DIRECTION

DEMONSTRATION OF VERY LOW ENERGY NEW BUILDINGS

DIRECTION

Demonstration at European Level of Innovative and Replicable Effective Solutions for very Low Energy new Buildings

D3.4: Metering project for demonstrator I

WP3, Task 3.2

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Authors: Roberto Sanz (CAR), Alvaro Corredera (CAR), Julia Vicente (CAR), Norberto Fco. González Hidalgo (1AI), Rosa Moratinos Real (1AI), Jan Kaiser (FHO)

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Demonstration of very low energy new buildings

Collaborative Project – GRANT AGREEMENT No. 285443

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Project Coordinator	Sergio Sanz Fundación CARTIF sersan@cartif.es
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[1] PU = Public

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CO = Confidential, only for members of the consortium (including the Commission Services).

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0 Abstract

This document describes the energy metering system, following the premises of task 3.2 found in annex I "Description of work" of Grant agreement no: 285443, to have energy consumption measures.

1 Introduction

The metering system is integrated into the monitoring project therefore all general specifications and information have been compiled in deliverable 3.1 "Monitoring project system for demonstrator I", and you can obtain more information in this document.

In this deliverable it defines the counters that are necessary to achieve the measures of these consumptions and their position. The treatment of these collected data is defined in the Deliverable D3.3 Monitoring System Project of Demonstrator III in the section 3.3 with the aim to obtain the building performance.

The main goal is to obtain **energy saving measurements**. To evaluate the energy consumption it is necessary to gather information about the insulated measurements and in the whole building.

This document defines an overview of the energy consumption in the building, the position of the sensors and the identification of the meters in its particular position.

In the building of CARTIF III integration of monitoring, measurement and control system, has based on devices with LONWORKS technology on twisted pair (FT-10). As well as a network of this type using the tool Echelon LONMAKER is mounted.

At a higher level it has developed a software control and monitoring to measure using the tool TAC Vista Workstation, and TAC Vista Server (Schneider).

TAC Vista is a building management system that allows you to monitor and control HVAC, lighting, access control and other security features across one or more facilities. Based on the open protocol LonWorks, it is among the most scalable and IT-friendly systems in the industry. This scalable solution can accommodate any size building management application. Open architecture allows seamless integration with third-party products and provides complete interoperability.

- TAC Xenta controllers: All TAC Xenta controllers provide an open and flexible system architecture and access to standardized LonWorks-based network technology.
- TAC Menta: TAC Menta is a graphical programming tool for the freely programmable controllers—TAC Xenta 300 and 400. TAC Menta can be installed as stand-alone software in a PC, or as a part of the TAC Vista software package.

TAC Vista is the software solution that efficiently controls, checks and analyzes the daily operation and economical running of a building. TAC Vista is available in a variety of packages designed to maximize efficiency and economy it is also modular, making it easy to expand the system as your needs change. Also, TAC Vista is available in an increasing number of languages

TAC Vista Server provides access to the environmental and security controls for operator workstations, and is the primary operator interface to the control system It displays daily operations through a graphical user interface, providing operators with ready access to alarms, historical logs and sophisticated data trend logs as well as standard and custom reports.

These tools have allowed the development of a user interface for the system. This interface allows us to govern the system in manual or automatic form using set points, for example temperatures of comfort in the spaces of the building intended for use as offices.

This software also offers the possibility to the user to define different points of monitoring and graphical representation of data, in other words, allows the user to define what variables wants to store for its subsequent graphical representation and analysis.

Because both the control system as the monitoring and metering are based on LONWORKS and support this Protocol, the interaction between these systems is total and direct, no more to set the network with their necessary characteristics and appropriate drivers.

An example of the architecture that TAC VISTA system offers can see in the image below.

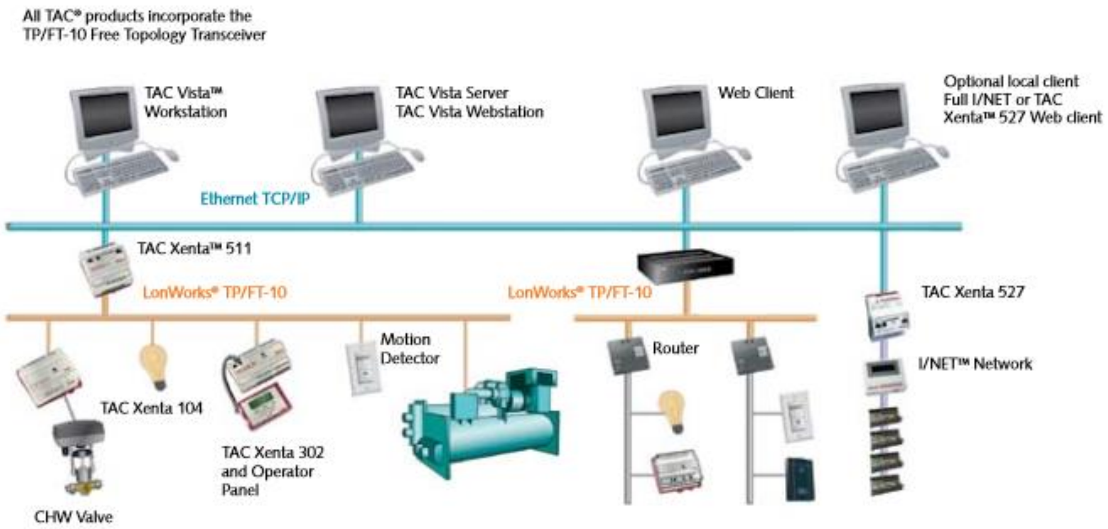


Figure 1: TAC VISTA Architecture

In the specific case of CARTIF III an example of the operation of the network and TAC VISTA, seen in the image below, which represents an example of how it interacts with the system, in particular with the control equipment for the production of heat from the building. You can see in addition as the software offers the possibility of manual runs, automatic, off, etc, and the display of certain data in an instant.

2 Systems overview

The thermal installation of the new building of Fundación CARTIF is entirely based on the production of the energy to cover all the energy needs of the building using different renewable sources as geothermal and biomass with a considerable decrease of CO2 emissions.

For the offices the main energy source are the geothermal energy which is based on the exploitation of the natural heat present on the soil to air-condition environmentally. This system works giving or extracting heat from the soil depending on the needs of cooling or heating of the building by means of a set of buried collectors filled with a mix water-glycol circulating. To cool the building during summer the system sends the extra hot of the building inside to the ground. On the opposite, during winter, this equipment allows heating the building with the reverse process, taking hot from the soil through the collectors to send it to the building.

The principal elements of the CARTIF III geothermal installation are:

1. A water-water reversible geothermal heat pump with nominal power of 101.5 kW for heating and 77 kW for cooling, and COP of 4.35 and EER equal to 3.81.

2. A heat exchanger introduces on 100 m deep boreholes consisting of 15 geothermal double U polyethylene collectors of high resistance and long life with a mix water-glycol inside. Using double U collectors a 30-40% higher performance is obtained as there is a double flow circulating with the same length of borehole.

3. A hydraulic pump, for the water-glycol solution flowing through the geothermal collectors.

The geothermal pump, as well as the rest of elements of this system, is placed on a technical room located on the basement.

To cover the heat needs of the industrial areas in winter as well as for the production of DHW of the whole building a 220kW biomass boiler fed with pellets and kindling wood will be used. For the boiler there will be power modulation from25% to 100% so as to adapt the installation to a changing power demand for partial loads with no problem, avoiding thus unnecessary stops/starts of the installation and achieving then simultaneously lower energy consumption and a longer useful life.

Apart from that there will be an intermediate inertial tank for the biomass boiler to guarantee a constant flow through the boiler and a better performance when the installation starts working. As for the geothermal system there will be a dedicated technical room located on the basement for this installation, containing the biomass boiler as well as the 3500l inertial storage tank.

From the collectors located on the technical rooms depart distribution circuits to each terminal unit which have been grouped according to the characteristics of consumptions, to create the zoning of the building.

- Industrial areas circuits: these circuits feed the air conditioning units located on the roof of each of the industrial areas and the offices, to heat and ventilate these areas.
- Offices circuit: to feed the radiant floor both for heating and cooling installed in these areas.
- DHW Circuit: To cover the domestic hot water needs of the building.

The **air conditioning of the industrial areas** will be done by air units. Each industrial area will have one AHU except the Ind. Area 1, which for its dimensions have two units. Each equipment is located on the roof of the building, driving the air through circular ducts and making the air diffusion through thermoregulable nozzles which are oriented depending on air temperature. The air conditioning units of the industrial areas have adequate filters, free cooling, adiabatic humidification, cold (pre-installed) and heat batteries.

The **air conditioning in the offices** is through radiant floor, heating to heat and cool to cold. In a system of this type heat is uniform and pleasant whenever is maintained a suitable soil surface temperature, because it produces no airflows and is completely silent. Is achieved a feeling of comfort and well-being leading to significant energy savings. Each radiant floor circuit is regulated by the temperature sensor of each room. The areas have been defined according to their orientation.

To ensure the required ventilation within the offices is installed an air conditioning unit equipped with hot and cold battery, free cooling, mixing box, energy recovery, adiabatic cooling, filters, and desiccant systems preinstallation. Both the AHU and the ductwork is sized to complement the installation of radiant floor both for heating and cooling covering a percentage of the thermal needs of each office area.

In addition for **the room of DPC** (data processing center) will be installed an air handling unit with condensation control, humidity control, filtration and temperature control, with nominal power of 5kW to cover the required indoor conditions of 18 ° C.

The **heat production for DHW** will be obtained through the biomass boiler. The installation system for domestic hot water is designed by accumulation, with automatic regulation system, and will have a thermostatic valve for its distribution.

The facility for DHW is intended to heat the water on the general distribution network at temperatures suitable for consumption. It controls water features, such as flow, temperature and hygienic quality.

HVAC CARTIF 3			
Generation		*Mode*	*Location*
GEOTHERMAL Heat Pump	RADIANT FLOOR	**HEAT**	OFFICES
	RADIANT FLOOR	**COOL**	CORRIDORS
	AHU in office	**COOL**	OFFICES
			CORRIDORS
BIOMASS Boiler	DHW	**HEAT**	All CARTIF
	AHU (Climate Unit)	**HEAT**	Industrial Area 1
			Industrial Area 2
			Industrial Area 3
			Industrial Area 4
			Industrial Area 5
			Industrial Area 6
			OFFICES
			CORRIDORS
Freecooling	AHU (Climate Unit)	**COOL**	Industrial Area 1
			Industrial Area 2
			Industrial Area 3
			Industrial Area 4
			Industrial Area 5
			Industrial Area 6
			OFFICES
			CORRIDORS

Figure 2: HVAC in CARTIF III

Electrical energy is used for the air handling units (AHU), lighting and as auxiliary energy for plants and other building services. Figure 4 give a schematic overview of installed devices at CARTIF building and their energy fluxes.

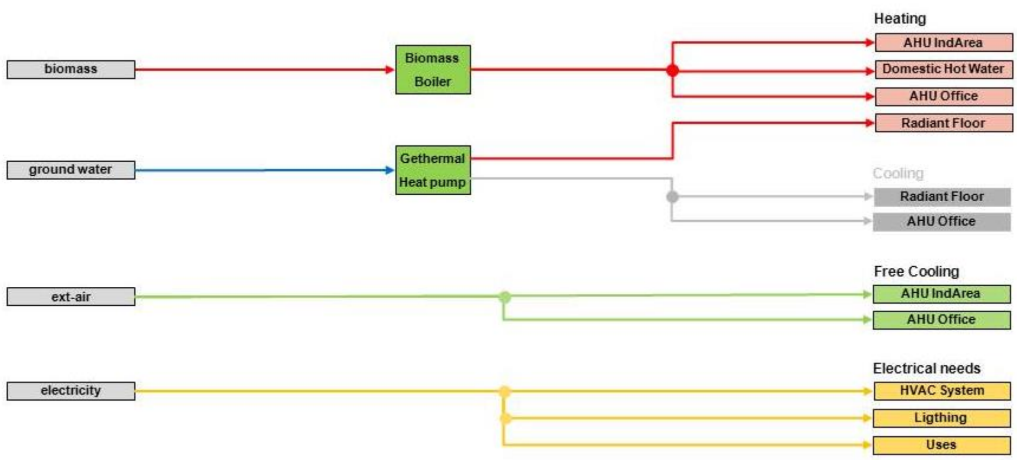


Figure 3: Energy fluxes winter

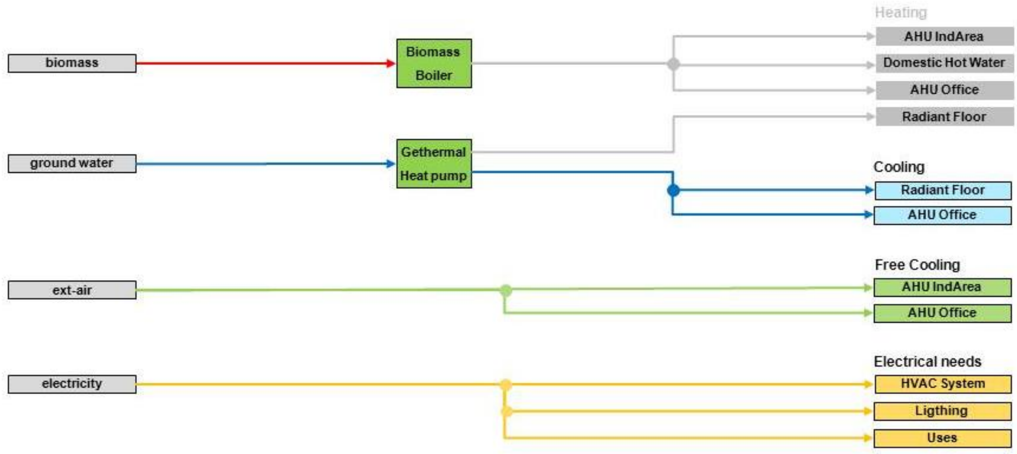
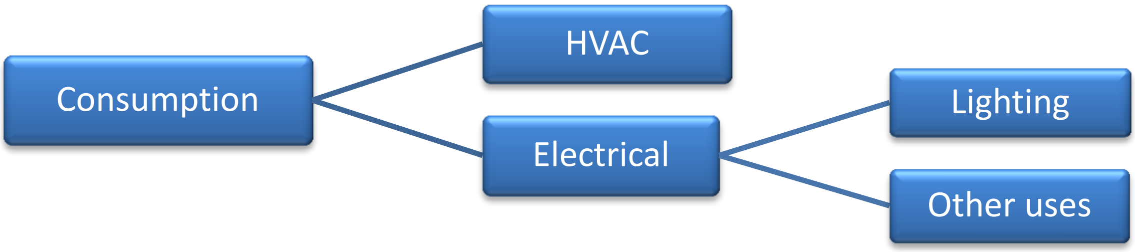


Figure 4: Energy fluxes summer

Basing on these schemes the positioning of needed meters and counters has to be defined in order to provide the building with a complete balance of energy, which can be later compared with calculated values, in this way we will know if we are approaching the main objective of the project which is to ensure a maximum annual consumption of 60 kWh/m^{2}yr.

3 Energy metering sensors selection

To facilitate the understanding of this point, we have decided to make a distinction between HVAC consumption and electrical consumption; the electrical consumption is divided between lighting consumption and other applications.



HVAC Consumption

Figure 5: KAMSTRUP Multical 602

Table 1 shows each heating and cooling counter will be installed in the building.

These calorimeters are composed of an ultrasonic flowmeter and two temperature probes. The model used is the KAMSTRUP MULTICAL 602, in which it is possible to add temperature probes or KAMSTRUP 62 model with characteristics similar to the previous, but without temperature probes. These devices are integrated within the network of control of the building, since it has a Lonworks communication interface.

Currently installed 3 calorimeters (named with Kx in the flow diagram scheme Figure 6), which are responsible for measuring the flow of water circulating through the pipe.

Flow meters are accompanied by temperature probes in impulsion and the return, for we can calculate the energy consumption through the pipe.

Table 1 shows each flow meters and the model that will be installed in CARTIF 3 building.

K1	**Heat tank**	**Kamstrup 601 (2 Tmp. Sensor)**
K2	Inlet geothermal heat pump	**Kamstrup 601 (2 Tmp. Sensor)**
K3	Geothermal tank	**Kamstrup 601 (2 Tmp. Sensor)**
H1	Outlet biomass boiler	**Kamstrup 62**

H2	Outlet geothermal heat pump	**Kamstrup 62**
H3	Inlet DHW tank	**Kamstrup 62**
H4	AHU Industrial Area 1A for heating	**Kamstrup 602 (1 Tmp. Sensor)**
H5	AHU Industrial Area 1B for heating	**Kamstrup 62**
H6	AHU Industrial Area 3 for heating	**Kamstrup 602 (1 Tmp. Sensor)**
H7	AHU Industrial Area 4 for heating	**Kamstrup 602 (1 Tmp. Sensor)**
H8	AHU Industrial Area 4Sup for heating	**Kamstrup 602 (1 Tmp. Sensor)**
H9	AHU Industrial Area 2 for heating	**Kamstrup 602 (1 Tmp. Sensor)**
H10	AHU Industrial Area 2Sup for heating	**Kamstrup 602 (1 Tmp. Sensor)**
H11	AHU for Heat in Office for heating	**Kamstrup 62**
H12	AHU for Cool in Office for cooling	**Kamstrup 62**
H13	Outlet DHW tank	**Kamstrup 602 (2 Tmp. Sensor)**
H14	Outlet geothermal tank for radiant floor for heating and cooling	**Kamstrup 62**

Table 1: Calorimeters list in CARTIF 3

Figure 6 shows a schematic HVAC metering of the CARTIF 3 building, in this diagram you can see each generation systems that it have the building, as well as each of the meters which are placed in it, calorimeters or electrical meters. This diagram also shows the different applications that have generation systems, for example: for heating, cooling and domestic hot water.

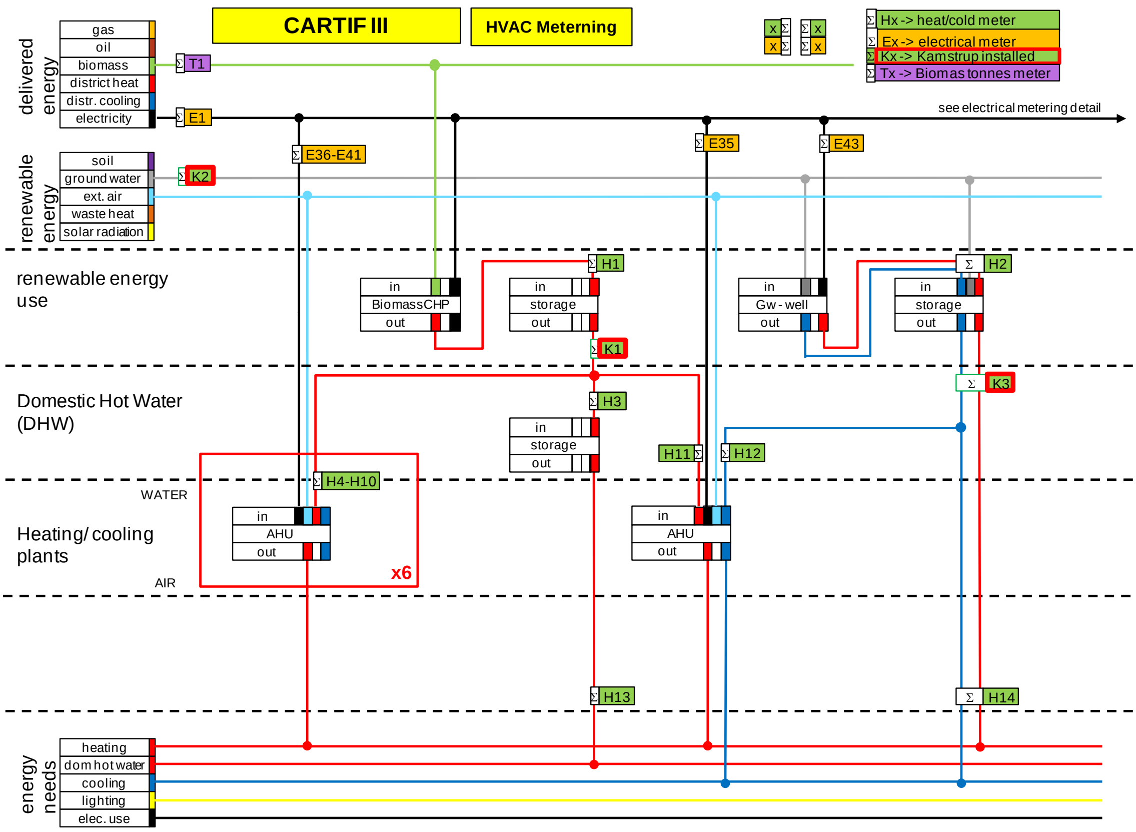


Figure 6 : HVAC Flow diagram scheme

Figure 7 shows the thermal plant and instrumentation that are installed in the building and we have detailed in the preceding paragraphs.

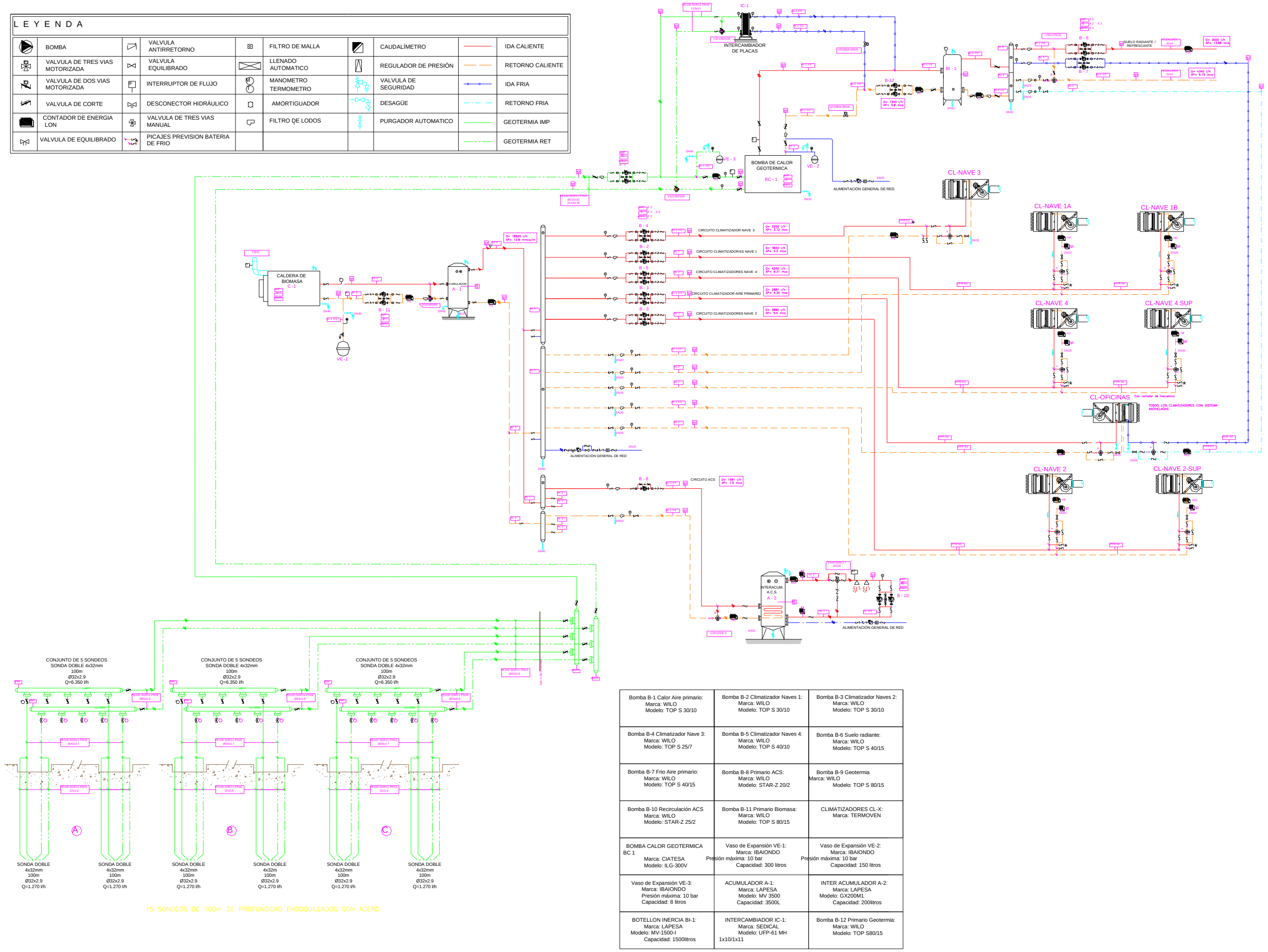


Figure 7: General installation scheme HVAC system

ELECTRICAL Consumption

Currently we are measuring the electrical consumption in the main cabinets of the building. The measured electrical circuits are as follows:

Entire Building	**E01**	**Micrologic NSX630**
Basement Cabinet	**E02**	**Micrologic NSX100-250**
Industrial Area 4 inf. Cabinet	**E03**	**Micrologic NSX100-250**
Industrial Area 2 inf. Cabinet	**E04**	**Micrologic NSX160**
Geothermal Room Cabinet	**E05**	**Micrologic NSX100-250**
Main Floor Cabinet	**E06**	**Micrologic NSX100**
First Floor Cabinet	**E07**	**Micrologic NSX100-250**
Industrial Area 1A. Cabinet	**E08**	**Micrologic NSX160**
Industrial Area 1B. Cabinet	**E09**	**Micrologic NSX160**
Industrial Area 4 Sup. Cabinet	**E10**	**Micrologic NSX100**
Industrial Area 3. Cabinet	**E11**	**Micrologic NSX160**
Industrial Area 2 sup. Cabinet	**E12**	**Micrologic NSX100-250**
Condensator Battery	**E13**	**Micrologic NSX630**
Second Floor Cabinet	**E14**	**Micrologic NSX100-250**
HVAC Cabient	**E15**	**Micrologic NSX100**
Biomass Room Cabinet	**E16**	**Micrologic NSX100-250**
Electric Generator. Cabinet	**E17**	**Micrologic NSX100-250**

Table 2: Electrical meters installed in CARTIF3

The equipment used to realise the measurements are:

- **Schneider Electric Compact NSX:** Automatic circuit breaker which has functions of integrated measurement and visualization features. The communication of these devices is done by an integrated control units called Micrologic , the control signal is transmitted in MODBUS RTU.

Figure 8: Electrical meter location. Compact NSX installed in CARTIF3

- **EGX300**: is an integrated gateway Ethernet which collects the MODBUS RTU signals and converts to MODBUS TCP, likewise, this gateway provides readings in real time measuring of Schneider Electric equipment connected to it and access to historical data stored in its internal memory through any web browser compatible, without the need for any additional software. It offers the possibility to select the logging interval, select variables to insert (up to 12) and automatically send the values reported by email or by FTP to perform a detailed analysis of these.
- **TAC XENTA 913**: The TAC Xenta 913 is a cost-effective way to integrate a large variety of products into a TAC network. The TAC Xenta 913 supports the most commonly-used open protocols, like Modbus, BACnet and LonWorks. It also supports some manufacturer-specific protocols, like I/NET and Clipsal C-bus. The TAC Xenta 913 acts

as a gateway and transfers data point values from one network to another. In our case we have made communication between the TCP/IP and Lonworks Protocol. XENTA 913 acts as a gateway and transfers the data from a network to another and viceversa.

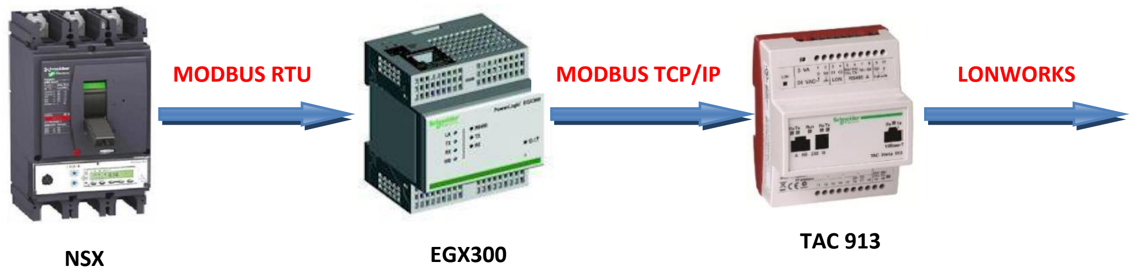


Figure 9: Connection scheme between devices for measuring electrical consumption

The types of variables collected by the group of equipment described above are as follows:

Voltage
Voltage Unbalance
Current
Current Unbalance
Active Power
Reactive Power
Apparent Power
Power Factor
Fundamental Power Factor (cosφ)
Frequency
Fundamental Reactive Power
Distortion Power
Total Harmonic Distortion (THD)
Active energy
Active energy

Active energy
Current demand
Active Power Demand
Reactive Power Demand
Apparent Power Demand

Table 3: List of variables gathered from Compact NSX

During the development of this project has been decided, in addition to the circuit shown in Table 1, to measure the electric circuits of lighting and electrical consumptions in the air handling units of the building, these variables that will show in the Table 4**¡Error! No se encuentra el origen de la referencia.**.

To know the consumption of each of the study areas, we have two options:

a) **MEASURED**: place a wattmeter for each electrical panel and a clip of measurement for each of the circuits to be measured. The wattmeter used are:

NICO8108L:
Nico 8108L is a single phase power meter. Multi-channel energy metering equipment and is used to measure power consumption
High-integration design and LON interface enables you to network with various devices.
8 channel single phase meter

Figure 10: NICO 8108L

NICO8404L: is a multiphase (3 phase) multi-channel power meter and is used to measure power consumption including active energy, active power, voltage, current, power factor and line frequency. 4 channel, 3 phase, 4 wires

Figure 11: NICO 8404L

The variables that we can register with these devices are as follows:

Voltage
Current
Frecuency
Active Power
Active energy
Power factor

Table 4: List of variables collected by NICO wattmeter

These power meters will be represented in the flow diagram scheme with a green box

b) **ESTIMATED**: by estimate real according to the hours of operation and consumption of luminaires, both parameters are known. It has to verify the correct estimate by comparison with areas where there is placed a wattmeter

GHP Room Cabinet	**E43**	Circuit 1	Geothermal Heat pump	Measured
Basement Cabinet	**E18**	Circuit 1	Lighting Industrial Area 2	Measured
	E19	Circuit 2	Lighting toilets	
	E20	Circuit 3	Lighting garage	
	E21	Circuit 6	Lighting Industrial Area 4	
Main Floor Cabinet	**E23**	Circuit 1	Lighting Industrial Area 1A	**Measured**
	E24	Circuit 2	Lighting Industrial Area 1B	
	E25	Circuit 3	Lighting Industrial Area 3	
	E26	Circuit 4	Lighting Office and other uses	
First Floor Cabinet	**E27**	Circuit 1	Lighting Industrial Area 4Sup	**Measured**
	E28	Circuit 2	Lighting Industrial Area 2Sup	
	E29	Circuit 3	Ligting Office Area	
Second Floor Cabinet	**E30**	Circuit 1	Lighting other circuits	**Measured**
	E31	Circuit 2	Lighting Office Area	
	E32	Circuit 3	Lighting Managers Office	
Industrial Area2 Cabinet	**E22**	Circuit 1	Lighting ATEX	**Estimated**

Electric Generator Cabinet	**E33**	Circuit 3	Lighting Corridor/Biomass	Estimated
	E34	Circuit 4	Lighting Garage	
HVAC Cabinet	**E36**	Circuit 1	Electrical AHU 1	Measured
	E37	Circuit 2	Electrical AHU 2Inf	
	E38	Circuit 3	Electrical AHU 2Sup	
	E39	Circuit 4	Electrical AHU 3	
	E40	Circuit 5	Electrical AHU 4Inf	
	E41	Circuit 6	Electrical AHU 4Sup	
	E35	Circuit 7	Electrical AHU Office	
	E42	Circuit1	Photovoltaic plant	

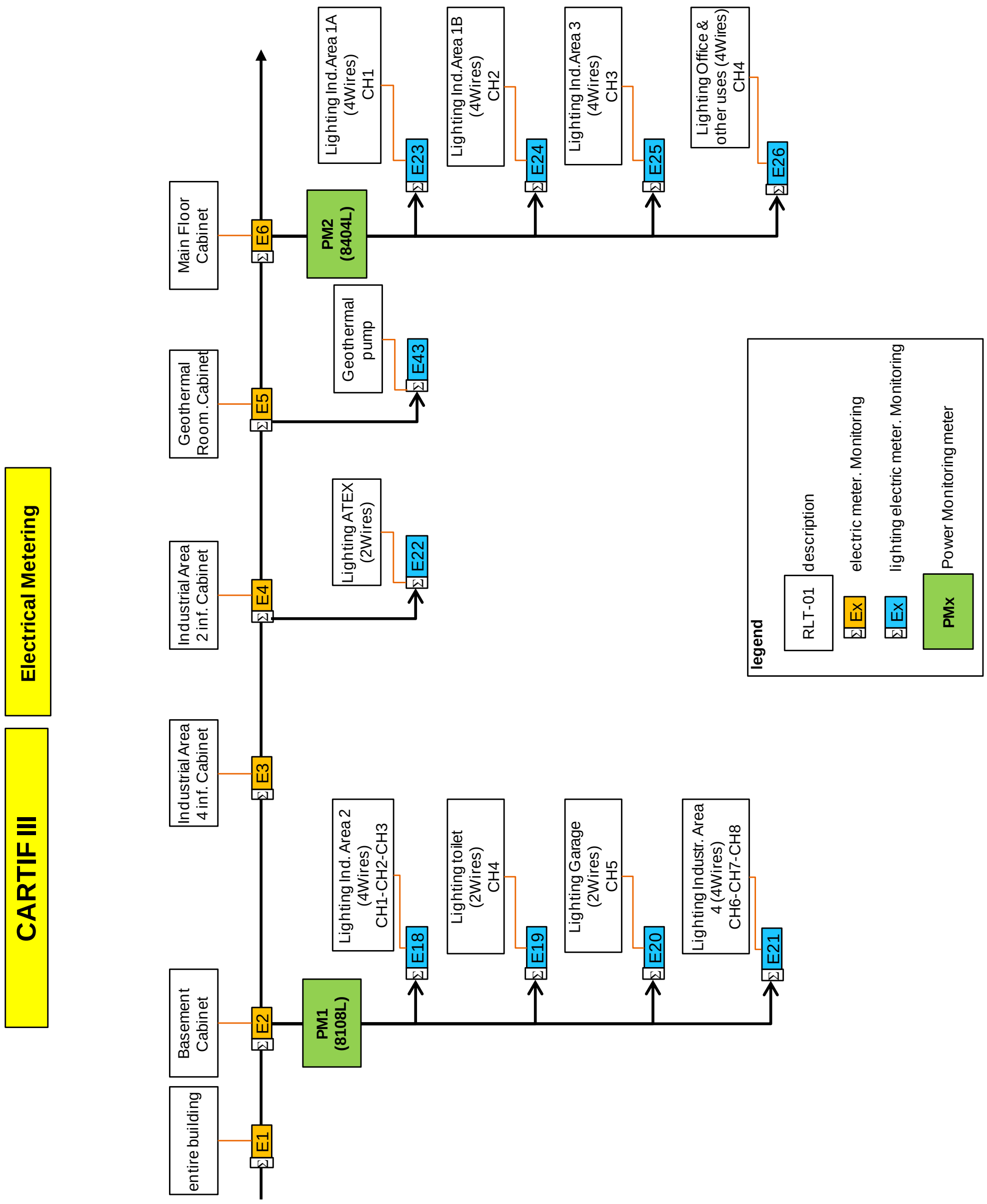
Table 5: List of electrical circuits that will be registered in CARTIF3

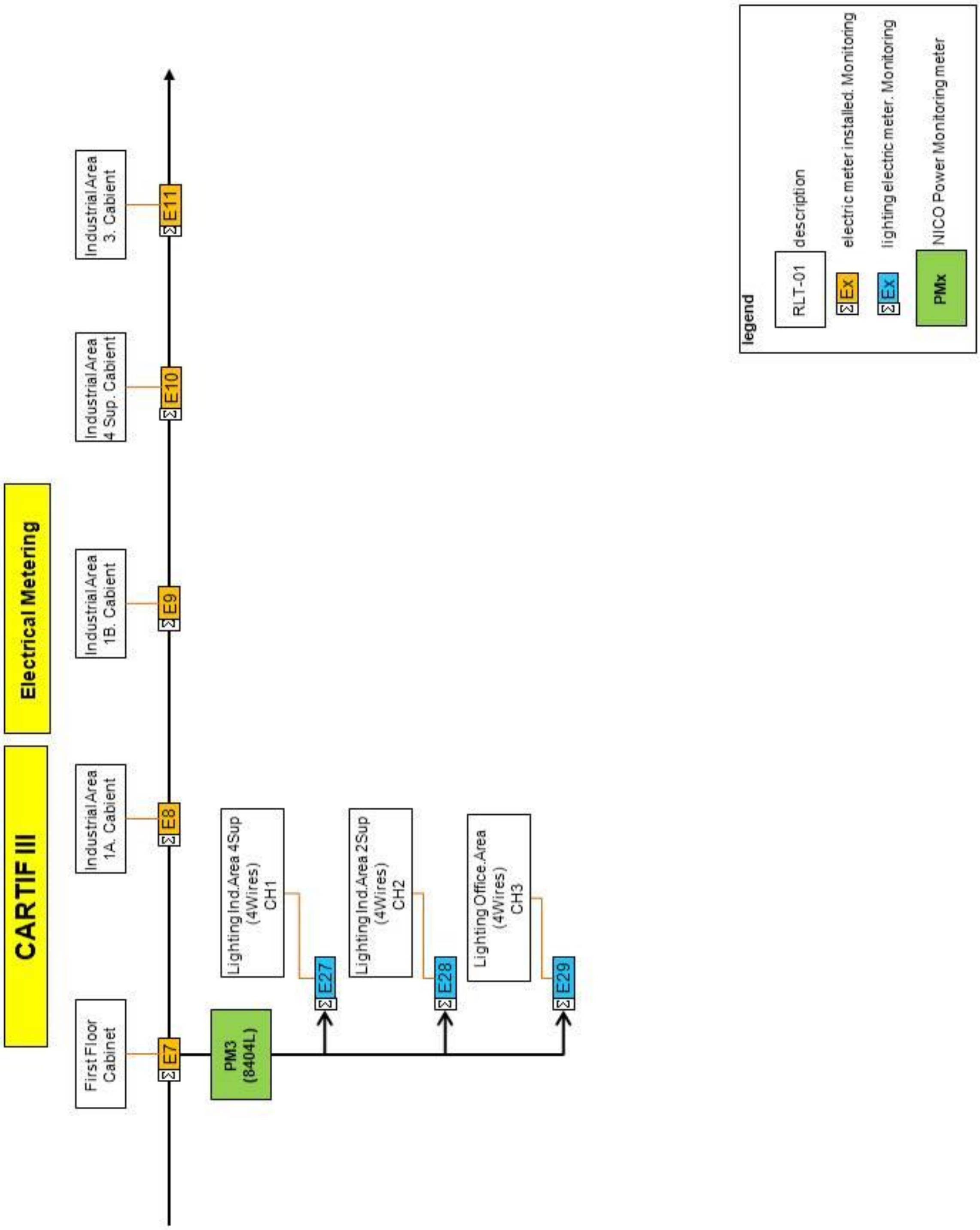
The following diagrams show clearly and schematic each meter that we can see in the Table 2 and in the Table 5, thus we can know each of the measured points in the building, as well as each of the equipment used for this purpose.

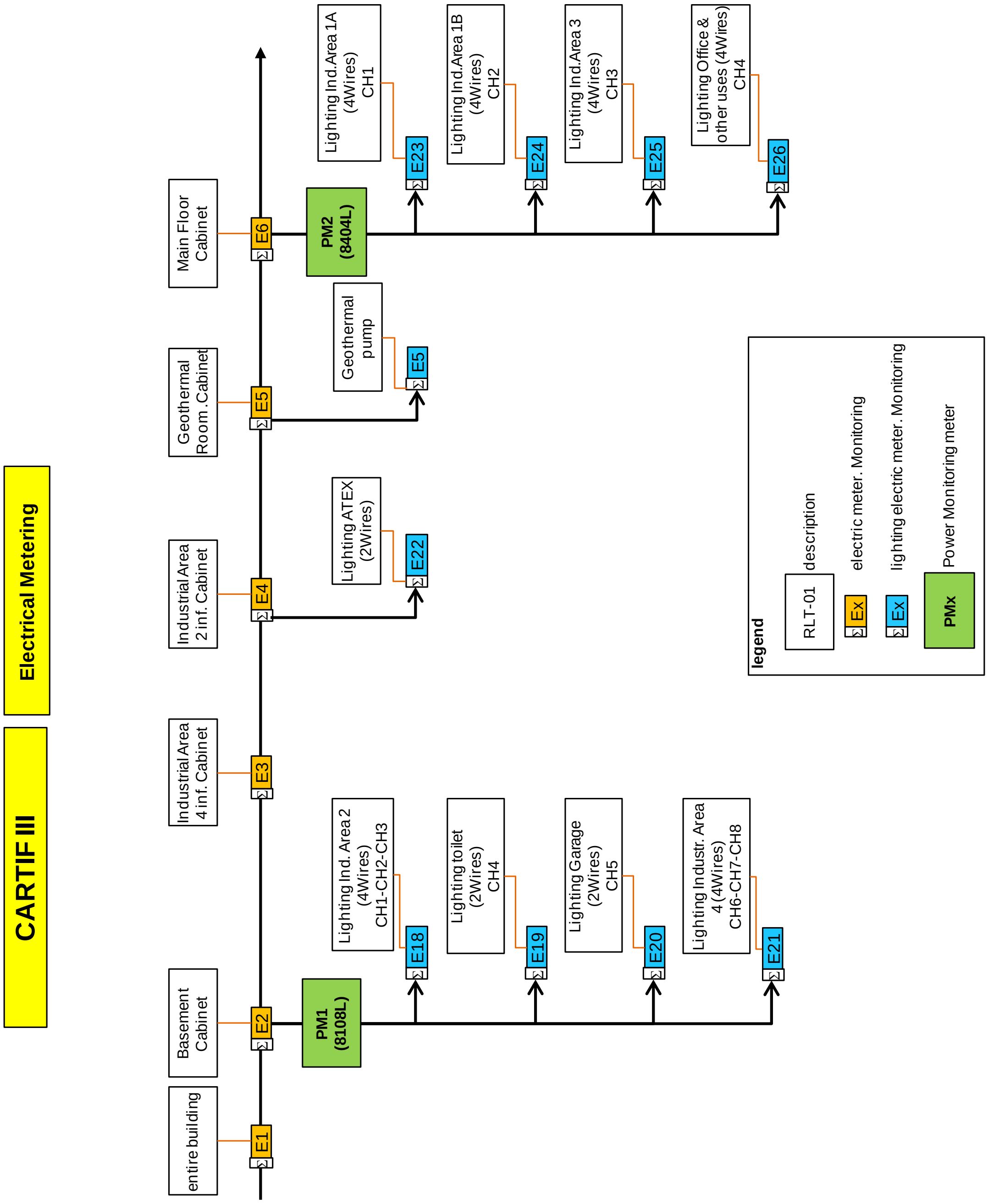
In the next figures, on the one hand the yellow boxes represent the location of counters that measure the consumption of the General Electric cabinets in the building, These electrical cabinets measure consumption in lighting, HVAC and conventional uses, the devices use are Schneider Electric Compact NSX , which previously have been mentioned. On the other hand in the diagram we have blue boxes, representing the points where we will measure lighting consumption of the building, the green box indicate modules that they will be measured through wattmeter NICO 8108 L (single-phase) or NICO 8104 (three-phase) and the meters that do not go since green box indicate that these points will be estimated. In addition to this in the diagram is indicated if the measure is (2-wire) single-phase or three phase (3 or 4 wires) and the number of channels of the wattmeter used to measure.

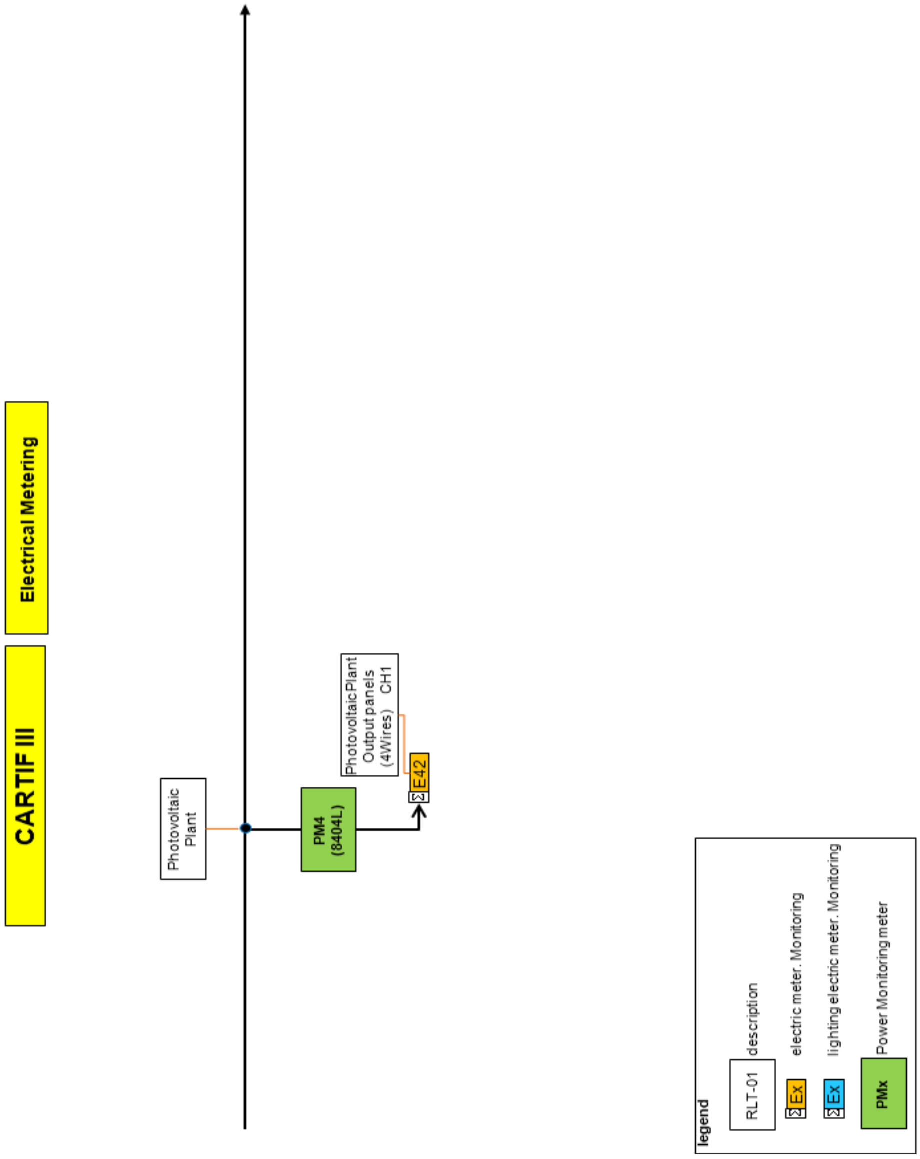
If you want to know the power consumption of the auxiliary equipments (mainly pumps) which are used in the HVAC system, we should know the consumption of geothermal room with E43 meter and biomass room with the E16 meter, both of them can be seen in Table 2.

At the end there are the electric schemes of each cabinet.


CARTIF III
Electrical Metering
entire building
Basement Cabinet
Industrial Area 4 inf. Cabinet
Industrial Area 2 inf. Cabinet
Geothermal Room. Cabinet
Main Floor Cabinet
E1
E2
E3
E4
E5
E6
PM1 (8108L)
PM2 (8404L)
Lighting Ind. Area 2 (4Wires) CH1-CH2-CH3
Lighting toilet (2Wires) CH4
Lighting Garage (2Wires) CH5
Lighting Industr. Area 4 (4Wires) CH6-CH7-CH8
E18
E19
E20
E21
Lighting ATEX (2Wires)
E22
Geothermal pump
E43
Lighting Ind. Area 1A (4Wires) CH1
Lighting Ind. Area 1B (4Wires) CH2
Lighting Ind. Area 3 (4Wires) CH3
Lighting Office & other uses (4Wires) CH4
E23
E24
E25
E26
legend
RLT-01 description
Ex electric meter. Monitoring
Ex lighting electric meter. Monitoring
PMx Power Monitoring meter


CARTIF III
Electrical Metering
First Floor Cabinet
E7
Industrial Area 1A. Cabient
E8
Industrial Area 1B. Cabient
E9
Industrial Area 4 Sup. Cabient
E10
Industrial Area 3. Cabient
E11
PM3 (8404L)
Lighting Ind.Area 4Sup (4Wires) CH1
E27
Lighting Ind.Area 2Sup (4Wires) CH2
E28
Lighting Office.Area (4Wires) CH3
E29
legend
RLT-01
description
Ex
electric meter installed. Monitoring
Ex
lighting electric meter. Monitoring
PMx
NICO Power Monitoring meter


CARTIF III
Electrical Metering
entire building
E1
Basement Cabinet
E2
PM1 (8108L)
Industrial Area 4 inf. Cabinet
E3
Industrial Area 2 inf. Cabinet
E4
Geothermal Room.Cabinet
E5
Main Floor Cabinet
E6
PM2 (8404L)
Lighting Ind. Area 2 (4Wires) CH1-CH2-CH3
E18
Lighting toilet (2Wires) CH4
E19
Lighting Garage (2Wires) CH5
E20
Lighting Industr. Area 4 (4Wires) CH6-CH7-CH8
E21
Lighting ATEX (2Wires)
E22
Geothermal pump
E5
Lighting Ind.Area 1A (4Wires) CH1
E23
Lighting Ind.Area 1B (4Wires) CH2
E24
Lighting Ind.Area 3 (4Wires) CH3
E25
Lighting Office & other uses (4Wires) CH4
E26
legend
RLT-01 description
Ex electric meter. Monitoring
Ex lighting electric meter. Monitoring
PMx Power Monitoring meter


CARTIF III
Electrical Metering
Photovoltaic Plant
PM4 (8404L)
E42
Photovoltaic Plant Output panels (4Wires) CH1
legend
RLT-01
description
Ex
electric meter. Monitoring
Ex
lighting electric meter. Monitoring
PMx
Power Monitoring meter

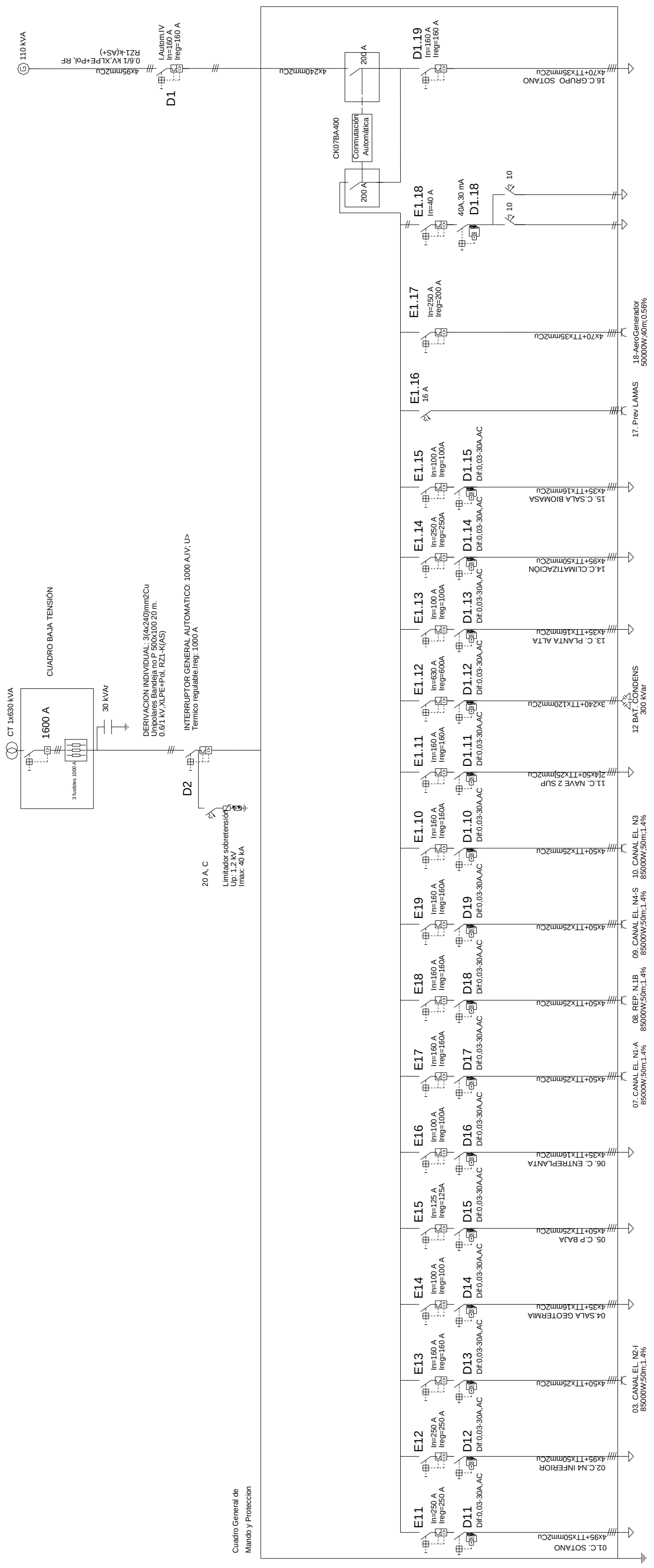


Figure 12: General cabinet

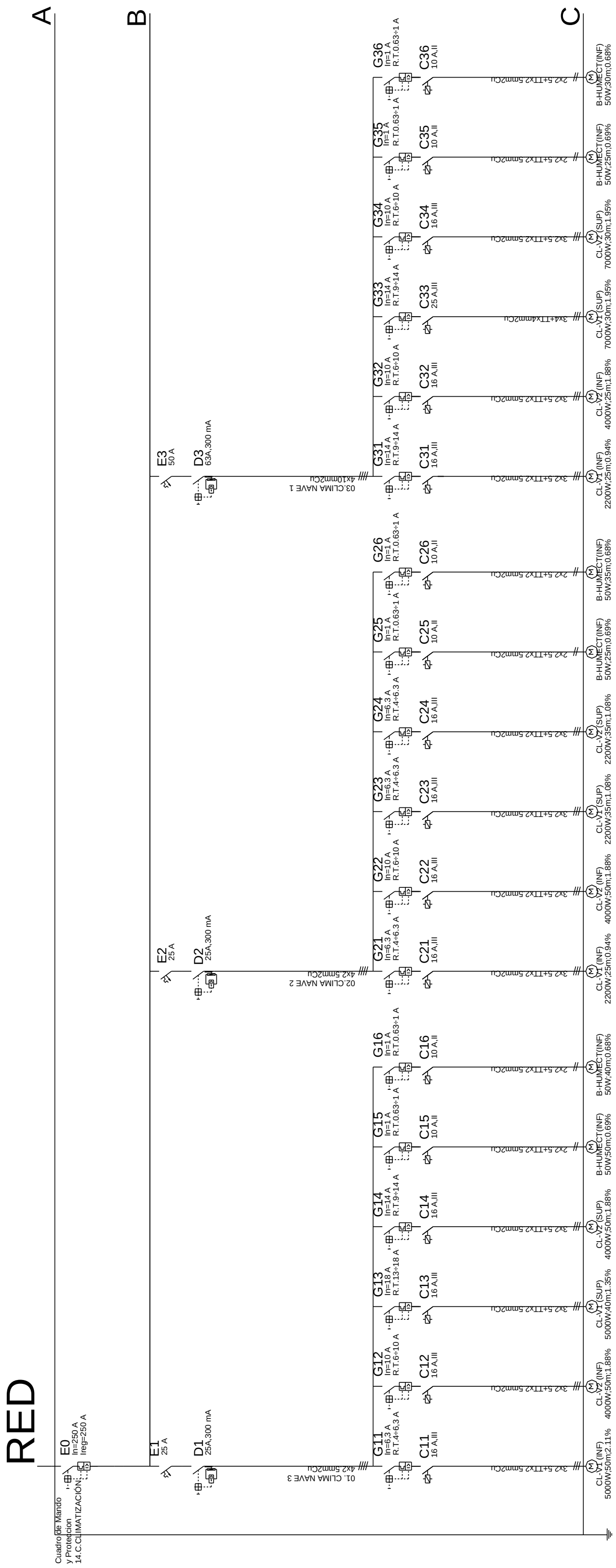


Figure 13: HVAC cabinet1

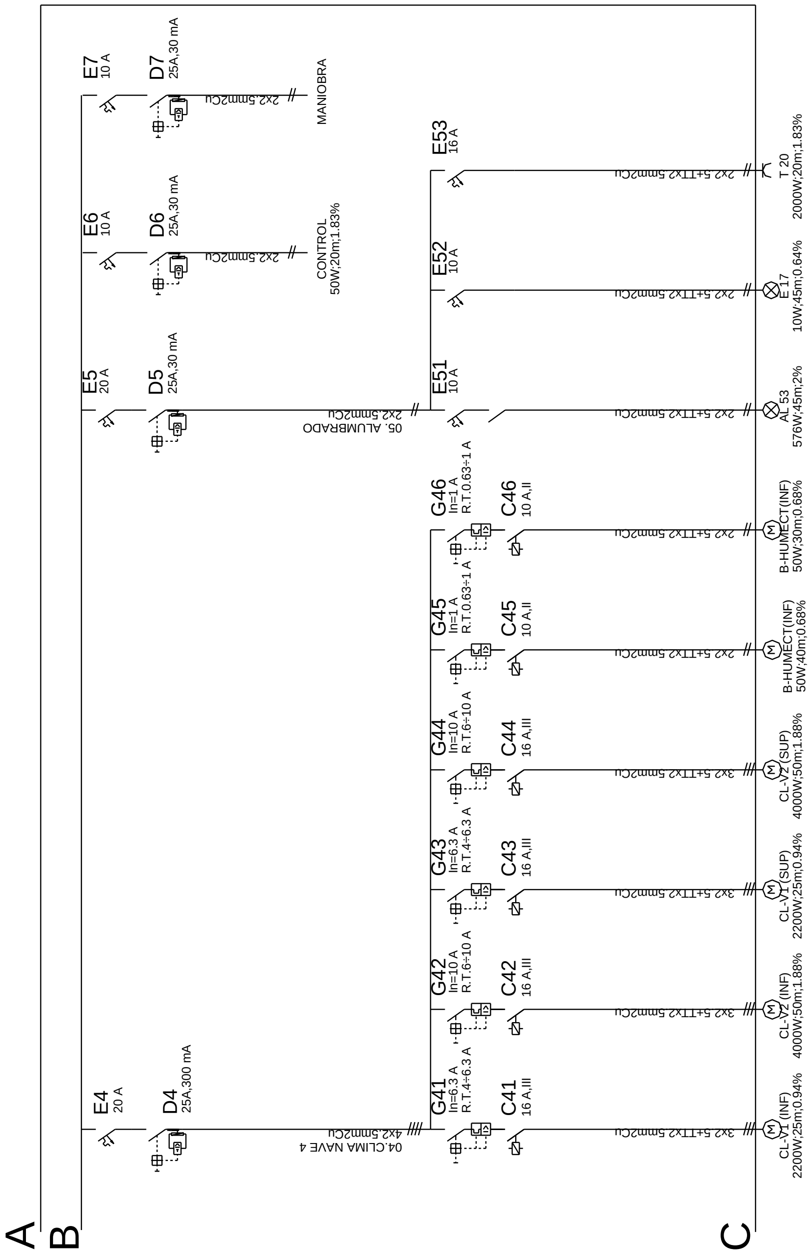


Figure 14: HVAC cabinet2

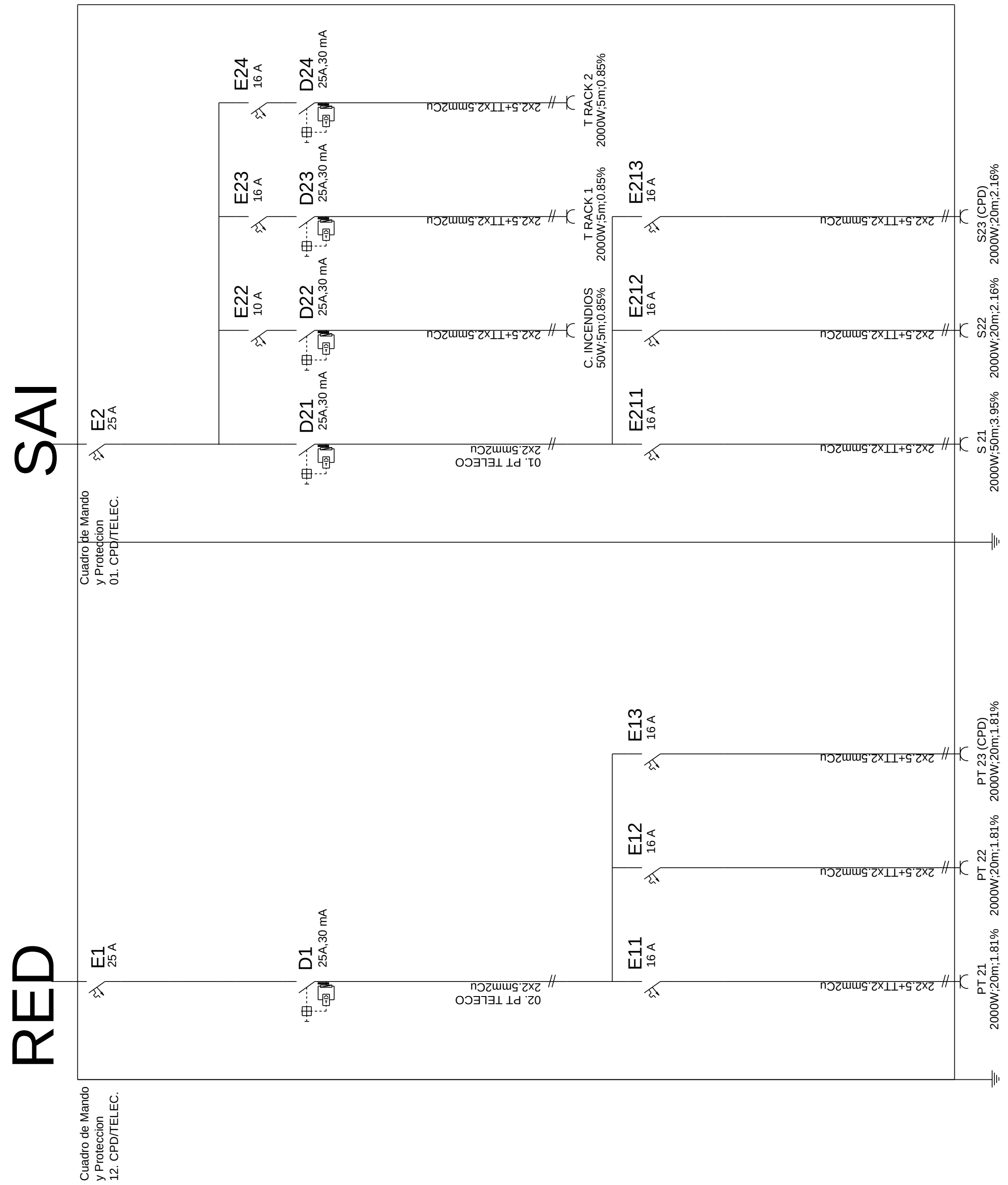


Figure 15: CPD cabinet

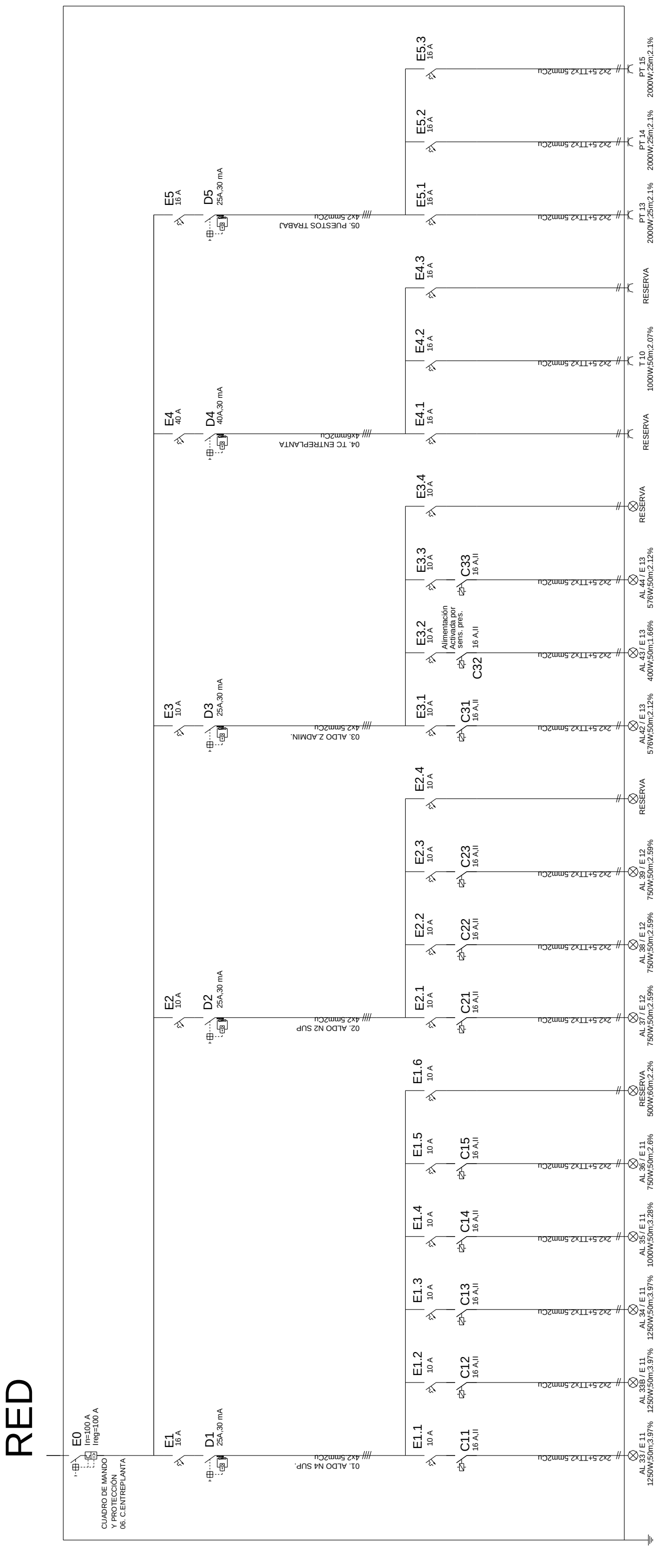


Figure 16: First Floor cabinet

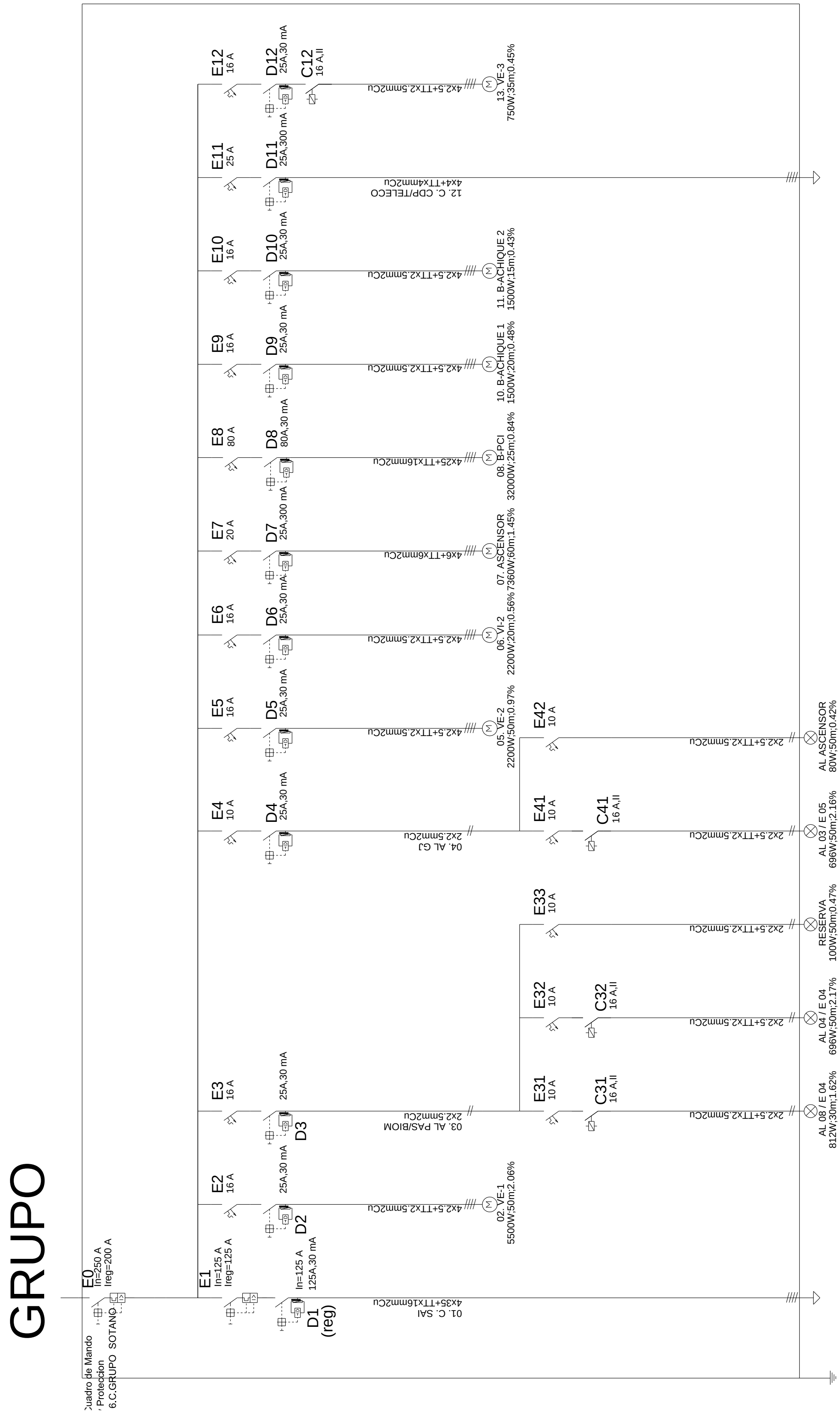


Figure 17: Electric Generator cabinet

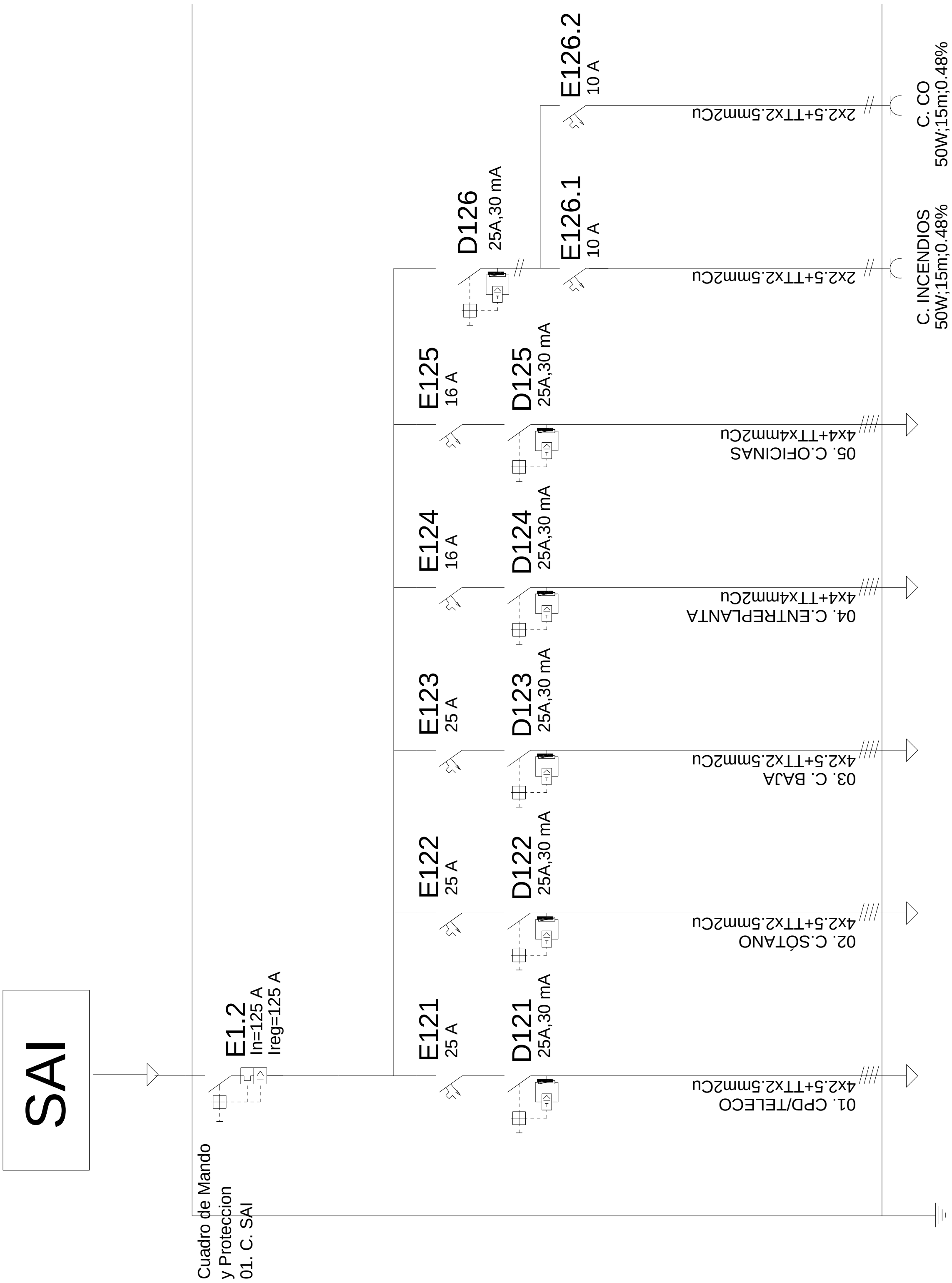


Figure 18: SAI cabinet

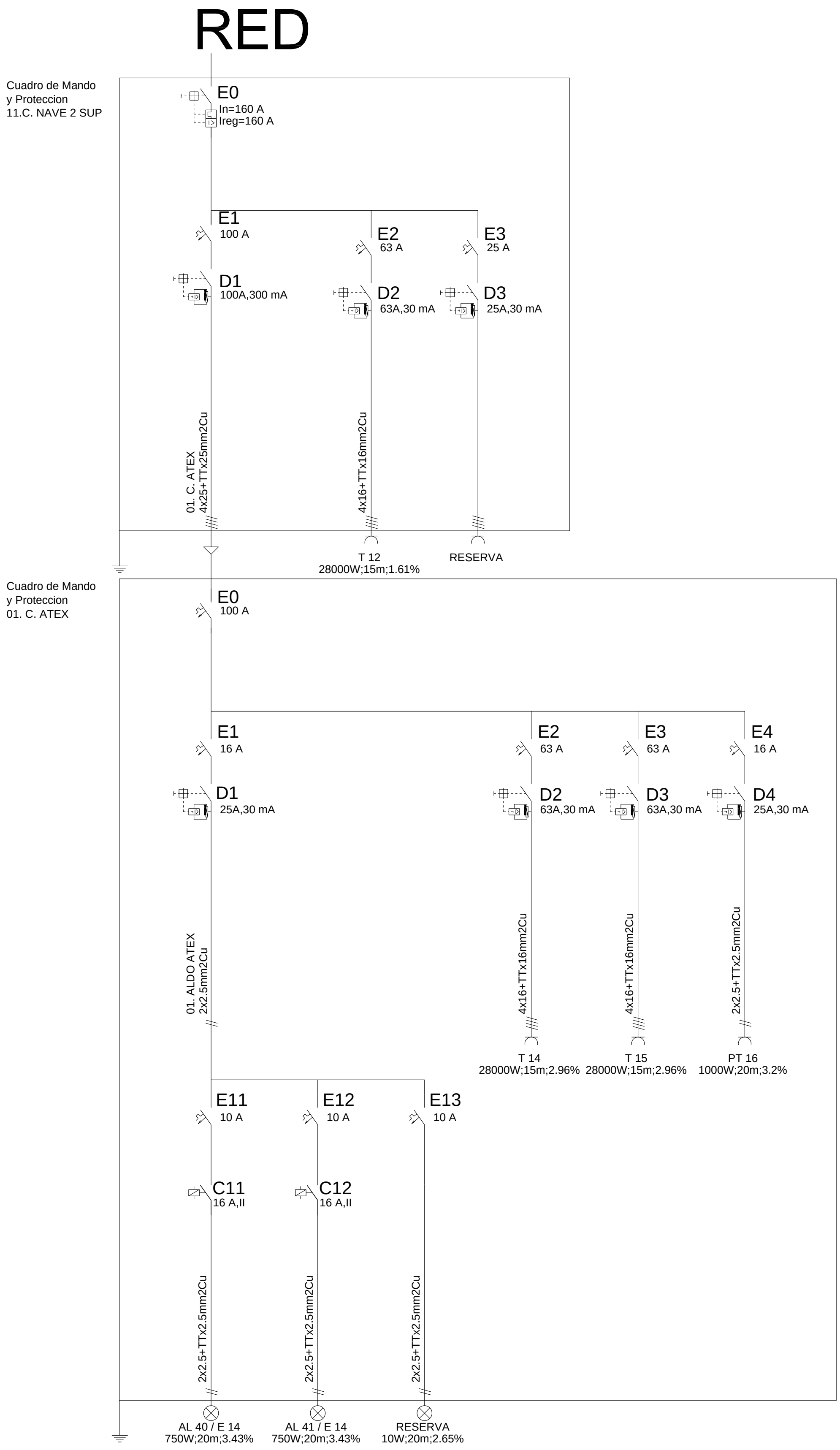


Figure 19: ATEX cabinet

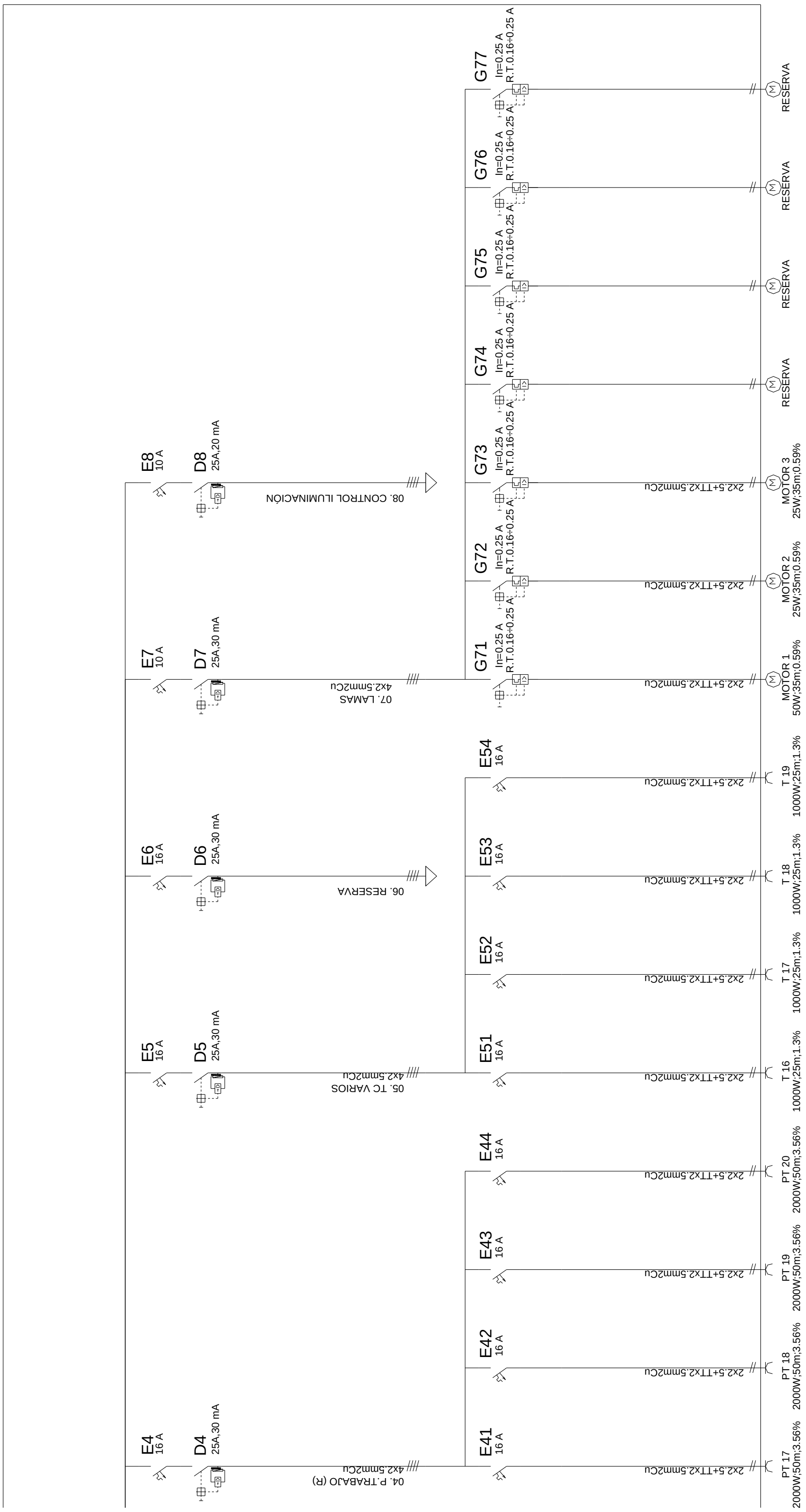


Figure 20: First Floor cabinet 1

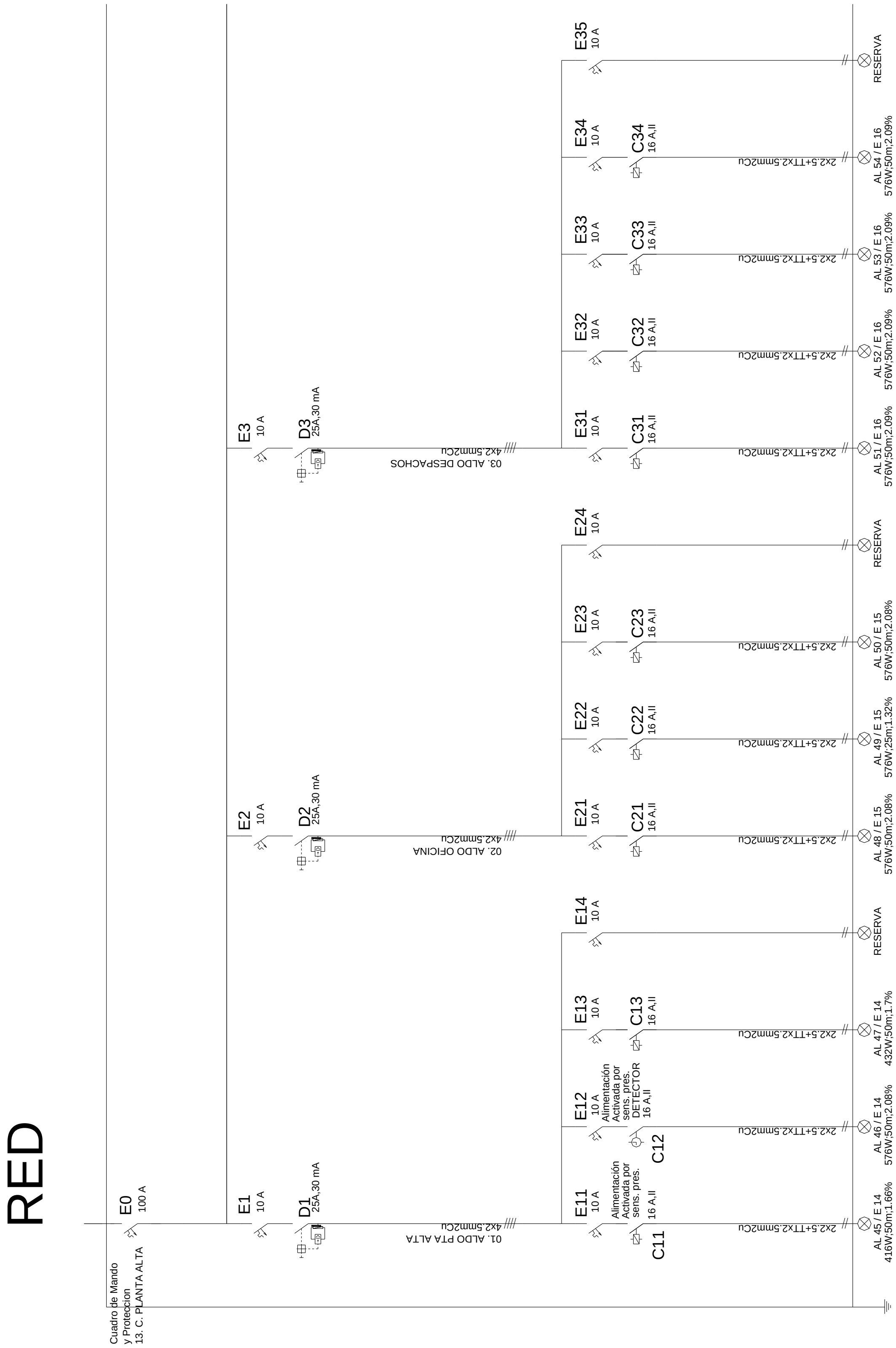


Figure 21: First Floor cabinet 2

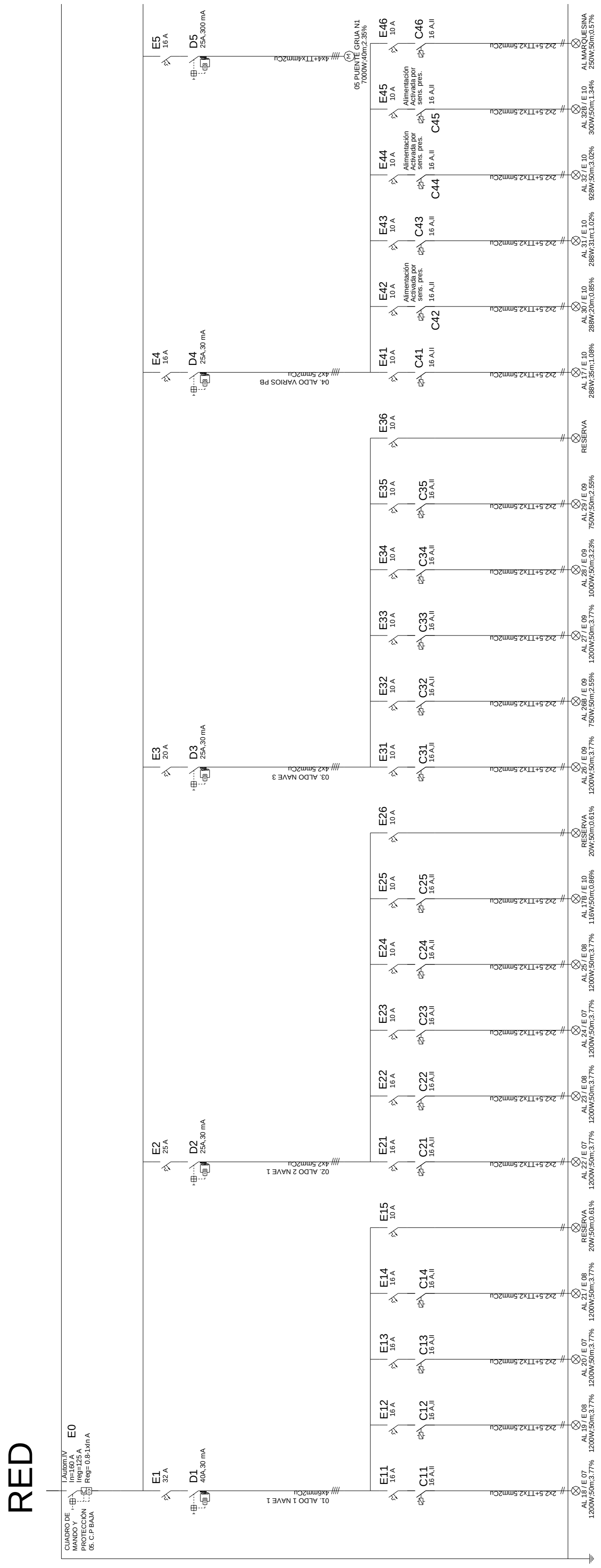


Figure 22: Main Floor cabinet 1

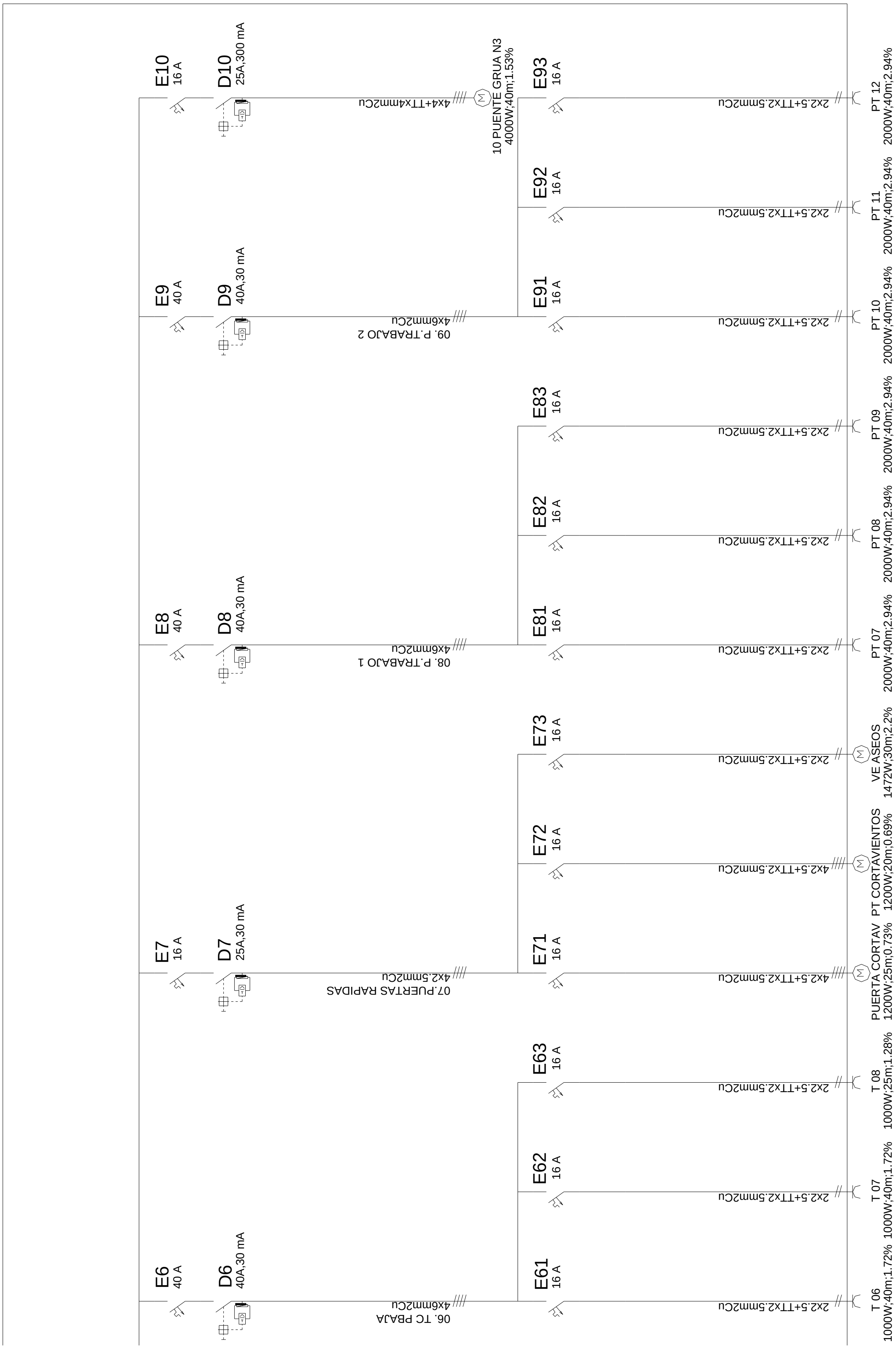


Figure 23: Main Floor cabinet 2

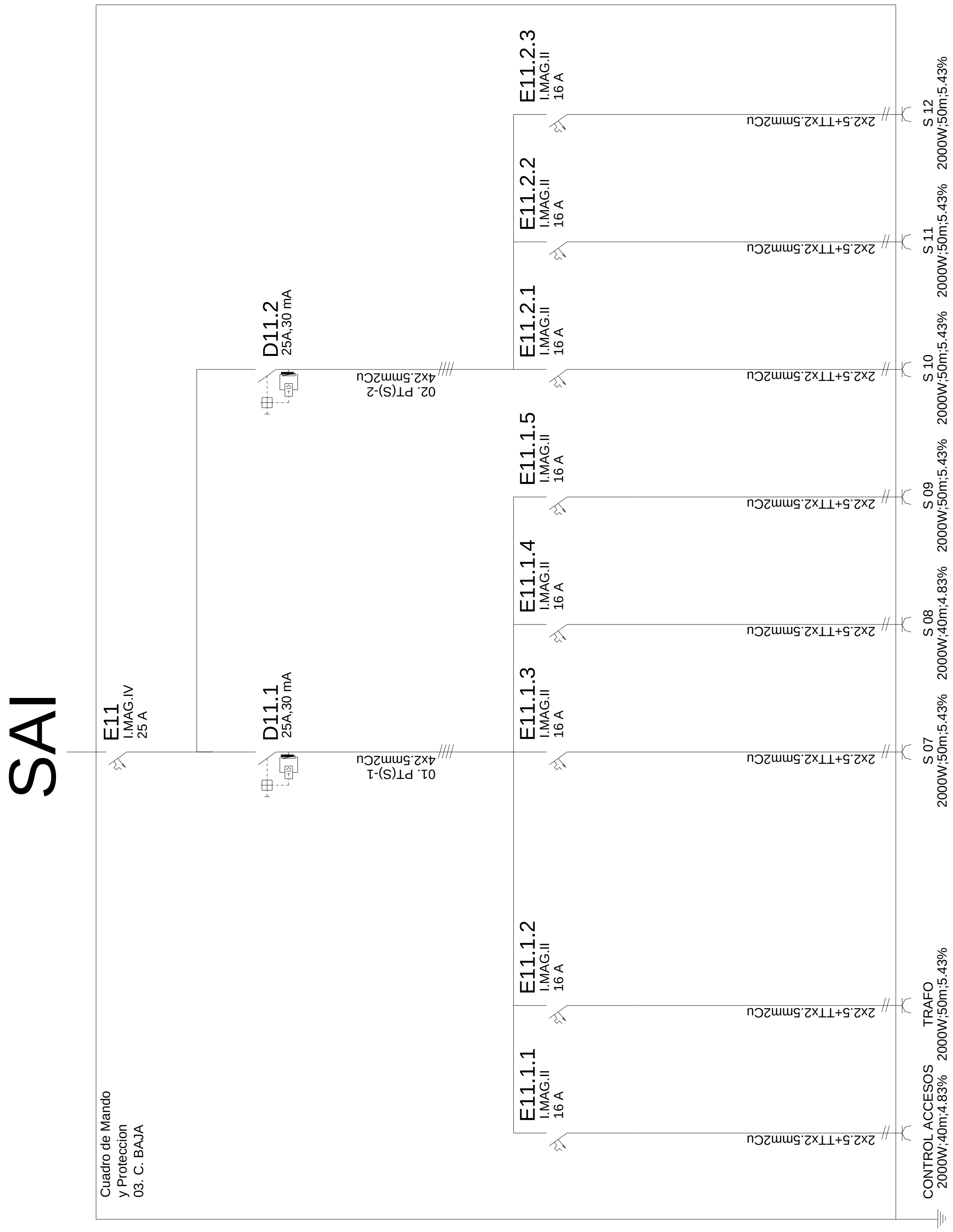


Figure 24: Main Floor cabinet 3

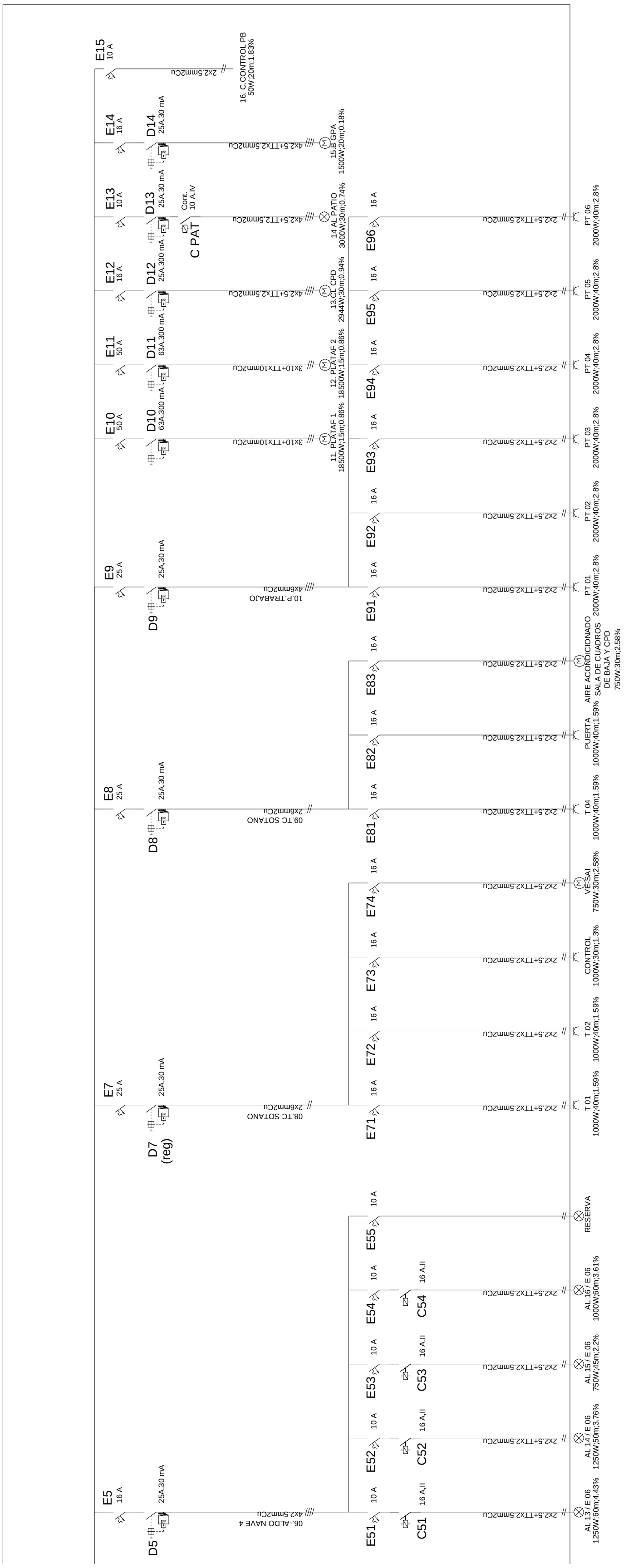

E15
E14
E13
E12
E11
E10
E9
E8
E7
E5
D14
D13
D12
D11
D10
D9
D8
D7
(reg)
D5
C PAT
E96
E95
E94
E93
E92
E91
E83
E82
E81
E74
E73
E72
E71
E55
E54
E53
E52
E51
C54
C53
C52
C51

Figure 25: Basement cabinet 1

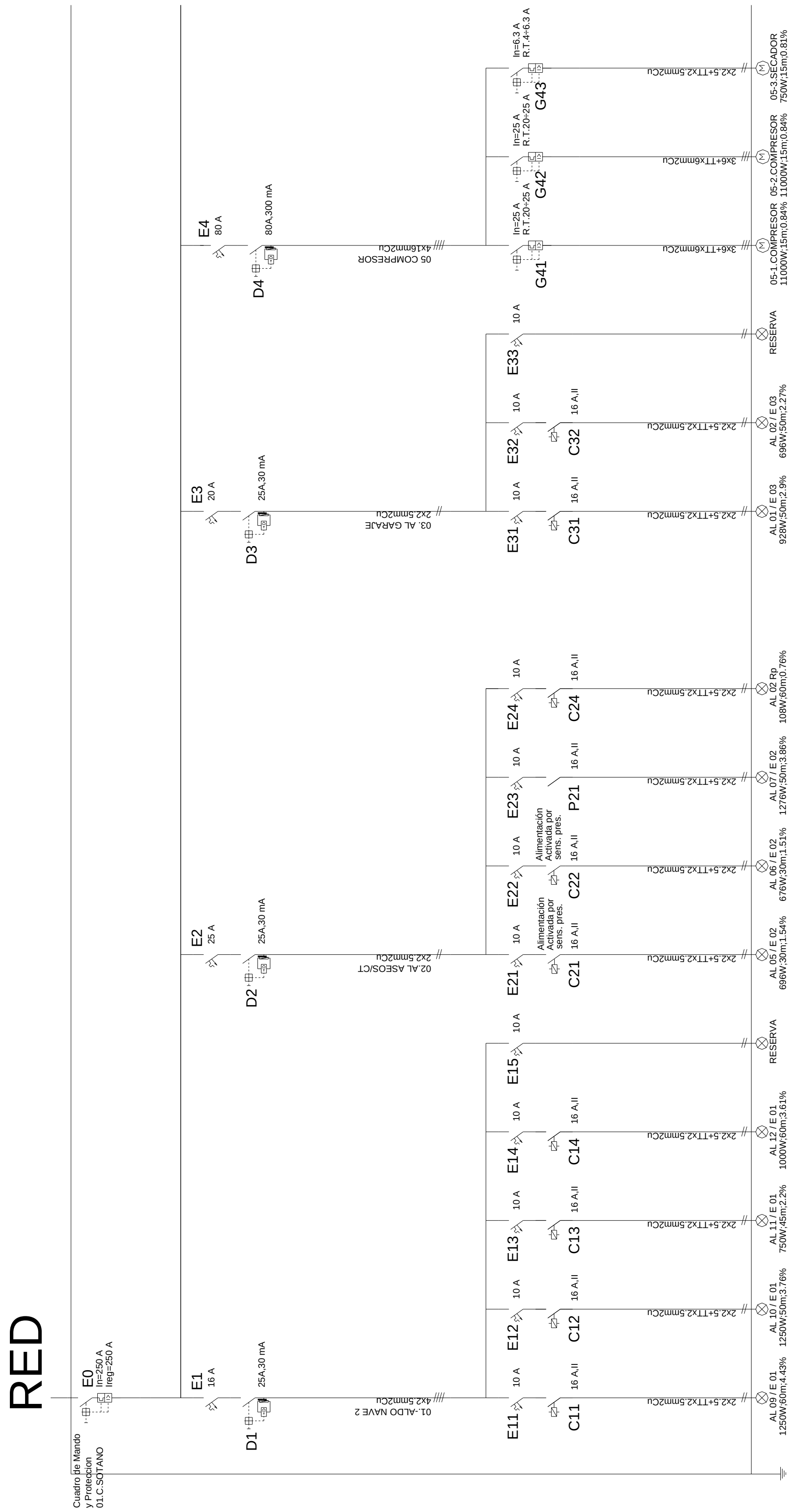


Figure 26: Basement cabinet 2

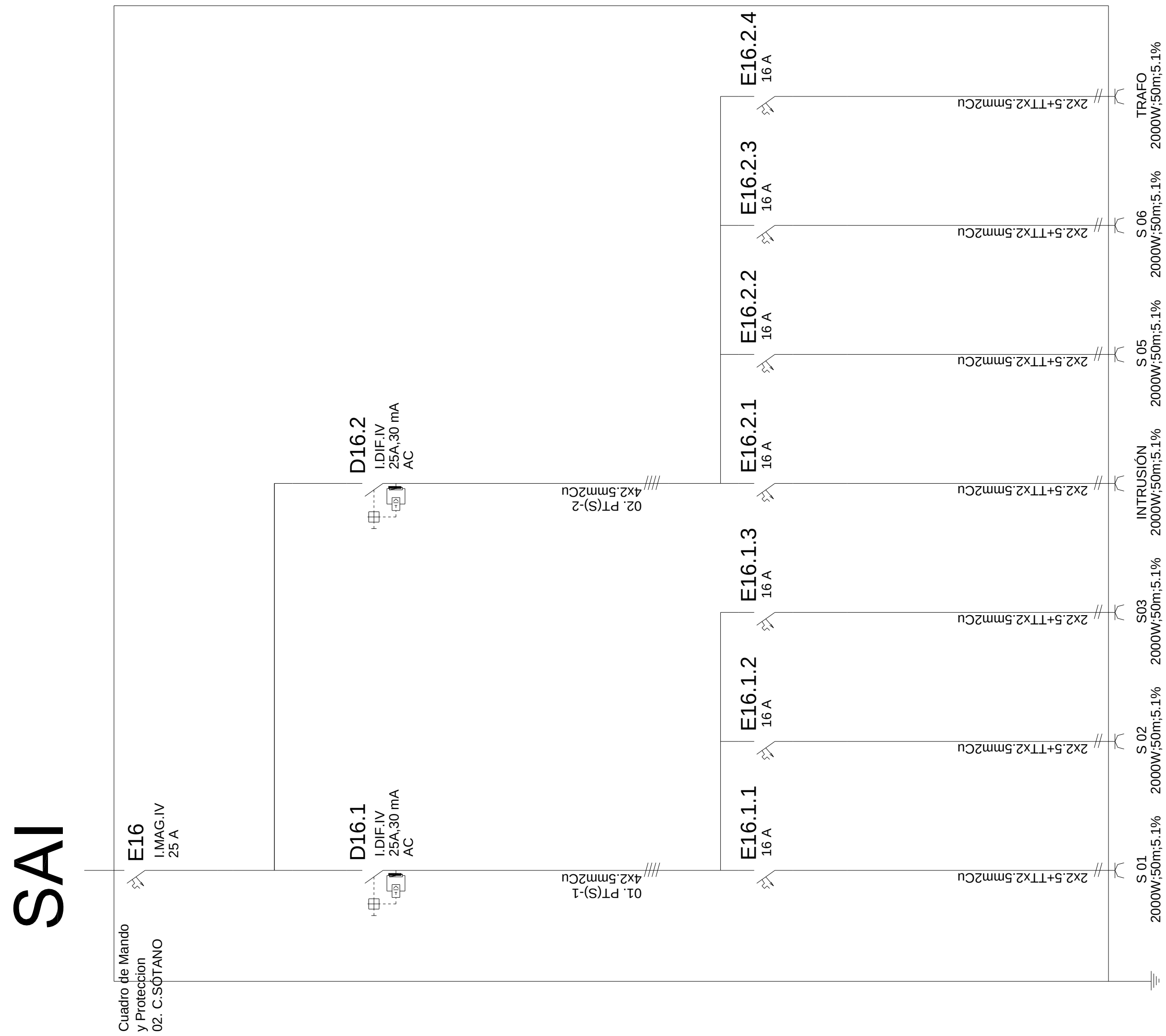


Figure 27: Basement cabinet 3

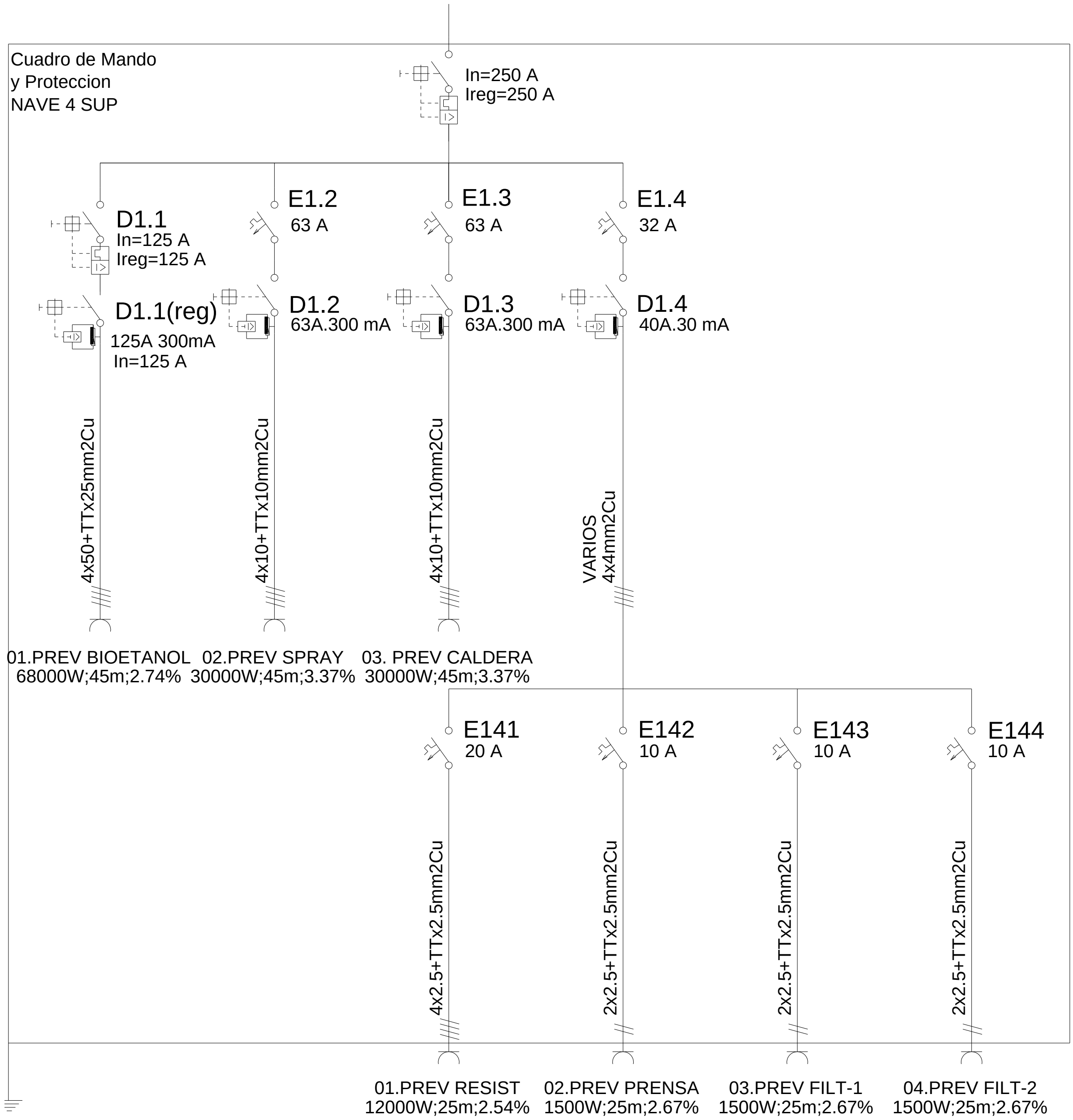


Figure 28: Industrial Area 4 Sup. Cabinet

4 Building energy consumption and subsystems performance

This section shows the methodology to obtain the overall energy consumption in the building and how to calculate the performance of the most important subsystems.

In order to evaluate the energy consumption it considers the following consumptions in the building:

- Thermal energy consumption for heating and cooling.
- Electrical consumption for building services (auxiliary energy for plants, pumps and ventilation, electrical lighting)

4.1 Building perfomance

The energy performance is obtained by comparing measured data with calculated values coming from simulations and calculations per EPBD. The objective is to compare the energy based parameters as described in the deliverable D3.1 Monitoring System Project of Demonstrator I in the section 3.5 “Data treatment and storing” with simulated and calculated values The following lines show how to of gather the energy data from the building in order to obtain complete information to evaluate its performance.

Figure 29 and 30 shows the location of the electrical and energy indicators:

- Heat counters in red.
- Refrigeration measurements in blue.
- Electrical consumption in green.

This figure represents the different sources of energy on the left (biomass, ground water and electricity) and how the different counters follow the energy used by the equipments.

In the case of the biomass the indicator Qh01 uses a calculation with the measured value tons of pellets (sensor T1) in order to calculate net energy, this calculation is like follows:

From the norm EN 15603 the energy content of solid fuels depends on their quality and density. The most accurate way of assessing it is to weigh the fuel; therefore NEC is equal to the multiplication the mass of biomass by gross calorific value (GCV) the specific value is in the manufacture information.

Take into account that the mass fuel is:

mass = (fuel weight in stock at the beginning of the assessment period) – (fuel weight in stock at the end of the assessment period) + (fuel weight bought during the assessment period).

$$NEC_{BIO} = mass.GCV$$

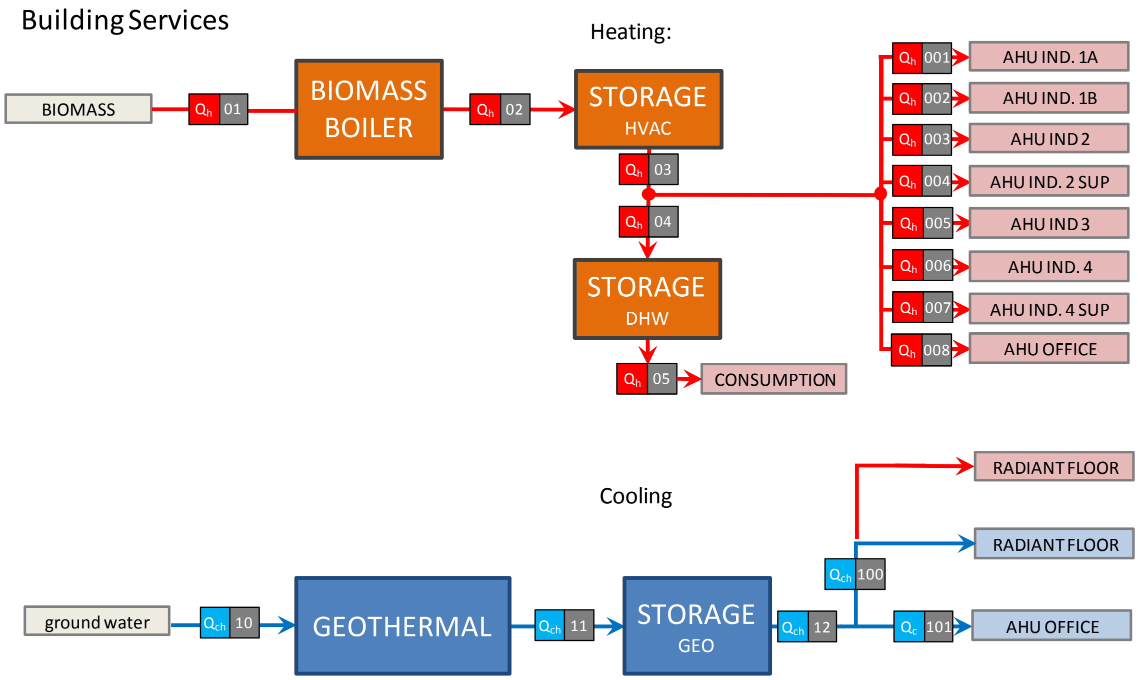


Figure 29: Location of the indicator for the quantification of the thermal consumption.

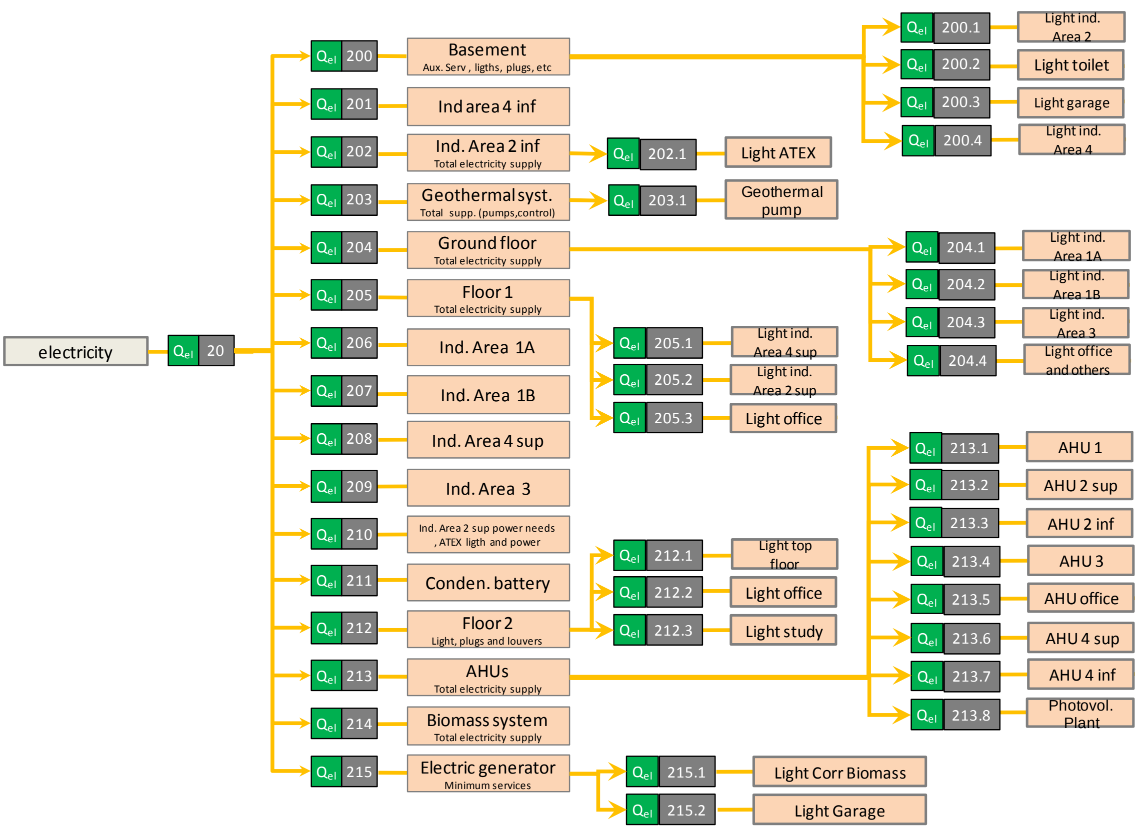


Figure 30: Location of the indicators for electricity.

4.2 NEC, Net Energy Consumed

Section 3.3.2 shows the formula used to evaluate the building's performance, which requires the NEC. The following table shows the connection between indicators and sensors.

Indicator	Energy counter related
Heat	
Qh01	∑T1
Qh02	∑H1
Qh03	∑K1
Qh04	∑H3
Qh05	∑H13
Qh001	∑H4
Qh002	∑H6
Qh003	∑H9
Qh004	∑H10
Qh005	∑H5
Qh006	∑H7
Qh007	∑H8
Qh008	∑H11
COOLING	
Qc101	∑H12
COOLING AND HEATING	
Qch10	∑K2
Qch11	H2
Qch12	∑K3
Qch010	∑H14

ELECTRICITY	
GENERAL COUNTERS	
Qel20	∑E1
Qel200	∑E2
Qel201	∑E3
Qel202	∑E4
Qel203	∑E5
Qel204	∑E6
Qel205	∑E7
Qel206	∑E8
Qel207	∑E9
Qel208	∑E10
Qel209	∑E11
Qel210	∑E12
Qel211	∑E13
Qel212	∑E14
Qel213	∑E15
Qel214	∑E16
Qel215	∑E17
COUNTER FOR LIGHTING	
Qel200.1	∑E18
Qel200.2	∑E19
Qel200.3	∑E20
Qel200.4	∑E21
Qel202.1	∑E22
Qel204.1	∑E23

Qel204.2	∑E24
Qel204.3	∑E25
Qel204.4	∑E26
Qel205.1	∑E27
Qel205.2	∑E28
Qel205.3	∑E29
Qel212.1	∑E30
Qel212.2	∑E31
Qel212.3	∑E32
Qel215.1	∑E33
Qel215.2	∑E34
EQUIPMENTS ELECTRIC COUNTERS	
Qel203.1	∑E43
Qel213.1	∑E36
Qel213.2	∑E38
Qel213.3	∑E37
Qel213.4	∑E39
Qel213.5	∑E35
Qel213.6	∑E41
Qel213.7	∑E40
Qel213.8	∑E42

Table 6: Relation between Indicators and sensors

The following table shows how to gather the NEC from each system and the interval of time used.

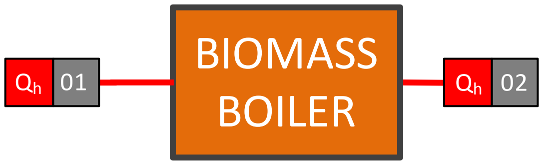
	Area	energy type	device	counter as per scheme	unit	Meas. interval
NEC Net Energy Consumed	Heating	thermal	biomass and geothermal pump	$Q_h01 + Q_h10$	kWh	15 min
	Cooling and heating	thermal, renewable	Ground Water well	$Q_{ch}10$	kWh	15 min
	H&C equipment	electrical	GHP, Pumps, Valves, control, etc..	$Q_{el}214 + Q_{el}203$	kWh	15 min
	Ventilation	electrical	AHU (1A, 1B, 2, 2 sup, 3, 4, 4 sup and offices)	$Q_{el}213.1 + Q_{el}213.2 + Q_{el}213.3 + Q_{el}213.4 + Q_{el}213.5 + Q_{el}213.6 + Q_{el}213.7$	kWh	15 min
	Ren. Energy	electrical	PV-Plant	Qel213.8	kWh	15 min
	Artificial [1] Light	electrical	Lighting Systems	$Q_{el}200.1 + Q_{el}200.2 + Q_{el}200.3 + Q_{el}200.4 + Q_{el}202.1 + Q_{el}204.1 + Q_{el}204.2 + Q_{el}204.3 + Q_{el}204.4 + Q_{el}202.1 + Q_{el}205.1 + Q_{el}205.2 + Q_{el}205.3 + Q_{el}212.1 + Q_{el}212.2 + Q_{el}212.3 + Q_{el}213.1 + Q_{el}213.2 + Q_{el}213.3 + Q_{el}213.4 + Q_{el}213.5 + Q_{el}213.6 + Q_{el}213.7 + Q_{el}215.1 + Q_{el}215.2$	kWh	15 min

Table 7: Net Energy Performance in CARTIF III.

4.3 Energy efficiency of HVAC systems

For the overview of the subsystems see figure 27 and 28. The following figures depict how to obtain the energy efficiency of heating and cooling systems. It takes into account the following:

- **BIOMASS BOILER:** In this case it used the value of the indicator Qh,01 from the sensor ∑T1 (see section 4.1 about building performance for further information) in order to have the consumption of the boiler, take into account that the use of electricity is a negligible value.



$$\eta_{BIO} = \frac{Q_{h,02}}{Q_{h,01}}$$

Figure 31: Performance of the biomass boiler.

- Ground water well: This is a renewable energy source. This subsystem has two modes of operation, heating and cooling, each one with a different performance although it used the same heat sensor for both modes of operation.

The counters used are as follows:

Electrical counter ∑H13 (indicator Qel,215.2) measures the consumption of the ground water pumps.
Heat counter ∑05 (indicator Qc,11) measures the heat contribution from the ground water to the AHP.

heat

$$COP_{GEO} = \frac{Q_{h,11}}{Q_{el,215.2}}$$

cool

$$EER_{GEO} = \frac{Q_{c,11}}{Q_{el,215.2}}$$

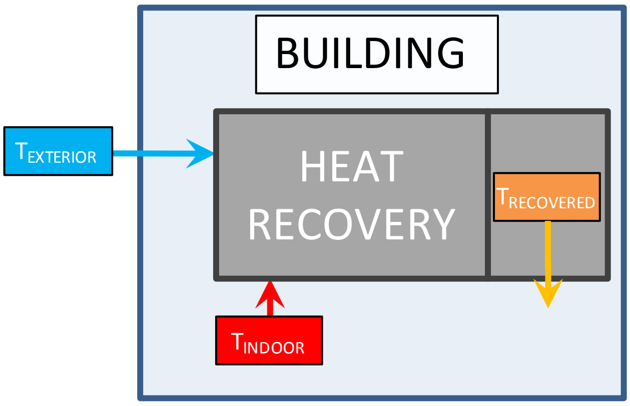
Figure 32: Performance of the Groundwater Well.

- **Heat recovery:** It uses the temperature measurements in order to relate the available energy and the energy recovered by the heat recovery.

- Texhaust: Temperature of the air after the heat recovery, this air is expelled outside.

- Texterior: Temperature outside in the atmosphere outside of the building.

- Tindor: Temperature of the air inside of the building.



$$EVA_{HR} = \frac{T_{RECOVERED} - T_{EXTERIOR}}{T_{INDOOR} - T_{EXTERIOR}}$$

Figure 33: Performance of the heat recovery.