energy efficiency at each generation point; ratio between cooling energy produced and energy consumed (electrical or gas) [%]. Sampling time: 1-15 minutes • **Greenhouse gas emissions:** calculation of emitted GHG [t-$CO_{2\text{-}eq}$]. Sampling time: 1-15 minutes
Test Acceptance Criteria	Key performance indicators (KPI): • **Employed energy cost:** INDIGO at VS-2 controller cost less than INDIGO at VS-0 controller cost. Indicative target cost saving 20%; acceptable saving 10% (targets to be further defined). • **Efficiency of power consumption at cool water generators:** INDIGO at VS-2 controller efficiency more than INDIGO at VS-0 controller efficiency. Indicative target efficiency increase 10% (targets to be further defined). • **Greenhouse gas emission:** INDIGO at VS-2 controller emissions less than INDIGO at VS-0 controller emissions. Indicative target emission reduction: 20% (targets to be

	further defined). Other indicators: • **Building temperature outside of comfort boundaries:** <5% (targets to be further defined). • **Use of renewable energy vs. total energy consumption:** >30% • **System payback time:** estimation of investment recovery for newly included components Self-learning performance: • **Prediction accuracy in short and long prediction horizons:** difference between predicted values and "real" values <20%; target gains with improved prediction methods with respect to the sole reduced model prediction: 50% RMSE reduction.
Notes	

ANNEXES

A. P&ID DIAGRAMS OF THE TEST SITES

A.1 BASURTO SITE



SIMBOLOGIA

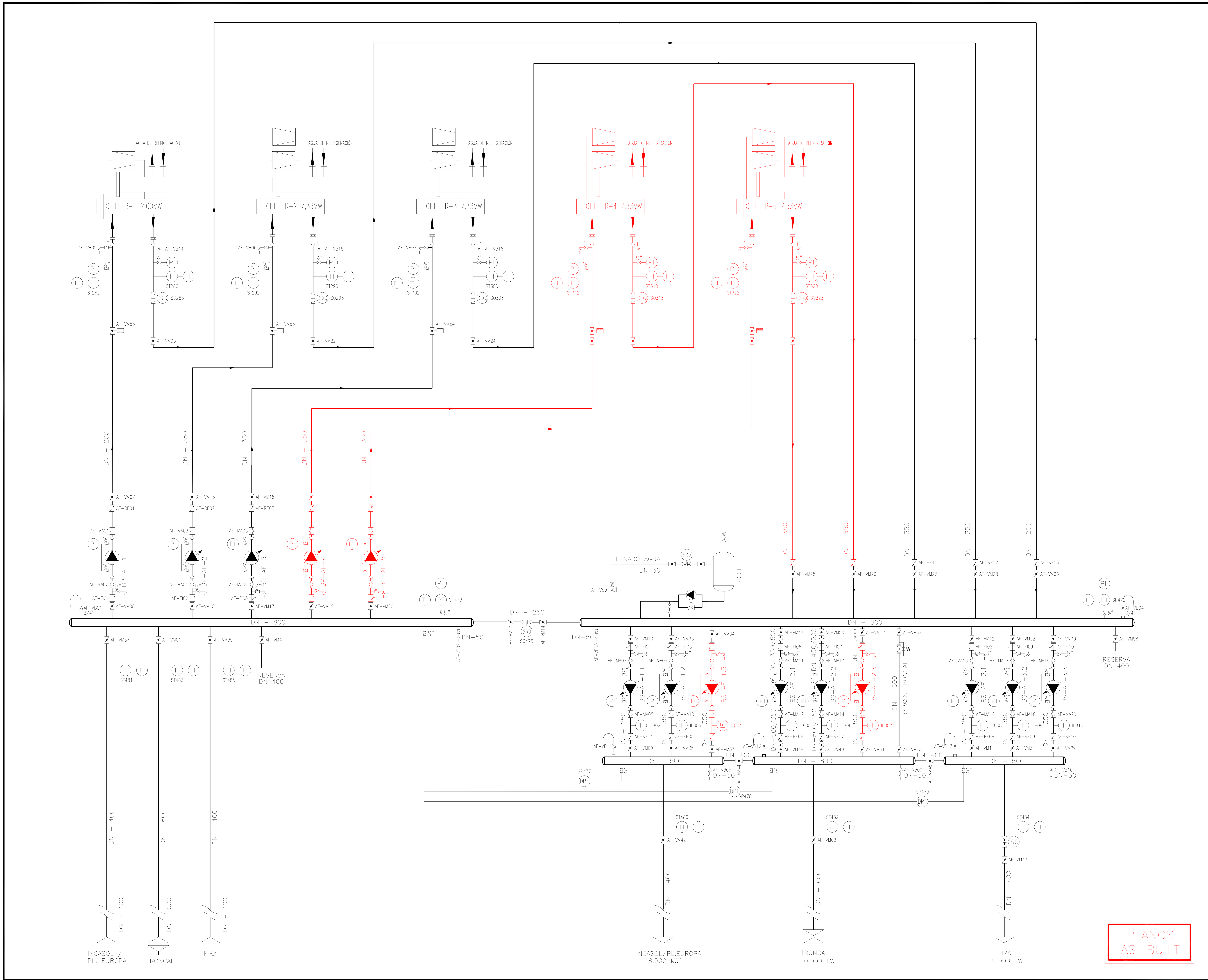
LLAVE MARIPOSA	SONDA DE CONTADOR
FILTRO	INTERRUPTOR DE FLUJO
ANTIVIBRATORIO	VALVULA DE SEGURIDAD
LLAVE DE BOLA	ANTIRRETORNO
CONTADOR	LLAVE DE BOLA
ELECTRONIVEL	VASO EXPANSION
REDUCTORA DE PRESION	MANOMETRO
V. REGULACION DE CAUDAL	RESISTENCIA DE CALENTAMIENTO
VALVULA 3 VIAS	BOMBA DOBLE
SONDA TEMPERATURA	BOMBA SIMPLE
TUBERIAS DE FRIO	TUBERIAS DE TORRES

LEYENDA ESQUEMA PRINCIPIO FRIO

NOMBRE	MARCA	MODELO	POTENCIA
1 TORRE FRIO 1, 2, 3	EVAPCO	SRL	
2 MC QUAY 1, 2	MC QUAY	AWS–XE 280 XNC 01	974 KW
3 RTHC	TRANE	RTHC E–3	
4 RTAC	TRANE	RTAC 200	
5 YORK	YORK	YIA–HW 3 B 2–50–B	
6 BROAD	BROAD	BDH 86 X72,5/102,5–35/29–7/12–125	1000 KW
7 TORRE BROAD 1, 2	EVAPCO	AT–28–524	2560 KW
8 BOMBA IMPULSION FRIO 1, 2, 3	SMEDEGAARD	N150–315–4/37/E	37 KW
8 BOMBA IMPULSION FRIO 4	BOM. PERFECTA	NE150–315–4/37/E	37 KW
9 BOMBA 1, 2 TORRES FRIO	SMEDEGAARD	N125–400–4/55	55 KW
10 BOMBA 1, 2 EVAPORADOR MC QUAY	BOM. PERFECTA	150–250–4/22	22 KW
11 BOMBA DOBLE 1, 2 EVAPORADOR RHTC	SMEDEGAARD	T–15–275–4D	15 KW
12 BOMBA DOBLE 1, 2 EVAPORADOR RTAC	SMEDEGAARD	T–10–160–2D	11 KW
13 BOMBA DOBLE 1, 2 YORK	SMEDEGAARD	T–10–150–2D	7,5 KW
14 BOMBA 1, 2 EVAPORADOR BROAD	BOM. PERFECTA	PDM 100–250–4/15	15 KW
15 BOMBA 1, 2 TORRES BROAD	BOM. PERFECTA	PDM 150–250–4/18,5	18,5 KW
16 BOMBA 1, 2, 3 TORRES FRIO	CALPEDA	NM 4125/25 EE	5,5 KW
17 CAUDALIMETRO EVAPORADOR MC QUAY	SIEMENS	SITRANS FM MAG 5100 W	
18 CAUDALIMETRO EVAPORADOR TRANE RTHC	SIEMENS	SITRANS FM MAG 5100 W	
19 CAUDALIMETRO EVAPORADOR TRANE RTAC	SIEMENS	SITRANS FM MAG 5100 W	
20 CAUDALIMETRO EVAPORADOR TRANE YORK	SIEMENS	SITRANS FM MAG 5100 W	
21 CAUDALIMETRO EVAPORADOR TRANE BROAD	SIEMENS	SITRANS FM MAG 5100 W	
22 CAUDALIMETRO GRAL. DISTRIBUCION FRIO	SIEMENS	SITRANS FM MAG 5100 W	
23 TRATAMIENTO ANTILEGIONELLA			
24 VALVULA 3 VIAS EVAPORADOR YORK	SIEMENS	ACVATIX SKC 62	28 VA
25 VALVULA 3 VIAS EVAPORADOR BROAD	SIEMENS	ACVATIX SKC 62	28 VA
26 VASO EXPANSION CIRCUITO TORRES FRIO	REFLEX	REFLEX N	
27 DEPOSITO INERCIA FRIO 26.000 L	TALLERES RUIZ	S / UNE	
28 CONTADOR DE IMPULSOS			
29 VASO EXPANSION 1000 L			
30 BOMBA RECIRCULACION TORRE BROAD	BOM. PERFECTA	MP 75 M	0,56 KW
31 VALVULA 2 VIAS EVAPORADOR MC QUAY 1, 2	SIEMENS	SQL 36 E 65	160 VA

PROYECTO: PROYECTO DE REFORMA DE LA INSTALACIÓN DE GAS Y PRODUCCIÓN DE CALEFACCIÓN Y FRIO EN EL HOSPITAL DE BASURTO	Giroa Grupo Dalkia	
PLANO: INSTALACIONES MECANICAS ESQUEMA DE PRINCIPIO FRIO		**Nº** W100739 IM-02 As Built -A0-
AUTOR DEL PROYECTO: Unai Mtez de la Hidalga Sarrigoitia INGENIERO INDUSTRIAL Nº colegiado COIIB: 4.344	**PETICIONARIO:** OSAKIDETZA Servicio Vasco de Salud	**Escala:** S/E **Fecha:** JUNIO 2011

A.2. LA MARINA SITE



LEYENDA

- VÁLVULA DE MARIPOSA
- VÁLVULA DE BOLA
- VÁLVULA DE RETENCIÓN
- VÁLVULA DE APERTURA RAPIDA
- VÁLVULA DE SEGURIDAD
- VÁLVULA REGULADORA DE PRESIÓN
- REDUCCIÓN: CONCÉNTRICA Y EXCÉNTRICA
- FILTRO
- MANGUITO ANTIVIBRATORIO
- UNIÓN VICTAULIC
- (PT) TRANSMISOR DE PRESIÓN
- (PI) INDICADOR DE PRESIÓN (MANÓMETRO)
- (TT) TRANSMISOR DE TEMPERATURA
- (TI) INDICADOR DE TEMPERATURA (TERMÓMETRO)
- (IF) INDICADOR DE TEMPERATURA (TERMÓMETRO)
- (DPT) TRANSMISOR DIFERENCIAL DE PRESIÓN
- (SQ) CONTADOR ELECTROMAGNÉTICO

- CONSTRUIDO
- FUTURA AMPLIACIÓN

BOMBA Referencia	CIRCUITO	CAUDAL l/s	PRESIÓN mca	Caudal Variable
BP-AF-1	PRIMARIO GENERACIÓN FRIO	53	10	SÍ
BP-AF-2		195	15	SÍ
BP-AF-3		195	15	SÍ
BP-AF-4		195	15	SÍ
BP-AF-5		195	15	SÍ
BS-AF-1.1	SECUNDARIO INCASOL /PL. EUROPA	100	50	SÍ
BS-AF-1.2		200		SÍ
BS-AF-1.3		200		SÍ
BS-AF-2.1	SECUNDARIO TRONCAL	155	52	SÍ
BS-AF-2.2		315		SÍ
BS-AF-2.3		470		SÍ
BS-AF-3.1	SECUNDARIO FIRA	100	30	SÍ
BS-AF-3.2		200		SÍ
BS-AF-3.3		200		SÍ

SITUACIÓN

REVISIONES

No.	Fecha	Descripción	Nombre	Revisado

Ecoenergies Barcelona — Dalkia — agefred Grupo Dalkia

Asunto: RED DH&C LA MARINA

Denominación: P&ID AGUA FRÍA

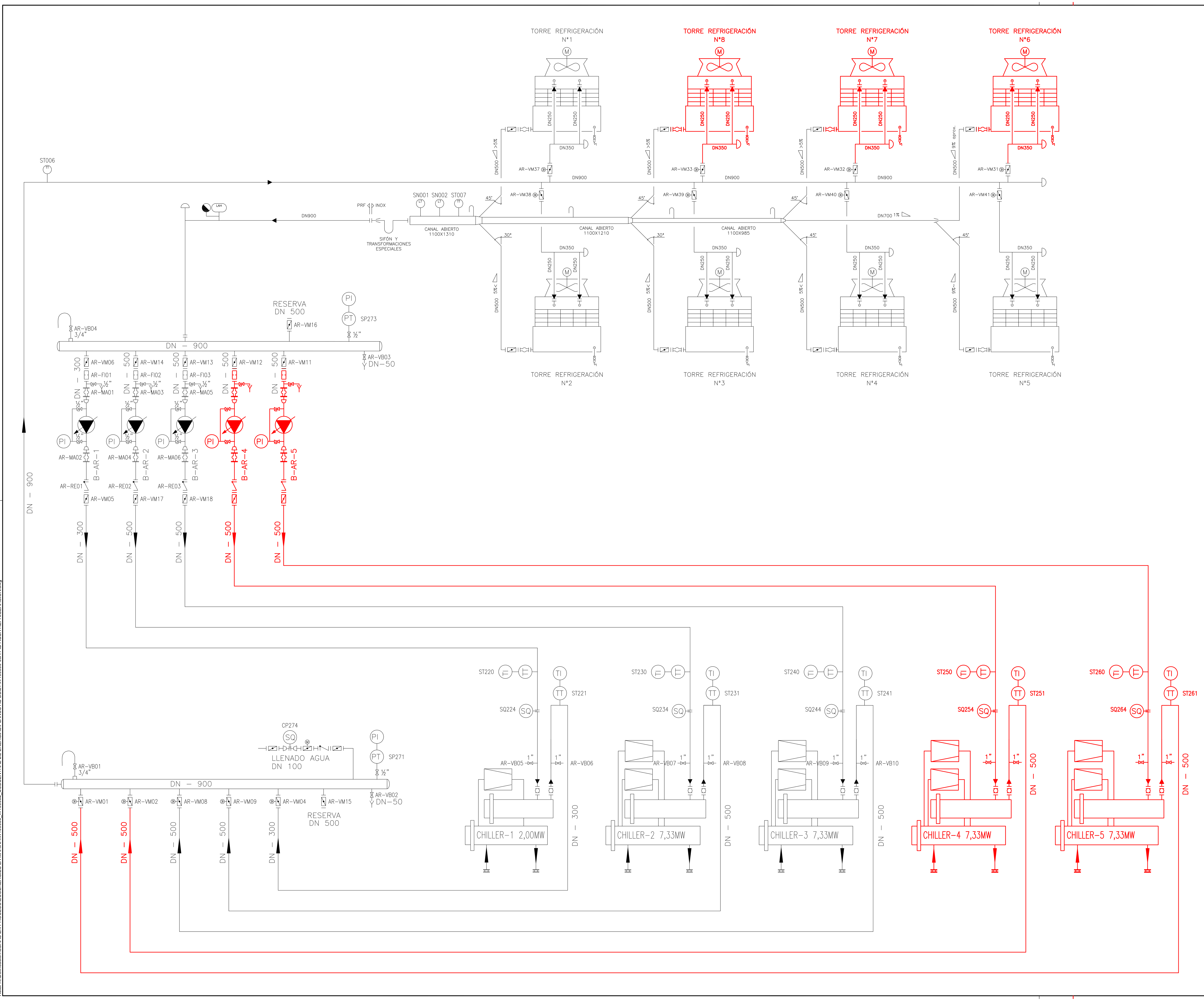
Cód.Gen.:

Cód.: W100050-06

Sustituye a:

Sustituido por:

	Fecha:	Nombre:	Firma:	Cotas en:	Escala:
Proyectado:	-	-		mm	S/E
Dibujado:	07-02-2012	C.VERDUGO			
Revisado:	09-02-2012	E.FERNÁNDEZ			



LEYENDA

- VÁLVULA DE MARIPOSA
- VÁLVULA DE BOLA
- VÁLVULA DE RETENCIÓN
- VÁLVULA DE TRES VÍAS
- REDUCCIÓN: CONCÉNTRICA Y EXCÉNTRICA
- FILTRO
- MANGUITO ANTIVIBRATORIO
- UNIÓN VICTAULIC
- PURGADOR
- PT TRANSMISOR DE PRESIÓN
- PI INDICADOR DE PRESIÓN (MANÓMETRO)
- TT TRANSMISOR DE TEMPERATURA
- TI INDICADOR DE TEMPERATURA (TERMÓMETRO)
- DPT TRANSMISOR DIFERENCIAL DE PRESIÓN
- CC CONTROLADOR DE CONDUCTIVIDAD
- SQ CONTADOR ELECTROMAGNÉTICO
- LT TRANSMISOR DE NIVEL
- LAH ALARMA DE NIVEL MÁXIMO

CONSTRUIDO
FUTURA AMPLIACIÓN

BOMBA Referencia	CIRCUITO	CAUDAL l/s	PRESIÓN mca	Presión nominal máx.	Caudal Variable
B-AR-1	AGUA REFRIGERACION	113	25	PN 10	NO
B-AR-2		413	33	PN 10	NO
B-AR-3		413	33	PN 10	NO
B-AR-4		413	33	PN 10	NO
B-AR-5		413	33	PN 10	NO

No.	Fecha	Descripción	Nombre	Revisado
-	-	-	-	-
-	-	-	-	-
-	-	-	-	-
-	-	-	-	-
-	-	-	-	-
A	16-11-2012	MODIF. CANAL SALIDA TORRES	C.VERDUGO	M.VERDUGO

Cliente: Ecoenergies Barcelona · Dalkia

agefred
Escultor canet,35-37
08028 Barcelona
Tel.:933 340 800
www.agefred.com

Asunto:
DH&C LA MARINA
SUBCENTRAL DE ENERGÍAS - FASE 1
AS BUILT

Denominación:
P&ID
AGUA DE REFRIGERACIÓN
-

Codigo plano: W100050-08

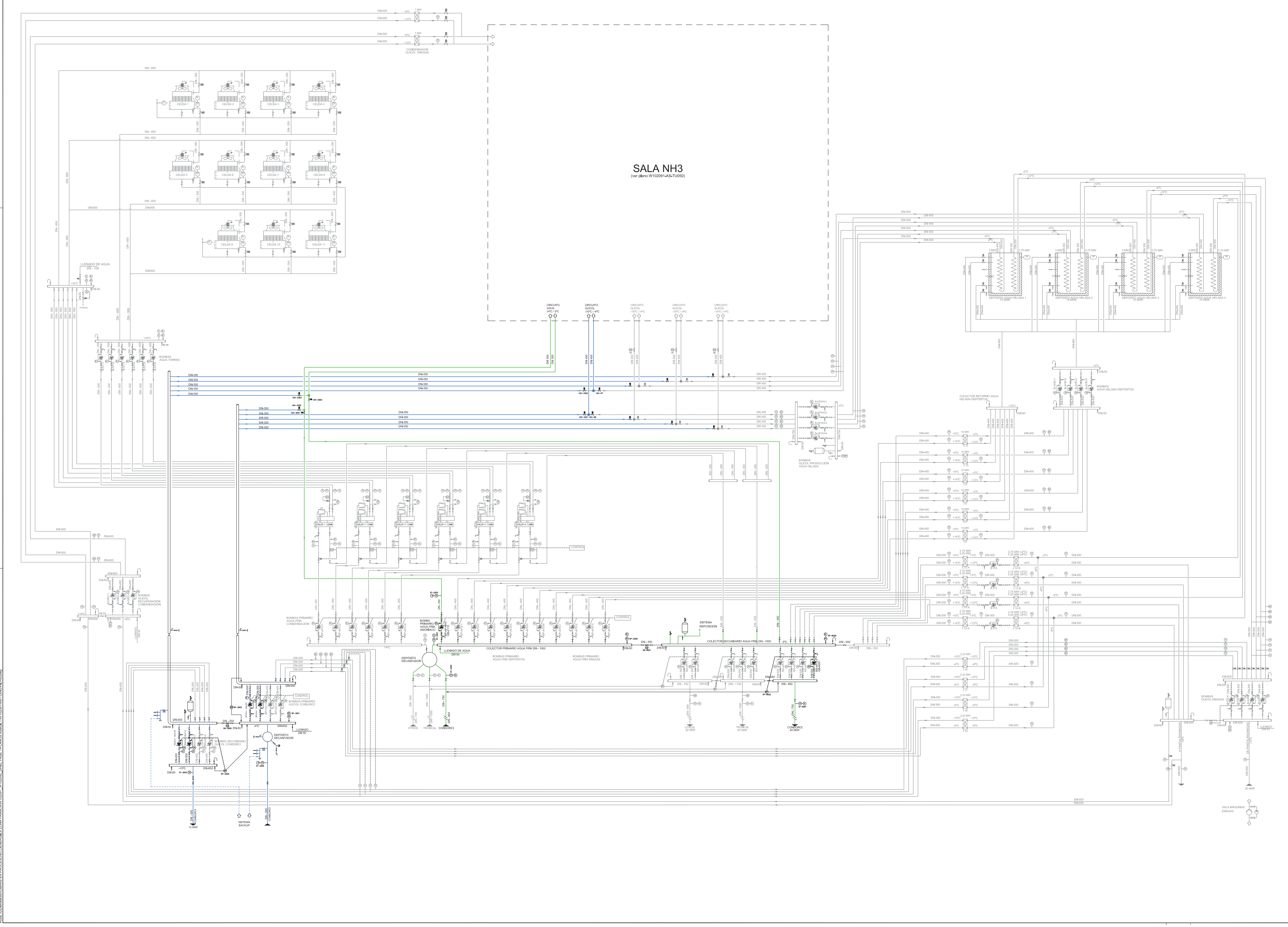
Pág. 1 de 1

Nombre archivo:
W100050-08A PID AGUA REFRIGERACION.DWG

A1 A3

S/E S/E

A.3. ZONA FRANCA SITE



No.	Fecha	Descripción	Nombre	Revisado
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-	-	-	-	-
-	-	-	-	-
-	-	-	-	-
-	-	-	-	-
00	07-09-2012	AS-BUILT	C.VERDUGO	M.VERDUGO

Cliente: Ecoenergies Barcelona · Dalkia

agefred
Escultor canet,35-37
08028 Barcelona
Tel.:933 340 800
www.agefred.com

Asunto:
DH&C ZONA FRANCA
FASE 1

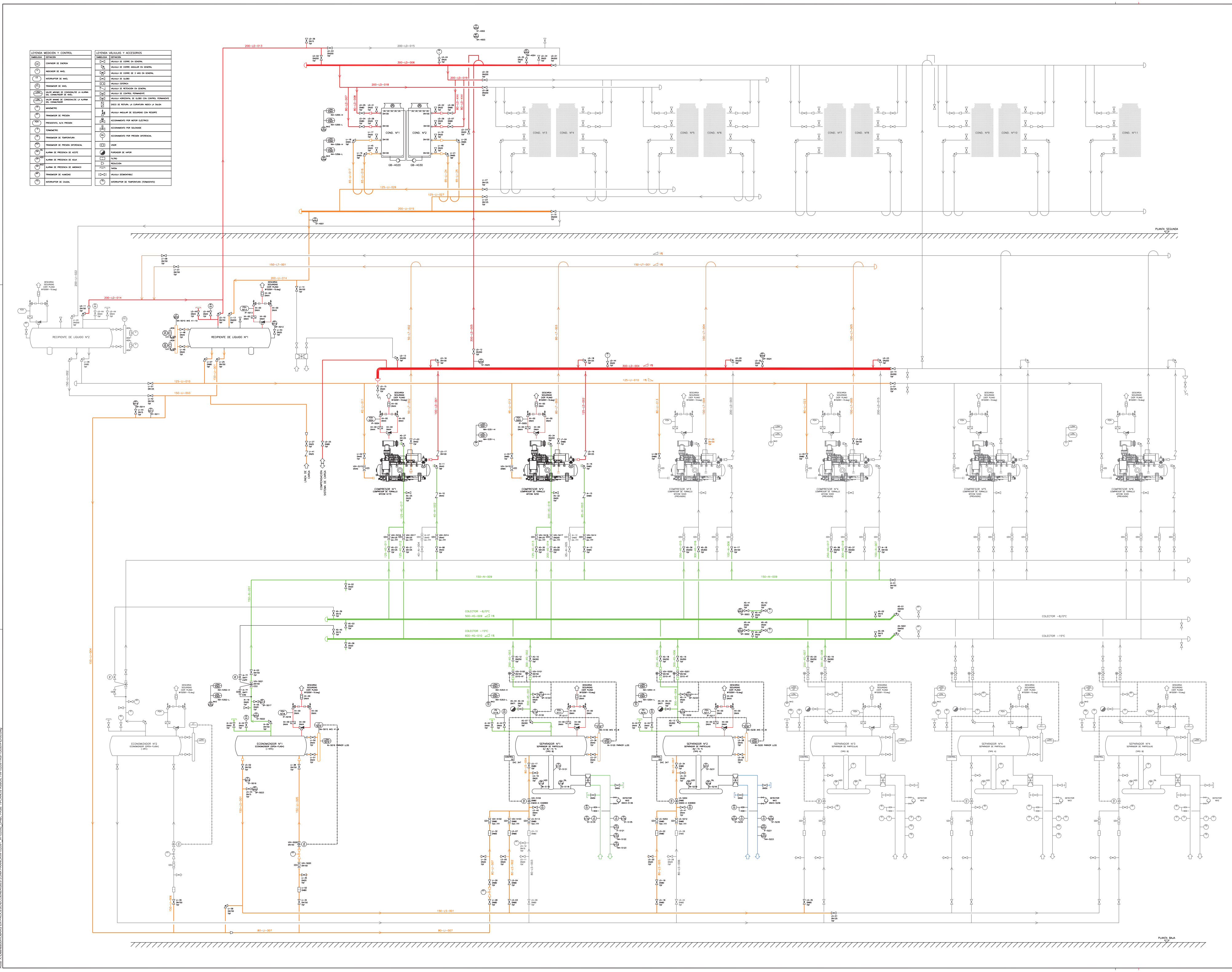
Denominación:
planta sótano
P&ID FRÍO GENERAL
ZONAS B y C (-3.95m)

Codigo plano: TU040

Pág. 1 de 1

Nombre archivo: W102091-AS-TU040-PID-00.DWG

A0 / A2 — S/E / S/E



No.	Fecha	Descripción	Nombre	Revisado
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-	-	-	-	-
-	-	-	-	-
-	-	-	-	-
-	-	-	-	-
00	07-09-2012	AS-BUILT	C.VERDUGO	M.VERDUGO

Cliente: Ecoenergies Barcelona · Dalkia

agefred
Escultor canet,35-37
08028 Barcelona
Tel.:933 340 800
www.agefred.com

Asunto:
DH&C ZONA FRANCA
FASE 1

Denominación:
planta baja
P&ID FRÍO (NH3)
ZONA B (±0.00m)

Codigo plano: TU050

Pág. 1 de 1

Nombre archivo:
W102091-AS-TU050-PID-00.DWG

A0
A2

S/E
S/E

B. LIST OF HVAC EQUIPMENT CONNECED TO THE DC IN BASURTO HOSPITAL

AIR HANDLING UNITS (AHU)

BUILDING	LOCATION	AHU DESIGNATION	MODEL
CONSULTAS	Falso techo, sala espera	Extracciones	Termoven CTH-5
CONSULTAS	Falso techo, cuarto calderas	Ginecología	Termoven CTH-7
CONSULTAS	Terracilla	Asistencias y Admisión	Termoven CTH-7
CONSULTAS	Terracilla	Pediatría 1ª Plta.	Termoven CTH-5
CONSULTAS	Terracilla	Pasillo trauma P.B.	Termoven CTH-7
CONSULTAS	Terracilla	Endoscopias 2ª Plta.	Termoven CTH-7
CONSULTAS	Terracilla	Hall de entrada	Termoven CTH-5
CONSULTAS	Terracilla	Traumatología	Termoven CTH-7
CONSULTAS	Sala espera trauma	Trauma y diputación	Termoven CTH-7
CONSULTAS	Sala espera, otorrino	Otorrino 1ª Plta.	Termoven CTH-5
CONSULTAS	Sala espera neurología	Neurología 1ª Plta.	Termoven CTH-7
CONSULTAS	Sala espera	Oftalmología 1ª Plta.	Termoven CTH-7
CONSULTAS	Sala espera neurología	Maxilofacial 1ª Plta.	Termoven CTH-5
CONSULTAS	Terraza 3ª Plta.	Psiquiatría B	Termoven CTH-4
CONSULTAS	Terraza 3ª Plta.	Psiquiatría A	Termoven CTH-4
CONSULTAS	Terraza 3ª Plta.	Cirugía A y B	Termoven CTH-5
CONSULTAS	Terraza 3ª Plta.	Cardiología	Termoven CTH-5
CONSULTAS	Terraza 3ª Plta.	Alergias	Termoven CTH-7
CONSULTAS	Terraza 3ª Plta.	Medicina interna	Termoven CTH-7
CONSULTAS	Terraza 3ª Plta.	Quirofanillo	
ITURRIZAR	Sala climat.	Quirófanos	Trox TKM-86
ITURRIZAR	Sala climat.	Neonatología	Trox TKM-50
SAN VICENTE	Sala Intercambiador	Sótano	Tecnivel CHC-11-B
SAN VICENTE	Trasera San Vicente	ACELERADOR 2	Tecnivel PHF-11-A
ALLENDE	Azotea	Quirófano	Tecnivel PHF-8-A
ALLENDE	Azotea	U.C.I.	Tecnivel PHF-7-A
GURTUBAY	Sala máquinas	SUROESTE	Tecnivel PPHF-31-AE
GURTUBAY	Sala maquinas	NORESTE	Tecnivel PHF-25-A
GURTUBAY	Sala maquinas, pequeña	VESTUARIOS	Tecnivel PHF-6-A
MAKUA	Planta 0 CL-A		
MAKUA	Planta 0 CL-B		
MAKUA	Planta 0 CL-C		
MAKUA	Planta 0 CL-D		
MAKUA	Planta 0 CL-E		
MAKUA	Planta 0 CL-F		
MAKUA	Planta 0 CL-G		

MAKUA	Planta 0 CL-H		
MAKUA	Planta 3 CL-A		
MAKUA	Planta 3 CL-C		
MAKUA	Planta 3 CI-D		
MAKUA	Planta 3 CI-E		
MAKUA	Planta 3 CI-F		
MAKUA	Planta 6º	Quirofanos	
MAKUA	Planta 6º	Reanimacion	
MAKUA	Planta 6º	Aire primario	
MAKUA	Sotano	Biobanco	
MAKUA	Planta 4º	Zona Nueva + Consultas1Plt	
AREILZA	Sotano -2	CL-1	
AREILZA	Sotano -2	CL-2	
AREILZA	Sotano -2	CL-3	
AREILZA	Sotano -2	CL-4	
AREILZA	Sotano -2	CL-5	
AREILZA	Sotano -2	CL-6	
AREILZA	Sotano -2	CL-7	
AREILZA	Sotano -2	CL-8	
AREILZA	Sotano -2	CL-9	
AREILZA	Sotano -2	CL-10	
AREILZA	Sotano -2	CL-11	
AREILZA	Sotano -2	CL-21	
AREILZA	Sotano -2	CL-22	
AREILZA	Sotano -2	CL-23	
AREILZA	Sotano -2	CL-24	
AREILZA	Sotano -2	Hall de entrada	
AREILZA	Sotano -2	Capilla 1	
AREILZA	Sotano -2	Capilla 2	
AREILZA	Sotano -2	Capilla 3	
AREILZA	Sotano -2	Capilla 4	
AREILZA	Planta 1	Frente Box 5	
AREILZA	Planta 1	Frente Box 10	
AREILZA	Planta 1	Frente Box 12	
AREILZA	Planta 1	Frente Box 18	
AREILZA	Planta 1	Frente Box 29	
AREILZA	Planta 1	Frente Box 27	
AREILZA	Sotano -2	Control enfermeria	
AREILZA	Sotano -2	Hall ascensores	
AZTARAIN	Bajo cubierta	Clima Aire Primario	
AZTARAIN	Bajo cubierta	Clima Presion positiva	
AZTARAIN	Sotano CL- SA	Mostrador SA	
AZTARAIN	Sotano CL- SB	Mostrador SB	

AZTARAIN	Sotano CL- SC	Mostrador SC	
AZTARAIN	Sotano CL- SD	Mostrador SD	
AZTARAIN	Sotano CL- SE	Mostrador SE	
AZTARAIN	Sotano CL- SF	Mostrador SF	
AZTARAIN	Sotano CL- SH	Mostrador SH	

FAN COILS

BUILDING	LOCATION	FANCOIL DESIGNATION	MODEL
CONSULTAS	Sala espera, Endocrino	Nº1 2ª Plta.	
CONSULTAS	Secretaria, Endocrino	Nº2 2ªPlta.	
CONSULTAS	Sala espera, Urología	Nº3 2ªPlta.	
CONSULTAS	Secretaria, Urología	Nº4 2ªPlta.	
CONSULTAS	Sótano, cuarto cuadros eléctricos	Vestuarios	
CONSULTAS	Sotano tunel archivo 1	Archivo 1	Aermec FCA-62
CONSULTAS	Sotano tunel archivo 2	Archivo 2	Aermec FCW-41
MAKUA	Nº 1 Yesos,RX,Box G	Planta baja	
MAKUA	Nº 2 Boxes 9 al 18	Planta baja	
MAKUA	Nº 3 Boxes 1 al 8	Planta baja	
MAKUA	Nº 4 TRIAJE	Planta baja	
MAKUA	Nº 8 Boxes 9 al 15	1ª planta	
MAKUA	Nº 9 Boxes 1 al 9	1ª planta	
MAKUA	Nº 10 Pasillos	1ª planta	
MAKUA	Nº 11 Scaner	1ª planta	
MAKUA	Nº 12 Despachos	1ª planta	
MAKUA	Nº 13 Laboratorio	2ª planta	
MAKUA	Nº 14 Pasillo Quirof.	2ª planta	
MAKUA	N º15 URPA, preoperatorio	2ª planta	
MAKUA	Nº 16 Area Administrativa	2ª planta	
MAKUA	Nº 18 Zona interior	4ª planta	
MAKUA	Nº 19 Zona exterior	4ª planta	
MAKUA	Nº 20 Zona interior	5ª planta	
MAKUA	Nº 21 Zona exterior	5ª planta	
MAKUA	Nº 22 Hospitalización Día	3ª planta	
MAKUA	Nº 23 Hospitalizacion Día	3ª planta	
MAKUA	Nª 25 Pediatría	Planta baja	
MAKUA	Nº 26 Apoyo boxes Cl2	Planta baja	
MAKUA	Nº 27 Apoyo boxes CL3	Planta baja	
MAKUA	Scanner	Planta 1ª	

MAKUA	Ecografía	Planta 1ª	
MAKUA	Sotano Aula 1	Aula	
MAKUA	Sotano Aula 2	Aula	
MAKUA	Sotano Biobanco	Biobanco 1	
MAKUA	Sotano Biobanco	Biobanco 2	
MAKUA	Sotano Hospidom	Hospidom	
MAKUA	Sotano tubo neumatico	taller tubo neumatico	
MAKUA	Planta 0º Rayos X	Planta baja	
REVILLA	Hab. 317-318	ZONA NORTE	DWKMod631-2T
REVILLA	Hab. 319-320	ZONA NORTE	DWKMod631-2T
REVILLA	Hab. 305-306	ZONA NORTE	DWKMod631-2T
REVILLA	Hab. 307-308	ZONA NORTE	DWKMod631-2T
REVILLA	PASILLO	ZONA NORTE	DWKMod631-2T
REVILLA	Hab. 327-328	ZONA NORTE	DWKMod631-2T
REVILLA	Hab. 323-324	ZONA NORTE	DWKMod631-2T
REVILLA	Hab. 321-322	ZONA NORTE	DWKMod631-2T
REVILLA	Cuarto médicos 3	ZONA NORTE	DWKMod631-2T
REVILLA	Cuarto medicos 4	ZONA NORTE	DWKMod631-2T
REVILLA	Cuarto medicos 2	ZONA NORTE	DWKMod631-2T
REVILLA	Hab. 341-342	ZONA NORTE	DWKMod631-2T
REVILLA	Cuarto limpieza	ZONA NORTE	DWKMod631-2T
REVILLA	Cuarto medicación	ZONA NORTE	DWKMod631-2T
REVILLA	Cuarto médicos izq.	ZONA NORTE	DWKMod631-2T
REVILLA	Sala espera pasillo izq.	ZONA SUR	DWKMod631-2T
REVILLA	Despacho médico vacio	ZONA SUR	DWKMod631-2T
REVILLA	Hab. 311-312	ZONA SUR	DWKMod631-2T
REVILLA	Hab. 313-314	ZONA SUR	DWKMod631-2T
REVILLA	COCINA	ZONA SUR	DWKMod631-2T
REVILLA	Hab. 301-302	ZONA SUR	DWKMod631-2T
REVILLA	Hab. 339-340	ZONA SUR	DWKMod631-2T
REVILLA	Hab. 335-336	ZONA SUR	DWKMod631-2T
REVILLA	Hab. 333-334	ZONA SUR	DWKMod631-2T
REVILLA	Sala espera pasillo dcha.	ZONA SUR	DWKMod631-2T
REVILLA	SUPERVISORA	ZONA SUR	DWKMod631-2T
REVILLA	Hab. 329-330	ZONA SUR	DWKMod631-2T
REVILLA	Cuarto limpieza	ZONA NORTE	DWKMod631-2T
REVILLA	COCINA	ZONA NORTE	DWKMod631-2T
REVILLA	Hab. 405-406	ZONA NORTE	DWKMod631-2T
REVILLA	Hab. 407-408	ZONA NORTE	DWKMod631-2T
REVILLA	Hab. 421-422	ZONA NORTE	DWKMod631-2T
REVILLA	Hab. 423-424	ZONA NORTE	DWKMod631-2T
REVILLA	Hab. 427-428	ZONA NORTE	DWKMod631-2T
REVILLA	Sala médicos 3	ZONA NORTE	DWKMod631-2T

REVILLA	JABEDUA No existe	ZONA NORTE	DWKMod631-2T
REVILLA	Pasillo	ZONA NORTE	DWKMod631-2T
REVILLA	Secretaría Cuarto medico	ZONA NORTE	DWKMod631-2T
REVILLA	Hab. 441-442 439/440	ZONA NORTE	DWKMod631-2T
REVILLA	Hab. 401-402	ZONA NORTE	DWKMod631-2T
REVILLA	Cuarto medicación	ZONA NORTE	DWKMod631-2T
REVILLA	Sala médicos izq.	ZONA NORTE	DWKMod631-2T
REVILLA	Sala espera	ZONA SUR	DWKMod631-2T
REVILLA	Cuarto médico vacío	ZONA SUR	DWKMod631-2T
REVILLA	Hab. 411-412	ZONA SUR	DWKMod631-2T
REVILLA	Hab. 413-414	ZONA SUR	DWKMod631-2T
REVILLA	Hab. 417-418	ZONA SUR	DWKMod631-2T
REVILLA	Hab. 419-420	ZONA SUR	DWKMod631-2T
REVILLA	Hab. 433-434	ZONA SUR	DWKMod631-2T
REVILLA	Hab. 435-436	ZONA SUR	DWKMod631-2T
REVILLA	Hab. 429-430	ZONA SUR	DWKMod631-2T
REVILLA	SUPERVISORA	ZONA SUR	DWKMod631-2T
GURTUBAY	2 Planta presion negativo	Micobacterias	
GURTUBAY	Sotano -1 UPS Gurtubay	UPS Gurtubay	
AREILZA	Despacho Juan Luis	Planta sotano -2	Aermec FCA 62
AREILZA	Taller Electromedicina	Planta sotano -2	Aermec FCA 62
AREILZA	Taller Fontaneros	Planta sotano -2	Aermec FCA 62
AREILZA	Taller Electromecanicos	Planta sotano -2	Aermec FCA 62
AREILZA	Despacho Jefe seguridad	Planta sotano -2	Aermec FCA 62
AREILZA	Despacho Anero	Planta sotano -2	Aermec FCA 62
AREILZA	Despacho Fernando	Planta sotano -2	Aermec FCA 62
AREILZA	Oficina Mto 1	Planta sotano -2	Aermec FCA 62
AREILZA	Oficina Mto 2	Planta sotano -2	Aermec FCA 62
AREILZA	Ordenador Clima	Planta sotano -2	Aermec FCA 62
AREILZA	Comarca	Planta sotano -2	Aermec FCA 62
AREILZA	Sala de Reunion	Planta sotano -2	Aermec FCA 62
AREILZA	Biobanco ADN	Planta sotano -2	Aermec FCA 62
AREILZA	Taller clima	Planta sotano -2	AermeFCW412 V
AREILZA	UPS	Sótano -2	
AREILZA	Autoclaves Esterilización	Sótano -2	